Fisheries Scientific Committee

Final Determination

Narrow *Euastacus* (*Euastacus angustus*)

Assessment outcome CRITICALLY ENDANGERED
IUCN Category B1ab(iii,v)+B2ab(iii,v)

The Fisheries Scientific Committee, established under Part 7A of the New South Wales *Fisheries Management Act 1994* (the FM Act), has assessed the ***Euastacus angustus*** **(narrow *Euastacus*)** under the FM Act and the Common Assessment Method and has determined that it is eligible to be listed as a **CRITICALLY ENDANGERED SPECIES**.

The Fisheries Scientific Committee, with reference to the criteria relevant to this species, prescribed by Part 14 of the Fisheries Management (General) Regulation 2019 has assessed and determined that:

- The listing of CRITICALLY ENDANGERED is provided for by Part 7A, Division 2 of the FM Act.
- The species is facing an extremely high risk of extinction in New South Wales in the immediate future and in the opinion of the Fisheries Scientific Committee it meets the criteria specified for CRITICALLY ENDANGERED. The species is proposed to be added to Part 1of Schedule 4A in the FM Act.
- The assessment has been determined in accordance with the national Common Assessment Method (CAM), which provides a nationally consistent approach to the assessing and listing of threatened species in Australia.
- The assessment documentation below indicates the eligibility of the species for listing under both FM Act requirements and IUCN criteria as prescribed by the CAM.

- For more information about the CAM, visit Common Assessment Method – –DCCEEW
- This assessment was submitted as a public nomination to the Commonwealth for listing under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*. This nomination was provided to the Fisheries Scientific Committee and the Department of Primary Industries and Regional Development in accordance with the Memorandum of Understanding on the CAM with the Commonwealth on national threatened species assessments..

Assessment against Fisheries Management (General) Regulation 2019 criteria

In its assessment of the nomination the Fisheries Scientific Committee has had regard to Regulation Clause 237 *Criteria—reduction in abundance, geographic distribution or genetic diversity* and Regulation Clause 238 *Criteria—threatening processes.*

237 Criteria—reduction in abundance, geographic distribution or genetic diversity

(1) It is observed, estimated, inferred or reasonably suspected that the species has undergone, or is likely to undergo, within a time frame appropriate to the life cycle and habitat characteristics of the taxon—

(a) for ***critically endangered species***—an extremely large reduction in 1 or more of the following—
(i) an index of abundance appropriate to the taxon,
(ii) geographic distribution,
(iii) genetic diversity
The information to support this assessment is in Attachment A.

238 Criteria—threatening processes

(1) For ***critically endangered***, ***endangered*** and ***vulnerable species***, there is, or there is observed, estimated, inferred or reasonably suspected to be, a historical, current or potential threatening process, or threatening processes affecting the species.

(2) The Fisheries Scientific Committee must have regard to the following in determining the relevant extent of the effect of the threatening process or processes—

(a) the number and nature of the threatening processes,
(b) the potential for synergistic effects between threatening processes,
(c) the extent of the threatening processes relative to the geographic distribution of the species,
(d) the impact of the threatening processes on the diversity and quality of the species' habitat,
(e) the level of protection offered to the species within existing reserve systems, other forms of refuge or by current management strategies.

The information to support this assessment is provided in the Threats section below.

Conservation Advice for *Euastacus angustus* (narrow *Euastacus*)

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

Acknowledgements

This Listing Assessment and Conservation Advice was initiated by the World Wide Fund for Nature Australia (WWF), and was subsequently revised by the NSW Fisheries Scientific Committee under the Common Assessment Method Memorandum of Understanding. The species was prioritised due to its proximity to the Border Ranges WWF fire-impacted landscape and lack of IUCN conservation status. The following experts contributed to Listing Assessment and the Conservation Advice: James M. Furse (Griffith University), Maiko Lutz (Nature Glenelg Trust), Robert McCormack (Australian Aquatic Biological), and Nick Whiterod (Nature Glenelg Trust).

Euastacus angustus in a captive setting. Image does not depict the species' natural habitat © Copyright, Rob McCormack.

Conservation status

Euastacus angustus is proposed to be listed in the Critically Endangered category of the threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Euastacus angustus was assessed to be eligible for listing as Critically Endangered under Criterion 2. The assessment is at Attachment A. The assessment of the species' eligibility against each of the listing criteria is:

- Criterion 1: Insufficient data
- Criterion 2: B1ab(iii,v)+B2ab(iii,v): Critically 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 Critically Endangered category are the impacts of climate change (extreme weather events, increased temperature, increased severity and frequency of bushfire) on its highly restricted distribution, which will very likely lead to a continuing decline in the area, extent, and quality of habitat and the number of mature individuals.

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 *Euastacus angustus* Coughran and Dawkins, 2013 (described in Furse et al. 2013) (Family: Parastacidae). Recent phylogenetic results have confirmed its validity as a distinct taxon (Austin et al. 2022).

Description

Euastacus angustus was described from a single male specimen collected by Dr Jason Coughran in October 2002 (Coughran 2005; Furse et al. 2013). It is one of the nine poorly spinose species of *Euastacus* (poorly spinose, Coughran 2008) that are known to occupy the montane rainforests of south-eastern Queensland (Qld) and northern New South Wales (NSW) (Furse et al. 2013). The occipital-carapace length (OCL; Morgan 1997) of the *E. angustus* Holotype is 21.74 mm (Furse et al. 2013). Unpublished survey data from 2022 reported a 28.02 mm OCL male specimen (R.B. McCormack 2022 unpub.).

On collection, colouration of the single specimen was described as light olive-brown to orange-brown from above (dorsally), and cream from below (ventrally). From above, chelae (i.e. claws) orange overall with darker orange, or orange-red markings at articulations, from below: lighter orange-yellow with orange markings at articulations, “fingers [of chelae] washed bluish-green” (Furse et al. 2013).

