

Consultation on Species Listing Eligibility and Conservation Actions

Xyris exilis (Stirling Range xyris)

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

1) the eligibility of *Xyris exilis* (Stirling Range xyris) 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: <u>species.consultation@environment.gov.au</u>

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 29 June 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: <u>http://www.awe.gov.au/system/files/pages/d72dfd1a-f0d8-4699-8d43-5d95bbb02428/files/tssc-guidelines-assessing-species-2021.pdf</u>.

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.

CONSULTATION QUESTIONS FOR XYRIS EXILIS (STIRLING RANGE XYRIS)

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?

SECTION C 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:

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 \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
- 11. Are you able to comment on the extent of decline in the species/subspecies' total population size over the last approximately 27 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

 \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

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

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
- 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?



Australian Government

Department of Agriculture, Water and the Environment

Conservation Advice for *Xyris exilis* (Stirling Range xyris)

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 xyris. It provides a foundation for conservation action and further planning.

Xyris exilis © Copyright. Photography by G.J. Keighery & L. Anderson. 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 Tuesday, 11 January 2022.

Conservation status

Xyris exilis (Stirling Range xyris) is currently listed in the Vulnerable category and is proposed to be transferred to the Critically Endangered category under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act).

Xyris exilis 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: Endangered: A4abce

Criterion 2: Critically Endangered: B1ab(i,ii,iii,v)+B2ab(i,ii,iii,v)

Criterion 3: Endangered: C1+C2a(ii)

Criterion 4: Vulnerable: D

Criterion 5: Insufficient data

The main factors that make the species eligible for listing are its 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 Xyris exilis Doust & B.J.Conn (1997). Family: Xyridaceae.

Description

Xyris exilis (Stirling Range xyris) is a slender, erect, tufted, perennial herb to 40 cm high. Lateral shoots are protected by a sheath that is wrinkled in appearance (this sheath is smooth in the related *X. inaequalis*). It produces between 10 and 20 sedge-like green to yellowish-green leaves, which are 6–19 cm long, very thin (0.25–0.5 mm) and round in cross-section, with shiny reddish-brown basal sheaths 12–18 mm long. The flower spike contains a globular, terminal inflorescence with 2–4 flowers on a scape 13–37 cm in length (scape is usually >50 cm in *X. inaequalis*). The inflorescence is <7 mm long and <6 mm wide, with the old inflorescences being retained on the plant for several years. The yellow flowers appear one at a time and have three delicate, unscented petals (to 4 mm long and 2 mm wide), lack staminodes, have a three-branched style (style undivided in *X. indivisa*) and are surrounded by dark-brown bracts with neat edges (fertile bract with torn or jagged edges in *X. flexifolia*). The flowers produce nectar and last only a few hours during the day, opening in the morning. Seeds are about 1 mm long and 0.4 mm wide. Description from Robinson & Coates (1995); Conn & Doust (1997), Brown et al. (1998); DEWHA (2008).

Distribution

Stirling Range xyris is endemic to Koikyenunuruff/Stirling Range in the Esperance Plains bioregion (IBRA7) of Western Australia. The species occurs within the South Coast Natural Resource Management Region.

The species occurs in a single subpopulation within Stirling Range National Park, with five known sites across a distance of <2 km. Estimating the number of individuals can be difficult for this species where clumps of plants occur close together (S. Barrett 2022 pers. comm. 4 January). In 1993 site 1a had >100 mature individuals and >1000 seedlings (DBCA 2022 pers. comm. 4 January). However, several new subpopulations have been discovered since 2010 (S. Barrett 2022 pers. comm. 4 January). The most recent estimate of the Stirling Range xyris population is 770 mature plants and 240 juveniles in 2022 (Table 1).

Subpopulation (site)	Date	Mature individuals	Juveniles	Confidence level	Notes/fire history
1a	17/03/2022	280	90	-	From 2022: 1a now includes former sites 1a + 1e + 1d.
1b	17/03/2022	490	150		From 2022: 1b now includes former sites 1b + 1c.
1 (a,b,c,d,e)	10/2/2021	300	600	Medium	Majority of mature individuals occur in the original site 1a, the only site to have (partially) escaped fires in 2018 and 2019. Sites 1b and 1c burnt in 2018, 1d burnt in 2018 and probably 2019, and 1e burnt in 2019.
1 (a,b,c,d,e)	28/10/2016	1000	50	Low	
1 (a,b,c,d,e)	2010 & 2011	>1100	not recorded	Medium	

 Table 1 Recent monitoring data for Stirling Range xyris

Source: S. Barrett 2022 pers. comm. 4 January; A. Hutchinson 2022 pers. comm. 30 March.





