

Consultation on Species Listing Eligibility and Conservation Actions

Nannoperca oxleyana (Oxleyan Pygmy Perch)

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

1) the eligibility of *Nannoperca oxleyana* (Oxleyan Pygmy Perch) for inclusion on the EPBC Act threatened species list in the Endangered category; and

2) the necessary conservation actions for the above species.

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

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

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

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

Please include species scientific name in Subject field.

or by mail to:

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

Responses are required to be submitted by 5 January 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/recovery-plans.

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

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

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

Privacy notice

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

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

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

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

Information about this consultation process

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

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

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

CONSULTATION QUESTIONS FOR NANNOPERCA OXLEYANA (OXLEYAN PYGMY PERCH)

SECTION A - GENERAL

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

PART 1 – INFORMATION TO ASSIST LISTING ASSESSMENT

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

Biological information

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

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

Population size

- 6. Has the survey effort for this taxon been adequate to determine its national adult population size? If not, please provide justification for your response.
- 7. Do you consider the way the population size has been derived to be appropriate? Are there any assumptions and unquantified biases in the estimates? Did the estimates measure relative or absolute abundance? Do you accept the estimate of the total population size of the species/subspecies? If not, please provide justification for your response.
- 8. If not, can you provide a further estimate of the current population size of mature adults of the species/subspecies (national extent)? Please provide supporting justification or other information.

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

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

□ 1–50 □ 51–250 □ 251–1000 □ >1000 □ >10 000

Level of your confidence in this estimate:

- \Box 0–30% low level of certainty/ a bit of a guess/ not much information to go on
- \Box 31–50% more than a guess, some level of supporting evidence
- \Box 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

<u>SECTION D</u> 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 2010s *(at or soon after the start of the most recent 10-year 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:

□ 1–50 □ 51–250 □ 251–1000 □ >1000 □ >10 000

Level of your confidence in this estimate:

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

] 51–95	% - re	easonably	certain,	information	suggests	this I	range
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95–100% - high level of certainty, inform	nation indicates quantity within this range
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- \Box 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 10 years (i.e.,10-year period)? Please provide justification for your response.

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

Decline estimated to be in the range of:

□ 1–30% □31–50% □51–80% □81–100% □90–100%

Level of your confidence in this estimated decline:

- \Box 0–30% low level of certainty/ a bit of a guess/ not much information to go on
- \Box 31–50% more than a guess, some level of supporting evidence
- \Box 51–95% reasonably certain, suggests this range of decline
- 95–100% high level of certainty, information indicates a decline within this range
- \Box 99–100% very high level of certainty, data are accurate within this range
- 12. Please provide (if known) any additional evidence which shows the population is stable, increasing or declining.

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

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

- 13. Does the assessment consider the entire geographic extent and national extent of the species/subspecies? If not, please provide justification for your response.
- 14. Has the survey effort for this species/subspecies been adequate to determine its national distribution? If not, please provide justification for your response.
- 15. Is the distribution described in the assessment accurate? If not, please provide justification for your response and provide alternate information.
- 16. Do you agree that the way the current extent of occurrence and/or area of occupancy have been estimated is appropriate? Please provide justification for your response.
- 17. Can you provide estimates (or if you disagree with the estimates provided, alternative estimates) of the extent of occurrence and/or area of occupancy?

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

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

 \Box <100 km² \Box 100 – 5 000 km² \Box 5 001 – 20 000 km² \Box >20 000 km²

Level of your confidence in this estimated extent of occurrence

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

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

 \Box 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:

 \Box <10 km² \Box 11 – 500 km² \Box 501 – 2000 km² \Box >2000 km²

Level of your confidence in this estimated extent of occurrence:

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

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

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

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

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

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

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

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

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

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

 \Box <100 km² \Box 100 – 5 000 km² \Box 5 001 – 20 000 km² \Box >20 000 km²

Level of your confidence in this estimated extent of occurrence

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

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

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

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

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

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

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

 \Box <10 km² \Box 11 – 500 km² \Box 501 – 2000 km² \Box >2000 km²

Level of your confidence in this estimated extent of occurrence:

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

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

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

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

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

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

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

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

PART 3 – ANY OTHER INFORMATION

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

Conservation Advice for *Nannoperca oxleyana* (oxleyan pygmy perch)

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

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

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

This document combines the draft conservation advice and listing assessment for the species. It provides a foundation for conservation action and further planning.



Nannoperca oxleyana © Copyright, John Esdaile (from Atlas of Living Australia) (<u>https://fishesofaustralia.net.au/home/species/1829</u>)

Conservation status

Nannoperca oxleyana (oxleyan pygmy perch) is listed in the Endangered category of the threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act) effective from 16 July 2000. The species is eligible for listing because prior to the EPBC Act, it was listed as Endangered under the *Endangered Species Protection Act 1992* (Cwlth).

Nannoperca oxleyana (oxleyan pygmy perch) was assessed by the Threatened Species Scientific Committee to be eligible for retention in the Endangered category under Criterion 2. The Committee's assessment is at Attachment A. The Committee assessment of the species' eligibility against each of the listing criteria is:

- Criterion 1: Insufficient data
- 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 species eligible for listing in the Endangered category are a continuing decline in the habitat and estimated area of occupancy (AOO), and severely fragmented population.

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

Species information

Taxonomy

Conventionally accepted as Nannoperca oxleyana Whitley (1940).

Description

The oxleyan pygmy perch is a very small perch-like freshwater fish restricted to the Oxleyan faunal region of coastal mid-eastern Australia (Whitley 1940 cited in Knight 2016). The species can reach up to 60 mm but more commonly grows to 45 mm (Pusey et al. 2004; Knight et al. 2012). The species is characterised by a laterally compressed body covered by scales with a comb-like edge (found in higher order teleost fishes) and a square (truncate) caudal fin (Pusey et al. 2004). The dorsal fin is deeply notched with six to eight spines and seven to nine rays; the anal fin consists of three spines and seven to nine rays (Kuiter & Allen 1985, and Whitley 1940 cited in Knight 2016). Further distinguishing features include the absence of a lateral line, a small mouth with jaws reaching to below the pupil and enlarged teeth in the front of its lower jaw (Pusey et al. 2004). The body is mottled light brown to olive in colour, darker on the back, and paler on the sides with three to four patchy dark brown bars extending from head to tail. There is a prominent round black spot with an orange margin at the base of the caudal fin. The fins are mainly clear except during breeding when males develop more intense red and brown fin and body colouration, and have jet-black pelvic fins (Knight et al. 2007). Females also

undertake a similar colour transformation during breeding, however changes are less intense and the pelvic fins remain transparent (Knight et al. 2007).

Distribution

The oxleyan pygmy perch is confined to freshwater systems draining through sandy coastal lowlands ('wallum') ecosystems in northern New South Wales (NSW) and southern Queensland (Qld) (Arthington 1996; Knight 2000; Pusey et al. 2004). The oxleyan pygmy perch is the most northerly distributed of the Australian pygmy perches (*Nannoperca* and *Nannatherina* spp.) (Unmack et al. 2011). The species range extends from Coongul Creek on K'gari (Fraser Island), Qld (25º 16'S, 153º 09'E) south to Tick Gate Swamp near the township of Wooli, NSW (29º 54'S, 153º 15'E) and stretches across approximately 534 km of coastline (Knight & Arthington 2008; TSSC 2016) (Table 1, Map 1). The species range is separated into northern (Qld) and southern (NSW) subpopulations disconnected by a distance of 250 km (Knight 2016). The northern subpopulations are rarer and more fragmented than the southern subpopulations; small subpopulations are spread across three isolated, mainland drainages throughout the Mary, Noosa and Maroochy river catchments as well as a number of small coastal catchments, and 15 discrete drainages distributed across K'gari, Moreton and North Stradbroke islands (Knight & Arthington 2008; Knight 2016). The southern subpopulations have contracted in range; subpopulations are found in 86 waterbodies within 67 permanently connected drainage systems located within eight subcatchments of the Richmond and Clarence river catchments (Knight 2016 and references therein). Southern subpopulations extend approximately 100 km inland, and are encompassed by, or adjacent to, the Broadwater, Bundjalung and Yuraygir National Parks (Knight 2016). One of the southern subpopulations is located on Commonwealth land (Table 1) (Knight et al. 2009).

