

Consultation on Species Listing Eligibility and Conservation Actions

Choretrum spicatum subsp. spicatum (spiked sour-bush)

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

1) the eligibility of *Choretrum spicatum* subsp. *spicatum* (spiked sour-bush) for inclusion on the EPBC Act threatened species list in the Endangered category; and

2) the necessary conservation actions for the above species.

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

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

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

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

Please include species scientific name in Subject field.

or by mail to:

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

Responses are required to be submitted by 8 July 2022.

Contents of this information package	Page
General background information about listing threatened species	2
Information about this consultation process	3
Consultation questions specific to the assessment	4
Information about the species and its eligibility for listing	12
Conservation actions for the species	25
References cited	28
Listing assessment	34

General background information about listing threatened species

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

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

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

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

Privacy notice

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

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

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

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

Information about this consultation process

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

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

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

<u>CONSULTATION QUESTIONS FOR CHORETRUM SPICATUM SUBSP.</u> <u>SPICATUM</u>

SECTION A - GENERAL

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

PART 1 – INFORMATION TO ASSIST LISTING ASSESSMENT

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

Biological information

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

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

Population size

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

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

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

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

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

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

Level of your confidence in this estimate:

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

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

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

Evidence of total population size change

10. Are you able to provide an estimate of the total population size during the 1950s to mid-1980s (at or soon after the start of the most recent three generation period)? Please provide justification for your response.

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

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

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

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

Level of your confidence in this estimate:

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

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

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

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

- 99–100% very high level of certainty, data are accurate within this range
- 11. Are you able to comment on the extent of decline in the species/subspecies' total population size over the last approximately 36–75 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

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

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

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

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

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

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

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

Level of your confidence in this estimated extent of occurrence

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

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

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

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

Level of your confidence in this estimated extent of occurrence:

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

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

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

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

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

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

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

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

PART 3 – ANY OTHER INFORMATION

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

Conservation Advice for Choretrum spicatum subsp. spicatum (spiked sour-bush)

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 spiked sour-bush. It provides a foundation for conservation action and further planning.



Choretrum spicatum subsp. spicatum © Copyright South Australian Seed Conservation Centre (from Plants of SA).

Conservation status

Choretrum spicatum subsp. *spicatum* (spiked sour-bush) is proposed to be listed as Endangered under the *Environment Protection and Biodiversity Conservation Act* 1999 (Cwlth) (EPBC Act).

Choretrum spicatum subsp. *spicatum* was assessed by the Threatened Species Scientific Committee to be eligible for listing as Endangered under criteria 2 and 3. The Committee's assessment is at Attachment A. The Committee's assessment of the subspecies' eligibility against each of the listing criteria is:

- Criterion 1: Insufficient data
- Criterion 2: Endangered: B1ab(iii)+B2ab(iii)
- Criterion 3: Endangered: C2a(ii)
- Criterion 4: Ineligible
- Criterion 5: Insufficient data

The main factors that make the subspecies eligible for listing are the suspected substantial reduction in population size, restricted geographic distribution and low population size with 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 *Choretrum spicatum* F.Muell. subsp. *spicatum* (Lepschi 2010). Family: Santalaceae.

Description

Spiked sour-bush is a shrub to 0.8–1.5 m high with rigid, woody branches that are round in cross-section (i.e. not angular) and longitudinally ridged. Leaves are scale-like, persistent (retained on the branchlets and gradually weathering away), 1.3–2 mm long, 0.5–0.6 mm wide, and spreading or recurved away from the stem. Tiny white flowers occur in a single-flowered inflorescence (flower spike) on the branchlets. Fruits are fleshy and green with pinkish-red flush with age. Seeds are woody globular seed to 4 mm long and 3 mm wide, with deep vertical striation. Description from Lepschi (2010) and Plants of SA (2021).

Choretrum spicatum subsp. *spicatum* differs from the mainland *C. spicatum* subsp. *continentale* by having leaves that are spreading or recurved away from the stem, whereas leaves are appressed close to the stem in *C. spicatum* subsp. *continentale* (Lepschi 2010).

Spiked sour-bush sometimes co-occurs with *Choretrum glomeratum* (common sour-bush), the only other *Choretrum* species on Kangaroo Island. Spiked sour-bush differs from common sour-bush by having a single-flowered inflorescence (2–7 flowered in common sour-bush)

surrounded by 8–20 bracts (3–4 in common sour-bush) and with round branches (angular branches in common sour-bush) (Lepschi & Barlow 2012).

Distribution

Spiked sour-bush is endemic to Kangaroo Island (KI) and occurs in the western third of the island (ALA 2021a). The subspecies occurs in Flinders Chase National Park and Ravine Des Casoars Wilderness Protection Area, Kelly Hill Conservation Park, Cape Bouguer Wilderness Protection Area, and private property, including unprotected land and land covered by Heritage Agreements (HA 93, HA 294, HA 362, HA 375, HA 424, HA 496, HA 552, HA 650, HA 947, HA 1346) (ALA 2021a; Davies et al. 2021). There are approximately 10 historical (pre-1970) records from the centre and eastern end of the island from cleared areas that are likely to be extinct (ALA 2021a).

The number of subpopulations of spiked sour-bush has not been documented. The subspecies has had limited survey effort across its range (H. Klein 2021 pers. comm. 17 Dec). However, the subspecies is likely to occur in a single large subpopulation spanning much of the western third of KI. The assessment of a single subpopulation is due to low survey effort for the subspecies and, therefore, the likely presence of additional undocumented plants within its range, combined with the lack of obvious spatial clustering of existing records (ALA 2021a), and the ecology of the subspecies having likely bird-dispersed fruit, which is likely to result in gene flow across the population (Kuijt & Hansen 2015; DELWP 2021).

There are no population estimates for the spiked sour-bush. Lepschi (2010) notes that spiked sour-bush "is not an abundant taxon within its range". Database records of spiked sour-bush usually observed a small number of individuals. There are 10 records with abundance data in Atlas of Living Australia (ALA 2021a) of which nine have ≤ 10 individuals noted, and 21 collections of spiked sour-bush at the State Herbarium of South Australia (AD) with qualitative notes on abundance, of which three observed the subspecies as locally common or numerous, and 18 observed the subspecies as uncommon, localised, rare, infrequent or only a single individual seen (P. Lang 2021 pers. comm. 6 Dec). However, a relatively large number of plants do occur in some areas, with at least 200–300 plants in a small area of vegetation on the margins of a dry lagoon on West Bay Track, one of the few sites of this subspecies that was not burnt in the 2019/20 bushfire (D. Duval 2021 pers. comm. 16 Dec).



Map 1 Modelled distribution of spiked sour-bush

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 subspecies 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.

Kangaroo Island has important cultural significance to the Kaurna, Ngarrindjeri, Narungga and Ramindjeri nations, and these groups maintain a spiritual connection to the region (DEH 2006; Ngarrindjeri Nation 2007). The Kaurna, Ngarrindjeri, Narungga and Ramindjeri peoples would like to be involved in the development and implementation of natural resources management in their traditional lands and waters (Ngarrindjeri Nation 2007). Current members of these nations have a strong understanding of Country and feel responsible for lands and waters (Ngarrindjeri Nation 2007; NRKI 2017).

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 subspecies has or is associated with some cultural and/or community significance.

Relevant biology and ecology

Habitat

Spiked sour-bush occurs in sand, loamy-sand, clay and clay-loams in heath, shrubland, mallee, eucalypt woodland or low open-forest, usually with a dense shrubby understorey (Lepschi & Barlow 2012; Davies et al. 2021; Plants of SA 2021). It often occurs on laterite soils in winter inundated flats, gentle slopes leading down to ephemeral watercourses and shallow open gullies adjacent to creeks or around small seasonal lakes (Lepschi & Barlow 2012; Davies et al. 2021; Plants of SA 2021).

Associated vegetation is mostly *Eucalyptus remota* (Kangaroo Island ash) low woodland with an understorey dominated by very sparse *Allocasuarina muelleriana* (slaty sheoak), *Banksia marginata* (silver banksia) and *Xanthorrhoea semiplana* subsp. *tateana* (Tate's grass-tree), or in wetter habitats, *E. cosmophylla* (cup gum) low open woodland over *Melaleuca brevifolia* (mallee honey-myrtle) or *M. gibbosa* (slender honey-myrtle) (Davies et al. 2021). Other co-occurring species may include *E. baxteri* (brown stringybark), *E. cladocalyx* (sugar gum), *E. diversifolia* (soap mallee), *E. leucoxylon* (yellow gum), *Eucalyptus obliqua* (messmate stringybark), *Acacia armata* (kangaroo thorn), *Adenanthos terminalis* (gland flower), *Adriana quadripartita* (bitter bush), *B. ornata* (desert banksia), *Boronia filifolia* (slender boronia), *Chamaescilla corymbosa* (blue stars), common sour-bush, *Conospermum patens* (slender smoke-bush), *Daviesia genistifolia* (broom bitter-pea), *Darwinia micropetala* (small darwinia), *Hakea rostrata* (beaked hakea), *Leptospermum continentale* (prickly tea-tree), *Leptospermum juniperinum* (prickly tea-tree), *Petrophile multisecta* (cone bush), *Pultenaea viscidula* (dark bush-pea), and *Spyridium vexilliferum* (winged spyridium) (ALA 2021a).