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 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 the 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). This is a precautionary approach in line with the purpose of the mapping as indicative. 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 it is shared and used.

Stirling Range xyris 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 Noongar Peoples and features in Dreaming stories (DPAW 2016; South West Aboriginal Land & Sea Council 2022). Bula Meela (Bluff Knoll), where Stirling Range xyris 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 xyris occurs (DPLH 2020). Additionally, the Wagyl Kaip & Southern Noongar 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 xyris occurs.

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.

Relevant biology and ecology

Habitat

Stirling Range xyris is found growing in perched wetlands on upper slopes and mountain summits in Koikyenunuruff/Stirling Range. It grows on sandy peat over quartzite near small streams, swamps and seasonally wet bogs, often among moss cushions. Associated species include *Gonocarpus benthamii* subsp. Stirling, *Drosera pulchella* (pretty sundew), *Lepidosperma* sp. Bluff Knoll robust (spreading sword-sedge), *Homalospermum firmum*, *Hakea florida*, *H. ambigua* and *Gahnia* spp. (sword sedge) (Robinson & Coates 1995; Brown et al. 1998; DSEWPAC 2008; ALA 2022).

The species is part of the Western Australian Protected Ecological Community *Coyanerup Wetland Suite*.

Reproductive biology

Little is known about the reproductive ecology of Stirling Range xyris, and as a result, this section draws largely on published literature from species in the same genus or family.

Flowering occurs from November to February (Robinson & Coates 1995; Brown et al. 1998; DSEWPAC 2008). The flowers are reportedly visited by female bees seeking pollen (DSEWPAC 2008). Due to the very small size of its seed, seed dispersal is probably limited to the immediate vicinity of the adult plant. Water may possibly disperse seed at some sites if directional overland water flow occurs soon after seed is released, although the lack of records of Stirling Range xyris downstream from its known subpopulation suggests that either this is a rare event (e.g. if most sites supporting the species do not experience directional overland water flow), or that downstream habitat is unsuitable for the species.

A study of *X. lanata* from southwest Western Australia suggests germination may be enhanced by both cold and warm stratification (Merritt et al. 2007). Germination in response to cold stratification suggests germination in the wild could occur in late winter/early spring, while germination in response to warm stratification suggests germination in the wild may occur in autumn (Cochrane 2019). Desiccation and inundation may also affect seed dormancy, with desiccation partially overcoming dormancy acquired during periods of inundation in tropical *Xyris* species (Oliveira et al. 2017).

Internationally, there is some evidence that germination and seedling growth of *Xyris* species may be enhanced by mycorrhizal fungi (Tamura et al. 2008), although whether there is an obligate requirement for mycorrhizal infection is not known.

The length of the primary juvenile period is likely to be about three to four years (S. Barrett 2022 pers. comm. 29 March). The maximum longevity of adult plants is unknown, but was estimated at around 15 years for *Xyris juncea* in DELWP (2021).

Fire ecology

Stirling Range xyris appears to be an obligate seeder (S. Barrett 2022 pers. comm. 4 January). Seeds of tropical *Xyris* species can persist in the soil for at least several years and form a soil seed bank (Oliveira et al. 2017) and it is possible this also occurs with Stirling Range xyris. Germination of Xyris species may occur post-fire (Benwell 1998; Keith et al. 2007) and this is the case with Stirling Range xyris. In addition, there was some evidence of inter-fire recruitment on moss beds in 2016 (S. Barrett 2022 pers. comm. 4 January). Minimum and maximum tolerable fire intervals are unknown. DSEWPAC (2008) recommended fire be excluded for "several years after the current seedling generation has flowered and produced seed", suggesting that, with a likely primary juvenile period of three to four years and accounting for several years of flowering to accumulate a soil seed bank, intervals of five to 10 years between successive fires could maintain persistence of populations of this species. However, Stirling Range xyris likely accumulates its seed bank more rapidly than other species in the adjacent Eastern Stirling Range Montane Heath and Thicket Threatened Ecological Community (DPAW 2016), and minimum fire intervals for the community must therefore be determined based on the species with the slowest rate of seed bank accumulation in the community, as well as accounting for impacts from other mechanisms of fire regimes and interactions with other threats (DAWE 2021a).

Habitat critical to the survival

Stirling Range xyris is found growing in perched wetlands near small streams, swamps and seasonally wet bogs in the higher mountains and upper slopes of the eastern Koikyenunuruff/Stirling Range.

Habitat critical for survival includes all vegetation types listed above that occur within the species' range in eastern Koikyenunuruff/Stirling Range (see Distribution section). Until further 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 xyris are changes to temperature and precipitation patterns, inappropriate fire regimes and grazing by native and introduced herbivores.