The morphological characteristics used to identify the small and poorly spinose *Euastacus* are subtle, with the differences often a few spines, and/or the presence of a groove. *Euastacus angustus* should be distinguishable from the very similar looking and sympatric *Euastacus dalagarbe* (mud gully crayfish) by the presence of a large ventromesial carpal spine, and the unusual laterally-compressed body shape for which it was named (i.e. narrow *Euastacus*, slender dwarf crayfish, narrow dwarf crayfish) (Coughran 2005; Furse et al. 2013). Accurate and reliable identification of the small and poorly spinose *Euastacus* is challenging and requires technical terminology to describe the morphological features separating the species. Detailed descriptions can be found in Coughran (2005) and Furse et al. (2013).

Distribution

Euastacus angustus is endemic to north-eastern NSW, with the species’ entire distribution contained within subtropical rainforest of the north-eastern quadrant of the Border Ranges National Park (NP) (Coughran 2005; Furse et al. 2013). This species in known from a small headwater stream, 760 m above sea level (ASL) in the upper Richmond River Basin (Furse et al. 2013) where the species has been collected from three proximal sites (Coughran 2005; Furse et al. 2013; R.B. McCormack 2022 unpub.). Therefore, the species is considered a short-range endemic

(Harvey 2002). The mud gully crayfish and *Euastacus sulcatus* (mountain crayfish) are known to occur at the type locality of the species (Coughran 2005; Furse et al. 2013).

Despite extensive efforts (over many years), Furse et al. (2013) reported additional specimens of *Euastacus angustus* had not been located at the type locality, or in the surrounding area, and reported in the scholarly literature. More recent unpublished collection records include additional specimens collected adjacent to the type locality (R.B. McCormack 2022 unpub.), which were confirmed as *Euastacus angustus* by Austin et al. (2022).

Additional areas of potentially suitable habitat do exist in the Border Ranges National Park and adjacent Lamington National Park (Queensland); however, these areas are already occupied by one or more of the other 13 species of *Euastacus* known to occur in the region (Coughran 2005, 2007; Coughran & Furse 2010; Furse et al. 2012b; Furse et al. 2013). All available information indicates that this species does not occur outside of its currently known distribution.

The population is afforded a degree of protection as it is contained within the boundary of the Border Ranges National Park, but the park is not actively managed for conservation of *E. angustus* (*sensu* Coughran & Furse 2010).

The Qld-NSW border region occupied by this crayfish is an area of extremely high rainfall. Annual average rainfall in the region typically exceeds 2,000 mm; and is known to routinely exceed 3,000 mm per annum at nearby Springbrook (BOM 2021). Mean annual temperature in the region is in the range ~15–21 °C (BOM 2021).

Map 1 Modelled distribution of *Euastacus angustus*

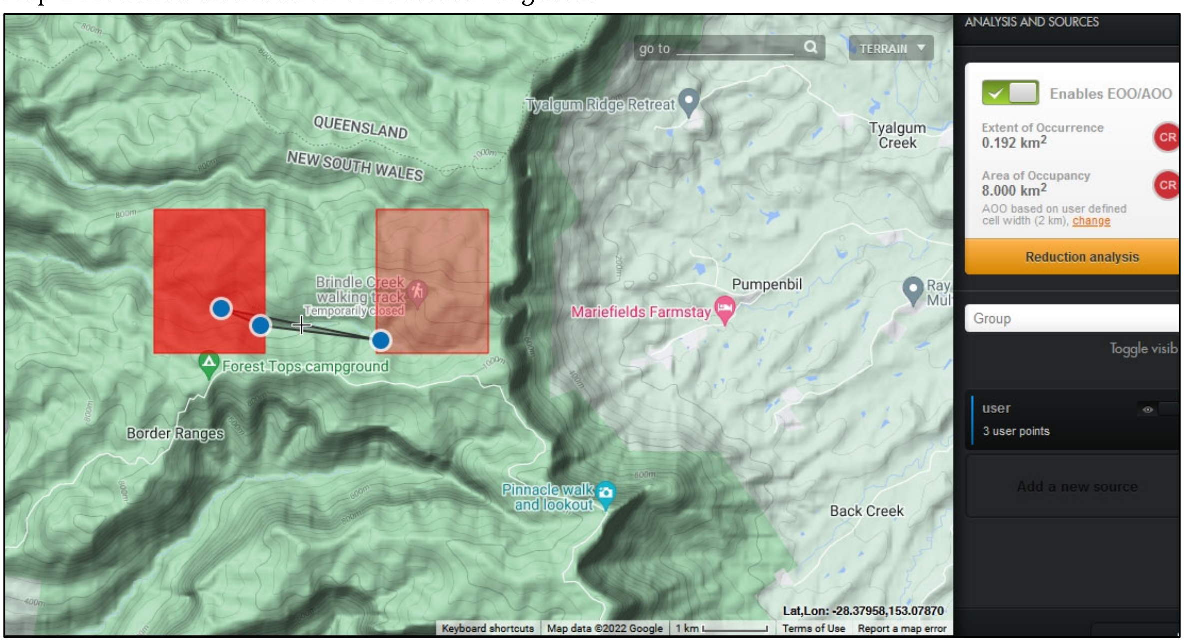

Figure 1. Distribution of *Euastacus angustus*, blue dots denote sites where the species has been collected. Source: Furse et al. 2013. McCormack 2022 (R.B. McCormack unpub. collection records, in part reported in Austin et al. 2022), GeoCAT, Google Earth. Map prepared by James M. Furse 2022.

Cultural and community significance

The cultural, customary and spiritual significance of species and the ecological communities they form are diverse and varied for the many Indigenous peoples that live in the area and care for Country. This section describes some examples of this significance but is not intended to be comprehensive or applicable to, or speak for, Indigenous peoples. Such knowledge may be only held by Indigenous groups and individuals who are the custodians of this knowledge and have the rights to decide how this knowledge is shared and used..

