Consultation on Species Listing Eligibility and Conservation Actions

Thelymitra orientalis (hoary sun-orchid)

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

1) the eligibility of *Thelymitra orientalis* (hoary sun-orchid) for inclusion on the EPBC Act threatened species list in the Critically Endangered category; and

2) the necessary conservation actions for the above species.

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

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

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

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

Please include species scientific name in Subject field.

or by mail to:

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

Responses are required to be submitted by 8 July 2022.

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General background information about listing threatened species

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

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

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

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

Privacy notice

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

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

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

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

Information about this consultation process

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

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

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

CONSULTATION QUESTIONS FOR *THELYMITRA ORIENTALIS* (HOARY SUN-ORCHID)

SECTION A - GENERAL

1. 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

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

Biological information

4. Can you provide any additional or alternative references, information or estimates on longevity, average life span and generation length?

5. Do you have any additional information on the ecology or biology of the species/subspecies not in the current advice?

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

Population size

6. Has the survey effort for this taxon been adequate to determine its national adult population size? If not, please provide justification for your response.

7. Do you consider the way the population size has been derived to be appropriate? Are there any assumptions and unquantified biases in the estimates? Did the estimates measure relative or absolute abundance? Do you accept the estimate of the total

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

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

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

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

   ☐ 1–250 ☐ 250–1000 ☐ 1000–2500 ☐ 2500–10,000 ☐ >10,000

   Level of your confidence in this estimate:

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

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

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

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

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

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

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

Evidence of total population size change

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

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

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

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

☐ 1–250 ☐ 250–1000 ☐ 1000–2500 ☐ 2500–10,000 ☐ >10,000

Level of your confidence in this estimate:

☐ 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 33 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:

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

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

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

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

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

12. Please provide (if known) any additional evidence which shows the population is stable, increasing or declining.

SECTION E ARE YOU AWARE OF INFORMATION ON THE TOTAL RANGE OF THE SPECIES/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:

    ☐ <100 km^2 ☐ 100 – 5000 km^2 ☐ 5000 – 20,000 km^2 ☐ >20,000 km^2

    Level of your confidence in this estimated extent of occurrence

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

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

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

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

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

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

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

☐ <10 km^2 ☐ 10 – 500 km^2 ☐ 500 – 2000 km^2 ☐ >2000 km^2

Level of your confidence in this estimated extent of occurrence:

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

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

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

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

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

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

    ☐ <100 km^2 ☐ 100 – 5000 km^2 ☐ 5000 – 20,000 km^2 ☐ >20,000 km^2

    Level of your confidence in this estimated extent of occurrence

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

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

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

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

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

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

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

    ☐ <10 km^2 ☐ 10 – 500 km^2 ☐ 500 – 2000 km^2 ☐ >2000 km^2

Level of your confidence in this estimated extent of occurrence:

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

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

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

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

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

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

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

SECTION H 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?

SECTION I 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 *Thelymitra orientalis* (hoary sun-orchid)

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

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

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

This document combines the approved conservation advice and listing assessment for *Thelymitra orientalis* (hoary sun-orchid). It provides a foundation for conservation action and further planning.

Thelymitra orientalis from The Marshes Native Forest Reserve, SA © Copyright, June Niejalk

Conservation status

Thelymitra orientalis (hoary sun-orchid) is proposed to be listed as Critically Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act).

Thelymitra orientalis was assessed by the Threatened Species Scientific Committee to be eligible for listing as Critically Endangered under criteria 3 and 4. The Committee's assessment is at Attachment A. The Committee's assessment of the species' eligibility against each of the listing criteria is:

- Criterion 1: Insufficient data
- Criterion 2: Endangered: B2a,b(i,ii,iii,iv,v)
- Criterion 3: Critically Endangered: C2a(i,ii)
- Criterion 4: Critically Endangered: D
- Criterion 5: Insufficient data

The main factors that make the species eligible for listing are the small population size, evidence of decline, severe fragmentation and restricted geographic distribution.

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

Species information

Taxonomy

Conventionally accepted as *Thelymitra orientalis* R.J.Bates (Bates 2010). Family: Orchidaceae. Further taxonomic study into the difference between hoary sun-orchid and plum sun-orchid is the main research priority for this species (J. Jeanes 2021 pers. comm. 23 Nov). See further discussion in the *Description* section below.

Description

Hoary sun-orchid is a terrestrial, herbaceous, non-clonal orchid with a single, narrow leaf 3–5 cm long by 1–2 mm wide, and a flower spike 7–10 cm tall with usually one (rarely two) blue flowers. Perianth segments (petals) are 5–7 mm long, deep blue with reddish tones. The column is slender, 3–4 mm long, purplish, mid-lobe expanded into hood over the anther, with little or no waxy bloom, and lateral lobes with a sparse shaggy toothbrush-like arrangement of cream or yellow hairs. Description from Bates (2010).

Hoary sun-orchid is closely related to *T. mucida* (plum sun-orchid) from which it was split by Bates (2010). The distinguishing features of hoary sun-orchid include: inflorescence always <12 cm tall (usually 12–30 cm tall in plum sun-orchid) with one or rarely two flowers (usually 3–6 flowers in plum sun-orchid) with shortly ovate perianth segments (ovate–lanceolate in plum sun-orchid), column has a post-anther lobe with little to no silvery bloom (a powdery covering, which is present on plum sun-orchid), the two apical halves of the post-anther lobe are >1 mm apart at their widest (<1 mm apart in plum sun-orchid), and trichomes (hairs) of the lateral lobes are at least partly inserted into the orifice of the post-anther lobe and not exceeding it in

height (not inserted into the orifice and often exceeding it in height in plum sun-orchid) (Bates 2010). Jones (2021) suggests that plum sun-orchid is restricted to Western Australia, in which case records from South Australia, Victoria and Tasmania would represent misidentifications of related species, although this approach is not currently accepted by state herbaria.

