Conservation Advice for *Euastacus* sp. 1 *coughrani* (McCormack & Fetzner) (Coughran's crayfish)

In effect under the *Environment Protection and Biodiversity Conservation Act 1999* from 15 November 2023.

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



Euastacus sp. 1 coughrani (McCormack & Fetzner) (Coughran's crayfish) in a captive setting. Image does not depict the species' natural habitat © Copyright, Rob McCormack.

Conservation status

Euastacus sp. 1 *coughrani* (McCormack & Fetzner) (Coughran's crayfish) is listed in the Endangered category of the threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act) effective from 15 November 2023.

Coughran's crayfish was assessed by the Threatened Species Scientific Committee (the Committee) to be eligible for listing as Endangered under Criterion 2. The Committee's assessment is at Attachment A. The Committee's assessment of the species' eligibility against each of the listing criteria is:

- Criterion 1: Insufficient data
- Criterion 2: B1ab(iii)+B2ab(iii): 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 (alterations to hydrological regimes, increased temperature, extreme weather events, fire regimes that cause declines in biodiversity) and human disturbance (increased soil erosion and sedimentation and habitat destruction), which will very likely lead to a decline in the area, extent, and quality of habitat.

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

Euastacus sp. 1 *coughrani* (McCormack & Fetzner) is in the process of being described (McCormack & Fetzner in prep). It has also been known informally as the Arte spiny crayfish. The molecular taxonomic analyses of Austin et al. (2022) confirm its validity as a distinct taxon (as *Euastacus* sp. 1) and its close evolutionary relationship with *Euastacus diversus* (Orbost spiny crayfish).

Description

Coughran's crayfish is a poorly spinose species (Coughran 2008) with a maximum recorded occipital carapace length (OCL: Morgan 1997) of 50.56 mm (McCormack & Fetzner in prep). It is dark brown to olive green above, and tan to orange below (McCormack & Fetzner in prep). A range of white, cream-yellow, and yellow spines adorn various parts of the body; the tips of the walking legs and chelae are highlighted with blue (McCormack & Fetzner in prep).

The morphological characteristics used to identify individual species of the small and poorly spinose *Euastacus* are subtle, with the differences often a few spines, and/or the presence of a groove. This means that accurate and reliable identification is challenging and requires technical terminology to describe the morphological features separating the species. Detailed descriptions of other *Euastacus* species can be found in papers and field guides (Coughran 2005, 2006). Coughran's crayfish is morphologically most similar to *E. diversus* (Orbost spiny crayfish) and *Euastacus bidawalus* (East Gippsland spiny crayfish) and can be distinguished by features of the thorax, abdomen, chelae, and gastric mill. A full species description will be found in McCormack & Fetzner (in prep).

