Fisheries Scientific Committee

Final Determination

Terrestrial crayfish (*Euastacus maccai*)

Assessment outcome ENDANGERED
Category 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 maccai*** **(terrestrial crayfish)** under the FM Act and the Common Assessment Method and has determined that it is eligible to be listed as an **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 ENDANGERED is provided for by Part 7A, Division 2 of the FM Act.
- The species is facing a very high risk of extinction in New South Wales in the near future and in the opinion of the Fisheries Scientific Committee it meets the criteria specified for ENDANGERED. The species is proposed to be added to Part 2 of Schedule 4 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—

(b) for ***endangered species***—a very 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.

Conservation Advice for *Euastacus maccai* (terrestrial crayfish)

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

Acknowledgements

This listing assessment and Conservation Advice was initiated and developed by 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 following experts contributed to listing assessment and the Conservation Advice: Maiko Lutz (Aquasave–NGT), James M. Furse (Griffith University), Rob McCormack (Australian Aquatic Biological) and Nick Whiterod (Aquasave–NGT).

Euastacus maccai (terrestrial crayfish) in a captive setting. Image does not depict the species' natural habitat © Copyright, Rob McCormack.

Conservation status

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

Euastacus maccai was assessed to be eligible for listing as 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: B2ab(iii,v): Endangered
- Criterion 3: Insufficient data
- Criterion 4: Insufficient data
- Criterion 5: Insufficient data

The main factors that make the species eligible for listing in the Endangered category are the impacts of climate change (extreme weather events, increased temperature, increased severity and frequency of bushfire), which will very likely lead to a decline in the area, extent, and quality of habitat and 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 maccai* McCormack & Coughran, 2008 (Family: Parastacidae). Phylogenetic results have confirmed its validity as a distinct taxon (Austin et al. 2022).

Description

The terrestrial crayfish is medium-sized species of *Euastacus* typically with a small number of short to medium sized spines (*sensu* Coughran 2008). The maximum recorded occipital carapace length (OCL; Morgan 1997) is 57.4 mm and maximum recorded weight of 100 g (McCormack & Coughran 2008). The body is brown to black dorsally and off-white to bone ventrally; the claws are reddish-brown with spines that are tipped in orange (McCormack & Coughran 2008).

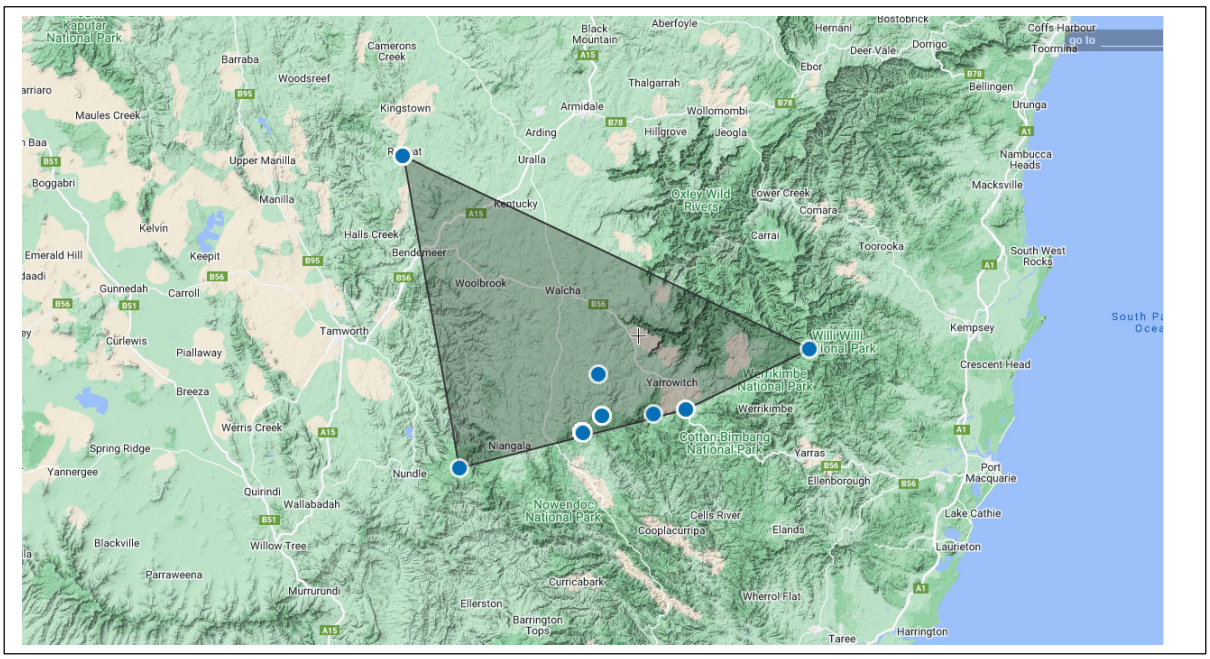
The morphological characteristics used to identify *Euastacus* species from another are subtle, with the differences often a few spines, and/or the presence of a groove. For example, the terrestrial crayfish can be distinguished from *Euastacus simplex* (simple crayfish) on the basis of the number, shape and size of the spines (McCormack & Coughran 2008). This means that accurate and reliable identification is challenging and requires technical terminology to describe the morphological features separating the species. Detailed descriptions can be found in the original description paper by McCormack & Coughran (2008).

