



Consultation on Species Listing Eligibility and Conservation Actions

Mordacia praecox (non-parasitic lamprey)

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

- 1) the eligibility of *Mordacia praecox* (non-parasitic lamprey) for inclusion on the *Environment Protection and Biodiversity Conservation Act 1999* (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 Traditional Owners, 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 EPBC Act or for a transfer of an item already on the list to a new listing category. The Threatened Species Scientific Committee (the Committee) undertakes the assessment of species to determine eligibility for inclusion in the list of threatened species and provides its recommendation to the Australian Government Minister for the Environment.

Responses are to be provided in writing by email to:
species.consultation@environment.gov.au . Please include species scientific name in Subject field.

or by mail to:

The Director
Marine and Freshwater Species Conservation Section
Protected Species and Communities Branch
Biodiversity Conservation Division
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 1 March, 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: <http://www.environment.gov.au/biodiversity/threatened/index.html>.

Public nominations to list threatened species under the EPBC Act are received annually by the department. In order to determine if a species is eligible for listing as threatened under the EPBC Act, the Threatened Species Scientific Committee (the Committee) undertakes a rigorous scientific assessment of its status to determine if the species is eligible for listing against a set of criteria. These criteria are available on the Department's website at: <http://www.environment.gov.au/system/files/pages/d72dfd1a-f0d8-4699-8d43-5d95bbb02428/files/tssc-guidelines-assessing-species-2018.pdf>.

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

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

Privacy notice

Personal information means information or an opinion about an identified individual, or an individual who is reasonably identifiable.

The department collects your personal information (as defined by the *Privacy Act 1988*) in relation to information you provide as part of this consultation for the purposes of the nomination, assessment and listing process set out in Part 13 of the EPBC Act.

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.

The department may disclose your personal information to the Committee, the Australian Government Minister for the Environment, State and Territory Governments, and other Australian government agencies, persons or organisations where necessary for the above purposes, provided the disclosure is consistent with relevant laws, in particular the *Privacy Act 1988* (Cth) (Privacy Act).

Further, the Commonwealth, State and Territory governments have agreed to share threatened species assessment documentation (including comments) to ensure that all States and Territories have access to the same documentation when making a decision on the status of a potentially threatened species. This is also known as the '[Common Assessment Method](#)'. 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.

Your personal information will be used and stored in accordance with the Australian Privacy Principles.

See the [department's Privacy Policy](#) to learn more about accessing or correcting personal information or making a complaint. Alternatively, email the department at privacy@awe.gov.au.

Information about this consultation process

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

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

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

Consultation questions

1. Do you agree with the current taxonomic position of the Australian Faunal Directory for this taxon (as identified in the draft conservation advice)?
2. Can you provide any additional references, information or estimates on longevity, age of maturity, average life span and generation length?
3. Has the survey effort for this taxon been adequate to determine its national distribution and adult population size?
4. Do you accept the estimate provided in the nomination for the current population size of the taxon?
5. For the total population or any subpopulation with which you are familiar, do you agree with the population estimate provided? If not, are you able to provide a plausible estimate based on your own knowledge? If so, please provide in the form:
Lower bound (estimated minimum):
Upper bound (estimated maximum):
Best Estimate:
Estimated level of Confidence: % (the level of confidence should be > 50 %)
6. Can you provide any additional data, not contained in the current draft conservation advice, on declines in population numbers over the past or next 10 years or 3 generations, whichever is the longer?
7. Is the distribution as described in the nomination valid? Can you provide an estimate of the current geographic distribution (extent of occurrence or area of occupancy in km²) of this taxon?
8. Has this geographic distribution declined and if so by how much and over what period of time?
9. Do you agree that the taxon is eligible for inclusion on the threatened species list, in the category listed in the draft conservation advice?
10. Do you agree that the threats listed are correct and that their effects on the taxon are significant?
11. To what degree are the identified threats likely to impact on the taxon in the future?
12. Can you provide additional or alternative information on threats, past, current or potential that may adversely affect this taxon at any stage of its life cycle?
13. In seeking to facilitate the recovery of this taxon, can you provide management advice for the following:
 - What individuals or organisations are currently, or need to be, involved in planning to abate threats and any other relevant planning issues?
 - Does recovery of the taxon involve multiple stakeholders and/or cooperation across land tenures and/or jurisdictions?
 - What threats are impacting on different subpopulations, how variable are the threats and what is the relative importance of the different subpopulations?
 - Would the development and implementation of a translocation strategy be of benefit?

- What recovery actions are currently in place, and can you suggest other actions that would help recover the taxon? Please provide evidence and background information.

14. Can you provide additional data or information relevant to this assessment?

15. Can you advise as to whether this species is of cultural significance to Indigenous Australians?



Conservation Advice for *Mordacia praecox* (non-parasitic lamprey)

In effect under the *Environment Protection and Biodiversity Conservation Act 1999* from **dd month yyyy**.

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



Non-parasitic lamprey from Water Park Creek, Queensland (adult top, larva bottom). Copyright, David Moffatt (Queensland Department of Environment and Science)

Mordacia praecox (non-parasitic lamprey) is currently not listed in any category of the threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act).

The non-parasitic lamprey is being assessed by the Threatened Species Scientific Committee (the Committee). The Committee's assessment (at Attachment A) finds the species likely to be eligible for listing as **Endangered** under the EPBC Act. The Committee assessment of the species' eligibility against each of the listing criteria is:

- Criterion 1: Insufficient data
- Criterion 2: B2ab(iii): Endangered
- Criterion 3: Insufficient data
- Criterion 4: Insufficient data
- Criterion 5: Insufficient data

The main factor that makes the species eligible for listing in the Endangered category is a restricted and declining area, extent and/or quality of habitat due to the impacts of habitat degradation from human mediated landscape change (e.g., sedimentation, water quality).

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

Species information

Taxonomy

Conventionally accepted as *Mordacia praecox* Potter, 1968.

There are taxonomic uncertainties relating to the non-parasitic lamprey because lamprey taxonomy as a whole is in a “state of flux” (Docker & Hume 2019). There is debate within the lamprey systematics community on the status of taxa that are not parasitic (in Australia, *Mordacia praecox*) relative to their closely related sister taxa (known as “paired-species”; Docker 2009), in this case, *Mordacia mordax* (short-headed lamprey) (Potter 1968). This is because paired-species almost always have larvae that are morphologically and ecologically identical, and the parasitic and non-parasitic forms are not distinguishable through standard DNA barcode methods (Docker & Potter 2019). This is the case for the non-parasitic lamprey and the short-headed lamprey (Potter 1968; Garbutt 2015). Indeed, it is possible that the non-parasitic lamprey may not be a separate biological species, but instead an ecomorph of the short-headed lamprey, displaying an alternative life-history resulting from phenotypic plasticity in response to local environmental conditions (Docker 2009; Mateus et al. 2013).

