AUSTRALIAN CRAYFISH PROJECT
"Conservation & Research"

FINAL REPORT PROJECT 100086

EUASTACUS SURVEYS

PROJECT: 100086
SAVING THE SPINYS: URGENT ACTIONS TO CONSERVE THE
EUASTACUS FRESHWATER CRAYFISH

30th June 2023

ISSUE 2

Prepared by

Robert B McCormack

Final Report 19
Project 100086 to

Aquasave–NGT

Australian
Aquatic Biological

Acknowledgements

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I extend heartfelt thanks to my wife Cheryl, whose unwavering support, companionship during the surveys, and meticulous documentation of survey site results have been invaluable contributions to this endeavour. Additionally, I wish to express my gratitude to my esteemed colleagues in the field, Mark Lintermans and Tarmo Raadik, whose tireless efforts and dedication have significantly enriched our understanding of *Euastacus* species.

As part of the Save the Spinys Project, the genetic analysis of over 70 *Euastacus* species from the Australian Crayfish Project and the Save the Spinys Project was expertly conducted by Chris Austin and Yin Peng Lee from Deakin University. Their invaluable assistance and expertise have propelled significant advancements in our knowledge of *Euastacus* species, for which we are immensely grateful.

Abbreviations

AB Aberrant (Not normal, neither male nor female but both genitals)
AABio Australian Aquatic Biological P/L
a.s.l. Above sea level
ACP Australian Crayfish Project
B Box trap
Berried Female crayfish with a clutch of eggs under the tail
D1-1 Day 1 Site 1
F Female
lm Lineal metre (of stream length)
M Male
OCL Occipital carapace length; measured from the posterior margin of the orbit to the dorsal posterior of carapace (Morgan 1986).
SP Species point – with regard to a Waypoint on GSP and Maps
STSP Save the Spinys Project

Document Information

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FINAL REPORT PROJECT 100086 *EUASTACUS* SURVEYS

Recipient:	Nick Whiterod Ecologist Aquasave–NGT PO Box 2177, Mt Gambier, SA, 5290 nick.whiterod@aquasave.com.au
Copies issued:	Shane Ahyong, Tarmo A Raadik, Mark.Lintermans, Chris Austin.

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Figure 1 The Border Ranges National Park NSW, singed but not severely burnt

Summary

Project motivation

The motivation behind this project stemmed from the direct impact of the prolonged drought and the subsequent 2019/20 mega bushfires on the spiny freshwater crayfish within the *Euastacus* genus. These often overlooked creatures became inconspicuous casualties of the widespread and enduring bushfires that profoundly affected Australia during this period. Like many other freshwater animals, spiny crayfish faced direct consequences as the bushfires swept across the landscape. However, their challenges persisted even after the fires due to subsequent rainfall and runoff carrying burnt timber, ash, and sediment into waterways from the affected areas.

Moreover, the loss of vegetation canopies over cool, flowing streams posed a significant threat to crayfish reliant on cool or cold waters. The alteration of stream hydrology caused by the bushfires further compounded these challenges. These collective impacts continue to pose significant threats to the survival and recovery of these species, with potential repercussions persisting for months and possibly years.

Twenty-two *Euastacus* species were identified as priority species profoundly impacted by the devastating 2019/2020 bushfires (Legge *et al*., 2021a; Legge *et al*., 2021b). In response, the Save the Spinys Project was initiated as part of the Federal Government's Wildlife and Habitat Bushfire Recovery Program. Specifically, within Project 100086, research focused on 18 of these priority species, aiming to comprehensively investigate and support their recovery in the aftermath of the bushfires.

Project aims

The primary objective of Project 100086 was to assess the ramifications of the catastrophic 2019/2020 mega bushfires on 18 prioritized *Euastacus* species. Our goal encompassed conducting comprehensive surveys across all known locations documented for each of these 18 species. The aim was to meticulously compare the current conditions of stream environments and the population health of these species with their pre-fire status.

The Australian Crayfish Project has devoted 16 years to studying these 18 species, providing a valuable baseline for our investigations. Within the constraints of this project's timeframe, our ambition was to survey as many documented occurrence sites for each species as practically feasible.

As part of our efforts, new genetic samples obtained from specimens collected during this project, in addition to selected specimens from the existing ACP collection, were slated for sequencing by Deakin University. This genetic analysis aimed to enhance our understanding of species validity and their distribution patterns, augmenting our insights into the impact of the bushfires on these species.

Overview of the report

The report encapsulates the extensive astacological surveys conducted between August 2020 and March 2022, encompassing research on 18 *Euastacus* species across eastern Australia. Our survey methodology aimed to cover as many documented sites as feasible, relying on presence/absence surveys. However, our efforts encountered significant challenges due to the aftermath of the mega bushfires and subsequent floods that intermittently afflicted the region during the project's duration. Compounding these challenges were the stringent Covid-19 border restrictions and lockdowns, further impeding access to various species' habitats. Despite these formidable constraints, we persevered and successfully completed comprehensive surveys for all the species under investigation.

The report offers an in-depth analysis of each species' health and well-being within the timeframe of 2020-2022, despite the adversities encountered during the surveys. To assess the status of each species, we applied the IUCN criteria from 2019, utilizing all available and current information at our disposal. The assessments provided in this report represent a meticulous evaluation based on the culmination of our survey data and other pertinent sources.

Results Summary

The following is a brief summary of our results for each species with our assessment of the species Conservation listing per the requirements of the IUCN/EPBC Act.

Table 1 Conservation Assessment Summary (order based on survey report completion date)

Report No.	Species	Group	Conservation Listing	Major Threats
1.	*Euastacus dalagarbe* The mud gully crayfish	Dwarf	**Critically Endangered**	Climate refugee at top of catchment. Threatened by drought, illegal fishing, habitat destruction and lack of protection in NSW
2.	*Euastacus jagabar** The blue-black crayfish	Dwarf	**Critically Endangered**	Small population, reproduction difficulties, threatened by drought, illegal fishing, habitat destruction and lack of protection.
3.	*Euastacus girurmulayn* The smooth crayfish	Dwarf	**Endangered**	Climate refugee at top of catchment. Threatened by drought, land clearing, water extraction, illegal fishing and lack of protection
4.	*Euastacus gumar* The bloodclaw crayfish	Intermediate	**Endangered**	Threatened by drought, illegal fishing and lack of protection
5.	*Euastacus pilosus* The hairy cataract crayfish	Intermediate	**Endangered**	Threatened by drought, illegal fishing and lack of protection.
6.	*Euastacus jagara* The Jagara hairy crayfish	Dwarf	**Critically Endangered**	Climate refugee at top of catchment. Threatened by drought and climate change.
7.	*Euastacus suttoni** Sutton's crayfish	Giant	**Endangered**	Climate refugee at top of catchment. Threatened by land clearing, stock grazing, drought, illegal fishing, *Cherax destructor* and lack of protection in NSW.
8.	*Euastacus spinichelatus* The small crayfish	Dwarf	**Endangered**	Climate refugee at top of catchment. Threatened by land clearing, stock grazing, drought, bushfire and lack of protection in NSW
9.	*Euastacus gamilaroi* The Gamilaroi crayfish	Intermediate	**Endangered**	Climate refugee at top of catchment. Threatened by severe bushfire, land clearing, stock grazing, drought, illegal fishing, *Cherax destructor* and lack of protection in NSW.
10.	*Euastacus simplex* The small mountain crayfish	Intermediate	**Endangered**	Climate refugee at top of catchment. Threatened by climate change, land clearing, stock grazing, drought, illegal fishing, *Cherax destructor* and lack of protection in NSW.