Threat	Status ^a	Evidence
Climate change		
Changes to temperature and precipitation patterns	 Status: current Confidence: known Likelihood: almost certain Consequence: catastrophic 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 and hydrological niche in which the Stirling Range xyris 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 mountain 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 xyris 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 xyris (Monks et al. 2019). The species' habitat occurs in the highest elevational niche available in the region - in Koikyenunuruff/Stirling Range. Therefore, suitable climate refugia may not exist for this species, although it is not known if it could persist at lower elevations. Droughts may have a substantial effect on the hydrology of soils in which the species grows. If water regimes change substantially, species reliant on high soil moisture can be negatively affected, through mortality or increased competition from species adapted to drier soil conditions (Alba et al. 2019). As Stirling Range xyris is dependent on waterlogged soils, it is likely to be extremely susceptible to changes in soil moisture and hydrology as a result of reduced precipitation. Stirling Range xyris plants appeared to be suffering from drought stress in 2016 at site 1b, and observations from 2004 suggested the entire population appears to be contracting in association with drying habitat, although no quantitative data exist to support this (S. Barrett 2022 pers. comm. 4 January). The interaction between fire and drought is also a threat for obligate seeders, whi
Habitat loss, disturba	nce and modifications impac	ts
Fire regimes that cause biodiversity decline ¹	 Timing: current Confidence: inferred Likelihood: likely Consequence: catastrophic Trend: increasing Extent: across the entire range 	Stirling Range xyris appears to be an obligate seeder (S. Barrett 2022 pers. comm. 4 January), with adult plants killed by fire and recruiting from seed. Sites 1b and part of 1a were burnt in May 2018, while most of 1a was burnt in December 2019 (S. Barrett 2022 pers. comm. 4 January). Part of site 1a is the only site to remain unburnt by the 2018 or 2019 fires and at the time of last monitoring, most mature plants occurred at this site (S. Barrett 2022 pers. comm. 4 January). Approximately 43% of the modelled range area of the species was burnt in the December 2019 bushfire (Gallagher 2020). 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 wildfires (BOM 2018; Office of Bushfire Risk Management 2018). There are a number of mechanisms by which the fire regime impacts a species with obligate seeding traits (Keith 1996; D. UMP).

Table 2 Threats impacting Stirling Range xyris

Threat	Status ^a	Evidence
		interactions between fire and climate change, fire and herbivory, and potentially fire and pollinator availability.
		Short fire interval
		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). Stirling Range xyris has a primary juvenile period of around three to four years (S. Barrett 2022 pers. comm. 29 March). The species likely requires multiple flowering seasons to restore the soil seed bank to pre-fire levels and possibly longer if other threats such as grazing reduce fecundity. Short fire intervals are a threat to this species as evidenced by fires burning the species' habitat in May 2018 and December 2019. Such short inter-fire periods are likely to cause population decline or extinction. Stirling Range xyris occurs with other species that are likely to have substantially longer minimum tolerable fire intervals (DPAW 2016).
		the species because it has been observed recruiting sporadically in the absence of fire (S. Barrett 2022 pers. comm. 4 January).
		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'Connell 1991; Auld & Ooi 2009). Failure to do this can result in a low rate of recruitment, seed bank attrition and subsequent population decline (Regan et al. 2003). Although it is unknown if Stirling Range xyris has temperature-sensitive dormancy, low severity fires could pose a risk to the species, until further research suggests otherwise.
		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
		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.
		Stirling Range xyris appears to be adapted to seasonal fire regimes consisting of fire during the dry dormant summer periods followed by moist conditions during the growing and reproductive period. The species is likely to have physiologically dormant seeds, a type of dormancy that may reduce and delayed germination responses to out-of-season fires (Ooi et al. 2007). If fires occur during the growing season, standing plants will be killed before seed is produced, and this may reduce population viability, particularly if the soil seed bank is relatively short-lived and/or exhausted by single fire events (Auld & Denham 2006).
		Out-of-season prescribed burning is likely to negatively impact post-fire recruitment of other obligate seeder monocots in south-western Western Australia (Meney et al. 1994). Impacts on Stirling Range xyris are unclear, as good germination

