Australian Government
Department of Agriculture, Water and the Environment

Consultation on Species Listing Eligibility and Conservation Actions

Banksia montana

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

1) the eligibility of *Banksia montana* 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 1 February 2022.

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/recovery-plans.

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 'Common Assessment Method' (CAM). 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: https://www.awe.gov.au/about/commitment/privacy .

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.

Consultation questions for *Banksia montana* (Stirling Range Dryandra)

SECTION A - GENERAL

1. Is the information used to assess the nationally threatened status of the species 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? If so, in what capacity?

PART 1 – INFORMATION TO ASSIST LISTING ASSESSMENT

SECTION B DO YOU HAVE ADDITIONAL INFORMATION ON THE ECOLOGY OR BIOLOGY OF THE SPECIES? (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?

SECTION C ARE YOU AWARE OF THE STATUS OF THE TOTAL NATIONAL POPULATION OF THE SPECIES? (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? 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 (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 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:

☐ 1–10 ☐ 10 – 50 ☐ 50–100 ☐ 100 – 250 ☐ >250

Level of your confidence in this estimate:

☐ 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

SECTION D ARE YOU AWARE OF TRENDS IN THE OVERALL POPULATION OF THE SPECIES? (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 1980s *(at or soon after the start of the most recent three generation)*? 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 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:

    ☐ <50 ☐ 50 – 250 ☐ 250 – 500 ☐ 500 – 1000 ☐ >1000

    Level of your confidence in this estimate:

    ☐ 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' total population size over the last approximately 39 to 40.5 years (i.e. three generations)? 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:

    ☐ 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, 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.

SECTION E **ARE YOU AWARE OF INFORMATION ON THE TOTAL RANGE OF THE SPECIES? (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? If not, please provide justification for your response.

14. Has the survey effort for this species 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:

    ☐ <20 km^2 ☐ 20 – 50 km^2 ☐ 50 – 100 km^2 ☐ >100 km^2

    Level of your confidence in this estimated extent of occurrence

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

    ☐ 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:

    ☐ <10 km^2 ☐ 10 – 20 km^2 ☐ 20 – 50 km^2 ☐ >50 km^2

Level of your confidence in this estimated extent of occurrence:

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

☐ 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

SECTION F ARE YOU AWARE OF TRENDS IN THE TOTAL RANGE OF THE SPECIES? (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:

    ☐ <20 km^2 ☐ 20 – 50 km^2 ☐ 50 – 100 km^2 ☐ >100 km^2

Level of your confidence in this estimated extent of occurrence

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

☐ 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:

☐ <10 km^2 ☐ 10 – 20 km^2 ☐ 20 – 50 km^2 ☐ >50 km^2

Level of your confidence in this estimated extent of occurrence:

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

☐ 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

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

SECTION G DO YOU HAVE INFORMATION ON THREATS TO THE SURVIVAL OF THE SPECIES? (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 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 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?

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

25. What planning, management and recovery actions are currently in place supporting protection and recovery of the species? 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?

27. Would you recommend translocation (outside of the species' historic range) as a viable option as a conservation actions for this species?

SECTION I DO YOU HAVE INFORMATION ON STAKEHOLDERS IN THE RECOVERY OF THE SPECIES?

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 has?

30. What individuals or organisations are currently, or potentially could be, involved in management and recovery of the species?

31. How aware of this species are land managers where the species is found?

32. What level of awareness is there with individuals or organisations around the issues affecting the species?

    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?

Conservation Advice for *Banksia montana* (Stirling Range dryandra)

In effect under the *Environment Protection and Biodiversity Conservation Act 1999* from DATE.

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.

Note: 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 species. It provides a foundation for conservation action and further planning.

Photo of *Banksia montana* (Stirling Range dryandra) © Copyright Sarah Barrett 2021

Conservation status

Banksia montana (Stirling Range dryandra) is proposed to be transferred from the Endangered category to the Critically Endangered category of the threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999.*

Stirling Range dryandra was assessed by the Threatened Species Scientific Committee to be eligible for listing as Critically Endangered under Criteria 2 and 3. 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: A4ae: Endangered
- Criterion 2**:** B1ab(i,ii,iii,iv,v)c(iv)**:** Critically Endangered
- Criterion 3: C2b: Critically Endangered
- Criterion 4: D1: Endangered
- Criterion 5: Insufficient data

The main factors that make the species eligible for listing in the Critically Endangered category are; rapid population reduction over the past three generations due to inappropriate fire

regimes and *Phytophthora cinnamomi* dieback; a very restricted distribution and number of locations; severe fragmentation; and a small total population size.

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 Species Profile and Threat Database.

Species information

Taxonomy

Conventionally accepted as *Banksia montana* (C.A Gardner ex A.S. George) A.R Mast & K.R Thiele (2007).

A member of the family Proteaceae, Stirling Range dryandra was first formally described as *Dryandra montana* in 1996 (George 1996). In 2007, all dryandras were transferred to the genus *Banksia*, and thus the species became *Banksia montana* (Mast & Thiele 2007).

Description

Stirling Range dryandra is an erect woody shrub 1–2.5 m in height. The leaves are 60–225 mm long and 9–12 mm wide, hairy, and contain 22–52 elongated, triangular lobes cut to the mid-rib and pointing towards the apex. The yellow flowers are produced from January to March, are covered with small villi, and form inflorescences about 17–20 mm long on the old wood inside the foliage. The pistil (female organs of the flower) is 25–30 mm, curved and hairy. The upper stems and fruits are covered by short red hairs. This information was adapted from Gilfillan et al. (2008) and Florabase (2020).

Distribution

Stirling Range dryandra is endemic to mountain summit areas between 900 m and 1080 m above sea level in the Stirling Range, approximately 70 km north of Albany, on the southern coast of Western Australia (WA) (Gilfillan et al. 2008; Map 1). Its range is entirely within the Stirling Range National Park, and the species is part of a group of plants forming the Eastern Stirling Range Montane Heath and Thicket Community (DPAW 2016). The species occurs in four subpopulations on a few eastern peaks, occupying a total area of less than 5 km^2, and possibly less than 1 km^2 (Silcock et al. 2021). It is considered to be locally extinct from one (Silcock et al. 2021).

Stirling Range dryandra was first discovered in 1964. Six natural subpopulations have been identified, with the four known extant subpopulations located on Bluff Knoll, East Bluff, Pyungoorup and Isongerup. The closest town to these subpopulations is Mount Barker. It is unlikely other subpopulations exist (S Barrett pers comm 2020, cited in Silcock et al. 2021; Table 1). One subpopulation, Coyanarup, is presumed extinct. A subpopulation at Kyanorup Eminence may also have gone extinct, though the lower altitude and different plant community suggests that Stirling Range dryandra may never have been present at this location (Gilfillan et al. 2008).