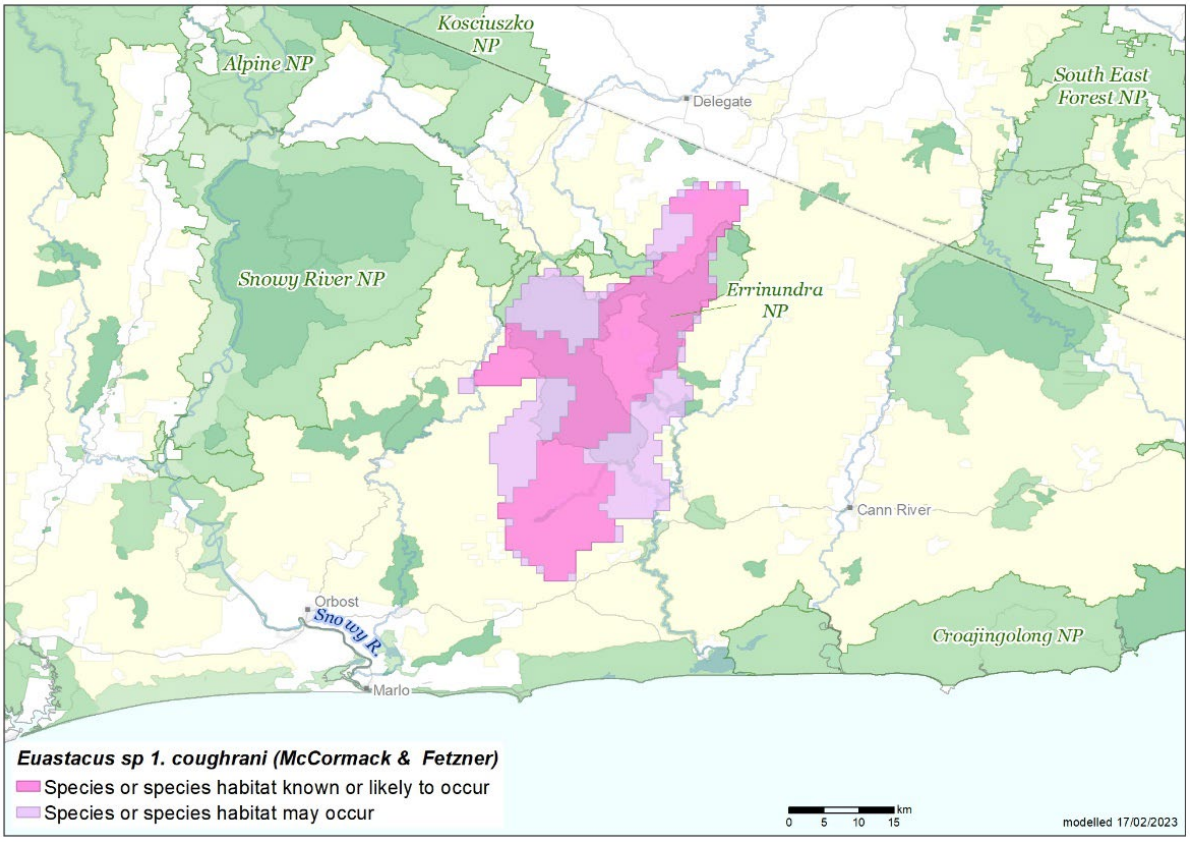
Distribution

Coughran's crayfish is endemic to the area where the East Gippsland and Snowy River basins meet in eastern Victoria. The species is predominately distributed in the Bemm River Catchment, although the species has also been identified from a discrete and restricted area of the upper Queensborough River Catchment to the north of the main distribution and the Brodribb River Catchment to the south (McCormack 2022; Austin et al. 2022; McCormack & Fetzner in prep). The species has been recorded from pools and edge habitats of small to medium clear-flowing and heavily shaded streams at altitudes between 250–1050 m above sea level (McCormack & Fetzner in prep).

Field survey and molecular taxonomy sequencing efforts has been substantial in the region, and it is thought unlikely that Coughran's crayfish is found far outside its known distribution as similar streams in nearby catchments are already occupied by other species of *Euastacus* (Austin et al. 2022; McCormack & Fetzner in prep). The *Euastacus* specimens found in Ellery Creek to the west of the main distribution were originally thought to be Orbost spiny crayfish based on morphology (McCormack & Fetzner in prep), but recent genetic results have indicated the specimens are Coughran's crayfish (C. Austin et al. 2023 unpub.). Part of the distribution of the Coughran's crayfish overlaps with the Orbost crayfish, the larger *E. kershawi* (Gippsland spiny crayfish) and *Engaeus orientalis* (East Gippsland burrowing crayfish) (Austin et al. 2022; McCormack & Fetzner in prep).

The majority of the Bemm River Catchment is public land, such as Bemm River Scenic Reserve, Errinundra and Lind national parks, whereas sites on the Queensborough River occur in the Bendoc State Forest.

Map 1 Modelled distribution of Coughran's crayfish



Source: Base map Geoscience Australia; species distribution data Species of National Environmental Significance database.
Caveat: The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything containing herein.
Species distribution mapping: The species distribution mapping categories are indicative only and aim to capture (a) the habitat or geographic feature that represents to recent observed locations of the species (known to occur) or habitat occurring in close proximity to these locations (likely to occur); and (b) the broad environmental envelope or geographic region that encompasses all areas that could provide habitat for the species (may occur). These presence categories are created using an extensive database of species observations records, national and regional-scale environmental data, environmental modelling techniques and documented scientific research.

Cultural and community significance

The cultural, customary and spiritual significance of animals, plants and ecological communities are diverse and varied for Indigenous Australians and their stewardship of Country. This section describes some examples of this significance but is not intended to be comprehensive or applicable to, or speak for, Indigenous Australians. Such knowledge may be held by Indigenous Australians who are the custodians of this knowledge and have the rights to decide how this knowledge is shared and used.

Coughran's crayfish occurs on the lands of the Kurnai people (AIATSIS 2021). The cultural significance of Coughran's 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 group has or is associated with some cultural and/or community significance.