Distribution

The terrestrial crayfish is endemic to the highland areas (850–1,400 m above sea level (ASL)) of northern New South Wales (McCormack & Coughran 2008; Coughran & Furse 2010) and can be considered a short range endemic (Harvey 2002). Its patchy distribution extends from Retreat in the north, south to near Hanging Rock and east to Werrikimbe National Park (McCormack & Coughran 2008; Coughran & Furse 2010; R.B. McCormack 2022 unpub.). Across its distribution, it is restricted to the upland reaches of the drainages it inhabits (Coughran & Furse 2010).

Part of the range of this species is afforded a degree of protection by being contained within protected areas, including Werrikimbe and Mummel Gulf national parks, and Enfield, Riamukka and Nundle state forests.

Map 1 Modelled distribution of terrestrial crayfish



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.

The terrestrial crayfish occurs on the lands of the Biripi, Nganyaywana and Dainggatti people (AIATSIS 2022). First Nations groups are typically consulted to inform the management of national parks in New South Wales (NPWS 2005; 2020). Numerous culturally important sites have been identified within Werrikimbe National Park (NPWS 2005). The cultural significance of the terrestrial crayfish is currently 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 has or is associated with some cultural and/or community significance.

Relevant biology and ecology

It is recognised that *Euastacus* species have a suite of common biological characteristics, and many of these characteristics apply to the terrestrial crayfish (Furse & Coughran 2011a). Various studies have established that *Euastacus* are slow-growing (growth increments of a few mm OCL yr^{-1}) and 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). However, the biology and ecology of the terrestrial crayfish is not well known.

Habitat

The terrestrial crayfish inhabits burrows that are not connected to streams or creeks but which penetrate down to subsurface water, with terrestrial vegetation growing on the surface of the burrows (McCormack & Coughran 2008; R.B. McCormack 2022 unpub.). The ability to survive without surface water permits terrestrial crayfish to occupy habitats that are not considered aquatic. Terrestrial crayfish have been collected from ephemeral soaks, cow paddocks, flood plains and spring-fed swampy areas at the top of catchments (850–1,400 m ASL) (McCormack & Coughran 2008; R.B. McCormack 2022 unpub.).

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). Female terrestrial crayfish are thought to reach sexual maturity at 45–50 mm OCL (McCormack & Coughran 2008). The actual growth rates, population sizes and generation lengths of the terrestrial crayfish are not known.

Many species of *Euastacus* are winter brooders (mating in late summer/autumn with females carrying eggs over winter) and brooding periods may be long (6–10 months is typical). Some species only breed biennially 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). No reproductive (i.e. berried) female terrestrial crayfish have been captured (McCormack & Coughran 2008). The species is likely to be a poor disperser, with slow growth and low fecundity (Harvey 2002).

Diet

The diet of the terrestrial crayfish is not well understood, but the species is likely omnivorous, as with many species of spiny crayfish (McCormack 2012).

Co-occurring species

The terrestrial crayfish co-occurs with *Euastacus clarkae* (Clark's crayfish) in the upper Forbes and Hasting Rivers and *Euastacus spinichelatus* (small crayfish) in the upper Fenwick Creek (McCormack 2015). It has also been recorded near areas inhabited by *Cherax destructor* (common yabby) (R.B. McCormack 2022 unpub.).

