Australian Government
Department of Agriculture, Water and the Environment

Consultation on Species Listing Eligibility and Conservation Actions

Pseudemoia cryodroma (alpine bog skink)

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

1) the eligibility of *Pseudemoia cryodroma* (alpine bog skink) 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 about conservation actions and further planning. As such, the below draft assessment should be considered **tentative** as it may change following the submission of 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@environment.gov.au. Please include the species' scientific name in the 'Subject' field.

or by mail to:

The Director
Species Listing, Information and Policy
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 Thursday 12 May 2022.

General background information about listing threatened species

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

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: http://www.awe.gov.au/system/files/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: http://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: http://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. Personal information means information or an opinion about an identified individual, or an individual who is reasonably identifiable.

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. Alternatively, email the department at privacy@awe.gov.au. 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

1. Are you able to share additional information about alpine bog skink ecology or biology that is not outlined in the current draft conservation advice?
2. Do you have additional information you are able to share about the social and/or cultural significance of the alpine bog skink?
3. Do you consider that all major threats have been identified and described adequately? Do you have further information on potential impacts of foxes?
4. Do you have additional information about planning and management actions that are currently in place to support alpine bog skink protection and recovery? To what extent have they been effective?
5. Do you consider the conservation and management actions that are outlined to be reasonable and achievable?
6. Can you recommend additional or alternative conservation and management actions that would aid with alpine bog skink protection and recovery?
7. Do the key assessment parameter values used in the assessment seem reasonable? If not, please provide justification for your response.
8. Has alpine bog skink survey effort been adequate to assess its threatened species status? If not, please provide justification for your response.
9. Does the listing advice adequately outline the rationale for the listing assessment outcome?
10. Do you have comments on any other matters relevant to the alpine bog skink assessment?

Contents

Australian Government
Department of Agriculture, Water and the Environment

Conservation Advice for *Pseudemoia cryodroma* (alpine bog skink)

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 eligibility of the species for listing and inform conservation actions, further planning and the potential need for a Recovery Plan.

The draft assessment below should therefore be considered **tentative** at this stage, as it may change as a result of responses to this consultation process.

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

This document combines the approved conservation advice and listing assessment for the alpine bog skink. It provides a foundation for conservation actions and further planning.

Female (front) and male (back) alpine bog skinks (*Pseudemoia cryodroma*) © Copyright, Nick Clemann, Lake Mountain.

Conservation status

Pseudemoia cryodroma (alpine bog skink) is proposed to be listed in the Endangered category of the threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act).

Pseudemoia cryodroma was assessed by the Threatened Species Scientific Committee to be eligible for listing under criterion 2 as Endangered. The Committee's assessment is at **Attachment A**. The Committee assessment of alpine bog skink eligibility against each of the listing criteria is:

- Criterion 1: Ineligible
- Criterion 2: B2ab(i,ii,iii,iv): Endangered
- Criterion 3: Insufficient data
- Criterion 4: Insufficient data
- Criterion 5: Insufficient data

The main factors that make the alpine bog skink eligible for listing in the Endangered category are a restricted area of occupancy and number of locations; ongoing declines in area of occupancy, habitat extent and quality; and projected future declines in the extent of occurrence, area of occupancy and habitat extent and quality.

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 *Pseudemoia cryodroma* (Hutchinson & Donnellan 1992). The alpine bog skink is a distinct species (Haines et al. 2017) despite historical and current hybridisation with the tussock skink (*P. pagenstecheri*) and the southern grass skink (*P. entrecasteauxii*) where they co-occur (Haines et al. 2016). Haines et al. (2014) estimate the alpine bog skink and tussock skink diverged 2.6 million years ago, and the alpine bog skink and southern grass skink diverged 2.2 million years ago.

Description

The alpine bog skink is a small (up to 60 mm snout-to-vent length) metallic brown to green-brown skink that can co-occur with the tussock skink and the southern grass skink. It is a morphological intermediate between these two species, with all three species forming a clade within the *Pseudemoia* genus (Haines et al. 2014; Haines et al. 2016). The alpine bog skink and hybrids (with tussock skink or southern grass skink) can be challenging to separate in the field (Clemann 2002; Haines et al. 2016; Amor et al. 2021). They can also look superficially similar to skinks in the *Acritocoscincus* and *Lampropholis* genera, which have a different arrangement of large scales on top of their head (Robertson & Coventry 2019).

The alpine bog skink has a broad dark zone along the side and the following series of clear or indistinct pattern features: 1) usually a black or dark brown stripe along the spine, 2) one pale stripe along each side of the back, and 3) a pale line between the front and back legs. It shares these features with the tussock skink and southern grass skink. (Hutchinson & Donnellan 1992; Robertson & Coventry 2019; Wilson & Swan 2021).

In areas where they co-occur, the alpine bog skink can be differentiated from the tussock skink and southern grass skink by analysing the pattern of stripes and markings on the back and side in detail (see Robertson & Coventry 2019). The alpine bog skink is typically darker and more metallic in colour than the other two species and, except for one subpopulation, the male usually has no red pigment on its unmarked pale underside when breeding. The white line between the front and back legs is usually flushed rose pink to scarlet in breeding male alpine bog skinks, and the scales are very glossy with an iridescent green sheen in sunlight (Hutchinson & Donnellan 1992; Robertson & Coventry 2019; Wilson & Swan 2021).

