Australian Capital Territory

Nature Conservation (Threatened Species Nominations) Public Consultation Notice 2025

Notifiable instrument NI2025–14

made under the

Nature Conservation Act 2014, s 84 (Nominations—public consultation)

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1 Name of instrument

This instrument is the *Nature Conservation (Threatened Species Nominations) Public Consultation Notice 2025*.

2 Commencement

This instrument commences on the day after its notification day.

3 Nominations—threatened native species list

(1) The nomination for the Canberra Raspy Cricket (*Cooraboorama canberrae*) to the threatened native species list is at schedule 1.

(2) The nomination for the Perunga Grasshopper (*Perunga ochracea*) to the threatened native species list is at schedule 2.

(3) The nomination for the Cold Spiny Crayfish – Murunung Naruwi (*Euastacus crassus*) to the threatened native species list is at schedule 3.

4 Submissions

(1) Anyone may give a written submission about the nominations to the:

Scientific Committee
Environment, Planning and Sustainable Development Directorate
GPO Box 158, CANBERRA ACT 2601
Email: ScientificCommittee@act.gov.au

(2) Submissions may only be given during the public consultation period. The public consultation period begins on the day this notice is notified and ends on 26 February 2025.

Dr Linda Neaves
Chair, Scientific Committee
10 January 2025

Schedule 1 Canberra Raspy Cricket (*Cooraboorama canberrae*)

(see s 3 (1))

ACT Government
Environment, Planning and Sustainable Development

ACT Scientific Committee

Threatened Native Species Nomination

for amending the list of Threatened Native Species under Chapter 4 of the *Nature Conservation Act 2014*

The purpose of this form is to nominate a native species for assessment under the *Nature Conservation Act 2014* (ACT)(NC Act) by the ACT Scientific Committee (the Committee) for recommendation to the Minister for inclusion on the Threatened Native Species List or for reassessment for consideration for listing under another category of threat. The Criteria for listing Threatened Native Species in the ACT can be found at: http://www.legislation.act.gov.au/di/2016-254/default.asp.

Species information

Scientific name: ***Cooraboorama canberrae***
Common name(s): Canberra Raspy Cricket
Current listing category under the NC Act and EPBC Act: Not listed
Proposed nominated listing category under the NC Act and EPBC Act: Endangered

Canberra Raspy Cricket – Lawson, ACT © Copyright, Rob Speirs

Taxonomy

Conventionally accepted as: *Cooraboorama canberrae* Rentz, 1990 (Rentz and John 1990)

Family: *Gryllacrididae*

Description

Cooraboorama canberrae is a large, long legged, large headed, pale yellow-brown Raspy Cricket, in the family Gryllacrididae. Females are larger and more robust than males, measuring 28 - 52 mm, compared to 28 - 40 mm for males. In females, the ovipositor is long and straight, ranging in size from 12 - 38 mm and is shorter than the length of the body (Rentz and John 1990). The species possess small, vestigial wings and is flightless (Rentz and John 1990).

The species is the only described member of its genus, and can be distinguished from other gryllacridids by the combination of yellow-brown colouration and large black eyes; by the hind femur, which has 0-1 teeth near the apex and on the outer margin, and a single tooth near the apex of the inner margin, and by the abdominal stridulatory region, which is a patch, rather than a row of pegs as in other species (Rentz and John 1990).

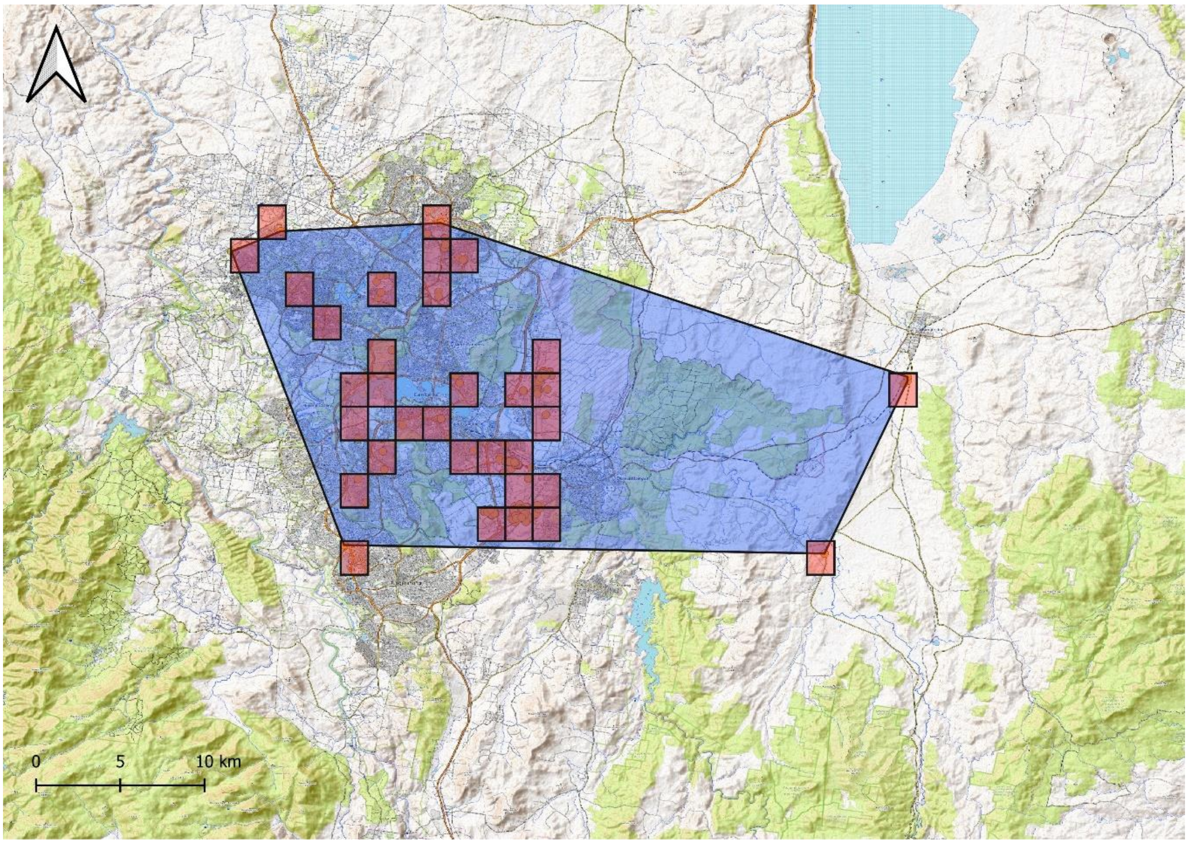
Distribution

The known range of *C. canberrae* is encapsulated within the area stretching from Gunghalin, ACT at the north extent, Turallo Nature Reserve, NSW in the east, the southern boundary marked by a line between Wongara, NSW and Wanniassa, ACT, and extending to just north of Holt, ACT to the west. All recent records are from areas of natural temperate grassland or native pasture, including some records from suburban gardens (Driscoll 1994), and all historical and recent records are from areas that are estimated to have been natural temperate grassland pre-European settlement (Reid et al. 2018).

In this assessment, 1,472 occurrence records were collated, spanning from 1936 to 2024. The majority of known occurrence points for the species were collected via surveys conducted for other species, particularly the Striped Legless Lizard (*Delma impar*) and the Grassland Earless Dragon (*Tympanocryptis lineata*). These surveys utilise artificial burrows for *T. lineata*, which are readily adopted by *C. canberrae*, and so whilst records from these surveys are secondary aims, they provide an effective survey technique for the cricket (Reid et al. 2018) and represent important medium-long term survey effort and monitoring of *C. canberrae*. The species has also been recorded using pitfall trapping in grassland surveys for *D. impar* (Rauhala et al. 1995). Surveys for *T. lineata* that extend further south and east of *C. canberrae*'s known range failed to record *C. canberrae,* indicating that the species does not occur in these areas and thus supporting a highly restricted range for the species (Reid et al. 2018). This fits with what is known for many other species of gryllacridid, which are habitat specialists, and have highly localised distributions (Rentz and John 1980).

Mapping of occurrence records for this species shows that most records do not occur on protected land (around 70%, or n = 1022). Additionally, it is likely that the species no longer occurs in many of the historic occurrence points, as they are now located within heavily developed areas. In addition, the conservation needs of this species may not be met by the conservation actions used for other taxa in protected areas (an example is the potential threat posed by mice to this species, which would require specific management in times of high mouse abundance). Therefore, the listing of this species will have additional conservation benefit to these areas, protecting a suite of invertebrates with similar traits and vulnerabilities, that would otherwise not be protected. This is especially important given the underrepresentation of invertebrate taxa listed as threatened under the NC Act and EPBC Act and their specific conservation requirements.

Taking into account all historic and present occurrence records for the species, the Extent of Occurrence (EOO) is 691.608 km^2 and the Area of Occupancy (AOO) is 132.00 km^2. These figures likely represent an overestimation of the species range given development of areas in which historic records occur. A relative paucity of species-specific surveys for *C. canberrae* means that under-sampling is a likelihood, however given the species is flightless (Rentz and John 1990) and likely a habitat specialist, it is considered that it is probably that the species is genuinely range restricted.



Distribution of Canberra Raspy Cricket: EOO=691km^2 and AOO=132km^2 (2x2km grid)

Cultural and community significance

There is no known cultural significance associated with this species.

The cultural, customary and spiritual significance of species and the ecological communities they form 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.

Relevant biology and ecology

Habitat

Species in the Gryllacrididae family, to which *C. canberrae* belongs, are found across Australia from tropical to temperate regions and occur in a range of habitat types, including wet tropical forests, grasslands, and arid inland (Rentz and John 1990; Hale and Rentz 2001). Despite these wide-ranging affinities at the family level, individual species typically are highly habitat specialist (Hale and Rentz 2001).

Cooraboorama canberrae is only known from natural temperate grassland or native pasture in the Canberra region and evidence suggests it is restricted to such (Rentz and John 1990; Hale and Rentz 2001; Reid et al. 2018). The species has been recorded as living in leaf litter and under bark associated with grasslands (Driscoll 1994). It has been found in suburban gardens, where it was collected in leaf litter (Driscoll 1994).

The species occupies burrows, which are dug into the ground. These are vertical burrows, circular in cross section vertical and usually with a lid, which is made of silk and clay. Burrows are around 12-20 cm in depth and 1.2-2 cm in diameter (Rowell 2009). Burrows are often found in loose groups and each burrow is surrounded by a patch of bare soil (Reid et al. 2018).

Feeding

Although species level data is anecdotal, evidence suggests that individuals in the species are opportunistically omnivorous, likely consuming other invertebrates, plant material, and grass seed heads (Bland and Rentz 1991; Hale and Rentz 2001; Reid et al. 2018).

Reproduction and life cycle

Adults of *C. canberrae* have been collected from December to March, with a nymph collected in May (Driscoll 1994).

Little is known of the reproductive ecology of *C. canberrae*, however, where reproduction has been observed in other species in the family, copulation occurs at night, takes place on plant material, twigs and leaves, and lasts for up to an hour (Hale and Rentz 2001). The only mating events observed for *C. canberrae* are discussed by Reid et al. (2018) and occurred at night, taking place on native grass tussocks. Many gryllacridid species appear to be facultatively parthenogenetic, with unmated females laying eggs that result in all female young (Rentz 1997), however it is not known whether this applies to *C. canberrae*. In the gryllacridids, mating typically occurs from autumn to summer (Morton and Rentz 1983; Hale and Rentz 2001).

Gryllacridid females typically lay eggs the in soft soil or sand (Hale and Rentz 2001) and given the relatively long length of the ovipositor in *C. canberrae,* it is likely the species does similar (Reid et al 2018). Records for gryllacridid species suggest egg clutches vary in size from around 20 eggs to around 80 (Hale 2000; Hale and Rentz 2001). Eggs typically hatch between late summer and early autumn and laboratory studies indicate hatching appears to be temperature and water dependent, with eggs needing heat and soaking with water to enable hatching (Hale 2000; Hale and Rentz 2001). These findings match those known for species in another Orthopteran family, the Tettigoniidae (Hartley 1990). Upon hatching records for various gryllacridid species indicate young instars moult frequently and juveniles overwinter, reaching maturity in summer, so that nymphs and adults are found in spring (Morton and Rentz 1983; Hale and Rentz 2001).

The lifespan of most Gryllacrididae species is not known, but for those that have been studied has been estimated to be around a year (Hale and Rentz 2001).

Movement

All gryllacridids are believed to be nocturnal (Hale and Rentz 2001). Whilst there is no direct data on the home range size of *C. canberrae*, this large insect is flightless and has low vagility and low dispersal abilities, so it is likely that its home range is restricted, which aligns with known occurrence points and with the published literature (for example Rentz and John 1990; Hale and Rentz 2001).

Ecological interactions

The Critically Endangered Canberra Earless Dragon (*Tympanocryptis lineata*) occupies burrows excavated by *C. canberrae* and by lycosid spiders (Doucette et al. 2023).

Population trend

Whilst data deficiencies prevent estimation of population size, museum collection records, targeted surveys and records from inter-taxon surveys, published literature, and reports indicate that the species was once relatively common in suitable habitat within its range, but that there has been a decline in population size with urbanisation and the species is now considered rare (Rentz and John 1990; Clarke and Spier-Ashcroft 2003; Rowell 2009, Mulvaney 2014; Reid et al. 2018).