Euastacus angustus occurs on the lands of the Githabul people who are associated with the Border Ranges National Park (NSW NPWS 2004). Any cultural significance of *E. angustus* remains unknown. However, given the acknowledged importance to Aboriginal peoples of Connection to Country and the widespread importance of Caring for Country (which includes biodiversity, 'place', custom and totemic elements) it is considered likely that the species may have or is associated with some cultural and/or community significance.

Ascertaining any details on the cultural significance of this species is a priority in the Conservation and Recovery Actions.

Relevant biology and ecology

It is recognised that the *Euastacus* have a suite of common biological characteristics, and many of these characteristics will apply to *Euastacus angustus* (e.g. Furse & Coughran 2011a). Various studies have established that *Euastacus* are slow-growing (growth increments of a few mm OCL yr^{-1}), long-lived and can take many decades (35−50 years) to reach the adult sizes that are recorded for some species (Honan & Mitchell 1995a; Turvey & Merrick 1997a; Morey 1998; Furse & Wild 2004; Coughran 2011, 2013). *Euastacus angustus* is not likely a typical, stream-dwelling crayfish (Coughran 2005, 2007, 2011; Furse & Coughran 2011b; Furse et al. 2013). Instead, the species occupies small ephemeral tributaries, wet soaks and damp gullies where surface water may typically be absent (Coughran 2005, 2008). The ability to survive without surface water permits *E. angustus* to occupy habitats that are not considered aquatic (Coughran 2007). The biology and ecology of *E. angustus* are not well known (Furse et al. 2013), indeed, Furse and Coughran (2011c) identified critical knowledge gaps (e.g. biology, ecology, distributions) for the *Euastacus* in general, and many of the knowledge gaps apply in particular to this species. The species is likely to be a poor disperser, with slow growth and low fecundity (Harvey 2002).

Reproductive Ecology

Reproductive studies show that *Euastacus* are typically late maturing and have slow reproductive cycles with females only reaching reproductive maturity after 5–10 years (e.g., Honan & Mitchell 1995a; Turvey & Merrick 1997a; Borsboom 1998; Furse & Wild 2004; Coughran 2013). The growth rate, population sizes and generation length of *E. angustus* are not known. The species is likely to be a poor disperser, with slow growth and low fecundity (Harvey 2002).

Many species of *Euastacus* are winter brooders, mating in late summer–autumn with females carrying eggs over winter, and brooding periods typically 6–10 months. Some species only breed biennially (to balance the energetic cost of growth and moulting) and pleopodal egg fecundity (number of fertilised eggs attached to underside of a gravid female) varies considerably between species, typically ranging from 20–1,500 eggs per female (Clark 1937; Barker 1992; Honan & Mitchell 1995b; Turvey & Merrick 1997b; Borsboom 1998; Honan 1998; Morey 1998; Furse & Wild 2004; Coughran 2006, 2013; McCormack et al. 2010). Due to the small documented size of n *E. angustus* pleopodal egg fecundity is likely in the range 20–80 eggs (Coughran 2011).

Co-occurring species

Euastacus dalagarbe (mud gully crayfish) and *Euastacus sulcatus* (mountain crayfish) are known to occur at the type locality of the species (Coughran 2005; Furse et al. 2013).

Habitat

Euastacus angustus occupies small, ephemeral tributaries, wet soaks and damp gullies where surface water may typically be absent (Coughran 2005, 2007, 2008). The ability to survive without surface water permits *E. angustus* to occupy habitats that are not considered aquatic (Coughran 2007). The species is associated with cool habitat conditions and a specific vegetation type (subtropical rainforest) (Coughran 2005; Furse et al. 2013). The thermal limit of this species remains unknown, however other highland rainforest-dwelling species of *Euastacus* such as the co-occurring mountain crayfish are intolerant of high temperatures (Bone et al. 2014) and it is likely that *E. angustus* is too. Based on the work of Bone et al. (2014) environmental temperatures may only be a few degrees away from levels that may cause thermal stress in this species (i.e. ~23 °C).

Euastacus angustus is likely to occupy some form of burrow or simple excavation, and opportunistically seek shelter under rocks and vegetative debris (Coughran 2005, 2007; Furse et al. 2013). It is likely that the species uses these shelters as temporary refuges from environmental disturbance. This species is not known to be associated with flowing water, with the type locality characterised by surface water being either absent or negligible for most of the year (see Coughran 2007) therefore, sub-surface water and soil moisture are likely important habitat characteristics for this species.

Diet

The diet of *E. angustus* is not known, but the species is likely omnivorous as with many species of spiny crayfish (McCormack 2012).

Threats and level of risk to the species

Assessment of threatening processes (under clause 238 of the Fisheries Management (General) Regulation 2019)

Established threats (habitat destruction, invasive species, human exploitation and climate change) and potential threats (disease such as *Aphanomyces astaci* [crayfish plague]; Panteleit et al. 2017) may put nearly all species of *Euastacus* at serious risk of population declines, or extinction, in less than a decade (Wells et al. 1983; Coughran 2007; Furse & Coughran 2011b; Furse 2014; Richman et al. 2015). Climate change is a key threat to *E. angustus*, with the species likely having limited capacity to relocate to higher, cooler altitudes, or move overland to other nearby suitably cool habitat which are already occupied by other species of *Euastacus* (Ponniah & Hughes 2004; Furse et al. 2012a). The highly restricted distribution of this species puts all individuals in the population at considerable risk of extirpation by a single stochastic event (e.g., natural disaster, or disease) impacting the species across its very small range (Furse & Coughran 2011b).