Threats

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

Established threats (habitat destruction, invasive species, and human exploitation,climate change), and potential future threats (disease such as *Aphanomyces astaci* [crayfish plague]; Panteleit et al. 2017; DAWE 2019) may put nearly all species of *Euastacus* at serious risk of population declines, or extinction in the immediate future (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 the terrestrial crayfish, with the species having limited capacity to relocate to

higher, cooler altitudes (Coughran & Furse 2010). The terrestrial crayfish was identified as in need of a conservation status assessment after the 2019–20 bushfires by Legge et al. (2021), as spatial data showed that part of the range of the species had been burnt (DAWE 2020). 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. The FSC considers the species to be at an extremely high risk of extinction in New South Wales in the immediate future.

Table 1 Threats

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

Threat	Status and severity [a]	Evidence
Climate change		
Increased average environmental temperature	• Timing: current and future • Confidence: observed • Likelihood: likely • Consequence: major • Trend: increasing • Extent: across the entire range	Increased average temperature is a direct, on-going, and persistent long-term impact of climate change. Unlike short-term heatwaves, this is a steady long-term increase in the mean temperature. Mean annual temperature is expected to increase in the North Coast and New England and North West regions 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 this species likely lacking the capacity to physiologically adapt or relocate to cooler habitats as temperatures increase (Lowe et al. 2010; Bone et al. 2015, 2017). As this species occupies habitats at top of catchments there is no scope for up-slope migration of this species (Coughran & Furse 2010), 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 and places the species at a very high risk of extinction. Bone et al. (2014) reported that when exposed to chronic, steadily increasing temperature, similarly-sized, small specimens of *E. sulcatus* became sluggish ~23 °C and were effectively incapacitated at ~27 °C (Bone et al. 2014). The upper thermal limit of this species remains unknown, however, projected increases in temperature in the region will likely impact this species across its range and puts the species at a very high risk of extinction. Other potential impacts of the projected increases in temperature may be a lowering of the local water table (particularly in winter; NSW OEH 2014). 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

Threat	Status and severity [a]	Evidence
Extreme weather events	• Timing: current and 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). Note that any short-term extreme weather events (e.g. heatwaves) are distinct from long-term, irreversible increasing temperature. 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 the terrestrial crayfish is anticipated to be impacted by an increase in severity and frequency of extreme heat events. By 2060–79, the North Coast region of NSW is expected to have 5–10 and the New England and North West regions of NSW to have 24 more hot days (over 35 °C) annually compared to 1990–2009 (NSW OEH 2014). Acute exposure to temperatures above the upper thermal tolerance limit of this species could result in deleterious physiological impacts, and mortalities, and could lead to population reductions. Rainfall patterns in the NSW North Coast region are projected to change, with summer, autumn, and spring rainfall increasing (by 7.5 %, 14.7 %, and 6.8 % respectively) and winter rainfall decreasing (by 4 %) by 2060–79 (NSW OEH 2014). Similar changes to rainfall patterns are projected for the New England and North West regions of NSW, with summer and autumn rainfall increasing (by 9.8 % and 16.8 % respectively) and decreasing during winter and spring (by 0.7 %) (NSW OEH 2014). Shifting precipitation patterns coupled with projected increases in temperature may lower the local water-table. Overall, this may result in a decrease of available habitat for this species. These extreme weather events have the capacity to seriously impact the population, potentially leading to a population decline or extirpation of the species. In addition, a single extreme weather event may lead to other localised natural disasters (e.g. flooding, landslides, and sedimentation events; Furse et al. 2012a). Sediment exposure can damage respiratory surfaces of gills and reduce the ability of crayfish to uptake oxygen from the water (Cramp et al. 2021).
Fire regimes that cause declines in biodiversity	• Timing: current and future • Confidence: observed • Likelihood: likely • Consequence: major • Trend: increasing • Extent: across the entire range	The frequency, severity and magnitude of bushfires is projected to increase under climate change scenarios (Di Virgilio et al. 2019, DAWE 2022). For the North Coast and New England and North West regions 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, change of water temperature and light regime 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*]) (NPWS 2004).