There is a demonstrated, complex continuum of levels of speciation between paired lamprey species worldwide, with some clearly being two distinct, good biological species, others clearly a single interbreeding species, but with most somewhere in between (Docker & Potter 2019). It has not yet been resolved where the non-parasitic lamprey and the short-headed lamprey fall along this speciation continuum (Docker 2009). However, the differences in adult body size, breeding cycle, breeding times, and feeding type (see Biology/Ecology section below), as well as the possibility of nuclear genomic divergence (demonstrated in other species pairs; Yamazaki et al. 2006; Mateus et al. 2013), combined with the necessity for a precautionary approach when dealing with taxonomic changes (Potter et al. 2015), suggest that these two taxa should be considered as distinct species until proven otherwise. Therefore, the current taxonomy, which regards the non-parasitic lamprey as a good biological species, has been followed in this assessment.

There is also taxonomic uncertainty at the smaller systematic and geographic scale. A geographically isolated lamprey population in the Noosa River area in Queensland (Qld) was initially assigned to *Mordacia praecox* (Teewah Creek, Searys Creek) (Gilligan et al. 2019b). However, evidence of genetic and morphological divergence of this population clearly shows that it represents a new, undescribed species of non-parasitic lamprey (ABC News 2012; D. Moffatt 2020 unpub). Therefore, the Noosa River population has not been included in this assessment.

Description

Adults have a typical lamprey, eel-like, long slender body, with two low dorsal fins near the tail. There are seven gill openings on each side behind the eyes, which are on the dorsal surface (Allen et al. 2002). In common with all lamprey species, adults are jawless and instead have a suctorial disk with small teeth around the edge.

The non-parasitic lamprey has only been described in southern New South Wales (NSW), where adults are bluish-black on the back, sometimes with a greenish tinge, and mottled grey on the stomach, while females with eggs have a yellow belly (Potter 1968; Allen et al. 2002). Adults are fairly small (~100–170 mm), with males a little larger than females (Potter 1968). When they first metamorphose from larvae, the sub-adults (macrophthalmia) are actually a little longer than adults (Docker 2009).

Where the non-parasitic lamprey occurs in sympatry with the short-headed lamprey in southern NSW, the two species are readily distinguishable as sexually mature adults (Garbutt 2015); the short-headed lamprey is much larger (300–420 mm) (Potter 1968) and has more developed radial teeth. The non-parasitic lamprey may also be sympatric with the pouched lamprey (*Geotria australis*) at the southern end of the non-parasitic lamprey's range. Again, adults are easily distinguished as the pouched lamprey is much larger (450–600 mm), has different dentition, and its eyes are more laterally situated (Allen et al. 2002; Potter et al. 2015; Miller et al. 2021).

Lamprey larvae (also known as ammocetes) are very different from adults, having no eyes or teeth (Potter et al. 2015). Larvae of the non-parasitic lamprey are small, brown, and worm-like with low fins (Potter 1970; Allen et al. 2002), although size and colour may vary with location (D. Moffatt 2020 pers comm 17 Nov). The larvae of the non-parasitic lamprey and the short-headed lamprey are indistinguishable (Potter 1968; Miller et al. 2021), which is common between paired-species (Docker 2009; M. Docker 2020 pers comm 18 Nov).

Distribution

Unlike most parasitic lamprey species, the non-parasitic lamprey is entirely a freshwater species, completing its life cycle in rivers and never migrating to brackish or marine systems. Consequently, it is restricted to individual river basins. Within each river system, specimens of the non-parasitic lamprey have only been reported relatively close to the coast (< 50 km) (Potter & Strahan 1968).

The non-parasitic lamprey is known from a small number of isolated coastal rivers in eastern Australia (Gilligan 2019b) (Figure 1). The species was originally described by Potter (1968) from the Tuross River and Deua River (Moruya River Basin) in southern coastal NSW; however, it likely went locally extinct at this location sometime between the 1995 and 2003 (Gilligan 2019b). The species has also been reported in far southern NSW from the Wallagaraugh River (East Gippsland Basin) on the NSW/Victorian border (Gilligan 2019b); northern NSW (Macleay River Basin) (Butler et al. 2016; Gilligan 2019b), far northern NSW (a larval specimen of *Mordacia* recorded from the Richmond River; D. Gilligan 2020 pers comm 16 Nov; Australian Museum Ichthyology Collection); south-eastern Qld (Maroochy River Basin [Coochin Creek]); and central Qld (Water Park Creek) (Gilligan 2019b; D. Moffatt 2020 pers comm 17 Nov).

There has been some confusion regarding the species' precise distribution because adults, which are identifiable to species, are rarely encountered (Miller et al. 2021), and most location records are of larvae (D. Gilligan 2020 pers comm 16 Nov), which are not readily distinguished between the non-parasitic and short-headed lamprey (see Taxonomy section).

The short-headed lamprey is distributed in coastal rivers from Adelaide to Sydney (including Tasmania) and overlaps the southern coastal NSW non-parasitic lamprey distribution (Gilligan 2019a, 2019b). Given they share the same habitat, some of the reported records of the non-parasitic lamprey from southern NSW and Victoria (e.g., Allen et al. 2002; ALA 2021) cannot be confirmed (Gilligan 2019b; D. Gilligan 2020 pers comm 16 Nov; T. Raadik 2021 pers comm 15 Feb). Gilligan (2019b) and T. Raadik (2021 pers comm 15 Feb) both consider Victorian records of the non-parasitic lamprey as unproven, although they may be in far eastern Victoria as the non-parasitic lamprey is known from the NSW portion of the Wallagaraugh River (East Gippsland Basin), which flows across the border into Victoria.

Geographically isolated lamprey populations are likely to be a freshwater species that is not parasitic (the non-parasitic lamprey) rather than an anadromous parasitic species (the short-headed lamprey) (Docker 2009; Gilligan 2019b; D. Gilligan 2020 pers comm 17 Nov). This is because parasitic species

are not philopatric (Docker & Hume 2019), so when they return to freshwaters, they do so to a general area, and are found spread across a series of contiguous river systems; a pattern followed by both the short-headed and pouched lampreys in southern Australia (Gilligan 2019a; Miller et al. 2021). In contrast, non-parasitic species are typically restricted to a single river basin.