Table 1 Threats impacting *Euastacus angustus*

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

Threat	Status and severity	Evidence
Climate change		

Threat	**Status and severity**	**Evidence**
Extreme weather events	Timing: current/future Confidence: observed Likelihood: likely Consequence: major Trend: increasing Extent: across the entire range	Increased intensity and frequency of extreme weather events (heatwaves, storms, cyclones, droughts (and fires –discussed below)) are broad geographic scale threats associated with climate change. These events are not persistent and may be relatively short-term in duration (i.e. hours to weeks). Extreme weather events have the capacity to seriously impact the population, leading to a decline or extirpation of the species (Coughran & Furse 2010). The highland habitat of *E. angustus* is anticipated to be impacted by an increase in intensity and frequency of extreme heat events. By 2060–79, the north coast region of NSW is expected to have 5–10 more hot days (over 35 °C) annually compared to 1990–2009 (NSW OEH 2014). Bone et al. (2014) reported that when exposed to chronic, steadily increasing temperature, similarly-sized, small specimens of the mountain crayfish became sluggish ~23 °C and were effectively incapacitated at ~27 °C (Bone et al. 2014). Acute exposure to temperatures above the upper thermal tolerance limit could result in deleterious physiological impacts, and mortalities, and could lead to population reductions. Given the species extremely restricted distribution, the entire population could be affected by a single acute event. Short-term extreme weather events (e.g. heatwaves) are distinct from long term, irreversible increase in temperature. High rainfall events leading to flash floods can scour high-altitude streams and this can be deadly to any *Euastacus* that seek refuge under leaves/fallen palm fronds, small rocks and logs. Mass mortality was recorded in *Euastacus valentulus* (powerful crayfish) in the nearby Numinbah Valley (Qld), when an intense rainfall event and flash flood killed hundreds, and possibly thousands, of crayfish (Furse et al. 2012b). Many of the crayfish killed in that event were a similar size to this species (30–40 mm OCL). In addition, a single extreme weather event may lead to other localised natural disasters (e.g., flooding, tree falls, landslides, and sedimentation events) (Furse et al. 2012b). Soils in the subtropical rainforests of the Qld-NSW border are poor, unstable and susceptible to landslides and erosion in the steep terrain where high rainfall is typical. This commonly leads to sediment influxes to streams and gullies in high relief montane areas occupied by this species (Ravindran et al. 2019) which is likely to interact with and negatively affect the species physiological tolerance of other environmental stressors (Cramp et al. 2021).
Increased average temperature	Timing: current/future Confidence: inferred Likelihood: likely Consequence: major Trend: increasing Extent: across the entire range	Increased average temperature is a direct, ongoing, and persistent long-term impact of climate change. Unlike short-term heatwaves, this is a steady long-term increase in average annual temperature. Mean annual temperature is projected to increase in the north coast region of NSW by 0.7 °C in the near future (2020–39) and 2 °C longer term (2060–79) (NSW OEH 2014). *Euastacus* are sensitive to increasing temperatures, with *E. angustus* likely lacking the capacity to physiologically adapt or relocate to cooler habitats as temperatures increase (Lowe et al. 2010; Bone et al. 2015, 2017). This will probably lead to altitudinal compression of habitat as there is limited scope for up-slope migration of this species and overland dispersal to other suitably cool habitats is blocked by the warm lowlands (Ponniah & Hughes 2004; Furse et al. 2012a; Bone et al. 2014). Additionally, nearby montane habitats in the region, that may be suitable, are already occupied by other species of *Euastacus* (Furse et al. 2012a). Projected increases in temperature in the region have the capacity to impact this species across its range (i.e. the single location) and places the species at a very high risk of extinction. Coughran (2007) reported water temperature in the habitat of this species was in the range 10–21 °C. The thermal limit of this species remains unknown, however based on the work of Bone et al. (2014) environmental temperatures may only

Threat	Status and severity	Evidence
		be a few degrees away from levels that may cause thermal stress in this species (i.e. ~23 °C). Other potential impacts of the projected increases in temperature may be a lowering of the local water table (particularly in winter; NSW OEH 2014), a reduction in soil moisture, and an increase in the seasonality of streams which this species will occupy (Coughran 2007). Overall, this may result in a decrease of available habitat for this species. Increasing average temperature associated with climate change will also interact with the other threats: - Fire regimes that cause declines in biodiversity - Extreme weather events - Alterations to hydrological regimes
Alterations to hydrological regimes	Timing: current/future Confidence: observed Likelihood: almost certain Consequence: major Trend: increasing Extent: across the entire range	Changes in moisture availability and increased ephemerality of hydrological systems due to global climate change, will impact the species itself, but also floral and faunal assemblages, across the species' range. *Euastacus* are known to be sensitive to effects of drought, but also effects of flooding (Furse et al. 2012b). Moisture deficits and excesses are threats that put this restricted range species at high risk of population declines, or extirpation. Rainfall patterns across the distribution of the *E. angustus* are projected to change as a result of climate change. Shifting precipitation patterns coupled with projected increases in temperature may lower the local water table and increase seasonality of streams in which *E. angustus* is resident. Changes to water availability would significantly impact this species.
Fire regimes that cause declines in biodiversity	Timing: current/future Confidence: observed Likelihood: likely Consequence: major Trend: increasing Extent: part or across entire range	The frequency and severity of bushfires is projected to increase under climate change (Di Virgilio et al. 2019, DAWE 2022). For the north coast region of NSW, average fire weather and severe fire weather days are projected to increase during summer and spring (NSW OEH 2014). 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; Gomez Isaza et al. 2022). Impacts may be immediate (habitat loss) or delayed (siltation and deoxygenation of habitat following a fire, possible change in stream water temperature and light regimes due to canopy loss). Crayfish from restricted distributions and cooler climates (e.g., at higher altitudes) are at an increased risk of decline as bushfires can change aquatic thermal and oxygen regimes (Cramp et al. 2021). Fires may increase the occurrence of weed species in the habitat. Various highly invasive non-native species of vegetation are known to exist in the region (e.g., lantana [*Lantana camara*]). In the subtropical rainforests of the Qld-NSW border, dense stands of lantana quickly establish in exposed areas after habitat disturbances (e.g., treefalls and landslides (Stock 2004), fires (Hines et al. 2020)) and may contribute to a negative feedback mechanism of increased habitat flammability and increased bushfire severity. *Euastacus angustus* did not occur within the footprint of the 2019–20 bushfires although nearby habitat in the Border Ranges National Park was burnt, including other rainforest areas within 20 km (DAWE 2020), and other species of *Euastacus* were affected. A single bushfire has the capacity to impact the entire population of this short-range endemic species, potentially leading to a population decline across the species' range, or extirpation of the species.
Illegal collection		
Illegal take	Timing: current Confidence: inferred Likelihood: likely	Illegal collectors specifically target rare species of *Euastacus* for personal collections and the aquarium trade (Coughran 2007; Coughran & Furse 2012; J.M. Furse 2021 unpub.). Their targets include species in