Threat	Status ^a	Evidence
		occurred following the May 2018 fire. Further research into the germination cues of the species, and its susceptibility to out-of-season fire are needed. In addition, 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. Realisation of such risks were recently documented for the nearby population of <i>Banksia montana</i> (Stirling Range Dryandra; DAWE 2021b).
		Interactions between fire and other threats
		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 xyris, the interaction between climate change and the fire regime could 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. 2014; 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). This is particularly important for a species that depends on specific hydrological conditions for reproduction and germination such as Stirling Range xyris.
		The two climate associated threat pathways can also act in concert through processes such as the '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).
		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 a year later by a wildfire in 2019 (OBRM 2018). Prescribed burns are a risk and can reduce the fire-free interval.
		Other potential fire-related threats include potential fire- drought, fire-herbivore and possibly fire-pollinator interactions (if pollinator communities are negatively impacted by inappropriate fire regimes, which is poorly understood at present). If co-occurring threats cause the depletion of annual fruiting that could reduce the size of soil seed banks, obligate seeder monocot populations may be negatively impacted (Meney et al. 1994). Indirect effects of fire-disease interactions may also influence the viability of populations of Stirling Range xyris (see below).
Invasive and native s	pecies	
Grazing by invasive and native species	 Timing: current Confidence: observed Likelihood: likely Consequence: major Trend: unknown 	Surveys since 1994 have confirmed the presence of European rabbit (<i>Oryctolagus cuniculus</i>) and Quokka (<i>Setonix brachyurus</i>) within the vicinity of the Stirling Range xyris population (Barrett 1996). Evidence of grazing of Stirling Range xyris plants (presumably by these species) has been observed on several occasions, including post-fire in 2021 (S. Barrett 2022 pers. comm. 4 January). Grazing may be a significant threat to the recovery of the species post-fire (S. Barrett 2022 pers. comm. 4 January) as has been documented in other obligate

Threat	Status ^a	Evidence
	• Extent: across the entire range	fire, drought or other threats if it reduces the size of soil seed banks, compounding the effects of these threats by reducing the seed bank available for recruitment post-fire or post-drought (Meney et al. 1994).
Disease		
Direct or indirect impacts of dieback caused by <i>Phytophthora</i> spp. infection	 Status: current Confidence: suspected Likelihood: unknown Consequence: moderate Trend: static Extent: across the entire range 	The Eastern Stirling Range Montane Heath and Thicket Community has been significantly affected by dieback caused by <i>Phytophthora cinnamomi</i> since it was identified in the region in 1974 (DPAW 2016). <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-rot fungus <i>Phytophthora cinnamomi</i> ' is listed as a Key Threatening Process under the EPBC Act (DOEE 2018). Stirling Range xyris is not thought to be susceptible to <i>P. cinnamomi</i> , as the pathogen is present across its habitat and the species appears unaffected (S. Barrett 2022 pers. comm. 4 January). However, no plants have been sampled to test for the presence of the pathogen, nor have plants been inoculated experimentally (S. Barrett 2022 pers. comm. 4 January). The effects of interactions between the pathogen and drought or fire (e.g. Barrett & Yates 2015) are also not well understood. Even if Stirling Range xyris is not directly susceptible, dieback caused by <i>Phytophthora</i> spp. could have possible indirect negative impacts on Stirling Range xyris (e.g. through impacts on insect pollinators; Wills 1993).

Timing—identify the temporal nature of the threat;

Confidence—identify the extent to which we have confidence 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—identify the severity of the threat;

Trend—identify the extent to which it will continue to operate on the species;

Extent—identify its spatial content in terms of the range of the species;

¹ Fire regimes that cause biodiversity decline include the full range of fire-related ecological processes that directly or indirectly cause persistent declines in the distribution, abundance, genetic diversity or function of a species or ecological community. 'Fire regime' refers to the frequency, intensity or severity, season, and types (aerial/subterranean) of successive fire events at a point in the landscape.

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.

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain					Changes to temperature and precipitation patterns
Likely				Grazing by invasive and native species	Fire regimes that cause biodiversity decline
Possible					
Unlikely					
Unknown			Direct or indirect impacts of dieback caused by <i>Phytophthora</i> spp. infection		

Table 3 Stirling Range xyris risk matrix

Risk Matrix legend/Risk rating:

Low Risk	Moderate Risk	High Risk	Very High Risk

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 extinction/extirpation

Priority actions have then been developed to manage the threat particularly where the risk was deemed to be 'very high' (red shading) or 'high' (yellow shading). For those threats with an unknown or low risk outcome (green and blue shading) 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 xyris 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 xyris sites or habitat.
- Avoid all further loss and fragmentation of habitat.
- 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).

Fire, climate change and extreme weather impacts

- Develop and implement a fire management strategy that optimises the survival of Stirling Range xyris.
- Avoid planned burns in all habitat until the fire-response and the minimal fire-interval period of Stirling Range xyris are better understood,
- Minimise incidence of out-of-season fires
- 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.
- Avoid applications of fire retardant chemicals in the vicinity of known populations during fire suppression operations.
- Identify 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.
- Spread the risk to the species associated with climate change and fire by establishing multiple translocated populations.