Table 1: River basins where the non-parasitic lamprey has been reported (from north to south) (Potter 1968; Lang et al. 2009; Hardy et al. 2011; Moore & Marsden 2011; Butler et al. 2016; Gilligan 2019b; D. Gilligan 2020 pers comm 16 Nov; D. Moffatt 2020 pers comm 17 Nov; ALA 2020, 2021; T. Raadik 2021 pers comm 15 Feb). * AIATSIS (1996)

River Basin	National Park (sampling site)	State	Traditional owners*	IBRA7 Region	IBRA7 Subregion
Water Park Creek	Byfield NP	Qld	Darumbal	Central Mackay Coast	Manifold
Maroochy River		Qld	Gubbi Gubbi	South Eastern Qld	Sunshine Coast-Gold Coast Lowlands
Richmond River		NSW	Bundjalung	South Eastern Qld	Clarence Lowlands
Macleay River		NSW	Dainggatti	NSW North Coast	Macleay Hastings
Moruya River (extinct)	Deua NP	NSW	Yuin	South East Corner	South East Coastal Ranges / Bateman
Tuross River (extinct)	Wadbilliga NP	NSW	Yuin	South East Corner	South East Coastal Ranges / Bateman
East Gippsland		NSW	Bidhawal	South East Corner	East Gippsland Lowlands / South East Coastal Ranges

Although found in a number of different areas, the non-parasitic lamprey is unlikely to be very common or widespread. This is because it appears to have fairly narrow habitat requirements (Potter 1970) and is typically found in a small proportion only of each river system (Gilligan 2019b; D. Moffatt 2020, 2021 pers comm 17 Nov., 10 Mar.). The species is thought to be broadly absent from most freshwater systems, as it has been rarely encountered even in those areas that have been extensively and frequently sampled (J. Johnson 2020 pers comm 17 Nov), for example southeast Qld by the Ecosystem Health Monitoring Project (Bunn et al. 2010).

Figure 1 Modelled distribution of the non-parasitic lamprey



Source: Base map Geoscience Australia; species distribution data [Species of National Environmental Significance](#) database.

Cultural and community significance

This section is not intended to be comprehensive, applicable to, or speak for Indigenous people. Species significance to Indigenous people may be only held by Indigenous groups and individuals who are the custodians of this knowledge. The non-parasitic lamprey has no known cultural significance to Indigenous communities (A. Miller 2021 pers comm 5 May). However, the pouched lamprey is a known food source for Indigenous groups in Western Australia (Miller et al. 2021), and this is likely also the case for *Mordacia* species, especially as the short-headed lamprey has been very common in some areas, especially at the start of adult upstream migration. The widely separated subpopulations of the non-parasitic lamprey are found on the lands of many different Indigenous groups (see Table 1). Ascertaining the cultural significance of *Mordacia* species is a research priority identified in the conservation actions.

Relevant biology and ecology

The general biology and ecology of the non-parasitic lamprey is not well understood as it has been the subject of only limited study since the early 1970s. However, the basic framework of lamprey development is well established, with a two-phase life cycle (Potter et al. 2015). The biology and ecology of the first larval phase of the non-parasitic lamprey is believed to be virtually identical to that of its paired sister species, the short-headed lamprey (Potter 1968; Garbutt 2015). The non-parasitic lamprey is the only described lamprey species from the Southern Hemisphere that does not have a host-parasite life-stage, whereas there are numerous examples in the Northern Hemisphere (Miller et al. 2021).

Larval phase

After hatching, lamprey larvae drift downstream to low-flow river areas with soft, silty substrate (Allen et al. 2002). The larvae are small, eyeless and worm-like, living sedentary lives, buried in soft sediments and filter-feeding for microorganisms (diatoms, unicellular algae, detritus), mostly at night (Potter 1968; Allen et al. 2002; Warrington et al. 2017). Non-parasitic lamprey larvae spend many years feeding and growing, building up reserves of lipids for later metamorphosis and spawning (Evans et al. 2018).

In the final year before metamorphosis, lamprey larvae increase their weight rather than length (Evans et al. 2018). The onset of metamorphosis may be temperature-related (Potter 1970) and is reported to begin in southern NSW in February/March for the short-headed lamprey (Hughes & Potter 1969; Potter 1970). The metamorphosis is very substantial, with the adults developing functional eyes, a suctorial oral disc and well-developed fins (Docker 2009).

The life cycles of the non-parasitic lamprey and the short-headed lamprey are virtually identical until the short-headed lamprey begins to metamorphose into a sexually immature young adult after about 3.5 years as a larva (Potter 1970). Then, they diverge radically. While the short-headed lamprey enters a standard parasitic lamprey juvenile/adult phase, where it spends about 1.5 years in marine habitats parasitising fish and growing much larger (Miller et al. 2021), the non-parasitic lamprey forgoes the entire parasitic feeding phase, and instead remains as larvae in freshwaters for about the same length of time that the short-headed lamprey is at sea. This makes the larval phase for the non-parasitic lamprey about five years (Potter 1970; Garbutt 2015; Gilligan 2019b; Miller et al. 2021).

Adult phase

Metamorphosis from larval to the adult non-parasitic lamprey has been recorded as beginning in October/November (Hughes & Potter 1969; Potter 1970) in southern NSW. After they metamorphose, juveniles immediately begin to mature sexually, and they are ready to spawn by July. However, the timing may vary between areas and years (Hughes & Potter 1969; Docker 2009; Gilligan 2019b). The non-parasitic lamprey appears to have a cohort breeding strategy in which all individuals breed roughly simultaneously.

After metamorphosis, adults from non-parasitic lamprey species do not feed, and even lack a functional digestive tract, making them the only known vertebrates with a non-trophic adult phase (Docker 2009; Docker & Potter 2019).

Mature adults make short, nocturnal upstream migrations from larval to spawning areas in faster flowing, better oxygenated headwaters (Allen et al. 2002; Warrington et al. 2017). Non-parasitic lamprey spawning behaviour is not known; however, the short-headed lamprey spawns in shallow, gravel-bottomed tributaries, with the female making a nest in a depression and the male using its oral disc to attach to the female (Allen et al. 2002). Spawning occurs from August to November (Hughes & Potter 1969; Potter 1970). Adults die soon after spawning due to a lack of energy reserves (Garbutt 2015). The non-parasitic lamprey has a lower fecundity than the short-headed lamprey (326–675 eggs per female vs. 3789–13372, respectively) (Hughes & Potter 1969). While the eggs are of a similar size, the non-parasitic lamprey's much smaller body size at sexual maturity explains its reduced fecundity (Docker 2009).

Habitat

The non-parasitic lamprey is found exclusively in the freshwater lower reaches of a few coastal rivers. The species spends an overwhelming proportion of its life as a larva in low-flow reaches, buried in soft sand, silt, and clay substrates (Potter 1970). Larger larvae may prefer coarser substrates (Potter

1970). Their downstream limit is likely determined by salinity (Potter 1970). Upstream spawning habitats are in areas of faster flow and are more gravel bottomed (Allen et al. 2002).

Habitat critical to the survival

It is difficult to define habitat critical to the survival of the non-parasitic lamprey narrowly as data are scant (Allen et al. 2002). The species has poorly defined habitat preferences beyond a requirement for freshwater habitats with soft substrates as larvae and, possibly, gravel substrates for spawning (Potter 1970).