Threat	Status and severity	Evidence
	Consequence: moderate Trend: static Extent: across the entire range	national parks (see Coughran & Furse 2012) and extremely remote areas (J.M. Furse 2021 unpub.). A series of these activities are known to have occurred and continue throughout eastern Australia, with illegally collected crayfish intercepted (outbound) at Australian international airports (J.M. Furse 2021 unpub.). Any collection of rare, slow-growing and short-range endemic species, such as *E. angustus* has the capacity to quickly lead to negative population-scale impacts. Specifically, removal of reproductive animals from a population, particularly females that may require >5 years to reach sexual maturity, is likely to seriously impact recruitment. Illegal collectors can also act as a vector for diseases/pathogens between catchments, waterways, and into isolated areas of habitat.
Invasive species		
Invasive fauna	Timing: current/future Confidence: inferred Likelihood: possible Consequence: moderate Trend: static to increasing Extent: across the entire range	Feral pigs (*Sus scrofa*) occur within the Border Ranges National Park and adjacent national parks in the region (NSW NPWS 2004; Coughran & Furse 2010; Furse & Coughran 2011b). Pigs eat crayfish (J. Coughran 2021 unpub.) and are a serious threat to crayfish in general, but species of burrowing crayfish in particular (e.g. *Engaeus martigener* (Furneaux burrowing crayfish)), both through predation and their rooting and wallowing behaviour (DEH 2017). A number of other invasive fauna species are known to occur within national parks in the region that are reported to impact crayfish in other regions of Australia and have the capacity to negatively impact this species through predation or habitat disturbance (feral cat [*Felis catus*], European red fox [*Vulpes vulpes*] and goats [*Capra hircus*]) (Coughran & Furse 2010; Furse & Coughran 2011b). Cane toads (*Rhinella marina*) are also a potential threat, both due to toxic effect of crayfish eating toads (including as carrion by juvenile crayfish), but also the consumption of the relatively small juvenile crayfish by toads.
Disease		
Crayfish plague	Timing: Current Confidence: projected Likelihood: possible Consequence: catastrophic Trend: unknown Extent: across entire range	*Aphanomyces astaci* (crayfish plague) is a highly contagious fungal disease that is uniformly fatal (100 % mortality) to susceptible species (Panteleit et al. 2017), and it is considered one of the world's worst invasive species (Lowe et al. 2000). Crayfish plague, introduced from North America, has devastated populations of native species of freshwater crayfish in Europe and Asia (Panteleit et al. 2017). In Scandinavia, national declines in crayfish populations were up to 80 % and some lakes where crayfish were eliminated became choked with aquatic plants (Abrahamsson 1966). Many strains of the disease prefer cooler temperatures, which is characteristic of this species habitat. Crayfish plague is not currently known in Australia, but is documented as fatal to Australian freshwater crayfish (Unestam 1975), and it is listed on Australia's National List of Reportable Diseases of Aquatic Animals (Animal Health Committee 2020). It poses an extremely high risk to native freshwater crayfish species when it reaches Australia (DAWE 2019). The vector for the movement of crayfish plague outside of its native range was the translocation of North American crayfish, in particular, *Pacifastacus leniusculus* (signal crayfish) and *Procambarus clarkii* (red swamp crayfish). Infected crayfish from the Americas are resistant carriers, and are largely unaffected by the disease (DAWE 2019). Illegally imported specimens of red swamp crayfish have been seized in multiple Australian states (Department of Primary Industries & Regional Development 2021; Business Queensland 2021), but not known to be infected. A single, illegally imported crayfish infected with crayfish plague has the capacity, via an unlicensed/illegal collector vector (or aquarium discard), to devastate the entire Australian crayfish fauna. Increasing

Threat	Status and severity	Evidence
		illegal wildlife/aquarium trade appreciably increases the risk of the disease's introduction to Australia (Furse 2014).

[a]Timing—identifies the temporal nature of the threat
Confidence—identifies the nature of the evidence about the impact of the threat on the species
Likelihood—identifies the likelihood of the threat impacting on the whole population or extent of the species
Consequence—identifies the severity of the threat
Trend—identifies the extent to which it will continue to operate on the species
Extent—identifies its spatial context in terms of the range of the species
[b]Fire regimes that cause declines in biodiversity include the full range of fire-related ecological processes that directly or indirectly cause persistent declines in the distribution, abundance, genetic diversity or function of a species or ecological community. 'Fire regime' refers to the frequency, intensity or severity, season, and types (aerial/subterranean) of successive fire events at a point in the landscape
Categories for likelihood are defined as follows:
Almost certain – expected to occur every year
Likely – expected to occur at least once every five years
Possible – might occur at some time
Unlikely –known to have occurred only a few times
Unknown – currently unknown how often the threat will occur
Categories for consequences are defined as follows:
Not significant – no long-term effect on individuals or populations
Minor – individuals are adversely affected but no effect at population level
Moderate – population recovery stable or declining
Major – population decline is ongoing
Catastrophic – population trajectory close to extinction

Each threat has been described in Table 1 in terms of the extent that it is operating on the species. The risk matrix (**Error! Reference source not found.**) 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; the spatial extent, and the efficacy of current management regimes, assuming that management will continue to be applied appropriately. The risk matrix and ranking of threats has been developed in consultation with experts and using available literature.