Both hoary sun-orchid and plum sun-orchid have been recorded on Kangaroo Island, with several subpopulations of plum sun-orchid observed following the 2020 bushfire (D. Duval 2021 pers. comm. 8 Dec). Some of these subpopulations of plum sun-orchid contained small plants that keyed out to hoary sun-orchid, including plants with 1–2 flowers about 12 cm tall with a sparse silvery bloom (D. Duval 2021 pers. comm. 8 Dec). These subpopulations also contained a wide range of medium-sized and larger plants, with consistent flower characters such that all plants in the subpopulation were considered to be plum sun-orchid (D. Duval 2021 pers. comm. 8 Dec). Plant size and number of flowers appeared to depend on the niche in which the plant was growing in the swamp, with taller plants growing in deeper pools in rich organic matter and smaller plants on margins and leached open flats in the swamp. (D. Duval 2021 pers. comm. 8 Dec).

Recent molecular evidence is not conclusive on the delimitation between hoary sun-orchid and plum sun-orchid, with small genetic differentiation observed between a sample of hoary sun-orchid from The Marshes NFR and a sample of plum sun-orchid from Western Australia (H. Zimmer 2022 pers. comm. 25 Feb). This may suggest that hoary sun-orchid and plum sun-orchid are separate sister taxa, or it may indicate the two are conspecific and that genetic differentiation exists within the plum sun-orchid species across a broad geographic range.

Photographs identified as plum sun-orchid with a single flower and ovate perianth segments exist from northwest Tasmania and could be misidentifications of hoary sun-orchid, although there is insufficient detail to be certain of this (ALA 2021). The re-examination of all plum sun-orchid and hoary sun-orchid specimens from eastern Australia is a recommended research action in this Conservation Advice.

Many plants previously referred to as plum sun-orchid in South Australia and Victoria (particularly southwest Victoria) were re-determined as *T. inflata* (inflated sun-orchid), *T. lucida* (glistening sun-orchid) or *T.* x *merraniae* (Merran's sun-orchid) (Jeanes 2004; Bates 2010). These species differ from hoary sun-orchid in being larger plants, with larger flowers, and different trichome and post-anther lobe arrangements (Bates 2010).

Distribution

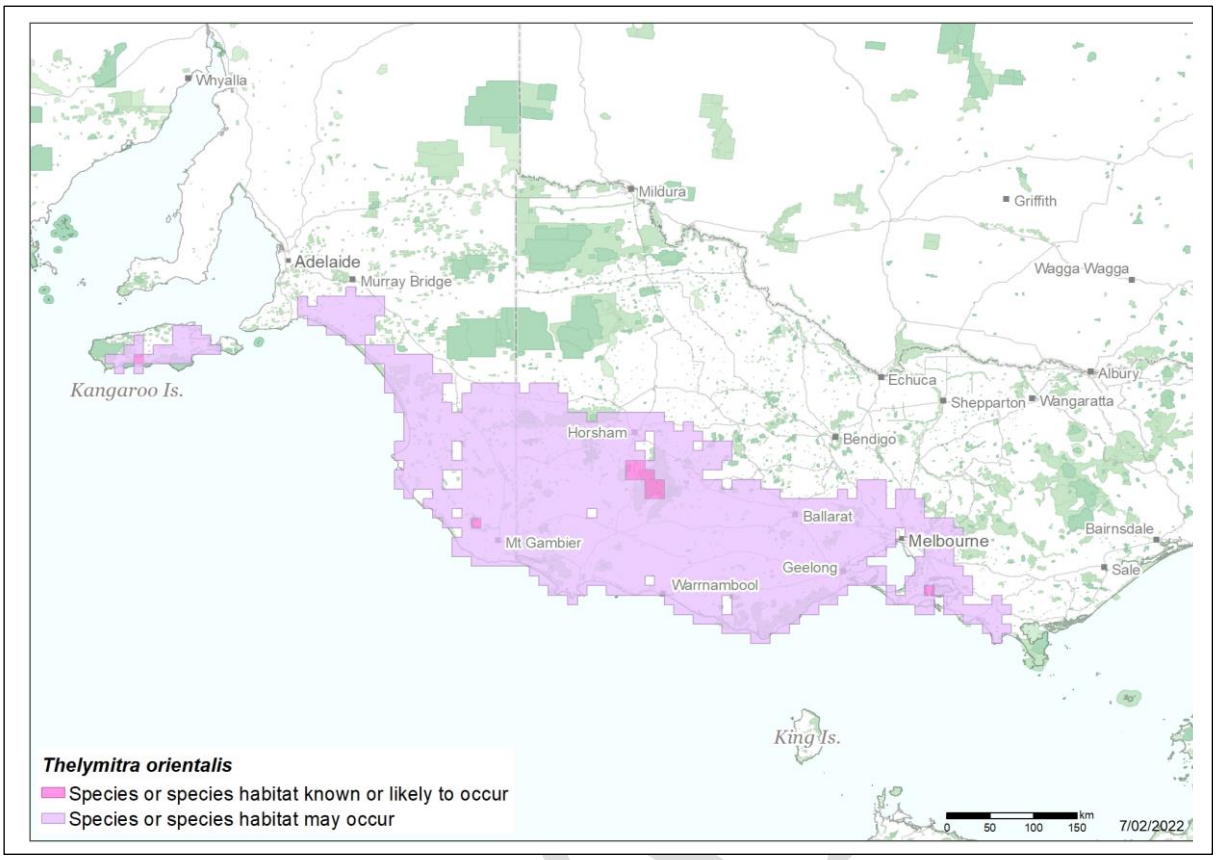
Hoary sun-orchid appears endemic to south-eastern Australia. The species appears to occur or have occurred in four subpopulations, Kangaroo Island (Mount Taylor swamp) and The Marshes Native Forest Reserve (NFR) near Nangwarry, South Australia, and Grampians National Park (NP) (Syphon Road swamp) and Crib Point in Victoria (Table 1). However, due to its similar appearance to plum sun-orchid and other species in the large *T. pauciflora* complex, hoary sun-orchid may be more widespread than currently known. Hoary sun-orchid has also been suggested to occur in a swamp near Rogers Road on the Myponga River at Myponga, South Australia, although plants have not been seen for many years (J. Niejalk 2022 pers. comm. 5 March). In addition, no voucher specimen exists of this subpopulation, and it is not included in Table 1.