In early 2000, the known population size was 137 mature individuals and 39 juveniles over four natural subpopulations (Gilfillan et al. 2008). A fire in spring 2000 reduced this number to 51–55 mature individuals (Gilfillan et al. 2008; DAWE 2017; Silcock et al. 2021) and did not stimulate recruitment at subpopulations previously burnt in 1991(Barrett & Yates 2015). The number of mature plants further declined to 40 in 2015 and 34 in 2016 (DAWE 2017; Silcock et

al. 2021). An escaped prescribed burn in May 2018 (BOM 2018; Office of Bushfire Risk Management 2018) and a bushfire in December 2019 led to 100 percent mortality of all known mature Stirling Range dryandra individuals (S Barrett 2020. pers comm 25 September). Recruitment of more than 1000 seedlings occurred after the 2018 fire, and in 2020, 857 juveniles were identified. This included 630 in the Bluff Knoll subpopulation, 9 at Pyungoorup, 204 and Isongerup and 14 at East Bluff (Silcock et al. 2021). It was considered that approximately 60 percent of the juveniles alive in 2019 survived until 2020 (S Barrett 2020. pers comm 25 September). By autumn 2021, 725 juveniles from the 2018 fire and 22 seedlings that germinated after the 2019 fire were present (DBCA 2021). These subpopulations are currently comprised entirely of juvenile plants and it is not known whether they will survive to reproductive maturity due to ongoing threats (Silcock et al. 2021). Mortality of seedlings and juveniles due to disease, drought and fire has occurred (S Barrett 2020. pers comm 25 September),

Ex situ subpopulations

In August 2003 and June 2004, 89 juvenile plants grown from seeds were planted ex situ at Luscombe's seed orchard, approximately 50 km from the natural range. There are now two translocated subpopulations, though the Benmore Tree farm established in 2010 only has a few individuals of the species (S Barrett 2020. pers comm 25 September; Table 1). Over several years, a total of 138 and 48 seedlings have been planted at these sites respectively, and as of 2019–20, 65 and two plants were surviving in each orchard respectively. No recruitment had occurred at either site prior to 2021(Silcock et al. 2021; DBCA 2021). These plants constitute a highly significant insurance subpopulation, and increasingly so, as extant subpopulations have declined and gone extinct (Cochrane et al. 2010). As of 2021, the seed orchards are the only subpopulations with mature individuals.

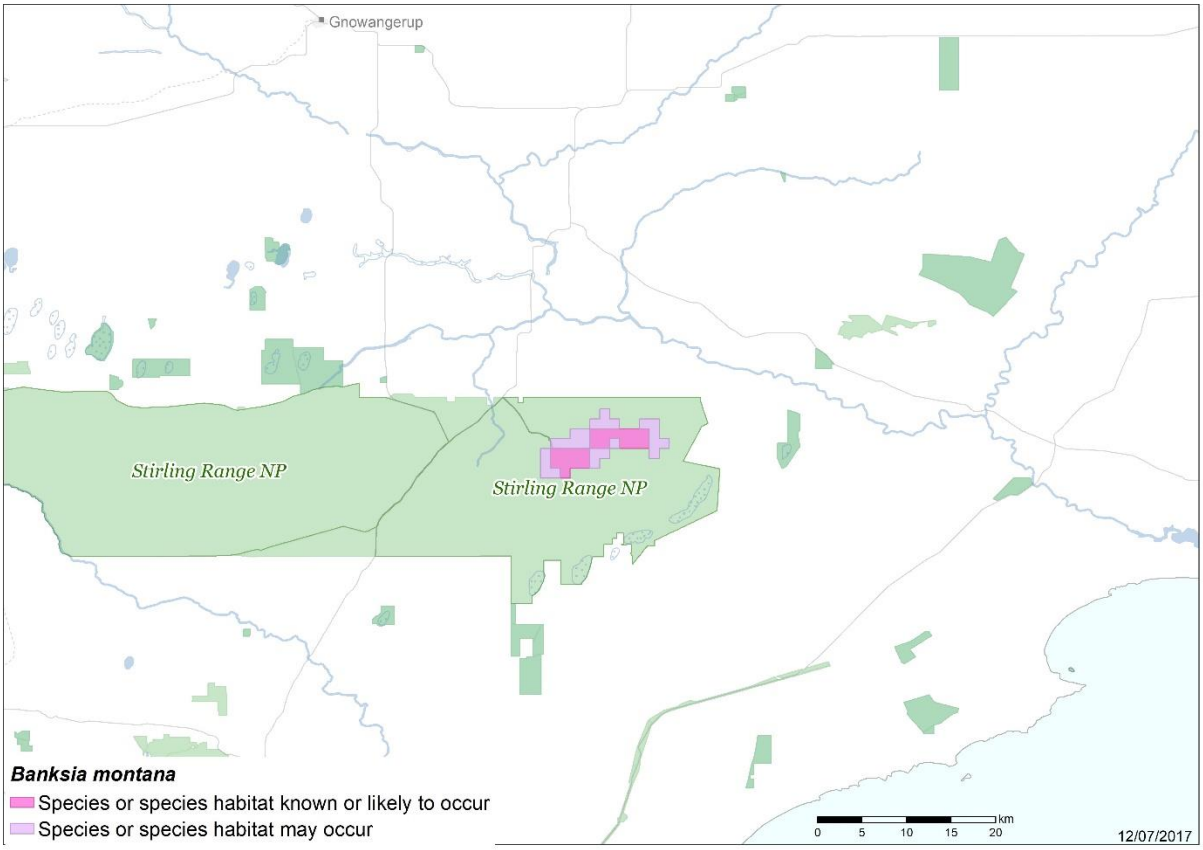
In 2019, seedlings from the larger ex situ subpopulation were translocated to three natural subpopulations to increase genetic diversity and population size. The seedlings planted during this trial are currently juveniles (S Barrett 2020. pers comm 25 September). Direct seeding was also trialled in 2018 and 2020, whereby seeds were directly planted into the soil in extant subpopulations. Information on the results of the direct seeding trials is currently unavailable.

Table 1 Summary of Stirling Range dryandra population information and threats as of December 2020, adapted from DBCA (2020), cited by Silcock et al. 2021.

Subpopulation (tenure)	Number of mature individuals (juveniles)	Trend
1 Bluff Knoll (National Park)	1995: 21 (0) 2004: 7 (15) 2018: 4T 2020: 0 (630) (34T)	Decreasing
2 Coyanarup (National Park)	2000: 0 (0) 2018: 0 (16T) 2020: 0 (13T)	Presumed extinct (as yet no evidence of natural recruitment from translocated plants)
3 Kyanorup Eminence (National Park)	2000: 0 (0) 2020: 0	Presumed extinct (but may have never been extant)
4 Pyungoorup (National Park)	1996: 23 (0) 2004: 19 (0) 2018: 7 2020: 0 (9)	Decreasing
5 Isongerup (National Park)	1997: 13 (1) 2004: 3 (0) 2018: 0 2020: 0 (204)	Decreasing
6 East Bluff (National Park)	1996: 61 (8) 2004: 16 (1) 2018: 1 (23T) 2020: 0 (14) (15T)	Decreasing
Ex-situ populations		
7 (T) Luscombe's Seed Orchard (private property)	2003-2010: (138T*) 2019: 65T	Increasing
8 (T) Benmore Tree Farm (private property)	2010-2013: (48T*) 2016: 21T 2020: 2T	Decreasing

(T) Translocated individuals/ subpopulation. *Total number of seedlings planted over multiple years

Map 1 Modelled distribution of Stirling Range dryandra



Source: Base map Geoscience Australia; species distribution data Species of National Environmental Significance 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 containing herein.
Species distribution mapping: The species distribution mapping categories are indicative only and aim to capture (a) the specific habitat type or geographic feature that represents to recent observed locations of the species (known to occur) or preferred 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

This section describes some published examples of this significance but is not intended to be comprehensive, applicable to, or speak for, all Indigenous people. Such knowledge may be only held by Indigenous groups and individuals who are the custodians of this knowledge.