Invasive and native species impacts

• If appropriate, install and maintain cages or fencing around seedling, juvenile and translocated plants to protect against grazing by Quokka and 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 pers. comm. 2021 cited in DAWE 2021b).
- Monitor and mitigate herbivore impacts post-fire.

Disease impacts

- Determine the susceptibility of Stirling Range xyris to *Phytophthora* spp. under different temperatures, soil moisture levels and stages of fire recovery.
- Promote research and development of treatments of *P. cinnamomi* dieback, including alternatives to phosphite.
- Ensure appropriate hygiene and management measures are undertaken to reduce the spread of *Phytophthora* spp. Refer to DOEE (2018) and DBCA (2020) for guidelines.
- Manage fire to minimise potential impacts of disease.

Ex situ recovery actions

- Collect and store additional seed to preserve genetic material, in accordance with the Plant Germplasm Conservation in Australia (Martyn Yenson et al. 2021).
- Investigate the requirements of the species for ex situ recovery.
- Undertake ex situ propagation and translocations in accordance with the Guidelines for the Translocation of Threatened Plants in Australia (Commander et al. 2018). Monitor all translocated individuals to maturity, seed set and recruitment to ensure they are viable and are contributing to a reduction in the extinction risk for the species.

Stakeholder engagement/community engagement

- Engage and involve Traditional Owners in conservation actions, monitoring and/or management actions.
- 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

- Undertake surveys for Stirling Range xyris across its range.
- 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

- Increase understanding of recruitment and soil-seed bank dynamics (particularly seed bank longevity and germination cues and sensitivity of germination to season of fire), appropriate fire regimes, seed and plant longevity, genetic structure, and minimum viable population size.
- Identify the pollinator(s) of Stirling Range xyris, 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 dieback from *Phytophthora* spp..
- Understand the potential influence of climate change on the long-term survival prospects of the species, due to altered temperatures, rainfall patterns, bushfires, and environmental stressors.
- Investigate the impact of drought on Stirling Range xyris.
- Ascertain the cultural significance of Stirling Range xyris.
- Determine habitat critical to the survival of Stirling Range xyris.
- Investigate the susceptibility of Stirling Range xyris to *Phytophthora* spp. including under different climatic, hydrological and fire scenarios.

Links to relevant implementation documents

This Conservation Advice is developed to be able to subsequently inform other planning instruments such as a Bioregional Plan or a multi-entity Conservation Plan.

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

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

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Department of Agriculture, Water and the Environment

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.

Attachment A: Listing Assessment for Xyris exilis

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 4 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	~900	800	1000	The most recent population estimate for Stirling Range xyris was made in 2021 when 770 mature individuals and 240 juveniles were recorded (Table 1). Depending on juvenile mortality rates, a plausible estimate of mature individuals when the current cohort of juveniles reaches maturity could be approximately 800–1000 individuals.
Trend	decline			Monitoring indicates a decline in the population size of Stirling Range xyris from >1100 mature individuals in 2010/11 to ~900 mature individuals currently (when juveniles reach maturity). Therefore, the species' population size is considered to be in decline.

Table 4 Key assessment parameters

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Generation time (years)	13	13	17	The generation length of Stirling Range xyris is not documented.
				The length of the primary juvenile period is likely to be about three to four years (S. Barrett 2022 pers. comm. 29 March). The maximum longevity of adult plants is unknown, but is likely to be at least 22 years based on plants that escaped the 2018 and 2019 fires, which germinated after a fire in 2000 (S. Barrett 2022 pers. comm. 29 March). Therefore, the generation length of Stirling Range xyris could be 13 years. Other estimates of longevity could
				give slightly different generation length estimates. If longevity of adult plants was around 30 years, the generation length could be closer to 17 years.
Extent of occurrence	4 km ²	4 km ²	4-8 km ²	The extent of occurrence (EOO) is based on the mapping of available point records from 1980 to 2021. The EOO was calculated using a minimum convex hull, based on the IUCN Red List Guidelines (IUCN 2019). The EOO is equal to the AOO as per IUCN (2019), because the raw EOO estimate is less than the AOO of 4 km ² . Maximum and minimum bounds represent estimates if the species is more or less widespread than current records suggest.
Trend	decline			There may have been some spatial contraction within sites (S. Barrett 2022 pers. comm. 4 January). Part of site 1a was assessed pre-fire in 2019, and there were no plants located in the northern section of the site where they had previously been recorded (S. Barrett 2022 pers. comm. 4 January). In addition, the impact of the 2018 and 2019 fires is not fully understood. A separate part of site 1a was assessed in February 2021, 14 months following the 2019 fire that partially burnt the site, and no seedlings were found within the burnt part of the site (S. Barrett 2022 pers. comm. 4 January). Based on these observations, it appears that the EOO of Stirling Range xyris may be in decline.
Area of Occupancy	4 km ²	4 km ²	4-8 km ²	The AOO is estimated is based on the mapping of available point records from 1980 to 2021. The AOO is calculated using a 2x2 km grid cell method, based on the IUCN Red List

