

DRAFT - Conservation Advice for *Euastacus fleckeri* (Flecker's crayfish)



Flecker's crayfish in a captive setting. Image does not depict the species' natural habitat © Copyright, Rob McCormack.

Conservation status

Euastacus fleckeri (Flecker's 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 fleckeri 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: B1ab(iii,v)+B2ab(iii,v): Endangered
- Criterion 3: Insufficient data
- Criterion 4: D2 Vulnerable
- 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) on its highly restricted distribution, which will very likely lead to a continuing 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, see the [Species Profile and Threat Database](#).

Species information

Taxonomy

Conventionally accepted as *Euastacus fleckeri* (Watson, 1935) (Family: Parastacidae). Phylogenetic results have confirmed its validity as a distinct taxon (Shull et al. 2005; Austin et al. 2022).

Description

Flecker's crayfish belongs to the *fleckeri* – *robertsi* clade (Coughran 2008) of North Queensland (Riek 1969; Morgan 1988; Ponniah & Hughes 2004). *Euastacus robertsi* (Robert's crayfish) and Flecker's crayfish have long been considered as probably distinct from the other species of *Euastacus*. They are potentially different enough to warrant the erection of a new genus (Morgan 1988).

It is one of the larger species in the genus (Coughran & Furse 2010) and is recorded as reaching at least 119.1 mm occipital-carapace length (OCL, Morgan 1997) (Morgan 1998; Coughran 2008). The species typically presents as blue coloured, with striking fluorescent orange/orange-red antennae and tips of chelae (claws). Specimens are adorned with numerous similarly coloured fluorescent spines (Morgan 1998).

The morphological characteristics used to identify *Euastacus* are typically subtle, with the differences often a few spines, and/or the presence of a groove. Morphologically, *E. fleckeri* is most similar to Robert's crayfish from Mount Finnigan, ~89 km to the north. In addition to its distinctive colouration, Flecker's crayfish can be distinguished from *E. robertsi* by the shape of its rostrum (round U-shaped in Flecker's crayfish acute triangular in Robert's crayfish: Monroe 1977) and propodal spine development and number (Morgan 1988). Flecker's crayfish has not been found sympatrically with other crayfish (McCormack 2012), with Robert's crayfish being the nearest species geographically, about 30 km to the northeast.

Accurate and reliable identification of *Euastacus* is challenging and requires technical terminology to describe the morphological features separating the species (for detailed descriptions see: Watson 1935, 1936; Morgan 1988; Coughran 2008).

Distribution

Flecker's crayfish is a short-range endemic (Harvey 2002). It is endemic to far North Queensland with the species' entire distribution contained within the rainforests of the adjoining Mount Lewis, Mount Spurgeon and Daintree national parks and Brooklyn Sanctuary (Morgan 1988; Coughran & Furse 2010).

This species is only known from altitudes >900 m above sea level (a.s.l.) where it occupies the headwaters of various streams (Morgan 1988; Coughran & Furse 2010). The species range is drained by the Mitchell River (to the west) and the Mossman River to the east.