11.	*Euastacus morgani* Morgan's crayfish	Intermediate	**Critically Endangered**	Threatened by climate change, drought, and lack of protection in NSW.
12.	*Euastacus guwinus* The Tianjara crayfish	Intermediate	**Critically Endangered**	Climate refugee at top of catchment. Threatened by climate change, drought, illegal fishing, and lack of protection and threatened by *Cherax destructor*
13.	*Euastacus clarkae* Ellen Clark's crayfish	Intermediate	**Endangered**	Climate refugee at top of catchment. Threatened by severe bushfire, climate change, drought, illegal fishing, exotic trout and lack of protection.
14.	*Euastacus polysetosus* The many-bristled crayfish	Intermediate	**Endangered**	Climate refugee at top of catchment. Threatened by climate change, drought, illegal fishing, lack of protection, exotic trout, bushfire and brumbies.
15.	*Euastacus claytoni* Clayton's crayfish	Intermediate	**Endangered**	Climate refugee at top of catchment. Threatened by climate change, land clearing, stock grazing, drought, illegal fishing, exotic trout, *Cherax destructor* and lack of protection in NSW
16.	*Euastacus bidawalus* The Bidhawal crayfish	Intermediate	**Endangered**	Threatened by climate change, land clearing, stock grazing, drought, illegal fishing and lack of protection in NSW
17.	*Euastacus diversus* The Orbost spiny crayfish	Intermediate	**Endangered**	Threatened by climate change, drought, illegal fishing, severe bushfire, exotic trout and threatened by *Cherax destructor*
18.	*Euastacus coughrani* sp.nov Coughran's crayfish	Intermediate	**Endangered**	Threatened by climate change, drought, illegal fishing, severe bushfire, exotic trout and threatened by *Cherax destructor*

NOTES:
*Euastacus jagabar** species currently in severe stress and this is more than likely the next species in NSW to go extinct within 20 years.
*Euastacus suttoni** species in significant decline, this is more than likely to be the first *Euastacus* in Queensland to go extinct within 20 years.

Figure 2 Burnt Forests and National Parks was the theme for this project

Introduction

Spiny freshwater crayfish belonging to the *Euastacus* genus became inconspicuous casualties of the extensive and enduring bushfires that significantly impacted Australia in 2019/20. Similar to numerous other freshwater species, these spiny crayfish faced direct consequences as the bushfires ravaged the landscape. Moreover, subsequent rainfall and runoff from burnt areas carried debris such as burnt timber, ash, and sediment into waterways, further affecting their habitats. The loss of vegetative cover over cool flowing streams also posed severe threats to crayfish reliant on these specific environmental conditions. The enduring repercussions of these impacts continue to jeopardize the survival of these species, potentially persisting for months or even years.

The *Euastacus* genus stands as the largest among the 10 Australian crayfish genera, currently (2023) comprising 54 described species. Notably, an additional 4 new species await publication, and there is potential for an additional 23 new species to be described (Austin *et al.,* 2022). These 54 *Euastacus* species account for 37% of all Australian freshwater crayfish species. Alarmingly, 80% of these *Euastacus* species are listed as threatened on the IUCN Red List, positioning *Euastacus* among the most threatened genera globally (Richman *et al*., 2015).

Within this context, 22 *Euastacus* species were identified as priority species profoundly affected by the devastating 2019/2020 bushfires. Initiated as part of the Federal Government's Wildlife and Habitat Bushfire Recovery Program, Project 100086 was launched specifically to conduct astacological surveys on 18 of these 22 priority species. The research on the remaining 4 species was carried out by separate researchers as part of this initiative.

Project Aims

The aim of this project is to investigate the impact of the devastating 2019/2020 bushfires on 18 of the 22 priority *Euastacus*. We aim to survey all the known locations documented for each species and compare the current on ground stream conditions and species population and health with those that existed pre fire. *Euastacus* has been previously well researched by the ACP between 2005-2020. The current project information will be compared with information gathered in the previous surveys.

Methods

McCormack (2012) pragmatically divided the *Euastacus* of Australia into 3 groups (dwarf, intermediate and giant) based on shared morphological and biological traits. Each of the species researched in this project are delegated to one of these groups and the method most suitable for each group were utilised in this project.

We are conducting presence/absence surveys for the target species at each survey site, plus a population estimate for these species. Survey sites are selected from the known history of the species. For this project we attempt to sample as many sites that the species is known to occur, as physically possible within the time constraints of this project.

Standard astacological survey methods (suitable to each crayfish group) were utilised for this project at each survey site. Typically, specimens were captured by hand or baited traps to identify the species. Methods included setting baited box traps, lifting structures and probing or excavating burrows. Visual observations of burrow structure, habitat preferences and general stream conditions and water temperature were also documented.

Specimens were identified on site and either a tissue sample taken, and the specimen released, or specimens were vouchered for further morphological examination and comparison.

1. Specimen tissue sampled for genetic analysis and released.

- Live specimen is weighed on a MH-Series pocket scale to 0.01 grams.
- Live specimens are measured (OCL) with digital Vernier callipers.
- A section of the fourth walking leg (right side) is snipped to supply a genetic sample.
- Sample is retained in 100% ethanol to better retain genetic integrity.
- Specimen is released back to the wild.

The genetic sample is sent to Deakin Genomics Centre, School of Life and Environmental Sciences, Deakin University, Pigdons Rd, Geelong, VIC.