Reproductive biology

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

Spiked sour-bush is a hemi-parasitic (partially parasitic) root parasite (Nickrent 2011). Root parasites attach to the roots of other plants with a modified root called a haustorium. Hemiparasites receive some of their nutrition from their host and produce some of their own sugars via photosynthesis. The identity of host plants for spiked sour-bush is not known, however other species of *Choretrum* may parasitise *Allocasuarina* (she oaks) or *Pimelea* (rice flowers) (Raj 1972), while other Australian Santalaceae may have specific host associations (e.g. *Leptomeria spinosa* parasitises *Eremaea pilosa*), generalist host associations (e.g. *Exocarpus humifusa* parasitises a variety of Myrtaceae, Proteaceae, Ericaceae and Asteraceae) (Herbert 1928), or a preference for some host taxa, while still being capable of generalist associations (e.g. *Santalum spicatum* (sandalwood); McLellan et al. 2021). The identification of the host plants for spiked sour-bush is a research priority.

Fruit is likely to be consumed and seed dispersed by a range of birds (Kuijt & Hansen 2015; DELWP 2021) and mammals (e.g. *Cercartetus concinnus* (western pygmy possum); Pestell & Petit 2007).

Germination seems to require some form of soil disturbance and has been observed following fire (Davies et al. 2021; D. Duval 2021 pers. comm. 16 Dec) and physical soil disturbance (Davies et al. 2021), and probably also occurs following minor soil disturbance caused by native fauna diggings (D. Duval 2021 pers. comm. 16 Dec). As such, spiked sour-bush likely recruits both continuously during fire intervals and in response to fire events (D. Duval 2021 pers. comm. 16 Dec). However, it is difficult to germinate in cultivation, and has morpho-physiological dormancy and complex germination requirements (Plants of SA 2021). Germination can be inconsistent and research into germinated seedlings of other Santalaceae species (sandalwood) can require 6–12 months post-germination to find and attach to the root systems of host plants, during which time they are vulnerable to drought stress (McLellan et al. 2021).

Other species of *Choretrum* are known to be hosts for larvae of native *Microcastalia* (metallic wood-boring beetles) (Lang & Stolarski 2020) and *Ogyris* spp. (azure blue butterflies) with ant-tended larvae (New 2011). Although currently unknown, it is possible that similar relationships exist between spiked sour-bush and other insects.

Spiked sour-bush flowers primarily from July–February (Lepschi & Barlow 2012) with fruits ripening in November–January (D. Duval 2021 pers. comm. 16 Dec). Although nothing is known of pollination in spiked sour-bush, pollination of other *Choretrum* species is likely to be undertaken by insects, due to the tiny size of flowers, possibly including *Antisella* (soldier fly) (Lessard et al. 2021).

Plants may produce their first flowers within four years of emergence (Plants of SA 2021). Plant longevity is not known, but may be as short as 15–20 years, inferred from observations of adult plants of common sour-bush in the same region beginning to senesce after this period of time (Plants of SA 2021; D. Duval 2021 pers. comm. 16 Dec). However, longevity estimates for the sister subspecies *C. spicatum* subsp. *continentale* are from 25–60 years in Victoria (DELWP 2021).

Fire ecology

Spiked sour-bush is an obligate seeder with adult plants killed by fire (Plants of SA 2021). Although minimum and maximum tolerable fire intervals are unknown, healthy recruitment was observed following the 2019/20 bushfire at a site burnt 13 years previously, and also at site burnt 35 years previously, suggesting the subspecies is able to tolerate fire frequencies at least within that range of fire intervals (Davies et al. 2021). Seed longevity in the soil seedbank is unknown, although is woody endocarp of the fruit suggests that seeds may persist for some years (D. Duval 2021 pers. comm. 16 Dec).

Habitat critical to the survival

Spiked sour-bush occurs in heath, shrubland, mallee, eucalypt woodland or low open-forest, on laterite soils in winter inundated flats, gentle slopes leading down to ephemeral watercourses and shallow open gullies adjacent to creeks or around small seasonal lakes (Lepschi & Barlow 2012; Davies et al. 2021; Plants of SA 2021).

Habitat critical survival includes all vegetation types listed above that occur within the subspecies' range in the western portion of Kangaroo Island (see Distribution section). Until further information is available, all habitat for this subspecies should be considered habitat critical for the subspecies' 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 (IUCN 2019), in keeping with the terminology used in the EPBC Act and state/territory environmental legislation.

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

Threats

The major threats to spiked sour-bush are inappropriate fire regimes, naturalisation by *Eucalyptus globulus* (southern blue-gum), dieback caused by *Phytophthora* spp. infection and the effects of climate change.

Threat	Status ^a	Evidence
Habitat loss, disturba	nce and modification impacts	
Fire regimes that cause decline in biodiversity	 Timing: future Confidence: inferred Likelihood: likely Consequence: major Trend: static Extent: across the entire range 	Spiked sour-bush is an obligate seeder with adult plants killed by fire, though is capable of germination in fire-free conditions (Plants of SA 2021). With few exceptions, all known records of spiked sour-bush, and approximately 81% of the modelled range area of the subspecies, burnt in the 2019/20 bushfire on KI (Gallagher 2020; Davies et al. 2021). A small area of vegetation containing at least 200–300 plants on the margins of a dry lagoon on West Bay Track, and several similarly small unburnt sites with 15–20 plants inside (e.g. Sandy Creek, West Bay fire track) or outside the fire scar on northwest KI, were the only sites not burnt in the 2019/20 bushfire (D. Duval 2021 pers. comm. 16 Dec). There are a number of mechanisms by which fire regimes may cause declines in species with obligate seeding traits (Keith 1996; DAWE 2021a). Spiked sour-bush may be sensitive to high fire frequency, out of season fires and interactions between fire and other threats. These may also limit populations of suitable host plants, although host specificity is currently unknown. <i>Too frequent fires</i> Obligate seeders require a minimum time between successive fires to allow time to accumulate sufficient soil-stored seed to ensure population persistence (Keith 1996; DAWE 2021a). If successive fires limit seed bank accumulation, high fire frequency could cause a decline of the spiked sour-bush. The primary juvenile period for spiked sour-bush is at least four years in the wild (Plants of SA 2021), although avoidance of population declines may require considerably longer fire-free intervals (e.g. if plants do not reach full reproductive capacity for several years after maturity or if seed bank accumulation is slow). Although the minimum of prequent fires burnt 65,000 ha, and in the following summer of 1954/55 bushfires burnt 35,000 ha, including some overlap areas that were burnt in both fires of 2422). Although these fire events were smaller than the 2019/20 bushfires that burnt about 200,000 ha, they demonstrate the potential for fr
		1) seedling mortality due to desiccation as a consequence of the interaction with fire-hydrological interactions

Table 1 Threats impacting spiked sour-bush

Threat	Status ^a	Evidence
		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.
		Spiked sour-bush is likely adapted to seasonal fire regimes consisting of fire during the dry dormant summer periods followed by moist conditions during the growing and reproductive period. If fires occur during the growing season, standing plants may be killed before seed is produced, reducing the rate of seed accumulation in soil. While obligate- seeding life history and morpho-physiological dormancy suggest potential susceptibility to recurring out-of-season fires (mid autumn – mid spring), there are no direct observations on spiked sour-bush. Out-of-season prescribed burning can negatively impact post-fire recruitment of some obligate seeder shrubs (reviewed in DAWE 2021a). 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 (e.g. DAWE 2021b). <i>Interactions between fire and other threats</i> There are a range of mechanisms by which fire interacts with other threats and impacts the subspecies recovery potential following fire (DAWE 2021a). For example, climate change may lead to higher frequency of fire, while also reducing
		resilience by slowing rates of maturation, lowering fecundity or increasing post-fire seedling mortality through post-fire drought (Enright et al. 2015; Henzler et al. 2018). Climate change also affects the risk of recruitment failure through coincidence of fires with pre-fire or post-fire droughts, which may limit seed production or seedling recruitment, respectively (Keith 1996; DAWE 2021a). Fires also interact with disease and herbivory, which elevate risks of recruitment failure in the post-fire environment (Bond & van Wilgen 1996; Moore et al. 2015; DAWE 2021a; Gallagher et al. 2022). The impact of inappropriate fire regimes on the putative insect pollinators of spiked sour-bush are unknown.
Land clearing and fragmentation	 Timing: current Confidence: inferred Likelihood: possible Consequence: moderate Trend: static Extent: across parts of the range 	While land clearing has slowed since the introduction of the <i>Native Vegetation Act 1991</i> in South Australia, intensive clearing occurred from the 1950s to 1980s (Robinson & Armstrong 1999). Approximately 2300 km ² of land on KI has been cleared and is used for agriculture and plantation forestry (Dohle 2007), mostly on the east and centre of the island. It is likely that spiked sour-bush was historically cleared on the island, as 10 records exist east of Gosse, all of which were collected prior to 1970 (ALA 2021a). However, most of the population now occurs in conservation reserves, and so is protected from large-scale clearing. Nevertheless, the risks posed by smaller road, tourism and infrastructure development are likely to continue to threaten some areas, particularly near roads and on private land, but also in conservation may also affect population viability, particularly by limiting dispersal, rescue and recolonisation processes.