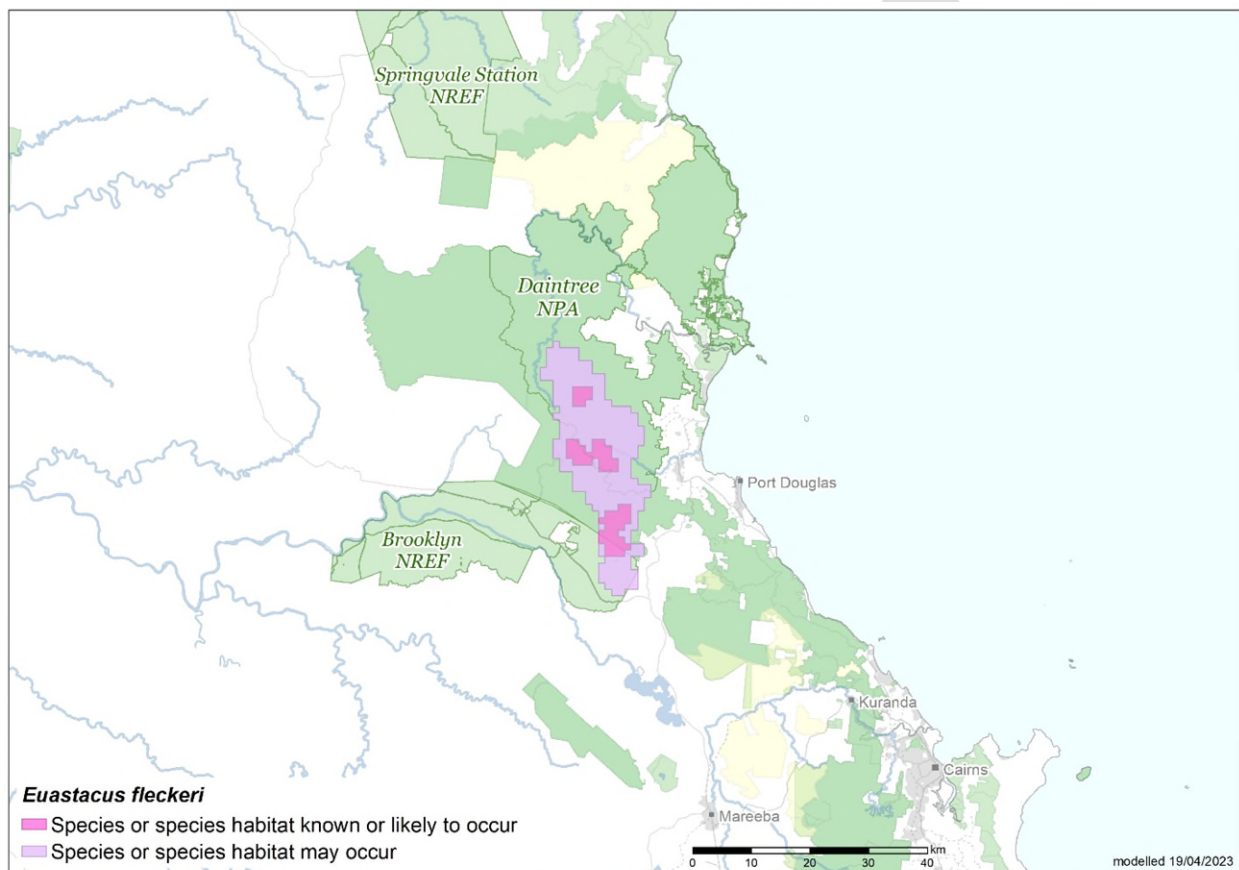
Additional areas of suitable habitat do exist in North Queensland, however they are not adjacent to this species' habitat, and are already occupied by one of the other species of *Euastacus* known to occur in North Queensland (Furse et al. 2012a). All indications are that this species is not found outside of its currently known distribution.

The North Queensland region occupied by this crayfish features exceptionally high rainfalls; median annual rainfall at Mossman Central Sugar Mill (~15 km east) is 2345 mm *per annum*, and

~100 km to the southeast at Bellenden Ker, median rainfall routinely exceeds 7600 mm *per annum* (BOM 2022), the highest rainfall, and wettest place in Australia. Mean annual temperature at Port Douglas, ~20 km to the east is 27.8 °C (BOM 2022).

Mount Lewis, Mount Spurgeon and Daintree national parks are part of the Wet Tropics World Heritage Area (DES 2021). The population is afforded a degree of protection as it is contained within the boundary of Mount Lewis, Mount Spurgeon and Daintree national parks, but the parks are not actively managed for conservation of Flecker's crayfish (*sensu* Coughran & Furse 2010).

Map 1 Modelled distribution of Flecker'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 contained herein. Due to limited survey effort and information available, *Euastacus fleckeri*, and its habitat, may occur in areas where it has not yet been recorded, and the modelled distribution (Map1) should be considered as indicative only.

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 species and the ecological communities they form are diverse and varied for First Nations peoples. Such knowledge may be only held by First Nations peoples who are the custodians of this knowledge and have the rights to decide how this knowledge is shared and used.

Flecker's crayfish occurs on lands of the Yalanji peoples (Queensland Government 2013a, 2019).