The Aboriginal Sites Register kept by the Western Australian Department of Department of Planning, Lands and Heritage lists one significant artifact/scatter site in the vicinity of Stirling Range dryandra's distribution (DPAW 2016). The Traditional Owner group for the area is the Minang People of the Wagyl Kaip Noongar Nation. The Eastern Stirling Range Montane Heath and Thicket Community is culturally significant to Aboriginal people in the area, and input from these groups is incorporated into the management of Stirling Range. Aboriginal involvement in the management of land is covered by an agreement under the Conservation and Land Management Act 1984 (DPAW 2016). Additionally, the Wagyl Kaip and Southern Noongar

Indigenous Land Use Agreements, executed by the Western Australian Government and the Noongar Peoples (17 Oct 2018), includes lands in or adjacent to known occurrences of the Stirling Range dryandra.

Relevant biology and ecology

Habitat

The Stirling Range dryandra grows on sandstone, metamorphosed sandstone and metamorphosed siltstone in the Stirling Range Montane Heath and Thicket Community (Barrett 2000; Silcock et al. 2021), more than 900 m above sea level on the eastern Stirling Range. It is found in dense heath and thicket dominated by *Banksia oreophila* (western mountains banksia) and *Kunzea montana* (mountain kunzea), and includes *Adenanthos filifolius*, *Andersonia axilliflora* (giant andersonia), *Aotus genistoides*, *Banksia brownii* (feather-leaved banksia), *Banksia coccinea* (scarlet banksia), *Beaufortia anisandra* (dark beaufortia), *Calothamnus montana* (hawkeswood), *Darwinia collina* (yellow mountain bell), *Leucopogon gnaphalioides* and *Sphenotoma* sp. Stirling.

No microtopographic climate data has been collected for the specific areas that Stirling Range dryandra inhabits, though data from the closest town, Mount Barker, suggest an average annual rainfall of 600 – 700 mm (BOM 2021). However, rainfall is likely to be considerably higher on the mountain peaks (Gilfillan et al. 2008). The conditions on these mountains are distinctively montane, with extreme temperatures, high humidity and occasional snowfall (DBCA 2020).

Reproduction and life history

The primary juvenile period for Stirling Range dryandra is estimated at 9 years, as flowering was first recorded nine years after the 2000 fire in extant wild subpopulations (Gilfillan et al. 2008). Flowering has been recorded earlier in seed orchards, likely due to improved moisture and nutrition (DAWE 2016). Individuals have lived for at least 30 years in wild subpopulations (Gilfillan et al. 2008), but maximum lifespans in the absence of fire or disease are probably longer.

Stirling Range dryandra flowers annually between January and March, with rates of flowering and seed production varying considerably between individuals and years (Gilfillan et al. 2008). Fruits persist in the canopy for at least four years, after which they begin to disintegrate. Several plants in all subpopulations assessed from 2001 to 2004 produced very little seed (Yates & Barrett, as cited in Gilfillan et al. 2008). The reasons for variable flower, fruit and seed production in Stirling Range dryandra subpopulations are not clear and may be related to plant age, health, vigour and the effectiveness of pollination.

Ladd et al. (1996) investigated pollen presenter and style characteristics in the genus *Banksia* (including dryandra species). In Stirling Range dryandra, the pollen presenter is 1 mm in length and 0.3 mm in diameter. The style is constricted below the pollen presenter and is bowed in shape and the stigmatic groove is oblique terminal. The approximate distance from the pollen presenter to the receptacle is 26 mm. Ladd et al. (1996) suggest that these characteristics are consistent with mammal or insect pollination. Honey possum (*Tarsipes rostratus*) has been recorded on infrared camera on Bluff Knoll (where one subpopulation is found) and are assumed to be a pollinator of Stirling Range dryandra (DBCA 2021).

Stirling Range dryandra is a serotinous, obligate seeding shrub that depends on fire to recruit seedlings. This means that, when a fire occurs, seeds stored in the canopy are released and germinate (Silcock et al. 2021). Flowering and seed production vary between individuals and years, and may reflect plant age, health and pollination effectiveness (Gilfillan et al. 2008). In 2000, 116 individuals were killed by a prescribed fire and only 13 seedlings emerged post-fire (Gilfillan et al. 2008), however the 2018 fires led to considerably higher levels of germination. Recruitment success likely varies with post-fire rainfall, as has been shown in other *Banksia* species (e.g., Burgman & Lamont 1992).

Commensal species
In 2013, a new species of mealybug, *Pseudococcus markharveyi (Banksia montana* Mealybug), was described (Gullan et al. 2013). The species is morphologically similar to other species in the genus *Pseudococcus* (Westwood 1840; Gullan et al. 2013) and is found exclusively on Stirling Range dryandra. Mealybugs were originally discovered on Stirling Range dryandra plants in 2007 (Moir et al. 2012a, b), and subsequent sampling of 34 species from the surrounding region for host specificity determined it was only present on Stirling Range dryandra. The species feeds exclusively on the sap of Stirling Range dryandra plants. Thus, loss of plant biomass and mortality of Stirling Range dryandra individuals poses a large threat to the survival of the *Banksia montana* Mealybug. Given the conservation status of the remaining extant subpopulations of Stirling Range dryandra, the *Banksia montana* Mealybug is listed as critically endangered (Moir et al. 2012a; Gullan et al. 2013; Moir et al. 2016; DAWE 2017) and may be extinct.

Habitat critical to the survival

The Stirling Range dryandra is restricted to mountain summit areas between 900 m and 1080 m above sea level in the Eastern Stirling Range and is endemic to the Eastern Stirling Range Montane Heath and Thicket Community (Barrett 2000). This community comprises a heathland and dense shrub thicket with several endemic species and 13 threatened plant species. Maintenance of the health of the Eastern Stirling Range Montane Heath and Thicket Community is critical for the survival of Stirling Range dryandra, as it is only known from areas where this community is found. Furthermore, with only four subpopulations occupying a total area of less than 1 km^2 (Silcock et al. 2021), the area above 900 m, including all current and historical Stirling Range dryandra habitat, is habitat critical for the survival of the species.

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.

All populations are important to the ongoing survival and recovery of Stirling Range dryandra, as well as the breeding, dispersal and genetic diversity of the species.

The two ex situ populations, established in seed orchards approximately 50 km from the extant range, are also important populations for the ongoing survival of the species. These orchards are required to preserve genetic diversity and to help recover the extant populations through

breeding, the use of reinforcement translocations and direct seeding (S Barrett 2020. pers comm 25 September).

Threats

Stirling Range dryandra is threatened by prescribed burning practices, altered fire regimes associated with climate change, disease, grazing and browsing by native and introduced species and habitat disturbance by human recreation. The species is threatened by several fire-related threats, including high frequency fire, fire-disease interactions, fire-drought interactions, and fire-herbivore interactions. The small population size and limited distribution of the species leaves it vulnerable to extinction through stochastic events such as bushfires.