The species is not definitively known to occur on Commonwealth lands, however the northernmost location at Water Park Creek is on the border of the Shoalwater Bay Military Training Area, which is itself listed on the Australian Heritage Database based on its natural values (DAWE 2021). No Critical Habitat as defined under section 207A of the EPBC Act has been identified or included in the Register of Critical Habitat.

Important populations

Because each subpopulation is likely demographically and geographically isolated, often by a large distance, every population is potentially important. However, Water Park and East Gippsland certainly qualify as important populations (*sensu* Commonwealth of Australia 2013) as they are both near the limit of the species range. Further, Maroochy should also be considered as an important population, as it, and the two previously mentioned populations, are the only locations where the species has been regularly found, and so all three serve as source populations and potential arks for the species.

Threats

The impacts of the various threats to the non-parasitic lamprey do not exist in isolation, but interact and can compound each other. For example, climate change is resulting in more frequent and severe droughts and heatwaves, leading to more intense bushfires (Nolan et al. 2020), which when followed by extreme rainfall events (also becoming more frequent), aquatic fauna can be severely impacted (Silva et al. 2020). Compounding the ongoing threats associated with climate change, past and present land management practices (mining, agriculture, urbanisation) likely have already impacted the non-parasitic lamprey in a number of areas (Gilligan 2019b; T. Raadik 2021 pers comm 8 March).

The complexity of the life cycle of the non-parasitic lamprey (long larval stage, cohort breeding strategy) means there are numerous ways in which it can be disrupted (Miller et al. 2021). This is especially so as the species is prone to genetic bottlenecks due to its geographic isolation and reduced fecundity and mobility (Mateus et al. 2013). This means that subpopulations are vulnerable to stochastic events, as well as continuous ramp pressure threats (Table 2), and even to low level threats, that in isolation may not have presented an existential threat. These low/potential threats include 1) invasive fish species feeding on lamprey larvae (Gilligan 2019b; Miller et al. 2021); 2) higher temperatures leading to a possible change in the timing of metamorphosis and sexual maturation (Potter 1970; Docker & Potter 2019; Lucas et al. 2020); 3) the spread of diseases from pouched lampreys (haemorrhagic septicaemia in Western Australia, lamprey reddening syndrome in New Zealand; Miller et al. 2021).

Table 2 Threats impacting non-parasitic lamprey

Threat	Status and severity	Evidence
Habitat loss, disturbance and modifications		
Habitat degradation/loss	Status: current Confidence: inferred Consequence: severe Trend: increasing Extent: catchment-specific	<p>The non-parasitic lamprey is found exclusively close to the coast in eastern Australia. This is an area of large-scale habitat alteration and degradation due to past and present human activities, such as land clearing and water extraction for urbanisation, agriculture, forestry and mining, and the associated impacts, such as sedimentation, water pollution, and increased salinisation (AMOG Consulting 2003; Howson et al. 2009; Gilligan et al. 2019b; Miller et al. 2021; T. Raadik 2021 pers comm 15 February, 8 March). Habitat degradation is one of the major threats to lampreys worldwide (Lucas et al. 2020).</p> <p>An increase in the input of sediments into streams can smother the riverbed and fill in smaller pools and can change the composition of the sediment from finer silt/clay material to coarser sand/gravel derived from surface run-off (Rutherford et al. 2000; AMOG Consulting 2003). Increased sedimentation may be a particular issue for the non-parasitic lamprey as they spend most their lives buried in fine sediments as larvae, and so any changes are very disruptive (Gilligan 2019b; Miller et al. 2021). Increased sedimentation can reduce the habitat quality and area available to larvae, and make spawning areas unsuitable, and smother eggs (Metzeling et al. 1995). However, the precise impacts of sediment of lampreys are not fully known (Clemens et al. 2020).</p> <p>The intensity of human activities, and therefore impacts, varies greatly based on location, especially given the very large area over which the species is found. For example, high rates of sedimentation due to past gold mining was likely relevant to the presumed extinct location in the Moruya Basin in southern NSW (AMOG Consulting 2003), and the Macleay Basin in northern NSW is largely cleared agricultural land (WMA Water 2009), whilst the non-parasitic lamprey sites in Water Park Creek in central Qld are in a largely unimpacted national park.</p>
Instream barriers to movement	Status: current Confidence: inferred Consequence: low – moderate Trend: stable Extent: catchment-specific	<p>Instream barriers to movement are a recognised threat to lampreys generally (Petherbridge et al. 1998; Morris et al. 2001). However, the primacy of connectivity to lamprey conservation may be more relevant to parasitic species that need access to both the sea and to sites often far upstream (Moser et al. 2020), whereas the non-parasitic lamprey moves much less, and likely only makes short migrations upstream (Docker & Potter 2019; Miller et al. 2021). Harris & Gehrke (1997) reported more non-parasitic lampreys in unregulated rivers without barriers, but this may have been confounded by misidentification with the short-headed lamprey (Gilligan et al. 2019b). The threat that barriers present is not clear; however, there is some evidence of reduced genetic diversity in some non-parasitic species in the Northern Hemisphere, especially downstream from barriers (Docker & Potter 2019).</p>

Mordacia praecox (non-parasitic lamprey) Conservation Advice

Climate change		
Increase in bushfire frequency/intensity	<p>Status: current</p> <p>Confidence: inferred</p> <p>Consequence: severe</p> <p>Trend: increasing</p> <p>Extent: across the entire range</p>	<p>Climate projections for eastern Australia include a decrease in annual average rainfall, increased average temperatures, and more frequent droughts (Hobday & Lough 2011; CSIRO & Bureau of Meteorology 2015). These conditions will increase the scale, frequency, and intensity of bushfires (CSIRO 2020). Bushfires can lead to complex direct and indirect effects on aquatic ecosystems (Gresswell 1999; Lyon & O'Connor 2008).</p> <p>Direct effects of bushfires are often short-term, including increased water temperature and change in water chemistry (Lyon & O'Connor 2008). Whereas indirect effects can be long-lasting and are compounded by the bushfires' impact on the surrounding landscape. The biggest indirect impact for aquatic fauna is probably post-fire rainfall leading to sediment runoff or "sediment slugs" into waterways, which can also include ash, toxic contaminants, nutrients and fire retardant (Lyon & O'Connor 2008; Alexandra & Finlayson 2020; Silva et al. 2020). The larvae of various lamprey species can bioaccumulate various toxicants that may be harmful (Clemens et al. 2020).</p> <p>The amount of sediment run-off can increase by orders of magnitude after a bushfire (Wilkinson et al. 2007; Johnston 2021). Sediment slugs can change water temperature (Mulvey 2021) and clog gills, and also cause toxic algal blooms which deoxygenate the water, leading to fish kills (Alexandra & Finlayson 2020). Impacts to aquatic ecosystems have been documented long distances downstream (50–80 kms) of the direct fire impacted area (Lyon & O'Connor 2008; Silva et al. 2020).</p> <p>Non-parasitic lamprey habitat is often in bushfire prone areas (e.g., wallum and eucalypt swamps) (Gilligan 2019b). Further, non-parasitic lamprey larvae are potentially very sensitive to changes in sediment composition and distribution associated with bushfires (see habitat degradation/loss above).</p> <p>Recent significant bushfire events have extensively overlapped with the distribution range of the non-parasitic lamprey, in particular during 2019-20, when catastrophic bushfire conditions culminated in fires that overlapped substantially with the species distribution (Legge et al. 2021). This sort of event is increasingly likely to reoccur as a result of climate change.</p>