A number of historic localities of the species collected prior to 1976 no longer exist due to land development, e.g., Beerwah, Noosa and Maryborough in Qld, and Bookram Creek and Cassons Creek in NSW (Knight 2016). Some records of natural species occurrence are also erroneous. For example, a sole record in the Pine River Basin included a translocation of the species into a farm dam which no longer exists (R Wager 2016. pers comm cited in Knight 2016). New localities of the species are also being documented such as the subpopulation identified in 2007 near Red Rock, NSW, extending the known range south of Yuraygir National Park, and the subpopulations identified between 2013 and 2015 as part of the Pacific Highway Upgrade to the west of Bundjalung National Park (NSW DI 2015). However, spatially explicit information to support these new localities are unavailable.



Map 1 Modelled distribution of the oxleyan pygmy perch

Source: Base map Geoscience Australia; species distribution data <u>Species of National Environmental Significance</u> database. **Caveat:** The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything containing herein.

Species distribution mapping: The species distribution mapping categories are indicative only and aim to capture (a) the 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.

State	Catchment /Region	Localities present# (year)	Localities absent	Land Status	Source
Qld	K'gari	Rocky Ck (1994), Bogimbah Ck (1984, 1987, 1990, 2021), Moon Point (1996, 2013), Coongul Ck (1987, 1990), Woralie Ck (1970, 1984, 1985, 1990, 2021).	Moon Point^	National Park	WildNet database (2021); Kennard et al. (unpublished data); Arthington (1996)
	Mary River Catchment	Coondoo Ck (1994), Tiana Ck (1997).		State Forests.	WildNet database (2021); Kennard et al. (unpublished data) Arthington (1996)
	Noosa River Catchment, Rainbow Beach	Rainbow Beach (1996), Searys Ck (1992, 1993), Carland Ck (1982, 1992, 1993, 2021), Noosa River and tributaries (1970, 1972, 1985, 1990, 1993, 2000, 2021), Kin Kin Ck.	Western catchment from Rainbow^, some locations along backwaters of the Noosa River and its tributaries^	State Forest, private land and crown land	WildNet database (2021); Kennard et al. (unpublished data); Arthington (1996)
	Noosa River Catchment, Noosa Heads	Marcus Ck (1993), Marcus Beach (1978, 1982, 1993), near Lake Weyba (1981).		National Park, private land	WildNet database (2021); Arthington (1996)
	Maroochy River Catchment, Yandina	Maroochy River (1970), Coolum Ck Conservation Park (1970).		Private land (farm) and Conservation Park	WildNet database (2021)
	Maroochy River Catchment, Beerwah	Bluegum Ck (1994, 2004–2010), Mellum Ck (1987, 1990).		National Park and State Forest	WildNet database (2021); Kennard et al. (unpublished data), Arthington (1996)
	Moreton Island	Lake Jabiru/Jabiru Swamp (1988, 1993, 2009, 2010), Spitfire Ck (1982, 1988, 1993, 1999, 2008, 2009, 2010, 2021), Blue Lagoon (1975, 1999, 2008, 2009, 2010), North Warrajamba Ck (1999, 2008, 2009, 2010), South Warrajamba Ck (1999, 2008, 2009, 2010), unnamed Ck south	Blue Lagoon and adjacent Honeyeater Lake [^] , unnamed Ck south of Blue Lagoon [^]	National Park, private land	WildNet database (2021); Kennard et al. (unpublished data), Arthington (1996)

Table 1 Recorded distribution of the oxleyan pygmy perch

	North	of Blue Lagoon (1993), Ben Ewa Swamp, Creeks between Bulwer and Tangalooma airport (Tempest Ck, Cravens Ck (1940, 1985, 1993, 1999, 2009, 2010, 2021). Little, Canalpin Ck, 18 Mile		National Park	WildNet database
	Stradbroke Island	Swamp (1994, 2002) Freshwater Ck (2007).			(2021); Arthington (1996)
NSW	Richmond River Catchment	Richmond river tributaries including Riley's Hill Canal (2001, 2019,), McDonalds Ck tributaries (2001, 2020), Evans River tributaries (2001, 2012, 2019), Bullocky Ck and adjacent wetlands (2002), Culvert Ck (2002).		Private land (rural), National Park, Commonwealth land	WildNet database (2021); ALA (2021); Arthington (1996); Knight (2016); Bruce et al. (2019); Kennard et al. (unpublished data)
	Clarence River Basin, Esk River subcatchment	Esk River subcatchment (2001) including near Gap Rd (2002, 2012, 2019), Jerusalem Ck (2002), Wendoree Lagoon (2002, 2012), Tee Tree Swamp (2002), Little Marsh (2002), Tabbimoble Ck (2014).	Esk River subcatchment [^] , near Gap Rd [^] , Jerusalem Ck [^] , Wendoree Lagoon ^{*^} , vicinity of Little Marsh and North Lake ^{*^}	National Park, private land	Knight (2016); ALA (2021); Bruce et al. (2019).
	Clarence River Catchment, Angourie	Mara Ck (2002), Wooloweyah Lagoon tributary (2002) including Hayley's Ck tributary (2002).	Mara Ck*, Hayley's Ck tributary*	National Park	Knight (2016); Bruce et al. (2019)
	Bellinger River Catchment, Wooli	Lake Minnie Water and surrounds (2002, 2019, 2020), Lake Hiawatha (2002), un-named creeks by Diggers camp Rd and Wooli Rd (2002, 2013, 2019, 2020), Wooli Wooli River (2012, 2020), Tick Gate Swamp (2002).	Wooli River^, Tick Gate Swamp*	National Park, State Forest	Knight (2016); Bruce et al, (2019); ALA (2021); Kennard et al. (unpublished data).

*Bruce et al. (2019); ^Kennard et al. (unpublished data); # the species is found in slow-flowing pools and backwaters of river channels and tributaries as well as in swampy drainages, lakes, ponds and dams associated with these localities.

Cultural and community significance

The cultural significance of the oxleyan pygmy perch is unknown. However, coastal lowland wallum swamps and wetlands are of material and cultural importance to Indigenous people (Barry 2010; Rissik et al. 2011). The oxleyan pygmy perch has been located in wallum habitat on Aboriginal land west of Bundjalung National Park in NSW (NSW DPI 2005a) and there are several locations where the oxleyan pygmy perch is located on Aboriginal Land in Qld (e.g., Moreton Island and North Stradbroke Island). At least one of these Qld sites dates back to the late Pleistocene (20 560 BP) from Wallen Wallen Creek on North Stradbroke Island (Robins et al. 2015).

Areas where the species have been recorded are located within the regions of the Badtjala, Gubbi Gubbi, Yuggera, Bundjalung and Gumbainggir people, according to the Map of Indigenous Australia (AIATSIS 1996). The Dirawong Reserve trust indicated support for the species Recovery Plan when consulted on the draft Plan (NSW DI 2015). Indigenous management of threatened fish species is implemented more broadly in NSW through the Indigenous Fisheries Strategy. Further work should determine whether the oxleyan pygmy perch is of specific interest to the Indigenous community in Qld and seek opportunities for awareness and comanagement of the species.

Relevant biology and ecology

Habitat Ecology

The oxleyan pygmy perch is restricted to dystrophic, acidic (pH< 7), freshwater systems draining through sandy coastal lowlands ('wallum') ecosystems (Knight & Arthington 2008). Wallum country is characterised by *Banksia*-dominated heath vegetation growing on siliceous (quartz-dominated) sands (Griffith et al. 2003). The species is found only in oligotrophic, slow-flowing pools and backwaters of river channels and tributaries as well as in swampy drainages, lakes, ponds and dams (Knight & Arthington 2008). The habitat ranges from low conductivity, clear waters (pH 6 to 6.5) to darkly stained acidic waters (pH 4 to 6), over siliceous sands (NSW DPI 2005b). Individuals are found closely associated with structural aquatic vegetation in the form of beds of emergent or submerged plants, the presence of steep/undercut banks fringed with semi-submerged branches, and fine rootlets of riparian vegetation or leaf litter and snags (Knight & Arthington 2008).

Population Biology and Dynamics

The abundance of the oxleyan pygmy perch appears to vary between localities; the species is prominent at some locations and rare in others (Arthington 1996; Pusey et al. 2004; Knight 2016). For example, sampling of the subpopulation within the Esk River catchment in Bundjalung National Park recorded ~100 individuals, making up 55% of the total fish catch amongst all sampled areas; at other sites located within the same drainage system considerably fewer fish were caught (~3% of the total catch) (Knight et al. 2016). Population fluctuations over time have also been observed at several sites. For example, the owere found in Blue Lagoon on Moreton Island in 1976 and not again until 2000, despite several surveys carried out throughout the 1980s (Moss et al. 1990; Arthington 1996; NSW DPI 2005b). Overall however, the species abundance at individual sites is low (Arthington & Marshall 1996; Pusey et al. 2004;

Page et al. 2012), even for secure subpopulations in well-protected areas in National Parks (Rissik & Esdaile 2011; Marshall et al. 2011).