Figure 3 Fourth walking leg on right hand side taken as sample

Justification: The right hand side is always sampled to ensure identification of any recaptures and this is the easiest for me to hold in my left hand and use scissors to cut into a container with my right hand. The fourth walking leg is the preferred sample location for all crayfish species of both sexes. With large crayfish it is not so important as the sample needed is small and the crayfish large, however, for the smaller crayfish species the size of the sample is significant. The fourth walking leg offers an optimal balance between obtaining a sufficient genetic sample and minimizing the impact on the crayfish. Furthermore, the fourth leg is chosen for its relatively lesser impact on the crayfish compared to other appendages. Legs are rich in muscle tissue and experience robust blood flow, making them prone to natural loss or regeneration. Additionally, the wound from the sample instantly seals, and the limb regenerates swiftly, ensuring minimal long-term impact or discomfort to the crayfish post-sampling. This strategic choice prioritizes the welfare and minimal disturbance to the specimen while ensuring an effective genetic sampling process.

2. Selected voucher specimens were retained for further taxonomic examination.

- Specimens are photographed in life
- Specimens are weighed alive on a MH-Series pocket scale to 0.01 grams.
- Live specimens are measured (OCL) with digital Vernier callipers,
- A section of the fourth walking leg is snipped to supply a genetic sample for the Deakin Genomics Centre, School of Life and Environmental Sciences, Deakin University, Pigdons Rd, Geelong, VIC.
- Sample is retained in 100% ethanol to better retain genetic integrity.
- A section of the fourth walking leg is snipped to supply a genetic sample for Carnegie Museum.

- Sample is retained in a genetics tube filled with cell lysis buffer for subsequent DNA analysis, as part of the broader ACP via our Carnegie Museum of Natural History, USA genetics program.
- Live specimens are then euthanized by freezing (typically overnight)
- Then preserved in 70% ethanol and deposited in the collections of the Australian Crayfish Project (ACP), Australian Museum, Sydney (AM), Queensland Museum (QM), Museum Victoria (MV) and Carnegie Museum of Natural History, USA (CMNH).

Additionally, results of surveys will be included in the NSW Bionet (Atlas of NSW Wildlife http://www.bionet.nsw.gov.au/).

Vouchered specimens were taxonomically examined under a Premiere dissection microscope. Morphological terminology, measurements, and size descriptors including follow Morgan (1997). Terminology for size, sharpness and density of spines and tubercles on the carapace, abdomen and major cheliped, such as “small”, “medium”, “large”, “moderate”, “dense” etc, is as defined and figured by Morgan (1997). Specimen measurements are of carapace length (CL), measured along the midline from the apex of the rostrum to the posterior margin of the carapace, and occipital (postorbital) carapace length (OCL) measured from the posterior margin of the orbit to the posterior margin of the carapace.

An intensive polygenetic study of the *Euastacus* genera as part of the Save the Spinys Project has discovered significant new information on the species and their distributions (Austin *et al*., 2022).

Molecular Taxonomy

The molecular taxonomy aspect of this research involved the acquisition of tissue samples, extracted from crayfish leg muscle tissue. These samples were subjected to sequencing procedures at the Deakin Genomic Centre, situated within Deakin University, Victoria.

The sequencing process encompassed the analysis of next-generation sequence datasets from a total of 234 samples. This dataset included mitochondrial genes extracted during the primary main analysis, comprising 202 new sequences along with two unpublished sequences denoted as CA201 to CA202. Additionally, a supplementary targeted analysis involving 32 sequences, coded as CA210 to CA241, was conducted.

These analyses collectively spanned samples obtained from 173 distinct waterways spanning across 35 river basins situated in eastern Australia. The sampling range extended from the Glenelg River Basin (housing E. *bispinosus*) in southwestern Victoria to the Brisbane River Basin (home to *E. jagara*) in southern Queensland (*Austin et al*., 2022). This extensive geographical coverage facilitated a comprehensive molecular investigation of various *Euastacus* species across diverse river basins in the eastern Australian region.

Figure 4 Rob McCormack taking a genetic sample of *E. guwinus* prior to release

Survey Locations & Constraints

Survey locations were recorded using a Garmin 64S handheld GPS and/or a Hema HX Navigator, and or a Garmin Drivetrack 71 GPS. At each survey location the time, GPS Coordinates, elevation, distance, stream and air temperature were recorded. The stream condition and bushfire impacts are documented.

Survey locations were allocated based on the knowledge base. The ACP has a vast data base on each species, and this was utilised as the base source of sites of occurrence. We then added all sites from original descriptions, plus any later species manuscripts and Museum Parastacidae collection records.

Unfortunately, many of the original species' descriptions and early museum collections do not have accurate information as to where the sample was collected and we need to allocate a site that is "best guess".

One of the major obstacles to the project were border closures. Our next problem was that the bushfires had devastated the forests, then the storm damage and flooding that followed further destroyed access with landslides and washed-out roads. Even roads that had been cleared were subject to constant new landslips and treefalls which made both getting into sites and out of sites a major effort.

Figure 5 Closed borders (Rob McCormack at NSW/Qld Border. Lions Road)

Figure 6 Fallen trees and blocked roads was a major problem

Figure 7 Trees, trees and more trees across our track

Figure 8 Road closures were another major problem

Figure 9 Burnt or destroyed bridges dramatically restricted access

Figure 10 Constantly clearing obstacles slowed our progress significantly

Figure 11 Even when we made it to a site, snakes were a constant threat and kept us on guard. A, Pythons were abundant in every State. B, Rough scaled snakes were a problem in Qld. C, Brown snakes were a problem in NSW

Figure 12 Unfortunately, many roads no longer existed, they had fallen into disuse over the last 10 years or so

Figure 13 Driving through flood waters is always both risky and scary (Crossing the Gloucester River in full flood)

Figure 14 Some sites/access was permanently barred from our surveys for the full duration of this 2 year project (Barrington Tops National Park road closure)

Preparation

The preparatory phase preceding each survey expedition involved meticulous planning and logistics:

- Species List and Mapping: Compilation of a species list detailing all known GPS locations followed by the creation of ARC GIS and Basecamp maps. These maps were transferred to laptops, vehicle GPS units, and handheld devices. The mapping phase involved plotting survey locations, outlining access points, exit routes, and establishing general timelines for the surveys.
- Contact was made with National Park Rangers/Forestry managers re access and road conditions, etc. Additionally, arrangements regarding nightly accommodations in the survey areas were made in advance.
- Vehicle Maintenance: The survey vehicle underwent thorough cleaning at a local car wash. The underside of the vehicle was pressure-cleaned with soapy water and rinsed.
- Equipment and Gear: All survey equipment such as traps, nets, boots, and waders were meticulously cleaned and prepared for use.
- Supplies: Water bottles, hand and foot sterilization bottles, ethanol bottles, etc., were cleaned, refilled, and readied for fieldwork.
- Food and Drink Preparation: The vehicle's fridge-freezer was activated a day prior, stocked with food and drinks. Additionally, a travel esky in the vehicle was filled with sandwiches and fruits to ensure immediate availability upon departure, typically scheduled for the early hours between 3-4 am.