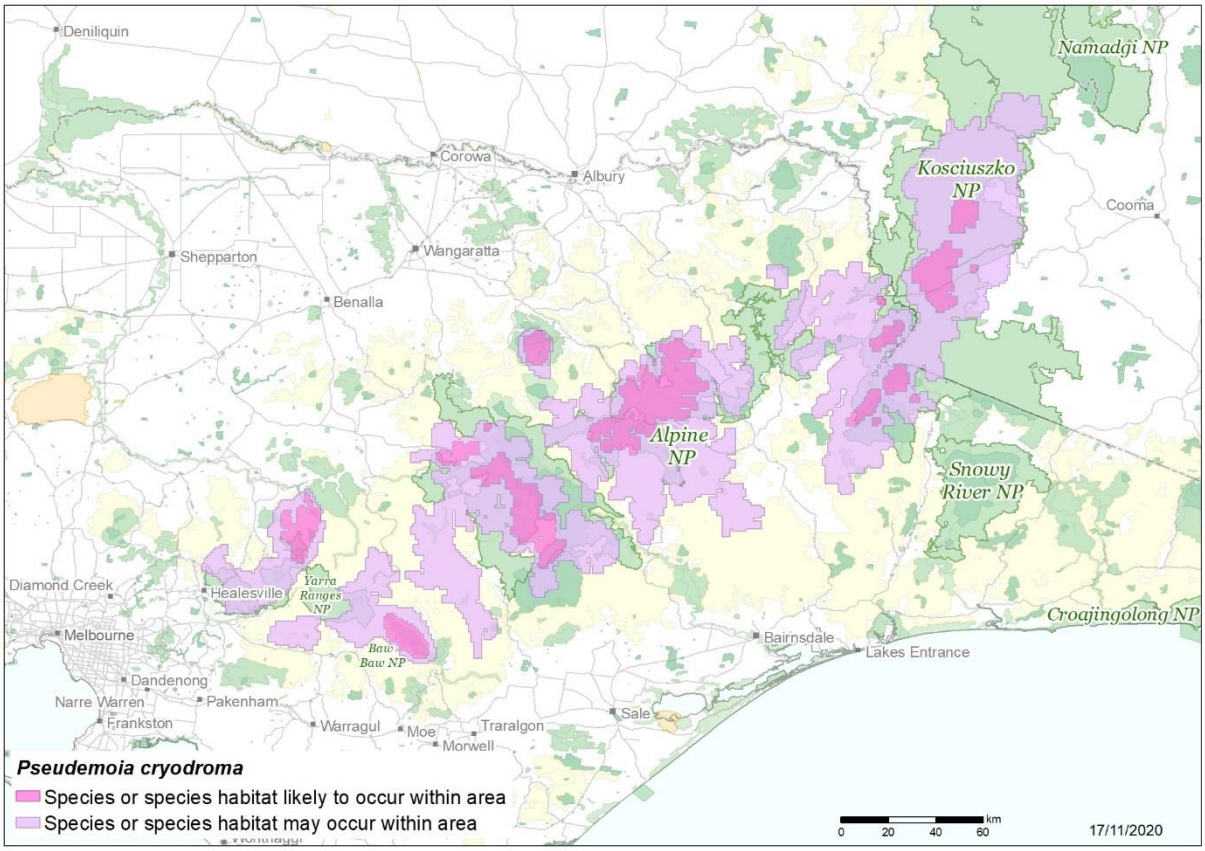
Distribution

The alpine bog skink is endemic to the Australian Alps Bioregion (IBRA 7). It occurs above 1000 m elevation throughout subalpine and alpine Victoria (Hutchinson & Donnellan 1992; ALA 2021; Amor et al. 2021). It may also occur in adjacent alpine regions of New South Wales (Howard et al. 2012; ALA 2021).

The national alpine bog skink population is fragmented into 'sky islands' (McCormack et al. 2009; Atkins et al. 2018) due to its patchy high-altitude distribution in the Australia Alpine Bioregion (Clemann et al. 2019). It is recorded from Lake Mountain near Marysville, Mt Baw Baw, Bennison High Plains, Dargo High Plains, Mt Buller, Mt Buffalo, Mt Higginbothan, Mt Hotham and the Bogong High Plains, Cobberas, and Tom Groggin in Victoria (Hutchinson & Donnellan 1992; Howard et al. 2014; Wilson & Swan 2021; ALA 2021). Specimens collected from the Mt Kosciuszko-Thredbo area in New South Wales (ANWC 2021) require species confirmation following taxonomic reviews by Haines et al. (2014, 2016, 2017).

The alpine bog skink occurs almost exclusively in areas managed for nature conservation, with some locations bordering or entering forestry tenements. Specifically, it occurs in the Alpine, Baw Baw, Yarra Ranges, and Mount Buffalo National Parks in Victoria and it may also occur in Kosciuszko National Park in New South Wales. Part of the core alpine bog skink distribution occurs on land covered by the Gunaikurnai Indigenous Land Use Agreement. It is not known to occur on Commonwealth land.

Map 1 Modelled distribution of the alpine bog skink



Source: Base map Geoscience Australia; species distribution data Species of National Environmental Significance database.
Caveat: The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything containing herein.
Species distribution mapping: The species distribution mapping categories are indicative only and aim to capture (a) the 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 alpine bog skink and its high-altitude habitat occur within interconnected cultural landscapes that are significant for the Bidawal, Dhudhuroa, Waywurru, Jaithmathang, Taungurong, Gunaikurnai, Monero-Ngarigo, Ngarigu-Currawong and Wurundjeri Peoples as Traditional Custodians (AANP undated; GLWAC 2015; TLWC 2016; Aboriginal Victoria 2021; ACHRIS 2021; Parks Victoria 2016; 2021).

The distribution of the alpine bog skink overlaps significantly with the Australian Alps National Parks and Reserves National Heritage Place, which is identified as being of national significance to the Australian people partly due to its unique cold adapted animals, and to the water retention properties of the bog and fen communities, both of which are highly relevant to the alpine bog skink.

Relevant biology and ecology

The life expectancy of the alpine bog skink is estimated to be five years, with sexual maturity assumed at one year of age and generation length estimated to be 2–3 years (DELWP 2021a). The breeding season occurs in the warmer months from December to March (Haines et al. 2016). Females usually bear 2–5 live young in February, after which mating probably occurs (Hutchinson & Donnellan 1992).

During relatively warm conditions the alpine bog skink remains within ground cover, emerging to bask when the weather is cool and sunny (Hutchinson & Donnellan 1992). It basks on grass tussocks, low emergent rocks and the base of *Eucalyptus pauciflora* (snow gum), and can be observed clambering among the leaves of low (< 1 m) heathy plants (Hutchinson & Donnellan 1992). It feeds on small invertebrates (Robertson & Coventry 2019).

The alpine bog skink can be locally common in isolated habitat patches (Clemann et al. 2019; Clemann 2021 pers. comm. 18 Nov).

Connectivity and dispersal

Subpopulations from Bogong High Plains, Mount Higginbotham, Mt Buller-Mt Stirling, Mt Baw Baw, and Lake Mountain are geographically and reproductively isolated from each other (Haines et al. 2017; Amor et al. 2021). A further 3–7 isolated subpopulations are likely based on the findings by Haines et al. (2017).

The patchy distribution and isolation of alpine bog skink subpopulations suggest its capacity for dispersal is limited. Without management interventions (e.g. translocations) the alpine bog skink is unlikely to maintain gene flow among fragmented subpopulations, re-colonise distant habitat that is no longer occupied, or move into areas with the potential to be habitat in the future as climate change progresses (Haines et al. 2016; Haines et al. 2017).

Habitat

Alpine bog skink habitat includes areas that are continuously, periodically, or historically occupied by this species. The alpine bog skink may be periodically or permanently absent from habitat due to current or historical threats e.g. intense fire, impacts from feral horses.