There are no formal population estimates for hoary sun-orchid. Approximately 20–45 plants were known from The Marshes NFR in slashed heath on the edge of a track. A single plant that appears to be of this species has been seen at Crib Point in the last 10 years that appears to be of this species (G. Backhouse 2021 pers. comm. 24 Nov). Sporadic searches of the Syphon Road swamp site in Grampians NP over the last decade have failed to find the species (G. Backhouse 2021 pers. comm. 24 Nov). Its status on Kangaroo Island is not known, but it has not been recorded since 2008 (ALA 2021).

Table 1 Known subpopulations of hoary sun-orchid

Location	**Most recent record**	**Most recent population estimate (year)**	**Land Manager**	**Comments**
South Australia				
The Marshes Native Forest Reserve	2016	20–45 plants	Forestry SA	Impacted by vehicles in the past (R. Bates 2021 pers. comm. 6 Dec).
Mount Taylor Road, Kangaroo Island	2008	unknown	Kangaroo Island Council	Roadside on edge of peat bog (R. Bates 2021 pers. comm. 6 Dec). Unclear if plants persist.
Victoria				
Grampians National Park (Syphon Road swamps)	1985	unknown	Parks Victoria	Plants have not been seen since, despite sporadic searches (G. Backhouse 2021 pers. comm. 24 Nov).
Crib Point	Seen at least twice from 2010–2020	1 plant (2010–2020) 3 plants (2003)	Victorian Department of Treasury and Finance	Plant formerly identified as plum sun-orchid prior to the description of hoary sun-orchid, but its appearance appears to match hoary sun-orchid in its small size and single flower (J. Jeanes 2022 pers. comm. 23 Nov; G. Backhouse 2021 pers. comm. 24 Nov)

Map 1 Modelled distribution of hoary sun-orchid



Source: Base map Geoscience Australia; species distribution data Species of National Environmental Significance database.
Caveat: The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything contained herein.
Species distribution mapping: The species distribution mapping categories are indicative only and aim to capture (a) the habitat or geographic feature that represents to recent observed locations of the species (known to occur) or habitat occurring in close proximity to these locations (likely to occur); and (b) the broad environmental envelope or geographic region that encompasses all areas that could provide habitat for the species (may occur). These presence categories are created using an extensive database of species observations records, national and regional-scale environmental data, environmental modelling techniques and documented scientific research.

Cultural and community significance

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

The cultural significance of hoary sun-orchid is not well known. The species occurs on land covered by native title agreements with the First Nations of the Southeast People in South Australia and Bunurong People in Victoria (NNTT 2021; ACHRIS 2021). Traditional Owners of the Grampians in Victoria have not been formally recognised (ACHRIS 2021). 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). Although little is known of the cultural significance of Duck's-head Wasp-orchid, other orchid species are culturally significant plants for Indigenous peoples, with their tubers used as a food source (Australian National Botanic Gardens 2007). Ascertaining the cultural significance of this species is an information/research priority identified in the Conservation and Recovery Actions.

Relevant biology and ecology

Habitat

Hoary sun-orchid occurs in leached white (often peaty) sand, in heathland, damp heathy flats and seepage areas, usually close to sedge-dominated wetlands (Bates 2010). Common co-occurring flora species at The Marshes NFR include *Eucalyptus ovata* (swamp gum) and *Acacia melanoxylon* (blackwood), while co-occurring orchids include *T. holmesii* (blue star sun-orchid), *T. lucida* (glistening sun-orchid), *T. abrupta* (abrupt sun-orchid), *T juncifolia* (rush-leaf sun-orchid), *Cryptostylis subulata* (large tongue-orchid) and *Spiranthes* sp. Marshes (ladies tresses) (R. Bates 2021 pers. comm. 6 Dec; J. Niejalke 2022 pers. comm. 11 Feb). At Crib Point hoary sun-orchid was recorded in moist sandy loam in heathy woodland with *Eucalyptus viminalis* subsp. *pryoriana* (coastal manna-gum) with *Themeda triandra* (Kangaroo Grass) and *Austrostipa* spp. (spear grass) (ALA 2021). At the Grampians NP it occurred with *Thelymitra holmesii* (blue star sun-orchid) and *Microtis atrata* (yellow onion-orchid) (ALA 2021). At KI the species grew on the edge of a peat bog (R. Bates 2021 pers. comm. 23 Nov).