Threat	Status and severity [a]	Evidence
		Dense stands of lantana quickly establish in the exposed areas created by habitat disturbances (e.g., tree falls and landslides (Stock 2004). They can quickly smother habitat (Stock 2004) and may increase the chance and severity of bushfires (Hines et al. 2020). The terrestrial crayfish was identified as in need of a conservation status assessment after the 2019–20 megafires (Legge et al. 2021) as spatial data showed that habitat inhabited by this species had been burnt (DAWE 2020). Bushfire remains a very serious and increasing threat under climate change with the potential to lead to population decline across the species' range, or extirpation of the species.
Alterations to hydrological regimes	• Timing: current and future • Confidence: known • Likelihood: almost certain • Consequence: major • Trend: increasing • Extent: across the entire range	Changes in moisture availability and increased ephemerality of hyrdological 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 and also the 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. The restricted highland distribution of the terrestrial crayfish indicates this species is associated with cooler conditions and it may be vulnerable to increases in water temperature and reductions in hydrological stability/security (Coughran & Furse 2010). Rainfall patterns in the NSW North Coast region are projected to change, with summer, autumn, and spring rainfall increasing (by 7.5 %, 14.7 %, and 6.8 % respectively) and winter rainfall decreasing (by 4 %) by 2060–79 (NSW OEH 2014). Similar changes to rainfall patterns are projected for the New England and North West regions of NSW, with summer and autumn rainfall increasing (by 9.8 % and 16.8 % respectively) and decreasing during winter and spring (by 0.7 %) (NSW OEH 2014). Shifting precipitation patterns coupled with projected increases in temperature may lower the local water-table. Overall, this may result in a decrease of available habitat for this species.
Invasive species		
Invasive fauna	• Timing: current and future • Confidence: suspected • Likelihood: possible • Consequence: minor • Trend: static to increasing • Extent: across the entire range	A number of invasive fauna species that are reported to impact crayfish in other regions of Australia are known to occur within the range of the terrestrial crayfish and have the capacity to negatively impact this species through predation or habitat disturbance (feral pigs [*Sus scrofa*], feral cats [*Felis catus*], European red foxes [*Vulpes vulpes*], cane toads [*Rhinella marina*]; Coughran & Furse 2010). 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* Horwitz), both through predation and their rooting and wallowing behaviour (DEH 2017). Cane toads are 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, but data on any specific impacts on this species are not available (Coughran & Furse 2010).
Exploitation		
Illegal collection	• Timing: current • Confidence: inferred • Likelihood: possible • Consequence: moderate • Trend: unknown	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 national parks (see Coughran & Furse 2012) and extremely remote areas (J.M. Furse 2021 unpub.).

Threat	Status and severity [a]	Evidence
	• Extent: across the entire range	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. maccai*, 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.
Disease		
Crayfish plague (*Aphanomyces astaci*)	• Timing: Current • Confidence: projected • Likelihood: possible • Consequence: catastrophic • Trend: n/a • 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 *A. astaci* outside of its native range was the translocation of North American crayfish, in particular, *Pacifastacus leniusculus* (Dana) (signal crayfish) and *Procambarus clarkii* (Girard) (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 illegal wildlife/aquarium trade appreciably increases the risk of the disease's introduction to Australia (Furse 2014).
Agriculture & aquaculture		
Livestock farming & ranching	• Timing: current • Confidence: observed • Likelihood: possible • Consequence: minor • Trend: unknown • Extent: across part of the range	*Bos taurus* (domestic cattle) occur on private land throughout the region occupied by this species, and are associated with absence of this species from otherwise suitable habitats (Coughran & Furse 2010, Furse & Coughran 2011a). Mechanisms of cattle impacts on any crayfish are unclear, but trampling of burrows, stream habitat (where cattle can access waterbodies) plus sediment influxes and pollution via increased nutrient loads are probable factors. Some areas of highland habitat associated with the Great Dividing Range have been converted to agricultural land, but the terrestrial crayfish appears to be able to tolerate at least some impacts of agriculture (Coughran & Furse 2010), but additional research is required to investigate any impacts of agriculture on this species.