This comprehensive preparatory routine ensured that all logistical and equipment-related aspects were meticulously addressed, guaranteeing a smooth start to each survey expedition.

Bushfire

Bushfire severity is categorised as per the Federal Governments classification:

Table 2Bushfire severity

Severity category	Description	Aquatic equivalents
Unburnt	Understory and canopy unburnt	No impact to aquatic ecosystem
Low	Burnt understory with unburnt canopy. For grasslands without a canopy it represents unburnt grass.	Limited impact in relation to ash and sediment influx, burnt organic matter and water quality
Medium	The canopy is partially burnt. A mix of burnt and unburnt canopy vegetation. May act as a refugia within the fire ground that may act for native fauna. The	Moderate impact in relation to ash and sediment influx, burnt organic matter and water quality

	understorey may be burnt.	
High	The canopy and understory are likely to be completely burnt (scorched)	High impact in relation to ash and sediment influx, burnt organic matter and water quality
Very high	The canopy or highest stratum have been completely consumed.	Very high impact in relation to ash and sediment influx, burnt organic matter and water quality

Stream condition assessment is categorised by the following table:

Table 3 Stream condition

Stream condition	Water flow	Riparian zone	Stream Bed
Excellent	Normal	Natural vegetation	Natural
Good	Flowing but not at capacity	Natural vegetation & exotic	Some problems
Poor	Just flowing or pooled	None native vegetation	Partly sedimented
Bad	No flow	No vegetation	Fully sedimented or scoured

Population Estimates

Species population estimates are given as number of individuals per lineal metre of stream length (lm). Population estimates are entirely subjective and represent best guess. Estimates are based on a large number of factors. If crayfish are abundant and easily captured, then estimates are easy. When crayfish are not easily captured then an estimate of their presence and population numbers can be estimated from burrow entrances per lineal metre of stream length.

Burrow entrances can be counted over a given length of stream, to give a total number. This then needs to be sorted into active and inactive burrows (species present in burrow or an old, abandoned burrow). Active burrows are indicated by freshly excavated material, smooth surfaces and or moisture, etc. Inactive burrows show no sign of recent use, fine particles, debris, dust, cobwebs, etc.

Caution: Multiple crayfish species may occur together within any lineal metre of stream length. Some species only have one burrow entrance, some species have multiple burrow entrances; the researcher needs to know exactly which species occur in the region and each of

those species burrow preferences for construction and location within the stream bed or forest floor, etc. For the intermediate and giant group crayfish species, baited traps can be used to lure crayfish from their burrows. Placement of traps consecutively along a stream can also be used to estimate population numbers.

Figure 15 *Euastacus guwinus* an intermediate group crayfish on top of trap

Traps both catch crayfish and also attract crayfish to the trap or the immediate area of the traps. Good observational skills are required when checking traps to see just how many crayfish have been lured from their burrows.

Figure 16 Using Flags to count burrow entrances A, *E. morgani*; B, *E. claytoni*

The *Euastacus* Species

The 2019–20 megafires were predicted to have significantly impacted 22 species of *Euastacus* (Legge *et al*., 2021a; Legge *et al*., 2021b) of these 18 were investigated as part of Project 100086 (Blue table 4).

Table 4. 22 Priority species, Blue Project 100086; Green other investigators

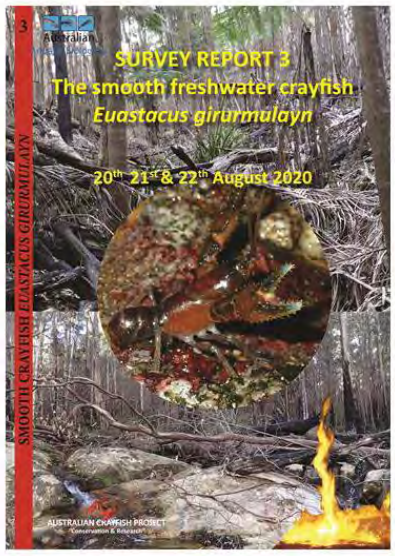
Number	Common Name	Scientific Name	Authority
1	Bidhawal crayfish	*Euastacus bidawalus*	Morgan, 1986
2	Ellen Clark's crayfish	*Euastacus clarkae*	Morgan, 1997
3	Clayton's spiny crayfish	*Euastacus claytoni*	Riek, 1969
4	Alpine crayfish	*Euastacus crassus*	Riek, 1951
5	Mud gully crayfish	*Euastacus dalagarbe*	Coughran, 2005
6	Orbost Spiny crayfish	*Euastacus diversus*	Riek, 1969
7	Gamilaroi crayfish	*Euastacus gamilaroi*	Morgan, 1997
8	Smooth crayfish	*Euastacus girurmulayn*	Coughran, 2005
9	Bloodclaw crayfish	*Euastacus gumar*	Morgan, 1997
10	Tianjara crayfish	*Euastacus guwinus*	Morgan, 1997
11	Blue-black crayfish	*Euastacus jagabar*	Coughran, 2005
12	Jagara hairy crayfish	*Euastacus jagara*	Morgan, 1989
13	Morgan's crayfish	*Euastacus morgani*	Coughran & McCormack, 2011
14	Hairy cataract crayfish	*Euastacus pilosus*	Coughran & Leckie, 2007
15	Many-bristled crayfish	*Euastacus polysetosus*	Riek, 1951
16	Riek's crayfish	*Euastacus rieki*	Morgan, 1997
17	Small mountain crayfish	*Euastacus simplex*	Riek, 1956
18	Small crayfish	*Euastacus spinichelatus*	Morgan, 1997
19	Sutton's crayfish	*Euastacus suttoni*	Clark, 1941
20	Coughran's crayfish	*Euastacus coughrani* n.sp	McCormack & Fetzner 2022 (in prep)
21	Cann Spiny Crayfish	*Euastacus sp*. 2	TBA-
22	West Snowy Spiny Crayfish	*Euastacus sp*. 3	TBA-

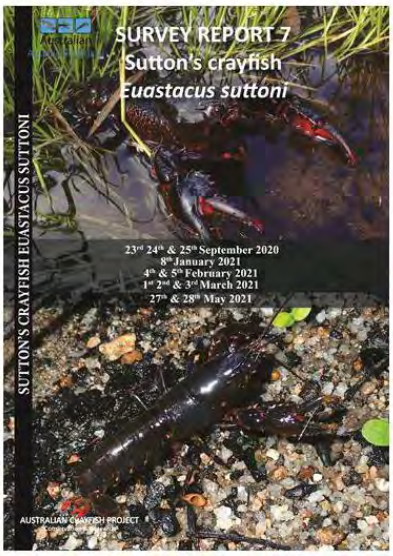
Mark Lintermans and Tarmo Raadik were the other investigators field researching the four other *Euastacus* as part of the Save the Spinys Project.