The species is also missing in sites of potential habitat. For example, less than 20% of all suitable waterbodies surveyed in NSW contained the oxleyan pygmy perch (Knight 2016). The abundance of the oxleyan pygmy perch is dependent on habitat characteristics (e.g., lacustrine [lake], palustrine [wetlands] or riverine ecosystems[rivers and creeks], presence of riparian vegetation), seasonal variation (i.e., spawning periods versus non-spawning periods), and threatening process (e.g., invasive species, competition with native species, drought) (Knight & Arthington 2008; Knight 2016). Routine surveys conducted by the NSW Department of Primary Industries (DPI) between 2008 and 2012 at 11 sites across the species range in NSW suggested a declining abundance at most sites and the species was absent at some sites where it had been detected previously (NSW DI 2015). Similar findings have been observed across the known range for the species since 2019 (Table 2, Bruce et al. 2019; Kennard et al. unpublished data).

The oxleyan pygmy perch has a lifespan of 6.5 years in the wild and 6 years in aquaria (Knight et al. 2012). The species has an estimated generation length of 2.3 years (Butler et al. 2019) or 2.75 years (Kennard et al. unpublished data). The oxleyan pygmy perch are carnivores and feed on prey <5–6 mm in length including zooplankton, aquatic insects, atyid shrimps, terrestrial arthropods and flying aquatic insects (Pusey et al. 2004). Adults have been observed foraging alone or in pairs along the stems of aquatic plants, while younger fish forage in groups of three or four (Arthington 1996).

Reproductive Ecology

The reproductive biology of the oxleyan pygmy perch has been studied in both captive and wild populations (Wager et al. 1992; Kuiter et al. 1996 cited in NSW DPI 2005; Pusey et al. 2004; Knight et al. 2007). Knight et al. (2007) confirmed that captive broodfish mirror those in wild populations, with minor differences in length at maturity dependent on location. The minimum length at maturity for females and males at Spitfire Creek in Qld is 19mm, compared to 20 mm and 23 mm at Evans Head, NSW, respectively (Knight et al. 2012). The minimum age at maturity in the wild is 8 and 18 months for females and males, respectively (Knight et al. 2012) and 4–5 months in aquaria (Pusey et al. 2004). Spawning occurs from September to May, with peak periods observed from October to December (Arthington 1996; Pusey et al. 2004; Knight et al. 2012) and from February to April (Knight et al. 2012). The spawning season is marked by a change in body colour with males showing more intense changes (see Description section). Spawning has been shown to be induced by an increase in water temperature >20°C (Pusey et al. 2004 and references therein; Miller et al. 2018).

The reproductive behaviour of the oxleyan pygmy perch has only been studied in aquaria. Courtship and mating rituals appear to vary: casual interludes have been observed where pairs approach each other and quickly shudder to release eggs and milt (Wager et al. 1992); territorial behaviour has also been expressed, where the female approaches the male's territory (spawning site containing submerged substrate) before uniting temporarily to release eggs and sperm (Knight et al. 2007). Pairs serially spawn during the day throughout the breeding season (mean of 57 per cent of the time) and release an average of eight eggs per day (range of 1–51 eggs per day) (Knight et al. 2007). The mean fecundity of captive females is 1323 eggs (range 405–2045) over one breeding season and the relative fecundity is 587 eggs per gram of body mass (Knight et al. 2007). The fecundity of wild populations is likely to be lower. For example, Arthington (1996) estimated the fecundity at 225–270 eggs, although this low number could be explained by the time of collection, which took place toward the end of the breeding season.

The oxleyan pygmy perch reproductive strategy is thought to be an adaptation to the harsh and intermittent environment that the species occupies, because if environmental conditions change the impact overall is minimal due to the small investment in each batch (spawn) (Knight et al. 2007). Further, it also enables a greater number of eggs to be produced than would otherwise be possible given their small body size (Wootton 1992 cited in NSW DPI 2005b). Eggs sink once released and adhere to aquatic vegetation or substrate (Pusey et al. 2004). Males have also been observed to display simple parental care involving guarding the eggs and larvae (Knight et al. 2007), which had not observed previously (Wager 1992; Pusey et al. 2004).

The eggs of the oxleyan pygmy perch are typical of those of most teleosts, follow the general pattern of embryogenesis, and are morphologically similar to those described for other Nannoperca species (Pusey et al. 2004; Knight & Trnski 2011 and references therein). Development of the eggs is similar to that of *N. australis* (Southern Pygmy Perch), although the oxleyan pygmy perch has a faster development rate (Knight & Trnski 2011). The morphology of the larvae is similar to other percichthyids in Australia, however there are some differences that make the oxleyan pygmy perch distinguishable, e.g., identifying qualitative features such as the number of scales, pigmentation patterns and an absence of larval specialisations such as an absence of preopercular spines during larval development (Knight & Trnski 2011). Larvae hatch within two (Knight & Trnski 2011) to four days (Legget & Merrick 1987; Wager 1992) depending on temperature. Four to five days post-hatching marks a transitional period where larvae begin actively searching for food as well as absorbing egg yolk (Knight & Trnski 2011). Nine to 12 days post hatching, larvae switch to full exogenous feeding, during which mortality rates increase from 30% (<10 days post hatching) to 90% (>10 days post hatching) (Knight & Trnski 2011). The length of individuals from wild populations have been observed to increase from 14 mm to >28 mm (total length) over a one year period (NSW DPI 2005b).

Genetics

The oxleyan pygmy perch is the most divergent of the *Nannoperca* spp., with a divergence time of 12 (±0.01) million years (Buckley et al. 2018). Oxleyan pygmy perch have a very low heterozygosity within subpopulations (Hardy-Weinberg equilibrium (HWE) average 0.016), which is considered low for freshwater fish (HWE average 0.046) (Ward et al. 1994; Hughes et al. 1999). This indicates that the oxleyan pygmy perch has very limited dispersal abilities currently. Subpopulations appear to be connected only where they share the same drainage system, such as Lake Jabiru and Spitfire Creek, on Moreton Island, Qld (Hughes et al. 1999). Distinct genetic differentiation is apparent among the Qld subpopulations, for example between Moreton Island, K'garid and the Noosa River subpopulations (Hughes et al. 1999) and the NSW subcatchments (Knight et al. 2009). This indicates that the majority of subpopulations have been isolated from each other for a considerable length of time. However, of the nine haplotypes detected in the species, one was distributed over the majority of the species range in both NSW and Qld, indicating historical connectivity which likely occurred during periods of lower sea levels (Hughes et al. 1999; Knight et al. 2009).

Two subpopulations were identified as having the highest haplotypic diversity (h); South Evans Head, NSW (h 0.594) and Marcus Creek, Qld (h 0.475) (Knight et al. 2009). These two subpopulations were vastly higher than remaining subpopulations included in the study (h range 0–0.594), indicating that these subpopulations should be prioritised for special management, particularly as source populations for captive breeding programs and as sites prioritised for rescue given future climate change impacts.

Habitat critical to the survival

Habitat critical to the survival of the oxleyan pygmy perch includes all known and likely locations where the species is found. The species is found in habitat defined to have the following chracteristics:

- freshwater systems draining through sandy coastal lowland 'wallum' ecosystems including palustrine and lacrustrine environments;
- slow-flowing pools and backwaters of river channels and tributaries;
- water bodies with structural aquatic vegetation in the form of beds of emergent or submerged plants;
- presence of steep/undercut banks fringed with semi-submerged branches, and fine rootlets of riparian vegetation or leaf litter and snags;
- oligiotrophic waters: and
- clear waters (pH 6 to 6.5) to darkly stained acidic waters (pH 4 to 6).

Habitat critical to survival also includes adjacent subcatchments, not currently found to contain the species, that facilitate fish passage and connection between subpopulations during high and low flow events. Habitat critical also includes additional occurrences of similar habitat outside of the known range for the species that may have contained the species in the past and may be suitable for translocations to facilitate natural range expansion.