Coughran's crayfish was named for Dr Jason Coughran in recognition of his substantial contributions to improving our understanding of the crayfish of Australia, in particular the genus *Euastacus.*

Relevant biology and ecology

The biology and ecology of Coughran's crayfish is not well understood; however, it is recognised that the species of *Euastacus* have a suite of common biological characteristics and many of these apply to this species (Furse & Coughran 2011). Various studies have established that *Euastacus* are slow-growing (growth increments of a few mm OCL yr^{-1}) and long-lived (e.g., Honan & Mitchell 1995a; Turvey & Merrick 1997a; Morey 1998; Furse & Wild 2004; Coughran 2011; Coughran 2013).

Reproductive studies of a few species 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). For females in this species, reproductive activity has been recorded at approximately 39 mm OCL (McCormack & Fetzner in prep). The actual growth rates, population size and generation length of the species 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 varies considerably between species, typically ranging from 20–1500 eggs per female (Clark 1937; Barker 1992; Honan & Mitchell 1995b; Turvey & Merrick 1997b; Borsboom 1998; Honan 1998; Morey 1998; Furse & Wild 2004; Coughran 2006; McCormack et al. 2010; Coughran 2013). Based on inspection of a single gravid female, pleopodal egg fecundity may be at least 100 eggs (McCormack 2022). The actual timing of breeding is not known for Coughran's crayfish but is likely to conform to the general *Euastacus* pattern of winter brooding.

Little is also known about this species' general biological characteristics. It appears to respond to water temperature, with crayfish in higher altitude areas becoming inactive when water temperature falls below 7°C (July-August), while those in lower areas evidently remain active year-round (McCormack & Fetzner in prep).

The species occurs with three other freshwater crayfish, *Euastacus diversus* (Orbost spiny crayfish), *Euastacus kershawi* (Gippsland spiny crayfish) and *Engaeus orientalis* (East Gippsland burrowing crayfish) (McCormack & Fetzner in prep).

Habitat

Coughran's crayfish inhabits smaller, low order streams, with clear flowing water. It is typically collected in association with an understory of tree ferns and a dense vegetative canopy with streams typically heavily shaded. The species has not been collected from streams lacking a vegetative canopy (McCormack 2022; McCormack & Fetzner in prep). The species occupies burrows connected to open or flowing water and tend to be located under rocks and vegetative debris (McCormack & Fetzner in prep). It is reported that in the presence of predatory fish (eels and other fishes), the species inhabits shallow areas, while in areas without predators it occupies deeper areas of the stream (McCormack & Fetzner in prep).

Diet

The species may be more active at night (McCormack & Fetzner in prep). The diet of Coughran's crayfish is not known, but the species may be omnivorous like many species of spiny crayfish (McCormack 2012). The species readily takes baits.

Habitat critical to the survival

Coughran's crayfish is known from a relatively small area, where it is found in cool, clear, flowing streams, that are shaded and densely vegetated. Coughran's crayfish appears to occupy streams with permanent subsurface water. Therefore, all of its known, peripheral, and likely habitat in the Bemm River and Queensborough River Catchment is critical to the survival of this species. Specific details on attributes such as temperature, water regime requirements, etc are not known.

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

Important populations

In this section, the word "population" is used to refer to a subpopulation, in keeping with the terminology used in the EPBC Act and state/territory environmental legislation.

All populations of Coughran's crayfish are important for the conservation of the species across its restricted range, because their limited dispersal capabilities mean local extinctions are not readily recolonised.

Threats

Established threats (habitat destruction, bushfires, exotic species, drought, and overcollection), emerging threats (climate change), and potential future threats (disease such as *Aphanomyces astaci* [crayfish plague]; Panteleit et al. 2017; DAWE 2019) may put many species of *Euastacus* at serious risk of population declines, or extinction, in less than a decade (Wells et al. 1983; Coughran 2007; Furse & Coughran 2011; Furse 2014, Coughran et al. 2015; Richman et al. 2015).