The alpine bog skink occurs primarily in alpine bog, riparian and wet heath areas above 1100 m elevation, and less commonly in alpine and subalpine grassland and dry treeless heath, drainage lines in subalpine meadows, and in snow gum woodland (Hutchinson & Donnellan 1992; Clemann et al. 2019). These areas provide the alpine bog skink with all the resources it requires for its lifecycle (i.e. food, water, shelter and breeding). The alpine bog skink usually occurs in wetter areas than the tussock skink and more open areas than the southern grass skink (Hutchinson & Donnellan 1992).

Alpine bog skink habitat, as currently understood, includes areas with suitable ground cover for continued alpine bog skink occupancy within the following ecosystem types:

- Alpine bog, riparian and wet heath.
- Alpine and subalpine grassland and dry treeless heath.
- Drainage lines in subalpine meadows.
- Snow gum woodland.

Due to limited survey effort, alpine bog skink habitat may occur in areas where species distribution modelling indicates it is likely to occur but is yet to be recorded (Map 1).

The lower limit of alpine bog skink occurrence is projected to increase from the current 1000 m to 1200–1400 m altitude by the year 2050 (Camac et al. 2021) and alpine bog skink genetic diversity increases with elevation (Haines et al. 2017). Therefore, habitat at higher altitude may initially appear to be more critical to the long-term genetic diversity and survival of the alpine bog skink than habitat at lower elevations. However, exclusive protection and conservation management of high-altitude habitat (i.e. > 1400 m) will result in an overly fragmented national population and a high risk of inbreeding depression linked to small subpopulation sizes (Haines et al. 2017). The identification and delineation of large and interconnected climate refuges incorporating both recorded and potential future habitat is critical to ensuring long-term persistence of the alpine bog skink.

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

Threats

The primary threats to alpine bog skink persistence are loss of habitat due to climate change, frequent fires, damage to habitat by feral hard-hoofed animals, and commercial development. These threats interact to exacerbate their independent impacts. Additional threats include predation by *Felis catus* (cat) after fire, and habitat degradation by weeds and actions to manage them. Details and the extent to which each threat is operating on the national alpine bog skink population are outlined in **Error! Not a valid bookmark self-reference.**.

Table 1 Threats to the alpine bog skink

Threats in Table 1 are noted in approximate order of highest to lowest impact, based on available evidence.

Threat	Status [a]	Evidence
Climate change		
Habitat shift and alteration	• Timing: current and future. • Confidence: projected. • Consequence: catastrophic. • Trend: increasing. • Extent: across the entire range.	Australia is experiencing adverse impacts from a rapidly changing climate, with 2019 identified as the hottest year in recorded history (CSIRO & BOM 2020). Climate change impacts are occurring within the Australian Alpine Bioregion and they are projected to increase in the future (McDougall & Broome 2007; IPCC 2013). Loss of alpine bog skink habitat due to ecosystem alteration is predicted as climate change impacts progress: increased daily temperatures and reduced rainfall are projected to dry out alpine bog systems (Hope et al. 2009) and tussocky grasses are being outcompeted by flammable shrubs in the Bogong High Plains, with this trend predicted to continue in the future and to occur more broadly (Hoffman et al. 2018). As climate change progresses, the alpine bog skink and its habitat are expected to become further fragmented into smaller isolated 'sky islands' as the suitable climate envelope for persistence shifts to higher elevations (McDougall & Broome 2007; Haines et al. 2016; Clemann et al. 2019). There is a hard upper elevation limit to the capacity for alpine bog skinks and their habitat to migrate upwards because subpopulations at, or close to, the highest point of a mountain or range cannot move any higher. Habitat alteration and migration to higher elevations with climate change are both predicted to result in a net loss and significant fragmentation of the national alpine bog skink population (Haines et al. 2016; Clemann et al. 2019). Haines et al. (2016) predict the alpine bog skink and its habitat may be lost by 2050 without management intervention to reduce interacting threats. **Threat interaction** Fire: Climate change is increasing the frequency of high intensity fires in the Australian Alpine Bioregion (CSIRO & BOM 2020), which is a primary driver of alpine wetland and grassland ecosystem alterations (Hope et al. 2009; Hoffman et al. 2018).
Loss of genetic diversity	• Timing: future. • Confidence: suspected. • Consequence: major. • Trend: predicted to increase. • Extent: across the entire range.	The loss, vertical migration and fragmentation of alpine bog skink habitat is expected to reduce both the overall genetic diversity of the alpine bog skink and the genetic diversity and resilience of geographically isolated subpopulations (Haines et al. 2016; 2017). Low incidences of inbreeding at two extant subpopulations suggest that inbreeding depression and reduced genetic diversity may increase the risk of isolated subpopulations being lost to stochastic events and/or ongoing threats (Haines et al. 2017).

Threat	Status [a]	Evidence
Fire regimes that cause declines in biodiversity		
Increased fire frequency (habitat shift and alteration)	• Timing: current. • Confidence: inferred. • Consequence: major. • Trend: increasing. • Extent: across the entire range.	Fire historically occurred infrequently in Australian alpine ecosystems: approximately every 20–100 years at a given location (Zylstra 2003; Williams et al. 2008). However, the most frequent fire recurrence interval recorded is ten years at one site (Zylstra 2003). Based on dendrology and pollen analyses, fire frequency is estimated to have increased five- to seven-fold in the Australian Alpine Bioregion since colonisation (Zylstra 2003) and damaging fires are becoming more frequent, with successive high intensity and extensive wildfires in 2003, 2006–2007, 2009, 2012, and 2019–2020 (Williams et al. 2014; Ward et al. 2020). A historical review by Zylstra (2013) determined that snow gum woodlands burnt in the last 14 years were 2.3 times more likely to burn again than older forests. The historical increase in fire frequency is attributed to intentional burning by graziers changing the dynamics of vegetation community succession and increasing the cover of flammable vegetation (Zylstra 2003), and increases since the late 1900s are due to climate change (CSIRO & BOM 2020). Frequent and intense fires can stimulate ecosystem alteration and contribute to the loss of alpine bogs and other wetlands (Hope et al. 2009) that are critical habitat for the alpine bog skink. The alteration of alpine bog skink habitat by too-frequent fire may have been occurring since settlement and may now be accelerating. **Threat interaction** Climate change is increasing the frequency of high intensity fires in the Australian Alpine Bioregion (CSIRO & BOM 2020). Horse and deer: The post-fire recovery of alpine ecosystems is significantly inhibited by disturbance (Williams et al. 2012) and this was observed in alpine bog skink habitat that was further degraded by horse and deer impacts after the 2019–2020 fires (Clemann & Atkins 2021 pers. comm. 1 Jun). Weeds: Frequent fires can increase the potential for weeds such as willow (*Salix cinerea*) to establish and invade alpine wetlands (McDougall et al. 2005).
Increased fire extent and frequency (direct mortality)	• Timing: current. • Confidence: inferred. • Consequence: major. • Trend: increasing. • Extent: across the entire range.	Approximately 22 % of the alpine bog skink distribution was burnt in high or very high intensity fire in 2019-2020 (DAWE 2020), including severe damage to swamps (ARI 2021). An expert elicitation process, completed in the absence of monitoring data for this species, inferred that this species was sensitive to fire when compared to other reptile species in the assessment. However, given the overlap between the 2019-20 wildfires and the alpine bog skink distribution was moderate (22 %), the assessment predicted a population decline of just 9 % one year after these fires and a sustained reduction of up to 7 % ten years post-fire pending no further fire impacts (Legge et al. 2021a). However, there is high uncertainty in the long-term population impact estimate due to insufficient knowledge about the alpine bog skink response to fire (i.e. the 80 % confidence limits for the population change after 10 years was +5 to -30 %). The alpine bog skink shelters in vegetation and under surface objects (Hutchinson & Donnellan 1992; Howard et al. 2012), which are strategies that can result in high mortality rates during fire; and this species can be undetectable at known locations for up to 12 years post-fire (Howard et al. 2012; Amor et al. 2021; Clemann 2021 pers. comm. 18 Nov). The alpine bog skink has low fecundity (Hutchinson & Donnellan 1992) and may require an alpine fire-free interval typical of the pre-colonisation era for subpopulations to recover.