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
				Guidelines (IUCN 2019). Maximum and minimum bounds represent estimates if the species is more or less widespread than current records suggest.
Trend	decline			Several sites appear to be contracting in area based on mapping and anecdotal observations (S. Barrett 2022 pers. comm. 4 January). Sites supporting Stirling Range xyris may be contracting. If this trend continues and some sites become extinct (as appears likely, particularly in the face of worsening climate change), the AOO of the species will decline.
Number of subpopulations	1	1	1	The maximum distance between sites of Stirling Range xyris is approximately 800 m, with all five sites located within an area of <2 km from the northernmost to southernmost sites. Occasional gene flow among sites might be expected due to limited seed dispersal among some sites by directional overland water flow, and the possibility of occasional pollen transfer among sites by insect pollinators (reportedly bees). Therefore, Stirling Range xyris is likely to have a single subpopulation containing two distinct sites. Note that the term 'population' in this document refers to the total number of individuals of a taxon, with 'subpopulation' referring to geographically distinct groups of individuals, between which there is little genetic exchange, as per IUCN (2019). The term 'sites' has been used to describe smaller, distinct patches that are distinguished as separate by the Department of Biodiversity, Conservation and Attractions (i.e. 1a, 1b).
Trend	stable			Despite a likely decline in population size, EOO and AOO, as Stirling Range xyris likely has a single subpopulation, the number of subpopulations is not yet in decline
Basis of assessment of subpopulation number	See justification f	for Number of subp	oopulations.	suppopulations to not yet in accime.
No. locations	1	1	1	The most significant threats to the species are inappropriate fire regimes, climate change and interactions with herbivory. Stirling Range xyris appears to be an

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
				obligate seeder (S. Barrett 2022 pers. comm. 4 January). Although the species has a short primary juvenile period (estimated at 3-4 years), fires in 2018 and 2019 occurred around 18 months apart, illustrating the potential for high frequency to cause the rapid elimination of the species. Climate change could also cause the elimination of the species, which occurs in susceptible perched wetland habitat on the upper slopes of Koikyenunuruff/Stirling Range that is likely to be negatively impacted by projected declines in rainfall and increasing frequency of drought. However, it is unlikely that climate change alone would cause the elimination of the species within one generation of the species (13 years). The interaction of the threat of inappropriate fire regimes with climate change and/or herbivory could cause the rapid elimination of the species' single subpopulation. Grazing of the species has been observed and if high grazing pressure reduces the size of the soil seed bank through reduced adult fecundity or post-fire seedling survival, it could increase the likelihood that inappropriate fire regimes or drought could cause the elimination of the species. Similarly, the interaction between climate change and inappropriate fire regimes could also cause the rapid elimination of the species, if 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). Therefore, accounting for its very small geographic distribution and the serious threats that are impacting the species, Stirling Range xyris is likely to have a single location.
Trend	stable			Despite a likely decline in population size, EOO and AOO, as recruitment has been observed at some sites, as Stirling Range xyris likely has a single location, the number of locations is not yet in decline.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Basis of assessment of location number	See justification for Number of locations.			
Fragmentation	Stirling Range xyris is considered to occur as a single subpopulation. Therefore, no assessment of severe fragmentation is possible.			
Fluctuations	Not subject to extreme fluctuations in EOO, AOO, number of subpopulations, locations or mature individuals.			

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, <i>A</i>	\3, A4	≥ 80%	≥ 50%		≥ 30%
A1 A2	Population reduction observed, estimate past and the causes of the reduction are understood AND ceased. Population reduction observed, estimate past where the causes of the reduction be understood OR may not be reversible	ed, inferred or suspected in clearly reversible AND ted, inferred or suspected in may not have ceased OR ma	n the ay not	(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 A4	Population reduction, projected or susp to a maximum of 100 years) [(<i>a</i>) <i>canno</i> An observed, estimated, inferred, proje reduction where the time period must i future (up to a max. of 100 years in future reduction max. of 100 years in future	bected to be met in the futur t be used for A3] cted or suspected populatio include both the past and th ure), and where the causes c	e (up Based on any of the following of	(d) (e)	actual or potential levels of exploitation the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites
	reduction may not have ceased OR may be reversible.	not be understood OR may	not		

Criterion 1 evidence

Eligible under A4abce as Endangered

Generation time

The length of the primary juvenile period is likely to be about three to four years (S. Barrett 2022 pers. comm. 29 March). The maximum longevity of adult plants is unknown, but is likely at least 22 years (S. Barrett 2022 pers. comm. 29 March).