Relevant biology and ecology

It is recognised that the *Euastacus* have a suite of common biological characteristics, and many of these characteristics will apply to this species (e.g., Furse & Coughran 2011a). Various studies have established that *Euastacus* are slow-growing (growth increments of a few mm OCL yr⁻¹), long-lived and can take many decades (35–50 years) to reach the adult sizes that are recorded for some species (Honan & Mitchell 1995a; Turvey & Merrick 1997a; Morey 1998; Furse & Wild 2004; Coughran 2011, 2013). However, the biology and ecology of Flecker's crayfish remain unknown. Furse & Coughran (2011c) identified critical knowledge gaps (e.g. biology, ecology, distributions) for the *Euastacus* in general, and the knowledge gaps apply in particular to this poorly understood species.

Reproductive Ecology

Reproductive studies show that *Euastacus* are typically late maturing and have slow reproductive cycles with females only reaching reproductive maturity after 5–10 years (e.g., Honan & Mitchell 1995a; Turvey & Merrick 1997a; Borsboom 1998; Furse & Wild 2004; Coughran 2013). The growth rate, population sizes and generation length of Flecker's crayfish are not known.

Many species of *Euastacus* are winter brooders, mating in late summer/autumn with females carrying eggs over winter, with brooding periods typically 6–10 months. 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, 2013; McCormack et al. 2010). The species is likely to be a poor disperser, with slow growth and low fecundity (Harvey 2002). Indications are that this species is a winter brooder (JM Furse 2022 unpub) and due to the very large size of this species, pleopodal egg fecundity is likely in the range 20–80 eggs (Coughran 2008) or much higher. Coughran (2008) estimated female Flecker's crayfish reach maturity in the range 40–60 mm OCL, as a 40 mm OCL reproductive (berried) female captured and released in June 2014 was carrying approximately 40 eggs (JM Furse 2022 unpub).

Co-occurring species

Cherax cairnsensis (Cairns yabby) is endemic to the region and has been collected from streams on Mount Lewis in close proximity to streams occupied by Flecker's crayfish (JM Furse 2022 unpub). It is likely these species co-occur.

Habitat

Flecker's crayfish is known from 12 sites within a highly restricted distribution (Morgan 1988; Coughran & Furse 2010) and all of its known, peripheral, and likely habitat in the high-altitude rainforests within Mount Lewis, Mount Spurgeon and Daintree national parks.

Flecker's crayfish is associated with cool habitat conditions. Water temperature in the habitat of this species are known to range between 15–22 °C (winter-summer) (JM Furse 2022 unpub). The species occupies small upper headwater streams within a closed rainforest canopy (Morgan 1988; Horwitz 1990; Coughran & Furse 2010). Morgan (1988) noted “creeks are well shaded and log and leaf litter are abundant”. Flecker's crayfish is known to construct burrows under rocks or logs (Horwitz 1990) and will likely opportunistically seek shelter under other vegetative debris. It is not known if this species is typically associated with flowing water, or not. However, given the region's high rainfall, the streams in the area likely flow year-round (e.g. Queensland Government 2013b) and flowing surface water is likely an important habitat characteristic for this species.

The thermal tolerance of Flecker's crayfish is unknown, but other highland rainforest-dwelling species of *Euastacus*, such as *Euastacus sulcatus* (mountain crayfish), are intolerant of high temperatures (Bone et al. 2014).

Diet

The diet of Flecker's crayfish is not known, but the species is likely omnivorous, as with many species of spiny crayfish (McCormack 2012).

Threats

Established threats (habitat destruction, , invasive species, human exploitation and climate change) and potential threats (disease *Aphanomyces astaci* [crayfish plague]; Panteleit et al. 2017) may put nearly all species of *Euastacus* at serious risk of population declines, or extinction in less than a decade (Wells et al. 1983; Coughran 2007; Furse & Coughran 2011b; Furse 2014; Richman et al. 2015). Climate change is a key threat to Flecker's crayfish with the species having limited capacity to relocate to higher, cooler altitudes, or move overland to other nearby suitably cool habitat which are already occupied by other species of *Euastacus* (Ponniiah & Hughes 2004; Furse et al. 2012a). Flecker's crayfish was assessed as vulnerable to the climate conditions modelled for 2050 by Hossain et al. (2018). 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 restricted range (Furse & Coughran 2011b).