Threats

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

Table1. Threats

Threat	Status [a]	Evidence
Habitat loss, disturbance and modifications impacts		
Historic habitat loss	• Timing: historical, current, and future • Confidence: observed and projected • Likelihood: almost certain • Consequence: major • Trend: static • Extent: across the entire range	Available evidence suggests *C. canberrae* was once relatively common in suitable habitat in the Canberra region, but following urban development the species is no longer commonly found, and intensive collecting by experts has failed to detect specimens outside of its known range (Rentz and John 1990; Clarke and Spier-Ashcroft 2003; Rowell 2009; Mulvaney 2014; Reid et al. 2018). Estimates suggest that 98.8% of natural temperate grassland has been lost in the ACT region due to extensive post-settlement clearance for agriculture and urban development (Threatened Species Scientific Committee 2016). Only 55 km^2 of habitat now remains within the species' EOO, occurring as small, fragmented patches, subject to impact from threatening processes (Reid et al. 2018). A combination of low vagility, restricted dispersal ability and high habitat specificity means it is unlikely that *C. canberrae* is able to disperse between remnant patches of habitat, impacting escape from threats, plus post-threat recolonisation, as well as gene flow and maintenance of genetic diversity. The impacts of historical clearance are thus likely to be multifaceted. Impacts are likely to have occurred via historic population decline as a direct result of habitat loss, in addition to ongoing and future impacts through reduced gene flow, isolation of subpopulations into small patches, increased vulnerability to disturbance and threats, such as prescribed fire, and stochastic extirpation events, and reduced ability to recolonise following disturbance.
Invasive animals: foxes, cats, house mice, rabbits, pigs	• Timing: historical, current, and future • Confidence: suspected • Likelihood: likely • Consequence: major • Trend: increasing • Extent: across the entire range	Foxes (*Vulpes vulpes*), cats (*Felis cattus)*, rabbits (*Oryctolagus cuniculus*), the house mouse (*Mus musculus*), and pigs (*Sus scrofa*) have been listed as major - severe threats in Natural Temperate Grasslands (Threatened Species Scientific Committee 2016). Whilst further research is needed on species specific impacts of feral animals on *C. canberrae*, evidence taken from broader studies provides strong evidence for direct threat to *C. canberrae.* The dominant predator in Natural Temperate Grasslands is the red fox (Threatened Species Scientific Committee 2016). Modelled density of foxes in Australia show that foxes occur at high density across the ACT, with greater than one fox per km^2 (Stobo-Wilson et al. 2022). Studies show that Orthoptera form a substantial component of a foxes' diet in Australia and globally (Green and Osborne 1981; Ricci et al. 1998; Molsher et al. 2000; Dell'Arte and Leonardi 2009; Davis et al. 2015), with epigaeic species (Koike et al. 2012), insects with large body sizes (Ricci et al. 1998; Tomita 2021) and from grasslands habitats (Koike et al. 2012) at elevated risk. Foxes occur at the urban interface, as well as in more intact

Threat	Status [a]	Evidence
		areas and when they occur around cities they show a preference for inhabiting reserves, parklands (Kobryn et al. 2023), which are likely important remnant habitats for *C. canberrae*, given the large area of habitat loss. Cats have also been shown to predate on Orthoptera, which was the most frequently recorded order of invertebrates in feral cat dietary samples (Woolley et al. 2021). Similarly for foxes, prey choice was impacted by body size, with large-bodied invertebrates being at most risk of predation (Medina et al. 2007). Cats are opportunistic predators and may take large numbers of individuals in one predation event (Woolley et al. 2021), for example a single cat stomach sample from South Australia was found to contain 400 grasshoppers (Woinarski et al. 2018) and another single cat stomach sample was found to contain 40 individuals of the wingless grasshopper *Phaulacridium vittatum* in Great Dog Island (Hayde 1992). The impact of cats on Orthoptera in Australia has been raised as a specific conservation concern (Woolley et al. 2021). The house mouse (*Mus musculus*) is listed in the Approved Conservation Advice for the Natural Temperate Grassland of the South Eastern Highlands (Threatened Species Scientific Committee 2016) as a prominent invasive species in Natural Temperate Grasslands. Studies from Australia and globally cite predation by mice as a key threat for insects and is responsible for the decline of species, particularly large-bodied invertebrates (Jones et al. 2003; St Clair 2011; Watts et al. 2022). Large-bodied, ground living Orthopterans are at particular risk (Bertoia et al. 2024). Rabbits cause impacts to natural temperate grasslands through grazing on native plant species, consuming plants and preventing plant regeneration (Threatened Species Scientific Committee 2016). Both of which are likely to have indirect impacts on *C. canberrae* through changes to habitat structure and vegetation complexity. In addition, digging by rabbits represents a major source of disturbance to grasslands, leading to a loss of vegetation cover, disturbance to soil properties, erosion of soil, and promoting sites for weed invasion (Threatened Species Scientific Committee 2016). For species that are closely tied to soil structure for burrowing, such as *C. canberrae*, this disturbance likely represents a substantial and major threat. In addition to this, by supporting populations of introduced cats and foxes, rabbits are likely to increase the predation load on *C. canberrae* by these species, especially at times when rabbits are more scarce. Predation by feral pigs and decline in habitat quality due to trampling and rooting are a known concern for litter dwelling, soil living and epigaeic invertebrates (e.g., Taylor et al. 2011; Parkes et al. 2015; Marshall et al. 2020, Wehr et al. 2020). Given the traits that *C. canberrae* holds, feral pigs have the potential to impact the species and in combination with other threats, cause a further decline of the species in its remnant habitat. The cumulative impact of non-native animals on C*. canberrae* is likely to be very high. In times when prey items, such as rabbits, or mice are in low

Threat	Status [a]	Evidence
		numbers, predation pressure on *C. canberrae* from foxes and cats is likely to increase, potentially resulting in catastrophic impacts on subpopulations. Conversely, mouse or rabbit plagues are also likely to result in increased habitat degradation and an increase of predation pressure from mice. When they occur, mouse plagues can extend over a large area (up to 1,500 km^2 (Brown et al. 2010)), and whilst they tend to be centred on grain growing cropping areas, the impact of plagues can affect neighbouring areas, such as Canberra's grasslands. It is recognised that many Orthopteran species are of conservation concern globally (Dirzo et al. 2014). The large-scale loss and fragmentation of this species habitat in combination with threats posed by invasive animals on such large-bodied, flightless, epigaeic, habitat specialist, and low dispersing species are considered to be having major impact. Whilst the direct impact of these species on *C. canberrae* has not been studied, information from closely related species indicate that it is plausible and likely that impact is high. Invasive animals are therefore considered to represent a likely and major threat.
Invasive plants causing habitat degradation	• Timing: historical, current, and future • Confidence: suspected • Likelihood: possible • Consequence: moderate • Trend: increasing • Extent: across the entire range	Occurrence records and ecological data taken from closely related taxa indicate that *C. canberrae* has high habitat specificity, with bare ground and open habitat with native grass tussocks being important for the species (Rentz and John 1990; Hale and Rentz 2001; Reid et al. 2018). Broad expected impacts of weeds on *C. canberrae* include changes to the structural complexity or species composition of the vegetation community as a result of invasion by weeds, is likely therefore expected to lead to the degradation of habitat for the species through alteration in the availability of bare ground, and changes to food plant availability. In addition to these impacts, ground matting weeds, such as the Weed of Environmental Significance Bridal Creeper *(Asparagus asparagoides)* are likely to present a specific threat to this species. Bridal Creeper forms a thick mat of underground tubers impeding the root growth and seedling establishment of other plants (DPI 2020). It is a documented threat to spiders that construct similar burrows as *C. canberrae* (Threatened Species Scientific Committee 2022) and is considered likely to be a key threat to the species.
Ongoing loss and modification of habitat	• Timing: current and future • Confidence: estimated • Likelihood: possible • Consequence: moderate • Trend: static • Extent: across the entire range	Processes that cause the loss or degradation of habitat for *C. canberrae* such as clearance, weed infestation, altered drainage patterns, changes to soil pH and nutrients and changes to trophic interactions (Reid et al. 2018), are a threat to *C. canberrae.* The threat of degradation is especially acute where grassland occurs near to urban areas. Natural Temperate Grassland of the South Eastern Highlands are listed under the NC Act and EPBC Act as Critically Endangered and thus have some protection from the threatening process listed above, although development in close proximity will likely have flow on effects.

Threat	Status [a]	Evidence
Inappropriate disturbance regimes		
Inappropriate grazing regime	• Timing: historical, current, future • Confidence: suspected • Likelihood: likely • Consequence: major • Trend: unknown • Extent: across the entire range	Grazing is a key driver of ecosystem change in temperate grasslands in Australia, influencing species composition and abundance and structural complexity of vegetation (Lunt 2005; Price 2019). Overgrazing effectively simplifies the ecosystem - removing leaf litter and organic detritus, reducing plant diversity and structural complexity, impacting the structure of microhabitats, aiding the spread of weeds, impacting soil, and affecting the microclimate by increasing temperature / reducing humidity through shade reduction (Duffey 1974; Dorrough et al. 2004; King and Hutchinson 2007; Reid and Hochuli 2007). Studies have shown invertebrate abundance to decrease with increasing stock levels (for example King and Hutchinson 1983). Orthopteran abundance was shown to decline as sheep stocking levels increased in grasslands in NSW (Hutchnson and King 1980). An absence of grazing can result in an accumulation of litter and organic material, reduced inter-tussock space, increased weeds, and loss of biodiversity (Reid et al. 2018). Moderate levels of grazing have been shown to have biodiversity gains, when compared to ungrazed land (for example Durrough et al. 2004; Howland et al. 2014). Additionally, it is suspected that loose soil or sand is important for *C. canberrae* for burrow construction, similar to other gryllacridids (Hale and Rentz 2001). Therefore, impaction of soil by overgrazing, especially by hard-hooved animals, could potentially impact burrow construction and detrimentally affect *C. canberrae*. Whilst there are data gaps on the precise habitat affinities of *C. canberrae*, it is expected that both overgrazing and an absence of grazing may be deleterious to the species.
Inappropriate fire regime	• Timing: historical, current, future • Confidence: suspected • Likelihood: likely • Consequence: major • Trend: unknown • Extent: across the entire range	Alterations to historical fire regimes, either from too frequent, or too severe fire, or conversely too infrequent fire, can cause changes to grassland diversity and functional composition (Lunt et al. 2012). There is little detail on pre-settlement fire regimes, but burning by Indigenous Peoples is likely to have played a role in shaping community dynamics of grasslands (Threatened Species Scientific Committee 2016). Too frequent, or too severe fire can simplify ecosystems - removing leaf litter and organic detritus, reducing plant diversity and structural complexity, causing loss of tussocks (Prober et al. 2007), and aiding the spread of fire responsive weeds. Too infrequent burning can result in an accumulation of litter and organic material, reduced inter-tussock space, increased weeds, and loss of biodiversity. It is probable that leaf litter and organic debris are important habitat attributes for *C. canberrae* (Driscoll 1994) and therefore from that perspective, it is likely that too frequent fire, or severe fire represents a key threatening process. Conversely, the species requirement for inter-tussock space indicates that too infrequent fire could also be a threat and

Threat	Status [a]	Evidence
		that some fire is beneficial for maintaining habitat structure, especially lower severity, patchy fire. More research is needed. The direct impacts of fire on *C. canberrae* can be inferred from the species traits and the microhabitat the species occupies. Given *C. canberrae* lives in burrows, it would likely receive some protection from lethal radiant heat, especially for lower severity wildfires or planned fire. However, as the species is flightless, individuals caught outside of the burrow during fire will likely have reduced ability to escape. This is particularly a risk with large-scale high severity fires, which are predicted to increase in frequency with climate change (Canadell et al. 2021; CSIRO 2024). Even with lower severity fires, such as planned burns, if fire were to be too frequent, it could cause a cumulative decline of subpopulations over time, which may threaten their persistence. Given the habitat specialism of *C. canberrae* and the sensitivity of the important habitat attributes to burning, it is considered likely that inappropriate fire regimes, especially from too frequent, widespread, or severe fires have the potential to degrade the habitat of *C. canberrae*, kill individuals, and are considered a major and likely threat.
Climate change		
	● Timing: current, future ● Confidence: projected ● Likelihood: likely ● Consequence: major ● Trend: increasing ● Extent: across the entire range	Models predict that with climate change we will see larger and more individual rainfall events, with longer dry spells between them. For the region in which *C. canberrae* is found CSIRO modelling predicts with 1) *very high confidence* that average temperatures will increase, and that there will be more hot days, and 2) with *high confidence* that there will be fewer frosts, increased intensity of extreme rainfall events, and a harsher fire-weather climate, and 3) with *medium confidence* that the average winter rainfall will decrease (CSIRO 2024). Such conditions will likely favour establishment of woody vegetation or previously grassland areas (Hughes 2003). It is also likely that we will see increased fire frequency and severity (Canadell et al. 2021). Drought will likely become more common, impacting grassland biodiversity, increasing weed presence (Manea et al. 2016), and changing resource availability. The impacts of this could degrade the habitat important for *C. canberrae.* In addition, it is inferred that hatching of eggs is temperature and water dependent, requiring soaking and warm weather (Hale 2000; Hale and Rentz 2001). Therefore, in addition to impacting habitat quality, there is also the potential for direct impacts on *C. canberrae's* reproduction. When in combination with other threats acting on the grasslands and biota, climate change has the potential to be a major and likely threat to *C. canberrae*.

[a]Timing – identifies the temporal nature of the threat
Confidence – identifies the nature of the evidence about the impact of the threat on the species
Likelihood – identifies the likelihood of the threat impacting on the whole population or extent of the species
Consequence – identifies the severity of the threat
Trend – identifies the extent to which it will continue to operate on the species

Extent – identifies its spatial context in terms of the range of the species

Categories for likelihood are defined as follows:

Almost certain – expected to occur every year

Likely – expected to occur at least once every five years

Possible – might occur at some time

Unlikely – known to have occurred only a few times

Unknown – currently unknown how often the threat will occur

Categories for consequences are defined as follows:

Not significant – no long-term effect on individuals or populations

Minor – individuals are adversely affected but no effect at population level

Moderate – population recovery stable or declining

Major – population decline is ongoing

Catastrophic – population trajectory close to extinction

Each threat has been described in Table 1 in terms of the extent that it is operating on the species. The risk matrix (Table 2) provides a visual depiction of the level of risk being imposed by a threat and supports the prioritisation of subsequent management and conservation actions. In preparing a risk matrix, several factors have been taken into consideration, they are: the life stage they affect; the duration of the impact; the spatial extent, and the efficacy of current management regimes, assuming that management will continue to be applied appropriately. The risk matrix and ranking of threats has been developed using available literature.

Table 2. Risk Matrix

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain				Historic habitat loss	
Likely				Climate change Inappropriate grazing regime Inappropriate fire regime Invasive animals	
Possible			Invasive plants Ongoing loss and modification of habitat		
Unlikely					
Unknown					

Risk Matrix legend/Risk rating:

Low Risk	Moderate Risk	High Risk	Very High Risk

Conservation and recovery actions

Primary conservation objective

The primary conservation objective is the ongoing protection of *C. canberrae*, to allow the long-term persistence of viable subpopulations. At the end of ten years, habitat for *C. canberrae* will be better protected and its habitat affinities better understood. The species will be included by name in relevant management plans, which will enable decision-makers to prevent further threats. Decision-makers will also better understand the likelihood of threats and be able to triage responses following threat events accordingly.

This objective is supported by the following sub-objectives:

- Better understand the habitat requirements of the species, including associations lower than community level, and temperature and moisture requirements
- Subsequently undertake species distribution modelling to identify all possible areas of habitat for the species
- Ensure that all relevant management plans and strategies account for the requirements of the species and include the species by name.