[a]Timing—identifies the temporal nature of the threat
Confidence—identifies the nature of the evidence about the impact of the threat on the species

Likelihood—identifies the likelihood of the threat impacting on the whole population or extent of the species
Consequence—identifies the severity of the threat
Trend—identifies the extent to which it will continue to operate on the species
Extent—identifies its spatial context in terms of the range of the species

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

Each threat has been described in Table 1 in terms of the extent that it is operating on the species. The risk matrix (Table 2) 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: – Alterations to hydrological regimes – Increased environmental temperature	–
Likely				Climate change: – Extreme weather events – Increasing frequency and magnitude of bushfires – Altitudinal compression of habitat	–
Possible		Livestock farming & ranching Invasive fauna	Illegal collection		Disease Crayfish plague (*Aphanomyces astaci*)
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 terrestrial crayfish are stable or increasing, and major threats are effectively managed, and resilience to climate change impacts is maximised.
Conservation and management priorities

Climate change and extreme weather impacts

- Investigate feasibility and, if appropriate, plan and establish facilities for potential ex situ short-term, active conservation intervention(s), including:

- Establish a capacity to maintain a captive population of this species over a short-term, in response to an extreme weather event, for subsequent re-release to natural habitat.
- When the species physiological tolerances are known, or using closely related or nearby occurring species as proxies, establishing an environmental monitoring system in the species' habitat, to provide alerts of dangerous environmental conditions, if appropriate. These could be in-situ monitoring and/or based on model projections.
- Developing or accessing local weather and climate models to project when extreme weather events might require moving animals to *ex situ* facilities.

Increased temperature

- Investigate 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 can include:
  - Actively protect fire sensitive sites, and manage surrounding areas.
  - 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 siltation.

Habitat loss, disturbance and modifications impacts

- Ensure that the habitat quality remains high through management actions (e.g., weed removal, fire management, etc.) in national park(s) where the species is found.
- Ensure that any human-mediated changes to surface and groundwater hydrology account for the species habitat requirements.
- Ensure land managers are aware of the species' occurrence and provide protection measures against key and potential threats.

Illegal collection

- Regularly carry out surveillance of species habitats, websites, forums, collectors' groups, etc. to detect if illegal collection is occurring and if terrestrial crayfish are offered for sale, and then take action against the sellers where appropriate.
- Assess compliance of any recreational fishers with State fisheries regulations.

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

- Develop and implement long-term strategies to control introduced predators by implementing eradication programs where feasible.
- 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 or incorrect chemical use does not adversely impact the terrestrial crayfish.

Disease impacts

- Ensure authorised collectors are aware of required hygiene protocols, and assess compliance.

- Take steps (i.e. potentially limit 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 may be appropriate to limit opportunities for incidental importation of disease (including on infected crayfish)
- Develop agreed protocols for responding to incursions or reports of non-Australian crayfish (responsibilities, rapid response, reporting).

Breeding, propagation and other ex situ recovery action

- 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 or natural disasters), for subsequent re-release to natural habitat.
    - Establishing captive breeding populations 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 terrestrial crayfish and other similar crayfish species in the region with input from 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 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.

Survey and monitoring priorities

- Establish, and then monitor the population size and trajectory of this species through time.
- Determine the contemporary geographic distribution of the terrestrial crayfish.
- 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.

Information and research priorities

- Address the previously identified critical knowledge gaps on the biology, ecology and life history of the terrestrial crayfish.

- Investigate the species' habitat 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:
    - Assess the thermal tolerance of the terrestrial crayfish (using non-lethal methods if required) 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 what are the species' moisture requirements and how these would be affected via changes in precipitation and increased temperature.
    - 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 the terrestrial crayfish.

Links to relevant implementation documents

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Attachment A: Listing Assessment for *Euastacus maccai*

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—

(b) for ***endangered species***—a very 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 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			Not known for this species.
Trend	n/a			
Generation time (years)	Unknown			The longevity, fecundity, and age of sexual maturity in females is presently unknown for the terrestrial crayfish. In addition, there is little information available from other species of *Euastacus*. Therefore, generation length cannot be estimated.
Extent of occurrence	5,150 km^2			Based on published, unpublished and known survey and collection records from McCormack & Coughran (2008), R.B. McCormack (2022 unpub.). Calculated using the Geospatial Conservation Assessment Tool (GeoCAT; Bachman et al. 2011).
Trend	Unknown			
Area of Occupancy	32 km^2			Based on published, unpublished and/or known survey and collection records from McCormack & Coughran (2008), R.B. McCormack (2022 unpub). Calculated using the Geospatial Conservation Assessment Tool (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	Unknown			
Number of subpopulations	Unknown			No population data is available for this species.
Trend	n/a			n/a
Basis of assessment of subpopulation number	n/a			