Table 1 Threats impacting Flecker's crayfish

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

Threat	Status and severity	Evidence
Climate change and extreme weather impacts		
Increased average temperature	Timing: current/future Confidence: inferred Likelihood: likely Consequence: major Trend: increasing Extent: across the entire range	Increased average temperature is a direct, ongoing, and persistent long-term impact of climate change. Unlike short-term heatwaves, this is a steady long-term increase in average annual temperature. Most of the years between 2019 and 2028 are projected to be amongst the top 10 warmest years globally with more than 99% probability (Arguez et al. 2020). Minimum, maximum and average temperatures in Far North Queensland are projected to continue to rise with an annual average warming of 0.5 to 1.4 °C above the climate from 1986–2005 by 2030 (DSE 2019). By 2070, mean annual temperature in the Wet Tropics bioregion of Queensland is expected to increase by 1 – 2 °C (Representative Concentration Pathway (RCP) 4.5) to 1.9 – 3.1 °C (RCP 8.5) (Syktus et al. 2020). A 50% decline in the distribution and extent of highland rainforest environments of north Queensland are projected with only 1 °C rise in temperatures (Hilbert et al. 2001). The cooler upland sections of the Wet Tropics where Flecker's crayfish occurs provide unique habitat for many

Threat	Status and severity	Evidence
		<p>heat intolerant and range restricted species (ANU 2009). It is unlikely that these species that have adapted to the cooler conditions on mountain tops and higher tablelands can survive and reproduce under warming conditions (Rainforest CRC 2003; Pearson et al. 2015; de la Fuente & Williams 2022).</p> <p><i>Euastacus</i> are known to be sensitive to increasing temperatures, with Flecker's crayfish likely lacking the capacity to physiologically adapt or relocate to cooler habitats as temperatures increase (Lowe et al. 2010; Bone et al. 2015, 2017). This will probably lead to altitudinal compression of habitat as there is limited scope for up-slope migration of this species and overland dispersal to other suitably cool habitats is blocked by the warm lowlands (Morgan 1988; 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 <i>Euastacus</i> (Furse et al. 2012a).</p> <p>Projected increases in temperature in the region will impact this species across its restricted range (i.e. the single location) and puts the species at a very high risk of extinction. Water temperature in the habitat of this species are known to range between 15–22 °C (Winter-Summer) (JM Furse 2022 unpub). The upper thermal limit of this species remains unknown, however, given the species association with cooler temperatures, and based on the work of Bone et al. (2014) environmental temperatures may only be a few degrees away from temperatures that may cause thermal stress in this species (i.e. >23 °C). <i>E. fleckeri</i> was assessed as a crayfish species vulnerable to the climate conditions modelled for 2050 by Hossain et al. (2018).</p> <p>Increasing average temperature associated with climate change will also interact with the other threats:</p> <ul style="list-style-type: none"> - Fire regimes that cause declines in biodiversity - Extreme weather events - Alterations to hydrological regimes
Extreme weather events	<p>Timing: current/future Confidence: inferred Likelihood: likely Consequence: major Trend: increasing Extent: across the entire range</p>	<p>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). Severe weather events have the capacity to seriously impact the population, leading to a decline or extirpation of the species (Coughran & Furse 2010).</p> <p>The highland habitat of Flecker's crayfish is anticipated to be impacted by an increase in intensity and frequency of extreme heat events. Climate change modelling projects increased length and duration of droughts, longer periods of consecutive wet days, and longer and more frequent heatwaves for the region where this species is found (Syktus et al. 2020). By 2060–79, the Wet Tropics Bioregion of North Queensland is expected to have ~1.5–13 additional hot days (>35 °C) <i>per annum</i> compared to the reference period (1986–2005) (Syktus et al. 2020).</p> <p>Bone et al. (2014) reported that when exposed to chronic, steadily increasing temperature, similarly-sized, small specimens of <i>E. sulcatus</i> became sluggish ~23 °C and were effectively incapacitated at ~27 °C (Bone et al. 2014). Acute exposure to temperatures above the upper thermal tolerance limit of this species could result in deleterious physiological impacts, and mortalities, and could lead to population reductions. The thermal limit of this species remains unknown, however based on the work of Bone et al. (2014) environmental temperatures may only be a few degrees away from temperatures that may cause thermal stress in this species. A single heatwave event could potentially lead to water temperatures reaching the upper thermal tolerance threshold, and result in physiological impacts, or even mortalities.</p> <p>High rainfall events leading to flash floods can scour high-altitude streams and this can be deadly to any <i>Euastacus</i> that seek refuge under leaves/fallen palm fronds, small rocks and logs. Mass mortality was recorded in <i>Euastacus valentulus</i> (powerful crayfish) in the Numinbah Valley (Southeast Qld), when an intense rainfall event and flash flood killed hundreds, and</p>