Conservation and management priorities

Habitat loss, disturbance and modifications impacts

- Long term conservation and protection of all remaining remnants of natural temperate grassland is a priority for this species. For those areas not protected in a reserve system, liaison with land holders is important to encourage conservation management. Whilst the prime habitat for the species is natural temperate grassland, it also occurs in native pasture, and protection should be extended to this habitat. This is especially important for areas of native pasture that connect fragmented patches of natural temperate grassland, or that are adjacent to it.
- Restoration to increase the size of remnant patches of habitat, to improve connectivity between patches, and to control threats within the habitat (ie weed removal) will provide some protection of habitat, increase resilience to threats, such as climate change, and provide protection for *C. canberrae.*

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

- A range of feral animals are known to occur in habitat for *C. canberrae* and represents a key threat to the species, through direct predation and reduction of habitat quality. We therefore recommend control of feral animals in areas of suitable habitat, particularly foxes, cats, house mice, feral pigs, and rabbits.
- Grazing by non-native herbivores and impaction of soil are likely to represent a threat to *C. canberrae*. However, management of grass biomass and structure to maintain an open habitat structure, with bare ground is also likely to be important for the species. Further research is needed on the optimal management regime, however, managed lower-level grazing by domestic species might have some benefits by maintaining an open, patchy, mosaic structure, however the trade off with soil impaction from hard hooves needs research. Pending further research we recommend following the conservation management actions for protecting and conserving natural temperate grasslands as outlined in *Approved Conservation Advice (including listing advice) for Natural Temperate Grassland of the South Eastern Highlands* (Threatened Species Scientific Committee 2016) and the *ACT native grassland conservation strategy and action plans* (ACT Government 2017).

Fire impacts

- The direct impact of inappropriate fire regimes on *C. canberrae* are not well understood, however too frequent or too infrequent fires are likely to affect habitat quality for the species via a number of mechanisms (see Table 1). Given the habitat specialism of *C. canberrae* and the sensitivity of the important habitat attributes to burning, it is considered likely that inappropriate fire regimes, especially from too frequent, widespread, or severe fires have the potential to degrade the habitat of *C. canberrae* and cause mortality.
- Pending research to better elucidate the impact of fire and the optimal fire regime for this species, we recommend that any prescribed fires are patchy and low severity, to minimise exposure of individuals to lethal radiant heat, and to maintain sufficient unburnt habitat.
- Information on the species and its vulnerabilities should be disseminated to fire managers, so that it may be incorporated into fire management planning and implementation.

Disease impacts

- NA

Impacts of domestic species impacts

- Overgrazing by domestic animals is likely to impact *C. canberrae*, through simplification and degradation of its habitat. However, management of grass biomass and structure to maintain an open habitat structure, with bare ground is likely to be important for the species. Further research is needed on the optimal management regime, however, grazing by native herbivores may be beneficial for maintaining an open, patchy, mosaic structure.

Climate change and severe weather impacts

- Droughts – ensure that habitat is maintained where possible and supported against the impacts of drought.
- Temperature extremes – ensure that fire management and other land management actions retain sufficient cover for insulation.
- Climate change and severe weather-unspecified – ensure land managers are aware of the species' occurrence and provide protection measures against key and potential threats.

Ex situ recovery actions

- Ex situ recovery actions are not recommended until there is more information about the genetics of the species. It is likely the species has limited dispersal ability and restricted gene flow between subpopulations and therefore a better understanding of the species' population genetics should be acquired to conserve genetic integrity and diversity of subpopulations.

Stakeholder engagement/community engagement

- Prepare a management strategy with input from local experts. These should include Traditional Custodians, local land managers, local landholders, and existing specialist researchers.
- Engage and involve Traditional Custodians in conservation actions, including the implementation of Indigenous fire management and other survey, monitoring and management actions.
- Ensure information on *C. canberrae* and its habitat is shared between local land managers, conservation decision makers, and stakeholders. New population data and research should be available to all

stakeholders to continue to implement best-practice land management that minimises the impacts of potential threats on the species.

- Where research identifies potential habitat for the species in areas that are privately-owned, liaise with landholders to provide information on the species and its habitat requirements, and encourage reporting of any sightings.

Survey and monitoring priorities

- Surveys are required to better elucidate the distribution of the species, especially within the Extent of Occurrence, in order to determine presence or absence of the species within areas of potential habitat.
- To inform knowledge on the ecology of the species in relation to its conservation, surveys should also be conducted to determine the microhabitat affinities of the species, and increase knowledge of the factors that are important for determining the distribution of the species within a site.

Information and research priorities

- Specific research is needed on the impacts of management regimes (primarily grazing and burning) on *C. canberrae* in order to determine the optimal management regime for the species.
- Knowledge gaps mean that most information on threats to this species is derived from inferences drawn from related species. As such, there is a limited understanding of the requirements of the species for persistence, the key threats to the species, or how best to manage them. Priority for research should thus be to gain a better understanding of the ecology and habitat affinities of *C. canberrae.* Particular focus should be paid on gaining a better understanding of 1) how threats, such as foxes, weeds, drought, habitat simplification etc may impact the species, 2) how reliant the species is on specific habitat and microhabitats, to better inform the likely impact of threatening process and prioritise actions.

Links to relevant implementation documents

Approved Conservation Advice (including listing advice) for the Natural Temperate Grassland of the South Eastern Highlands (EC 152) (environment.gov.au)

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Attachment A: Listing Eligibility for *Cooraboorama canberrae*

Assessment of eligibility for listing against the criteria

This assessment uses the criteria set out in the Nature Conservation (Threatened Native Species Eligibility) Criteria 2016. The thresholds used correspond with those in the IUCN Red List criteria. 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	Information on population numbers are not known for this species
Trend	Unknown			
Generation time (years)	14.25 months	11.5 months	17 months	Reid et al. 2018 estimated the generation length of the species to be between 11.5 months and 17 months, using information taken from known related taxa and occurrence data on when life stages have been collected. In this assessment we take the mean value of this range.
Extent of occurrence	691.608 km^2	671.947 km^2	691.608 km^2	The EOO used for this species was calculated using all available occurrence data, historical and recent. Some of these historic points have since been developed. However, under-sampling and a lack of targeted surveys across potentially suitable habitat may underestimate EOO, therefore, following Reid et al. 2018, we are using this figure in this assessment. The lower limit reflects the EOO with all occurrences pre 2000 removed.
Trend	stable			Although threats are impacting the quality of remaining habitat, it is not expected the EOO will decrease.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Area of Occupancy	132.00 km^2	116 km^2	132.00 km^2	A Geocat assessment using all occurrences yielded a value of 132 km^2. The minimum value is the AOO where occurrences pre 2000 have been removed.
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			Further surveys are needed for this species to better determine the trend in AOO. However, museum records, plus published papers and reports indicate a likely historic decline in AOO. The trend into the future is not well known.
Number of subpopulations	8	5	18	Given the high levels of habitat fragmentation and a likely low dispersal ability, the number of subpopulations in the relatively small area is likely high. The estimate used is based upon occurrence across the species EOO and assuming that gene flow may occur in geographically close subpopulations, even over cleared, or developed terrain. The upper estimate is assuming that no dispersal over such barriers could occur and the lower value that dispersal is occurring more broadly.
Trend	Declining			Given the fragmented landscape, the low dispersal ability of the species, the number of threats and the close proximity to urban areas, it is likely that the number of subpopulations will decline.
Basis of assessment of subpopulation number	The estimate is based on examination of known occurrences, mapping, plus inferences that due to the species traits dispersal may occur over short geographic distances, even if habitat is missing between these occurrences, but not over larger distances.			

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
No. locations	3	1	5	An estimate of three locations was used in this assessment, with the subpopulations at the urban interface being counted as one location and the western subpopulations in NSW counting as an extra two. The minimum value was estimated with the whole range as one location, reflecting the likelihood a mouse plague could impact all sites. See below for justification.
Basis of assessment of location number	Although a number of threats are likely impacting *C. canberrae*, the combined impact of predation and habitat degradation by non-native animals is considered to be amongst the most serious of threats. Red foxes, feral cats, European rabbits, feral pigs and house mice are all widespread in the species's range and all present plausible threats to the species, with studies from Australia and globally showing large-bodied and flightless Orthoptera likely being at particular risk. Foxes occur at a density of greater than one fox per km^2 in the broad region that *C. canberrae* occurs in, with cats occurring at around half this density (Stobo-Wilson et al. 2022). Pressure from these threats are likely to be temporal in nature to some extent. Att times when prey items, such as rabbits, or mice are in low numbers, predation pressure on *C. canberrae* from foxes and cats is likely to increase and could result in serious impacts on subpopulations. Conversely, mouse or rabbit plagues are also likely to result in increased habitat degradation and an increase in predation pressure from mice. When they occur, mouse plagues can extend over a large area (up to 1,500 km^2 (Brown et al. 2010)), and whilst they tend to be focussed on grain growing cropping areas, the impact of plagues can affect neighbouring areas, such as Canberra's grasslands. Foxes and feral cats occur in the urban interface, with studies showing that in urban areas, foxes show a preference for occupying nearby reserves and parks (Kobryn et al. 2023). The distribution of *C. canberrae* ranges from heavily urbanised areas to natural temperate grasslands. The pressure from non-native animals is likely to vary between these areas, according to different mechanisms controlling population sizes, plagues, and preferential habitat usage of non-native species. Taking this into account, along with the species low mobility and habitat specialism, we estimate the number of locations to be three, with the urbanised regions reflecting a single location and the western extent for the species representing the remaining two locations.			
Trend	Stable			
Fragmentation	The subpopulations of the species are likely to be isolated as a result of the combined effects of low dispersal ability, habitat specialism, and loss and degradation of much of the species' historic habitat. However, there is no current evidence that it is severely fragmented.			
Fluctuations	There is no evidence for fluctuations.			

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, inferred 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 assessment outcome

Not eligible

Criterion 1 evidence

Insufficient data for listing under this criterion. The species' generation length is estimated at 14.25 months, which means that a value of 10 years is used for estimates of reduction in numbers. Most of the estimated decline of this species was likely to have occurred through historic vegetation clearance and there is insufficient evidence to indicate a 30% or greater reduction in the last 10 years. Given Temperate Natural Grasslands, and Native Grassland are protected under federal and state legislation, there is insufficient evidence to expect that a decline of 30% or more should occur in the next 100 years.

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 assessment outcome

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

Criterion 2 evidence

The EOO for this species is 691.608 km^2 and the AOO is 132 km^2. The species occurs in isolated subpopulations, and many of the sites in which it occurs are at the urban interface, with two geographically more remote western sites in NSW. Ongoing and potentially increasing threats from predation and habitat degradation by non-native animals give three locations, based on a combination of geographic proximity and closeness to urbanisation.

It is estimated that around 90% of this species habitat has been lost through clearance and development. There is an inferred and projected ongoing decline in area, extent and / or quality of habitat due to ongoing and pervasive impacts of historic land clearance, causing fragmentation of subpopulations and loss of habitat. The impact of other threats, acting synergistically with fragmentation and habitat loss, are further driving decline and impeding recovery. Such threats include climate change, land degradation from inappropriate grazing and fire regimes, and ongoing degradation of habitat by key non-native animals, which are recorded as widespread through the region and are listed as severe or major threats to temperate natural grasslands. In addition, there is an inferred and projected ongoing decline in the number of mature individuals as a result of predation from feral cats, foxes, house mice and pigs.

There is no evidence for extreme fluctuations.

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 generations (whichever is longer)**	**Substantial rate** **10% in 10 years or 3 generations (whichever is longer)**
C2. An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions:			
(a) (i) Number of mature individuals in each subpopulation	**≤ 50**	**≤ 250**	**≤ 1,000**
(a) (ii) % of mature individuals in one subpopulation =	**90 – 100%**	**95 – 100%**	**100%**
(b) Extreme fluctuations in the number of mature individuals			

Criterion 3 assessment outcome

Ineligible

Criterion 3 evidence

Insufficient data 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 assessment outcome

Not Eligible

Criterion 4 evidence

Insufficient data 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 assessment outcome

Not eligible

Criterion 5 evidence

Insufficient data for listing under this criterion

Short summary of criteria under which the species is eligible for listing

Cooraboorama canberrae (Canberra Raspy Cricket) is proposed to be listed to the Endangered category of the threatened species list under the *Nature Conservation Act 2014* (ACT).

- Criterion 1: Insufficient data
- Criterion 2: B1ab(iii, v)+B2ab(iii, v): Endangered
- Criterion 3: Insufficient data
- Criterion 4: Insufficient data
- Criterion 5: Insufficient data

The main factors that make the species proposed for listing in the Endangered category are:

- *Cooraboorama canberrae* is known from only three locations, with an EOO of 691.608 km^2 and an AOO of 132 km^2.
- Most of the species' habitat was cleared following colonisation and what remains is highly fragmented and close to urban areas.
- Substantial threats from non-native animals, including foxes, feral cats, house mice, rabbits and pigs are likely to cause ongoing decline in habitat quality and number of mature individuals through predation and degradation of habitat.
- A number of threats are acting on the species, which when combined with the interacting effects of fragmentation mean it is at ongoing risk of decline.

Adequacy of survey

The species' distribution is known from 1,472 occurrence records, which are from a range of sources, including citizen science records from NatureMapr, surveys for other taxa, direct surveys for the species, and opportunistic samples. The species is large and easy to identify, therefore there is high confidence that these represent accurate records of the species.

The occurrence records, plus evidence from the published literature and reports provide support that the species genuinely has a highly restricted distribution and is a habitat specialist.

As with most species, there is potential that additional targeted surveys will reveal a greater range for the species, however, the species EOO is well within the 5,000 km^2 bound for listing as Endangered at 691.618 km^2, and given the small amount of habitat left for the species post-clearance, there is high confidence that additional records will not increase the species' EOO above this value. Similarly, for the AOO of 132 km^2 which is well within the upper bound for Endangered of 500 km^2.

Whilst further surveys are needed to confirm details on the species' microhabitat affinities and to better determine the species' occurrences within suitable habitat in the EOO, we deem there is sufficient scientific data to support assessment of the species.