Therefore, the generation length of Stirling Range xyris could be approximately 13 years.

Generation time = age of first reproduction + [0.5 * (length of reproductive period)]Generation time = 4 + [0.5 * (22 - 4)] = 13 years

This gives an estimated three-generation period of approximately 39 years.

Population trend

The current population size of Stirling Range xyris is estimated at approximately 900 mature individuals (when current juveniles reach maturity) (Table 4).

Monitoring indicates a decline in the population size of Stirling Range xyris from >1100 mature individuals in 2010/11. This represents a decline of at least 18 percent in 11 years. Assuming exponential decline, this equates to an exponential decay rate of: $\ln(0.82)/11 = -0.01804$ per year (where 0.82 is the percentage survival, and 11 is the time in years).

To calculate the decline in the Stirling Range xyris population over a three generation period (2011–2050) it is necessary to project the number of mature individuals using the above rate of exponential decay. Using the above rate of decline, the number of individuals present at the end of a three generation period from 2011–2050, can be estimated with the equation: $1100 * e^{-0.01804*39} = 544$ plants, where 1100 is the number of mature individuals present in 2011 and 39 is the three generation period in years. This equates to a projected decline over this period of 51 percent (100-[544/1100*100] = 51 percent).

Anecdotal observations suggest that the population is undergoing a severe reduction. Site 1a was estimated to have >100 mature individuals and >1000 seedlings in 1993, compared to a 2022 estimate of 210 mature individuals and 90. Although some other sites were not known at the time, making estimates of the species' entire population size prior to 2010 difficult, this indicates that the species has experienced a sustained period of decline over the last several decades. Anecdotal reports also suggest there may have been some spatial contraction within sites (S. Barrett 2022 pers. comm. 4 January). Part of site 1a (formerly 1e) was assessed pre-fire in 2019, and there were no plants located in the northern section of the site where they had previously been recorded (S. Barrett 2022 pers. comm. 4 January). The impact of the 2018 and 2019 fires is not fully understood, however part of site 1a was assessed in February 2021, 14 months following the 2019 fire that partially burnt the site, and no seedlings were found within the burnt part of the site (S. Barrett 2022 pers. comm. 4 January).

The likely threats causing the decline include reduced precipitation and increased droughts caused by climate change, inappropriate fire regimes and herbivory (Table 2). These threats have not ceased, and the impacts climate change (and possibly other threats) are likely to increase in the future, and ongoing population decline is likely to continue.

Therefore, Stirling Range xyris appears to be 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 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) 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 B1ab(i,ii,iii,v)+B2ab(i,ii,iii,v) as Critically Endangered

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

The EOO and AOO of Stirling Range xyris are 4 km² (Table 4).

The EOO and AOO appear to meet the requirements for listing as Critically Endangered under B1 and B2.

Severely fragmented

Stirling Range xyris is considered to occur as a single subpopulation. Therefore, no assessment of severe fragmentation is possible and 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 inappropriate fire regimes, climate change and interactions between these threats and with herbivory.

Inappropriate fire regimes are a threat to Stirling Range xyris that could cause the rapid elimination of the species' single subpopulation. Stirling Range xyris appears to be 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. The species is known from a single subpopulation made up of five sites within a very small area (<2 km separating the furthest sites). All sites were impacted by fires in 2018 or 2019 (only part of site 1a remained unburnt by either fire).

This illustrates the potential for two fires within a period of time shorter than the primary juvenile period (approximately three to four years) to impact the species. It is possible that fire

intervals shorter than the species' primary juvenile period could occur in the future and affect the species' entire subpopulation, particularly considering the predicted decline of median rainfall and increasing frequency of droughts predicted as a result of climate change (Enright et al. 2015; Nolan et al. 2021; Table 2). Germinable soil seed banks of other southwest Western Australian obligate seeder monocots (Restionaceae) have been reported to be totally depleted following fire (Meeney et al. 2004). Therefore, it is plausible that if two fires did occur within the primary juvenile period it could cause the elimination or severe reduction of Stirling Range xyris.