Threat	Status ^a	Evidence
Climate change		
Changes to temperature and precipitation patterns when seedlings are establishing	 Timing: current/future Confidence: inferred Likelihood: almost certain Consequence: major Trend: increasing Extent: across the entire range 	The CSIRO & Bureau of Meteorology (2020) project that KI is likely to experience increased mean temperatures and fire danger weather, and decreased median rainfall. By 2050, annual rainfall is projected to decline by 7.5–8.9% under intermediate and high emissions pathways, respectively. Droughts may have a substantial effect on the hydrology of the environments in which the subspecies grows, and many plant species are vulnerable to mortality through drought stress and hydraulic failure (Choat et al. 2018; Nolan et al. 2021). Post-fire drought on KI is a likely contributing factor in poor recruitment of spiked sour-bush at drier sites, as wetter sites generally had higher recruitment (Davies et al. 2021). This indicates an interaction between fire and drought, including pre-fire and post-fire droughts, is a major threat to spiked sour-bush (DAWE 2021a; Nolan et al. 2021). Davies et al. (2021) suggested a possible mechanism may be the lack of mature, healthy shrubs in burnt vegetation limiting the ability of young spiked sour-bush seedlings to parasitise deep-rooted plants that have access to soil moisture during periods of drought. It is possible that as a root-parasite, recruitment of spiked sour-bush is particularly vulnerable to drought during the early seedling stage (McLellan et al. 2021). More severe post-fire drought events might therefore be expected to result in larger post-fire declines (Enright et al. 2015; Nolan et al. 2021). Warmer temperatures and changes to precipitation patterns may also favour the spread of established weeds and allow
		naturalised plants to become invasive (Scott et al. 2014; Roger et al. 2015).
Invasive species		
Competition with, and hydrological changes caused by, forestry plantations of southern blue- gum	 Timing: current Confidence: observed Likelihood: likely Consequence: major Trend: increasing Extent: across parts of the range 	Forestry plantations of southern blue-gum were widely established on Kangaroo Island in the early 2000s (Davies et al. 2021). Following the 2019/20 bushfire, major incursions of southern blue-gum seedlings have occurred across large tracts of native vegetation on western KI (Davies et al. 2021). Southern blue-gum seedlings from wind-dispersed seed were observed up to 87 m from adjoining plantations, and seedlings from water-dispersed seed (along drainage lines) were observed up to 615 m into native vegetation downstream from the nearest plantation (Davies et al. 2021). Post-fire densities of southern blue-gum seedlings in native vegetation near plantations on western KI averaged 9309 seedlings/ha, with up to 29,500 seedlings/ha in wet heath vegetation and 250,000 seedlings/ha in native vegetation along drainage lines (Davies et al. 2021). At such densities southern blue-gum are likely to outcompete other native species, including spiked sour-bush, and affect the hydrology of its habitat by causing drying of swamps and wet heath vegetation (Potts et al. 2004; Benyon et al. 2006; Jury 2006; Davies et al. 2021). In western Europe, fire and other disturbance events known to facilitate invasion of southern blue-gum into native vegetation from adjacent plantations (Silva et al. 2016; 2021). Southern blue-gum has been reported to escape from plantations and naturalise in native vegetation across higher-rainfall districts of South Australia (Jury 2006). Southern blue-gum naturalisation currently threatens most spiked sour-bush plants located near plantations. With time, if incursions are not eliminated, southern blue-gum will continue to spread and degrade additional areas of spiked sour-bush habitat.

Threat	Status ^a	Evidence
Weed invasion	 Timing: current Confidence: observed Likelihood: likely Consequence: moderate Trend: unknown Extent: across parts of the range 	Eight Weeds of National Significance and 27 Declared Weeds of SA are found on KI, including notable fire-adapted and fast- growing 'pioneer' weeds: bluebell creeper (<i>Sollya</i> <i>heterophylla</i>), gorse (<i>Ulex europaeus</i>), Montpellier broom (<i>Genista monspessulana</i>), bridal creeper (<i>Asparagus</i> <i>asparagoides</i>), variegated thistle (<i>Silybum marianum</i>), African boxthorn (<i>Lycium ferocissimum</i>), blackberry (<i>Rubus</i> <i>fructicosus</i>) and one-leaf cape tulip (<i>Moraea flaccida</i>) (Thorp & Lynch 2000; NRKI 2020; Landscape South Australia 2021a,b). Weeds are capable of outcompeting native plants for light and nutrients (Morin & Scott 2012; Noble et al. 2021). A significant threat to spiked sour-bush appears to be annual weeds competing with seedlings following fire, particularly near areas with historic pastoralism (e.g. at campground flats, in the old Rocky River Station area) (D. Duval 2021 pers. comm. 16 Dec). Ten months post-fire a dense cover of weeds including flatweed (<i>Hypochaeris glabra</i>), fescue (<i>Vulpia sp.</i>), rostraria (<i>Rostraria sp.</i>) and hairgrass (<i>Airia sp.</i>) was observed at several sites containing spiked sour-bush seedlings (D. Duval 2021 pers. comm. 16 Dec). Competition with annual weeds following fire may compound the negative impact of any post-fire drought conditions, particularly as <i>Santalaceae</i> may be prone to drought impacts during the early seedling stage (McLellan et al. 2021).
Soil disturbance and herbivory from feral pigs	 Timing: current Confidence: suspected Likelihood: likely Consequence: minor Trend: unknown Extent: across the entire range 	Feral pigs are found in all states and territories of Australia and are listed as a Key Threatening Process (KTP) under the EPBC Act (DoEE 2017). Feral pigs are widespread across the western side of Kangaroo Island, including in the Western River Wilderness Protection Area (DEH 2006, 2009; NRKI 2017). Feral pigs can destroy native vegetation by trampling plants, causing soil disturbance and facilitating weed invasion (DoEE 2017). Feral pigs primarily impact wet or waterlogged areas, and although there are no direct observations of their impact on the subspecies, they probably pose a threat to spiked sour-bush growing in wetter areas (e.g. drainage lines and gullies). A feral pig control program is currently underway on KI (PIRSA 2021).
Disease		
Disease caused by <i>Phytophthora</i> spp. infection	 Timing: current/future Confidence: suspected Likelihood: unknown Consequence: unknown (potentially major) Trend: unknown Extent: across the entire range 	<i>Phytophthora</i> spp. are soil-borne pathogens that infect and kill roots of susceptible plants, facilitating plant death (DOEE 2018). The susceptibility of spiked sour-bush to disease caused by <i>Phytophthora</i> spp. is unknown. Although other <i>Santalaceae</i> species can be unaffected by the disease (Shearer et al. 2004), at two sites where no post-fire recruitment of spiked sourbush was recorded, dead Tate's grass-tree plants indicated that <i>Phytophthora</i> spp. may be present. Testing of the susceptibility of spiked sourbush to <i>Phytophthora</i> spp. is a recommended research priority. Even if this subspecies is not directly susceptible, dieback caused by <i>Phytophthora</i> spp. is likely to continue to degrade its' habitat by removing susceptible species, with possible indirect negative impacts on spiked sour-bush (e.g. through impacts on host plant availability or on its putative insect pollinators).

Threat	Status ^a	Evidence
Disease caused by Australian honey fungus infection	 Timing: future Confidence: suspected Likelihood: unknown Consequence: unknown (potentially moderate) 	Australian honey fungus is a native pathogenic fungus that infects a wide range of plant species and is widespread across Australia, including in western KI (Kile et al. 1983; ALA 2021b). Although the impact of the fungus on spiked sour- bush is unknown, it has been reported to kill the related common sour-bush in Western Australia (Shearer et al. 1997). However, as a native species of fungus, it may be a lesser threat than introduced pathogenic fungi such as <i>Phytophthora</i> spp.
	• Trend: unknown	
	• Extent: across the entire range	

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.