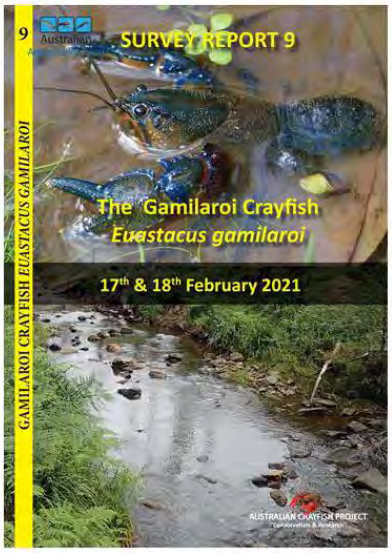
Survey Results

Each species was surveyed with the results tabled in astacological survey reports 1-18 issued to Aquasave-NGT. The following provides a precis of each species and its current population health and overall prosperity. Each species has been assessed against current IUCN Red List Category (IUCN Version 14 August 2019) based on current data documented in survey

reports 1-18. For full details see individual reports. A total of 18 Astacological Survey reports were issued on the 18 priority *Euastacus* species. These reports are represented by their covers below.





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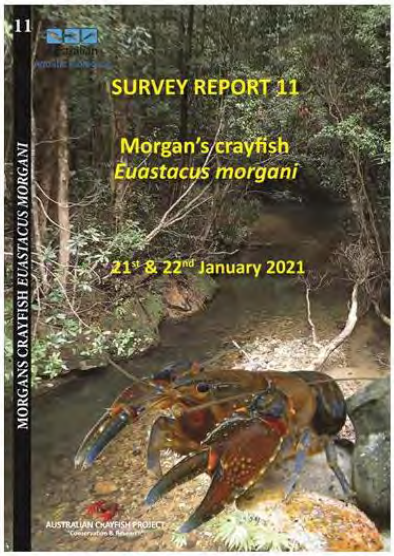
SURVEY REPORT 10
The small mountain Crayfish
Euastacus simplex
2nd March 2020
27th, 28th & 29th May 2021
18th October 2021
10th & 11th February 2022
THE SMALL MOUNTAIN CRAYFISH EUASTACUS SIMPLEX
AUSTRALIAN CRAYFISH PROJECT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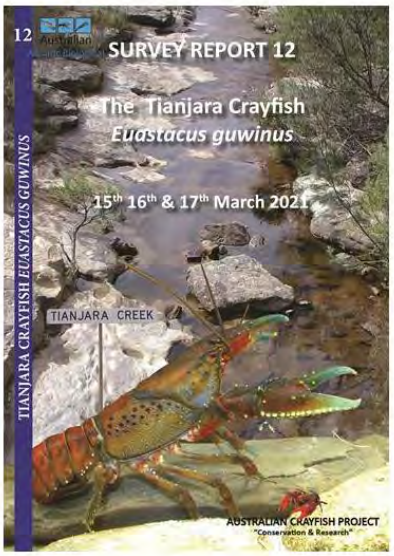
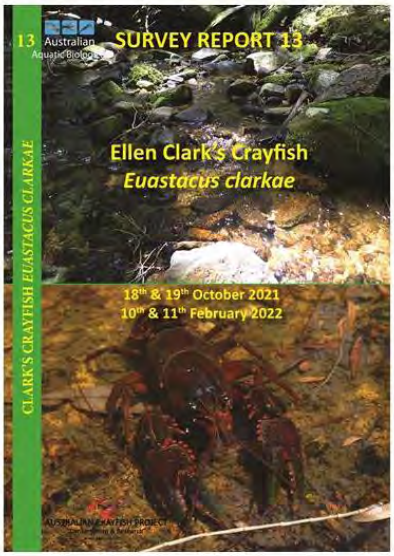
SURVEY REPORT 11
Morgan's crayfish
Euastacus morgani
21st & 22nd January 2021
MORGANS CRAYFISH EUASTACUS MORGANI
AUSTRALIAN CRAYFISH PROJECT


12
SURVEY REPORT 12
The Tianjara Crayfish
Euastacus guwinus
15th 16th & 17th March 2021
TIANJARA CREEK
TIANJARA CRAYFISH EUASTACUS GUWINUS
AUSTRALIAN CRAYFISH PROJECT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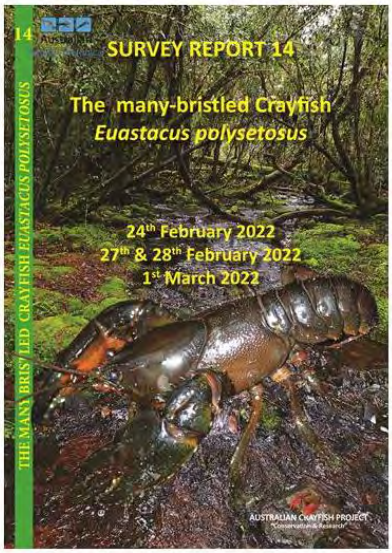
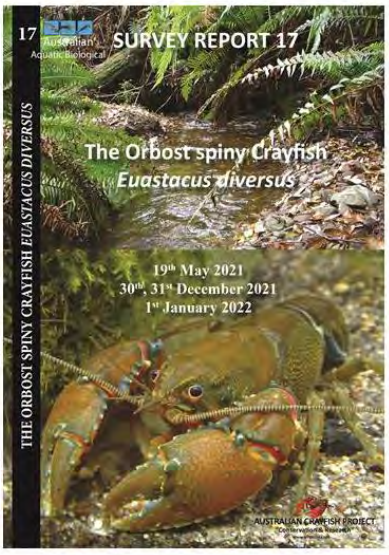
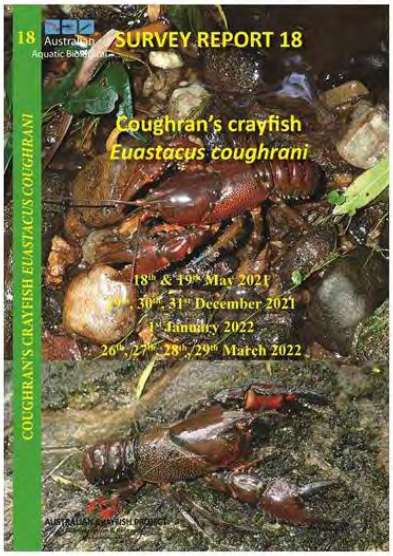
SURVEY REPORT 13
Ellen Clark's Crayfish
Euastacus clarkae
18th & 19th October 2021
10th & 11th February 2022
CLARK'S CRAYFISH EUASTACUS CLARKAE