Table 1 Threats

Threat	Status [a]	Evidence
Climate change and severe weather		
Alterations to hydrological regimes	Timing: current / future Confidence: inferred Likelihood: almost certain Consequence: major Trend: increasing Extent: across the entire range	Changes in moisture availability, driven by climate change, impact not only the species itself but also floral and faunal assemblages across the species' range. *Euastacus* species are sensitive to both drought and flooding (Furse et al. 2012a). Moisture deficits and excesses are threats that put this restricted-range species at high risk of population declines, or extirpation. Rainfall patterns in the region occupied by the Coughran's crayfish are projected to change, with annual rainfalls projected to decline by 15 % by 2090, with the decline greatest in spring (29 %) (Clarke et al. 2019). Shifting precipitation patterns, coupled with projected increases in temperature (see increased temperature section below), may lower the local water table and increase seasonality of streams in which Coughran's crayfish reside. The species may be restricted to streams with permanent subsurface water and its burrows are reportedly in or connected to open or flowing water (McCormack 2022; McCormack & Fetzner in prep). Therefore, any changes to water availability are likely to significantly impact this species.
Increased temperature	Timing: current / future Confidence: inferred Likelihood: almost certain Consequence: major Trend: increasing Extent: across the entire range	Under a high emission scenario, mean maximum temperature in Gippsland, Victoria, is expected to increase by 1.2˚C (by 2039) and 2˚C by mid-century (Clarke et al. 2019). Furthermore, under climate change, the severity and frequency of extreme weather events, including heatwaves, are projected to increase. In Gippsland, the number of hot days is expected to double by 2050 compared to 1986-2005 (Clarke et al. 2019). The habitat of Coughran's crayfish is anticipated to be impacted by the increase in severity and frequency of extreme heat events and increasing environmental temperatures. *Euastacus* species are sensitive to increasing temperatures (Lowe et al. 2010; Bone et al. 2015, 2017), and Coughran's crayfish may be unable to physiologically adapt or relocate to cooler habitats as temperatures increase. Dispersal is limited by the lack of availability of nearby suitable habitat. The species may require cooler conditions as it may be restricted to forested streams, and any temperature increase in its distribution will potentially contract habitat upstream (McCormack & Fetzner in prep). Increases in temperature and number of extreme heat events in the region are inferred to have impacted this species across its range and could put the species at risk of extinction with projections for both to increase in the near future under climate change.

Threat	**Status** [a]	**Evidence**
Extreme weather events	Timing: current / future Confidence: inferred Likelihood: likely Consequence: major Trend: increasing Extent: across the entire range	Increased severity and frequency of extreme weather events (heatwaves, storms, droughts) are broadscale threats associated with climate change (Coughran & Furse 2010). These events are not persistent and may be relatively short term in duration (i.e., hours to weeks). Climate change is projected to increase the severity and frequency of extreme weather events. These extreme weather events have the capacity to seriously impact Coughran's crayfish, potentially leading to a population decline. In addition, a single severe weather event may lead to other localised natural disasters (e.g., flooding, landslides, and sedimentation events) (Furse et al. 2012b). As reported in other species (Furse et al. 2012) smaller specimens of this species may construct burrows under rocks and logs and other debris (McCormack & Fetzner in prep) which may get washed away in flood events (sensu Furse et al. 2012). In the Gippsland region, extreme rainfall events are expected to become more intense on average through this century (Clarke et al. 2019). Natural events, such as bushfire, landslides and tree falls, can lead to major sediment influxes to streams and gullies.
Fire regimes that cause declines in biodiversity [b]	Timing: current / future Confidence: inferred Likelihood: likely Consequence: major Trend: increasing Extent: across the entire range	The frequency and magnitude of bushfires is predicted to increase under climate change scenarios (Di Virgilio et al. 2019). Throughout the range of Coughran's crayfish, the average number of annual fire weather days is expected to increase (Clarke et al. 2019). Impacts may be immediate (habitat loss) or delayed impacts such as siltation and deoxygenation of waterway caused by increased sediment and ash influx following a fire, or a possible change of stream water temperature due to canopy loss. Spatial analysis predicted that roughly 38 % of the Coughran's crayfish habitat was burnt, or exposed to high risk of sedimentation, by the 2019–20 megafires (Legge et al. 2021). Any destruction of riparian vegetation during bushfires may lead to reduction in the amount of suitable habitat available to this species as it is associated with forested streams (McCormack & Fetzner in prep). A single bushfire has the capacity to impact this restricted range species, potentially leading to a population decline across the majority of the species range, or extirpation of the species.
Human Disturbance (e.g., direct mortality and stress/encroachment from human activities)		
Increased soil erosion and sedimentation and habitat destruction	Timing: current Confidence: observed Likelihood: almost certain Consequence: major Trend: unknown Extent: across part of the range	Much of the lower Bemm River Catchment is cleared for agriculture or currently used for timber harvesting. As Coughran's crayfish appears to only inhabit forested streams, further land clearance is inferred to reduce the suitability of habitat. Possible impacts include increase in water temperature with reduced canopy, changes in the amount of organic debris in the stream, increased primary productivity in the stream and/ changes to the amount of organic debris in the stream and increased sedimentation (McCormack & Fetzner in prep).