Reproductive biology

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

Flowering occurs from late October to early November, with flowers opening on warm days (Jones 2021). Flowers are reported to be short lived, lasting only a week (J. Niejalk 2022 pers. comm. 11 Feb). As flowering material is required for identification, surveys must be undertaken during this period. Flowers are reported to be self-pollinating (J. Niejalk 2022 pers. comm. 11 Feb) as flowers age and the pollinia crumbles and falls onto the stigma. Although, other blue-flowering *Thelymitra* species are pollinated by food deception of native bees (Jones 2021; Edens-Meier et al. 2014) and it's possible that pollination by native bees also occurs in hoary sun-orchid. Fruits of *Thelymitra* spp. take approximately four weeks to mature following pollination. Each mature capsule contains hundreds or thousands of minute seeds that are dispersed by wind when the capsule splits. After fruits have ripened, the plant dies back to its dormant subterranean tubers. Plants reproduce from seed but not clonally, with each tuber annually replaced by a new tuber prior to the old tuber withering. Seed germination requires infection by mycorrhizal fungi from the genus *Tulasnella* (Warcup 1973).

No data are available regarding the generation length or plant longevity for hoary sun-orchid. However, estimates for other terrestrial orchids in southern Australia are typically in the order of several decades (DELWP 2021).

Fire ecology

The fire response of hoary sun-orchid is unknown. However, the closely related plum sun-orchid displays strong post-fire flowering (TSS 2021). The response of many terrestrial orchids to fire occurring at unnatural times of year (e.g. planned burns) is unknown, but fires during the active growth and flowering stages (April–November) are likely to be deleterious (Jasinge et al. 2018). Fires may also affect pollinator communities on which the orchid is dependent for pollination (Brown et al. 2016).

Habitat critical to the survival

Hoary sun-orchid inhabits leached white (often peaty) sand, in heathland, damp heathy flats and seepage areas, usually close to sedge-dominated wetlands in south-east Australia.

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

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

Important populations

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

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

Threats

The most serious threats to hoary sun-orchid include inappropriate fire regimes, land clearing, vehicle damage, grazing by feral pigs (*Sus scrofa*), and changes to temperature and precipitation patterns.

Table 2 Threats impacting hoary sun-orchid

Threat	Status and severity [a]	Evidence
Habitat loss, disturbance and modifications		
Land clearing and fragmentation	• Timing: historical/current • Confidence: inferred • Likelihood: possible • Consequence: catastrophic • Trend: static • Extent: across parts of the range	Historical land clearing has likely caused a major decline of the hoary sun-orchid throughout its range, particularly in south eastern South Australia. Clearing for plantations is likely to have been particularly damaging, and occurred up until 1973 (ForestrySA 2021). While land clearing has slowed since the introduction of the *Native Vegetation Act 1991* in South Australia, intensive clearing occurred from the 1950s to 1980s (Robinson & Armstrong 1999), although clearing currently occurs at very low levels (Dohle 2007). The species occurs in ForestrySA estate at The Marshes NFR. In Victoria, the species is protected in the Grampians

Threat	Status and severity [a]	Evidence
		National Park. Although the threat of large-scale land clearing appears to have passed, the risks posed by smaller road and infrastructure development are likely to continue to threaten some areas, particularly on roadsides (KI) and unreserved public land (Crib Point). The Marshes NFR subpopulation is also threatened by any change in the management of fire breaks, e.g. from slashing (which orchids can survive) to ploughing (that kills orchid plants) (R Bates 2021 pers. comm. 23 Nov).
Fire regimes that cause decline in biodiversity	• Timing: current • Confidence: inferred • Likelihood: possible • Consequence: major • Trend: static • Extent: across the entire range	Hoary sun-orchid is a tuberous terrestrial orchid that is vulnerable to threats from out of season fires, peat fires, and interactions between fire and other threats. The KI subpopulation was burnt in the 2019/20 bushfire. *Out-of-season fires* When fire occurs out of season there are a number of mechanisms that lead to recruitment failure and reduce the recovery potential of species following fire (DAWE 2021). These include: 1) seedling mortality due to desiccation as a consequence of the interaction between out of season fires and fire-hydrological interactions (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. Hoary sun-orchid may be threatened by out-of-season fires, which may disrupt leaf phenology (Miller et al. 2019), mycorrhizal fungal communities (Jasinge et al. 2019) or pollinator communities (Brown et al. 2016). If fires occur soon after leaf emergence, the tubers may store insufficient resources to sustain a second flush of leaf production, resulting in tuber mortality (Jasinge et al. 2019). *Peat fires* Peat fires burn peat-rich subsoil typically in low-lying, seasonally-inundated areas of waterlogged vegetation (DAWE 2021). Peat fires can be extremely destructive, consuming the substrate and killing plants, including orchids (DAWE 2021). Although there is no evidence that peat fires have affected hoary sun-orchid in the past (including 2019/20), the species often grows in susceptible habitat and thus peat fires pose a potential risk to the species. *Fire interactions* There are a range of mechanisms by which fire interacts with other threats and impacts the species recovery potential following fire (DAWE 2021). For example, drought conditions increase the likelihood of peat fires (DAWE 2021). Inappropriate fire regimes may affect mycorrhizal fungal communities (Cairney et al. 2007) and disrupt pollinator communities (Brown et al. 2016). Certain types of fires may increase and spatially concentrate the foraging activity of herbivores such as pigs (see above), particularly small, patchy and low