Table 1 describes the extent over which each threat may affect the subspecies. The risk matrix (Table 2) 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 2 Spike	d sour-bush	risk matrix
---------------	-------------	-------------

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain				Changes to temperature and precipitation patterns when seedlings are establishing	
Likely		Soil disturbance and herbivory from feral pigs	Weed invasion	Fire regimes that cause decline in biodiversity Competition with, and hydrological changes caused by, forestry plantation of southern blue- gum	
Possible			Land clearing		
Unlikely					
Unknown			Disease caused by Australian honey fungus infection	Disease caused by <i>Phytophthora</i> spp. infection	

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

 ${\it Catastrophic-population\ extinction/extirpation\ }$

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 spiked sour-bush 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 modification impacts

- Avoid all further loss and fragmentation of habitat.
- Where possible, purchase habitat currently on private land and incorporate into the conservation reserve system.

Fire, climate change and extreme weather impacts

- Ensure that the locations of all subpopulations are recorded on relevant state databases, including those used by land management and fire response agencies.
- Exclude planned fire (and bushfire where possible) from all subpopulations for at least ten years post-fire, unless specific conservation benefits are identified from occasionally shorter fire intervals. If planned fire impacts subpopulations, managers must ensure that subsequent fires do not occur within the critical regeneration period to allow the subspecies to rebuild its soil seed bank to sustain the population through the next fire event.
- Identify and protect habitat likely to become refugia for the subspecies due to the impacts of climate change.
- Map populations relative to their vulnerability to drought stress taking into account soil conditions, topography and rainfall patterns as the basis for targeted interventions to minimise drought mortality.
- Investigate options for maintaining in situ persistence as the climate changes, for example by minimising other population pressures, enhancing resilience and promoting recruitment or supplementing existing subpopulations.

Invasive species impacts

- Remove all southern blue-gum individuals from spiked sour-bush habitat in western KI. Removal is easiest and most effective when undertaken in the first three to five years following fire (Davies et al. 2021). Removal should be undertaken at regular intervals and particularly following fire events. Methods of removal should avoid and minimise nontarget impacts to native vegetation. Cutting of southern blue-gum stems below the developing lignotuber was the most effective method of removing southern blue-gum with no off-target impact in Davies et al. (2021).
- Introduce minimum buffer zones (areas with no plantation species separating plantations and native vegetation) for all current and future plantations to avoid naturalisation of plantation species into potential habitat for spiked sour-bush. Following observations post-2019/20 bushfire, buffers for southern blue-gum must be a minimum width of 87 m, except along drainage lines where plantations must be a minimum of 615 m from downstream spiked sour-bush habitat.

- Implement site-based weed control using appropriate methods in consultation with land managers and community groups to ensure that there is no impact on spiked sour-bush individuals.
- Continue feral pig population control measures in consultation with land managers and community groups in and near subpopulations of spiked sour-bush.

Disease impacts

- Ensure appropriate hygiene protocols are in place, particularly during track and road management (e.g. do not introduce infected soil, gravel or plant material to spiked sourbush habitat, ensure appropriate drainage of roads). Refer to DOEE (2018) for general guidelines.
- Determine which species of *Phytophthora* are present in spiked sour-bush habitat.
- Map the extent of *Phytophthora* spp. within spiked sour-bush habitat.
- Promote research and development of treatments of *P. cinnamomi* dieback, including alternatives to phosphite.

Ex situ recovery actions

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

Stakeholder engagement/community engagement

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

Survey and monitoring priorities

• Undertake surveys for spiked sour-bush across its range.

- Estimate the population size of spiked sour-bush using repeatable methods to enable comparison with future survey outcomes.
- Maintain a monitoring program to:
 - monitor subspecies recruitment and plant health after fire events;
 - determine trends in population size;
 - document the 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

- Understand the germination requirements of spiked sour-bush in cultivation.
- Understand the host-requirements of spiked sour-bush throughout its life cycle (i.e. during germination, seedling and adult phases).
- Increase knowledge surrounding the ecology of spiked sour-bush. This includes improving understanding of habitat requirements, recruitment and soil-seed bank dynamics (especially seed bank longevity and germination cues), appropriate fire regimes, pollination biology, seed and plant longevity, genetic structure, and minimum viable population size.
- Investigate the impact of drought on spiked sour-bush recruitment and seedling growth.
- Ascertain the cultural significance of spiked sour-bush.
- Determine habitat critical to the survival of spiked sour-bush.
- Investigate the susceptibility of spiked sour-bush to *Phytophthora* spp. and Australian honey fungus.
- Undertake vulnerability assessments of the species' sensitivity and adaptive capacity to changing climatic conditions which draw on genetic, physiological or ecological evidence.
- If vulnerability assessments indicate the species has a high likelihood of extinction due to climate change, undertake research to identify climate refuges that may be suitable for translocations, including both modelling and experimental approaches (e.g. trial translocations). Consideration should be given to the benefits to the species in mitigating climate change related threats, as well as the risks to the recipient site (e.g. introduction of diseases, pests and/or pathogens, and invasiveness of the species).

Links to relevant implementation documents

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.

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

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

<u>Threat abatement plan for predation, habitat degradation, competition and disease transmission</u> <u>by feral pigs (*Sus scrofa*) (2017)</u>

Conservation Advice and Listing Assessment references

- ALA (2021a) *Choretrum spicatum* species information page. *Atlas of Living Australia*. Commonwealth Scientific and Industrial Research Organisation, Canberra. Viewed: 2 December 2021. Available at: https://bie.ala.org.au//species/https://id.biodiversity.org.au/taxon/apni/51294079
- ALA (2021b) Armillaria luteobubalina species information page. Atlas of Living Australia. Commonwealth Scientific and Industrial Research Organisation, Canberra. Viewed: 2 December 2021. Available at: https://bie.ala.org.au//species/e6d2b97e-bcd0-4f47-8a21ad935fce79da
- Benyon RG, Theiveyanathan S & Doody TM (2006) Impacts of tree plantations on groundwater in south-eastern Australia. *Australian Journal of Botany* 5, 181–192.
- Bond WJ & van Wilgen BW (1996) *Fire and plants.* Chapman and Hall, London.
- Choat B, Brodribb TJ, Brodersen CR, Duursma RA, López R & Medlyn BE (2018) Triggers of tree mortality under drought. *Nature* 558, 531–539.
- Commander L (2018) *Guidelines for the translocation of threatened plants in Australia.* Australian Network for Plant Conservation.
- Commander L (Ed.) (2021) Florabank Guidelines best practice guidelines for native seed collection and use. 2nd edn. Florabank Consortium Australia. Available at <u>https://www.florabank.org.au/guidelines</u>
- CSIRO & Bureau of Meteorology (2020) *Climate Change in Australia Information for Australia's Natural Resource Management Regions.* Technical Report, CSIRO and Bureau of Meteorology, Australia.
- Data SA (2022) Bushfires and prescribed burns history. South Australian Government Data Directory. Viewed: 23 Jan 2022. Available at: <u>https://data.sa.gov.au/data/dataset/fire-history</u>
- Davies RJ-P, Bianco B & Reynolds T (2021) *Enhancing bushfire recovery of Kangaroo Island's rare and threatened, endemic flora on private land and roadsides.* Final report for Australian Government's Wildlife and Habitat Bushfire Recovery program grants. Nature Conservation Society of South Australia, Adelaide.
- DAWE (2018) *Threat abatement plan for disease in natural ecosystems caused by* Phytophthora cinnamomi. Department of the Environment and Energy, Canberra. Viewed: 12 December 2021. Available at: https://www.awe.gov.au/environment/biodiversity/threatened/publications/threatened/

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

DAWE (2021a) *Draft listing assessment for 'Fire regimes that cause biodiversity decline' as a key threatening process.* Department of Agriculture, Water and Environment, Canberra.