Threat	Status [a]	Evidence
Illegal collection	Timing: current / future Confidence: suspected Likelihood: possible Consequence: moderate Trend: increasing Extent: across the entire range	Illegal collectors specifically target rare species of *Euastacus* for personal collections and the aquarium trade (Coughran 2007; Coughran & Furse 2012; Furse 2021 unpub). Their targets include species in national parks (see Coughran & Furse 2012) and extremely remote areas (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 (Furse 2021 unpub). Protected freshwater crayfish species are available via the internet (Olden & Carvalho 2023). Any collection of slow-growing and rare species, such as the Coughran's crayfish, has capacity to 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 species' recruitment. Whilst small *Euastacus* species are protected from recreational fishing by the minimum legal size of 90 mm carapace length (Victorian Fisheries Authority 2021), they can be caught accidentally. Illegal collectors can also act as a vector for diseases/pathogens between catchments, waterways, and into isolated areas of habitat.
Exotic invasive species, problematic native species, pathogens and disease		
Crayfish plague (*Aphanomyces astaci)*	Timing: future 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 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 a characteristic of Coughran's crayfish 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). Therefore, it poses an extremely high risk to native freshwater crayfish species (DAWE 2019). The vector for the disease's movement outside of its native range was translocation of North American crayfish, in particular the signal crayfish (*Pacifastacus leniusculus*) and the red swamp crayfish (*Procambarus clarkii*), both of which are available for purchase on the internet (Olden & Carvalho 2023). 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 (Business Queensland 2021; Department of Primary Industries & Regional Development 2021) but are not known to be infected. The worldwide online trade in freshwater crayfish is large and growing (Olden & Carvalho 2023). A single, illegally imported crayfish, infected with crayfish plague, has the capacity to devastate the entire Australian crayfish fauna. Increasing illegal wildlife/aquarium trade appreciably increases the risk and probability of the disease's introduction to Australia (Furse 2014).

Threat	Status [a]	Evidence
Problematic native species: Common yabby (*Cherax destructor*)	Timing: current / future Confidence: suspected Likelihood: likely Consequence: moderate Trend: static to increasing Extent: across part of the range	The common yabby (*Cherax destructor*) is widespread throughout much of the range of Coughran's crayfish, which is outside of the yabby's natural range. Use as live bait for recreational fishing is considered a significant pathway for introduction to areas outside its natural range across Australia (Coughran & Daly 2012). The common yabby is a fast-growing species with high reproductive output (early maturity, multiple broods per year) contrasting strongly with *Euastacus* species (Beatty et al. 2005). Common yabby invasion is considered a significant threat to many species of *Euastacus* as they may prey on juveniles and compete with native crayfish species (McCormack 2012). The pattern of abundance of *Euastacus* species and common yabby is often inversely correlated.
Invasive fauna: trout	Timing: current / future Confidence: observed Likelihood: likely Consequence: moderate Trend: increasing Extent: across part of the range	Introduced fish, including brown trout (*Salmo trutta*) and rainbow trout (*Onchorhynchus mykiss*), occur within the taxon's range, and predation on juveniles may have a detrimental impact on crayfish populations (Merrick 1995; McCormack & Fetzner in prep), particularly in streams which have been heavily impacted by sedimentation (Coughran et al. 2015). While the level of threat to the Coughran's crayfish by introduced trout is unclear, trout are known to feed on small crayfish. The pattern of abundance of the related Orbost spiny crayfish and brown trout was found to be inversely correlated during surveys in the Brodribb River Catchment (Lieschke et al. 2014). Brown trout might be impacting Coughran's crayfish subpopulations by causing declines in abundance or by hampering recovery after disturbances such as fires (Lieschke et al. 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 (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				Alterations to hydrological regimes; Increased temperature; Increased soil erosion and sedimentation and habitat destruction	
Likely			Problematic native species: Common yabby (*Cherax destructor*); Invasive fauna	Extreme weather events; Fire regimes that cause declines in biodiversity	
Possible			Illegal collection		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 Coughran's 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 severe weather impacts

- If appropriate, establish facilities for potential ex situ short-term, active conservation intervention(s) (see 'Breeding, propagation and other ex situ recovery action' below).
    - Establish an environmental monitoring system in the species' habitat, to provide alerts of dangerous environmental conditions, when the species physiological tolerances are known.
    - Develop or access local weather and climate models to predict when extreme weather events might require moving animals to ex situ facilities.
- Determine how any relatively 'cool' microclimates may aid conservation as temporary refuges.