No Critical Habitat as defined under section 207A of the EPBC Act has been identified or included in the Register of Critical Habitat. A process for declaring critical habitat for this species was initiated in NSW under state legislation (Knight et al. 2012). However, the potential impacts on operational matters of local authorities (such as fire hazard reduction) prevented the process from continuing (NSW DI 2015).

Important populations

Due to the small size of known populations of the oxleyan pygmy perch, all subpopulations within each drainage system are considered important populations due to their likely role in maintaining connectivity between subcatchments, important for breeding and dispersal. Subpopulations located in south Evans Head, NSW and Marcus Ck, Qld, are particularly important populations for the maintenance of genetic diversity necessary for the ecological survival of the species (Knight et al. 2009).

Threats

The freshwater coastal lowland wallum ecosystems of South-east Qld and Northern NSW, where oxleyan pygmy perch persist, have been substantially reduced through clearing for urban development, agriculture, forestry production and sand mining throughout the 20th century (Pusey et al. 2004; Knight 2016). For example, oxleyan pygmy perch habitat has become highly

fragmented and subpopulations of the oxleyan pygmy perch have seen a substantial reduction in distribution and abundance because of habitat modification, disturbance and loss (Knight 2016). Within NSW and the sand islands of Qld, the majority of remnant subpopulations are protected in, or adjacent to, coastal National Parks, Ramsar sites (Morton Island and parts of North Stradbroke and K'gari) and World Heritage-listed areas (K'gari) and thus threatening process have been considerably reduced. Within mainland Qld, the majority of subpopulations occur within private land, State Forests or Crown Land and are still susceptible to threats. However, the emerging threat of climate change (fire and drought) presents a risk to all subpopulations of the oxleyan pygmy perch. Further, the cumulative impact of these threats and the interaction between multiple threats could lead to synergistic effects and the extinction of entire subpopulations (Knight et al. 2012).

Active rescue and translocations from severely impacted sites from threats such as drought and fire are a prioritised management response in NSW (NSW DI 2015; Bruce et al. 2019). These interventions are not reflected in Qld (DAWE 2020).

Threat	Status and severity ^a	Evidence
Habitat loss, dist	urbance and modification	
Land clearing for development and agriculture	 Timing: historical/current/future Confidence: observed Consequence: major Trend: static/increasing Extent: across part of its range 	Land clearing for urban development and agriculture has had a substantial impact on the habitat and distribution of the oxleyan pygmy perch (Knight et al. 2012; Knight 2016). Land clearing drains wetlands, and fragments and degrades large areas of wetland habitat (NSW DPI 2005b; Knight 2016). The hydrological impacts of clearing on drainage is responsible for the current limited distribution of the oxleyan pygmy perch, as freshwater, coastal, lowland wallum ecosystems used to occupy a vast majority of land throughout south-east Qld and northern NSW, extending beyond the current species range (Arthington & Marshall 1996). For example, subpopulations have been extirpated at Coraki and Cassons creeks, Evans Head (Knight 2016) and in the Greater Brisbane Area as a direct consequence of land clearing and conversion (Arthington & Marshall 1996). The majority of NSW subpopulations and several subpopulations in Qld are protected inside National Parks and RAMSAR sites; however, land clearing is still a threat to subpopulations on private land, state forest or other crown land. For example, freshwater coastal lowland wallum ecosystems are still cleared for land development in Qld, such as the development currently taking place in Caloundra South (Sunshine Coast Council 2021). Land clearing increases the impacts associated with other threats including habitat disturbance and modification, invasive species, low genetic diversity and climate change related threats. Land clearing is an ongoing threat for subpopulations
Drainage	 Timing: historical/current/future Confidence: observed Consequence: major Trend: static/increasing Extent: across part of its range 	Drainage is a threat associated with modification of habitat due to agriculture and development which interferes with the degree to which the oxleyan pygmy perch can move and interbreed within the more expansive water systems (Pusey et al. 2004; NSW DPI 2005b). Impacts on drainage operating downstream of the oxleyan pygmy perch habitat can create sink habitats, that is, where the waterway downstream is modified or obstructed preventing the species from returning upstream. An example of this is the wallum swampy drainage leading to sugar cane drains through a culvert pipe near the Richmond River, permanently impeding upstream passage (Knight 2000; Knight & Arlington 2008). Drainage of groundwater can also be a risk to oxleyan pygmy perch that occupy perennial streams. Activities that impact on drainage and connectivity within a drainage line includes the construction and

Table 2 Threats impacting the oxleyan pygmy perch

Threat	Status and severity a	Evidence
		maintenance of management trails, drainage works and cattle traversing small streams and swamps (Pusey et al. 2004; NSW DPI 2005b).
Other habitat modification due to development, mining and agriculture	 Timing: historical/current/future Confidence: observed Consequence: major Trend: static/increasing Extent: across part of its range 	Urban development, agricultural and forestry activities, and sand mining impact the oxleyan pygmy perch directly and indirectly, by reducing the quality of their habitat and associated habitats upstream and downstream of drainage lines. Direct impacts include a reduction in water quality
		(Pusey et al. 2004 and references therein), disruption to fish passage, change in the natural water flow conditions and persistence, and direct habitat damage (Knight et al. 2012). For example, road and bridge construction have increased bank erosion and sediment loads in a number of small coastal creeks along the Sunshine Coast (Wager 1992; Arthington 1996). Management trails and cattle traversing small streams and swamps can disrupt the connectivity of natural drainage systems, impede flow and damage wetland habitat (Pusey et al. 2004; NSW DPI 2005b). Change in the natural flow conditions can have substantial impacts on the species habitat because low flow is an important characteristic of the oxleyan pygmy perch habitat (Knight & Arthington 2008). Sand mining has had a major impact on the species habitat in NSW dune lakes by damaging the organic layer underlying the aquifer, leading to saltwater intrusion or freshwater loss (Ferguson 1997 and Timms 1997 cited in NSW DPI 2005b). Although the operation is now phased out in NSW, it continues to occur within the oxleyan pygmy perch habitat on Stradbroke Island, Qld (NSW DPI 2005b).
		Impacts from indirect threats include damage to the diversity and biomass of riparian and aquatic vegetation that the oxleyan pygmy perch have close association with (Pusey et al. 2004). For example, the disturbance of aquatic plant communities has had significant implications for the persistence of the oxleyan pygmy perch within subcatchments (Arthington 1996; Knight & Arthington 2008).
		Habitat modification can also introduce invasive plants that are capable of severely impacting the quality of aquatic habitat, e.g., para grass (<i>Brachiara mutica</i>) (Bunn et al. 1997; Pusey et al. 2004). Habitat modification can also increase the threat of invasive predators (e.g., eastern gambusia (<i>Gambusia holbrooki</i>)) and competitors (Pusey et al. 2004).
		Subpopulations located on unprotected land, and on land downstream and upstream of degraded areas, are susceptible to these threats.

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Threat	Status and severity a	Evidence
Fire		
Inappropriate fire regimes	 Timing: current/future Confidence: suspected Consequence: moderate Trend: unknown 	Although freshwater coastal lowland wallum ecosystems ecosystems are adapted to natural fire events, altered fire regimes due to prescribed burns and wildfires is a potential threat.
	Extent: across part of its range	The processes by which fire impacts freshwater habitats are complex and depend on the characteristics of the fire event, condition of the contributing catchment and hydrological cycle pre- and post- fire (Silva et al. 2020). Freshwater fish located downstream of catchments with high elevation and steep slopes, and which are exposed to periods of high rainfall immediately following fire, can be susceptible to watershed toxicity from increased loads of sediment and ash entering lowland areas (Silva et al. 2020). Toxicity coupled with hypoxia and thermal stress from fire has been shown to have significant impacts on the closely related species, the southern pygmy perch (Mulvey 2021). However, how these impacts translate to more coastal lowland species, such as the oxleyan pygmy perch, is unknown. Post-fire surveys suggest that the impact of fires on the habitat is dependent on the characteristics of the water body; large deep lacustrine ecosystems (lake) are likely to be more resistant to fire in the riparian zone and contributing catchment, compared to shallow palustrine (wetland) vegetated ecosystems that can burn across the habitat (M Kennard 2021. pers comm 5 May).
		Fire management activities related to prescribed burns can negatively affect the species in a number of ways: water quality and quantity can be reduced from the use of fire surfactants and water abstraction activities for fire- fighting purposes, and habitat can be degraded through the creation of fire trails (Knight et al. 2012). Subpopulations downstream and within the vicinity of fire-managed land are most susceptible to the threat of prescribed burns.
		The suppression of fire regimes can also affect wetlands. For example, land change analysis using aerial photographs taken between 1958 and 2016 showed that forest and woodland communites have invaded the fringes of a restaid dominated wetland due to low fire frequency on K'gari (Le Compte Forsyth Stewart 2017). The study projected that continued fire suppression would result in a loss of wetland extent by 2066 by 30% as the surrounding vegetation thickens, enabling it to encroach on wetland habitat (Le Compte Forsyth Stewart 2017). High fire severity by wildfires has been shown to impact the species habitat on a local and broad scale. For example, an intense localised wildfire in 2001 resulted in a 99% reduction in abundance of the oxleyan pygmy perch in a small stream near Evans Head (Knight et al. 2012).