- DAWE (2021b) *Draft conservation advice and listing assessment for* Banksia montana *(Stirling Range dryandra)*. Department of Agriculture, Water and Environment, Canberra.
- DEH (2001) *Biodiversity plan for Kangaroo Island South Australia*. Department for Environment and Heritage (SA), Adelaide.
- DEH (2006) *Cape Torrens and Western River Wilderness Protection Areas management plan.* Department for Environment and Heritage (SA), Adelaide.
- DEH (2009) Fire management plan: Cape Forbin integrated fire management plan. Department for Environment and Heritage (SA), Adelaide.Dohle L (2007) Report of condition of agricultural land on Kangaroo Island. Department of Water, Land and Biodiversity Conservation (SA), Adelaide.
- DELWP (2021) *Conservation Status Assessment for* Choretrum spicatum *subsp.* continentale. Department of Environment, Land, Water and Planning, Melbourne.
- DEW (2020) *Guide to climate projections for risk assessment and planning in South Australia.* Department of Environment and Water, South Australia.
- DOEE (2017) Threat abatement plan for Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (Sus scrofa). Department of the Environment and Energy (Cwth), Canberra.
- DOEE (2018) *Threat abatement plan for disease in natural ecosystems caused by* Phytophthora cinnamomi. Department of the Environment and Energy (Cwth), Canberra.
- Duval D (2021) Personal communication via email, 16 December.
- Enright NJ, Fontaine JB, Bowman DM, Bradstock RA, Williams RJ (2015) Interval squeeze: altered fire regimes and demographic responses interact to threaten woody species persistence as climate changes. *Frontiers in Ecology and the Environment* 13, 265–272.
- Gallagher RV (2020) *National prioritisation of Australian plants affected by the 2019-2020 bushfire season.* Report to Department of Agriculture, Water and Environment (Cwth), Canberra. Accessed 3 December 2020. Available on the Internet at: <u>http://www.environment.gov.au/biodiversity/bushfire-recovery/priority-plants</u>.
- Gallagher RV, Allen S, Mackenzie BDE, Yates CJ, Gosper CR, Keith DA, Merow C, White MD, Wenk E, Maitner BS, He K, Adams VN & Auld TD (2021) High fire frequency and the impact of the 2019–2020 megafires on Australian plant diversity. *Diversity and Distributions* 27, 1166–1179.
- Gallagher RV, Allen S, Mackenzie BDE, Keith DK, Nolan RH, Rumpff L, Gosper C, Pegg G, Van Leeuwen S, Ooi MKJ, Yates CJ, Merow C, Williams RJ, Nikopoulous E, Beaumont LJ and Auld TD (2022) An integrated approach to assessing abiotic and biotic threats to postfire plant species recovery: lessons from the 2019-20 Australia fire season. *Global Ecology and Biogeography*. https://doi.org/10.1111/geb.13478
- Henzler J, Weise H, Enright NJ, Zander S & Tietjen B (2018) A squeeze in the suitable fire interval: Simulating the persistence of fire killed plants in a Mediterranean-type ecosystem under drier conditions. *Ecological Modelling* 389, 41–49.

- Herbert DA (1928) The parasitism of *Exocarpus humifusa* R.Br.. In: *Papers and Proceedings of the Royal Society of Tasmania*, p. 28–30.
- IUCN (2019) *Guidelines for Using the IUCN Red List Categories and Criteria. Version 14.* Prepared by the Standards and Petitions Committee. Viewed: 17 June 2021. Available on the internet at: <u>http://www.iucnredlist.org/documents/RedListGuidelines.pdf</u>.
- Jasinge NU, Huynh T, & Lawrie AC (2018) Changes in orchid populations and endophytic fungi with rainfall and prescribed burning in *Pterostylis revoluta* in Victoria, Australia. *Annals* of Botany 121, 321–334.
- Jury T (2006) True blue or risky business. Threats posed by Tasmanian blue gum plantations to biodiversity. *Xanthopus* 24, 1–3.
- Keith D (1996) Fire-driven extinction of plant populations: a synthesis of theory and review of evidence from Australian vegetation. *Proceedings of the Linnean Society of New South Wales* 116, 37–78.
- Keith DA, Dunker B, & Driscoll DA (2020). Dispersal: The eighth fire seasonality effect on plants. *Trends in Ecology and Evolution*, 35, 305–307.
- Kile GA, Watling R, Malajczuk N, Shearer BL (1983) Occurrence of *Armillaria luteobubalina* Watling and Kile in Western Australia. *Australasian Plant Pathology* 12, 18–20.
- Klein H (2021) Personal communication via email, 17 December.
- Kuijt J & Hansen B (eds.) (2015) *Santalales, Balanophorales*. In: Kubutzki K. (ed.), *The families and genera of vascular plants Vol. 12: Flowering plants. Eudicots.* Springer Verlag: Berlin.
- Landscape South Australia (2021a) *Bushfires and weeds*. Viewed: 30 November 2021 Available at: <u>https://landscape.sa.gov.au/ki/land-and-</u> <u>water/Bushfire recovery/Bushfires and weeds</u>
- Landscape South Australia (2021b) *Pest plants priority weeds on Kangaroo Island*. Viewed: 30 November 2021 Available at: <u>https://landscape.sa.gov.au/ki/plants-and-animals/pest-plants</u>
- Lang P (2021) Personal communication via email, 6 December.
- Lang PJ & Stolarski AM (2020) New host plants and distribution records in South Australia for *Microcastalia heller* (Coleoptera: Buprestidae) with a summary of the taxonomic history of the genus. *The Australian Entomologist* 47, 195–211.
- Lepschi BJ & Barlow BA (2012) *Santalaceae (version 1)*. In: Kellermann, J. (ed.), *Flora of South Australia (ed. 5)*. State Herbarium of South Australia: Adelaide. Accessed: 17 December 2021, Available at: <u>www.flora.sa.gov.au/ed5</u>
- Lepschi BJ (2010) A new subspecies in *Choretrum spicatum* F.Muell. (Santalaceae) from South Australia. *Journal of the Adelaide Botanic Gardens* 24: 53–55

- Lessard BD, Yeates DK & Woodley NE. (2021) Revision of the Australian soldier fly genus Antissella White including six new species (Stratiomyidae: Antissinae). Insect Systematics & Evolution 1, 1–33.
- Martyn Yenson AJ, Offord CA, Meagher PF, Auld T, Bush D, Coates DJ, Commander LE, Guja LK, Norton SL, Makinson RO, Stanley R, Walsh N, Wrigley D, Broadhurst L (2021) *Plant Germplasm Conservation in Australia: strategies and guidelines for developing, managing and utilising ex situ collections. Third edition.* Australian Network for Plant Conservation, Canberra.
- McLellan RC, Dixon K & Watson DM (2021) Prolific or precarious: a review of the status of Australian sandalwood (*Santalum spicatum* [R. Br.] A. DC., Santalaceae). *The Rangeland Journal. RJ21017*
- Miller G, Tangney R, Enright NJ, Fontaine JB, Merritt DJ, Ooi MKJ, Ruthrof KX & Miller BP (2019) Mechanisms of fire seasonality effects on plant populations. *Trends in Ecology and Evolution* 34, 1104–1117.
- Moore N, Barrett S, Howard K, Craig MD, Bowen B, Shearer B, Hardy G (2014) Time since fire and average fire interval are the best predictors of *Phytophthora cinnamomi* activity in heathlands of south-western Australia. *Australian Journal of Botany* 62, 587–593.
- Morgan JW (1995). Ecological studies of the endangered *Rutidosis leptorrhynchoides. I.* Seed production, soil seed bank dynamics, population density and their effects on recruitment. *Australian Journal of Botany* 43, 1–11.
- Morin L & Scott JK (2012) *Asparagus asparagoides* (L.) Druce bridal creeper. *Biological control of weeds in Australia*. CSIRO Publishing, Melbourne.
- New TR (2011) Unity in richness: azure blues (Ogyris spp.) in patchy environments. In: Butterfly conservation in South-Eastern Australia: progress and prospects. Springer, Dordrecht.
- Ngarrindjeri Nation (2007) Ngarrindjeri Nation Yarluwar-Ruwe plan: caring for Ngarrindjeri sea country and culture, prepared by the Ngarrindjeri Tendi, Ngarrindjeri heritage committee and Ngarrindjeri native title management committee. Ngarrindjeri land and progress association, Camp Coorong, Meningie.
- Nickrent DL (2011) *Santalales (Including Mistletoes)*. In: *Encyclopedia of Life Sciences (ELS)*. John Wiley & Sons, Ltd: Chichester.
- Noble MR, Adair RJ, Ireland KB (2021) *Biology of Invasive Plants 2.* Lycium ferocissimum *Miers. Invasive Plant Science and Management* 14, 41–56.
- Nolan RH, Collins L, Leigh A, Ooi MK, Curran TJ, Fairman TA, Víctor Resco de Dios, Bradstock R (2021). Limits to post-fire vegetation recovery under climate change. *Plant, cell & environment* 44, 3471–3489.
- NRKI (2017) *Kangaroo Island natural resources management plan 2017-2027.* Kangaroo Island Natural Resources Management Board, Kingscote.
- NRKI (Kangaroo Island Natural Resources Management Board) (2020) *Weeds declared for Kangaroo Island*. Kangaroo Island Natural Resources Management Board (SA), Kingscote.