Threat	Status [a]	Evidence
		Threat interaction Climate change: Climate change is increasing the frequency of high intensity fires in the Australian Alpine Bioregion (CSIRO & BOM 2020). Feral cat hunting success increases in open areas where ground cover has been removed by fire (Leahy et al. 2016; McGregor et al. 2015a, 2015b), potentially leading to exacerbated mortality of alpine bog skinks post-fire. Horse and deer congregate in unburnt areas after fire, concentrating their impacts. The recovery of vegetation cover in alpine bog skink habitat after the 2019–2020 fires was significantly impeded by horse and deer (Clemann & Atkins 2021 pers. comm. 1 Jun).
Introduced hard-hoofed animals		
Habitat loss and damage by *Equus caballus* (horse)	• Timing: current. • Confidence: observed. • Consequence: major. • Trend: predicted to decline with planned management interventions. • Extent: across the entire range.	Horses are abundant across the Australian Alpine Bioregion (Parks Victoria 2017; DPIE 2021). Pugging and rolling damage and remove ground vegetation cover, and grazing reduces grass height (Driscoll et al. 2019; Eldridge et al. 2019; Sato et al. 2019; ISC 2021). The recovery of damaged ecosystems is slow due to the short summer growing season (Driscoll et al. 2019; ISC 2021). Prolonged loss and damage to ground vegetation cover reduces the availability of this critical shelter resource for the alpine bog skink (Hutchinson & Donnellan 1992) and has led to the loss of alpine bog skink habitat through ecosystem alteration in northeast Victoria (Clemann 2021 pers. comm. 21 Oct). Impacts from horses are particularly acute in riparian and bog areas (Robertson et al. 2019) inhabited by the alpine bog skink. Loss and damage to alpine bog, riparian and tussock grassland habitat by horses is ongoing within the distribution of the alpine bog skink (Parks Victoria 2017). **Threat interactions** Fire: Horses congregate in unburnt areas after fire, concentrating their impacts. The recovery of vegetation cover in alpine bog skink habitat after the 2019–2020 fires was significantly impeded by horse and deer (Clemann & Atkins 2021 pers. comm. 1 Jun). Deer and pig: The combined impacts of horse, deer and pig trampling, wallowing and grazing can significantly reduce the availability of critical ground vegetation cover for the alpine bog skink. Weeds: Horses are a vector for dispersing weed seeds (Parks Victoria 2017) and trampling and overgrazing can increase the potential for weeds to establish (McDougall et al. 2005).
Habitat damage by deer	• Timing: current. • Confidence: inferred. • Consequence: moderate. • Trend: stable. • Extent: across the majority of its range.	Deer occur patchily across the Australian Alpine Bioregion (Claridge 2016). Trampling and wallowing impacts – primarily by Sambar deer (*Cervus unicolor*) but also fallow deer (*Dama dama*) – are most acute in the bog and riparian habitats inhabited by the alpine bog skink (Claridge 2016). Of 29 bogs surveyed on the Bogong High Plains, 79 % were impacted by deer and 42 % had fresh wallows. In contrast no deer sign was detected at 16 bogs across the Mount Buffalo southern plateau (Claridge 2016). Damage by deer to alpine bog skink habitat is ongoing (Claridge 2016). **Threat Interactions** Horse: Deer graze on new growth and shrubs not targeted by horses (Côté et al. 2004; Claridge 2016). The combined impacts of horse and deer grazing and trampling has significantly reduced the availability of critical vegetation cover for the alpine bog skink in the east of alpine Victoria (Clemann 2021 pers. comm. Nov 18). Fire: The recovery of burnt bog systems and alpine vegetation after the 2019-2020 bushfires was inhibited by ongoing deer (and horse) trampling and grazing (Clemann & Atkins 2021 pers. comm. 1 Jun). Weeds: Deer are a vector for for dispersing weed seeds (Claridge 2016), and trampling and overgrazing can increase the potential for weeds to establish (McDougall et al. 2005).