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
No. locations	≤5	1	5	This is a restricted range species that is exposed to numerous threats such as climate change, habitat degradation, exotic species, and bushfire throughout most of its distribution. While it is found at a number of localities, it is possible that almost all subpopulations are affected by some of the major threats identified for this species.
Trend	Unknown			
Basis of assessment of location number	This is a restricted range species that is exposed to numerous threats such as climate change, habitat degradation, exotic species, and bushfire throughout most of its distribution. While it is found at a number of localities, it is possible that almost all subpopulations are affected by some of the major threats identified for this species.			
Fragmentation	It is not known if the subpopulations can be considered to be severely fragmented. Its highland distribution in northern New South Wales is patchy due to the barrier effects of mountain ridges and unsuitable habitat in the intervening lowlands (Coughran & Furse 2010).			
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 bushfire.			

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

The generation length of the terrestrial crayfish is unknown and there are **insufficient data** to determine eligibility for listing in any category under Criterion 1.

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

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

Criterion 2 evidence

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

Extent of Occurrence (EOO) and Area of Occupancy (AOO)

The terrestrial crayfish is endemic to the highland areas (850-1,400 m above sea level (ASL)) of northern New South Wales (McCormack & Coughran 2008; Coughran & Furse 2010). On the basis of surveys and records from 2005 to 2019, the EOO is estimated at 5,150 km² and the AOO at 32 km², calculated using the IUCN standard convex polygon and 2 x 2-km grid method respectively (IUCN Standards and Petitions Committee 2024) with the Geospatial Conservation Assessment Tool (GeoCAT: Bachman et al. 2011). The EOO estimate meets the threshold for listing as Vulnerable under Criteria B1 and the AOO estimate meets the threshold for listing as Endangered under B2.

Number of locations

The terrestrial crayfish is naturally restricted to highland areas where there is limited suitable habitat available to this species. The restricted range of the species means that all sites are in close proximity and are exposed to similar conditions over time. Therefore, extreme weather events associated with climate change (e.g., , heatwaves, severe storms/cyclones, droughts and fires) is the major threat to the species. and likely to be experienced in a relatively uniform fashion across all or most sites While the species is known from numerous sites, it is assessed to be restricted to ≤ 5 threat defined locations (IUCN Standards and Petitions Committee 2024), meeting the threshold for listing as Endangered under subcriterion (a).

Continuing decline

It is projected that there will be a decline in area, extent and/or quality of habitat due to impacts of climate change (principally increasing temperature and extreme weather events including fire) satisfying subcriterion (b)(iii). Mean annual temperature is expected to increase in the North Coast and New England and North West regions of NSW by 0.7 °C in the near future (2020–39) and 2 °C longer term (2060–79) (NSW OEH 2014). This is likely to lead to altitudinal compression of the species' habitat, as there is limited scope for up slope migration by the terrestrial crayfish. 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 AOO is highly restricted, the species occurs at only 1 – 2 locations, and a continuing decline I projected in the area, extent and/or quality of habitat and number of mature individuals. Therefore, the terrestrial crayfish is eligible for listing as **Endangered B2ab(iii, v)** under this criterion.

Criterion 3 Population size and decline

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

Criterion 3 evidence

Insufficient data to determine eligibility

There are no estimates of numbers of mature individuals or any population-decline data that will allow assessment of the terrestrial crayfish 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 the terrestrial crayfish is not known.

Although ≤ 5 locations are identified (see Criterion 2), there are **insufficient data** to demonstrate if the species is eligible for listing under subcriterion D2. Population demographics are not known for this species, and the extent to which the species has been impacted by significant threats has not been ascertained. Therefore, it is uncertain whether a plausible future threat could drive the species towards extinction in a very short time (within two generations).

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 appropriate (see sources for EOO and AOO estimates) and there is sufficient published scientific evidence to support this assessment.