14
SURVEY REPORT 14
The many-bristled Crayfish
Euastacus polysetosus
24th February 2022
27th & 28th February 2022
1st March 2022
THE MANY BRISTLED CRAYFISH EUASTACUS POLYSETOSUS
AUSTRALIAN CRAYFISH PROJECT


15
SURVEY REPORT 15
Clayton's Crayfish
Euastacus claytoni
10th 11th & 12th April 2021
27th 28th 29th & 30th April 2021
27th 28th & 29th March 2022
CLAYTON'S CRAYFISH EUASTACUS CLAYTONI
AUSTRALIAN CRAYFISH PROJECT


16
SURVEY REPORT 16
Bidhawal Crayfish
Euastacus bidawalus
11th April 2021
28th, 29th & 30th April 2021
18th May 2021
BIDHAWAL CRAYFISH EUASTACUS BIDAWALUS
AUSTRALIAN CRAYFISH PROJECT


17
SURVEY REPORT 17
The Orbost spiny Crayfish
Euastacus diversus
19th May 2021
30th, 31st December 2021
1st January 2022
THE ORBOST SPINY CRAYFISH EUASTACUS DIVERSUS
AUSTRALIAN CRAYFISH PROJECT


18
SURVEY REPORT 18
Coughran's crayfish
Euastacus coughrani
18th & 19th May 2021
30th, 31st December 2021
1st January 2022
26th, 27th, 28th, 29th March 2022
COUGHRAN'S CRAYFISH EUASTACUS COUGHRANI
AUSTRALIAN CRAYFISH PROJECT

The assessment of Extent of Occurrence (EOO) and Area of Occupancy (AOO) for conservation purposes has been conducted through GeoCAT reduction analyses. GeoCAT facilitates data-driven conservation assessments in a transparent, repeatable, and efficient manner within a user-friendly framework (Bachman *et al.,* 2011). These analyses rely on the most recent data on actual occurrence sites, excluding traditional historic sites where some species, such as *E. simplex* and *E. suttoni*, for example, are now extinct due to habitat unsuitability caused by extensive development in Australia over the past 50 years, which has significantly altered species distributions.

Species validity was established or revised through the Save the Spinys Project (STSP), a comprehensive molecular taxonomic analysis representing a significant advancement in *Euastacus* taxonomy. It integrated targeted field surveys and examined curated sample collections, generating over 200 new *Euastacus* sequence datasets via genome skimming. By combining these datasets with publicly available COI gene sequences submitted to GenBank, a comprehensive dataset encompassing all recognized *Euastacus* species and potential new species was compiled (Austin *et al.,* 2022).

McCormack's pragmatic division of Australian *Euastacus* into three groups—dwarfs, intermediates, and giants—was based on shared morphological, biological, and ecological traits. Each species was allocated to one of these groups, and survey methods were tailored to suit the characteristics of each group.

For instance, the dwarf group, characterized as small, often referred to as hairy crayfish, typically lack thoracic spines and have limited spine development (poorly spinose). They exhibit 3-5 mesial carpal spines, possess a male cuticle partition, tend to inhabit marginal areas, coexisting with intermediate and giant group species. Their cryptic nature and proficiency in extensive burrow-building make them challenging to capture. Juveniles are easily distinguished from intermediate and giant group crayfish as they lack light bands on somites 1 & 6. This group exhibits lower fecundity and smaller population numbers. While occasionally found in traps at the upper catchment, they are predominantly captured by hand, under rocks, or through burrow excavation due to their behaviour and habitat preferences.

Assigning each of the 18 species in this report to a specific group facilitates a more comprehensive understanding among stakeholders regarding the species' unique traits, biological characteristics, and habitat requirements, aiding in tailored conservation and management strategies.

Euastacus dalagarbe

AUSTRALIAN CRAYFISH PROJECT "Conservation & Research"

Euastacus dalagarbe is a very small crayfish of the dwarf group that prefers muddy gullies, hence the common name. One of an increasing number of dwarf crayfish from the northern region of New South Wales and SE Qld.

DISTRIBUTION

Euastacus dalagarbe has a small distribution over a small area of north-eastern New South Wales and south-eastern Queensland. Found in micro streams and wet gullies feeding Gradys, Brindle, Sheepstation and Collins creeks, all tributaries of the Richmond River NSW and Running Creek, Logan River drainage, Lamington National Park, Qld.

NEW KNOWLEDGE

As a result of this project the molecular taxonomy analyses by Austin et al. (2022) confirmed *E. dalagarbe* as a distinct taxon, and also identifying the species distribution in the adjacent Logan River drainage, Qld.

ABUNDANCE

Populations can be high in suitable areas, with 3–5 per lineal metre of stream length; other more marginal sections of the stream may only have one per every 6 lm.

Drought has eliminated the species from many upper sections of stream.

Species specific points of note:

- **Subterranean habit**
- **Climate refuge at top of catchment**
- **Cool water species**
- **Permanent water species**
- **Highland species 570-999 m a.s.l.**
- **Small AOO = 40 km²**
- **Critical maximum water temp = 23˚C**
- **Type 2 Burrows**
- **Nocturnal**

Current IUCN Assessment

Euastacus dalagarbe satisfies the IUCN Red List criteria for listing as Critically Endangered, CR B1+2(a), (b) iii, based on: an EOO , <100 km^2 (72.225 km^2), AOO 40 km^2, severely restricted and fragmented distribution (five known headwater streams, in two drainage divisions/all within Gondwana Rainforest = 1 site), and anticipated decline in area, extent and/or quality of habitat and EOO due to climate change, with threats from rising water temperatures, bushfire and drought.

DWARF GROUP

The largest specimen documented in our research project was ACP Spec 465, 28 grams, 37.2 mm OCL, from Collins Crk, Border Ranges National Park.

CONSERVATION FACTORS

A climate refuge restricted to cool water over 570 m a.s.l. in the uppermost catchment.

The species only occurs where permanent water is available. Surface water is not a prerequisite but permanent subsurface ground water is. This project documents reduced distributions in upper catchment due to drought.

Euastacus dalagarbe dependent on the presence of stream lily or visa versa. Stream lily seems to be a reliable indicator of suitable habitat.

Our surveys suggests a very small female breeding pool, low fecundity (35 eggs) and large egg size similar to that noted for other dwarf spiny crayfish species .