Threat	Status [a]	Evidence
Habitat damage by *Sus scrofa* (feral pig)	• Timing: current and future. • Confidence: inferred. • Consequence: minor. • Trend: increasing. • Extent: across part of its range.	Feral pigs damage wetland ecosystems in southeast Australia (DELWP 2017). Feral pig rooting in the Namadgi National Park, adjacent to the modelled alpine bog skink distribution, was most prevalent in areas above 1000 m elevation (Hone 1988). Historical pig abundance and impacts in the Victorian alpine region are limited, but the pig population is expanding across Victoria and pigs have been present in the Dargo High Plains since at least 2006 (Kambouris & Pascoe 2006). Rooting by feral pigs may be damaging alpine bog skink habitat in some locations and the distribution of impacts is likely to increase in the future. **Threat Interactions** Fire: There is significant concern about compounding pig impacts on sensitive alpine ecosystems after the 2019–2020 fires (DPIA 2020; Parks Victoria 2020). Horse and deer: The combined impacts of horse, deer and pig trampling, wallowing and grazing can significantly reduce the availability of critical vegetation cover for the alpine bog skink. Weeds: Wallowing and rooting can increase the potential for weeds to establish in wetland areas (McDougall et al. 2005).
Development		
Habitat loss and degradation by development and maintenance of commercial operations.	• Timing: current and future. • Confidence: observed and projected. • Consequence: moderate. • Trend: increasing. • Extent: across parts of its range.	The development and maintenance of ski infrastructure (buildings, ski runs, other snow sport runs) occurs across the known and modelled distribution of the alpine bog skink, and habitat has been lost during the development, and also during upgrades to, alpine resort facilities at Mt Hotham (Clemann 2013). Construction and maintenance of ski runs significantly reduces the structural complexity of alpine habitats (Sato et al. 2014b). A close relative of the alpine bog skink, the tussock skink, occurs at fewer sites where ski infrastructure is developed and maintained relative to undeveloped sites (Sato et al. 2014b). Given their close taxonomic relationship and habits, the alpine bog skink may also occur less frequently at ski runs. There are ongoing plans to expand and upgrade ski and non-ski tourism facilities across the modelled distribution of the alpine bog skink (NSW NPWS KNP 2001; ARCC 2019). The Falls to Hotham Alpine Crossing (18 MB) development has the potential to degrade and remove alpine bog skink habitat, and further habitat is at risk of being lost or degraded by road construction to service logging coupes on and near the Dargo High Plains. **Threat Interactions** Weeds: Resort gardens with introduced plants increase the risk of weed propagation in surrounding areas, and ski run development and management creates bare areas that are intentionally or unintentionally stabilised by invasive weed species (McDougall et al. 2005). Cats: Ski resorts may increase the risk of domestic cat predation on adjacent subpopulations of alpine bog skink. Loss of genetic diversity: Alpine bog skinks naturally hybridise with tussock skinks and southern grass skinks at very low rates (Haines et al. 2016). Alpine bog skink subpopulations adjacent to ski infrastructure show elevated rates of hybridisation where these species co-occur (Haines et al. 2016).

Threat	Status [a]	Evidence
Introduced predators		
Cat predation	• Timing: current. • Confidence: suspected. • Consequence: moderate. • Trend: unknown. • Extent: across the entire range.	Feral cats primarily prey on mammals, particularly in cooler parts of Australia (Doherty et al. 2015). However, skinks are a major component of their reptile prey (Woinarski et al. 2018). **Interacting Threats** Fire, horse, deer: Cats are more effective hunters in open habitats (McGregor et al. 2015a). The loss of ground vegetation in alpine bog skink habitat due to fire, horses and/or deer is likely to increase the risk of unsustainable predation by cats.
European red fox predation	• Timing: current. • Confidence: suspected. • Consequence: unknown. • Trend: unknown. • Extent: across the entire range.	European red fox densities are highest in cool areas of Australia and in areas with dense human populations (Stobo-Wilson et al. 2022). Reptiles are a minor component (< 1 %) of the fox diet in alpine and subalpine areas of Australia (Green 2003) where mammals and invertebrates are more frequently consumed (Green 2003; Stobo-Wilson et al. 2022). However, the proportion of reptiles in the diet increases with less vegetation cover and more vegetation disturbance (Stobo-Wilson et al. 2022). High fox densities in alpine Australia may be having a negative impact on the alpine bog skink in areas of high human density (e.g. ski resorts) and disturbed ground cover. **Interacting Threats** Fire, horse, deer: The loss of ground vegetation in alpine bog skink habitat due to fire, horses and/or deer may increase the risk of unsustainable predation by foxes. Development: Areas of high human density may increase the density of foxes and subsequent predation pressure on the alpine bog skink.
Weed invasion		
Habitat degradation and loss from weed invasion	• Timing: current. • Confidence: observed. • Consequence: minor. • Trend: unknown. • Extent: across the entire range.	Although the general impact of weeds is low in the Australian Alpine Bioregion (McDougall et al. 2005), weed invasion is identified as a potential threat to alpine bog skink habitat (Clemann 2002) and at least one species – willow – is particularly invasive in alpine bogs, wetlands, and riparian areas (McDougall et al. 2005; Gijohann et al. 2011). Weeds have the potential to change and outcompete ground layer vegetation, which is a critical habitat resource for the alpine bog skink. Weed management activities also have the potential to damage and degrade alpine bog skink habitat through trampling (Clemann 2019 pers. comm. 18 Nov). **Interacting Threats** Fire, horse, deer and pig impacts can increase the potential for weeds to establish and spread in wetland areas (McDougall et al. 2005). Ski and tourism infrastructure: The development of ski resorts and infrastructure increases the risk of introduced weeds propagating and spreading into nearby areas (McDougall et al. 2005) and affecting alpine bog skink habitat.

[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 population
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 1 in terms of the extent that it is operating on the alpine bog skink. The risk matrix (Table 2) provides a visual depiction of the risk level being imposed by a threat and supports prioritisation for subsequent management and conservation actions. In preparing a risk matrix, several factors have been taken into consideration including the duration of the impact; the spatial extent, and the efficacy of current management regimes, assuming 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 Risk Matrix

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain				Habitat alteration (frequent fire)	Climate change
Likely		Feral pigs Weeds	Deer Development Cat	Horses Fire mortality Loss of genetic diversity	
Possible		Hybridisation			
Unlikely					
Unknown					

Risk Matrix legend/Risk rating:

Low Risk	Moderate Risk	High Risk	Very High Risk

Priority actions have then been developed to address 'very high' (red shading) and 'high' (orange shading) risk threats. Impacts from threats with unknown consequences (cat predation, weeds, hybridisation) are not addressed directly and will best be co-mitigated through management of the very high level and high level threats.

Conservation and recovery actions

Parks Victoria implement ongoing deer, pig and weed control programs to improve the condition and reduce threats to alpine bogs (i.e. alpine bog skink habitat) across the Victorian alpine area, and to maintain the southern alpine area as horse and feral pig free (Paterson 2022 pers. comm. 7 Jan.). In addition, the Alpine National Park Feral Horse Action Plan 2021 (and preceding iterations) provides guidance for actions to significantly reduce the impacts of horses on threatened alpine vegetation communities and fauna habitats, particularly wetlands, alpine bogs and streambanks (i.e. areas alpine bog skinks are known to inhabit).