Table 2: Threats impacting Stirling Range dryandra

Threat	Status and severity [a]	Evidence
Habitat disturbance and modification		
Inappropriate fire regimes	• Timing: current • Confidence: known • Consequence: catastrophic • Trend: increasing • Extent: across the entire range	Obligate seeders like the Stirling Range dryandra are sensitive to frequent fire regimes and require a minimum fire-free interval to reach reproductive maturity to maintain population size. Local extinction will occur where fire intervals are shorter than the time taken for the plants to reach reproductive maturity (the primary juvenile period), which is likely to lengthen in a drying climate. The primary juvenile period for Stirling Range dryandra is likely in the order of nine years in the wild. Furthermore, in species that store their seed in the canopy, all seeds are often exhausted in a single fire and may be less resilient to high fire frequency due to the lack of a buffering from a residual soil stored seedbank (Kenny 2003). 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). However, the species has a long lifespan, at least 30 years (Gilfillan et al. 2008), and maximum lifespans in the absence of fire or disease are likely longer. As such, rare recruitment events in the absence of fire may sustain the population. Thus, fire exclusion may not pose a significant threat to the ongoing sustainability of the population, and high fire frequency and post-fire drought, herbivory and disease, are currently more significant threats to the species. Gill and Nicholls (1989) proposed that "Until further data becomes available it is suggested that a doubling of the general juvenile period of the species observed at the monitoring site be used as the guide to when the species is likely to be able to replace itself to pre-fire abundance levels". For Stirling Range dryandra, the juvenile period is nine years and therefore the minimum fire interval for it to persist is estimated at 18 years. Major bushfires have impacted Stirling Range dryandra subpopulations in 1972, 1991, 2000, 2018 and 2019, with some

		subpopulations affected by several of these fires. The 1991 bushfire affected a small part of East Bluff and a significant part of Bluff Knoll, though the full impact of these fires and those in 1972 is unknown. In contrast, the impact of the 2000 prescribed burn on Stirling Range dryandra was closely monitored and resulted in 70% mortality in three subpopulations and 8% of the Pyungoorup population (Yates and Barrett, unpublished data, as cited in Gilfillan et al. 2008). Seedling recruitment following the 2000 prescribed fire was very low and considerably less than the number of plants killed by the fire. After the fire, the previous population of 137 adults and 38 juveniles was reduced to 51 adults, nine juveniles and 30 seedlings (Gilfillan et al. 2008). The negative impact of this burn was exacerbated by high levels of post-fire vertebrate browsing and grazing. The May 2018 fire was the result of an escaped prescribed burn in the area. Strong winds resulted in prescribed burns on crown land growing out of control and becoming bushfires (BOM 2018; Office of Bushfire Risk Management 2018). Post fire surveying suggested substantial population reduction in fire-affected Stirling Range dryandra subpopulations. Thirty-three of the 41 remaining extant mature plants were killed. However, seedling recruitment was relatively high. More than 1000 seedlings germinated compared to approximately 30 after the 2000 fire (DBCA 2021). The impacts of the 2018 fire were compounded by a bushfire in December 2019, which killed all remaining mature individuals (S Barret 2020. pers comm 25 September), with the combination of the 2018 and 2019 bushfires burning 100% of known subpopulations and killing 100% of known mature individuals. Some seedlings that germinated after the 2018 fire were also killed, though most mortality since 2018 is thought to have been due to drought conditions (S Barret 2020. pers comm 25 September). The loss of all extant mature individuals in 2018-2019 increases the risk of extinction for the *Banksia montana* Mealybug. Fires also interact with disease and herbivores, which elevate risks of recruitment failure in the post-fire environment (Moore et al. 2015; Bond & van Wilgen 1996) (see below). Overall, fire regimes that threaten Stirling Range dryandra involve a range of mechanisms, including high frequency fires and interactions between fire and drought, disease and herbivores. Prescribed burning is likely to increase the risks from all of these processes. Although not currently a threat, low frequency fire could be an issue in the

		unlikely event that the population remains unburnt for many decades.
Disturbance by human recreation	• Status: current • Confidence: suspected • Consequence: moderate • Trend: unknown • Extent: across parts of the range	The higher peaks of the eastern Stirling Range attract visitors interested in bushwalking, nature observation and rock-climbing. Negative impacts of these recreation activities include habitat degradation through braiding of paths, erosion, bare ground occurrence, changes to soil nutrients and, most importantly, introduction and spread of *P. cinnamomi* (Barrett et al. 2000; DPAW 2016). Human activity is thought to have spread the pathogen through the transport of infected soil, mostly by foot access, as a result of recreational and other activities (Gillen & Watson 1993; Wills 1993). Bluff Knoll is the most visited site, so has the highest levels of human disturbance.
Disease		
Dieback caused by *P. cinnamomi*	• Status: current • Confidence: known • Consequence: catastrophic • Trend: static • Extent: across the entire range	The Eastern Stirling Range Montane Heath and Thicket Community has been significantly affected by dieback caused by *P. cinnamomi* since it was identified in the region in 1974. *Phytophthora cinnamomi* 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-rot fungus *Phytophthora cinnamomi*' is listed as a Key Threatening Process under the EPBC Act (DAWE 2018). Stirling Range dryandra is susceptible to dieback caused by *P. cinnamomi* (Barrett et al. 2008; Shearer et al. 2013), though disease susceptibility may vary between plants, with some individuals continuing to survive in a healthy state after inoculation by a standard method (Barrett et al. 2008). This contrasts with some other highly susceptible species that are uniformly susceptible (McCredie et al. 1985). *Phytophthora cinnamomi* has infested the Bluff Knoll, East Bluff and Pyungoorup subpopulations of Stirling Range dryandra. Most of the Isongerup population remains unaffected (Barrett & Yates 2015). The disease has killed plants in the three affected subpopulations, though some healthy individuals persisted in infested vegetation (Barrett & Yates 2015). At least one population has become locally extinct, presumably from dieback infestation, possibly in conjunction with fire (Gilfillan et al. 2008). Comparative photography shows that healthy stands in the 1960s and 1980s on the summit of Bluff Knoll had become rare. This is thought to be as a result of dieback. (DPAW 2016). *Phytophthora cinnamomi* dieback may also interact with fire to increase the impact of the disease and accelerate collapse of obligate seeding plants such as Stirling Range dryandra (Moore et al. 2015). In areas where the pathogen is present, the densities of these plant species are highest in areas not affected by recent fires (Barrett & Yates 2015).