Threat	Status and severity	Evidence
		<p>possibly thousands, of crayfish (Furse et al. 2012b). Many of the crayfish killed in that event (30–40 mm OCL) were in a similar size-range to this species.</p> <p>A single extreme weather event may lead to other localised natural disasters (e.g., flooding, tree falls, landslides, and sedimentation events) (Furse et al. 2012b). Sediment exposure can damage respiratory surfaces of gills and reduce the ability of crayfish to uptake oxygen from the water (Cramp et al. 2021).</p> <p>Soils in the rainforests (including Mount Lewis National Park) of North Queensland are often sandy (Queensland Government 2013b) poor, unstable and susceptible to landslides and erosion in the steep terrain where very high rainfalls, and tropical cyclones, are typical. This may lead to sediment influxes to streams and gullies in high relief montane areas occupied by this species, as is common in other regions with similar geologies and rainfall (Ravindran et al. 2019).</p>
Alterations to hydrological regimes	<p>Timing: current/future</p> <p>Confidence: observed</p> <p>Likelihood: almost certain</p> <p>Consequence: major</p> <p>Trend: increasing</p> <p>Extent: across the entire range</p>	<p>Changes in moisture availability and increased ephemerality of hydrological systems due to global climate change, will likely impact the species itself, but also floral and faunal assemblages, across the species' range. <i>Euastacus</i> are known to be sensitive to effects of drought, but also effects of 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.</p> <p>Changes to rainfall patterns in the tropical rainforest region of North Queensland are more complex to project accurately, but models suggest that areas up to 200 km inland from the coast could experience changes in annual rainfall ranging from -45 to +23 % compared to 1990 (Suppiah et al. 2007). Rainfall patterns in the region occupied by this species are projected to alter as a result of climate change, with both annual precipitation and mean number of consecutive wet days potentially declining by 2060–79 (Syktus et al. 2020).</p> <p>Furthermore, the duration and frequency of droughts are, on average, projected to increase by 2060–79 throughout the region where this species is found (Syktus et al. 2020). Shifting precipitation patterns coupled with projected increases in temperature may lower the local watertable and may introduce seasonality to the otherwise perennial streams in which this species resides. Changes to availability of water might significantly impact this species.</p>
Fire regimes that cause declines in biodiversity	<p>Timing: current/future</p> <p>Confidence: observed</p> <p>Likelihood: likely</p> <p>Consequence: major</p> <p>Trend: increasing</p> <p>Extent: part or across entire range</p>	<p>The frequency and severity of bushfires is projected to increase under climate change (Di Virgilio et al. 2019, DAWE 2022) but in Far North Queensland it is unclear how these changes will manifest. While the range of this species was not directly impacted by the 2019–20 bushfires, vegetation within ~10 km of sites known to be inhabited by Flecker's crayfish were burnt (DAWE 2020).</p> <p>Some impacts of bushfires on crayfish are quite well understood and may be immediate (habitat loss) or delayed (siltation and deoxygenation of habitat following a fire, possible change in stream 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). This is a particular concern given the species association with cooler temperatures.</p> <p>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 Wet Tropics Region, including in the adjoining Daintree National Park (e.g., lantana (<i>Lantana camara</i>)) (Queensland Government 2019). In the rainforests of the region, thick infestations of lantana are known to establish (Queensland Government 2013b, 2019) and <i>per</i> Hines et al. (2020) this may increase the chance and severity of bushfires.</p> <p>A single bushfire has the capacity to impact the entire population of this short range endemic species, potentially leading to a population decline across the species' range, or extirpation of the species.</p>