Commencing in 2020, the Victorian State Government implemented targeted control programs for deer, feral pigs and feral cats in bushfire-impacted areas of the state, including an aerial cull

program in the Alpine National Park, Mount Buffalo National Park, Avon Wilderness Park, and other protected areas outside the distribution of the alpine bog skink (DELWP 2021b). Emerging alpine bog weed infestations are also targeted (Paterson 2022 pers. comm. 7 Jan.).

The Australian alpine bushfire region received funding to support on-ground actions for species and ecological communities that were severely impacted by the 2019–20 fires in southeast Australia. Approximately 5% of this regional budget was allocated to cohesive cross-border fire management planning for both unburnt fire sensitive areas and recently burnt areas (DAWE 2020). In addition, Parks Victoria actively manage fire to prevent the risk of bushfire impacting alpine bogs through planned burning programs (Paterson 2022 pers. comm. 7 Jan.).

Surveys commenced in early 2020 for alpine bog skink and other reptiles in the Victorian alpine region as part of the Victorian Government's Bushfire Biodiversity Response and Recovery program (ARI 2021) to understand the post-fire resilience of alpine reptiles and to increase knowledge about their occurrence and requirements for persistence. The survey program aims to cover the recorded distribution of the alpine bog skink in Victoria, with tissue samples collected to better understand subpopulation interactions and genetic diversity (Clemann 2021 pers. comm. 21 Oct.).

Primary conservation objective

The conservation goal for the alpine bog skink is for a genetically diverse national population to persist long-term in the Australian Alpine Bioregion.

Despite intervention, the alpine bog skink is projected to continue to qualify for listing as threatened under the EPBC Act over the next ten years due to its restricted area of occupancy (well below the eligibility level for Criterion B) and unmanageable threats that will continue to reduce its distribution, occurrence, and availability of habitat as climate change impacts progress. However, considerable progress in alleviating alpine bog skink declines is plausible within the next 10 years by implementing the conservation and management priorities outlined below.

Conservation and management priorities

The alpine bog skink has a significantly increased risk of extinction due to the exacerbation of climate change impacts by interacting threats (Pickering 2007; Haines et al. 2016). To maximise the potential for the alpine bog skink to persist, effective mitigation for threats that can be managed (fire, introduced ungulates, unsustainable development) must be actioned to reduce their compounding impacts as climate change progresses (Haines et al. 2017).

Climate change impacts

- Spatially define proposed areas for large and interconnected alpine bog skink climate refuges using preliminary distribution, altitude and ecosystem association information.
  - Ground-truth areas of potential habitat within proposed climate refuge locations to assess alpine bog skink presence, abundance and threat risk. Review and iteratively finalise climate refuge maps after ground-truthing.
  - Reassess and update climate refuge maps as required when significant new information about alpine bog skink occurrence and/or responses to climate change impacts is discovered.

- Implement effective threat removal and management programs in alpine bog skink climate refuges to exclude fire and introduced ungulates, and ensure development does not have a negative impact on this species, including from habitat degradation.

Ex situ recovery actions

- Where required, develop and implement translocation and/or captive breeding programs to ensure a genetically robust national alpine bog skink population is retained as climate change impacts progress. The National Environment Science Program (NESP) Threatened Species Recovery Hub developed an ex-situ management planning and assessment tool to assist with this process.

Fire impacts

- Continue to develop and implement an effective cross-jurisdictional collaborative regional fire management strategy for the Australian alpine region (see DAWE 2020). The strategy must:
  - Continue to engage and include input from people and organisations with experience managing fire for biodiversity benefits in alpine and adjacent areas including Traditional Owners, and
  - Include secure ongoing funding sources to enable effective fire management for biodiversity benefits in the region, and
  - Include a requirement for all fire management plans and fire management actions within the modelled distribution of the alpine bog skink to consider and mitigate negative impacts to this species and its habitat.
- All fire management plans and actions (municipal, cultural, regional etc.) within, or affecting, areas within the modelled alpine bog skink distribution must:
  - Consider alpine bog skink ecology.
  - Engage with alpine bog skink and habitat experts and Traditional Owners.
  - Identify and delineate alpine bog skink habitat including climate refuges.
  - Avoid physical damage to alpine bog skink habitat during fire management operations.
  - Exclude fire from alpine bog skink habitat, pending further investigations into fire disturbance thresholds.
  - When fire does occur in or near alpine bog skink habitat, implement:
    - Immediate horse, deer and pig control in burnt habitat to facilitate recovery.
    - Ongoing horse, deer and pig control where these species congregate in, or near, unburnt habitat, until surrounding areas recover.
    - Immediate and ongoing feral cat control in and around burnt habitat.
  - Include an adaptive management approach to adjust management actions as new information comes to light about the resilience or susceptibility of the alpine bog skink to fire and interacting threats.

Hard-hoofed animal impacts

- Exclude hard-hoofed animals (horse, deer, pig) from alpine bog skink climate refuges, and continue to alleviate impacts across known, likely and potential alpine bog skink habitat (Map 1).

- Develop restoration programs in consultation with alpine bog skink experts and Traditional Owners to restore habitats impacted by hard-hoofed animals in mapped alpine bog skink climate refuges, and implement the programs.

Development impacts

- Promote and regulate ecologically sustainable development for tourism and other infrastructure in the Australian Alpine Bioregion as outlined by Good (1995). Specifically for the alpine bog skink:
  - All potential impacts from threats outlined in Table 1 must be comprehensively addressed in consultation with alpine bog skink experts during impact assessments for development proposals within the modelled distribution of this species.
  - Construction and maintenance actions must not result in the temporary or permanent loss, degradation or fragmentation of alpine bog skink habitat.
  - Managers and owners of existing developments in mapped alpine bog skink climate refuges must implement maintenance actions that maintain and restore alpine bog skink habitat e.g. bog rehabilitation, ski-run grooming that retains or restores native vegetation cover etc.
  - Managers and owners of existing developments adjacent to mapped alpine bog skink climate refuges must implement maintenance actions that ensure the ongoing integrity of alpine bog skink habitat in the climate refuge.

Stakeholder engagement/community engagement

- All land managers and Traditional Owners within the modelled distribution of the alpine bog skink engage in alpine bog skink conservation by:
  - Understanding the importance of the land they manage to alpine bog skink long-term persistence,
  - Co-developing and implementing adaptive management plans to address threats to the alpine bog skink and its habitat on their land,
  - Co-developing and implementing effective monitoring programs for the alpine bog skink and its threats on their land, and
  - Keeping up-to-date with information that is relevant to alpine bog skink conservation.
- State and Commonwealth environment agency/s co-ordinate, manage, and promote threat mitigation strategies and actions that are relevant to the alpine bog skink.
- State and Commonwealth environment agency/s and research institutions co-ordinate, manage, analyse and distribute mapping and survey information including genetic assessments.
- Local nature conservation groups and other interested parties engage in promotional activities to increase public awareness about, and interest in, alpine bog skink conservation.