Additional Comments/Information

Schedule 2 Perunga Grasshopper (*Perunga ochracea*)

(see s 3 (2))

ACT Government
Environment, Planning and Sustainable Development

ACT Scientific Committee

Threatened Native Species Nomination

for amending the list of Threatened Native Species under Chapter 4 of the *Nature Conservation Act 2014*

The purpose of this form is to nominate a native species for assessment under the *Nature Conservation Act 2014* (ACT)(NC Act) by the ACT Scientific Committee (the Committee) for recommendation to the Minister for inclusion on the Threatened Native Species List or for reassessment for consideration for listing under another category of threat. The Criteria for listing Threatened Native Species in the ACT can be found at: http://www.legislation.act.gov.au/di/2016-254/default.asp.

Species information

Scientific name: *Perunga ochracea*

Common name(s): Perunga Grasshopper

Current listing category under the:

NC Act: Vulnerable

EPBC Act: Not listed

Proposed nominated listing category under the NC Act and EPBC Act: Endangered

Reason for transfer

If the nomination is to transfer a species between categories in the threatened species list, please tick the relevant box(es) below:

☐ Genuine change of status
☐ New knowledge
☐ Taxonomic change
    ☐ Newly described
    ☐ ‘split’
    ☐ ‘lumped’
    ☐ No longer valid
☐ Mistake
☒ Other: Reassessment of a legacy species against new criteria under the CAM.

With regard to the listing criteria, how have circumstances changed since the species was listed that now makes it eligible for listing in another category:

The Common Assessment Method MOU was agreed in 2015 and the criteria for listing changed in 2016 to align with the international criteria of the IUCN.

The Perunga Grasshopper was listed in the ACT as a Vulnerable species on 30 May 1997 in accordance with section 21 of the *Nature Conservation Act 1980*. At that time, the Flora and Fauna Committee assessed that this species met the criteria for listing as Vulnerable due to a serious decline in distribution and being seriously fragmented across a small range.

Most of the species’ habitat was cleared following colonisation and what little remains is highly fragmented and close to urban areas. Several threats continue to act on the species’ habitat, which when combined with the interacting effects of fragmentation result in a likelihood of ongoing risk of decline.

Perunga Grasshopper – Strathnairn, ACT (Photo – Steve Borkowskis)

Taxonomy

Conventionally accepted as: *Perunga ochracea* Sjöstedt, 1921 (Sjöstedt 1921)

Family: *Acrididae*

Description

Perunga ochracea, or the Perunga grasshopper, in the family Acrididae, subfamily Catantopinae, subtribe Apotropina (Rentz 1996), is the only described species in its genus. The only other known member of the genus is an undescribed species from South Australia (ACT Government 2017a). Members of the subtribe Apotropina can be distinguished from other subtribes of Catantopinae by the stout femur of the hind leg, by the presence of an auditory tymapnum on the anterior abdomen under the wings, and a forked stricture (furcula) on the abdomen of males (Rentz 1996).

Perunga ochracea is flightless grasshopper, with both males and females having small wings, which are shorter than the length of the pronotum. Females are around 30 mm long, with males around 15 mm. The species can be distinguished by a combination of 1) a wrinkled and caudally extended pronotum, and 2) the presence of a pale cross on the upper side of the thorax and a pale dorsal streak extending from the pronotum to the tip of the abdomen. The dorsal colour of the species can vary seasonally and annually, from tan to grey-brown to dull or bright green, with a tendency towards greener colour in wet years and grey-brown in dry years (ACT Government 1999a); ventrally, the body is yellow and the tarsi are blue.

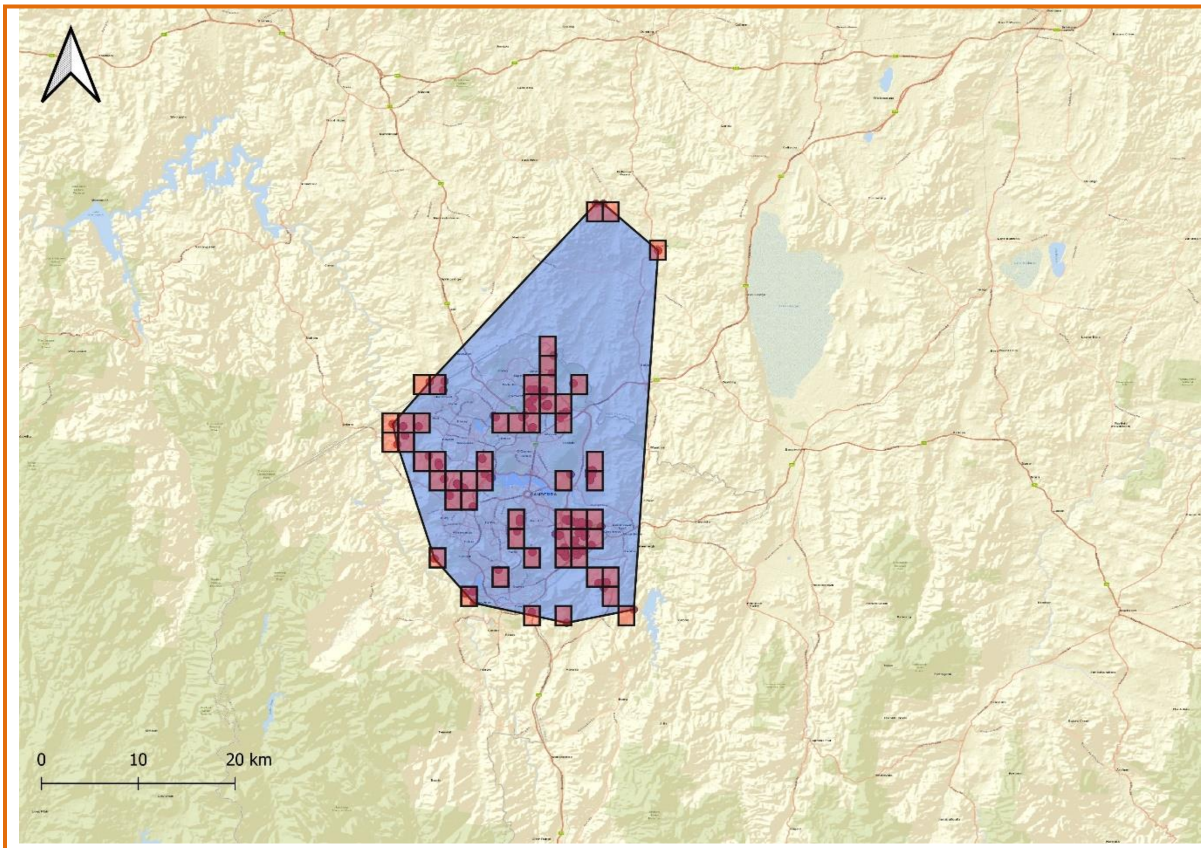
Distribution

The distribution of *Perunga ochracea* is restricted to the Southern Tablelands and South-Western Slopes of NSW and the ACT, and is predominantly known from native dominated grasslands (Farrow 2012; ACT Government 2017). The northerly extent of the species' known range is at Gang Gang, Yass River, and a nearby record from Gundaroo, NSW marks the most easterly occurrence. The southernmost record is from near Googong, NSW; with Strathnairn, in the Belconnen District, ACT marking the westerly extent. Within this range, the species occurs in protected areas, including Budjan Galindji Grasslands Nature Reserve, Callum Brae Nature Reserve, Crace Grasslands, Ginninderry Conservation Corridor, Gungaderra Grasslands Nature Reserve, Jerrabomberra West Grasslands Nature Reserve, Mount Mugga Mugga Nature Reserve, Mulanggari Grasslands Nature Reserve, Red Hill Nature Reserve, Tuggeranong Hill Nature Reserve (ACT Government 2021; Conservator of Flora and Fauna 2024).

Over 90% of Natural Temperate Grassland in Australia has been lost since colonisation (Threatened Species Scientific Committee 2016), and what exists is now highly fragmented. It is estimated that only around 5% (1,000 ha) of the original area of Natural Temperate Grassland still exists in a moderate to good condition in the ACT (ACT Government 1997, 2017b) and only 3-4% of the original area of Yellow Box, Red Gum Grassy Woodland community still exists in a relatively natural state (ACT Government 1999b). *Perunga ochracea* records are mostly from larger areas of remnant habitat (ACT Government 2017a), and it is likely that the Area of Occupancy of the species within its Extent of Occurrence is low. A number of historical collections sites for the species in the ACT and NSW have since been developed (ACT Government 2017).

The species' cryptic coloration, frequent concealment in vegetation, and rarity means that it is difficult to detect in surveys, and longer term, targeted surveys are required to better understand its distribution. For this assessment, 302 records were available, running from 1999 to 2023. Most of these records were incidental, or collected as a by-product of surveys for other fauna, however citizen science records through Canberra Nature Map (Canberra Nature Map 2024) have provided new sightings and confirmed its range in a number of locations.

Records for the species occur in protected areas and reserves managed for conservation (around 80% of records), as well as in areas that are not protected. Given the overlap of protected areas, there is protection for most of the species range, however the conservation needs of this species may not be met by the conservation actions used for other taxa in these areas (an example is the potential threat posed by mice to this species, which would require specific management in times of high mouse abundance). Therefore, the listing of this species will have additional conservation benefit to these areas, protecting a suite of invertebrates with similar traits and vulnerabilities, that would otherwise not be protected. This is especially important given the underrepresentation of invertebrate taxa listed as threatened under the NC Act and the EPBC Act and their specific conservation requirements.



Distribution of Perunga Grasshopper: EOO=987km² and AOO=216km² (2x2km grid)

Cultural and community significance

There is no known cultural significance associated with this species.

The cultural, customary and spiritual significance of species and the ecological communities they form 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.

Relevant biology and ecology

Habitat

The majority of records for *Perunga ochracea* are from Natural Temperate Grasslands, dominated by Speargrasses (*Austrostipa* spp.), Wallaby Grasses (*Rytidosperma* spp.), and Kangaroo Grass (*Themeda triandra*) (ACT Government 2017a), and other native grasslands. It has also been collected from open woodland with a grassy understorey, including the nationally and federally listed Endangered Yellow Box - Red Gum Grassy Woodland community.

Records and observations indicate that tussocks are important for the species for shelter. Individuals have been recorded jumping into the nearest tussock when disturbed and when the species is found in heavily grazed habitats, with a low density of tussocks, the species is often recorded close to or on tussocks (ACT Government 2017a).

The majority of *P. ochracea* records are from open habitats, with inter-tussock space (Farrow 2012) and it is suspected that dense conditions would be less favourable to the species, as is the case for other grasshopper species (Farrow 2012; Kearney et al. 2021). Inter-tussock spaces likely facilitate the establishment of a greater number of food-plant forb species (ACT Government 2017a), and provide bare ground next to tussocks to lay eggs and to be used as basking grounds, which are important for many grasshopper species (Kemp et al. 1990; Knapp et al. 2023). Experimental trials indicated that the population density of *P. ochracea* can respond positively to experimental treatments of grassland which created an increase in bare ground, a decrease in litter, and higher native forb cover (Rowell 2016; ACT Government 2017a). Whilst such information indicates the species may have a preference for open habitat, due to the difficulties in detecting the species in denser habitat, further surveys are needed to determine the species' occurrence in denser vegetation (Farrow 2012).

Ecological interactions

The parasitic mite *Charletonia feideri* (Acarina, Erythraeidae) is known to parasitise *P. achracea*. The levels of parasitisation or how the parasite might impact *P. ochracea* are not known, however mites of the family Erythraeidae, including *Chareltonia,* have been recorded as 'natural enemies' of agricultural pests (Muñoz-Cárdenas et al. 2015), so there may be some detrimental impact on *P. ochracea*.

Feeding

Whilst the diet of *P. ochracea* is little known and more research is needed, evidence indicates that the species consumes forbs (ACT Government 1999). A previous study indicated that there may be some affinity to plants in the genus *Chrysocephalum*, particularly Common Everlasting Daisy (*Chrysocephalum apiculatum*) (Retz 1996), however there is no direct evidence of the species consuming this species (ACT Government 2017a) and further research is needed to determine feeding preferences for the species.

Reproduction and life cycle

Relatively little is known about the reproduction and life cycle of *P. ochracea* and more research is needed. The species overwinters as nymphs, adults are present from autumn through to early summer, and the species life cycle is a year (Rentz 1996, ACT Government 2017a, collection records).

Movement

Whilst the species is flightless, it is a powerful jumper, able to traverse a distance of around a metre, or more (ACT Government 2017a).

Population trend

Dedicated surveys for this species have failed to find it occurring in large numbers, suggesting it is rare where it occurs (ACT Government 2017a). There have been no studies on the population size of this species, but it is inferred that population numbers have declined due to substantial historic habitat loss, plus the interacting impacts of other threats (ACT Government 2017a).