Threat	Status and severity [a]	Evidence
		severity fires that result in high survival rates of the herbivores (Wan et al. 2014).
Vehicle damage	• Timing: current • Confidence: observed • Likelihood: possible • Consequence: minor • Trend: static • Extent: across parts of the range	Vehicle damage is a threat to the subpopulation at The Marshes NFR (R Bates 2021 pers. comm. 23 Nov) and probably also at Crib Point, which is an urban bushland reserve. The Marshes NFR subpopulation was impacted by vehicles in recent years, although the impacts are not fully understood (R Bates 2021 pers. comm. 23 Nov).
Invasive species		
Grazing by feral pigs	• Timing: current • Confidence: suspected • Likelihood: possible • Consequence: major • Trend: unknown • Extent: across parts of the 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 south-eastern South Australia and south-western Victoria (DEH 2006, 2009; NRKI 2017). Disturbance and herbivory from feral pigs (*Sus scrofa*) is a listed Key Threatening Process under the EPBC Act (DOEE 2017) and can have serious impacts on orchids (Wraith & Pickering 2019) by eating tubers and causing soil disturbance that can facilitate weed invasion (DOEE 2017). Feral pigs primarily impact wet or waterlogged areas, and therefore pose a threat to hoary sun-orchid. However, the extent to which feral pigs are impacting the species is not well understood. A feral pig control program is currently underway on Kangaroo Island (PIRSA 2021).
Weed invasion	• Timing: current • Confidence: suspected • Likelihood: possible • Consequence: moderate • Trend: unknown • Extent: across parts of the range	Eight Weeds of National Significance (WoNS) and 27 Declared Weeds of SA (DWoSA) are found on Kangaroo Island, including notable fire-adapted and fast-growing 'pioneer' weeds: bluebell creeper (*Sollya heterophylla*), gorse (*Ulex europaeus*), Montpellier broom (*Genista monspessulana*), bridal creeper (*Asparagus Asparagoides*), variegated thistle (*Silybum marianum*), African boxthorn (*Lycium ferocissimum*), blackberry (*Rubus fructicosus*) and one-leaf cape tulip (*Moraea flaccida*) (Thorp & Lynch 2000; DEW 2020; Landscape South Australia 2020a,b; NRKI 2020). Weeds capable of growing in seasonally inundated areas, such as blackberry, are the most likely to threaten hoary sun-orchid. Blackberry threatens understorey plants by outcompeting them for light and nutrients (Scott et al. 2014).
Climate Change		
Changes to temperature and precipitation patterns	• Timing: current • Confidence: inferred • Likelihood: almost certain • Consequence: major • Trend: increasing • Extent: across the entire range	The CSIRO & Bureau of Meteorology (2020) project that Kangaroo Island is projected to experience increased mean temperatures 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 vegetation in which the species grows. If the water regime changes substantially, species reliant on high soil moisture can be negatively affected, through mortality or increased competition from species adapted to drier soil conditions (Alba et al. 2019). Drought may also have a substantial impact on the vegetation structure of the region, as some plants are vulnerable to mortality through

Threat	Status and severity [a]	Evidence
		drought stress and hydraulic failure (Choat et al. 2018). As hoary sun-orchid is dependent on winter waterlogged soils, it may be threatened by changes in soil moisture and hydrology as a result of reduced precipitation. Warmer temperatures and changes to precipitation patterns may also favour the spread of weeds (Scott et al. 2014). Hoary sun-orchid may also be threatened by changes to rainfall patterns and warming which can act synergistically with inappropriate fire regimes to increase the risk of peat fires.

[a]Timing—identifies the temporal nature of the threat
Confidence—identifies the nature of the evidence about the impact of the threat on the species
Likelihood—identifies the likelihood of the threat impacting on the whole population or extent of the species
Consequence—identifies the severity of the threat
Trend—identifies the extent to which it will continue to operate on the species
Extent—identifies its spatial context in terms of the range of the species

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

Each threat has been described in Table 2 in terms of the extent that it is operating on the species. The risk matrix (Table 3) provides a visual depiction of the level of risk being imposed by a threat and supports the prioritisation of subsequent management and conservation actions. In preparing a risk matrix, several factors have been taken into consideration, they are: the life stage they affect; the duration of the impact; and the efficacy of current management regimes, assuming that management will continue to be applied appropriately. The risk matrix and ranking of threats has been developed in consultation with experts and using available literature.

Table 3 Hoary sun-orchid risk matrix

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain				Changes to temperature and precipitation patterns	
Likely		Vehicle damage			
Possible			Weed invasion	Fire regimes that cause decline in biodiversity Grazing by feral pigs	Land clearing and fragmentation
Unlikely					
Unknown					

Risk Matrix legend/Risk rating:

Low Risk	Moderate Risk	High Risk	Very High Risk

Categories for likelihood are defined as follows:
Almost certain – expected to occur every year
Likely – expected to occur at least once every five years
Possible – might occur at some time
Unlikely – such events are known to have occurred on a worldwide bases but only a few ties
Unknown – currently unknown how often the incident will occur

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

Priority actions have then been developed to manage the threat particularly where the risk was deemed to be 'very high' (red shading) or 'high' (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 taxonomy of hoary sun-orchid will have been confirmed, and its population will have increased in abundance and viable subpopulations are sustained in habitats where threats are managed effectively.

Conservation and management priorities

Habitat loss, disturbance and modifications impacts

- Avoid all further loss and fragmentation of habitat and avoid any negative impacts to known subpopulations.
- Incorporate the Crib Point subpopulation into the conservation reserve system (currently unreserved public land).
- Update the location details of the KI subpopulation and confirm its presence with land managers.
- Update the identification of the Crib Point subpopulation (currently identified as plum sun-orchid) and inform land managers of its presence.
- Protect all subpopulations from vehicle damage by physically preventing vehicle access (Crib Point), or installing bollards or signage warning land managers and fire agencies of its presence (KI, The Marshes NFR).

Fire impacts

- Ensure that the locations of all subpopulations are recorded on relevant state databases, including those used by land management, forestry and fire response agencies.
- Exclude planned fire from all subpopulations during the growing season (May–October).
- Develop emergency response plans in case of peat fires at The Marshes NFR.

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

- Develop or maintain feral pig population control measures in consultation with land managers and community groups in and near subpopulations of hoary sun-orchid.
- Implement site-based weed control using appropriate methods in consultation with land managers and community groups to ensure that there is no impact on hoary sun-orchid.