Change to precipitation patterns (increased drought & flood)	<p>Status: current</p> <p>Confidence: inferred</p> <p>Consequence: severe</p> <p>Trend: increasing</p> <p>Extent: across the entire range</p>	<p>Climate projections for eastern Australia include an increase in extreme rain events, and more frequent and severe droughts in southern areas (CSIRO & Bureau of Meteorology 2015).</p> <p>Flooding rains that follow bushfires are associated with severe impacts on aquatic fauna (see increased intensity/frequency of bushfire section, above). Flooding in absence of fire has also been shown to impact the non-parasitic lamprey directly by removing silt bed habitat and sweeping larvae into estuarine waters where they are presumably killed by high salinity (Potter 1970). Indirect impacts, such as changes in growth rates and delays in metamorphosis, have also been seen in response to floods (Hughes & Potter 1969; Potter 1970).</p> <p>The non-parasitic lamprey is a fully freshwater species and therefore vulnerable to drought, which has led to larvae disappearing from downstream sites as brackish waters intrude upstream during low flows (Potter 1970). Drought also reduces usable habitat area as shallow portions of streams dry out (Potter 1970). There was a decline in the larvae of the short-headed lamprey in Victoria associated with the Millennium Drought (T. Raadik 2021 pers comm 8 Mar). As the non-parasitic lamprey larvae are sympatric and have a near identical biology and ecology (Potter 1968; Garbutt 2015), they were probably similarly impacted. However, the effect of drought may be reduced for some subpopulations where there are perennial springs (Gilligan 2019b).</p>
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Status—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.

Table 3 non-parasitic lamprey risk matrix

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain	Low risk	Moderate risk	Very high risk	Very high risk Habitat degradation/loss	Very high risk
Likely	Low risk	Moderate risk	High risk	Very high risk Increase in fire frequency/intensity; Change to precipitation patterns	Very high risk
Possible	Low risk	Moderate risk	High risk Instream barriers to movement	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

Conservation and recovery actions

Conservation and recovery actions for the non-parasitic lamprey are severely hampered by a lack of information about the species, even down to an inability to easily find or identify it (Docker 2009).

There are large knowledge gaps regarding the species' environmental preferences and tolerances,

responses to perturbations, and even its basic taxonomy and distribution. This makes identifying relevant threats and then countering them with effective conservation and mitigation actions challenging (Silva et al. 2020). Some lessons can be transferred across from studies on the closely related short-headed lamprey, especially those actions relating to larvae (Hammer et al. 2009). However, most short-headed lamprey conservation work relates to its adult migration phase (Bice et al. 2019), which is not very relevant to the non-parasitic lamprey. In some cases, it may be more effective in terms of resources and conservation to manage both species together as a single unit where they are sympatric (Docker & Hume 2019). However, each location should be managed independently to recognise the lack of geneflow between them, and the likelihood of significant genetic and environmental divergence.

Primary conservation outcome

- Stabilise current sub-populations and recover lost sub-populations.
- Clarify the status of sub-populations so that recovery needs can be properly assessed and measured.

Habitat loss, disturbance and modifications

- Identify the species' breeding and non-breeding habitat locations and requirements, and evaluate factors influencing the quality and availability of suitable habitat across its distribution.
- Assess the effectiveness of current land management practices in ameliorating disturbance to the habitat of the species, and revise management practices as necessary.
- Identify riparian areas responsible for increased erosion and sedimentation (particularly in the wake of bushfires).
- Conduct habitat restoration works to support the regeneration of riparian vegetation.
- Stabilise upstream areas responsible for sand slug material and remove instream sand where appropriate.

Conservation and management priorities

2019-20 bushfire response

- Conduct on-ground surveys to establish extent of population response to the 2019-20 bushfires and to provide a baseline for ongoing monitoring. The design of these surveys should reflect considerations in Southwell (2020).
- Establish the impact of fire retardants used to fight bushfires on fish populations.

Climate change-induced intensified drought and flooding

- Investigate the impact of flooding on the species.
- Establish the importance of springs and groundwater on the species' persistence during drought.

Stakeholder engagement/community engagement

- Work with landowners and managers to raise awareness of the importance of maintaining riparian zones as part of land management regulations.
- Provide input into the various impact assessment and planning processes on measures to protect the non-parasitic lamprey and its habitat. These include water resource plans, park management plans, and environmental impact assessments.

- Use workshops to aid stakeholders in developing the skills and knowledge required to manage threats to this species while undertaking these activities.
- Liaise with government agencies and stakeholders to ensure information on the non-parasitic lamprey subpopulations and threat identification and management is conveyed to land/water managers and included in relevant management processes.

Survey and monitoring priorities

- Survey sites within the known distributional range of the species where the environment is considered likely to be suitable for the species to identify whether subpopulations exist that are previously unknown.
- Undertake electrofisher surveys to determine the current distribution and spatial, temporal, and demographic characteristics of the species.
- Adopt non-traditional, passive techniques for surveying and monitoring to bolster current efforts and identify any new areas. These include: 1) environmental DNA (eDNA), 2) pheromones, 3) bile acid (petromyzonol sulfate) (Miller et al. 2021).
- Use genetic and recruitment modelling to assess demographic status and trajectories of different subpopulations.

Information and research priorities

- Conduct alpha taxonomic research to clearly delineate the species boundaries of the non-parasitic lamprey relative to the short-headed lamprey and the undescribed lamprey species in the Noosa River area. This should include nuclear genomic data to establish if feeding type and species differentiation is genetically determined. The publication of the sea lamprey (*Petromyzon marinus*) genome has made this more feasible (Smith et al. 2013).
- Conduct distributional surveys to better understand the distribution of the non-parasitic lamprey to delineate more clearly actual distribution and environmental preferences.
- Conduct basic biological and ecological research to better understand environmental tolerances of the species.
- Establish long-term monitoring sites so the response of the non-parasitic lamprey to various future perturbations can be accurately assessed.
- Establish the cultural significance of the non-parasitic lamprey to Indigenous groups and enquire about their knowledge relating to this species and its habitat.
- Identify all potential threatening processes that may have affected the species' distribution and abundance, then evaluate their relative contribution to the decline and impediment to recovery. In particular:
 - Assess the effects of bushfire on survival and reproduction, including:
 - The impact of altered environmental attributes, such as sediment loads, stream hydrological regimes, and riparian vegetation structure and composition.
 - Low dissolved oxygen tolerance of adults, juveniles, larvae and eggs.
 - The species' long-term response to major bushfire events or altered fire regimes, through identifying those parts of its range that are most vulnerable, or conversely, where there are opportunities to enhance refuges from fire.