Threat	Status and severity a	Evidence
		The effect of the wide-spread catastrophic 2019-2020 wildfires on the species was considered likely significant for the species with a modelled 27% of the oxleyan pygmy perch habitat impacted by the severe fire event under the most plausible scenario (Legge et al. 2021). Greater than 50% of this burn was at high or very high severity (DAWE 2020). These fire projections also do not include the K'gari fires from 2021. In Qld and NSW, 20% of sites were predicted to be affected by the 2019-2020 wildfires, based on spatial interpolation from Kennard et al. (unpublished data) matched with locations where the oxleyan pygmy perch were found previously (Table 2). However, there are other factors which could have contributed to this apparent decline, including the preceding drought in 2019, other threatening processes (habitat modification, invasive species, etc.), natural temporal variability, sampling errors (false absences) and erroneous historic records (M Kennard 2021 pers comm 20 May).
		Other fire-related threats include fire-drought interactions. For example, prolonged drought conditions prior to fire can exacerbate the effect of fire on freshwater species by facilitating more severe fires and allowing them to become more wide-spread (Climate Council 2019; Nolan et al. 2020).
		Other fire-related threats also include fire-hydrology interactions.
Climate Change		
Increased frequency and severity of drought	 Timing: current/future Confidence: observed Consequence: catastrophic Trend: increasing Extent: across the entire range 	Climate change related drought has severe impacts on the oxleyan pygmy perch. Drought conditions can limit dispersal, reduce the number of marginal, shallow habitats, reduce food resources and increase intraspecific competition (Bruce et al. 2019). Prolonged drought which is capable of drying wetlands has the potential to extirpate entire subpopulations and affect the species range by reducing connectivity, and consequently, genetic diversity (M Kennard 2021. pers comm 5 May). Palustrine ecosystems are likely to be more affected than lacustrine ecosystems; the latter could provide a refuge for fish in deeper pools (M Kennard 2021. pers comm 5 May). For example, large areas of shallow swampy depressions in Broadwater National Park have been observed to dry up during years of drought (Zukowski et al. 2021). Drought response management in NSW rescued ~292 oxleyan pygmy perch for ex situ maintenance and production following the extreme drought conditions in 2019 (driest year on record, 40% below the recorded average for rainfall; BoM 2019) may have resulted in substantial declines of the species. Following surveys in the peak of the drought period, a 20% reduction was observed in the number of sites that previously had healthy populations of the oxleyan pugmy perch for example percent in NSW (Pruce et al.

Threat	Status and severity a	Evidence
		2019). Surveys conducted during high drought conditions in 2002 (Karoly et al. 2003) also explained the prevalence of 'dry' sites unsuitable for sampling (20% of normally 'wet' sites were dry), and was considered a contributing factor to explain the large variation in the relative abundance of the oxleyan pygmy perch among sites sampled (Knight 2016).
		A study of how southeastern freshwater fish fared under the 'Millennium' drought showed that the most impacted species were the invertivores and omnivores with specific traits (Chessman 2013). The oxleyan pygmy perch had four of the six vulnerable traits identified, including low age at maturity, prolonged spawning period, low fecundity and demersal eggs. This supports the vulnerability of the oxleyan pygmy perch to climate change related drought impacts.
		Interactions between drought and fire are also a risk to the species.
		Future wide-scale drought is predicted across the known species range (BoM 2019). All subpopulations are potentially susceptible to the threat of increased frequency and severity of drought driven by climate change.
Invasive species		
Predation and competition by invasive species	 Timing: current Confidence: observed Consequence: moderate Trend: unknown Extent: across part of its range 	Several invasive species have been located in catchments that support the oxleyan pygmy perch. Species thought to have established self-sustaining populations include eastern gambusia (<i>Gambusia holbrooki</i>), Green swordtail (<i>Xiphophorus helleri</i>), and southern platyfish (<i>X. maculatus</i>) (Pusey 2004; Knight et al. 2012). Eastern gambusia is of most concern because: it is a known predator of fish eggs and larvae, including other <i>Nannoperca</i> spp. (Belk & Lydeard 1994; Rowe et al. 2008); it competes for food and habitat resources (Arthington & Marshall 1996); and it is aggressive towards native fish, including the oxleyan pygmy perch, thereby competing for resources (Cronin 2001 cited in Rowe et al. 2008; Knight et al. 2012). Eastern gambusia has been implicated in the decline of many freshwater fish in Australia (NSW DPI 2005). It has been found in several localities in Qld and NSW, including approximately 45% of habitat supporting the oxleyan pygmy perch in NSW (Pusey et al. 2004; Knight 2008). Invasive species described here are a known threat to some subpopulations in NSW including sites within the Esk River subcatchment, Riley's Hill, Jerusalem Creek, Lake Haiawatha and Minnie Water and some locations within the Clarence River basin (Angourie) (Knight 2016). Invasive species are also a threat to Qld subpopulations, although specific localities have not been documented.

Nannoperca oxleyana	(Oxleyan Pygmy Perch)	Conservation Advice
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Threat	Status and severity a	Evidence
Low genetic diversity	 Timing: current Confidence: observed Consequence: moderate Trend: unknown Extent: across part of its range 	In comparison to other freshwater fish, the oxleyan pygmy perch has low genetic diversity within subpopulations because of its long isolation (circa 8 000 years BP) and poor connectivity between river catchments (Hughes et al. 1999; Knight et al. 2009). Further, despite genetic differentiation between subpopulations, haplotypic diversity remains low overall (Knight et al. 2009). This pattern has been described as characteristic of population booms and busts linked to drought-refuge source habitats and ephemeral sink habitats in other species with similar life-history patterns (Huey et al. 2006). This is particularly evident in the NSW subpopulations where droughts are suspected to have prevented genetic flow, expected to occur during flooding events (Knight et al. 2009). Subpopulations with a higher than average haplotypic diversity, e.g. South Evans Head, are dominated by permanent swampy drainage systems that are capable of retaining genetic diversity (Knight et al. 2009). This subpopulation also escaped development, unlike other subpopulations throughout the species range, as the area was included in a Commonwealth military training area since 1940 (Knight et al. 2009). Genetic data indicate that the loss of a subpopulation, which could remain extinct as a consequence of low dispersal ability (Hughes et al. 1999; Knight et al. 2008). Further low levels of standing genetic diversity reduce the capacity of the species for adaptive change, which is of relevance given the current and projected climate-related changes (Mather et al. 2015). Low genetic diversity is a risk to all subpopulations in NSW, excluding South Evans Head, and the majority of
		subpopulations in Qiu, excluding Marcus creek.
Breeding and col	llection	
Collection for aquaria	 Timing: current Confidence: suspected Consequence: unknown Trend: unknown Extent: across part of its range 	The collection of the oxleyan pygmy perch for aquaria is a potential threat to the species, particularly for small, restricted populations (Knight et al. 2012). While the specific extent of collection of the oxleyan pygmy perch is unknown, collection of large numbers of native fish in wallum heath wetlands has been observed previously (Arthington 1996; NSW DPI 2005a). Although collection alone is unlikely to remove entire subpopulations, any reduction in numbers may affect the population's capacity to recover from random events such as drought and wildfire or from other threats (Arthington 1996; NSW DPI 2005b). Collection activities can also disturb the fragile coastal wetlands and streams and potentially introduce disease (Knight et al. 2012). Easily accessible, small and isolated subpopulations are most at risk from the threat of collection for aquaria

Timing—identify the temporal nature of the threat;

Confidence—identify the extent to which we have confidence about the impact of the threat on the species; Consequence—identify the severity of the threat;

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

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

Each threat has been described in Table 2 in terms of the extent that it is operating on the species. The risk matrix (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 in-house expertise using available literature. Threats with unknown consequences (collection for aquaria) have not been included in Table 3.