Table 2 Risk Matrix

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain				**Climate change:** – Severe weather events	
Likely			Invasive weeds and weed incursion Invasive fauna Illegal take	**Climate change:** – Increased intensity/ frequency of bushfire	**Climate change:** – Increased temperature **Disease:** - *A. astaci* Crayfish plague
Possible					
Unlikely					
Unknown					

Risk Matrix legend/Risk rating:

Low Risk	Moderate Risk	High Risk	Very High Risk

Priority actions have then been developed to manage the threats, particularly where the risk was deemed to be 'very high' (red shading) or 'high' (orange shading). For those threats with an unknown or low risk (blue and green shading respectively) research and monitoring actions have been developed to understand and evaluate the impact of the threats, where appropriate.

Conservation and recovery actions

Primary conservation objective

- Ensure the AOO and EOO of the *E. angustus* are stable or increasing, and major threats are effectively managed, and resilience to climate change impacts is maximised.

Conservation and management priorities

Survey and monitoring priorities

- The following recommendations involving capture and removal of live specimens from the wild, and/or captive populations are made on the assumption that a suitably large population of this extremely rare species actually exists in the wild.
- Establish, and then monitor the population size and trajectory of this species through time.
- Determine the contemporary geographic distribution of *E. angustus*.
- Use population genetics to provide an indirect estimate of effective population size, heterozygosity, and structure among the various subpopulations, which can also form a baseline for ongoing monitoring.

Climate change and severe weather impacts

- Investigate feasibility and, if appropriate, plan and establish facilities for potential *ex situ* short-term, active conservation intervention(s), including:
    - Establishing a capacity to maintain a captive population of this species over the short-term, in response to an extreme weather event, for subsequent re-release to the wild (see Zukowski et al. 2021).
    - Establishing an environmental monitoring system in the species' habitat, to provide alerts of dangerous environmental conditions, when the species physiological tolerances are known. These can be *in-situ* monitoring and/or based on model projections.
    - Develop or access local weather and climate models to project when extreme weather events might require moving animals to *ex situ* facilities.

Increased temperature

- Determine if the species natural habitat features any relatively "cool" pockets of micro-habitat that may act as temporary refuges.

Fire impacts

- Review and revise existing fire management plans, including hazard reduction and fire suppression practices, to ensure they are appropriate for the distribution and habitat requirements of this species. These could include:
    - Actively protect fire sensitive rainforest areas, and manage surrounding areas.
    - Reduce the prevalence of fire-prone lantana where infestations have established and support natural regeneration. If required, replant locally native species to rehabilitate areas that have been cleared of lantana.
        - Ensure rehabilitation plans are consistent with the native reference ecosystem, to support ecological processes that are required for maintenance and recovery.
        - Ensure long-term weed management and enrichment planting for replacement of the reference community species is maintained.
    - Avoid using chemical fire suppressants near to sites where the species occurs.
- Monitor and, if necessary, manage impacts from any upstream fires on the species habitat, including riparian erosion and influxes of sedimentation.

Illegal collection

- Restrict publicity on the species so as to not facilitate illegal collection.
- Regularly carry out surveillance of species habitat; and monitor websites, forums, collectors' groups, etc. to detect if illegal collection is occurring and if crayfish are offered for sale, and then take action against the sellers where appropriate.

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

- Develop and implement long-term strategies to control introduced predators by implementing management programs where feasible.
- Monitor for and control any damage to riparian areas by feral pigs. If required, control numbers and fence sites, where feasible. This may require a collaborative strategy with

surrounding land holders and local government authorities to limit feral pigs from crossing into national parks.

- Undertake weed control in the local area and identify and remove weeds that could become a threat to the species, ensuring any possible disturbance/overspray and appropriate use of chemicals does not adversely impact this species.

Disease impacts

- Ensure authorised researchers and rangers are aware of required hygiene protocols, and assess compliance.
- Take steps (i.e., limit all publicity) to minimise frequency of potential disease vectors entering the species habitat. For example, not facilitating illegal collectors, or members of the public, identifying and visiting the species' habitat.
- Biosecurity at international borders should be reviewed and updated as appropriate to limit opportunities for incidental importation of disease (including on infected crayfish).

Habitat loss disturbance and modifications

- Ensure national parks and other relevant stakeholders maintain high quality habitat (e.g., weed removal, fire suppression, etc.).

Breeding, propagation and other *ex situ* recovery action

- If the population size of the species permits, investigate feasibility and plan for potential short and long-term active conservation intervention(s), including *ex situ* initiatives such as:
    - Establishing captive husbandry methods and protocols for the species.
    - Establishing a capacity to maintain captive populations over the short-term (i.e., in response to extreme weather events) for subsequent re-release to the wild.
    - Establishing a captive breeding population as a source of animals to augment the wild population, if required.
- Investigate feasibility of translocations to assist conservation of the species.

Stakeholder engagement/community engagement

- Prepare a management and engagement strategy for this species and similar species of crayfish in the region with input from *bona-fide* crayfish experts, national park managers, and other identified stakeholders.
- Actively engage Traditional Owners in the conservation of the species and its habitat and work with them to divulge any traditional knowledge associated with the species, ensuring the practices to record, store and share this knowledge are mutually supported.
- Limit publicity for this species due to risks from illegal and over collection and disease. Information should be restricted until key knowledge-gaps have been addressed, and thus full community engagement may not be beneficial to the species.
- Adopt best practice for effective threat management through an adaptive management approach based on partnerships around co-design, co-implementation and social learning. Promote wide acceptance and capacity building, including explicit use of local knowledge in planning, management actions. and monitoring supported by cost-effectiveness and risk based collective decision making.