Threats

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

Table1. Threats

Threat	Status [a]	Evidence
Habitat loss, disturbance and modifications impacts		
Historic habitat loss	• Timing: historical, current, and future • Confidence: observed and projected • Likelihood: almost certain • Consequence: major • Trend: static • Extent: across the entire range	This is an actual threat. Estimates suggest that over 90% of natural temperate grassland has been lost in Australia due to extensive post-settlement clearance for agriculture and urban development (Threatened Species Scientific Committee 2016). Remaining habitat is in small patches and highly fragmented. It is estimated that only around 5% (1,000 Ha) of the original area of Natural Temperate Grassland still exists in a moderate to good condition in the ACT (ACT Government 1997, 2017b), and only 3-4% of the original area of Yellow Box, Red Gum Grassy Woodland community still exists in a relatively natural state (ACT Government 1999b). This extensive fragmentation has likely increased the vulnerability of remnants to continuing degradation due to a number of threatening processes, including inappropriate fire and grazing regimes, weeds, disturbance by humans, development, and climate change induced severe weather events, such as prolonged drought. A combination of low vagility, restricted dispersal ability, and habitat specificity means it is likely that *P. ochracea* has a limited ability to disperse through cleared ground, or move between highly fragmented remnant patches of habitat. The impacts of historical clearance are thus likely to be multi-faceted, having caused historic population decline through direct habitat loss, as well as ongoing and future impacts through reduced gene flow, isolation of subpopulations into small patches, increased vulnerability to stochastic extirpation events, and reduced ability to recolonise following disturbance (Reed 2004).
Invasive animals: foxes, cats, house mice, rabbits, pigs	Timing: historical, current, and future Confidence: suspected Likelihood: likely	Foxes (*Vulpes vulpes*), cats (*Felis cattus)*, rabbits (*Oryctolagus cuniculus*), the house mouse (*Mus musculus*), and pigs (*Sus scrofa*) have been listed as major - severe threats in Natural Temperate Grasslands (Threatened Species Scientific Committee 2016). Whilst further research is needed on species specific impacts of feral animals on *P. ochracea*, evidence taken from broader studies provides strong evidence for direct threat. The dominant predator in Natural Temperate Grasslands is the red fox (Threatened Species Scientific Committee 2016). Modelled density of foxes in Australia show that foxes occur at high density across the ACT, with greater than one fox per km^2 (Stobo-Wilson et al. 2022). Studies show that Orthoptera form a

	Consequence: major Trend: increasing Extent: across the entire range	substantial component of a foxes' diet in Australia and globally (Green and Osborne 1981; Ricci et al. 1998; Molsher et al 2000; Dell'Arte and Leonardi 2009; Davis et al. 2015), with epigaeic species (Koike et al. 2012), insects with larger body sizes (Ricci et al. 1998, Tomita 2021) and from grasslands habitats (Koike et al. 2012) at elevated risk. Foxes occur at the urban interface, as well as in more intact areas and when they occur around cities they show a preference for inhabiting reserves, parklands (Kobryn et al. 2023), which are likely important habitats for *P. ochracea.* A study in NSW showed that foxes have a mean home range of 13.5 km^2 (Meek and Saunders 2000), which given a population density of more than one fox per km^2, the predation pressure on the range of *P. ochracea's* is likely high. Cats have also been shown to predate on Orthoptera, which was the most frequently recorded order of invertebrates in feral cat dietary samples (Woolley et al. 2021). Similarly for foxes, prey choice was impacted by body size, with large bodied invertebrates being at most risk of predation (Medina et al. 2007). Cats are opportunistic predators and may take large numbers of individuals in one predation event (Woolley et al. 2021), for example a single cat stomach sample from South Australia was found to contain 400 grasshoppers (Woinarski et al. 2018) and another single cat stomach sample was found to contain 40 individuals of the wingless grasshopper *Phaulacridium vittatum* in Great Dog Island (Hayde 1992). *Phaulacridium vittatum* belongs to the same family as *P. ochracea*, is of similar size and they are both flightless, and it can be inferred that *P. ochracea* would be prey to feral cats. The impact of cats on Orthoptera in Australia has been raised as a specific conservation concern (Woolley et al. 2021). The house mouse (*Mus musculus*) is listed in the Approved Conservation Advice for the Natural Temperate Grassland of the South Eastern Highlands (Threatened Species Scientific Committee 2016) as a prominent invasive species in Natural Temperate Grasslands. Studies from Australia and globally cite predation by mice as a key threat for insects and is responsible for the decline of species, particularly large-bodied invertebrates (Jones et al. 2003; St Clair 2011; Watts et al. 2022). Large-bodied, ground living Orthopterans are at particular risk (Bertoia et al. 2024). Rabbits cause impacts to natural temperate grasslands through grazing on native plant species, consuming plants and preventing plant regeneration (Threatened Species Scientific Committee 2016). Both of which are likely to have indirect impacts on *P. ochracea* through changes to habitat structure and vegetation

Threat	Status [a]	Evidence
		complexity and reduction in tussocks. In addition, digging by rabbits represents a major source of disturbance to grasslands, leading to a loss of vegetation cover, disturbance to soil properties, erosion of soil, and promoting sites for weed invasion (Threatened Species Scientific Committee 2016). By supporting populations of introduced cats and foxes, rabbits are likely to increase the predation load on *P. ochracea* by these species, especially at times when rabbits are more scarce. Predation by feral pigs and decline in habitat quality due to trampling and rooting are a known concern for epigaeic invertebrates (for example Marshall et al. 2020; Wehr et al. 2020). Given the traits that *P. ochracea* holds, feral pigs have the potential to impact the species and in combination with other threats, cause a further decline of the species in its remnant habitat. The cumulative impact of non-native animals on *P. ochracea* is likely to be very high. In times when prey items, such as rabbits, or mice are in low numbers, predation pressure on *P. ochracea* from foxes and cats is likely to increase, potentially resulting in catastrophic impacts on subpopulations. Conversely, mouse or rabbit plagues are also likely to result in increased habitat degradation and an increase of predation pressure from mice. When they occur, mouse plagues can extend over a large area (up to 1,500 km^2 (Brown et al. 2010)), and whilst they tend to be focussed on grain growing cropping areas, the impact of plagues can affect neighbouring areas, such as Canberra's grasslands. It is recognised that many Orthopteran species are of conservation concern globally (Dirzo et al. 2014). The large-scale loss and fragmentation of this species habitat in combination with threats posed by invasive animals on such large-bodied, flightless, epigaeic, habitat specialist, and low dispersing species are considered to be having major impact. Whilst the direct impact of these species on *P. ochracea* has not been studied, information from closely related species indicate that it is plausible and likely that impact is high. Invasive animals are therefore considered to represent a likely and major threat.
Ongoing loss and modification of habitat	Timing: current and future Confidence: estimated Likelihood: possible Consequence: major Trend: static Extent: across the entire range	This is a potential threat. Processes that cause the loss or degradation of habitat for *P. ochracea* such as clearance, weed infestation, altered drainage patterns, changes to soil pH and nutrients and changes to broader biodiversity are potential threats to *P. ochracea.* The threat of degradation is especially acute where grassland occurs near to urban areas.

Threat	Status [a]	Evidence
		Natural Temperate Grassland of the South Eastern Highlands is listed under the NC Act and EPBC Act as Critically Endangered and thus have some protection from the threatening process listed above, although development in close proximity will likely have flow on effects.
Invasive plants	• Timing: historical, current, and future • Confidence: suspected • Likelihood: likely • Consequence: moderate • Trend: increasing • Extent: across the entire range	Invasion by non-native plant species can change the structural complexity and species composition of grasslands (e.g., Farmilo and Moxham 2023). Although there are data gaps for the microhabitat requirements of *P. ochracea,* evidence suggests that the species favours an open habitat, and that native grass tussocks are important to the species for shelter (ACT Government 2017). Whilst the direct impact of weeds on *P. ochracea* needs further research, exotic vegetation is likely to lead to the degradation of habitat, altering vegetation structure, the amount of bare ground, and impacting biodiversity and trophic interactions more generally. It is thus suspected to represent a moderate threat to the species. When combined with the synergistic impact of fragmentation (particularly reduced gene flow and recolonisation ability) the impact of weeds in degrading habitat for existing subpopulations has the potential to be a moderate threat.
Inappropriate disturbance regimes		
Inappropriate grazing regime	• Timing: historical, current, future • Confidence: suspected • Likelihood: likely • Consequence: major • Trend: unknown • Extent: across the entire range	This is an actual threat. Grazing is a key driver for shaping grassland ecosystems in Australia, and alterations to the historic grazing regime, either from overgrazing by stock, or exclusion of grazing, can have detrimental impacts on biodiversity and ecosystem processes (Lunt 2005). Overgrazing can simplify the ecosystem - reducing plant diversity and structural complexity, spreading weeds, and causing a reduction in tussocks (Lunt 2005). These changes impact the structure of microhabitats, can reduce shelter and the availability of food plants, and increase soil temperature through a reduction in shade (Duffey 1974; King and Hutchinson 2007; Reid and Hochuli 2007). Overgrazing by stock has been shown to lead to a reduction in the abundance of invertebrates (King and Hutchinson 1983). In addition, tussocks are important to *P. ochracea* for shelter (Farrow 2012) and protection from predators, therefore a decline in tussocks may increase vulnerability of the species. Whilst *P. ochracea* has been found in grazed habitats, individuals were located near to tussocks, and it is suspected that tussocks are important habitat features for the species (ACT Government

Threat	Status [a]	Evidence
		2017a). During a survey, *P. ochracea* individuals were not detected in areas that were recovering following heavy grazing from domestic stock and kangaroos (Farrow 2012) and it is suspected that habitat simplification through overgrazing is detrimental to the species. An absence of grazing can result in an accumulation of organic material, loss of biodiversity, reduced inter-tussock space, and increased weeds Threatened Species Scientific Committee 2016; Reid et al. 2018). Inter-tussock space and bare ground are likely important to *P. ochracea*, facilitating the establishment of a greater number of food-plant forb species and providing bare ground for ovipositing (Farrow 2012, ACT Government 2017a). In sites where grazing had been excluded, increases in plant biomass altered the mosaic of scattered tussock grasses, likely reducing habitat quality for the species (Farrow 2012). Whilst there are knowledge gaps in the microhabitat affinities of *P. ochracea*, inappropriate grazing regimes are predicted to detrimentally impact the species and are considered a likely and major threat.
Inappropriate fire regimes	• Timing: historical, current, future • Confidence: suspected • Likelihood: likely • Consequence: major • Trend: unknown • Extent: across the entire range	This is an actual threat. Fire is a key driver of ecosystem change in temperate grasslands in Australia. Changes to the historical fire regime, both as a result of higher frequency and severity of fire with climate change, and alterations to the fire regime through prescribed burning, have the potential to impact the species. The fire ecology of *P. ochracea* is largely unknown. However, given the species is flightless and lives on the ground, individuals are likely to be more vulnerable to lethal radiant heat and less able to escape fire, or to recolonise post fire, especially in a highly fragmented landscape. If fire were to be too frequent, this combination of subpopulation decline, limited dispersal ability, and fragmentation could result in a cumulative decline in the size of subpopulations over time, which may threaten their persistence. For large scale, or severe wildfires, which are predicted to increase with climate change (Canadell et al. 2021; CSIRO 2024), fire impacts are likely to be amplified and extirpation of subpopulations is likely. Given the species is flightless and exists in a highly fragmented landscape, the impact of large, severe fires has the potential to be major. It is likely that alterations to the historical fire regime, from either too frequent fire, or conversely too infrequent fire will cause changes to grassland diversity, species composition, and functional composition (Lunt et al. 2012) and may detrimentally impact *P. ochracea*.

Threat	Status [a]	Evidence
		Too frequent burning can simplify the ecosystem - removing leaf litter and organic detritus, causing alterations to soil chemistry and structure, reducing plant diversity and structural complexity, and causing a reduction in tussocks (Prober et al. 2007). In addition, fire can lead to the spread of fire responsive weed species. Given tussocks are important to the species for shelter (Farrow 2012) and protection from predators, such changes are predicted to increase vulnerability of the species. Too infrequent burning can lead to an accumulation of litter and organic material, reduction in inter-tussock space, an increase in weeds, and a loss of biodiversity. Inter-tussock space and bare ground are likely of importance to the species, facilitating the establishment of a greater number of food-plant forb species and providing bare ground for ovipositing and basking (Farrow 2012, ACT Government 2017a). Seasonal timing of fire is also likely of importance. Large-scale planned fires that occur in winter may impact the species' eggs and fires in spring have the potential to impact emerging nymphs (ACT Government 2017a).
Climate change		
Severe weather events as a result of climate change	• Timing: current, future • Confidence: projected • Likelihood: likely • Consequence: major • Trend: increasing • Extent: across the entire range	This is a potential threat. Models predict that with climate change we will see larger rainfall events and a greater number of individual rain events, with longer dry spells between them (Hughes 2003). For the region in which *P. ochracea* is found CSIRO modelling predicts with 1) *very high confidence* that average temperatures will increase, and that there will be more hot days, and 2) with *high confidence* that there will be fewer frosts, increased intensity of extreme rainfall events, and a harsher fire-weather climate, and 3) with *medium confidence* that the average winter rainfall will decrease (CSIRO 2024). Such conditions will likely favour establishment of woody vegetation on previously grassland areas (Hughes 2003). It is also likely that we will see increases in fire frequency and severity with climate change. Drought will likely become more common, impacting grassland biodiversity, increasing weed presence (Manea et al. 2016), changing resource availability, and impacting soil structure. The cumulative impacts of the above threats are likely to result in ongoing degradation of habitat for *P. ochracea.* When in combination with other threats acting on the grasslands and biota, climate change has the potential to be a major threat to *P. ochracea*.

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

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

Categories for likelihood are defined as follows:

Almost certain – expected to occur every year
Likely – expected to occur at least once every five years
Possible – might occur at some time
Unlikely – known to have occurred only a few times
Unknown – currently unknown how often the threat will occur

Categories for consequences are defined as follows:

Not significant – no long-term effect on individuals or populations
Minor – individuals are adversely affected but no effect at population level
Moderate – population recovery stable or declining
Major – population decline is ongoing
Catastrophic – population trajectory close to extinction

Each threat has been described in Table 1 in terms of the extent that it is operating on the species. The risk matrix (Table 2) provides a visual depiction of the level of risk being imposed by a threat and supports the prioritisation of subsequent management and conservation actions. In preparing a risk matrix, several factors have been taken into consideration, they are: the life stage they affect; the duration of the impact; the spatial extent, and the efficacy of current management regimes, assuming that management will continue to be applied appropriately. The risk matrix and ranking of threats has been developed using available literature.

Table 2. Risk Matrix

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain				Historic habitat loss	
Likely			Invasive plants	Inappropriate grazing regime Inappropriate fire Severe weather events as a result of climate change Invasive animals	
Possible				Ongoing loss and modification of habitat	
Unlikely					
Unknown					

Risk Matrix legend/Risk rating:

Low Risk	Moderate Risk	High Risk	Very High Risk

Conservation and recovery actions

Primary conservation objective

The primary conservation objective is the long-term protection of and persistence of viable subpopulations of *P. ochracea*. This objective is supported by the following sub-objectives:

Habitat for *P. ochracea* is protected across its range, and habitat affinities, conservation-relevant ecology, and distribution are better understood.

The species will be included by name in relevant management plans, which will enable decision-makers to prevent further threats and plan management actions.

Decision-makers will also better understand the likelihood of threats and be able to triage responses following threat events accordingly.

Conservation and management priorities

Habitat loss, disturbance and modifications impacts

Given much of the species' habitat has been lost following post-colonisation clearance, and much of the remaining habitat is highly fragmented, long-term conservation and protection of all remnants of natural temperate grassland is a priority for this species. The primary habitat for the species is Natural Temperate Grasslands, but it also occurs in other native grasslands, and open woodland with a grassy understorey, including the listed Yellow Box - Red Gum Grassy Woodland community and these areas should also be protected, especially where they connect, or are adjacent to, fragmented patches of Natural Temperate Grassland. For areas of habitat not in a protected area, liaison with land holders and stakeholders should occur to encourage conservation management. Given the high levels of habitat loss and the difficulty in detecting the species, all suitable habitat, even if the species has not been detected there, should be protected.

Restoration to increase the size of remnant patches of habitat, to improve connectivity between patches, and to control threats within the habitat (ie weed removal) will provide some protection of habitat, increase resilience to threats, such as climate change, and provide protection for *P. ochracea.*

Until more information on the habitat affinities of *P. ochracea* is gathered, the aim of management should be to maintain quality native grassland by controlling weeds, and managing to create a mosaic of short, moderate and long grass, with inter tussock space.