Likelihood	Consequences	Consequences						
	Not significant	Minor	Moderate	Major	Catastrophic			
Almost certain	Low risk	Moderate risk	Very high risk	Very high risk Land clearing Habitat disturbance and modification	Very high risk Increased intensity and frequency of drought			
Likely	Low risk	Moderate risk	High risk Predation and competition by invasive species	Very high risk Inappropriate fire regimes	Very high risk			
Possible	Low risk	Moderate risk	High risk Low genetic diversity	Very high risk	Very high risk			
Unlikely	Low risk	Low risk	Moderate risk	High risk	Very high risk			
Unknown	Low risk	Low risk	Moderate risk	High risk	Very high risk			

Table 3 The oxleyan pygmy perch risk matrix

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' or 'high'. For those threats with an unknown or low risk outcome it may be more appropriate to identify further research or maintain a watching brief.

Conservation and recovery actions

Primary conservation objective

By 2030, the subpopulations of oxleyan pygmy perch will have increased in abundance and viable populations are sustained in habitat which are managed for ongoing threats.

Conservation and management priorities Habitat loss, disturbance and modifications

- Avoid further loss and fragmentation of habitat which supports oxleyan pygmy perch.
- Protect extant subpopulations from the impacts of land clearing, for example through:
 - the formation of additional conservation reserves,
 - the establishment of vegetation buffers around habitat, and
 - the establishment of voluntary management agreements with landholders to maintain or enhance the species and its habitat on unsecured private land.
- Prevent habitat disturbance, including:
 - Manage land use upstream and in drainage lines of all subpopulations to ensure impacts on water quality and riparian environments are minimised.
 - Maintain hydrological connectivity and flow within drainage systems to minimise inbreeding depression.
 - Control access routes by installing gates/fences to constrain livestock along river channels and backwaters, and areas that support subpopulations and areas likely to support the species (i.e., areas of freshwater coastal lowland wallum ecosystems).
 - Protect and rehabilitate riparian and aquatic vegetation by replanting known endemic riparian and aquatic species that provide shade cover and complexity to pools along the stream channels and swamps in degraded oxleyan pygmy perch habitat.
- Ensure land managers are aware of the species' occurrence and provide protection measures against key and potential threats.
- Maintain, enhance and restore oxleyan pygmy perch habitat in accordance with the National Standards of the practice of ecological restoration in Australia (SERA 2017).
- Rehabilitate riparian vegetation and increase structural complexity in degraded habitat occupied by the oxleyan pygmy perch.

Climate change and fire

- Develop and implement a drought management strategy that identifies recovery actions for important subpopulations when drought thresholds are exceeded. Ensure options for translocation of severly at-risk subpopulations and suitable holding facilities are identified in the strategy.
- Develop and implement a fire management strategy that optimises the survival of the oxleyan pygmy perch during wildfires.

- Provide maps of known occurrences to local and state Rural Fire Services and seek inclusion of mitigation measures in wildfire risk management plan/s, risk register and/or operation maps.
- Manage planned burns to minimise risk to the oxleyan pygmy perch. Measures should consider avoiding prescribed burning during the main breeding season (October to April), using a mosaic burning pattern to ensure less than one third of the wetland habitat is burnt in a given year, and avoiding pumping of water from the species' habitat.
- Prevent runoff from fire management activities into swamps, pools, streams and dune lakes where the oxleyan pygmy perch are known to occur and could potentially occur.
- Ensure that fire suppression and mop up operations do not cause physical and chemical impacts on the species habitat.

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

- Avoid translocation of invasive fish species within the known and potential range of the oxleyan pygmy perch. Develop and disseminate guidelines for translocation of invasive fish in southeastern Qld and Northern NSW in consultation with local angling clubs and fish management groups.
- Consider the feasibility of protecting important subpopulations from invasive species using a variety of strategies including eradication, habitat rehabilitation, restocking native species and minimising the movement of invasive species.

Ex situ recovery action

- Rescue important and 'at risk' subpopulations from loss during periods of prolonged and severe drought. This includes subpopulations located in south Evans Head, NSW and Marcus Creek, Qld. Hold rescued individuals in appropriate facilities until suitable conditions prevail for safe release into the wild.
- Ensure translocations of rescued species follow the translocation handbook guidelines (Zukowski et al. 2021).
- If required, undertake captive breeding and/or translocations to re-establish populations in areas where they were found historically, in order to increase the species' extent and persistence in the wild.
- Ensure that permitting and licensing systems prohibit the collection of oxleyan pygmy perch for aquaria. Review and assess the efficacy of these systems in protecting subpopulations.

Stakeholder engagement/community engagement

- Engage and involve Traditional Owners in conservation actions, including the implementation of Indigenous fire management and other survey, monitoring and management actions. Ensure Indigenous Land Use Agreements (ILUAs) contain provisions for the protection of the oxleyan pygmy perch habitat, if relevant.
- Liaise with the local community and government agencies to ensure that up-to-date population data and scientific knowledge inform the implementation of conservation actions for this species.

• Promote awareness of the oxleyan pygmy perch in the local community that live in proximity to oxleyan pygmy perch habitat, and encourage community participation in conservation actions.

Survey and monitoring priorities

- Conduct surveys in areas of potentially suitable habitat, including within the species' likely historical distribution, to more accurately determine its natural distribution and identify any additional subpopulations.
- Conduct surveys to identify potential climate change refuges within and outside of the species' known range. For example, survey areas south of its known range where the species could find refuge given projected temperature increases (Turak & Koop 2008).
- Design and implement a monitoring program that includes:
 - estimates of subpopulation size and identifying subpopulation trends through time;
 - the status of known subpopulations, including locations which have long-term temporal data to show habitat occupancy trends through time;
 - the response of subpopulations to fire, using an appropriate measure (occupancy, population abundance, etc.) based on knowledge of the species' ecology, and with a monitoring design that aims to improve understanding of the species' response to fire;
 - changes in extent of freshwater coastal lowland wallum ecosystems by monitoring the key environmental changes that affect oxleyan pygmy perch habitat, i.e. drought and fire. Develop a risk matrix to identify the risk to each subpopulation and inform actions for recovery;
 - identifying severe erosion events to support programs that rehabilitate riparian vegetation in areas occupied by the oxleyan pygmy perch;
 - the distribution of invasive species, such as eastern gambusia, in oxleyan pygmy perch habitat and evidence of their impact on the species; and
 - the effectiveness of management actions and the need to adapt them if necessary.
- Support and enhance citizen science monitoring, e.g., by Waterwatch groups, to ensure that data are robust and can be used for population monitoring.

Information and research priorities

- Undertake research on the life history of the oxleyan pygmy perch in situ to support surveys on population size and determine important populations for the species.
- Develop guidelines for thresholds that trigger conservation intervention, to enable the rescue of severely at risk important subpopulations during periods of prolonged and severe drought. Explore locations for appropriate facilities equipped to hold rescuedo.
- Identify suitable locations that act as refuges in periods of prolonged and severe drought, where rescued individuals could be released into.
- Research the impact of invasive species on the oxleyan pygmy perch.
- Understand the impact of fire on the oxleyan pygmy perch and its habitat. Identify appropriate fire regimes that benefit the oxleyan pygmy perch.
- Research the usefulness of citizen science monitoring programs where they exist or could be reasonably implemented.

Recovery plan decision

A recovery plan for the oxleyan pygmy perch was developed by NSW DPI (2005) and adopted as a national recovery plan under the EPBC Act in 2007. The plan was reviewed in 2015 (NSW DI 2015) and is due to expire in April 2022.

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

Links to relevant implementation documents

Recovery Plan for oxleyan pygmy perch

Background paper for oxleyan pygmy perch Recovery Plan

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Attachment A: Listing Assessment for Nannoperca oxleyana

Reason for assessment

This assessment follows prioritisation of a nomination from the TSSC and provision of information as a result of the catastrophic 2019-2020 wildfires. Twenty-seven percent of oxleyan pygmy perch habitat was predicted to be impacted by the fires under the most plausible scenario (Legge et al. 2021).