Climate change and severe weather impacts

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

Ex situ conservation

- To manage the risk of losing genetic diversity, undertake appropriate seed and mycorrhizae 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/mycorrhizae/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, and taxonomic issues have been resolved, 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. Work with Traditional Owners to divulge any traditional knowledge associates with the species ensuring the practices to record, store and share this knowledge are mutually supported.
- Liaise with relevant land managers to ensure that subpopulations are not accidentally damaged or destroyed. The approval and assistance of land managers should also be sought to implement recovery actions, and recent population data should inform management.
- Engage community groups by encouraging participation in surveys or monitoring for the species.
- Promote public awareness of biodiversity conservation and protection through dissemination of information through print and digital media.

Survey and monitoring priorities

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

Information and research priorities

- Confirm the taxonomic distinctiveness of hoary sun-orchid from plum sun-orchid and related taxa.
- Re-examine herbarium specimens of plum sun-orchid from eastern Australia and hoary sun-orchid.
- Increase knowledge surrounding the ecology of hoary sun-orchid. This includes improving understanding of habitat requirements, recruitment dynamics, appropriate fire regime, pollination biology (including identity and specificity of pollinators), plant longevity, genetic structure, and minimum viable population size.
- Investigate the impact of drought on hoary sun-orchid recruitment and seedling growth.
- Ascertain the cultural significance of hoary sun-orchid.
- Determine habitat critical to the survival of hoary sun-orchid.

- 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

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

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

Draft survey guidelines for Australia's threatened orchids (2013)

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Attachment A: Listing Assessment for *Thelymitra orientalis*

Reason for assessment

This assessment follows prioritisation of a nomination from the TSSC.

Assessment of eligibility for listing

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

Key assessment parameters

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

Table 4 Key assessment parameters

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Number of mature individuals	21–46	~21	~46	There are no formal population estimates for hoary sun-orchid. Based on all available count data, there are approximately 21–46 individuals (Table 1).
Trend	declining			It is unclear if the KI and Grampians subpopulations still exist, as the former has not been recorded since 2008 (ALA 2021) and the latter has not been observed since 1985 despite sporadic searches (G. Backhouse 2021 pers. comm. 24 Nov).
Generation time (years)	30	20	40	The generation time of sun-orchids is not well understood, but it is likely to be above 10 years, as orchids are typically long lived. Shefferson et al. (2020) estimated that average life expectancy from the seedling stage across all terrestrial orchids was 16.3 ± 5.5 years. However, estimates from Australian terrestrials orchids are typically >20 years (Swarts et al. 2009; Faast et al. 2010). Although there is no direct estimate of generation length for sun-orchids or comparable terrestrial orchids, a generation length of approximately 30 years is used here as a plausible estimate, given the long-lived nature of sun-orchids (DELWP 2021).

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Extent of occurrence	38,000 km^2	8 km^2	~150,000 km^2	The extent of occurrence (EOO) is based on the mapping of all available point records. The EOO was calculated using a minimum convex hull, based on the IUCN Red List Guidelines (IUCN 2019). The maximum plausible value represents the plausible EOO if subpopulations exist (e.g. if present, subpopulations in Tasmania would substantially increase the EOO). The minimum plausible value represents the plausible EOO if the KI (not recorded since 2008) and Grampians (not recorded since 1985) subpopulations no longer exist (the EOO of The Marshes and Crib Point subpopulations is equal to their AOO as there are only two data points; IUCN 2019).
Trend	contracting			It is unclear if the KI and Grampians subpopulations still exist, as the former has not been recorded since 2008 (ALA 2021) and the latter has not been observed since 1985 despite sporadic searches (G. Backhouse 2021 pers. comm. 24 Nov). Therefore, the EOO may have declined.
Area of Occupancy	16 km^2	8 km^2	~50 km^2	The AOO is estimated is based on the mapping of available point records. The AOO is calculated using a 2x2 km grid cell method, based on the IUCN Red List Guidelines (IUCN 2019). It is possible that two of the four known subpopulations are no longer extant as the KI subpopulation has not been recorded since 2008 and the Grampians subpopulations has not been seen since 1985. If these subpopulations were considered extinct, the minimum AOO estimate would be 8 km^2. However, the estimate of 16 km^2 has been retained in this assessment due to: the limited survey effort for species, that it may be prone to dormancy (impacting detectability), its identity is not well known among orchid enthusiasts, its habitat in the Grampians NP is in an intact area not affected by obvious threats, and because additional subpopulations may exist due to misidentifications. The maximum plausible value represents the plausible AOO if unknown subpopulations exist.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
AOO is a standardised spatial measure of the risk of extinction, that represents the area of suitable habitat known, inferred or projected to be currently occupied by the taxon. It is estimated using a 2 x 2 km grid to enable comparison with the criteria thresholds. The resolution (grid size) that maximizes the correlation between AOO and extinction risk is determined more by the spatial scale of threats than by the spatial scale at which AOO is estimated or shape of the taxon's distribution. It is not a fine-scale estimate of the actual area occupied. In some cases, AOO is the smallest area essential at any stage to the survival of existing populations of a taxon (e.g. breeding sites for migratory species).				
Trend	contracting			It is unclear if the KI and Grampians subpopulations still exist, as the former has not been recorded since 2008 (ALA 2021) and the latter has not been observed since 1985 despite sporadic searches (G. Backhouse 2021 pers. comm. 24 Nov). Therefore, the AOO may have declined.
Number of subpopulations	4	2	~5–30	The number of subpopulations of hoary sun-orchid is four based on known records (Table 1). However, it is unclear if the KI and Grampians subpopulations still exist, and so the minimum number of subpopulations may be two. The maximum number of subpopulations is based on the presence of currently unknown or misidentified subpopulations.
Trend	declining			It is unclear if the KI and Grampians subpopulations still exist, as the former has not been recorded since 2008 (ALA 2021) and the latter has not been observed since 1985 despite sporadic searches (G. Backhouse 2021 pers. comm. 24 Nov). Therefore, the number of subpopulations may have declined.
Basis of assessment of subpopulation number	see justification under Number of subpopulations (above).			