Information and research priorities

- Address the previously identified critical knowledge gaps on the population size, biology, ecology and life history of this species (see 'Relevant biology and ecology' above).
- Investigate the species' habitat requirements (including any soil moisture, environmental temperature, dissolved oxygen and shelter/refuge requirements).
- Investigate the potential influence of climate change on environmental stressors (altered temperatures, rainfall patterns, bushfires) and disease, and how these impact the long-term survival prospects of the species. This includes:
  - If the population size permits, assess the thermal tolerance of *E. angustus* (using non-lethal methods) to ascertain its physiological limits, sensitivity and vulnerability. Thermal tolerances are likely to be similar between closely related species occupying similar environments (Cramp et al. 2021). So, use of a more common *Euastacus* species which is physiologically and ecologically similar could be used to inform likely impacts to this threatened species.
  - Establish the impacts of climate change on the species' habitat (vegetation assemblages, water availability, water and air temperatures).
- Understand the threats and impacts of invasive species and diseases on *E. angustus*' .

Links to relevant implementation documents

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Attachment A: Listing Assessment for *Euastacus angustus* (narrow *Euastacus*)

Assessment under the NSW *Fisheries Management Act 1994* (FM Act)

Assessment of the species reduction in abundance, geographic distribution or genetic diversity (under clause 271 of the Fisheries Management (General) Regulation 2019)

In 2015 the NSW Government signed an Intergovernmental Memorandum of Understanding on the Agreement on a Common Assessment Method for listing of threatened species and threatened ecological communities (the CAM). The CAM provides a nationally consistent approach to assessing and listing threatened species in Australia, using the IUCN Redlist Categories and Criteria (Version 3.1). To ensure that this Proposed Final Determination meets the requirements under the CAM, an assessment against the IUCN Redlist Categories and Criteria (Version 3.1) has been included. This assessment also reflects the requirements for listing species provided under clause 271 of the Fisheries Management (General) Regulation 2019. For more information on the CAM please visit http://www.environment.gov.au/biodiversity/threatened/cam

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).

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

237 Criteria—reduction in abundance, geographic distribution or genetic diversity

(1) It is observed, estimated, inferred or reasonably suspected that the species has undergone, or is likely to undergo, within a time frame appropriate to the life cycle and habitat characteristics of the taxon—

(a) for **critically endangered** species—an extremely large reduction in 1 or more of the following—

(i) an index of abundance appropriate to the taxon,

(ii) geographic distribution,

(iii) genetic diversity

Reason for assessment

This public nomination was initiated by the World Wide Fund for Nature Australia (WWF). The species was prioritised due to its lack of IUCN conservation status and its proximity to the Border Ranges WWF fire-impacted landscape.

Assessment of eligibility for listing

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

Key assessment parameters

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

Table 3 Key assessment parameters

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Number of mature individuals	Unknown	Unknown	Unknown	Not known for this species.
Trend	n/a			
Generation time (years)	Unknown	Unknown	Unknown	The longevity, fecundity, and age of sexual maturity in females is presently unknown for *E. angustus*. In addition, there is little information available from other species of *Euastacus*. *Euastacus* are typically late maturing and have slow reproductive cycles with females only reaching reproductive maturity after 5–10 years (e.g., Honan & Mitchell 1995a; Turvey & Merrick 1997a; Borsboom 1998; Furse & Wild 2004; Coughran 2013). However, the growth rate, population sizes and generation length of *E. angustus* are not known. Therefore, generation length cannot be estimated.
Extent of occurrence	8 km^2			Based on published, unpublished and/or known survey and collection records (Coughran 2005; Furse et al. 2013; Austin et al. 2022; R.B. McCormack 2022 unpub.). Calculated using GeoCAT (Bachman et al. 2011). The EOO estimate (e.g. 0.192 km^2) is smaller than the Area of Occupancy (AOO), therefore, following the IUCN Red List guidelines, the EOO was adjusted to be equal to the AOO (IUCN Standards and Petitions Committee 2024).
Trend	Stable			The species is not known outside of the current EOO. The historical site of record (Coughran 2005; Furse et al. 2013) remains occupied by the species (R.B. McCormack 2022 unpub.).

Metric	**Estimate used in the assessment**	**Minimum plausible value**	**Maximum plausible value**	**Justification**
Area of Occupancy	8 km^2			Based on published, unpublished, and/or known survey and collection records (Coughran 2005; Furse et al. 2013; R.B. McCormack 2022 unpub.). Calculated using GeoCAT (Bachman et al. 2011).
AOO is a standardised spatial measure of the risk of extinction, that represents the area of suitable habitat known, inferred or projected to be currently occupied by the taxon. It is estimated using a 2 x 2 km grid to enable comparison with the criteria thresholds. The resolution (grid size) that maximizes the correlation between AOO and extinction risk is determined more by the spatial scale of threats than by the spatial scale at which AOO is estimated or shape of the taxon's distribution. It is not a fine-scale estimate of the actual area occupied. In some cases, AOO is the smallest area essential at any stage to the survival of existing populations of a taxon (e.g. breeding sites for migratory species).				
Trend	Stable			The historical site of record (Coughran 2005; Furse et al. 2013) remains occupied by the species (R.B. McCormack 2022 unpub.).
Number of subpopulations	1	1	1	Some 20 years of surveys in the Border Ranges National Park and environs have established the species is restricted to a single small area (Coughran 2005; Furse et al. 2013; R.B. McCormack 2022 unpub.).
Trend	Stable			The species is not known outside of the current distribution. The historical site of record (Coughran 2005; Furse et al. 2013) remains occupied by the species (R.B. McCormack 2022 unpub.).
Basis of assessment of subpopulation number	Some 20 years of surveys in the Border Ranges National Park and environs have established the species is restricted to a single small area (Coughran 2005; Furse et al. 2013; R.B. McCormack 2022 unpub.).			
No. locations	1	1	1	Some 20 years of surveys in the Border Ranges National Park and environs have established the species is restricted to a single small site (Coughran 2005; Furse et al. 2013; R.B. McCormack 2022 unpub.).
Trend	Stable			The species is not known outside of the current distribution. The historical site of record (Coughran 2005; Furse et al. 2013) remains occupied by the species (R.B. McCormack 2022 unpub.).
Basis of assessment of location number	All known sites for the species are adjacent each other within a small geographic range, with common threats over that range, and therefore are considered a single location.			
Fragmentation	The species occurs at one small site. No evidence of fragmentation has been documented.			
Fluctuations	Not known to be subject to any fluctuations in EOO, AOO, number of subpopulations, locations or mature individuals.			