		Observations indicate that the impact of *P. cinnamomi* may be exacerbated post-fire, due to altered hydrology and increased surface run-off (Barrett 1996), as well as increased root tissue vulnerability (B. Shearer, personal communication, cited in Gilfillan et al. 2008).
Invasive and native species		
Grazing by invasive and native species	• Status: current • Confidence: known • Consequence: major • Trend: decreasing • Extent: across the entire range	Montane ecosystems are vulnerable to the removal of vegetation by native and feral fauna (Leigh et al. 1987; Bridle & Kirkpatrick 1999; Bridle et al. 2001; DPAW 2016). Surveys since 1994 have confirmed the presence of European rabbits (*Oryctolagus cuniculus*) and the quokka (*Setonix brachyurus*) within the range of Stirling Range dryandra (Barrett 1996). Since the 2000 bushfire, the impacts of browsing by vertebrate fauna have become increasingly apparent, especially on seedling and juvenile plants (DPAW 2016). Subsequent management solutions include European rabbit control using oats containing the poison 1080, as well as fencing and caging of all Stirling Range dryandra plants to protect against herbivory (DPAW 2016). More recently, Calicivirus RHDV1-K5 has been released at three subpopulations (S Barret 2021. pers comm 3 May). Between 2011 and 2015, motion sensing cameras were installed to identify the vertebrates most responsible for native vegetation browsing. Quokkas were responsible for 75 percent of recorded herbivory events (Rathbone & Barrett 2017). This evidence, combined with dietary analysis, implicates Quokkas as the species most responsible for vegetation loss through grazing. Stirling Range dryandra is particularly vulnerable to grazing after fires, especially given its slow post-fire recovery. Forty percent of seedlings that emerged following the 2000 fire were heavily grazed by either European rabbits or Quokkas, though all seedlings were subsequently protected from further grazing with cages (Gilfillan et al. 2008). Juvenile plants that successfully regenerated after the fires were also partially to completely defoliated. After the 2018 and 2019 fires, 99 percent of seedlings and juveniles have been fenced to protect against grazing (S Barrett 2021, pers comm 3 May). Invertebrate damage has been observed on the foliage of in situ plants, but more so on plants in the ex situ seed orchards. where fruit predation has also been high (S. Barrett, pers obs, cited in Gilfillan et al. 2008). Considering the low number of individuals of Stirling Range dryandra, this grazing pressure may impact on subpopulations if it reduces the vigour of plants, though there has been no substantial impact on in situ individuals.

Climate Change		
Increased temperatures and reduced precipitation	• Status: current • Confidence: known • Consequence: catastrophic • Trend: increasing • Extent: across the entire range	The CSIRO & Bureau of Meteorology (2015) predict south-west Western Australia will experience decreased precipitation and increased average temperatures, as well as greater frequency of droughts. This may cause substantial changes to the unique climate in which the Stirling Range Dryandra occurs (Monks et al. 2019). The interaction between fire and drought are particularly problematic for obligate seeders, as they rely on fire for recruitment, yet seedlings have poorly established root systems and are vulnerable to post- fire drought (Burgman & Lamont 1992). 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 already have caused the contraction of some species to upland slopes and gullies. The drier, hotter conditions projected under climate change could accelerate this process, significantly reducing the area of habitat suitable for Stirling Range dryandra (Monks et al. 2019). However, the species can grow in lowland conditions when provided sufficient water and nutrients, as evidenced by growth and propagation in ex situ seed orchards. Further research is required to appropriately determine the impact of drier, hotter conditions on the species. Projections of higher temperatures, more frequent droughts and reduced mean precipitation for south-west Western Australia due to climate change suggest that the frequency, intensity and scale of bushfires in the region will increase (CSIRO & Bureau of Meteorology 2015). Therefore, the incidence of fire intervals shorter than the 18-year seed development threshold for this species is likely to rise (Barrett and Yates 2015).

Each threat has been described in Table 2 in terms of the extent that it is operating on the species. The risk matrix (Table 3) 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.

Table 3 Stirling Range dryandra risk matrix

Likelihood	**Consequences**				
	Not significant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	Low risk	Moderate risk	Very high risk	Very high risk **Grazing by native and invasive species**	Very high risk **Inappropriate fire regimes** **Dieback caused by *P. cinnamomi*** **Increased temperatures and reduced precipitation**
Likely	Low risk	Moderate risk	High risk **Disturbance by human recreation**	Very high risk	Very high risk
Possible	Low risk	Moderate risk	High risk	Very high risk	Very high risk
Unlikely	Low risk	Low risk	Moderate risk	High risk	Very high risk
Unknown	Low risk	Low risk	Moderate risk	High risk	Very high risk

Priority actions have then been developed to manage the threat particularly where the risk was deemed to be 'very high' or 'high'.

Conservation and recovery actions

Primary conservation objective

The population of Stirling Range dryandra will increase in abundance, viable populations are sustained in habitats where high risk threats are managed effectively, and known seed orchards remain to support natural subpopulations.

Conservation and management priorities

Breeding, seed collection, propagation and other ex situ recovery action

- Continue to maintain and protect from fire the two existing seed orchards (ex situ subpopulations) to ensure their ongoing survival and ability to provide seed and germplasm suitable for translocation to wild subpopulations. Where availability of propagules permits, expand the ex-situ subpopulations to represent the maximum amount of genetic diversity possible.
- Continue reinforcement translocations and direct seeding in the wild subpopulations, using plants and seed from ex situ subpopulations and maintain and publish records of survival and maturation.
- Establish new seed production areas outside of Stirling Range National Park and upgrade current seed orchards with better reticulation to improve plant health.
- Identify additional sites suitable for the establishment of new subpopulations through translocations, ensuring that translocation sites are free from *P. cinnamomi*.
- Continue to maintain stored seed and germplasm to preserve genetic material, such as the Stirling Range dryandra seed collection currently stored at the WA Threatened Flora Seed Centre.
- Continue to develop cutting propagation and tissue culture techniques. Material for tissue culture has been collected by the Botanic Gardens and Parks Authority (BGPA) and is important for restocking future subpopulations. Cuttings from in situ subpopulations have also been collected by BGPA.
- Investigate opportunities to secure ex situ populations within National Reserve System via land purchase or conservation covenants.
- Use genomic approaches to understand population structure and use this data to inform translocation programs (Rosetto et al. 2021). For example, through the use of disease resistant genotypes for re-introduction and translocations.

Fire and climate change

- Avoid risks of escape of prescribed fires, as has occurred in the past. Review the need for prescribed burning within or near Stirling Range National Park, identify essential needs, if any, and consider eliminating the practice. However, if prescribed fires are essential for other conservation values, then critically review the evidence that a proposed burn is controllable, cannot escape, and is unable to reach the peaks where Stirling Range Dyrandra is found, and only proceed when these outcomes can be achieved.
- Implement a fire management strategy to protect all known subpopulations from further fire. If possible, exclude fire from all subpopulations for the indefinite future (Barrett et al. 2020), or at least 18 years.
- Investigate the establishment of translocated subpopulations in suitable climate refugia.

Disease

- Ensure that sites where individuals will be translocated to are appropriately protected against dieback caused by *P. cinnamomi* and are not infected prior to translocation.

- Continue to manage and minimise the spread of *P. cinnamomi* dieback, initially by appropriate application of phosphite to all sites with extant and extinct subpopulations (DPAW 2016), until alternative disease treatments are developed. In order to minimise potential off-target impacts that may potentially result from the build-up of phosphorus in low-nutrient soils (Lambers et al. 2013; Hopper et al. 2021), ensure that applications of phosphite are highly localised where possible.
- Promote research and development of alternative treatments of *P. cinnamomi* and the disease it causes.
- Ensure that appropriate hygiene protocols are adhered to when entering Stirling Range dryandra subpopulations.
- Determine which lineages *of P. cinnamomi* are present across the Stirling Range dryandra population.