Threat	Status and severity	Evidence
Illegal collection		
Illegal take	<p>Timing: current</p> <p>Confidence: inferred</p> <p>Likelihood: possible</p> <p>Consequence: moderate</p> <p>Trend: static</p> <p>Extent: across the entire range</p>	<p>All spiny crayfish are no take species in Queensland (Queensland Government 2020). Illegal collectors specifically target rare species of <i>Euastacus</i> for personal collections and the aquarium trade (Coughran 2007; Coughran & Furse 2012; JM Furse 2021 unpub). Their targets include species in national parks (see Coughran & Furse 2012) and extremely remote areas (JM Furse 2021 unpub).</p> <p>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 (JM Furse 2021 unpub).</p> <p>Any collection of rare, slow-growing and short-range endemic species, such as Flecker's crayfish, 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.</p> <p>Illegal collectors can also act as a vector for diseases/pathogens between catchments, waterways, and into isolated areas of habitat.</p>
Invasive species		
Invasive fauna	<p>Timing: current/future</p> <p>Confidence: inferred</p> <p>Likelihood: possible</p> <p>Consequence: moderate</p> <p>Trend: static to increasing</p> <p>Extent: across the entire range</p>	<p>Feral pigs (<i>Sus scrofa</i>) occur in the region including in the adjoining Daintree National Park (Queensland Government 2019), and disturbance by pigs is common in other nearby national parks (Queensland Government 2013b). Pigs eat crayfish (Coughran 2021) and are a serious threat to crayfish in general, but species of burrowing crayfish in particular (e.g. <i>Engaeus martigener</i> (Furieux burrowing crayfish)), both through predation and their rooting and wallowing behaviour (DEH 2017).</p>
Disease		
Crayfish plague	<p>Timing: future</p> <p>Confidence: projected</p> <p>Likelihood: possible</p> <p>Consequence: catastrophic</p> <p>Trend: unknown</p> <p>Extent: across entire range</p>	<p><i>Aphanomyces astaci</i> (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).</p> <p>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).</p> <p>The vector for the movement of crayfish plague outside of its native range was the translocation of North American crayfish, in particular, <i>Pacifastacus leniusculus</i> Dana (signal crayfish and <i>Procambarus clarkii</i> 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.</p> <p>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).</p>

^aTiming—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

^bFire 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	
Likely				Increased average temperature Extreme weather events Fire regimes that cause declines in biodiversity	
Possible			Invasive fauna Illegal take		Disease: Crayfish plague
Unlikely					
Unknown					

Risk Matrix legend/Risk rating:

Low Risk	Moderate Risk	High Risk	Very High Risk
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Conservation and recovery actions

Primary conservation objective

- Ensure the AOO and EOO of Flecker's crayfish are stable or increasing, and major threats are effectively managed, and resilience to climate change impacts is maximised.

Conservation and management priorities

- The following recommendations involving capture and removal of live specimens from the wild, and/or captive populations are made on the assumption that a suitably large population of this poorly understood species exists in the wild.

Extreme weather events

- Investigate feasibility and, if appropriate, plan and establish facilities for potential ex situ short-term, active conservation intervention(s), including:
 - Establishing a capacity to maintain a captive population of this species over the short-term, in response to an extreme weather event, for subsequent re-release to the wild (see Zukowski et al. 2021).
 - Establish an environmental monitoring system in the species' habitat, to provide alerts of dangerous environmental conditions. 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

- Determine if the species natural habitat features any relatively “cool” pockets of micro-habitat and if they could act as temporary refuges.

Fire impacts

- Review and revise existing fire management plans, including hazard reduction and fire suppression practices, to ensure they are appropriate for the distribution and habitat requirements of this species. These could include:
 - Actively protect fire sensitive rainforest areas, and manage surrounding areas.
 - Reduce the prevalence of fire-prone lantana where infestations have established, and replant native species.
 - 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.

Illegal collection

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

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

- Develop and implement long-term strategies to control introduced predators by implementing eradication programs where feasible.
- Monitor for and control any damage to riparian areas by feral pigs. If required, control numbers and fence sites, where feasible. This may require a collaborative strategy with surrounding land holders and local government authorities to limit feral pigs from crossing into national parks.
- Undertake weed control in the area and identify and remove weeds that could become a threat to the species, ensuring any possible disturbance/overspray does not adversely impact this species. Replant native species, if possible.

Disease impacts

- Ensure authorised researchers and rangers are aware of required hygiene protocols.
- Take steps (i.e., limit all publicity) to minimise frequency of potential disease vectors entering the species habitat. For example, not facilitating illegal collectors, or members of the public, identifying and visiting the species' habitat.
- Ensure that appropriate guidelines for mitigating spread of disease is communicated to relevant stakeholders (including biosecurity).

Habitat loss disturbance and modifications

- Ensure that the habitat quality remains high through management actions (e.g., weed removal, fire management, etc.) where the species is found.