Assessment of eligibility for listing

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

Key assessment parameters

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

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Number of mature individuals	Unknown	Unknown	Unknown	The number of mature individuals is unknown.
Trend	Declining	Declining		Although the number of mature individuals is unknown, it is likely declining, due to inferred loss of several subpopulations from previously known locations from the extreme and persistent drought and subsequent 2019–20 wildfires. See Table 3 for further information.
Generation time (years)	3	2.3	3.8	The species generation length has been estimated based on two reported values and one estimation. Butler et al. (2019) reported a generation length of 2.3 years for the IUCN assessment of this species. Kennard et al. (unpublished data) calculated the generation length to be 2.75 years, using the formula (maximum age-age at maturity)/2) + age at maturity, based on a maximum age of 5.0 years and maximum age at maturity of 0.5 years. If the same formula is applied to data from wild subpopulations by Knight et al. (2012), a generation length of 3.8 years is estimated; based on a maximum age of 6.5 years and a mean maximum age at maturity for females of 0.7 and males of 1.5. Therefore, the mid estimate between the highest and lowest estimate is considered the most appropriate estimate of generation length.

Table 4 Key assessment parameters

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Extent of occurrence (EOO)	16 124 km ²	11 771 km²	20 974 km ²	The most plausible value has been calculated using records from about 1989–2019 for known subpopulations and applying the shortest continuous imaginary boundary which can be drawn to encompass these records in each locality in close proximity, as outlined in the Guidelines for Using the IUCN Red List Categories and Criteria (IUCN 2019). The minimum plausible value is based on the estimated 27% habitat loss from the 2019 drought and the 2019–20 wildfires (Legge et al. 2021) subtracted from the most plausible value. The maximum plausible value is based on the estimated EOO used in the IUCN assessment (Butler et al. 2019), which is likely to have excluded the impact from the drought of 2019 and wildfires of 2019–20.
Trend	Contracting			EOO is likely contracting, due to the ongoing loss of habitat resulting from land clearing, habitat modification from urban, agricultural and foresty activities and sand mining, drainage, persistent drought, and fires. See Table 3 for further information.
Area of Occupancy (AOO)	183 km²	105 km²	292 km ²	The most plausible value has been calculated using records from about 1989–2019 for known subpopulations and applying 2 x 2 km grid cells, as outlined in the Guidelines for Using the IUCN Red List Categories and Criteria (IUCN 2019). The minimum plausible value is based on the estimated 27% habitat loss from the 2019 drought and the 2019–20 wildfires (Legge et al. 2021) subtracted from the most plausible value. The maximum plausible value is based on the estimated AOO used in the IUCN assessment (Butler et al. 2019) which is likely to have excluded the impact from the drought of 2019 and wildfires of 2019–20.
Trend	Contracting		·	AOO is likely contracting, due to loss of suitable habitat resulting from continued disturbance from land clearing, habitat modification from urban, agricultural and foresty activities and sand mining, drainage,persistent, drought and fires. See Table 3 for further information.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification	
Number of subpopulations	46	35	75	This maximum plausible value of 75 is based on the number of observed discrete subpopulations for the species prior to the loss caused by the 2019 drought and the 2019–20 wildfires. Within Qld, the oxleyan pygmy perch were known to inhabit 21 discrete drainage systems; six are located on the mainland and 15 are distributed among K'gari, Moreton and North Stradbroke Islands (Knight & Arthington 2008). In NSW, the species was found in 54 discrete drainage systems within the Richmond and Clarence Rivers (Knight & Arthington 2008). The minimum plausible value represents the	
				observed estimated loss from the effect of drought and wildfires (average of 54% across both NSW and Qld) (see Table 1 and Table 5). This assessment is based on an inference of total subpopulation loss if not present at time of sampling and considers each sampling site to be a unique subpopulation.	
				However there were six sites historically absent but present after the 2019–20 fires (three in NSW and three in Qld) indicating that there could be other explanations for the variability in site detection. For example, sampling errors, habitat modification, active management and natural temporal variability are all factors that could result in false negative results (M Kennard 2021. pers comm 20 May). Sampling errors however, are unlikey to be a contributing factor as the survey methodology followed a validated sampling protocol (Knight et al 2016). Furthermore, a number of sites where oxleyan pygmy perch were absent post-fire, were resampled in the following 6 month period and still recorded no oxleyan pygmy perch (Kennard et al. unpublished data). Therefore the estimate used in the assessment represents the minimum plausible value	
				(35%) incorporating a 20% contingency (11 extra subpopulatons) due to other possible factors explaining sampling differences.	
Trend	Declining	Surveys at repeated sites through time suggest that subpopulations are on a declining trajectory because of the impacts of climate change, and habitat loss and disturbance (Arthington 1996; Knight & Arthington 2008; Knight et al. 2016; Bruce et al. 2019; Kennard et al. unpublished data).			
Basis of assessment of subpopulation number	Genetic analysis indicates that the species has very little ability to disperse between subpopulations (Hughes et al. 1999). The only subpopulations known to exchange gene-flow are Lake Jabiru and Spitfire Creek in Moreton Island, which are separated by a distance of less than 1 km and are within the boundaries of a National Park (Hughes et al. 1999). High level genetic structuring in mainland Qld indicates that subpopulations are isolated, likely because of barriers to dispersal from habitat modification, even during flood events (Knight 2016).				

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
No. locations	9	9	9	The oxleyan pygmy perch are exposed to several threatening processes (Table 3). However, the most serious plausible threat is from climate change, which is the associated effect of both drought and fire; these effects cannot be disassociated as prolonged drought increases the risk of severe wildfires (see Table 5). The maximum plausible value considers the impacts of drought and fire to catchments and islands separately. There are three catchments within NSW (Clarence river, Richmond river and Bellinger river), three catchments within Qld (Mary river, Maroochy river and Noosa river) and three discrete sand islands. This gives an estimated maximum plausible value of 9. The minimum plausible value and estimate used in the assessment is based on the maximum plausible value. The impact of the 2019-2020 drought and fire did not result in the localised extinction from any catchment, despite the potential overall loss to the
	5.11.1			population of 54% (Table 5).
Trend	Declining			The intensity and frequency of drought and fire is likely to increase due to climate change. There is also ongoing risk of habitat loss and disturbance in Qld subpopulations on unprotected land as urban expansion continues. Accordingly, although the number of locations in which these threats can rapidly affect individuals may not decrease, localities within the catchments are likely to decrease by up to 54%.
Basis of assessment of location number	Shallow freshwater habitats which support oxleyan pygmy perch are highly susceptible to drying up from persistent drought. The 2019 drought and 2019–20 fires impacted the entire area where Qld and NSW subpopulations occur (BoM 2019). However, the impact of the 2019-2020 drought and fire did not result in the localised extinction from any catchment, despite the potential overall loss to the population of 54% (Table 5). Therefore, the most plausible number of locations remains at 9, based on the total number of catchments.			
Fragmentation	The subpopulations were considered severely fragmented prior to the 2019–20 fires and remain so. Subpopulations are small and isolated with limited dispersal capabilities. For example, geneflow has been only been documented in two subpopulations. Subpopulations are likely to further fragment because shallow wetlands may dry up given climate change predictions about increased risk of drought.			
Fluctuations	There are no kn mature individu	own extreme f ials.	luctuations in EC	0, AOO, number of subpopulations, locations or

Criterion 1 Population size reduction

Redu	Reduction in total numbers (measured over the longer of 10 years or 3 generations) based on any of A1 to A4					
		Critically Endangered Very severe reduction	Enda Seve	ngered re reduction		Vulnerable Substantial reduction
A1		≥ 90%	≥ 709	%		≥ 50%
A2, A	.3, A4	≥ 80%	≥ 50%	%		≥ 30%
A1 A2	Population reduction observed, estimate past and the causes of the reduction are understood AND ceased. Population reduction observed, estimate past where the causes of the reduction	ted, inferred or suspected in e clearly reversible AND ted, inferred or suspected in may not have ceased OR ma	the the ay not		(a) (b) (c)	direct observation [except A3] an index of abundance appropriate to the taxon a decline in area of occupancy, extent of occupancy and (or quality of
A3 A4	 be understood OR may not be reversible. Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [(<i>a</i>) cannot be used for A3] 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 			Based on any of the following	(d) (e)	habitat actual or potential levels of exploitation the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites
	be reversible.)	J		

Criterion 1 evidence Insufficient data to determine eligibility

Population size

Although the population size of oxleyan pygmy perch could be in decline by an estimated 54% (Table 5), the trend in population size overtime cannot be adequately quantified because of a lack of temporal population size data.