Fire impacts

- Review and revise existing fire management plans, and hazard reduction practices, to ensure they are appropriate for the distribution and habitat requirements of this species. These can include:
    - Active protection of fire sensitive forest areas, and active management of surrounding areas.
    - Monitor and, if necessary, manage impacts from any upstream fires
        - In particular, those likely to result in increased erosion or ash influx to waterways on the species habitat.
- Ensure that fire suppression and mop-up operations do not cause physical and chemical impacts on the species habitat.
- Consult with and engage cultural knowledge custodians and land rights holders with the intention to enable knowledge sharing and Caring for Country practices, including cultural burning.

Habitat loss, disturbance and modifications impacts

- Ensure that the habitat quality remains high through actions of national parks and reserves where the species is found (e.g., weed removal, fire management, etc.).
- Ensure that any changes to surface and groundwater hydrology account for the species habitat requirements.
- Ensure land managers, forestry workers and contractors/other authorities are aware of the species' occurrence and provide protection measures against key and potential threats.
- Monitor and control damage to riparian areas by forestry activities (including timber harvesting and road construction). This may require a collaborative strategy with industry, surrounding landholders and local government authorities.

- Review management of roads and tracks in the catchments where the species occurs, including stream crossings (wet/dry, channel or drainage lines), to eliminate sources of direct sediment input into the stream drainage network and prevent illegal translocation of non-native fish species.
- Where additional subpopulations are established, identify and conserve habitat characteristics that facilitate movement between them.

Introduced species impacts (including from grazing, trampling, predation)

- Develop and implement long-term strategies to control introduced predators and competitors (such as brown trout, rainbow trout, redfin, common yabby) by implementing eradication programs where feasible.

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).

Illegal collection

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

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, informed by population genetic analysis, as a source of animals to augment wild or extirpated, population, and to establish new populations, if required.
    - Investigating the feasibility of translocations to unoccupied areas to assist conservation of the species.

Stakeholder engagement/community engagement

- Prepare a management and engagement strategy for Coughran's 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.
- 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.

Survey and monitoring priorities

- Establish the population size, and then monitor the population to determine the trajectory of this species through time.
- Undertake targeted surveys to locate any additional subpopulations and identify suitable translocation sites.
- 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.
- Clarify the species' contemporary distribution to facilitate the following actions:
    - Protect known sites occupied by the species.
    - Ensure land managers are aware of the species' occurrence and provide protection measures against key and potential threats.

Information and research priorities

- Address the previously identified critical knowledge gaps on the biology, ecology and life history of Coughran's crayfish (e.g., reproduction, diet, temperature tolerance, see 'Relevant biology and ecology' above).
- Establish the species' habitat requirements.
- Investigate the potential influence of climate change on the long-term survival prospects of the species, due to altered temperatures, rainfall patterns, bushfires and diseases. This includes:
    - population genetic structure, levels of genetic diversity and minimum viable population size;
    - life history traits, such as time to maturity, longevity, fecundity, spawning period and number of young;
    - diet and habitat preferences;
    - desiccation, low dissolved oxygen and water temperature tolerance (adults, juveniles, larvae and eggs)
- Assess the thermal tolerance of Coughran's crayfish (using non-lethal methods) to ascertain its physiological limits, sensitivity and vulnerability.
    - Establish what the species' moisture requirements might be and how these may 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).
- Establish Coughran's crayfish's resilience to invasive species and diseases.
- Research the impacts of salmonid stocking on Coughran's crayfish population.

Recovery Plan decision

As an approved, updated, and detailed Conservation Advice for the species would provide sufficient direction to implement priority conservation actions, mitigate key threats, enable recovery and provide foundation for further planning, a national Recovery Plan is not required at this time.

Consequently, the Threatened Species Scientific Committee has not recommended that a recovery plan be required (see Attachment A for TSSC recommendations regarding the need for a recovery plan).

Links to relevant implementation documents

Australian aquatic veterinary emergency plan (AQUAVETPLAN) for crayfish plague (2019)

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The Threatened Species Scientific Committee finalised this assessment on 18 April 2023.