Breeding, propagation and other ex situ recovery action

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

Stakeholder engagement/community engagement

- Prepare a management and engagement strategy this species and similar species of crayfish in the region with input from *bona-fide* crayfish experts, national park managers, and other identified stakeholders.
- Support engagement of Traditional Owners in the conservation of the species and its habitat.
- Limit publicity for this species due to risks from illegal-and- over collection and disease. Information should be restricted until key knowledge-gaps have been addressed. Full community engagement may not be beneficial to the species.
- Noting the requirement to limit publicity, 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.

Survey and monitoring priorities

- Establish, and then monitor the population size and trajectory of this species through time.
- Determine the contemporary geographic distribution of Flecker's 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 population size, biology, ecology and life history of this species (see 'Relevant biology and ecology' above).
- Investigate the species' habitat requirements (including any moisture, environmental temperature, dissolved oxygen and shelter/refuge requirements requirements).
- Investigate the potential influence of climate change on environmental stressors (altered temperatures, rainfall patterns, bushfires) and disease, and how these impact the long-term survival prospects of the species. This includes:

- If the population size permits, assess the thermal tolerance of Flecker's crayfish (using non-lethal methods) to ascertain its physiological limits, sensitivity and vulnerability. Thermal tolerances are likely to be similar between closely related species occupying similar environments (Cramp et al. 2021). So use of a more common *Euastacus* species which is physiologically and ecologically similar could be used to inform likely impacts to this threatened species.
- Establish the impacts of climate change on the species' habitat (vegetation assemblages, water availability, water and air temperatures).
- Investigate the impacts of invasive species and diseases on Flecker's crayfish.

Links to relevant implementation documents

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Attachment A: Listing Assessment for *Euastacus fleckeri* (Flecker's crayfish)

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.

Assessment of eligibility for listing

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

Key assessment parameters

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

Table 3 Key assessment parameters

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Number of mature individuals	Unknown	Unknown	Unknown	Not known for this species.
Trend	n/a			
Generation time (years)	Unknown	Unknown	Unknown	The longevity, fecundity, and age of sexual maturity in females is presently unknown for <i>E. fleckeri</i> . In addition, there is little information available from other species of <i>Euastacus</i> . Therefore, generation length cannot be estimated.
Extent of occurrence	154 km ²			Based on published, unpublished and known survey and collection records (e.g., Morgan 1988; J Coughran 2008 unpub; R McCormack 2008 unpub; JM Furse 2011, 2014 unpub).
Trend	Stable			The species is not known outside of the current EOO. Sites in the historical area of record (Watson 1935) remains occupied by the species (JM Furse 2014 unpub).
Area of Occupancy	64 km ²			Based on published, unpublished and known survey and collection records (e.g., Morgan 1988; J Coughran 2008 unpub; R McCormack 2008 unpub; JM Furse 2011, 2014 unpub). Calculated using GeoCAT (Bachman et al. 2011).

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
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			Sites in the historical area of record (Watson 1935) remains occupied by the species (JM Furse 2014 unpub).
Number of subpopulations	4			All records of the species are adjacent to each other in four distinct non-connected streams/gullies, which are treated as individual subpopulations.
Trend	Stable			As above.
Basis of assessment of subpopulation number	Distance and unsuitable habitat between the subpopulations means there is little chance of regular geneflow among them (Ponniah & Hughes 2006).			
No. locations	1			A series of surveys of the type locality and environs have established the species is restricted to a single threat defined location (e.g. Morgan 1988; J Coughran 2008 unpub; R McCormack 2008 unpub; JM Furse 2011, 2014 unpub).
Trend	Stable			
Basis of assessment of location number	All known sites for the species are adjacent each other within a small geographic range, with common threats posed by climate change over that range, and therefore are considered a single location.			
Fragmentation	There is not sufficient data to establish if the subpopulations can be considered to be severely fragmented.			
Fluctuations	Not known to be subject to any fluctuations in EOO, AOO, number of subpopulations, locations or mature individuals.			

Criterion 1 Population size reduction

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

Criterion 1 evidence

Insufficient data to determine eligibility

There are **insufficient data** to determine the eligibility of Flecker's crayfish for listing under Criterion 1. The population has not been specifically monitored since its original description. However, a series of collection records from unpublished surveys are known in the region of the type locality (J Coughran 2008 unpub; R McCormack 2008, 2010 unpub; JM Furse 2011, 2013, 2014 unpub).