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Attachment A: Listing Assessment for *Mordacia praecox*

Reason for assessment

This assessment follows provision of new information to the Committee.

Assessment of eligibility for listing

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

Key assessment parameters

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

Table 4 Key assessment parameters

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Number of mature individuals	No estimate used			There are insufficient data available to determine the number of mature individuals as adults of this species are very rarely encountered (Miller et al. 2021; D. Gilligan 2020 pers comm 16 Nov; T. Raadik 2021 pers comm 15 Feb).
Trend	No estimate used, but likely contracting due to threats (see Table 2) in most locations except Water Park Creek (Table 5).			See Criterion 1.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Generation time (years)	6	5.66	6.33	<p>The generation length of the non-parasitic lamprey is not known with certainty, but with available demographic data from this species (and its sister-species) a reasonable estimate of 6 years can be made. The short-headed lamprey begins metamorphosis after about 3.5 years, while the non-parasitic lamprey's larval life is longer (Potter et al. 2015), estimated at about 5 years (Gilligan 2019b). The non-parasitic lamprey's metamorphosis and sexual maturation takes about 9 months (Hughes & Potter 1969), followed by a short migration, spawning, and death, which makes for a generation length of approximately 6 years (Gilligan 2019b). This is the same estimate as for the short-headed lamprey (Gilligan 2019a). It is common for paired-species to have similar life spans and generation times (Docker 2009).</p> <p>Because each individual breeds only once, and likely at the same age, this makes estimates of generation length and life span almost the same. There is no confounding factor of differential reproductive output during an individual's lifetime or between individuals, and so there is potentially little variance in the estimate of generation length. One complication is whether all individuals have precisely the same length of larval phase, which is a common assumption, but it is not known for sure. The estimated minimum and maximum values here assume that one third of individuals emerge either earlier or later by one year.</p>
Extent of occurrence (km ²)	264,950	245,900	266,200	<p>Extent of occurrence (EEO) was calculated as a minimum convex hull in GeoCat (Bachman et al. 2011) using species occurrence records (see Distribution and Table 1 above). The minimum plausible value excludes the Moruya/Tuross location, because of probable local extinction, and the Richmond location, where the species' current status is unclear. The maximum plausible value includes all locations.</p> <p>The estimate used in the assessment does not include the extinct Moruya/Tuross location but does include the Richmond location.</p>
Trend	Stable or contracting			For the EEO to change appreciably would require a local extinction at one of the locations.
Area of Occupancy (km ²)	36	32	200	<p>Area of occupancy (AOO) was calculated in GeoCat (Bachman et al. 2011) with the standard IUCN cell size of 4 km² (IUCN Standards and Petitions Committee 2019). The estimate used in the assessment and minimum value makes the same assumptions as for EEO above. The maximum value comes from Gilligan (2019b) and recognises the cryptic nature of the species (in that it will have not been detected in some places), while also acknowledging that this species tends to only be found in a relatively small proportion of a catchment (D. Moffatt 2020 pers com 17 Nov) (see Criteria 1 and 2).</p>

Mordacia praecox (non-parasitic lamprey) Conservation Advice

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Trend	Contracting in most locations except Water Park Creek			See Criterion 1.
Number of subpopulations	5	4	7	Minimum/maximum plausible value assumptions as per EOO above. Subpopulations are restricted habitat areas within discrete river catchments, between which dispersal is unlikely.
Trend	Stable or contracting			As per EOO trend above.
Basis of assessment of subpopulation number	This species is fully freshwater adapted and is killed by high salinity, and so is very unlikely to venture outside its local coastal catchment. Therefore, each distinct river basin can represent a separate subpopulation given the low likelihood of geneflow between them. This is how they are treated here (basins as defined in Geoscience Australia 1997; see Table 1).			
No. locations	5	4	6	Minimum/maximum plausible value assumptions as per EOO above. Locations based on small discrete area within a catchment that will likely experience the same threatening process at the same level.
Trend	Stable or contracting			As per EOO trend above.
Basis of assessment of location number	The river basins (Table 1) are geographically isolated from each other (~140 – 600 km) and have distinct local threats (see Criterion 1) and so most serve as locations for this assessment. Tuross and Moruya are treated as a single location because they are adjacent and have a commonality of threats (bushfire, sedimentation).			
Fragmentation	The non-parasitic lamprey has a widespread distribution, having been recorded in a small number of isolated but widespread coastal catchments, that are naturally fragmented between catchments, with little expectation of natural geneflow between them. However, given the lack of long-term monitoring in all but a few catchments across its distribution range, it is unclear how vulnerable individual subpopulations are to extirpation, although there is some evidence of past local extinctions (Gilligan 2019b) (see Criteria 1 and 2 below). In particular, it is unknown whether the population is severely fragmented, requiring > 50% of the AOO to be in patches that are too small to support a viable population (the IUCN Standards and Petitions Committee 2019). The two extant locations/subpopulations that are most likely to be nonviable (Richmond, Macleay) make up only 22 % of the AOO.			
Fluctuations	Not known to be subject to extreme fluctuations in EOO, AOO, number of subpopulations, locations or mature individuals. No parameter has been shown to have changed by an order of magnitude by the 2019-20 bushfires.			

Criterion 1 Population size reduction

Reduction in total numbers (measured over the longer of 10 years or 3 generations) based on any of A1 to A4			
–	Critically Endangered Very severe reduction	Endangered Severe reduction	Vulnerable Substantial reduction
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3, A4	≥ 80%	≥ 50%	≥ 30%
<p>A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.</p> <p>A2 Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible.</p> <p>A3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [(a) cannot be used for A3]</p> <p>A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.</p> <p>Based on any of the following</p> <ul style="list-style-type: none"> (a) direct observation [except A3] (b) an index of abundance appropriate to the taxon (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat (d) actual or potential levels of exploitation (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites 			

Criterion 1 evidence

Insufficient data to determine eligibility

The non-parasitic lamprey presents a number of potentially difficult issues when trying to establish an accurate population size through time. Firstly, the species has not been the subject of any systematic attempt to quantify its population size across its entire distribution (see Distribution section above). Secondly, the non-parasitic lamprey has a cryptic, nocturnal behaviour, and spends its extended larval stage buried in sediment, leading to potential non-detection biases (Miller et al. 2021). Thirdly, even when reported, there are species identification challenges, since the larvae of the non-parasitic lamprey and the short-headed lamprey are indistinguishable. However, this is only relevant for locations where short-headed lamprey are definitively present, which is at the southernmost location (East Gippsland).