- Ooi, MJ, Auld TD & Whelan RJ (2007) Distinguishing between persistence and dormancy in soil seed banks of three shrub species from fire-prone southeastern Australia. *Journal of Vegetation Science* 18, 405.
- Penman TD, Binns D, Allen R, Shiels R, Plummer S (2008) Germination responses of a dry sclerophyll forest soil-stored seedbank to fire related cues. *Cunninghamia* 10, 547–555.
- Pestell AJ & Petit S (2007) Diet of the western pygmy possum, *Cercartetus concinnus* Gould (Marsupialia: Burramyidae), at Innes National Park, South Australia, and evaluation of diet sampling methods. *Australian Journal of Zoology* 55, 275–284.
- PIRSA (2020) *Kangaroo Island Feral Pig Eradication Action Plan.* Department of Primary Industries and Regions, Kingscote.
- Pisanu P, Rogers D, O'Connor J, Thompson D & Peters D (2014) *Identifying priority landscapes and ecosystems for nature conservation in the ecosystems for nature conservation in the Kangaroo Island NRM region*. DEWNR Technical Report 2013/14, Department for Environment, Water and Natural Resources, Adelaide.
- Plants of SA (2021) Choretrum spicatum *subsp.* spicatum *species page, Plants of South Australia*. Viewed: 17 December 2021. Available at: <u>http://syzygium.xyz/saplants/Santalaceae/Choretrum/Choretrum spicatum ssp. spicatum</u>.<u>html</u>
- Potts BM, Vaillancourt RE, Jordan G, Dutkowski G, Costa e Silva J, McKinnon G, Steane D, Volker P, Lopez G, Apiolaza L, Li Y, Marques C, Borralho N (2004) *Exploration of the Eucalyptus globulus gene pool*. In Borralho (ed.) *Eucalyptus in a Changing World*. Proc. Of IUFRO Conf. Aveiro II-I5 October.
- Prior LD, French BJ, Storey K, Williamson GJ, Bowman D (2020) Soil moisture thresholds for combustion of organic soils in western Tasmania. *International Journal of Wildland Fire* 29, 637–647.
- Raj B (1972) Morphological and Embryological Studies in the Family Santalaceae—XIII Choretrum Lateriflorum R. Br. *Österreichische Botanische Zeitschrift*, 120, 143–154.
- Robinson AC & Armstrong DM (1999) *A biological survey of Kangaroo Island South Australia in November 1989 and 1990.* Department for Environment, Heritage and Aboriginal Affairs, Adelaide.
- Roger E, Duursma DE, Downey PO, Gallagher RV, Hughes L, Steel J, Leishman MR (2015) A tool to assess potential for alien plant establishment and expansion under climate change. *Journal of Environmental Management* 159, 121–127.
- Scott JK, Murphy H, Kriticos DJ, Webber BL, Ota N and Loechel B (2014) *Weeds and Climate Change: supporting weed management adaptation.* CSIRO, Australia.
- Shearer BL, Byrne A, Dillon M, Buehrig R (1997) Distribution of *Armillaria luteobubalina* and its impact on community diversity and structure in Eucalyptus wandoo woodland of southern Western Australia. *Australian Journal of Botany* 45, 151–165.

- Shearer BL, Crane CE, Cochrane A (2004) Quantification of the susceptibility of the native flora of the South-West Botanical Province, Western Australia, to *Phytophthora cinnamomi*. *Australian Journal of Botany* 52, 435–443.
- Silva JS, dos Santos P, Sério AG, Gomes F (2016) Effects of heat on dehiscence and germination in *Eucalyptus globulus* Labill.. *International Journal of Wildland Fire* 25, 478–483.
- Silva JS, Nereu M, Pinho S, Queirós L, Jesús C, Deus E (2021) Post-fire demography, growth, and control of *Eucalyptus globulus* wildlings. *Forests* 12, 156.
- Thorp JR & Lynch R (2000) *The determination of weeds of national significance*. National Weeds Strategy Executive Committee, Launceston.
- Whelan RJ (1995) *The ecology of fire*. Cambridge University Press, Cambridge.

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 *Choretrum spicatum* subsp. *spicatum*

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 3 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	1400-2000	800	3000	There are no population estimates for the spiked sour-bush. However, the subspecies appears to be uncommon and Lepschi (2010) notes that spiked sour-bush "is not an abundant taxon within its range". There are 21 collections of spiked sour bush at the State Herbarium of South Australia (AD) with notes on abundance, of which three record the subspecies as locally common or numerous, and 18 record the subspecies as uncommon, localised, rare, infrequent or only a single individual seen (P. Lang 2021 pers. comm. 6 Dec). Out of 114 records on ALA (2021a), 10 records have abundance data. The combined count of these 10 records is 75 individuals, of which nine records have <10 individuals and one record has 50 individuals (ALA 2021a). Assuming a similar abundance across the remaining 104 records in ALA (2021a) that do not record abundance data, it is possible to extrapolate a very uncertain population estimate of approximately 850 individuals (using an estimate of 7.5 individuals per record x 114 records). However, this is highly likely to be an underestimate, considering a minimum of 200–300 plants were found following the 2019/20 bushfire in a small unburnt area near West Bay Road (D. Duval 2021 pers. comm. 16 Dec). Additionally, suitable habitat for the subspecies occurs across much of the western third of KI, and spiked sour-bush is likely to be under surveyed (H. Klein 2021 pers. comm. 17 Dec), so it is likely that the actual population size prior to the 2019/20 bushfire

Table 3 Key assessment parameters

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
				was substantially larger than 850 individuals, possibly somewhere in the order of 2000 ± 1000 mature individuals.
				mature individuals. Except for several small sites in and on the periphery of the fire scar, all spiked sour-bush appear to have burnt in the 2019/20 bushfires. Despite possible issues with low detectability, out of nine monitored sites, substantial recruitment was observed at six and no recruitment was observed at six and no recruitment was observed at three (Davies et al. 2021; D. Duval 2021 pers. comm. 16 Dec). Post- fire drought was suggested as the likely mechanism for the lack of recruitment at some sites, with sites located in habitats with higher soil moisture observed to have better recruitment (Davies et al. 2021). Rainfall on KI was substantially below-average during the winter of 2019/20 and autumn of 2021 (Davies et al. 2021). Infection by <i>Phytophthora</i> spp. was another suggested potential cause, with evidence of the disease at several sites where no recruitment occurred (Davies et al. 2021). If similar trends have occurred across the entire spiked sour-bush population, it is possible that there could have been a decline in the population size approaching 30% since the 2019/20 bushfire, equating to a current population of approximately 1400 ± 600 mature individuals. This assumes that sites with recruitment return to similar numbers of mature individuals as were present at an equivalent life-stage pre-fire (i.e. stable population at these sites). However, it is likely that low detectability of seedlings contributed to the lack of recruitment recorded at several sites, or that poor recruitment a sites outside the reserve system is not reflective of sites within conservation reserves, where substantial recruitment was observed (D. Duval 2022 pers comm 22 Feb). The three sites where no recruitment was observed were located outside the conservation reserve system. These unreserved populations including roadside remnants are small, in some instances known only from one or two
				individuals, so observations of poor recruitment at these sites may only be slightly applicable considering >90% of the subspecies distribution comprising large populations occurs within the reserve system (D. Duval 2022 pers comm 22 Feb).
				Therefore, the figure of 1400 ± 600 mature individuals is probably an underestimate, and the actual population is likely to be somewhere between 1400–2000 mature individuals.
				These estimates are obviously very uncertain and based on the extrapolation of limited data. An assessment of current population size is a priority conservation and management action.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Trend	decline			Nine sites of spiked sour-bush were monitored for post-fire recruitment in late 2020 (Davies et al. 2021; D. Duval 2021 pers. comm. 16 Dec). Although post-fire seedling recruitment was observed at six sites, no post-fire recruitment was observed at another three sites despite mature plants being seen at these latter three sites in the last five years (Davies et al. 2021). Although post-fire monitoring results may have been affected to some degree by low detectability of seedlings in the post-fire environment, based on these observations, it appears that the total population size of spiked sour-bush may be in decline.
Generation time (years)	12-25	12	50	The generation length of spiked sour-bush is not documented. The minimum estimate for the generation length of spiked sour-bush is 12 years, based on a primary juvenile period of four years, and a likely lifespan of ~20 years (Plants of SA 2021). The maximum estimate is based on the generation length of the closely related <i>C.</i> <i>spicatum</i> subsp. <i>continentale</i> which is estimated to be 50 years by DELWP (2021). This is based on a plausible longevity of 25–60 years and an inference from the low population density of the subspecies, that the taxon is likely to recruit sporadically and opportunistically in response to rare fire or other localised site disturbance events (DELWP 2021). As these two estimates are substantially different, the most likely generation length of the subspecies might be in the order of 12–25 years.
Extent of occurrence	1064 km ²	~800 km ²	~1500 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). Maximum and minimum bounds represent estimates if the subspecies is more or less widespread than current records suggest.
Trend	decline		<u>.</u>	Almost the entire population of spiked sour- bush was burnt in the 2019/20 bushfires (Davies et al. 2021). Although post-fire seedling recruitment was observed at least at six sites, no post-fire recruitment was observed at another three sites, despite mature plants being seen at the latter three sites in the last five years (Davies et al. 2021). Based on these observations, it appears that the EOO of spiked sour-bush may be in decline.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Area of Occupancy	128 km²	~80 km ²	250 km²	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 Guidelines (IUCN 2019). Maximum and minimum bounds represent estimates if the subspecies is more or less widespread than current records suggest. The currently documented AOO estimate may be more likely to be an underestimate given the low survey effort for the species to date, as it is based on point data rather than distribution of likely habitat.
Trend	decline			Almost the entire population of spiked sour- bush was burnt in the 2019/20 bushfires (Davies et al. 2021). Although post-fire seedling recruitment was observed at least at six sites, no post-fire recruitment was observed at another three sites, despite mature plants being seen at the latter three sites in the last five years (Davies et al. 2021). Based on these observations, it appears that the AOO of spiked sour-bush may be in decline.
Number of subpopulations	1	1	~10	Based on the lack of spatial clustering of records, high likelihood of additional undocumented occurrences and ecology of the subspecies (bird- dispersed seed; Kuijt & Hansen 2015; DELWP 2021), spiked sour-bush is likely to have a single large subpopulation covering much of the western third of KI (ALA 2021a). If a smaller distance is used to define separate subpopulations, the number of subpopulations could be higher (perhaps around 10 based on the spatial arrangement of records on ALA 2021a).
Trend	stable			Despite a likely decline in population size, EOO and AOO, as recruitment has been observed at some sites, and spiked sour-bush likely has a single, large subpopulation, the number of subpopulations is not yet in decline.
Basis of assessment of subpopulation number	See justification	for Number	of subpopulation	ons.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
No. locations	2-5	2	5	The most significant threats to the subspecies across its population are inappropriate fire regimes and post-fire drought. Inappropriate fire regimes are a potential threat to spiked sour-bush as the subspecies is an obligate seeder (Plants of SA 2021). Almost the entire population of spiked sour-bush was burnt in the 2019/20 bushfire. The primary juvenile period is at least four years, and a similar widespread fire event within this period could cause the elimination of the majority of the population. Two large-scale fire events within four years on western KI are plausible, particularly considering the predicted decline of median rainfall and increasing frequency of droughts as a result of climate change (DEW 2020; Table 1). Decreased rainfall may also cause the primary juvenile period to increase (Nolan et al. 2021). In addition, single fire events combined with post-fire drought appear to have caused a decline of the spiked sour-bush population (see justification for <i>Number of mature individuals</i> above). It is possible that as a root-parasite, recruitment of spiked sour-bush is particularly vulnerable to drought during the early seedling stage (McLellan et al. 2021). More severe post- fire drought likely to be exacerbated by competition with annual weeds (DAWE 2021a; Nolan et al. 2021; Table 1). Spiked sour-bush is likely to have several locations (perhaps 2–5), given the variation in fire footprints and hydrological conditions across its habitat that is likely to result in a stepwise decline in the subspecies across its range, rather than the sudden elimination of the entire population.
Trend	stable			There is no evidence that the number of locations is in decline.
Basis of assessment of location number	See justification	for Number	of locations.	
Fragmentation	Spiked sour-bush is considered to occur as a single subpopulation covering much of the western third of KI. 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