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

- A number of invasive animals co-occur with *P. ochracea* and it is likely that they negatively impact the species through direct predation and reduction of habitat quality. Invasive animals that are known to occur in habitat for the species, include foxes, feral cats, house mice, feral pigs, and rabbits. We therefore recommend control of these feral animals in areas of suitable habitat.
- Overgrazing by non-native, hard hooved animals may act as a threat to *P. ochracea*, however managed lower-level grazing by domestic species might have some benefits through maintenance of an open, patchy, mosaic structure. This requires further research.

Fire impacts

Little is known on how inappropriate fire regimes may directly impact *P. ochracea*, however it is likely that too frequent, or infrequent fires will lead to a degradation of habitat (see Table 1). Whilst the fire ecology of this species is not well known, we recommend balanced management focussed on conserving the remaining habitat, with any prescribed fires being patchy and lower severity.

Fire managers should be made aware of this species. Fire management should be planned to create a mosaic effect so that fire does not occur at harmful frequencies.

The effects of fire on eggs, nymphs and adults needs more research to better understand how the impact of out-of-season burns on the species.

Disease impacts

NA

Impacts of domestic species impacts

Overgrazing by domestic animals is likely to impact *P. ochracea*, through simplification and degradation of its habitat. However, management of grass biomass and structure to maintain an open habitat structure is likely to be important for the species. Although further research is needed, lower level grazing by native herbivores is likely to be beneficial for maintaining an open, patchy, mosaic structure.

Climate change and severe weather impacts

- Droughts – ensure that habitat is maintained where possible and supported against the impacts of drought.
- Temperature extremes – ensure that fire management and other land management actions retain sufficient cover for insulation.
- Climate change and severe weather-unspecified – ensure land managers are aware of the species' occurrence and provide protection measures against key and potential threats.

Ex situ recovery actions

- Ex situ recovery actions are not recommended until we have more information about the species, its distribution, ecology, and habitat and microhabitat requirements.

Stakeholder engagement/community engagement

Prepare a management strategy with input from local experts. These should include Traditional Custodians, local land managers, local landholders, and existing specialist researchers.

Engage and involve Traditional Custodians in conservation actions, including the implementation of Indigenous fire management and other survey, monitoring and management actions.

Ensure information on *P. ochracea* and its habitat is shared between local land managers, conservation decision makers, and stakeholders. New population data and research should be available to all stakeholders to continue to implement best-practice land management that minimises the impacts of potential threats on the species.

Where research identifies potential habitat for the species in areas that are privately-owned, liaise with landholders to provide information on the species and its habitat requirements, and encourage reporting of any sightings.

Survey and monitoring priorities

This species is cryptic and difficult to detect. Targeted surveys, either directly for the species, or using habitat as a proxy, are required to better elucidate the distribution of the species and its abundance. This is especially important within the Extent of Occurrence in order to determine presence or absence of the species within areas of potential habitat.

To inform knowledge on the ecology of the species in relation to its conservation, surveys are needed to determine the microhabitat requirements of the species, including features of the soil needed for egg laying.

Surveys are needed to delineate the likely impact of threats, such as exotic plants, and to monitor populations in areas that are subject to threatening processes.

Long term monitoring to determine subpopulation response to management actions, such as grazing / fire / slashing, is needed in order to better understand optimal management for the species.

Long term monitoring of subpopulations is needed to enable the population trajectory to be tracked and to determine impact of and population response to threat events.

Citizen science records, through Canberra Nature Map have been successful in providing verifiable photo records of the species in a number of sites, including new sites for the species. The involvement of citizen scientists should be encouraged, perhaps through a targeted campaign.

Information and research priorities

- Specific research is needed on the impacts of management regimes (primarily grazing and burning) on *P. ochracea* in order to determine the optimal management regime for the species. This is a priority.
- There is a limited understanding of the microhabitat requirements of the species, the key threats that are acting on it, or how best to manage them. Priority for research should thus be to gain a better understanding of the ecology and habitat affinities of *P. ochracea.* Particular focus should be paid on gaining a better understanding of:
  - the species' diet
  - dispersal abilities
  - how threats, such as foxes, weeds, drought, habitat simplification may impact the species.

Links to relevant implementation documents

Approved Conservation Advice (including listing advice) for the Natural Temperate Grassland of the South Eastern Highlands (EC 152) (environment.gov.au)

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Attachment A: Listing Eligibility for *Perunga ochracea*

Assessment of eligibility for listing against the criteria

This assessment uses the criteria set out in the the Nature Conservation (Threatened Native Species Eligibility) Criteria 2016. The thresholds used correspond with those in the IUCN Red List criteria. 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	Information on population numbers are not known for this species
Trend	Unknown			
Generation time (years)	<1 year		1 year	The generation time is unknown, however the species has a lifecycle of one year (Farrow 2012; ACT Government 2017), so it can be inferred that the generation length is less than a year.
Extent of occurrence	987.167 km^2	849.231 km^2	987.167 km^2	The EOO used for this species was calculated using all available occurrence data, historical and recent. Some of these historic points have since been developed. However, undersampling and a lack of targeted surveys across potentially suitable habitat may underestimate EOO, therefore we use this figure in the assessment. The lower limit reflects the EOO with all occurrences collected before the year 2000 removed, to reflect ongoing habitat decline.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Trend	Stable			Although threats are impacting the quality of remaining habitat, it is not expected the EOO will decrease.
Area of Occupancy	216 km^2	200 km^2	216 km^2	A Geocat assessment using all occurrences yielded a value of 216 km^2. The minimum value is the AOO where occurrences recorded before the year 2000 have been removed.
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			Further surveys are needed for this species to better determine AOO.
Number of subpopulations	9	3	16	Given the high levels of habitat fragmentation and a likely low dispersal ability, the number of subpopulations in the relatively small area is likely high. The estimate used is based upon the occurrence points and assuming that gene flow may occur in geographically close subpopulations, even over cleared, or developed terrain. The upper estimate is assuming that no dispersal over such barriers could occur and the lower value that dispersal is occurring more broadly.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Trend	Declining			Given the fragmented landscape and low dispersal ability of the species, increasing vulnerability to stochastic extinction events, plus the close proximity to urban areas and associated threats, it is projected that the number of subpopulations will decline.
Basis of assessment of subpopulation number	The estimate is based on examination of known occurrences, mapping and an inferences that due to the species traits, that dispersal may occur over short geographic distances, even if habitat is missing between these occurrences, but not over larger distances.			
No. locations	5	5	5	An estimate of five locations is used in this assessment, which represents the broad geographical groupings of the species. These locations were estimated using impacts from invasive animals (both from predation and by causing a decline in habitat quality) as a major and significant threatening process.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Basis of assessment of location number	Although a number of threats are likely impacting *P. ochracea*, the combined impact of predation and habitat degradation by non-native animals is considered to be amongst the most serious of threats. Red foxes, feral cats, European rabbits, feral pigs and house mice are all widespread in the species's range and all present plausible threats to the species, with studies from Australia and globally showing large-bodied and flightless Orthoptera likely being at particular risk. Foxes occur at a density of greater than one fox per km^2 in the broad region that *P. ochracea* occurs in, with cats occurring at around half this density (Stobo-Wilson et al. 2022). Pressure from these threats are likely to be, to some extent, temporal in nature and related to proximity to agricultural areas and human habitation. At times when prey items, such as rabbits, or mice are in low numbers, predation pressure on *P. ochracea* from foxes and cats is likely to increase and could result in serious impacts on subpopulations. At other times, increased abundance of mice or rabbits, such as when plagues occur, are likely to result in both increased habitat degradation and an increase in predation pressure (from mice). When they occur, mouse plagues can extend over a large area (up to 1,500 km^2 (Brown et al. 2010)), and whilst they tend to be centered on grain growing or cropping areas, the impact of plagues can affect neighbouring areas, such as Canberra's grasslands. The distribution of *P. ochracea* ranges from heavily urbanised areas to natural temperate grasslands. The pressure from non-native animals is likely to vary between these areas, according to different mechanisms controlling population sizes and preferential habitat usage of non-native species. Taking this into account, and based upon geographic range and subpopulation clusters, we estimate there to be five locations.			
Trend	stable			
Fragmentation	The species occurs as isolated subpopulations, likely with limited gene flow between, due to low vagility and the highly altered and fragmented habitat. However, there is no evidence that it is severely fragmented.			
Fluctuations	None			

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, inferred 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 assessment outcome

Not Eligible

Criterion 1 evidence

Insufficient data for assessment under Criterion 1

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

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

Criterion 2 assessment outcome

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

Criterion 2 evidence

The EOO of *P. ochracea* is 987.167 km^2 and the AOO is 216 km^2. The species' habitat is fragmented and many of the sites in which it occurs are small isolated fragments at the urban interface, low dispersal ability and habitat specificity means that subpopulations of the species are likely to be isolated with restricted gene flow.

Ongoing and potentially increasing threats from predation and habitat degradation by non-native animals gives five locations for the species, based on a combination of geographic location and closeness to urbanisation.

It is estimated that around 90% of this species habitat has been lost through clearance and development post-settlement. There is an inferred and projected ongoing decline in area, extent and / or quality of habitat due to ongoing and pervasive impacts of historic land clearance, causing fragmentation of subpopulations and loss of habitat. The impacts of other threats, acting synergistically with fragmentation and habitat loss, are further driving decline and impeding recovery. Such threats include climate change, land degradation from inappropriate grazing and fire regimes, and ongoing degradation of habitat by key non-native animals, which are recorded as widespread through the region and are listed as severe or major threats to temperate natural grasslands. In addition, there is an inferred and projected ongoing decline in the number of mature individuals as a result of predation from feral cats, foxes, house mice and pigs.

There is no evidence for extreme fluctuations.

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 generations** **(whichever is longer)**	**Substantial rate** **10% in 10 years or** **3 generations** **(whichever is longer)**
C2. An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions:			
(a) (i) Number of mature individuals in each subpopulation	**≤ 50**	**≤ 250**	**≤ 1,000**
(a) (ii) % of mature individuals in one subpopulation =	**90 – 100%**	**95 – 100%**	**100%**
(b) Extreme fluctuations in the number of mature individuals			

Criterion 3 assessment outcome

Ineligible

Criterion 3 evidence

Insufficient data 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. 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 assessment outcome

Not Eligible

Criterion 4 evidence

Insufficient data 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 assessment outcome

Not eligible

Criterion 5 evidence

Insufficient data for listing under this criterion

Short summary of criteria under which the species is eligible for listing

Perunga ochracea (Perunga Grasshopper) is proposed to be listed under the Endangered category of the threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999.*

Criterion 1: Insufficient data

Criterion 2: B1ab(iii, v)+B2ab(iii, v): Endangered

Criterion 3: Insufficient data

Criterion 4: Insufficient data

Criterion 5: Insufficient data

The main factors that make the species proposed for listing in the Endangered category are:

- *Perunga ochracea* is known from only five locations, with an EOO of 987.167 km^2 and an AOO of 216 km^2.
- Most of the species' habitat was cleared following colonisation and what little remains is highly fragmented and close to urban areas.
- Substantial threats from non-native animals, namely foxes, feral cats, house mice, rabbits and pigs are likely to cause ongoing decline in habitat quality and number of mature individuals through predation and degradation of habitat.
- A number of threats are acting on the species' habitat, which when combined with the interacting effects of fragmentation result in a likelihood of ongoing risk of decline.

Adequacy of survey

The species' distribution is known from 302 occurrence records, which are from a range of sources, including citizen science records from NatureMapr, surveys for other taxa, direct surveys for the species, and opportunistic samples. Whilst it is cryptic, the species is large, distinct, and relatively easy to identify, therefore there is high confidence that these represent accurate records of the species.

The occurrence records, plus evidence from the published literature and reports provide support that the species genuinely has a highly restricted distribution and is a habitat specialist.

As with most species, there is potential that additional targeted surveys will reveal a greater range for the species, however, the species EOO is well within the 5,000 km^2 bound for listing as Endangered, and given the small amount of habitat left for the species post-clearance, there is high confidence that additional records will not increase the species' EOO above this value. This is similarly true for the AOO.

Whilst further surveys are needed to confirm details on the species' microhabitat affinities and to better determine the species' occurrences within suitable habitat in the EOO, we deem there is sufficient scientific data to support assessment of the species.

Additional Comments/Information

Schedule 3 Cold Spiny Crayfish – Murunung Naruwi (*Eustacus crassus*)

(see s 3 (3))

Schedule 3

ACT Government
Environment, Planning and Sustainable Development

ACT Scientific Committee

Threatened Native Species Nomination

for amending the list of Threatened Native Species under Chapter 4 of the *Nature Conservation Act 2014*

The purpose of this form is to nominate a native species for assessment under the *Nature Conservation Act 2014* (NC Act) by the ACT Scientific Committee (the Committee) for recommendation to the Minister for inclusion on the Threatened Native Species List or for reassessment for consideration for listing under another category of threat. The Criteria for listing Threatened Native Species in the ACT can be found at: http://www.legislation.act.gov.au/di/2016-254/default.asp.

DRAFT – Conservation Advice for *Euastacus crassus*

This document provides a foundation for conservation actions and further planning.

Euastacus crassus © Copyright, Mark Jekabsons.

Conservation status

Euastacus crassus is not listed in any category of the Threatened Native Species List under the *Nature Conservation Act 2014 (ACT) or the Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act).

Euastacus crassus is nominated to be eligible for listing as Endangered under Criterion 2. The eligibility for assessment is addressed at Attachment A. The proposed eligibility against each of the listing criteria is:

- Criterion 1: Insufficient data
- Criterion 2: B1ab(iii,v) +2ab(iii,v): Endangered
- Criterion 3: Insufficient data
- Criterion 4: Insufficient data
- Criterion 5: Insufficient data

This species is potentially eligible for listing as Endangered based on its restricted distribution and number of locations. There is a projected decline in the area, extent and/or quality of habitat, and the number of mature individuals due to impacts of climate change, such as increased temperatures, alteration of hydrological regimes, increased frequency of extreme weather events, and increased frequency and severity of bushfires.