Survey and monitoring priorities

- Continue to monitor the alpine bog skink subpopulation and habitat responses to the extensive 2019-2020 fires, prioritising areas:
  - Above 1,200 m elevation, or within climate refuges once mapped.
  - Under direct pressure from very high risk and high risk threats (Table 2).
  - With no/limited subpopulation status or genetic diversity information.
- Develop and implement standardised, comprehensive and coordinated alpine bog skink monitoring across its distribution, prioritising likely and confirmed climate refuges. Include a genetic sampling component where required to confirm species identification and monitor subpopulation levels of genetic diversity.
- Develop and implement a threat impact monitoring program at each location where alpine bog skink threats are, or can be, actively managed and mitigated.
- Implement targeted inventory surveys in accessible alpine areas with the potential for habitat within the modelled alpine bog skink distribution, prioritising alpine locations with potential habitat in NSW.
- Assess the viability of using eDNA for alpine bog skink inventory and/or persistence surveys and implement eDNA-based survey methods if/where feasible.

Information and research priorities

- Continually assess alpine bog skink connectivity and genetic diversity as new subpopulations are sampled and use this information to identify source subpopulations for potential genetic rescue and/or captive breeding programs.
- Develop trigger thresholds and conditions for implementing a genetic rescue program.
- Assess the genetic diversity of monitored alpine bog skink subpopulations at appropriate intervals (e.g. every five years) and evaluate if genetic rescue is required to maintain resilient subpopulations.
- Determine minimum threshold fire intervals for alpine bog skink persistence.
- Investigate the relationships between fire patterns, feral ungulate impacts, and alpine bog skink persistence to determine if disturbance thresholds exist.
- Investigate the impact of post-fire feral cat predation on alpine bog skink subpopulations.
- Investigate the longevity and dispersal capacity of alpine bog skinks.
- Assess the taxonomic validity of alpine bog skink specimen records in NSW.

Links to relevant implementation documents

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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.

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Clemann N & Atkins Z (2021) personal communication via online group meeting on 1 June 2021. Statements reviewed in context and approved by Nick Clemann on 18 November 2021, prior to publication. Nick Clemann and Zak Atkins are alpine bog skink and Australia Alpine Bioregion experts.

Clemann N (2021) personal communications by telephone on 21 October 2021 and by email review in context on 18 November 2021. Statements approved in context prior to publication. Nick Clemann is an alpine bog skink expert from the Threatened Fauna Program at the Arthur Rylah Institute for Environmental Research within the Department of Environment, Land, Water and Planning, Victoria State Government.

Patterson M (2022) personal communication by email on 7 January 2022 about on-ground land management programs that are relevant to the alpine bog skink. Matthew Paterson is the Environment, Land and Water Regional Area Work Co-ordinator (eastern region) for Parks Victoria.

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

Attachment A: Listing Assessment for *Pseudemoia cryodroma*

Reason for assessment

This assessment follows evaluation by experts of the alpine bog skink conservation status following the 2019/20 bushfires.

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 3 includes the key assessment parameters used in the assessment of eligibility for listing against the criteria. The definition of each of the parameters follows the Guidelines for Using the IUCN Red List Categories and Criteria.

Table 3 Key assessment parameters

Metric	Estimate for assessment	Minimum plausible value	Maximum plausible value	Justification
Number of mature individuals	Unknown	Unknown	Unknown	No population estimates are available for this cryptic species, which is challenging to identify (Haines et al. 2014). However, it can be locally common in isolated areas of habitat (Clemann et al. 2019; 2021 pers. comm. 18 Nov).
Population Trend	Past and future decline of 0-30 %	No decline	> 30 % decline	An expert elicitation process was completed in the absence of monitoring data to assess the impacts of the 2019–2020 fires (Legge et al. 2021a). There is high uncertainty in the 10-year projected population response, with a range from 30 % decline to 5 % increase, assuming no further impacts from fire over that period. Increased fire intensity and frequency is already occurring in southeast Australia due to climate change and this trend is anticipated to continue (Pickering 2007) making a second high intensity fire event plausible within the 10-year recovery period (Hennessy et al. 2005).
	Declining			Inferred from field observations of habitat loss and degradation (DELWP 2021a; Clemann 2021 pers. comm. 19 Nov).
Generation time (years)	3 years i.e. a 10-year assessment period	2	3	Estimated at 2–3 years based on a longevity of 5 years and maturity at 1 year (DELWP 2021a), and no indication of an increase or decrease in breeding success with age.

Metric	Estimate for assessment	Minimum plausible value	Maximum plausible value	Justification
Extent of occurrence (EOO)	16 000 km^2	15 436 km^2	16 280 km^2	Minimum convex polygon estimate of 16 280 km^2 from point records (years 2000–2020); minimum plausible value of 15 436 km^2 from Clemann et al. (2019).
EOO Trend	Projected decline			Projected future contraction due to habitat alteration and upward migration caused by climate change (Haines et al. 2017; Camac et al. 2021).
Area of Occupancy (AOO)	200 km^2	192 km^2	228 km^2	Three estimates are available using 2 x 2 km grid cells (IUCN 2019), ranging from 192–499 km^2: • 499 km^2 as part of the IUCN Red List assessment (Clemann et al. 2018). • 228 km^2 for *The Action Plan for Australian Lizards and Snakes 2017* (Clemann et al. 2019). • 192 km^2 for the Victorian Conservation Status Assessment, prepared at the state scale (DELWP 2021a). Clemann (2021 pers. comm. 21 Oct) considers the more recent estimates to be the most representative due to the earlier figure being an overestimate.
AOO Trend	Ongoing and projected decline			Suspected to be contracting due to habitat loss from successive widespread high intensity fires across its distribution – including the 2019–2020 fires – and widespread habitat degradation and loss from introduced ungulates, primarily horses (Robertson et al. 2019; Parks Victoria 2017; 2021). AOO is projected to further contract in the future due to habitat alteration and altitude migration caused by climate change (Haines et al. 2017; Camac et al. 2021).
Number of subpopulations	10	8	12	Haines et al. (2017) identify fives genetically and geographically distinct subpopulations from six sampled locations in Victoria: Bogong High Plains, Mt Higginbotham, Mt Buller and Mt Stirling, Lake Mountain, and Mt Baw Baw. This is supported by Amor et al. (2021). A further 3–7 unsampled subpopulations are plausible based on Haines et al. (2017): Mount Buffalo, Bennison High Plains, and Cobberas are certain to be additional isolated subpopulations. Within these, based on altitudinal separation into sky islands (Map 1), 1–3 subpopulations are plausible within the Bennison High Plains area and 1–3 subpopulations are plausible within the Cobberas area.
Number of subpopulations trend	Unknown			Expected to decline in the future as subpopulations are lost due to habitat alteration and upward migration beyond hilltops, but also to increase as subpopulations become fragmented and reproductively isolated.