Redu	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	Endan Severe	gered reduction		Vulnerable Substantial reduction
A1		≥ 90%	≥ 70%			≥ 50%
A2, A	.3, A4	≥ 80%	≥ 50%			≥ 30%
A1 A2	Population reduction observed, estimat past and the causes of the reduction are understood AND ceased. Population reduction observed, estimat past where the causes of the reduction be understood OR may not be reversible	ed, inferred or suspected in e clearly reversible AND red, inferred or suspected in may not have ceased OR ma e.	the	¢	(a) (b) (c)	direct observation [except A3] an index of abundance appropriate to the taxon a decline in area of occupancy, extent of occurrence and/or quality of habitat
A3 A4	 3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [(<i>a</i>) cannot be used for A3] 4 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 		e (up n e of not	Based on any of the following	(d) (e)	actual or potential levels of exploitation the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites
	be reversible.		J			

Criterion 1 evidence

Insufficient data to determine eligibility

Generation time

Based on a primary juvenile period of four years, and a likely lifespan of \sim 20 years (Plants of SA 2021), the generation length of spiked sour-bush could be 12 years.

Generation time = age of first reproduction + [0.5 * (length of reproductive period)]Generation time = 4 + [0.5 * (20 - 4)] = 12 years

However, the generation length of the closely related *C. spicatum* subsp. *continentale* is estimated to be 50 years by DELWP (2021). This is based on a longer estimate of plausible longevity (25–60) years and an inference from the low population density of the subspecies, that the taxon is likely to recruit sporadically and opportunistically in response to rare fire or other localised site disturbance events (DELWP 2021).

As these two estimates are substantially different, a plausible generation length of the subspecies might be in the order of 12–25 years.

This gives an estimated three-generation period of approximately 36–75 years.

Population trend – past decline (A2)

A very uncertain population estimate of spiked sour-bush prior to the 2019/20 bushfire is approximately 2000 ± 1000 mature individuals (Table 3).

The 2019/20 bushfires burnt the majority of the subspecies' population. A small area of vegetation containing at least 200–300 plants on the margins of a dry lagoon on West Bay Track, and several similarly small unburnt sites with about 15–20 plants (e.g. Sandy Creek, West Bay fire track, outside the fire scar to the northwest), were the only sites not burnt in the 2019/20 bushfire (D. Duval 2021 pers. comm. 16 Dec). Following the 2019/20 bushfires, five sites were monitored by Davies et al. (2021) for post-fire seedling recruitment and four were monitored by Duval (2021 pers. comm. 16 Dec). Recruitment was observed at six of these nine monitored sites. No post-fire recruitment was observed at three sites monitored by Davies et al. (2021) in April 2021 (i.e. after germination was observed at other sites), despite mature plants being seen in the five years prior to the 2019/20 bushfire (Davies et al. 2021).

However, young seedlings of the subspecies are reportedly difficult to detect, with detectability increasing when plants reach four to five years of age (D. Duval 2022 pers comm 22 Feb). Further, post-fire seedling recruitment was usually only observed in the vicinity of burnt adult plants, however burnt adult plants of the subspecies were difficult to identify even when accurate GPS information was available, contributing to low detectability of seedlings (D. Duval 2022 pers comm 22 Feb). In addition, the three sites where no recruitment was observed were located outside the conservation reserve system. These unreserved populations including roadside remnants are small, in some instances known only from one or two individuals, so observations of poor recruitment at these sites may only be slightly applicable considering >90% of the subspecies distribution comprising large populations occurs within the reserve system (D. Duval 2022 pers comm 22 Feb). Nevertheless, based on the limited data available, it appears that the total population size of spiked sour-bush may be in decline. However, there is insufficient evidence to estimate accurately the magnitude of this decline following the 2019/20 bushfires, except that it is probably less than 30 percent.

Post-fire drought was suggested as the likely mechanism for the lack of recruitment at some sites, with sites located in habitats with higher soil moisture observed to have better recruitment (Davies et al. 2021). Rainfall on KI was substantially below-average during the winter of 2020, November/December 2020 and autumn of 2021 (Davies et al. 2021). It is possible that as a root-parasite, recruitment of spiked sour-bush is particularly vulnerable to drought (McLellan et al. 2021). Davies et al. (2021) suggested a possible reason may be the lack of mature, healthy shrubs in burnt vegetation limiting the ability of young spiked sour-bush seedlings to parasitise deep-rooted plants that have access to soil moisture during periods of drought. Infection by *Phytophthora* spp. was another suggested potential cause with evidence of the disease at several sites where no recruitment occurred (Davies et al. 2021), although the susceptibility of spiked sour-bush to is not confirmed and other *Santalaceae* species can be unaffected by the disease (Shearer et al. 2004).

A reduction in the population of spiked sour-bush over the last three generations is plausible because the three generation period captures the majority of widespread land clearing that occurred on KI from the 1950s to 1980s (Robinson & Armstrong 1999). Records from this period occur in now cleared areas near Edward Lagoon, Cape Borda and Karatta (ALA 2021a). It is also likely that undocumented occurrences of spiked sour-bush were cleared during this period. However, the extent of population decline due to historical land clearing is difficult to quantify due to a lack of pre-clearing data.

Therefore, there appears to be insufficient data to list spiked sour-bush under sub-criterion A2.

Population trend – past and future decline (A4)

The major threats of climate change, inappropriate fire regimes and southern blue-gum naturalisation are likely to intensify in future. Climate change projections for Kangaroo Island include reduced rainfall, increased mean temperatures and increased fire danger weather (see Table 3). This is likely to cause ongoing declines of the spiked sour-bush population, through increased fire frequency, negative impacts from drought and further competition with southern blue-gum. Therefore, as threats appear to have the potential to increase in severity, it appears plausible that the decline of spiked sour-bush will continue into the future. However, the magnitude of future declines is difficult to predict, and may be influenced by several factors including the effectiveness of management actions.