Invasive species (including threats from grazing, trampling, predation)

- Install and maintain cages or fencing around seedling, juvenile and translocated plants to protect against grazing by European rabbits.
- Maintain the European rabbit control program and continue baiting with 1080-laced oats in areas with a high European rabbit subpopulation, including East Bluff, Bluff Knoll and Pyungoorup (DPAW 2016) to ensure post-fire population recovery.
- 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 2021. pers comm 3 May).

Impacts of native species

- Install and maintain cages or fencing around seedling, juvenile and translocated plants to protect against Quokka grazing.
- Monitor and mitigate herbivore impacts for at least five years post-fire.
- Continue using remote cameras to monitor Quokka activity.

Habitat loss, disturbance and modification

- Ensure that extant, extinct and translocated subpopulations continue to be protected from habitat loss and disturbance.
- Protect subpopulations from trampling using signage, track markers and fencing.

Stakeholder engagement/community engagement

- Liaise with land managers and Indigenous communities regarding the management of Stirling Range dryandra. Consult with Traditional Owners to discuss issues or interests in areas where the species is found, as the Stirling Range National Park is in a culturally sensitive and significant area.
- Liaise with the local community and government agencies to ensure that up-to-date population data inform the implementation of management actions.

- Promote public awareness of biodiversity conservation and protection through dissemination of information through physical and digital media.

Survey and monitoring priorities

- Regularly monitor all extant and presumed extinct subpopulations, including population stability, pollinator activity, growth, reproduction, recruitment, longevity and response to threats. Use these data to assess the species' status and extent of population recovery after the 2018 and 2019 fires.
- Maintain the current subset of extant seedling and juvenile plants that are currently tagged for monitoring in all subpopulations (S Barrett 2021. pers comm 3 May).
- Monitor plants within translocated subpopulations and seed orchards. Record the number of surviving adult plants and seedlings, height of adults plants and seedlings, reproductive state, and general health.
- Survey suitable habitat for new subpopulations and possible translocation sites.
- Implement a monitoring program to evaluate the effectiveness of disease management.

Information and research priorities

- Increase knowledge surrounding the ecology of Stirling Range dryandra. This includes improving understanding of factors limiting seed production and recruitment, genetic structure, seed production and viability, seed predation, germination requirements, minimum viable population size and genotypes resistant to dieback.
- Understand the potential influence of climate change on the long-term survival prospects of the species, e.g., through changes to temperatures, rainfall patterns, fire regimes, environmental stressors and disease.
- Investigate the interaction between bushfires and *P. cinnamomi*.
- Map habitat critical to species survival. Although habitat mapping has already been undertaken for this species, updated and detailed mapping is likely required due to the changes in habitat (vegetation structure and composition) brought about by the 2018 and 2019 fires and the invasion of *P. cinnamomi*.
- Determine the impact of drier, hotter conditions on the species. and identify and protect modelled potential areas of climate refugia for the species under projected climate change scenarios.
- Investigate new methods for the effective control of *P. cinnamomi* and treatment of the disease it causes, in order to reduce potential off-target impacts caused by the application of phosphite.
- Collect and record climatic data (e.g., rainfall, soil and air temperatures, humidity).

Recovery plan decision

There is currently an existing Recovery Plan that is due to expire in 2022 (Gilfillan et al. 2008).

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.

Links to relevant implementation documents

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

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

Stirling Range dryandra (Dryandra Montana) Recovery Plan (2008)

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Attachment A: Listing Assessment for *Banksia montana*

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 EPBC Regulations. The thresholds used correspond with those in the IUCN Red List criteria except where noted in criterion 4, sub-criterion D2. The IUCN criteria are used by Australian jurisdictions to achieve consistent listing assessments through the Common Assessment Method (CAM).

Key assessment parameters

Table 4 includes the key assessment parameters used in the assessment of eligibility for listing against the criteria.

Table 4 Key assessment parameters

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Number of mature individuals	85	48	150	There are 0 mature individuals in known wild subpopulations, and it is considered unlikely that any currently unknown subpopulations exist (S Barrett pers comm 2020, cited in Silcock et al. 2021). However, as Stirling Range dryandra is an obligate seeder, it is killed by fire and recruits from soil-stored seed. To appropriately determine the true impact of recent fire, the number seedlings that survive to become mature individuals at the same life stage as those destroyed by the fires must be projected, based on seedling survival rates, rates of adult senescence and with knowledge of the pre-fire history of all sites. It is assumed that many plants were above 25 years old before the 2018 fires, as most plants were alive in 1996 (Gilfillan et al. 2008). To calculate survival rates, survival of seedlings recruited by the 2000 fire was used. The 2000 fire stimulated recruitment of 30 seedlings, of which four were alive before the 2018 fires (S Barrett 2020. pers comm 25 September). This indicates seedling survival of 13 percent over 18 years. Assuming exponential decay, the seedling survival can be calculated as: ln(0.13)/18 = -0.11335. The number of seedlings that are estimated to have germinated after the 2018 fire is >1000 (S Barret 2020. pers comm 25 September). Subsequent information noted that, as of 2020,

				there were 857 juveniles, which equalled approximately 60% of the seedlings alive in 2019 (S Barrett 2020. pers comm 25 September). This suggests that at least 1430 seedlings were germinated after the 2018 fire (857/0.6). Further monitoring from 2021 revealed 725 juveniles from the 2018 fire were extant and 22 seedlings that had germinated after the 2019 fire were present, bringing the total number of seedlings germinated by both fires to 1452. Using the above equation, and assuming that a total of 1452 seedlings germinated after both fires (combined), the number of mature individuals is projected to be 85 (48-150) at a future age of 25 years (20-30 year bound) comparable to the likely age of mature individuals prior to the 2018 fire.
Trend	Decreasing			Stirling Range dryandra was first discovered in 1964. By 2000, there were 137 mature individuals and 39 juveniles over four subpopulations remaining. A fire in spring 2000 reduced the original population to 55 mature individuals (DAWE 2017; Silcock et al. 2021). Bushfires in May 2018 and December 2019 led to 100% mortality of all known mature individuals. Natural subpopulations are currently comprised entirely of juvenile plants. Mature individuals are currently only found in ex situ subpopulations. As of 2019/20, 65 and two plants were surviving in each seed orchard respectively (Silcock et al. 2021).
Generation time (years)	20–30 years	10 years	30–40 years	The generation time of the species is considered to be approximately 20–30 years. The lower bound of 20 years was calculated using the IUCN Generation Length calculator, with fecundity set at 0 from 1–9 years and assumed to be consistent from 10–30 years. Survival was also assumed to be constant throughout its reproductive period (10–30 years) (IUCN 2019). The upper bound of 30 years was calculated as above, except with fecundity and survival constant from 10–50 years. Generation length in Silcock et al. (2021) was estimated at >10 years and is considered a minimum estimate.
Extent of occurrence	32 km^2	32 km^2	32 km^2	The extent of occurrence (EOO) is estimated at 32 km^2. This figure is based on the mapping of point records from 2018–2020 obtained from state governments, museums and CSIRO. This period was used as only four