Species information

Taxonomy

Conventionally accepted as *Euastacus crassus* Riek, 1969 (Riek 1969). Phylogenetic analyses by Shull et al. (2005) and Austin et al. (2022) confirm *E. crassus* as a distinct taxon. However, Austin et al. (2022) also identified a divergent lineage (*E.* cf. *crassus*), and several new, cryptic lineages, which were originally thought to be the species. These distinct lineages are considered to be distinct taxa and are not included in this assessment. The species was described by Riek (1951) without a common name. Since that time, common names of alpine crayfish, alpine spiny crayfish, thick crayfish and cold crayfish have been employed. Following consultation with the Winanggaay Ngunnawal Language Aboriginal Corporation, the Ngunnawal name of Murunung Naruwi was chosen to reflect its regional presence given its refined distribution.

Description

Euastacus crassus is one of the small and spinose species of *Euastacus* (Coughran 2008). The species has been recorded as reaching 58 mm occipital carapace length (OCL; Morgan 1997). The body of *E. crassus* is usually blue-green with abdominal segments reddish across the front half of body tending to blue-green toward the back and blue laterally (Riek 1951; Morgan 1997; McCormack 2012). The adult chelae (claws) are bright blue with an underside of chelae white (Riek 1951; Morgan 1997; McCormack 2012).

The morphological characteristics used to identify individual species of the small and spinose *Euastacus* are subtle, with the differences being often just a few spines, and/or the presence of a groove. For example, *E. crassus* and *Euastacus rieki* (Riek's crayfish) as well as *Euastacus claytoni* (Clayton's crayfish) are very similar in external appearance, particularly as juveniles. The colouration of *E. crassus* may distinguish it from Riek's crayfish, which is generally brown to green in colour (McCormack 2012). The spination on the claws and relative body dimensions can be distinctive (but also variable), with *E. crassus* usually having two apical dactylar spines and a shorter thorax, whereas Riek's crayfish usually has one apical dactylar spine (Morgan 1997). *Euastacus crassus* can be distinguished from Clayton's crayfish due to the latter having thin rostral carinae of medium length basally, the contiguous 2nd and 3rd mesial carpal spines and generally larger thoracic spines (Morgan 1997). However, the spine count is variable, and differences in the gastric mills can differentiate the three species (Morgan 1997).

Distribution

Euastacus crassus is endemic to the high country (>600 m above sea level (ASL) with records up to 1544 m ASL) in the western extent of Australian Capital Territory (ACT) (Morgan 1997; Coughran & Furse 2010; Hammer & Beitzel 2019; Austin et al. 2022). It was formerly considered to occur more widely in southern NSW as well as north-eastern Victoria, but the molecular genetic analyses of Austin et al. (2022) identified specimens from those regions as belonging to different lineages (see Taxonomy section). The species may occur in headwater streams (e.g. upper Goodradigbee River Catchment) of adjacent areas of NSW, but this habitat is anticipated to by limited given the knowledge of (non-overlapping) range of different lineages identified by Austin et al. (2022).

In the ACT, *Euastacus crassus* is recorded from the tributaries and bogs and fens (Gibraltar, Bushrangers, Condor and Tidbinbilla rivers and Mountain and Kangaroo creeks) of the upper Murrumbidgee and Cotter rivers. It is commonly found in the high country of Namadgi National Park, Tidbinbilla Nature Reserve, Lower Cotter Catchment and Woods Reserve.

Part of the range of this species is afforded a degree of protection by being contained within the EPBC listed Endangered Ecological Community *Alpine Sphagnum Bogs and Associated Fens* that also occur in protected areas and reserves (Namadgi National Park, Tidbinbilla Nature Reserve and Woods Reserve), but these areas are not actively managed for conservation of *E. crassus*. In the ACT, fish and crayfish are managed under the *Fisheries Act 2000* and the *E. crassus* is protected and cannot be targeted or caught (EPSDD 2024). It is also listed as a protected native species under the Nature Conservation Act 2014 (ACT) in the trade restricted category.

Cultural and community significance

The cultural, customary and spiritual significance of species and the ecological communities they form 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, all Indigenous Australians. Such knowledge may be held by Indigenous communities and individuals who are the custodians of this knowledge and have the rights to decide how this knowledge is shared and used.

Euastacus crassus occurs on the lands of the Ngunnawal and Ngarigo/Ngarigu people (AIATSIS 2024). The cultural significance of *E. crassus* is not available for this advice. Further investigation with local Indigenous groups is being undertaken. Following consultation with the Winanggaay Ngunnawal Language Aboriginal Corporation, the Ngunnawal name of Murunung Naruwi, meaning crayfish, was chosen to reflect its regional presence given its refined distribution. Murunung Naruwi.

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

Relevant biology and ecology

Knowledge on the biology and ecology of *E. crassus* is limited; however, it is recognised that *Euastacus* species have a suite of common biological characteristics (see below, but also summarised in Furse & Coughran 2011a), which also apply to *E. crassus*. Various studies have established that *Euastacus* species are slow-growing (growth increments of a few mm OCL yr−1), very long-lived, and for the larger species can take many decades (35–50 years in some species) to reach the large sizes that are recorded (e.g., Honan & Mitchell 1995a,b; Turvey & Merrick 1997; Morey 1998; Furse & Wild 2004; Coughran 2013). Some of the knowledge detailed below is drawn from the study of individuals across the former range of the species, and specific investigation of what is now defined as *E. crassus* is warranted.

Habitat

Euastacus crassus inhabits extensive burrow systems that generally start at the water level mark of small, high streams that have relatively undisturbed vegetation (Morgan 1997; McCormack 2012). It preferentially inhabits permanent, cold-water streams but can also be found in ephemeral streams. Permanent water in the burrows is a requirement of the species

(McCormack 2012). It is a nocturnal species that can travel up and down streams using temporary shelter (McCormack 2012).

Reproductive Ecology

Reproductive studies show that *Euastacus* species are typically late-maturing with females only reaching reproductive maturity at 5–10 years (e.g., Honan & Mitchell 1995a, b; Turvey & Merrick 1997; Borsboom 1998; Furse & Wild 2004; Coughran 2013). There are limited published studies or information on reproduction in *E. crassus*. They are considered winter breeders with females thought to approach maturity around 40–50 mm OCL (Morgan 1997; McCormack 2012). Berried females carrying around up to 200 eggs have been observed in Autumn, with the release of juveniles thought to occur between January to April based on water temperature (Morgan 1997; McCormack 2012). Eggs are pale orange in colour (Morgan 1997; McCormack 2012, ACT gov.).

Diet

The species is a vegetation/detritus feeder that will eat meat opportunistically (McCormack 2012).

Habitat critical to the survival

Euastacus crassus is known from a small distribution and can be considered a short-range endemic (Harvey 2002). *Euastacus crassus* is currently restricted to high-altitude permanent and ephemeral streams of the ACT and may possibly occur in adjacent high-altitude streams of NSW (Morgan 1997; Coughran & Furse 2010; Hammer & Beitzel 2019; Austin et al. 2022). Beyond this, it was not possible to define habitat critical to the survival of the species as there are insufficient data. Therefore, all of its known, peripheral, and likely habitat is critical to the survival of this species.

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

The number of mature adults is unknown, but the species is currently restricted to a small area within the ACT (see Distribution section above), and the population size is likely small. Apart from that, at the time of preparing the Conservation Advice, sufficient information to enable description of important populations was not available.

Threats

Established threats (habitat destruction, pollution, invasive and translocated native species, human exploitation, climate change and related changes to fire and flooding events) and potential threats (disease such as *Aphanomyces astaci* [crayfish plague]; Panteleit et al. 2017; DAWE 2019) may put nearly all species of *Euastacus* at serious risk of population declines, or extinction, over sub-decadal timeframes (Wells et al. 1983; Coughran 2007; Furse & Coughran 2011b; Furse 2014; Richman et al. 2015). Climate change is a key threat to most *Euastacus* (Hossain 2018), including *Euastacus crassus*, with the species having limited capacity to relocate to higher, cooler altitudes, or overland to other nearby suitably cool habitat. The species is impacted by invasive species (foxes, trout, translocated yabby, pigs) along with being attracted to baited traps making illegal fishing a concern (McCormack 2012).

Table 1 Threats

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

Threat	Status [a]	Evidence
Climate change and severe weather impacts		
Increased temperature	• Timing: current/future Confidence: projected • Likelihood: almost certain • Consequence: catastrophic • Trend: increasing • Extent: across the entire range	Increased temperature is the direct, on-going, and persistent long-term impact of global warming. Unlike short-term heatwaves, this is a steady irreversible increase in temperature. The mean annual temperature is expected to increase in the ACT by 0.7° C in the near future (2020-39) and 2° C longer term (2060-79) (OEH 2014). *Euastacus* species are sensitive to increasing temperatures, with *Euastacus crassus* likely lacking the capacity to physiologically adapt or relocate to cooler areas 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 environments is blocked by the warm lowlands (Ponniah & Hughes 2004; Furse et al. 2012; Bone et al. 2014). Predicted increases in temperature in the region will impact this species across its range. Increased water temperature may result in sublethal impacts such as changed habitat availability, crayfish activity patterns and reproductive capacity.
Extreme weather events	• Status: current/future • Confidence: observed • Likelihood: almost certain • Consequence: catastrophic • Trend: increasing • Extent: across the entire range	The habitat of *Euastacus crassus* is expected to experience an increase in severity and frequency of extreme heat events. By 2060–79, there are anticipated to be more hot days (over 35° C) across its range by 10–20 days annually compared to 1990–2009 (OEH 2014). Rainfall patterns in the regions where the species occurs are predicted to change, with summer, autumn, and spring rainfall increasing and winter rainfall decreasing by 2060–79 (OEH 2014). Shifting precipitation patterns, coupled with projected increases in temperature, may lower the local water table and increase seasonality of streams, and other habitat which this species may occupy (Morgan 1997; McCormack 2012). Overall, this may result in a decrease of available habitat for this species as it requires some water permanently in the base of the burrows (McCormack 2012). Recent observations in the field found that the species was absent from many areas within its known range possibly due to the lack of water in the burrows (M. Beitzel 2024, unpub data).
Drought	• Timing: current/future • Confidence: observed and projected • Likelihood: almost certain • Consequence: Major • Trend: increasing	Climate change modelling for the Murray Basin region (which encompasses the range of *Euastacus crassus*) predicts an increase in the percentage of time spent in drought and the frequency of extreme drought by 2090 (Timbal et al. 2015). Increasing frequency and length of droughts is likely to result in loss or degradation of surface

Threat	Status [a]	Evidence
	• Extent: across the entire range	and groundwater dependant habitats such as the ones inhabited by the *Euastacus crassus*
Fire regimes that cause declines in biodiversity[b]	• Timing: current/future • Confidence: suspected • Likelihood: likely • Consequence: major • Trend: increasing • Extent: part or across the entire range	The frequency and magnitude of bushfires is predicted to increase under climate change scenarios (Di Virgilio et al. 2019). For the ACT, average fire weather and severe fire weather days are projected to increase during summer and spring (OEH 2014). Impacts may be immediate (habitat loss and mortality) or delayed (siltation and deoxygenation of habitat following a fire, possible change of stream water temperature due to canopy loss). The range of the species is prone to the impacts of bushfire. All but the north-eastern sites were in areas that overlapped with the 2003 Canberra bushfires (ACT Government 2024). The most south-western parts of its range also overlapped with the 2019–20 Black Summer bushfires and a number of other sites were in proximity to bushfire affected areas (DAWE 2020). Any potential impacts by fires on the population of this species need to be further investigated. A single bushfire has the capacity to impact large numbers of the population of this species, potentially leading to a population decline across the species range, or extirpation of the species over time. Storm events following fire usually result in significant inputs of ash and sediment to streams which severely impact aquatic habitats. Post-fire sedimentation can impact waterways 50–80 km downstream of the burnt area (Lyon et al. 2008; Silva et al. 2020) and have severe effects on water quality and aquatic fauna including threatened fish and crayfish (Bixby et al. 2015; Legge et al. 2021). Ash and sediment inputs smother stream substrates, alter water chemistry, alters riparian shading and organic inputs. Post-fire rainfall impacts on aquatic habitats from high severity fire can significantly alter crayfish habitat and severely reduce local crayfish subpopulations within a single generation. The spatial extent of the threat from fires is not fixed for any one fire, and will vary with ignition point, fuel loads, antecedent climatic conditions (e.g., rainfall/drought) and weather variables. Consequently, individual fires are likely to impact different locations, within the entire distribution of *Euastacus crassus*. A synergistic threat to this species from fire is increased terrestrial predation by invasive predators such as foxes (*Vulpes vulpes*) and wild dog/dingo (*Canis familiaris*) in burnt landscapes. Fire removes riparian and wetland vegetation that provides cover to crayfish when emerging from burrows or traversing habitat such as bogs. Dramatic increases in predated crayfish remains have been observed following fires (Carey et al. 2003) and recent evidence from the 2019–20 fires has documented > 90 % of predator scats collected around upland bogs in the ACT contained crayfish remains (ACT Government 2021).
Disease impacts		

Threat	Status [a]	Evidence
Crayfish plague	• Timing: future • Confidence: projected • Likelihood: possible • Consequence: catastrophic • Trend: unknown • Extent: across entire range	*Aphanomyces astaci* (crayfish plague) is a highly contagious fungal disease that is uniformly fatal (100 % mortality) to susceptible species (Panteleit et al. 2017). It is one of the world's worst invasive species (Lowe et al. 2000). Crayfish plague, introduced from North America, has devastated populations of native species of freshwater crayfish in Europe and Asia (Panteleit et al. 2017). In Scandinavia, national declines in crayfish populations were up to 80% and some lakes where crayfish were eliminated became choked with aquatic plants (Abrahamsson 1966). Many strains of the disease prefer cooler temperatures, which is characteristic of this species' habitat. Crayfish plague is not currently known in Australia, but is documented as fatal to Australian freshwater crayfish (Unestam 1975), and it is listed on Australia's National List of Reportable Diseases of Aquatic Animals (Animal Health Committee 2020). It poses an extremely high risk to native freshwater crayfish species in the event of it reaching Australian rivers and streams (DAWE 2019). The vector for the disease's movement outside of its native range has been translocation of North American crayfish, in particular, *Pacifastacus leniusculus* (signal crayfish) and *Procambarus clarkii* (red swamp crayfish). Infected crayfish from the Americas are resistant carriers and are largely unaffected by the disease (DAWE 2019). Illegally imported specimens of red swamp crayfish have been seized in multiple Australian states (Department of Primary Industries & Regional Development 2021; Business Queensland 2021) but are not known to be infected. A single, illegally imported crayfish, infected with crayfish plague has the capacity, via an unlicensed/illegal collector vector (or aquarium discard), to devastate the entire Australian crayfish fauna. Increasing illegal wildlife/aquarium trade appreciably increases the risk and probability of the disease's introduction to Australia (Furse 2014).
Introduced species impacts		
Impact of common yabby	• Timing: current/future • Confidence: observed • Likelihood: likely • Consequence: moderate • Trend: increasing • Extent: across part of its range	The distribution of *Cherax destructor* (common yabby) has expanded beyond its natural range. The species is now found within the range of *Euastacus crassus* and is continuing to spread and increase in abundance. Used as live bait for recreational fishing is considered a significant pathway for introduction to new areas in Australia (Coughran & Daly 2012). The common yabby is fast-growing and has a high reproductive output (early maturity, multiple broods per year) compared to *Euastacus* species (Wingfield 2002; Beatty et al. 2005; Coughran et al. 2009). Common yabby invasion is considered a significant threat to many *Euastacus* species as they prey on juveniles and compete with native crayfish species (Coughran et al. 2009; Coughran & Furse 2010). The pattern of abundance of