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
No. locations	4	2	~5–30	The number of locations is estimated at four, due to the presence of very high-risk threats at each subpopulation that could cause the rapid elimination of the subpopulation. Land clearing threatens subpopulations at KI and Crib Point, both of which are on unreserved land at high risk of clearing (a roadside and urban block respectively). Inappropriate fire regimes (out-of-season fire and peat fire) threaten all subpopulations and could cause the elimination of any subpopulation within one generation (~30 years). Feral pigs are likely to threaten the KI, Grampians NP and The Marshes NFR subpopulations and are a known threat to tuberous terrestrial orchids that could also eliminate these subpopulations, particularly given the very low number of plants. The minimum number of locations could be two if the KI and Grampians NP subpopulations are extinct. The maximum number of subpopulations could be very large if the species is substantially more widespread (e.g. due to misidentifications) than is currently known. See Criterion 2 for further justification (below).
Trend	declining			It is unclear if the KI and Grampians subpopulations still exist, as the former has not been recorded since 2008 (ALA 2021) and the latter has not been observed since 1985 despite sporadic searches (G. Backhouse 2021 pers. comm. 24 Nov). Therefore, the number of subpopulations may have declined.
Basis of assessment of location number	See justification for 'No. locations' above.			
Fragmentation	Severely fragmented. The closest distance between the two nearest subpopulations is 170 km (between The Marshes NFR and the Grampians subpopulations). Therefore gene flow among subpopulations is unlikely to occur. All subpopulations are very small in population size (largest is The Marshes with 20–45 plants), and all are likely smaller than a rudimentary minimum viable population size estimate of 1000 individuals (as per Frankham et al. 2014). Therefore, it is likely that the majority of the species' AOO is comprised of subpopulations that are smaller than a rudimentary estimate of minimum viable population size, and the species is likely to be severely fragmented.			
Fluctuations	Not subject to extreme fluctuations in EOO, AOO, number of subpopulations, locations or mature individuals.			

Criterion 1 Population size reduction

Reduction in total numbers (measured over the longer of 10 years or 3 generations) based on any of A1 to A4			
	Critically Endangered Very severe reduction	**Endangered Severe reduction**	**Vulnerable Substantial reduction**
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3, A4	≥ 80%	≥ 50%	≥ 30%

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

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

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

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

Based on any of the following

(a) direct observation [except A3]
(b) an index of abundance appropriate to the taxon
(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
(d) actual or potential levels of exploitation
(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites

Criterion 1 evidence

Insufficient data to determine eligibility

Generation time

The generation length of hoary sun-orchid is inferred to be approximately 30 years, giving a 90-year period for this criterion (three generations) (Table 4).

Population trend

There are no available data on population trends over time. It is possible that two of the four known subpopulations are no longer extant as the KI subpopulation has not been recorded since 2008 and the Grampians subpopulations has not been seen since 1985 despite sporadic searches (G. Backhouse 2021 pers. comm. 24 Nov). However, no population counts are available for those subpopulations so an estimate of the percentage population decline is not possible. Therefore, there is insufficient information to determine the eligibility of the species for listing in any category under this criterion.

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

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

		Critically Endangered Very restricted	Endangered Restricted	Vulnerable Limited
B1.	Extent of occurrence (EOO)	**< 100 km²**	**< 5,000 km²**	**< 20,000 km²**
B2.	Area of occupancy (AOO)	**< 10 km²**	**< 500 km²**	**< 2,000 km²**
AND at least 2 of the following 3 conditions:				
(a)	Severely fragmented OR Number of locations	**= 1**	**≤ 5**	**≤ 10**
(b)	Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals			
(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 B2a,b(i,ii,iii,iv,v) for listing as Endangered

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

The EOO of hoary sun-orchid is 38,000 km² and the AOO is 16 km² (see Table 3). Therefore, the species' AOO appears to meet the threshold for Endangered under B2 (10–500 km²).

Severely fragmented

The closest distance between the two nearest subpopulations is 170 km (between The Marshes NFR and the Grampians subpopulations). Although orchids are theoretically capable of long distance dispersal, almost all seed falls within 2.5 m of the parent plant (Jersáková & Malinová 2007). Considering the large distance and very small size of known subpopulations, gene flow among subpopulations of hoary sun-orchid is unlikely. All subpopulations are very small in population size (largest is The Marshes with 20–45 plants), and all are likely smaller than a rudimentary minimum viable population size estimate of 1000 individuals (as per Frankham et al. 2014). Therefore, it is likely that the majority of the species' AOO is comprised of subpopulations that are smaller than a rudimentary estimate of minimum viable population size, and the species is likely to be severely fragmented.

Number of locations

Hoary sun-orchid is likely to have four locations, with each subpopulation being considered a separate location. Threats likely to cause the rapid elimination of subpopulations within one generation (30 years) include land clearing, inappropriate fire regimes and grazing by feral pigs.

Historical land clearing has likely caused a major decline of hoary sun-orchid throughout its range, particularly in south eastern South Australia. Although the threat of large-scale land clearing appears to have lessened, the risks posed by smaller road and infrastructure development are likely to continue to threaten the roadside subpopulation on KI and the unreserved subpopulation at Crib Point. The KI roadside subpopulation occurs on a very narrow roadside and adjoins cleared farmland on one side and a reserve on the other, and clearing by the adjacent farmer or by road or fire management agencies is possible. The Crib Point subpopulation is in a small patch of remnant bushland surrounded by urban development in the Crib Point township. Urban development is a serious threat to this subpopulation. Therefore, as it is plausible that either of these sites could be cleared within the next 30 years, it is likely that the threat of land clearing can be used to define these two subpopulation as separate locations. Subpopulations in The Marshes NFR and at the Grampians NP are reserved and therefore land clearing is not a likely threat for these subpopulations.