CURRENT THREATS

Climate Change	High
Drought	High
Illegal Fishing	High
No protection/enforcement	High
Future bushfires	Med
Exotic disease	Med
Competitive species	Med

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AUSTRALIAN CRAYFISH PROJECT "Conservation & Research"

Euastacus jagabar

Euastacus jagabar is a small dwarf group crayfish from north-eastern New South Wales. It is small, rare, secretive, elusive, and a pretty species (McCormack, 2012).

DISTRIBUTION

Euastacus jagabar is a lowland species requiring permanent water, distributed from 330 m to 430 m a.s.l. in the middle catchment of Sheepstation Creek a tributary of the Richmond River, NSW.

ABUNDANCE

No information is available on the abundance of this species. It is considered extremely rare with an extremely small population in an extremely small area.

When only two specimens of a species have ever been documented with eggs, and each of those specimens some 13 years apart only have 2 eggs per female is an alarming trend, of critical conservation concern. Typically, when I start catching females with only a few eggs they are usually from populations that are in stressful environments and in serious trouble.

Species specific points of note:

- **Subterranean habit**
- **Lowland species**
- **Cool water species**
- **Permanent water species**
- **Tiny AOO = 8 km²**
- **Type 2 Burrows**
- **Species stressed with high egg loss**
- **Habitat destruction**
- **Likely the first NSW *Euastacus* to go extinct**

Current IUCN Assessment

Euastacus jagabar satisfies the IUCN Red List criteria for listing as Critically Endangered, CR B1+2(a), (b) iii, based on: an EOO , <100 km2 (actual 0.256 km^2 = 8 km^2) & AOO < 10 km2 (8 km^2); severely restricted and fragmented distribution (1 site), and anticipated decline in area, extent and/or quality of habitat and EOO due to climate change, with threats from rising water temperatures, bushfire and drought .

DWARF GROUP

The largest specimen documented in our research project was ACP Spec 972, 21 grams, 36.26 mm OCL, from Sheepstation Creek, Border Ranges National Park, NSW.

CONSERVATION FACTORS

All habitat areas are well shaded, rainforest canopied clear flowing streams.

At all site where *E. jagabar* occurred either Piccabeen or Bangalow Palms (*Archontophoenix cunninghamiana*) or Rainforest Spinach (*Elatostema reticulatum)* or both occurred At all sites where *E. jagabar* was documented *E. sulcatus* was also present. *E. jagabar* is dominated by *E. sulcatus* and restricted to marginal habitats, within a deep burrow system.

Our surveys suggests a small female breeding pool, low fecundity (30 eggs) and large egg size (3.12 mm diameter), similar to that noted for other dwarf spiny crayfish species of *Euastacus*

CURRENT THREATS

Climate Change	High
Drought	High
Competitive species	High
Illegal Fishing and Collection	High
No protection/enforcement	High
Reproduction problems	High
Habitat destruction (rock flipping)	High
Future bushfires	Med

AUSTRALIAN CRAYFISH PROJECT
"Conservation & Research"

Euastacus girurmulayn

Euastacus girurmulayn is a very small smooth-shelled dwarf group crayfish. It is one of the rarer and harder to find crayfish from the northern region of New South Wales. (McCormack 2012)

DISTRIBUTION

Euastacus girurmulayn has a very restricted distribution; only found in micro streams and wet gullies feeding Tuntable, Terania, Gibbergunyah, Rocky and Coopers creeks, which are all tributaries of the Wilsons River, north of Lismore. Plus Chowan Creek, tributary of Tweed River, NSW.

NEW KNOWLEGE

As part of this project molecular taxonomy analyses of Austin et al. (2022) confirmed its validity as a in distinct species and extended its distribution into Goonengerry National Park and Mount Jerusalem National Park (Tweed River drainage). We lower the habitat preference to over 110 m.

Abundance

Most streams only 1 occasionally 2 crayfish per lineal metre of stream length. Perfect habitat areas up to 5-6/lm of stream .

Species specific points of note:

- **Subterranean habit**
- **Climate refuge**
- **Cool water species**
- **Rainforest species**
- **Permanent water species**
- **Drought major threat**
- **Small AOO = 36 km²**
- **Critical maximum water temp = 23˚C**
- **Type 2 Burrows**
- **Nocturnal**

Current IUCN Assessment

Euastacus girurmulayn satisfies the IUCN Red List criteria for listing as Endangered, B1+2(a), (b) iii, based on: an EOO , <120.823 km^2 & AOO < 36 km^2; severely restricted and fragmented distribution (1 site), and anticipated decline in area, extent and/or quality of habitat and EOO due to climate change, with threats from rising water temperatures, bushfire and drought .

DWARF GROUP

A very small species known to only reach 18 g and 34.7 mm OCL. The largest captured in this survey a female (berried) 15.87 gram, 32.62 mm OCL with 24 eggs (Egg size 2.8 x 3.4; 2.71 x 3.46 mm).

CONSERVATION FACTORS

Restricted to marginal areas and restricted to within an Type 2 extensive burrow network .

Of significance is that our surveys indicate that *E. girurmulayn* is intrinsically linked to the stream lily *Helmholtzia glaberrima*.

Although, Piccabeen or Bangalow Palms *Archontophoenix cunninghamiana* were also present at all sites where *E. girurmulayn* was found, they were also at many sites where they were not found. Stream lily only occurred where *Euastacus girurmulayn* occurred.

Female maturity >30 mm OCL, breeding commences May-June with release juveniles December. Fecundity is low with females baring 21-24 large eggs.

CURRENT THREATS

Mega Bushfires	High
Future bushfires	High
Climate Change	High
Drought	High
Warming water	High
Land clearing/rainforest loss	High
No protection/enforcement	High

Euastacus gumar

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This is an intermediate crayfish with a very limited distribution in northern New South Wales. Both overall populations and general distribution of this species are small. (McCormack 2012)

DISTRIBUTION

Known distribution is in tributaries of the Clarence and Richmond rivers. Generally found over 250 m a.s.l. with largest populations around the 450 to 500 m level. In the Clarence drainage in the Tooloom and Richmond ranges, main populations are known from the Gorge, Peacock, Culmaran, Tunglebung, Haystacks and Yabbra creeks. In the Richmond drainage they are known from streams in the Richmond Range, with populations also known from Myrtle, Mongogarie and Cherry Tree creeks.

NEW KNOWLEDGE

Confirmed as a distinct species however, genetic divergence between *E. gumar* and *E. pilosus* was the lowest found between pairs of described species in this study, with the strong possibility that *E. pilosus* is a variant of *E. gumar* (Austin et al. 2022)

Species specific points of note:

- **Forest stream species**
- **Drought a major threat**
- **Cool water species**
- **Distribution unknown**
- **EOO unknown and further surveys are required to define distribution**
- **Distribution extent unknown**
- **Type 1 & 2 Burrows**

Current IUCN Assessment

Euastacus gumar Endangered B1(a),(b)iii based on EOO: 1686 km^2 and AOO: 64 km^2, severely fragmented distribution (three distinct locations), and anticipated decline in area, extent and/or quality of habitat and EOO due to climate change.