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

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

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

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

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

Criterion 2 evidence

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

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

A series of surveys (i.e., J Coughran 2008 unpub; R McCormack 2008, 2010 unpub; JM Furse 2011, 2013, 2014) confirmed the highly restricted distribution of this species: EOO 154 km² and AOO 64 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 meets the threshold for listing as Endangered under Criterion B1 and the AOO meets the threshold for listing as Endangered under Criterion B2.

Flecker's crayfish is evidently a stream dwelling crayfish; the species occupies small tropical headwater streams (e.g., Watson 1935, 1936; Morgan 1988; Horwitz 1990; Coughran & Furse 2010) that may be perennial due to the typically very high rainfalls in the region. High altitude stream habitat of this type is not common in the rainforests of Far North Qld. This increases the risk of species extinction, with a large-scale meta-analysis by Bland (2017) reporting that small range size is the single most important factor that influence extinction risk in freshwater crayfish.

Number of locations

Flecker's crayfish has been recorded from 12 proximal sites (above 900 m a.s.l.), which are assessed as one threat defined location (IUCN Standards and Petitions Committee 2024), meeting the threshold for listing as Critically Endangered under subcriterion (a). The restricted range of the species means that all sites are in close proximity and are exposed to similar environmental stressors over time. Therefore, extreme weather events associated with climate change (e.g., heatwaves, severe storms/cyclones, fires) is the major threat to the species and

likely to be experienced in a relatively uniform fashion across the entire range of this species, with the likelihood of any habitat providing refuge from adverse conditions reduced to zero. Some species of *Euastacus* have been identified as having limited tolerance to abiotic changes (Lowe et al. 2010; Bone et al. 2014, 2017) and are susceptible to ongoing declines in habitat through climate change (Bruna 2004).

The isolation of this species to the headwaters of streams at high altitudes (>900 m a.s.l) increases the risk of extirpation of any individual subpopulations through environmental and demographic stochasticity (Bruna 2004; De Castro & Bolker 2005). Therefore, current and future threats could potentially rapidly eliminate all individuals in the taxon.

Continuing decline

By 2070, mean annual temperature in the Wet Tropics bioregion of Queensland is expected to increase by 1.0–2.0 °C (RCP 4.5) to 1.9–3.1 °C (RCP 8.5) (Syktus et al. 2020). This is likely to lead to altitudinal compression of the species' habitat, as there is limited scope for up slope migration by Flecker's crayfish. It is also unlikely that the species can migrate to other suitable habitat further south of its current range as this would involve moving through the warmer valleys that surround the mountain tops inhabited by the species (Rainforest CRC 2003). Furthermore, climate change is projected to increase bushfire risk making rainforest habitat more prone to burning (as was the case during the 2019–20 bushfire season) thereby reducing the availability of suitable habitat.

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, extreme weather events and reduced moisture availability) satisfying subcriterion (b)(iii). Additionally, a decline in the number of mature individuals due to impacts from extreme weather events such as heatwaves, plus more frequent and intense fires is projected, also satisfying subcriterion (b)(v).

Conclusion

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

Criterion 3 Population size and decline

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

Criterion 3 evidence**Insufficient data to determine eligibility**

There are no estimates of numbers of mature individuals or any population-decline data that will allow assessment of Flecker'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 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**Eligible under Criterion 4 D2 for listing as Vulnerable.**

There are insufficient data to assess Flecker's crayfish against the thresholds for listing under Criterion D1 as there is little information available to determine a robust estimate of the number of mature individuals. However, the species does qualify under Criterion D2 as Vulnerable (VU). This is because it is found in one location, and the combined threats of enhanced climate change, bushfires and feral predators could drive the species towards extinction in a short timeframe. The isolation of this species to the headwaters of streams at high altitudes (>900 m a.s.l.) of this species increases the risk of extirpation of any individual subpopulations through environmental and demographic stochasticity (Bruna 2004; De Castro & Bolker 2005). Therefore, current and future threats could potentially rapidly eliminate all individuals in the taxon.

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 (i.e. 2008, 2010, 2011, 2013 and 2014) and there is sufficient published scientific evidence to support this assessment.

DRAFT