				subpopulations are considered extant, and using records over a longer period would not be accurate. The maximum and minimum EOO are the same as the most plausible estimate, as it is unlikely other subpopulations exist. The EOO was calculated using a minimum convex hull, based on the IUCN Red List Guidelines (IUCN 2019).
Trend	Contracting			The EOO has declined due to the local extinction of the Coyanarup subpopulation. EOO may continue contracting if currently extant subpopulations become extinct. See Table 2 for further information.
Area of Occupancy	16 km^2	16 km^2	24 km^2	The AOO is estimated at 16 km^2. This figure is based on the mapping of point records from2018–2020 obtained from state governments, museums and CSIRO. This period was used as only four subpopulations are considered extant and using records over a longer period would not be accurate. The maximum plausible value is if extinct subpopulations are included. The AOO is calculated using a 2x2 km grid cell method, based on the IUCN Red List Guidelines (IUCN 2019).
Trend	Contracting			The EOO has declined due to the local extinction of the Coyanarup subpopulation. EOO may continue contracting if currently extant subpopulations become extinct. See Table 2 for further information.
Number of subpopulations	4	4	4	The species is currently known from Bluff Knoll, East Bluff, Pyungoorup and Isongerup on the eastern Stirling Range.
Trend	declining			The number of subpopulations has declined since the species was discovered in 1964 due to the extinction of the Coyanarup subpopulation.
Basis of assessment of population number	There are four known subpopulations, and it is considered unlikely there are any currently unknown subpopulations (S Barrett pers comm 2020, cited in Silcock et al. 2021).			
No. locations	1	1	2	The number of locations is estimated at one. A single large bushfire event could impact all extant Stirling Range dryandra subpopulations. All subpopulations are found within a restricted extent of occurrence, and previous bushfire events have impacted a large proportion of this range. With climate change increasing the scale of bushfires, it is plausible that all subpopulations of the species

				may be impacted by one large fire event. The maximum plausible number of locations is 2, as separate fires in 2018 and 2019 impacted all known natural subpopulations.
Trend	Contracting			The intensity, frequency and scale of catastrophic bushfires will likely increase due to climate change. Therefore, the number of locations in which a single bushfire can rapidly affect all individuals will likely decrease.
Basis of assessment of location number	The number of locations is estimated at one, as a large bushfire event could impact all extant Stirling Range dryandra subpopulations.			
Fragmentation	The population is severely fragmented. Each subpopulation is isolated, and genetic exchange between subpopulations is not occurring. It is likely that less than 50% of the AOO is in habitat patches that are not supporting minimum viable population, and other assessments have considered the species to be severely fragmented (Silcock et al. 2021).			
Fluctuations	Extreme fluctuations are likely, as most of the canopy stored seed can be exhausted in a single fire (IUCN 2019; Silcock et al. 2021).			

Criterion 1 Population size reduction

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	**Endangered Severe reduction**	**Vulnerable Substantial reduction**
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3, A4	≥ 80%	≥ 50%	≥ 30%

A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.

A2 Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [(*a) cannot be used for A3*]

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

Based on any of the following

(a) direct observation [except A3]

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

(d) actual or potential levels of exploitation

(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites

Criterion 1 evidence

Eligible under Criterion 1 A4ae Endangered

The generation time of the species is considered to be 20–30 years (see Table 4). Three generations gives a timeframe of 60–90 years for Criterion 1.

The primary threats to natural subpopulations (fire and *P. cinnamomi* dieback) are known and have not ceased (Table 2). These threats have led to a 100 percent reduction of the number of mature individuals over a three-generation period (Table 2; Table 5). Given that at least three fires have impacted the species within the past 18-year minimum fire interval of the species, it is likely that additional fires will occur. If sequential fire events occur across multiple populations before juveniles can reach reproductive maturity and replenish the seed bank, population decline and extinction is possible, especially as all seed is usually consumed in one fire for species with canopy-stored seeds (IUCN 2019; Silcock et al. 2021). This is increasingly likely given that climate change is increasing the frequency of bushfires in the region (Barret & Yates 2015), Indeed, this has already occurred to some extent, as the 2019 fire killed seedlings that had sprouted after the 2018 fire.

Fires in spring 2000 burnt the habitat of most subpopulations and reduced the original population of mature individuals by around 60 percent, without stimulating recruitment at previously burnt subpopulations (Barrett & Yates 2015). Bushfires in May 2018 and December 2019 led to further decline in the number of mature individuals, and though over 1000 seedlings germinated after the 2018 fire, many perished in the 2019 fire and others have since died due to drought-related causes. As of Autumn 2021, 725 juveniles from the 2018 were extant, and 22 seedlings were also observed that had been recruited from the 2019 fire (DBCA 2021). Known natural subpopulations are currently comprised entirely of juvenile and seedling plants and there are no mature individuals currently persisting in the wild. Using these direct observations, there has been an overall population reduction from 137 mature individuals in 2000 to 0 mature individuals in 2021.

Though fires have led to a population reduction of 100 percent of mature individuals, the Stirling Range dryandra has a life history in which standing plants are killed by fire and recruitment occurs from canopy-stored seed. Therefore, observed mortality due to a single bushfire event may be considered a fluctuation in the age classes of affected populations, and not a true decline in the species' population. To calculate the population decline of Stirling Range dryandra, the number seedlings that survive to become mature individuals at the same life stage as those destroyed by the 2018 and 2019 fires must be projected, as this is a better estimate of true population size. In the Stirling Range dryandra, the 2000 fire stimulated recruitment of 30 plants, of which four were alive before the 2018 fires (S Barrett 2020. pers comm 25 September). Two plants reached maturity and died prior to 2018, two became juveniles before dying, and the remainder died as seedlings. This indicates seedling survival of 13 percent over 18 years (less than three generations), excluding the impacts of fire,

Using survival rates documented following the 2000 fire, based on the number of seedlings recorded in 2020 and 2021, the number of individuals projected to reach a similar age to plants that were extant prior to 2018 (25 years) is estimated at 85 (48–150) (Table 4). This suggests that population reduction of 38 percent will occur from 2000 (when there were 137 mature individuals) to 2044 (25 years after the 2019 fire, when there are projected to be 85 mature individuals). Extrapolations of this population decline should be undertaken cautiously as the population trajectory of the species is highly dependent on fire events and their frequency. For example, one fire may destroy a large proportion of the number of juveniles before they can

produce seeds, which would substantially reduce the number of mature individuals in the future. It is not known whether current recruits will survive to reproductive maturity due to ongoing threats (Silcock et al. 2021), and impacts from frequent bushfires, *P. cinnamomi* dieback and drought may reduce survival and growth of the recently recruited seedlings. Mortality of seedlings since the fires has already occurred and has been linked to drought conditions and the 2019 fire (S Barrett 2020, pers comm 25 September). Therefore, the projected 38 percent population decline over the period 2000 to 2044 should be considered a minimum likely decline.

The above caveats notwithstanding, using an average rate of decline of 0.86 percent per year (0.38/44 * 100) population reduction over three generations can be estimated. Decline was assumed to be exponential, with a decay factor of 0.9914 (1 - 0.0086). Therefore, using the formula *1- 0.9914 ^ Number of Years*, the rate of population decline is projected to be 40 – 54 percent over three generations (60–90 years).