Threat	Status [a]	Evidence
		Euastacus species and common yabby is often inversely related.
Impact of alien rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*)	• Timing: current/future • Confidence: suspected • Likelihood: likely • Consequence: moderate • Trend: variable • Extent: across part of its range	Alien trout species are known to predate on juveniles of Euastacus species (Pigeon 1981; Horwitz 1990, 1995; 2010; Furse and Coughran 2011a; Merrick 1995; McCormack 2012) and alien trout predation is noted as a specific conservation concern for several species of *Euastacus*, including *Euastacus diversus* (The Orbost Spiny Crayfish) (Lieschke et al. 2014), and *E. crassus* (van Praagh 2003). Juvenile crayfish can be predated by all life stages of trout, alter foraging patterns and compete for refuge habitats (Reynolds 2011). Trout species have been recorded in several streams in the ACT where *E. crassus* occur (Lintermans 2000a,b; Rutzou et al. 1994).
Impacts of invasive ungulates	• Timing: future • Confidence: inferred • Likelihood: possible • Consequence: moderate • Trend: unknown • Extent: across part of its range	Feral pigs (*Sus scrofa*) are known to occur across the range of *E. crassus.* For instance, feral pig are present in Namadgi National Park with control measures attempting to limit numbers (Hone 2002). Other ungulates such as feral horses (*Equus feras caballus*) are not currently known to occur across the range of *E. crassus*. For instance, Namadgi National Park is considered horse free, with no resident feral horses recorded since 2011 (ACT Government 2020) and horse abundance significantly reduced for two decades prior to this. Feral horses have previously been present in Namadgi National Park but have fluctuated in response to natural events and control measures. Feral horse abundance has increased significantly in Kosciuszko National Park (KNP), which poses a threat of recolonisation in Namadgi National Park. Without active surveillance and implementation of control measures, it is possible that this threat will impact *E. crassus* in the future. Feral pigs uproot vegetation, create large patches of bare ground, reduce plant species richness, foul waterbodies, and prey on slow-moving animals such as frogs and turtles (Bengsen et al. 2017; Hone 2002). Feral pigs require frequent access to water (Bengsen et al. 2017), so also damage aquatic habitats, particularly after disturbance such as bushfire (McDougall and Walsh 2002). Feral horses negatively impact wetlands, watercourses, and riparian systems; alteration of the structure and composition of vegetation; and reduction in plant biomass. Feral horses graze bogs and other wet areas and can leave a dense network of tracks (Drying 1990; Hope et al. 2012). Wet soils are more susceptible to erosion than dry soils, and hooved animals walking through bogs can trample vegetation, which leads to further loss of soil and changes to the hydrology of bogs creating channels and potentially leading to draining of the wetland (Drying 1990; Hope et al. 2012). Feral pigs and feral horses also damage high country aquatic environments via stream bank damage, pugging, sedimentation, alteration of riparian vegetation (Tolsma & Shannon 2018; Robertson et al. 2019). The impacts of feral ungulates can be more pronounced following other disturbance such as bushfire.

Threat	Status [a]	Evidence
		Without ongoing active management, the impact of invasive ungulates such as feral pigs and feral horses (as well as feral deer) may pose significant impacts to the steam and bog habitat of *E. crassus*.
Illegal collection		
Illegal take	• Timing: current • Confidence: inferred • Likelihood: likely • Consequence: moderate • Trend: static • 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; J.M. Furse 2021 unpub). Their targets include species in national parks (see Coughran & Furse 2012) and extremely remote areas. A series of these activities are known to have occurred and continue throughout eastern Australia, with illegally collected crayfish intercepted (outbound) at Australian international airports (J.M. Furse 2021 unpub). *Euastacus crassus* is attracted to baited traps making illegal fishing a concern (McCormack 2012). Any collection of rare, slow-growing and short-range endemic species, such as *Euastacus crassus*, has the capacity to quickly lead to negative population-scale impacts. Specifically, removal of reproductive animals from a population, particularly females that may require >5 years to reach sexual maturity, is likely to seriously impact recruitment. Illegal collectors can also act as a vector for diseases/pathogens between catchments, waterways, and into isolated areas of habitat. Whilst the species is protected from recreational fishing harvest, the taking of large individuals has been identified as a potential threat (Coughran and Furse 2010).

[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				Drought	Increased temperature Extreme weather events
Likely			Impact of common yabby Impact of introduced trout Illegal take	Fire regimes that cause declines in biodiversity	
Possible			Impacts of invasive ungulates		Crayfish plague
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 *Euastacus crassus* continues as a secure, viable population in the wild.

Conservation and management priorities

Climate change (increased temperature) and severe weather impacts

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

  - Establish a capacity to maintain a captive subpopulation 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 for the species' habitat, to provide alerts of dangerous environmental conditions, when the species physiological tolerances are known. These can be in situ monitoring and/or based on model projections.
  - Develop or access local weather and climate models to predict when extreme weather events might require moving animals to ex situ facilities.
- Determine how naturally occurring relatively 'cool' pockets of micro-habitat would aid conservation as climate 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 areas and manage surrounding areas.
  - Reduce the prevalence of flammable weeds where infestations have established, and replant appropriate native species.
  - Avoid using chemical fire suppressants near to sites where the species occurs.
- Monitor and, if necessary, manage impacts from fires on the species habitat, including riparian erosion and siltation.
- Implement post fire invasive terrestrial (e.g. foxes) and aquatic (e.g. trout) predator control.

Disease impacts

- Ensure authorised collectors, researchers and rangers are aware of required hygiene protocols, and assess compliance.
- Review biosecurity at international borders and update as 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). (

Invasive species

- Develop and implement long-term strategies to control alien species (e.g. trout, foxes, common yabby) by implementing management programs, where feasible.
- Investigate ecological interactions between *E. crassus* and the common yabby.
- Provide information to fishers to reduce movement of the common yabby.
- Maintain the prohibition on stocking of trout in the ACT particularly within the range (or access to the range) of *E. crassus*.
- Monitor and control damage to bogs, wetlands, instream and riparian areas by feral animals.

- Ensure that any anthropogenic alterations to surface and groundwater hydrology account for the species habitat requirements.

Illegal collection

- Collection of any kind, specifically removal of any specimens from the wild, should be forbidden until the population size of this threatened species has been established.
- 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 against the sellers where appropriate.

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 severe weather events) for subsequent re-release to the wild.
  - Establishing a captive breeding population as a source of animals to augment the wild population, if required.
  - Investigate feasibility of translocations to assist conservation of the species.

Stakeholder engagement/community engagement

- Prepare a management and engagement strategy for this species and similar species of crayfish in the region with input from crayfish experts, national park managers, and other identified stakeholders.
- Ensure land managers and contractors/other authorities are aware of the species' occurrence and provide protection measures against key and potential threats.
- Actively engage Traditional Owners in the conservation of the species and its habitat and work with them to share any traditional knowledge associated with the species, ensuring the practices to record, store and share this knowledge are mutually supported.

Survey and monitoring priorities

- Establish a monitoring program to monitor the population size and trajectory of this species through time.
- 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 requirements).

- Investigate the potential influence of climate change on the long-term survival prospects of the species, due to altered temperatures, rainfall patterns/moisture availability, bushfires, environmental stressors and diseases. This includes:
    - Assess the thermal tolerance of *E. crassus* (using non-lethal methods) to ascertain its physiological limits, sensitivity and vulnerability.
    - Investigate the impacts of climate change on the species' habitat (vegetation assemblages, water availability, water and air temperatures).
- Investigate on-ground options for improving the outcomes before, during and after fire.
- Establish the resilience of *E. crassus* to invasive species and diseases.

Links to relevant implementation documents

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Attachment A: Listing Eligibility for *Euastacus crassus*

Reason for assessment

The species was prioritised due to its IUCN conservation status, the reduction in distribution resulting from molecular taxonomic analyses and threats posed to the species.

Assessment of eligibility for listing

This assessment uses the criteria set out in the Nature Conservation (Threatened Native Species Eligibility) Criteria 2016. The thresholds used correspond with those in the IUCN Red List criteria. 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 [Provide clear and succinct justification for the estimate chosen, minimum and maximum plausible values, citing sources]
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 this species. In addition, there is little information available from other species of *Euastacus*.
Extent of occurrence	227km^2			Based on published, and/or known survey and collection records (McCormack 2012; Hammer and Beitzel 2019; ACT Government 2021; Austin et al. 2022). Calculated using GeoCAT (Bachman et al. 2011)
Trend	Contracting			No long-term population data available, but given widespread threats from climate change, drought, and two severe wildfires since 2000, the range is assumed to be contracting.
Area of Occupancy	60km^2			Based on published, and/or known survey and collection records (McCormack 2012; Hammer and Beitzel 2019; ACT Government 2021; Austin et al. 2022). Calculated using GeoCAT (Bachman et al. 2011).

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification [Provide clear and succinct justification for the estimate chosen, minimum and maximum plausible values, citing sources]
AOO is a standardised spatial measure of the risk of extinction, that represents the area of suitable habitat known, inferred or projected to be currently occupied by the taxon. It is estimated using a 2 x 2 km grid to enable comparison with the criteria thresholds. The resolution (grid size) that maximizes the correlation between AOO and extinction risk is determined more by the spatial scale of threats than by the spatial scale at which AOO is estimated or shape of the taxon's distribution. It is not a fine-scale estimate of the actual area occupied. In some cases, AOO is the smallest area essential at any stage to the survival of existing populations of a taxon (e.g. breeding sites for migratory species).				
Trend	Unknown			No long-term population data available.
Number of subpopulations	<10			Species has a restricted range across the high country with subpopulations separated by lower altitude valleys and forests (from which the species is largely absent). Low vagility means that substantial areas of unsuitable habitat prevent inter-population dispersal.
Trend	Declining			No long-term population data available, but given widespread threats from climate change, drought, and two severe wildfires since 2000, the subpopulations are assumed to be contracting.
Basis of assessment of subpopulation number	Species is restricted to small isolated upland tributaries of the Cotter and Tidbinbilla valleys separated by a larger river ranges and forests (from which the species is largely absent).			
No. locations	1	1	1	Increased temperatures, frequency of drought and more severe bushfires (including subsequent predation by foxes) associated with climate change will impact the entire range of the species simultaneously.
Trend	Stable			Broad spatial range is thought to be contracting but number of locations is stable.
Basis of assessment of location number	Increased temperatures, frequency of drought and more severe bushfires associated with climate change will impact the entire range of the species simultaneously.			
Fragmentation	It is not known if the subpopulations can be considered to be severely fragmented.			
Fluctuations	Not subject to extreme fluctuations in EOO, AOO, number of subpopulations, locations or mature individuals.			

Criterion 1 Population size reduction

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

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

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

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

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

Based on any of the following

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

Criterion 1 evidence

Insufficient data to determine eligibility

The generation length of *Euastacus crassus* is unknown and there are insufficient data to determine eligibility for listing under Criterion 1. However, it is projected that there will be a future reduction in population size of *E. crassus* 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 (see Threats Table 1 above). A decline in Area of Occupancy (AOO), Extent of Occupancy (EOO) and quality of habitat is anticipated due to climate change, as increasing temperatures and reduced moisture availability displaces flora and fauna upslope, including the alpine habitat of this species.

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,v)+2ab(iii,v) for listing as Endangered

The distribution of *E. crassus* is restricted to the high country of the western extent of the ACT (Morgan 1997; Coughran & Furse 2010; Hammer & Beitzel 2019; Austin et al. 2022). Whilst the species can occur as low as ~600 m elevation, it is generally found in sub-alpine and alpine environments above 1000 m above sea level (Morgan 1997). Historical records and recent survey (Hammer and Beitzel 2019; ACT Government 2021) along with molecular analysis (Austin et al. 2022) helped to resolve the range of the species. The species has a restricted distribution: minimum EOO of 227 km^2 and AOO of 60 km^2. Both the EOO and AOO are below the threshold (EOO: <5000 km^2; AOO <500km^2) for listing as Endangered under B1 and B2.

Euastacus crassus has a naturally small range, it is considered a short-range endemic species (Harvey 2002). While the species is known from numerous sites, it is assessed to be restricted to one threat-defined location (IUCN Standards and Petitions Committee 2022), meeting the threshold for listing as Critically Endangered under subcriterion (a). The small range of this species is an important consideration as sites that are close, experience similar conditions over time (e.g., weather, temperature, fire) compared to sites that are at greater distance from each other. Therefore, major threats associated with climate change and fire are more likely to be experienced in a relatively uniform fashion across all or most sites.

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, reduced moisture availability and extreme weather events) and bushfires (and post-fire impacts of invasive ungulates) satisfying subcriterion (b)(iii). The mean annual temperature is expected to increase in the ACT by 0.7°C in the near future (2020–39) and 2°C longer term (2060–79) (OEH 2014). *Euastacus crassus* likely lack the capacity to physiologically adapt or relocate to cooler areas 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 environments is blocked by the warm lowlands (Ponniah & Hughes 2004; Furse et al. 2012a; Bone et al. 2014).

The above data indicate *E. crassus* is eligible for listing as Endangered B1ab(iii,v)+2ab(iii,v) under this criterion. However, the purpose of this consultation document is to elicit additional information to better understand the species' status. This conclusion should therefore be considered to be tentative at this stage, as it may be changed as a result of responses to this consultation process.

Criterion 3 Population size and decline

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

Criterion 3 evidence

Insufficient data to determine eligibility

The estimated total number of mature individuals of this species is unknown, and the number and proportion of individuals in each population or subpopulation is also unknown. 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 estimated total number of mature individuals of *E. crassus* is unknown. 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 for *E. crassus*. 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.

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