Attachment A: Listing Assessment for *Euastacus sp. 1 coughrani* (McCormack & Fetzner)

Reason for assessment

The devastating bushfires that burnt more than 10.3 million hectares across southern and eastern Australia in 2019-20 severely impacted native wildlife and habitat. This created an urgent need for hundreds of species and ecological communities (ECs) to be assessed against EPBC Act criteria for threatened listing status, so that the recovery and future resilience of fire-affected species and ECs could be supported by statutory protection commensurate with their post-fire status, and to ensure EPBC Act lists are as current and accurate as possible, helping improve environmental resilience and preparedness for future fire events.

This assessment results from Coughran's crayfish being identified, and then prioritised through the Australian Government Wildlife and Habitat Bushfire Recovery Program (Project Code 20-104, Saving the spinys: urgent actions to conserve the *Euastacus* freshwater crayfish). This assessment is part of the coordinated assessment of all 22 priority species of *Euastacus*, and is linked to the Australian Government's engagement of scientific experts to deliver a number of Species Expert Assessment Plans (SEAPs) for groups of fire-affected and non -fire-affected species and ECs, to enable hundreds of species and ECs to be assessed against EPBC Act criteria for threatened listing status and improve the currency of EPBC Act lists in a timely manner.

This assessment follows evaluation of the conservation status of the *Euastacus* sp. 1 *coughrani* through the SEAP project.

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.

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 the Coughran's crayfish. In addition, there is little information available from other species of *Euastacus*. Therefore, generation length has not been estimated.
Extent of occurrence (km²)	431	431	431	Based on published, and/or known survey and collection records (Austin et al. 2022; McCormack 2022; McCormack & Fetzner in prep; C. Austin 2023 unpub). Calculated using GeoCAT (Bachman et al. 2011).
Trend	Stable, but predicted to contract in the future			This is a newly discovered species, and there are no data about past declines in Area of Occupancy (EOO), but future declines are expected
Area of Occupancy (km²)	112	112	112	Based on published, and/or known survey and collection records (Austin et al. 2022; McCormack 2022; McCormack & Fetzner in prep; C. Austin 2023 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, but expected to contract in the future			This is a newly discovered species, and there are no data about past declines in Area of Occupancy (AOO), but future declines are expected
Number of subpopulations	<4	1	3	This species is restricted to connected sites in three catchments (Bemm, Brodribb and Queensborough rivers) across 2 basins (East Gippsland and Snowy River basins) (McCormack 2022; McCormack & Fetzner in prep),which may be considered separate subpopulations. There are no population data to confirm this, so number of subpopulations has not been specifically estimated.
Trend	n/a			

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Basis of assessment of subpopulation number	n/a			
No. locations	1	1	1	All specimens across the distribution of the species are considered to be part of one threat defined location, with relevant threats affecting all specimens at the same time.
Trend	Stable			
Basis of assessment of location number	This is a restricted range species with common threats across the area, in particular those associated with climate change. The most impactful threat is alterations to hydrological regimes, followed by increased temperature, extreme weather events and fire regimes that cause declines in biodiversity, as well as land clearing. Most of these will affect the entire species range equally and are all largely correlated with each other. Therefore, this species is considered to inhabit a single location.			
Fragmentation	It is not known if the species can be considered to be severely fragmented.			
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

There are no empirical data available on population trends over time from repeated surveys. While this species' habitat was heavily impacted by the 2019–20 bushfires (DAWE 2020; Legge et al. 2021), crayfish were observed in post-fire surveys in 2021 (McCormack & Fetzner in prep).

A report by the National Environmental Science Programme (NESP) Threatened Species Recovery (TSR) Hub (Legge et al. 2021) used a structured expert elicitation process to estimate the impacts of these fires on the population trajectory over the next three generations, estimating a future population decline of 23 % in Coughran's crayfish, and potentially as much as 39 % (bound of 80 % confidence limit). The estimation assumed no further extreme drought, heat or fire events, and so may be underestimates. It is likely that the cumulative effects of increasing bushfire frequency and intensity together with other threats will cause decline in the population of Coughran's Crayfish.

The Committee considers that 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)+B2ab(iii) for listing as Endangered.

Coughran's crayfish has a restricted distribution: Extent of Occurrence (EOO) of 431 km² and Area of Occupancy (AOO) of 112 km². The EOO and AOO meet the thresholds for listing as Endangered under Criterion B1 and B2.