General lamprey declines

There have been reported declines in both the short-headed lamprey and the pouched lamprey in the last 20 years (Lintermans 2009; Miller et al. 2021; T. Raadik 2021 pers comm 15 Feb). The larvae of these species are ecologically and biologically similar to the non-parasitic lamprey, and thus have similar vulnerabilities. As they are sympatric across parts of their ranges, declines in the short-headed lamprey and the pouched lamprey, caused by habitat degradation and modification due to land management practices (mining, agriculture, urbanisation), are likely to be similarly reflected in the non-parasitic lamprey (Docker 2009). Also, due to the difficulty in differentiating between larvae of these species, where they are sympatric, an observed decline in the short-headed lamprey may also mask a decline in unidentified non-parasitic lamprey subpopulations.

A decline in the short-headed lamprey could have negative impacts for the non-parasitic lamprey (Docker 2009) due to the possibility of geneflow between the sister species. This could be a potentially important reservoir of genetic diversity and population connectivity for the non-parasitic lamprey (McCauley et al. 2015).

Pre-2019 population reductions

The non-parasitic lamprey has not been recorded in the Tuross or Moruya basins (the type locations) since 1994 (or 1995 if an unverified specimen is included). This is despite a considerable amount of sampling effort. There has been a total of 36 sites sampled on 70 occasions over 50 different days between 1994 and 2012, including targeted lamprey surveys by NSW Department of Primary Industries from 2003 (NSW DPI Fisheries 2021 unpub). This has included re-visiting all of Ian Potter's (original species describer) sites with him to ensure the correct micro and meso habitats were being sampled (NSW DPI Fisheries 2021 unpub; D. Gilligan 2021 pers comm 25 June, 15 July). The species likely went locally extinct at this location sometime between 1995 and 2003 (Gilligan 2019; D. Gilligan 2020 pers comm 16 Nov.; D. Gilligan 2021 pers comm 15 July). However, this local decline/extinction cannot feature in the current population decline assessment as it pre-dates the three generation window (18 years for non-parasitic lamprey) over which declines can be calculated for this criterion.

A population decline has also been previously reported for the non-parasitic lamprey in the East Gippsland Basin (Wallagaraugh River), with an estimated local 79 percent decline based on catch per unit effort (CPUE) between 2003-11 (Gilligan 2019b). However, this was based on very small numbers and a single river, and the trend was not statistically significant (Gilligan 2019b). Non-parasitic lamprey adults and *Mordacia* larvae have since been identified there (in 2021), confirming population persistence at the location over three generations (NSW DPI Fisheries 2021 unpub), albeit at low numbers.

Impacts of the 2019–20 bushfires

Further to the declines detailed above, the population of the non-parasitic lamprey may have been reduced following the bushfires of 2019-20, which followed a severe drought (Nolan et al. 2020). The bushfires burned more than 10 million hectares from South Australia to Queensland (Alexandra & Finlayson 2020). This was the largest fire season since European settlement, burning across varied landscapes (Nolan et al. 2020; Ward et al. 2020). These bushfires burned more than 43 different river basins, causing the deaths of at least 27 species of fish (Silva et al. 2020). Any population decline in non-parasitic lamprey could be direct, through mortality due to fire and heated water, as well as indirect and ongoing, via habitat destruction and degradation, in particular due to sediment slugs and poor water quality (Wilkinson et al. 2007; Johnston 2021; Mulvey 2021).

The response of the non-parasitic lamprey to bushfire is not known (A. Miller 2021. pers comm 5 May). However, impacts on aquatic systems can be long-lasting (Lyon et al. 2008; Rust et al. 2019), and many NSW river basins continued to experience increased erosion and high sediment loads one year after the fires (Biswas 2021; Alluvium Consulting Australia 2021 cited by Biswas 2021). After the 2001 bushfires in the Sydney Catchment, Wilkinson et al. (2007) found that pre-fire sediment conditions returned after four years, which is close to the length of time that the non-parasitic lamprey spends as larvae. A large local impact due to bushfire, or even a relatively small one on an already reduced, threatened subpopulation, could lead to local extirpations. There are currently only on-ground data on the impacts of the 2019-20 bushfires on this species at a single location (East Gippsland), which was sampled post-fire in 2021 (catching 4 adults, 16 larvae; NSW DPI Fisheries 2021 unpub).

Broad fire impact analyses were carried out by a team from the National Environmental Science Program (NESP) Threatened Species Recovery (TSR) Hub (Legge et al. 2021), using remote sensing data across the whole distribution of the species. The spatial analyses included a five-kilometre buffer placed around the point locations and clipped to the watercourse layer and included a spatial model that predicted risk of instream sedimentation events. It showed that roughly 50 percent of the range of the non-parasitic lamprey was affected by the 2019-20 bushfires (43 percent overlapped with areas of high aquatic impacts, and a further 7 percent overlapped with areas of mild aquatic impacts). These estimates included the Tuross/Moruya basins, where the species is considered extinct, and the Noosa Basin, which hosts a different species. However, the results likely would not be very different if these areas were not included, as the highly fire impacted Tuross/Moruya is effectively cancelled out by the lowly impacted Noosa Basin.

Population size reduction assessment

Any historical and ongoing declines within the population could have been exacerbated by the 2019-20 bushfires, however both the species and fire impacts are patchily distributed. Any decline estimate must be across the entire population, which is composed of isolated locations from central Qld to southern NSW (Table 1, Figure 1). These locations have very different threat profiles and potentially different population size trajectories. For example, at least one of the Qld locations seems to have a stable population and have relatively high population numbers (Gilligan 2019b; D. Moffatt 2020 pers comm 17 Nov). Therefore, river basin-based information is required to provide local context to derive a population-wide estimate. Much of these data are inferred or anecdotal, with many unknowns. Table 5 is a compilation of relevant location-specific information (“locally abundant” is particular for this species, meaning that it is more common here compared to some other locations in which it is found).

No clear, coherent population-wide picture emerges when all locations are considered in detail (Table 5). There has been a local population estimate at only one extant location (East Gippsland), which showed no significant change over three generations (NSW DPI Fisheries 2021 unpub), but with low numbers of specimens caught. The population status at the other locations over three generations is either entirely unknown (Richmond, Macleay), or imperfectly known (Water Park, Maroochy). In terms of the impacts of the 2019-20 bushfires, these were likely minimal at the three northern locations (Table 5). There were severe fires at Macleay, where the populations status is entirely unknown, and East Gippsland, where a 2021 survey successfully collected adults and larvae and reported good habitat and water quality (NSW DPI Fisheries 2021 unpub).

The Committee considers there are **insufficient data** to determine 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.

Table 5: Non-parasitic lamprey local population status at the river basin scale.