Table 5. Summary of Stirling Range dryandra population information over time

Year	Number of mature individuals (juveniles)	Percentage of recorded number of mature individuals in 2000	Source
2000	137 (39)	100%	Gilfillan et al. 2008), DAWE (2017)
2001	51 – 55 (9)	37–40%	Gilfillan et al. 2008), DAWE (2017), Silcock et al. (2021)
2004	45 (16)	33%	DBCA (2020), cited in Silcock et al. (2021)
2015	40 (2)	29%	DAWE (2017)
2016	34–41 (unknown)	25% – 30%	S Barrett 2020, pers comm 25 September, Silcock et al. (2021)
2018 (pre 2018 fire)	34–41 (unknown)	25% – 30%	S Barrett 2020, pers comm 25 September, Silcock et al. 2021
2019 (pre 2019 fire)	8 (>1000 seedlings)	6%	S Barrett 2020, pers comm 25 September
2020 (post 2019 fire)	0 (857)	0%	S Barrett 2020, pers comm 25 September, Silcock et al. 2021
Autumn 2021	0 (727 juveniles and 22 seedlings)	0%	DBCA (2021)

Conclusion

Stirling Range dryandra has exhibited stepwise population decline due to multiple fires within a nine-year fire interval, likely has naturally low seedling survival, and is threatened by multiple interacting threats that will likely lead to mortality in the future. Population reduction over a

three-generation period from 2000 is projected to be a minimum of 40–54 percent. Utilising a precautionary approach by using the highest estimate of decline (54 percent) is reasonable, as very high risk threats continue to operate on the species and there are currently zero extant mature individuals.

The data presented above appear to demonstrate that the species is eligible for listing as **Endangered** under this criterion. However, the purpose of the consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered tentative at this stage, as it may be changed as a result of 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 km²**	**< 5,000 km²**	**< 20,000 km²**
B2.	Area of occupancy (AOO)	**< 10 km²**	**< 500 km²**	**< 2,000 km²**
AND at least 2 of the following 3 conditions:				
(a)	Severely fragmented OR Number of locations	**= 1**	**≤ 5**	**≤ 10**
(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 populations; (v) number of mature individuals			
(c)	Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or populations; (iv) number of mature individuals			

Criterion 2 evidence

Eligible under Criteria B1ab(i,ii,iii,iv,v)c(iv) as Critically Endangered

Stirling Range dryandra is a narrow-range endemic species and is known only from four subpopulations on the Stirling Range. The extent of occurrence (EOO) is estimated at 32 km² and the area of occupancy (AOO) is estimated at 16 km² (plausible range: 16km² – 24 km²). These figures are based on the mapping of point records from a 2- year period (2018–2020), obtained from state governments, museums, and CSIRO. The EOO was calculated using a minimum convex hull, and the AOO calculated using a 2x2 km grid cell method, based on the IUCN Red List Guidelines 2014 (IUCN 2019).

Given that the EOO is less than 100 km², the species meets the threshold for Critically Endangered under sub-criterion B1.

Severely fragmented and number of locations

A taxon can be considered severely fragmented if >50 percent 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, relative to its dispersive potential (IUCN 2019). Stirling Range dryandra is restricted to four isolated subpopulations on different mountains and has very low dispersive potential, with no genetic exchange occurring between subpopulations (Silcock et al. 2021). It is likely that less than 50 percent of the AOO is in habitat patches that are not supporting minimum viable population, and other assessments have considered the species to be severely fragmented (Barrett et al. 2020; Silcock et al. 2021).

Stirling Range dryandra is considered to occur at one location, based on the most plausible serious threat (fire) as per the IUCN Guidelines (IUCN 2019). Two separate bushfire events in 2018 and 2019 burnt all known subpopulations and it is plausible that another large fire event may impact all subpopulations. If this occurs whilst seedlings and juveniles are maturing, rapid population reduction or extinction is likely.

The species' distribution is severely fragmented and occurs at one location. Therefore, the species appears to meet the threshold for Critically Endangered under sub-criterion (a).

Continuing decline

The EOO, AOO, extent and quality of habitat, number of locations or subpopulations, and number of individuals have undergone ongoing decline due to ongoing threats from fire and *P. cinnamomi* (see Table 2), thereby meeting sub-criterion (b) (i,ii,iii,iv,v). Climate change is also impacting the population by increasing the frequency and severity of bushfires, which will result in continuing decline in the area, extent and quality of habitat, and number of mature individuals. The processes that generated this decline have not ceased, and future population reduction of current juveniles is likely.

Extreme Fluctuations

Extreme fluctuations in the number of mature individuals are likely, as most of the canopy stored seed can be exhausted after a single fire, and these fluctuations can change subpopulation size by an order of magnitude (IUCN 2019; Silcock et al. 2021). Subpopulations can fluctuate from a large number of mature individuals and a large seed bank to a small number of mature individuals, no seed bank and a large number of juveniles very quickly. Stirling Range dryandra subpopulations are isolated, and it is sufficient for the majority of subpopulations to undergo fluctuations separately for there to be considered to be extreme fluctuations (IUCN 2019).

As there are considered to be extreme fluctuations in the number of mature individuals, the species appears to meet the threshold for Critically Endangered under sub-criterion (c).

Conclusion
The data presented above appear to demonstrate that the species 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:				
(a)	(i) Number of mature individuals in each population	**≤ 50**	**≤ 250**	**≤ 1,000**
	(ii) % of mature individuals in 1 population =	**90 – 100%**	**95 – 100%**	**100%**
(b) Extreme fluctuations in the number of mature individuals				

Criterion 3 evidence

Eligible under Criterion C2b as Critically Endangered

There are currently zero mature individuals in known wild subpopulations. However, as the species resprouts after fire, the number of seedlings that survive to become mature individuals at the same life stage as those destroyed by the 2018 and 2019 fires must be projected, as this is a better estimate of true population size. Using survival rates documented following the 2000 fire, based on the number of seedlings recorded in 2020, the number of mature individuals projected to reach 25 years of age is estimated at 85 (48–150) (Table 4). This meets the requirements for listing as critically endangered under this criterion.

Continuing decline in total population size has been observed and is projected to continue (see Criterion 1). and there are extreme fluctuations in the number of mature individuals (see Table 4; Criterion 1; Criterion 2).

The data presented above appear to demonstrate that the species 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 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 km² 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 *common assessment method*.

Criterion 4 evidence

Eligible under Criterion D1 as Endangered

There are estimated to be 85 (48–150) mature individuals in natural subpopulations based on projections of seedling survival (see Table 4; Criterion 1; Criterion 2).

The data presented above appear to demonstrate that the species is eligible for listing as **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 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 for Stirling Range dryandra.

Conclusion

There are insufficient data to demonstrate if the species is eligible for listing 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 is considered adequate and there is sufficient scientific evidence to support the assessment.

Listing and Recovery Plan Recommendations

Stirling Range dryandra is listed as Critically Endangered in WA under the Biodiversity Conservation Act 2016 and is also listed as Critically Endangered on the IUCN Red List of Threatened Species (Barrett et al. 2020).

There is currently an existing Recovery Plan that is due to expire in 2022 (Gilfillan et al. 2008). A decision about whether there should continue to 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.

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

Cataloguing data

This publication (and any material sourced from it) should be attributed as: Department of Agriculture, Water and the Environment 2021, *Conservation advice for* Banksia montana *(Stirling Range dryandra)*, Canberra.

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