Inappropriate fire regimes threaten all subpopulations, with out-of-season fires, peat fires and fire-herbivory interactions the major threats. Out-of-season fires may disrupt leaf phenology (Miller et al. 2019), mycorrhizal fungal communities (Jasinge et al. 2019) or pollinator communities (Brown et al. 2016). If fires occur soon after leaf emergence, the tubers may store insufficient resources to sustain a second flush of leaf production, resulting in tuber mortality (Jasinge et al. 2019). Out-of-season fires for fuel reduction purposes are mostly likely to threaten the Crib Point subpopulation (close proximity to houses) and The Marshes NFR subpopulation (close proximity to timber plantations). Peat fires are likely to threaten the KI, The Marshes NFR and Grampians NP subpopulations, which occur in wet, peaty soil. Peat fires consume the substrate and are extremely destructive (DAWE 2021), and are likely to kill orchids. Therefore, the threat of inappropriate fire regimes can plausibly cause the rapid elimination of all subpopulations, and can be used to define all subpopulations as separate locations. The interactions between fire and herbivory also threaten the species. Certain types of fires may increase and spatially concentrate the foraging activity of herbivores, particularly small, patchy and low severity fires that result in high survival rates of the herbivores (Wan et al. 2014).

Feral pigs can be considered ecosystem engineers (Jones et al. 1997) because they are capable of causing severe ground disturbance that alters the floristic composition of ecosystems (Alexiou 1984). Pig rooting, even at relatively low levels, is capable of causing local extinction of plant species (Hone 2002). Feral pigs are known to reduce populations of tuberous perennial plants through selective herbivory and ground rooting (Alexiou 1984) and feral pigs are a known threat to orchids (DOEE 2017; Wraith & Pickering 2019). Feral pigs are likely to threaten the KI, Grampians NP and The Marshes NFR subpopulations (PIRSA 2020; DJPR 2021), although there is currently no evidence of impacts to the species. Nevertheless it is plausible that feral pigs could cause the elimination of one or more of these populations

Therefore, the species' number of locations meets the requirement for Endangered under subcriterion (a).

Continuing decline

There is evidence of continuing decline of in all of EOO, AOO, the number of locations or subpopulations, the number of mature individuals, and the area, extent and quality of habitat.

Two subpopulations may be extinct, with the KI subpopulation not recorded since 2008 (ALA 2021) and the Grampians subpopulation not observed since 1985 despite sporadic searches (G. Backhouse 2021 pers. comm. 24 Nov). It is not clear what threats may have contributed to the potential loss of these populations, but their loss represents a decline in EOO, AOO, the number of locations and subpopulations, and the number of individuals.

The threats most likely to cause continuing decline include land clearing, inappropriate fire regimes and feral pigs. All threats could cause declines in EOO, AOO, the number of locations or subpopulations, the number of mature individuals, and the area, extent and quality of habitat (see justification for Number of locations above). Land clearing is a potential threat at the unreserved KI and Crib Point subpopulations, inappropriate fire regimes (out-of-season fire or peat fires) threaten all subpopulations, and feral pigs are most likely to threaten the Grampians NP, KI and The Marshes NFR subpopulations.

The species appears to be experiencing continuing decline in all of EOO, AOO, the number of locations or subpopulations, the number of mature individuals, and the area, extent and quality of habitat. Accordingly, the species appears to meet the continuing decline requirement for listing under this criterion.

Extreme fluctuations

There are no known extreme fluctuations in EOO, AOO, number of subpopulations, locations or mature individuals. Therefore, hoary sun-orchid does not meet the threshold for listing as Endangered under sub-criterion (c).

Conclusion

The data presented above appear to demonstrate that hoary sun-orchid is eligible for listing as Endangered under this criterion.

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

Criterion 3 Population size and decline

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

The total number of mature individuals is estimated to be 21–46, which is very low. There are no data on the likely population reduction in the last 30 years (one generation; see Table 4) and a projection of future trends is uncertain as most threats are either stochastic (land clearing, vehicle damage, feral pigs) or the impacts are difficult to quantify (inappropriate fire regimes, weed invasion, climate change), so an assessment under C1 is not possible. However, the size of each subpopulation is ≤50 mature individuals and the percentage of plants in one subpopulation is 98–99 percent in the largest subpopulation (Table 1). The species does not appear to experience extreme fluctuations. Therefore, the species appears to meet the requirements for listing as Critically Endangered under this criterion.

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

Criterion 4 Number of mature individuals

	Critically Endangered Extremely low	Endangered Very Low	Vulnerable Low
D. Number of mature individuals	< 50	< 250	< 1,000
D2.[1] *Only applies to the Vulnerable category* Restricted area of occupancy or number of locations with a plausible future threat that could drive the species to critically endangered or Extinct in a very short time			D2. Typically: area of occupancy < 20 km² or number of locations ≤ 5

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

Criterion 4 evidence

Eligible under D for listing as Critically Endangered

As per the evidence presented above for Criterion 3, the number of known mature individuals is currently estimated at 21–46, which is extremely low. Therefore, the species appears to meet the requirements for listing as Critically Endangered under this criterion.

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

Criterion 5 Quantitative analysis

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

Criterion 5 evidence

Insufficient data to determine eligibility

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

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

Adequacy of survey

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

Listing and Recovery Plan Recommendations

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

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

Cataloguing data

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