Location	Local abundance	Trend	Potential Impacts of 2019-20 bushfires	Other information
Water Park	high	stable	None – Low: Sites not directly impacted but close (2 km). Water Park Basin 14 % burnt area (DAWE 2020), Manifold IBRA Subregion 1 % burnt area (GAIA 2021).	Sampled at 4 sites over 10 years (2001, 2002, 2011) over 18 km ² area (Moore & Marsden 2011; ALA 2020). Sites are in Byfield National Park.
Maroochy	low	stable / declining	None: No close fires. Maroochy Basin 1 % burnt (DAWE 2020), Sunshine Coast-Gold Coast Lowlands Subregion 2 % burnt (GAIA 2021).	Site is impacted by pesticides (D. Moffatt 2020, pers comm 17 Nov.). The creek is a water quality hotspot due to high nutrient and sediment run-off from agriculture (Pumicestone Passage Technical Working Group 2011).
Richmond	very low	stable/ declining	Low – Moderate: Site 7 km from fire. Richmond Basin 22 % burnt including upstream of site (DAWE 2020), Clarence Lowlands Subregion 26 % burnt (48 % of which High-Very High Severity; GAIA 2021). Erosion high 1 year after fire (Alluvium Consulting Australia 2021 cited by Biswas 2021).	Single larval specimen collected in 1966 (Australian Museum Ichthyology Collection; ALA 2020).
Macleay	very low	stable / declining	Very High: Site potentially directly impacted. Macleay Basin 41 % burnt (DAWE 2020) including the entire mid-catchment zone upstream from the site. Subregion Macleay Hastings 34 % burnt (48 % of which High-Very High; GAIA 2021). Macleay had highest recorded number of aquatic species killed, and downstream impacts 54 km from fire zone (Silva et al. 2020), with hundreds of thousands of fish reported killed by post-fire runoff (Guardian Australia 2020). Suspended sediment increases of 2 orders of magnitude, with very low levels of dissolved oxygen (Johnston 2021). Erosion high 1 year after fire (Alluvium Consulting Australia 2021 cited by Biswas 2021).	Discovered at 1 site in 2015 so little known (Butler et al. 2016; Gilligan 2019b). The basin has been extensively cleared for agriculture with issues of sedimentation and water quality (WMA Water 2009).
Moruya/ Tuross	extinct	extinct	Very High: Sites potentially directly impacted. Moruya Basin 73 % burnt, Tuross 80 % burnt, including almost all upstream areas above sites in both basins (DAWE 2020). Subregion South East Coastal Ranges 48 % burnt (63 % High-Very High), Subregion Bateman 54 % burnt (42 % High-Very High Severity) (GAIA 2021). 5 separate fish kill sites reported in Moruya/Tuross (Silva et al. 2020). Possible post-fire environmental impacts in freshwater sections of Moruya Basin are topic of ongoing research (S. Bracewell 2021 pers comm 21 April).	No specimens found since 1994/1995 (Gilligan 2019b; NSW DPI 2021 unpub). High levels sedimentation and erosion in Moruya Basin (AMOG Consulting 2003).
East Gippsland	low	stable	Very High: Sites potentially directly impacted. East Gippsland Basin 96 % burnt, including virtually all upstream areas above sites (DAWE 2020). Subregion South East Coastal Ranges 48 % burnt (63 % High-Very High), Subregion East Gippsland Lowlands 79 % burnt (51 % High-Very High) (GAIA 2021). 1 reported fish kill site in East Gippsland Basin (Silva et al. 2020). Erosion high 1 year after fire (Alluvium Consulting 2021 cited by Biswas 2021). Good habitat & water quality reported 2021 (NSW DPI Fisheries 2021 unpub).	Reported 79 % decline based on CPUE between 2003 and 2011 (Gilligan 2019b), but not significant, and trend reverses when successful sampling in 2021 is included (NSW DPI Fisheries 2021 unpub).

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

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

Criterion 2 evidence

Eligible under Criterion 2 B2ab(iii) for listing as Endangered

Extent of occurrence

The EOO for the non-parasitic lamprey has been calculated as a range between 245,900 km² and 266,200 km² (see Table 4). The widely distributed nature of the species means that the EOO is well above the threshold value for a listing (20,000 km² for Vulnerable); therefore, the non-parasitic lamprey is not eligible for listing under sub-criterion B1.

Area of occupancy

The AOO for the non-parasitic lamprey has been calculated as 36 km² (see Table 4). However, it is unlikely this represents all existing sites due to the likely misidentification of larvae with those of the nearly identical short-headed lamprey and the cryptic nature of both larvae and adults. Difficulty in detecting the species is compounded by the uncertainty surrounding habitat preferences and the use of inappropriate survey methods, as well as a limited survey effort to date. Gilligan (2019b) assumed a maximum value of 200 km² for this species, although this did not incorporate any possible site extinctions caused by the 2019–20 bushfires. Both of these values meet the threshold for listing as Endangered under sub criterion B2.

Locations

There are five locations for the non-parasitic lamprey, based on geographical isolation and distinct local threats (Table 5).

Continuing decline

Data for this species are limited, however there is likely an inferred and projected continuing decline in the area, extent and/or quality of habitat at all locations except Water Park Creek, largely due to habitat degradation/loss (sedimentation, water quality). Also, there are possible continuing declines in the area of occupancy and number of mature individuals.

The Committee considers that while the non-parasitic lamprey does not qualify for listing under sub-criterion B1 (EOO), it does appear to qualify under B2 given an AOO < 500 km², five locations, and a continuing decline. This suggests that the non-parasitic lamprey meets the criteria for listing as **Endangered (B2ab(iii))**. 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
(a) (ii) % of mature individuals in one subpopulation =	90 – 100%	95 – 100%	100%
(b) Extreme fluctuations in the number of mature individuals			

Criterion 3 evidence

Insufficient data to determine eligibility

There is no estimate for the number of non-parasitic lamprey adults, as adults are very rarely encountered (Miller et al. 2021). However, the population is likely declining at most locations except Water Park Creek (see Criterion 1).

The Committee considers the data presented above appear to demonstrate that there are **insufficient data** to demonstrate if the species is eligible for listing under this criterion. However, the purpose of this conservation advice 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 common assessment method.

Criterion 4 evidence

Insufficient data to determine eligibility

There is no estimate for the number of non-parasitic lamprey adults, as adults are very rarely encountered (Miller et al. 2021).

The Committee considers the data presented above appear to demonstrate that there are **insufficient data** to demonstrate if the species is eligible for listing under this criterion. However, the purpose of this conservation advice is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Criterion 5 Quantitative analysis

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

Criterion 5 evidence

Insufficient data to determine eligibility

Population viability analysis has not been undertaken. Therefore, there is insufficient information to determine the eligibility of the species for listing in any category under this criterion. However, the purpose of this conservation advice is to elicit additional information to better understand the

species' status. This conclusion should therefore be considered tentative at this stage, as it may be changed as a result of responses to this consultation process.

Adequacy of survey

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

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