Therefore, there appears to be insufficient data to list spiked sour-bush under sub-criterion A4.

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 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(iii)+B2ab(iii) as Endangered

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

The EOO of spiked sour-bush is 1064 km² and the AOO is 128 km² (Table 3), although the AOO may be an underestimate given the low survey effort for the species to date, as it is based on point data rather than distribution of likely habitat.

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

Severely fragmented

Based on the lack of spatial clustering of records, high likelihood of additional undocumented occurrences, and ecology of the subspecies (bird-dispersed seed), spiked sour-bush is likely to have a single large subpopulation covering much of the western third of KI (ALA 2021a). Therefore, spiked sour-bush does not appear to meet the severe fragmentation requirement for listing under this criterion as it only has one subpopulation.

Number of locations

The most significant threats to the subspecies across its population are inappropriate fire regimes and post-fire drought. Inappropriate fire regimes are a potential threat to spiked sourbush as the subspecies is an obligate seeder with a primary juvenile period of at least four years in the wild (Plants of SA 2021), although the minimum tolerable fire interval may be longer (e.g. if plants do not reach full reproductive capacity for several years after maturity). Almost the entire population of spiked sour-bush was burnt in the 2019/20 bushfire (Davies et al. 2021; D. Duval 2021 pers. comm. 16 Dec). A similar widespread fire event within this period could cause the elimination of the majority of the spiked sour-bush population. Two large-scale fire events within the primary juvenile period of spiked sour-bush is plausible, particularly considering the

predicted decline of median rainfall and increasing frequency of droughts predicted as a result of climate change (DEW 2020; Table 1).

Large bushfires have occurred in western KI in successive fire seasons in the past. In 1953/54, bushfires burnt 65,000 ha, and in the following summer of 1954/55 bushfires burnt 35,000 ha (Data SA 2022). Although these fire events only had a relatively small area of overlap (~2,500 ha), they demonstrate that the conditions necessary to support large bushfire events on Kangaroo Island can occur in successive seasons. The likelihood of two successive large bushfires overlapping across the majority of the subspecies' range within the primary juvenile period of spiked sour-bush (approximately 4 years) probably depends heavily on fuel loads being high enough to support the second fire. This is plausible if the duration between the two fires is closer to four years, allowing time for fuel loads to accumulate before spiked sour-bush reaches maturity. Other factors including southern blue-gum naturalisation, which is likely to increase fuel loads (Davies et al. 2021), or rainfall during the inter-fire period, may also contribute to increasing the plausibility that successive large bushfires could overlap across the majority of the subspecies' range.

Single large fire events, likely in combination with post-fire drought, appear to have already caused a decline of the spiked sour-bush population (Table 3). Detectability issues notwithstanding, out of nine monitored sites, substantial recruitment was observed at six and no recruitment was observed at three (Davies et al. 2021; D. Duval 2021 pers. comm. 16 Dec). Post-fire drought was suggested as the likely mechanism for the lack of recruitment at some sites, with sites located in habitats with higher soil moisture observed to have better recruitment (Davies et al. 2021). Rainfall on KI was substantially below-average during the winter of 2019/20 and autumn of 2021 (Davies et al. 2021). More severe post-fire drought events in future might be expected to result in increasing population declines (Enright et al. 2015; Nolan et al. 2021), with the impact of post-fire drought likely to be exacerbated by competition with weeds or potentially disease caused by *Phytophthora* spp. (DAWE 2021a; Nolan et al. 2021; Table 1).

Spiked sour-bush is likely to have several locations (perhaps 2–5), given the variation in fire footprints and hydrological conditions across its habitat that is likely to result in a stepwise decline in the subspecies across its range, rather than the sudden loss of the entire population.

Continuing decline

Habitat quality is expected to be declining due to negative effects of climate change and inappropriate fire regimes, competition from southern blue-gum seedlings and other weeds, herbivory by feral pigs and possibly by disease from *Phytophthora* spp. infection. Negative impacts of fire events on Kangaroo Island increasingly likely under climate change and are likely to cause continuing decline in habitat quality (Enright et al. 2015; DEW 2020; Nolan et al. 2021; Table 1). Southern blue-gum seedlings have naturalised in habitat near plantations across western KI and are a serious threat to plants sensitive to water-stress during their early seedling stage, such as spiked sour-bush (Table 1). Annual weeds were present at several sites following the 2019/20 bushfire (D. Duval 2021 pers. comm. 16 Dec) and also appear to be a substantial threat to spiked sour-bush as they compete with newly-germinated seedlings. Feral pigs are known to occur on western KI, and although subject to an active control program, are likely to cause continuing habitat decline particularly in damp drainage lines and gullies, where spiked sour-bush often occurs (Table 1). Dieback putatively caused by *Phytophthora* spp. was observed

at several sites where post-fire recruitment of spiked sour-bush had failed (Davies et al. 2021). Even if this subspecies is not directly susceptible, dieback caused by *Phytophthora* spp. is likely to continue to degrade its habitat by removing susceptible species, with possible indirect negative impacts on spiked sour-bush (e.g. through impacts on host plant availability or on its putative insect pollinators).

Accordingly, the subspecies 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, spiked sour-bush does not meet the threshold for listing as Endangered under sub-criterion (c).

Conclusion

The data presented above appear to demonstrate that spiked sour-bush 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 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 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 C2a(ii) as Endangered

The population of spiked sour-bush following the 2019/20 bushfire is tentatively estimated at 1400–2000 mature individuals (Table 3). Therefore the population size appears to be low.

Although there is evidence of decline due to poor recruitment following the 2019/20 bushfire (Davies et al. 2021), it is unknown whether the decline is greater than 20 percent over the last two generations (24–50 years) (see Criterion 1). Therefore, the subspecies does not appear to meet the requirements of sub-criterion C1.

The subspecies is considered to have a single subpopulation containing 100 percent of mature individuals (Table 3). Although potentially affected by low detectability of seedlings, post-fire monitoring appears to suggest that recruitment following the 2019–20 bushfires was limited or absent at some monitored sites (Davies et al. 2021). With negative impacts of fire events on KI increasingly likely under climate change (Enright et al. 2015; DEW 2020; Nolan et al. 2021; Table 1), it is likely that the population of spiked sour-bush will continue to decline. In addition, plant numbers adjacent to southern blue-gum plantations are likely to decline due to increased competition and altered fire and hydrological regimes from post-fire incursions of this eucalypt (Table 1). Therefore, the population appears likely to experience continuing decline and the subspecies appears to meet the requirements of sub-criterion C2.

Therefore, the subspecies 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> assessment method.

Criterion 4 evidence

Ineligible

As per the evidence presented above for Criterion 3, the number of mature individuals is tentatively estimated at 1400–2000 mature individuals (Table 3). Therefore, assuming that sites with recruitment return to similar numbers of mature individuals as were present at an equivalent life-stage pre-fire (i.e. stable population/natural fluctuation at these sites), the total population of spiked sour-bush appears unlikely to be less than 1000 mature individuals.

Therefore, the subspecies does not appear to meet the requirements for listing 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 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 subspecies for listing in any category 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.

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 subspecies has not yet been determined. The purpose of this consultation document is to elicit additional information to help inform this decision.

THREATENED SPECIES SCIENTIFIC COMMITTEE

Established under the Environment Protection and Biodiversity Conservation Act 1999

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

	100	3
	A	/
(C) Commonwealth of Australia 2022		,

Ownership of intellectual property rights

Unless otherwise noted, copyright (and any other intellectual property rights) in this publication is owned by the Commonwealth of Australia (referred to as the Commonwealth).

Creative Commons licence

All material in this publication is licensed under a <u>Creative Commons Attribution 4.0 International Licence</u> except content supplied by third parties, logos and the Commonwealth Coat of Arms.

Inquiries about the licence and any use of this document should be emailed to copyright@awe.gov.au.

 $(\mathbf{\hat{n}})$

Cataloguing data

This publication (and any material sourced from it) should be attributed as: Department of Agriculture, Water and the Environment 2022, *Conservation Advice for* Choretrum spicatum *subsp.* spicatum *(spiked sour-bush)*, Canberra.

This publication is available at the SPRAT profile for Choretrum spicatum subsp. spicatum (spiked sour-bush).

Department of Agriculture, Water and the Environment GPO Box 858, Canberra ACT 2601 Telephone 1800 900 090 Web <u>awe.gov.au</u>

The Australian Government acting through the Department of Agriculture, Water and the Environment has exercised due care and skill in preparing and compiling the information and data in this publication. Notwithstanding, the Department of Agriculture, Water and the Environment, its employees and advisers disclaim all liability, including liability for negligence and for any loss, damage, injury, expense or cost incurred by any person as a result of accessing, using or relying on any of the information or data in this publication to the maximum extent permitted by law.

Version history table

Document type	Title	Date [dd mm yyyy]
-	-	-
-	-	-