Metric	Estimate for assessment	Minimum plausible value	Maximum plausible value	Justification
Number of locations	2-5	2	5	The most imminent threat with the lowest plausible number of locations is fire. The alpine bog skink can be undetectable at known locations for up to 12 years post-fire (Howard et al. 2012; Amor et al. 2021; Clemann 2021 pers. comm. 18 Nov). The extent of wildfire cover in Victoria, as observed in 2003, 2006–2007 and 2019–2020, demonstrates that a single extreme wildfire event could burn the majority of the alpine bog skink distribution (DELWP 2021a; Legge et al. 2021a) and two adjacent and extreme wildfire events in short succession could burn the entire range (DELWP 2021a). This low likelihood but plausible scenario under current fire regimes provides a lower estimate of 2 locations. An estimated 22 % of the alpine bog skink distribution burnt in high to very high intensity fires during the 2019–2020 wildfire season (Legge et al. 2021a). This current observation information provides an upper plausible estimate of 5 locations. In contrast to pre-colonisation, the frequency of wildfire events now and predicted into the future (Williams et al. 2008) is suspected to provide insufficient opportunity for alpine bog skink subpopulations to recover prior to the next fire event (Legge et al. 2021a).
Number of locations trend	Unknown			
Fragmentation	Not severely fragmented.			The national alpine bog skink population is naturally fragmented, and fragmentation is predicted to increase as climate change impacts proceed (Haines et al. 2017; Clemann et al. 2019). Extirpated subpopulations are highly unlikely to be re-colonised without assistance due to a low estimated dispersal distance of tens of metres, limited genetic flow between current subpopulations, and increasing distances separating subpopulations into sky islands (Sato et al. 2014a; Haines et al. 2017). However, all five (of at least eight) subpopulations surveyed are currently considered viable based on an inbreeding depression analysis (Haines et al. 2017).
Fluctuations	Not a fluctuating taxon.			Australian skinks are not known to experience 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

Not eligible

The alpine bog skink has an inferred generation length of 2–3 years and therefore an assessment period of ten years is appropriate for analysing population trends.

There are no standardised alpine bog skink monitoring programs to enable an assessment of national population trends. An expert elicitation program to estimate the impacts of the 2019–2020 fires on the national alpine bog skink population resulted in widely varying values from 5 % increase to 30 % decline over ten years, assuming no further impacts from fire (Legge et al. 2021a). Future impacts from more frequent and intense fires across the distribution and habitats of the alpine bog skink are predicted, meaning the projected declines are likely to be an underestimate.

Although these figures suggest the species could be eligible for listing under Criterion 1, there is insufficient empirical data to support the estimates and therefore significant uncertainty, including a predicted increase. Following assessment of the data the Committee has determined that the alpine bog skink is not eligible for listing in any category under this criterion because the past, current or future population declines are thought unlikely to exceed 30 % in any 3-generation period.

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 Criterion 2 B2ab(i,ii,iii,iv) for listing as Endangered.

The alpine bog skink estimated extent of occupancy (EOO) is 16 000 km², meeting the threshold for Vulnerable under Criterion B1, and the estimated area of occupancy (AOO) is 200 km², meeting the threshold for Endangered under Criterion B2.

Alpine bog skink subpopulations, although isolated, are considered genetically viable. Therefore the national population is not considered to be severely fragmented as per the IUCN guidelines. The national population is projected to become severely fragmented with low genetic diversity under future climate scenarios, however projection cannot be used for this sub-criterion.

The threat with the lowest number of locations is fire, with a lower plausible value of two and an upper plausible value of five. A range of 2-5 locations is used in this analysis to account for significant year-to-year variation in fire severity and extent.

A continuing decline in AOO is inferred due to an observed decline in habitat quality and extent caused by widespread high severity fires and the widespread impacts of horses. EOO, AOO, habitat quality and extent, and the number of subpopulations are all projected to decline in the future as climate change progresses and habitat at lower altitudes becomes inhospitable.

The Committee considers the alpine bog skink eligible for listing as Endangered B2ab(i,ii,iii,iv) under Criterion 2 due to a restricted area of occupancy (~200 km²) combined with a restricted number of locations in relation to fire impacts (4–5), and observed and projected continuing declines extent of occurrence, area of occupancy, habitat area, extent and quality, and number of subpopulations. The Committee notes the alpine bog skink is also eligible under this criterion as Vulnerable B1ab(i,ii,iii,iv).

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**
(a) (ii) % of mature individuals in one subpopulation =	**90 – 100 %**	**95 – 100 %**	**100 %**
(b) Extreme fluctuations in the number of mature individuals			

Criterion 3 evidence

Insufficient data to determine eligibility.

There are no population estimates available for the alpine bog skink. Therefore, the Committee considers there is insufficient information to determine the eligibility for alpine bog skink to be listed under Criterion C.

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

Insufficient data to determine eligibility.

There are no population estimates available for the alpine bog skink. Therefore, the Committee considers there is insufficient information to determine the eligibility for alpine bog skink to be listed under Criterion D.

The alpine bog skink is estimated to occur in ≤ 5 locations, however it currently has an area of occupancy much larger than 20 km² (~200 km²) and there are no conceivable threats that could drive this species to qualify for Critically Endangered or Extinct within two generations i.e. 6 years. Therefore, the alpine bog skink has not met the required elements of Criterion D2.

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 eligibility of the alpine bog skink for listing under this criterion.

Adequacy of survey

Survey effort and population monitoring information for the Alpine bog skink are both limited. Inventory surveys in remote areas and sustained repeatable survey effort – as outlined in the conservation and management priorities section – is required to effectively manage conservation planning and implementation for this species (see Legge et al. 2021b).

Public consultation

Notice of the proposed amendment and a consultation document is made available for public comment for a minimum of 30 business days. Any comments received that are relevant to the survival of the alpine bog skink will be considered by the Committee as part of the assessment process.

Listing and Recovery Plan Recommendations

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

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 Pseudemoia cryodroma* (alpine bog skink, Canberra. 

This publication is available at the SPRAT profile for *Pseudemoia cryodroma* (alpine bog skink).

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Version history table

Document type	Title	Date
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