The species evidently only occurs in streams with permanent subsurface water and has not been recorded in streams lacking riparian vegetation (McCormack & Fetzner in prep). Therefore, the actual area of habitat available is a small fraction of the calculated EOO. The small area of suitable habitat increases the risk of species extinction, with a large-scale metaanalysis by Bland (2017) finding that small range size is the single most important factor that influence extinction risk in freshwater crayfish.

Coughran's crayfish is known from numerous forested perennial creeks within one location (IUCN Standards and Petitions Committee 2022). The small range and proximity of the sites to each other means that major threats associated with climate change are more likely to be experienced in a relatively uniform fashion across all sites occupied by Coughran's crayfish, with the likelihood of any site providing refuge from adverse conditions reduced (McCormack & Fetzner in prep). Some species of *Euastacus* have been identified as having limited tolerance to abiotic changes (temperature, water availability) (Lowe et al. 2010; Bone et al. 2014; Bone et al. 2017) and are susceptible to ongoing declines in habitat through climate change (Bruna 2004).

Changes in moisture availability, due to global climate change, will impact the species itself as *Euastacus* are known to be sensitive to effects of drought (Furse et al. 2012a). Climate change modelling for the Gippsland region (Victoria) predicts a decline in rainfall (15 % annually), especially during spring (29 %), by 2090 (Clarke et al. 2019). Coughran's crayfish is reportedly restricted to streams with permanent subsurface water and its burrows are typically in or connected to flowing water (McCormack & Fetzner in prep). Therefore, any changes to water availability are likely to impact this species. Similarly, increased temperature will likely impact the species' directly and reduce the amount of available suitable habitat (McCormack & Fetzner in prep). Under a high emission scenario mean maximum temperature and number of hot days in Gippsland are expected to increase (Clarke et al. 2019). The habitats of Coughran's crayfish are anticipated to be impacted by the increase in severity and frequency of extreme heat events, plus through any lowering of water tables. The species may require cooler conditions as it is evidently restricted to forested streams, and as temperatures increase its distribution will likely contract upstream (McCormack & Fetzner in prep).

Throughout the range of Coughran's crayfish, the average number of annual fire weather days is expected to increase (Clarke et al. 2019). Impacts may be immediate (habitat loss) or delayed (siltation and deoxygenation of water caused by sediment and ash influx following a fire, plus possible change of stream water temperature due to canopy loss). Much of the range of this species was affected by the 2019–20 megafires (DAWE 2020). Any destruction of riparian vegetation during bushfires may lead to reduction in the amount of suitable habitat available to this species as it is evidently associated with forested streams. A single bushfire has the capacity to impact the entire population of this restricted range species, potentially leading to a population decline across the species range, or extirpation of the species.

It is predicted 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) and bushfires satisfying subcriterion (b)(iii).

The above data indicate Coughran's crayfish is eligible for listing as **Endangered B1ab(iii)+B2ab(iii)** 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 Coughran's 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 km² or number of locations ≤ 5

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

Criterion 4 evidence

Insufficient data to determine eligibility

The number of mature individuals of the Coughran's crayfish 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 has been considered adequate and there is sufficient scientific evidence to support the assessment.

Public consultation

Notice of the proposed amendment and a consultation document was made available for public comment for at least 30 business days between 29 June 2023 and 11 August 2023. No submissions were received.

Listing and Recovery Plan Recommendations

The Threatened Species Scientific Committee recommends:

i) that the list referred to in section 178 of the EPBC Act be amended by including *Euastacus* sp. 1 *coughrani* in the Endangered category.

ii) that there not be a Recovery Plan for *Euastacus* sp. 1 *coughrani* in accordance with the provisions of the EPBC Act and the Committee's conservation planning principles as follows:

- An approved conservation advice is an effective, efficient and responsive document to guide the implementation of priority management actions, mitigate key threats and support the recovery of this species.
- An approved conservation advice would support the species recovery by identifying priority actions, stakeholders for engagement, and the survey and research priorities to facilitate a better understanding of key threats as well as biological and ecological knowledge gaps.
- The threats facing the entity, and the recovery actions needed can most effectively be guided via an approved conservation advice.
- *Euastacus* sp. 1 *coughrani* is endemic to a restricted distribution in eastern Victoria. Coordination of conservation actions is restricted to a few key stakeholders.
- The main threats to the species are associated with the impacts of climate change (alterations to hydrological regimes, increased temperature, extreme weather events, increased intensity/frequency of bushfire).

iii) Having regard to the above factors, a recovery plan is not required as it would not provide a significant conservation planning benefit above existing mechanisms.

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