Climate change is another threat to Stirling Range xyris that could cause the elimination of the species. Stirling Range xyris occurs in perched wetlands on the higher peaks of Koikyenunuruff/Stirling Range, which are dependent on rainfall to maintain the hydrology necessary to support this habitat. 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), particularly as Stirling Range xyris occurs on the higher peaks and upper slopes of Koikyenunuruff/Stirling Range and already occupies the highest possible elevational niche. If hydrology changes substantially, species reliant on high soil moisture can be negatively affected, through mortality or increased competition from species adapted to drier soil conditions (Alba et al. 2019). Stirling Range xyris plants appeared to be suffering from drought stress in 2016 at site 1b, and anecdotal observations (rather than quantitative on-ground monitoring) from 2004 suggested the entire population appears to be contracting in association with drying habitat (S. Barrett 2022 pers. comm. 4 January). However, it is unlikely that climate change alone would cause the elimination of the species within one generation of the species (13 years), as the species has soil-stored seed that could, presumably, germinate following the cessation of an extreme drought event if adult plants were killed.

The interaction of the threat of inappropriate fire regimes with climate change and/or herbivory could cause the rapid elimination of the species' single subpopulation. Evidence of grazing of Stirling Range xyris plants (presumably by Quokka and/or European rabbit) has been observed on several occasions, including post-fire in 2021 (S. Barrett 2022 pers. comm. 4 January). If high grazing pressure reduces the size of the soil seed bank through reduced adult fecundity or post-fire seedling survival, it could increase the likelihood that inappropriate fire regimes or drought could cause the elimination of the species. Similarly, 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). It is possible that the impacts of these interactions are already being observed. Site 1a was assessed following the 2019 fire and no seedlings were found within the burnt part of the site (S. Barrett 2022 pers. comm. 4 January).

Therefore, accounting for its very small geographic distribution and the serious threats that are impacting the species, Stirling Range xyris is likely to have a single location.

Continuing decline

Monitoring of Stirling Range xyris has documented a minimum 18 percent decline of mature individuals since 2010/11 (likely to be at the higher end of this estimate, see Criterion 1). Several sites appear to be contracting in area (S. Barrett 2022 pers. comm. 4 January). At part of

site 1a (pre-fire) there were no plants located in the northern section of the site where they had previously been recorded, and at a separate part of the site there was no recruitment observed 14 months post-fire (S. Barrett 2022 pers. comm. 4 January). Based on these observations, it appears that sites supporting Stirling Range xyris are contracting. If this trend continues and some sites become extinct (as appears likely, particularly in the face of worsening climate change), the EOO and AOO of the species will continue to decline.

Habitat quality is also expected to be declining due to inappropriate fire regimes, climate change, herbivory, and dieback of associated vegetation caused by *Phytophthora* spp. (Table 2). Fires in 2018 and 2019 have likely contributed to declines in habitat quality, as have been observed in declines of Stirling Range xyris, Stirling Range Dryandra (DAWE 2021b) and probably many other species. The species occurs in perched wetland habitat on the upper slopes of Koikyenunuruff/Stirling Range that is likely to be negatively impacted by projected declines in rainfall and increasing frequency of drought. The impacts of climate change are already being observed, with the entire population appearing to be contracting in association with drying habitat. Evidence of grazing of Stirling Range xyris plants (presumably by Quokka and/or European rabbit) has been observed on several occasions, including post-fire. *Phytophthora cinnamomi* is present throughout the species' habitat. Although Stirling Range xyris is presumed to be resistant (S. Barrett 2022 pers. comm. 4 January), dieback caused by *Phytophthora* spp. has degraded its habitat by removing susceptible species, with possible indirect negative impacts on Stirling Range xyris (e.g. through impacts on its insect pollinators).

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. Therefore, Stirling Range xyris does not meet the threshold for listing as Endangered under sub-criterion (c).

Conclusion

The data presented above appear to demonstrate that Stirling Range xyris 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 C1+C2a(ii) as Endangered

The population of Stirling Range xyris is estimated at approximately 900 individuals, when the current cohort of juveniles reaches maturity (Table 4). Therefore the population appears to be low.

The species has declined by at least 18 percent since 2010/11 (see evidence presented for Criterion 1). Anecdotal observations of additional decline (see Criterion 1) suggest that the actual decline over the last two generations (26 years) could plausibly be 20 percent. Therefore, it meets the requirements of subcriterion C1. As the species is considered to have a single subpopulation that contains 100 percent of mature individuals (see Table 4), the species also meets the requirements of the subcriterion C2. Therefore, Stirling Range xyris 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 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 <u>common</u> <u>assessment method</u>.

Criterion 4 evidence

Eligible under D as Vulnerable

As per the evidence presented above for Criterion 3, the number of mature individuals is estimated at approximately 900 mature individuals, when the current cohort of juveniles reaches maturity (Table 4). Therefore, the species appears to meet the requirements for listing under this criterion as Endangered.

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.

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