Therefore, there are insufficient data to demonstrate if the species is eligible for listing under this criterion. However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

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

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

Criterion 2 evidence

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

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

The most plausible extent of occurrence (EOO) and area of occupancy (AOO) of the oxleyan pygmy perch are estimated at 16 124 km² and 183 km², respectively. The EOO is based on spatial data points from survey locations known to contain the species and calculated by applying the shortest continuous imaginary boundary which can be drawn to encompass these records (IUCN 2019). Ungeneralised spatial records have been interrogated from WildNet database (2021), ALA (2021), Bruce et al. (2019), Kennard et al. (unpublished data), Arthington (1996) and Knight (2016) and range in date from 1940 to April 2021. The AOO was calculated using a 2 x 2 km grid cell method over each spatial data point. The species estimates meet the requirements for AOO (AOO < 500 km²) for listing as Endangered under B2 and for EOO (EOO < 5 000 km²) for listing as Vulnerable under B2.

A time period of about 30 years was used for the AOO and EOO estimates, due to under sampling within the species' range. Despite intense surveys throughout NSW (Knight 2016; Bruce et al. 2019) and moderate survey efforts in Qld (Kennard et al. unpublished data; WildNet database 2021), it is possible that the species will occur in other locations, particularly in unsurveyed freshwater coastal lowland wallum ecosystems areas in Qld. The low abundance of the species when present suggests that the species could remain undetected, despite systematic methods of sampling. Within Qld there are approximately 2 527 lacustrine and palustrine ecosystems within the freshwater biogeographic province encompassing approximately 795 km² which covers the entire species range in Qld (DES Qld 2013). In NSW, freshwater coastal lowland wallum ecosystems area occupied for this species (Knight 2016). Therefore, unknown subpopulations may occur in suitable habitat elsewhere

than currently recorded outside of the species range in NSW and within unsurveyed areas inside the species range in Qld, suggesting that either the EOO and/or AOO may be greater than currently estimated.

In spite of this, the small size of areas of habitat and drainage lines and impact of the 2019 drought and 2019–20 fires indicate that new locations for the species are unlikely to significantly increase the AOO beyond a factor of 2 (i.e. from 183 to >500). This is because older sites may no longer support the species considering they date back to about 1989 and wetlands in South-East Qld and Northern NSW are predicted to dry as weather patterns change under climate change predictions. Accordingly, until targeted surveys of all suitable habitat can eliminate the possibility of other subpopulations, the current AOO is considered the most plausible estimate of habitat area known to contain the species.

Number of locations

Persistent and extreme drought conditions in 2019 (driest year on record, 40% below the recorded average for rainfall, BoM 2019) followed by catastrophic wildfires affected an estimated 27% of the species habitat (Legge et al. 2021). Within Qld, greater than 50% of the burn was at high or very high severity (DAWE 2020). Results from post-fire and drought sampling of historic localities show that the combined effect of drought and fire is estimated to have potentially reduced known subpopulations in Qld and NSW by 54% (Table 5). Substantial deficiencies in rainfall continue to prevail in some parts of the species range, such as in the Mary river catchment (BoM 2020). Future wide-scale drought is predicted across the known species range (BoM 2019). Wide-scale drought is capable of affecting the entire species range, as suspected to have occurred in the 2019 drought. Prolonged drought is capable of drying persistent wetlands and thus has the potential to extirpate entire subpopulations (M Kennard 2021. pers comm 5 May). Prolonged drought makes vegetation more flammable and therefore more likely to support severe fire behaviour (Climate Council 2019). However, despite the overall potential population decline, extinctions within catchments did not occur from the 2019-2020 drought and fire. Therefore the most plausible locality is based on the maximum plausible scenario which is nine (see Table 4).

The species' number of locations appears to meet the requirement for listing as Vulnerable under subcriterion (a).

Table 5 Sampling of localities following the 2019 drought and 2019-20 wildfires. Localities defined as individual lakes, palustrine wetlands and river segments more than 150 m apart. Historic localities only include those locations with survey data post-2019 fire.

State	No. of historic localities recorded to contain oxleyan pygmy perch pre-drought and fire (Knight & Arthington 2008)	No. of historic localities where oxleyan pygmy perch was absent post- drought and fire (Kennard et al. unpublished data)	Estimated loss of localities containing oxleyan pygmy perch (%)	Average potential estimated loss
Qld	27	18	67	54%
NSW	10	4	40	

Severe fragmentation

The species occurs in habitat that is highly fragmented (Arthington 1996; Pusey et al. 2004; Knight et al. 2012; Knight 2016) and poorly connected (Hughes et al. 1999). Evidence for severe fragmentation is also shown in recent post-fire surveys (Dec 2020 – Jan 2021) which showed only 32 out of 85 localities contained oxleyan pygmy perch, despite all areas sampled within suitable palustrine, lacrustine and riverine habitat for the species (Kennard et al unpublished data). Genetic research also provides evidence to support severe fragmentation because the only locality known to share genetic material occurs within a protected area and is separated by less than 1 km (Hughes et al. 1999). Oxleyan pygmy perch is unlikely to recolonise habitat once it has become locally extirpated because of poor connectivity. The very limited dispersal ability of the species puts it at high risk of extinction, particularly to broad-scale threats such as increased severity and frequency of drought.

The species' meets the requirement for severally fragmented for listing as Endangered under subcriterion (a).

Continuing decline

As indicated previously an estimated 15 subpopulations may have been lost because of the 2019 drought and subsequent catastrophic wildfires. Surveys carried out in subsequent years following the drought and fires (2019–2021) indicate that these subpopulations could be lost permanently (e.g., Wendoree Lagoon). This is supported by the known limited genetic dispersal of the species and the limited opportunities for connectivity under low rainfall conditions (Hughes et al. 1999).

The intensity and frequency of drought and fire is likely to increase within southeast Qld and northern NSW due to climate change (BoM 2019). Coastal shallow wetlands are highly susceptible to drying out under persistent low rainfall conditions (Zukowski et al. 2021). There is also ongoing risk of habitat loss in Qld subpopulations on unprotected land. Further, there are ongoing risks associated with habitat disturbance and invasive species directly and within drainage lines to all subpopulations. Accordingly, continuing declines are likely to occur in the area, extent and quality of habitat, and number of locations and subpopulations.

The species appears to meet the continuing decline requirements for listing as Endangered under subcriterion (b).

Extreme fluctuations

There are no known extreme fluctuations in EOO, AOO, number of subpopulations, locations or mature individuals.

The Committee considers that the species' Extent of Occurrence (EOO) is limited, Area of Occupancy (AOO) is restricted, the habitat is severely fragmented, and a continuing decline is estimated.

Therefore, the species has met the relevant elements of Criterion 2 to make it eligible for listing as Endangered. However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Criterion 3 Population size and decline

	Critically Endangered Very low	Endangered Low	Vulnerable Limited
Estimated number of mature individuals	< 250	< 2,500	< 10,000
AND either (C1) or (C2) is true			
C1. An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future)	Very high rate 25% in 3 years or 1 generation (whichever is longer)	High rate 20% in 5 years or 2 generation (whichever is longer)	Substantial rate 10% in 10 years or 3 generations (whichever is longer)
C2. An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions:			
(i) Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
(ii) % of mature individuals in one subpopulation =	90 - 100%	95 - 100%	100%
(b) Extreme fluctuations in the number of mature individuals			

Criterion 3 evidence Insufficient data to determine eligibility

Population size

The number of mature individuals is unknown.

There are insufficient data to demonstrate if the species is eligible for listing under this criterion. However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

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 km ² or number of locations ≤ 5

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

Criterion 4 evidence Insufficient data to determine eligibility

Number of mature individuals

The number of mature individuals is unknown. Additionally, the oxleyan pygmy perch is not eligible for listing as Vulnerable under sub-criterion D2.

There are insufficient data to demonstrate if the species is eligible for listing under this criterion. However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

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

Population viability analysis has not been undertaken for the oxleyan pygmy perch.

There are insufficient data to demonstrate if the species is eligible for listing under this criterion. However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Adequacy of survey

Wide-scale surveys have been carried out throughout habitat suitable for oxleyan pygmy perch in NSW and Qld (Arthington 1996; Knight 2016). Fine scale systematic surveys have been carried in NSW where known subpopulations have been detected (Knight 2016). Targeted fine scale surveys have also been carried out in Qld, although less comprehensively than in NSW (Arthington 1996) and areas of intact freshwater coastal lowland wallum ecosystems are still yet to be surveyed (M Kennard 2021. pers comm 5 May). Despite this, 126 data records exist in the Qld WildNet database (2021) covering the entire known species range in Qld. Consequently, survey effort has been considered adequate in both States and there is sufficient scientific evidence to support the assessment. © Commonwealth of Australia 2021



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

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