Criterion 1 Population size reduction

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

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

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

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

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

Based on any of the following

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

Criterion 1 evidence

Insufficient data to determine eligibility

There is insufficient data to determine eligibility of *E. angustus* for listing under Criterion 1. The population has not been subject to targeted monitoring since its original 2002 collection or 2013 description. However, three additional specimens have reportedly been collected adjacent to the type locality (R. B. McCormack 2022 unpub.).

It is projected that is likely to be a future reduction in population size of *E. angustus* due to the impacts of climate change. This species, and other cool-adapted species of crayfish, likely do not have the capacity to adapt to the current or projected rates of warming (Bone et al. 2014) (see Threats Table 1 above). A decline in Area of Occupancy (AOO), Extent of Occupancy (EOO) and quality of habitat is anticipated due to climate change as increasing temperatures and reduced moisture availability, especially in the soil, displaces flora and fauna upslope, including the rainforest in which the species is found.

The species' highly restricted distribution, at one location, leaves it susceptible to extinction from events such as heatwaves, increased temperatures, extensive fires, extreme flooding or disease, or other threats (see Criterion 2 below). However, there are no population data to support such an assessment at the present time, with the population size of the species unknown, making it difficult to quantify any previous or likely future changes in the population.

There is insufficient information to determine the eligibility of the species for listing in any category under this criterion.

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

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

Criterion 2 evidence

Eligible under Criterion 2 B1ab(iii,v)+B2ab(iii,v) for listing as Critically Endangered.

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

Euastacus angustus is restricted to habitat in a small section of a headwater stream in the subtropical rainforests of the Border Ranges National Park in north-eastern NSW. The original collection (in 2002, Furse et al. 2013) and more recent unpublished records (R. B. McCormack 2022 unpub.) confirmed the highly restricted distribution of this species: EOO = 8.0 km² and AOO = 8.0 km². The EOO meets the threshold for listing as Critically Endangered under Criterion B1 and the AOO meets the threshold for listing as Critically Endangered under Criterion B2.

Number of locations

Euastacus angustus has been recorded from one stream, which is assessed as one location (IUCN Standards and Petitions Committee 2024), meeting the threshold for listing as Critically Endangered under subcriterion (a). Extreme weather events associated with climate change (e.g., heatwaves, severe storms/cyclones, droughts and fires) is the major threat to this species and likely to be experienced in a uniform fashion across the entire range of this species, with the likelihood of any habitat providing refuge from adverse conditions reduced to zero. Some species of *Euastacus* have been identified as having limited tolerance to abiotic changes (Lowe et al. 2010; Bone et al. 2014, 2017) and are susceptible to ongoing declines in habitat through climate change (Bruna 2004).

The isolation of this species increases the risk of extirpation of any individual subpopulations through environmental and demographic stochasticity (Bruna 2004; De Castro & Bolker 2005). Therefore, current and future threats could potentially rapidly eliminate all individuals in the taxon.

Continuing decline

It is inferred that there will be a decline in area, extent and/or quality of habitat due to impacts of climate change (principally increasing temperature, and reduced moisture availability) satisfying subcriterion (b)(iii). Mean annual temperature is projected to increase along the north coast region of NSW by 0.7 °C in the near term (i.e., within 20 years), and by 2 °C later in the century (NSW OEH 2014). This is likely to lead to altitudinal compression of the species' habitat, as there is limited scope for upslope migration by *E. angustus*. Additionally, a decline in the number of mature individuals due to impacts from intense weather events such as heatwaves, plus more frequent and intense fires is projected, also satisfying subcriterion (b)(v).

Conclusion

The species' EOO and AOO are highly restricted, the species occurs at only one location, and a continuing decline is projected in the area, extent and/or quality of habitat and number of mature individuals. Therefore, the species meets the relevant elements of Criterion 2 to make it eligible for listing as **Critically Endangered**.

Criterion 3 Population size and decline

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

Criterion 3 evidence

Insufficient data to determine eligibility

There are no estimates of numbers of mature individuals or any population-decline data that will allow assessment of *E. angustus* for eligibility for listing under Criterion 3.

The data presented suggest that there are **insufficient data** to demonstrate if the species is eligible for listing under this criterion.

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.

Criterion 4 evidence

Insufficient data to determine eligibility

The number of mature individuals of *E. angustus* is not known.

Although only one location is identified (see Criterion 2), there are **insufficient data** to demonstrate if the species is eligible for listing under subcriterion D2 due to a lack of data on the number of mature individuals.

The data presented suggest that there are **insufficient data** to demonstrate if the species is eligible for listing under this criterion.

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.

Adequacy of survey

The survey effort for this assessment is limited (2002, 2010, 2020 and 2022) but is deemed appropriate given the extensive surveys for the species, and there is sufficient published scientific evidence to support this assessment.