This assessment is now in doubt as *E. pilosus* was not distinguished as a valid species in this study. Reassessment is recommended.....

INTERMEDIATE GROUP

Reaches a maximum size of 43 g and 44.2 mm OCL.

The largest specimen collected in this survey was from Cherry Tree Creek, Mallanganee National Park, (Richmond River drainage). 34.25 gram, 40.21 mm OCL.

CONSERVATION FACTORS

Euastacus gumar is an intermediate group crayfish that excavates a very deep burrow into subsurface groundwater when needed. A hardy and adaptable species, that occurs in streams with surface flows may occasionally run dry, relying on their deep burrows for survival. Burrows can be constructed from deep below water level in the stream bed to well above water level. Burrows are typically in the stream bed or along the stream banks.

Not all females breed each year. Females mature at approximately 30 mm OCL, and capable of carrying medium batches of 20–150 crimson eggs

CURRENT THREATS

Land clearing	High
Drought	High
Climate Change	High
Invasive species	High
Illegal Fishing	High
No protection/enforcement	High
Altered hydrology	High

Euastacus pilosus

Euastacus pilosus is a small intermediate group crayfish found in a relatively small region of northern New South Wales. This is a relatively newly discovered species that closely resembles *Euastacus gumar*, found in the same general area. (McCormack 2012)

DISTRIBUTION

Small known distribution in the lower parts of tributary streams of the Cataract and upper Clarence rivers, 20 to 50 km north-east of Tenterfield, New South Wales. The main populations can be found in Flaggy, Slaty, Crooked and Morgan creeks (Cataract River), Bull Camp Creek (Boonoo Boonoo River), Pretty Gully Creek (Clarence River) and Long Creek (Timbarra River). Known to occur from 330 – 850 m a.s.sl.

NEW KNOWLEDGE

As part of this project Austin et al. (2022) did not confirm *E. pilosus* as a distinct species; genetic divergence between the *E. gumar* and *E. pilosus* was the lowest found between pairs of described species in this study, with the strong possibility that *E. pilosus* is a variant of *E. gumar.*

ABUNDANCE

Populations can be high in suitable areas, with 2–3 per lineal metre of stream; other more marginal sections of the stream may only have one per every 10 lineal metres. Most streams only 1/lm crayfish per lineal metre of stream length. Perfect habitat areas up to 6/Lm of stream.

Species specific points of note:

- **Needs forested stream**
- **Drought a major threat**
- **Cool water species**
- **Permanent water species**
- **Type 1 & 2 Burrows**

Current IUCN Assessment

IUCN Status: EN B1(a),(b)iii based on EOO: 459 km^2, and AOO: 52 km^2, fragmented distribution (restricted to highland sites of different streams), and anticipated decline in area, extent and/or quality of habitat and EOO due to climate change.

This assessment is in doubt as *E. pilosus* was not distinguished as a valid species in this study. Further research and reassessment is recommended.....

INTERMEDIATE GROUP

They reach a maximum size of 50 g and 42.2 mm OCL.

The largest animal collected in this survey was 31 grams and 38.29 mm OCL from upper Flaggy Creek.

CONSERVATION FACTORS

The majority of sites surveyed were impacted by bushfire to one extent or another but the species seemed little impacted. The biggest current problem the species is facing is lack of water within their habitat streams. The majority of streams are dry without surface water despite the drought breaking and good rainfall being received.

Unfortunately, the bushfires destroyed tree canopies, damaged the water catchments, destroying ground cover and changing hydrology.

May to June breeders with release of juveniles around December to January. Not all adult females breed each year . with approximately 100 burgundy coloured eggs.

CURRENT THREATS

Drought	High
Land clearing	High
Climate Change	High
Invasive species	High
Illegal Fishing	High
No protection/enforcement	High
Altered hydrology	High

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Euastacus jagara

Euastacus jagara is a dwarf group crayfish from south-east Queensland that lives in clear, flowing streams below the highland rainforest canopy. (McCormack 2012)

DISTRIBUTION

Euastacus jagara has a very small distribution, only known from the highland, headwater reaches of five small first order streams in two different drainage divisions (MDB and NEC), at elevations ranging from 714-1028 m a.s.l. During this survey, the lowest we found the species was 740 m a.s.l. (Fig 37). This is some 600 metres further upstream than previously recorded in Dalrymple Creek.

Eastern drainage; found in the upper reaches of Flaggy, Shady and upper Blackfellow creeks, tributaries of Blackfellow – Tenthill – Lockyer creeks – Brisbane River.

Western drainage; found in tributaries of Dalrymple Creek, (Condamine-Darling River).

All streams are clear flowing rainforest streams.

ABUNDANCE

Most streams only 1-2 crayfish per lineal metre of stream length. Perfect habitat areas up to 5-10/lm of stream.

Species specific points of note:

- **Rainforest species**
- **Subterranean habit**
- **Climate refuge**
- **Cool water species**
- **Permanent water species**
- **Small AOO = 28 km2**
- **Critical maximum water temp = 23˚C**
- **Type 1 & 2 Burrows**
- **Nocturnal**

Current IUCN Assessment

IUCN Status: CR B1+2(a),(b)iii based on EOO 28 km^2, and Area of Occupancy 28 km^2; severely restricted distribution (five streams at one site), and anticipated decline in area, extent and/or quality of habitat and EOO due to climate change.

DWARF GROUP

A maximum size of 50.23 mm Occipital Carapace Length was recorded during previous ACP surveys, exceeding the maximum originally documented for the species (47.1 mm OCL; Morgan, 1988). During this survey a maximum size of 24.2 gram, 35.51 mm OCL.

CONSERVATION FACTORS

Euastacus jagara is a relic population (Morgan 1988), confined to high altitude forested sites with cool flowing water conditions.

A rainforest stream species that constructs intricate burrow systems. Burrows can be within the stream bed or along the stream banks. Burrow complexes are huge, with five or more entrances that penetrate into the forest floor several metres from the stream bank.

Commence breeding May to June with release of juveniles around January.

The species has low fecundity (50-70 eggs per clutch) and large egg size, similar to that noted for other Qld dwarf species such as, *E. urospinosus* (McCormack and Van der Werf 2013).

CURRENT THREATS

Mega Bushfires	High
Future bushfires	High
Climate Change	High
Drought	High
Warming water	High
Illegal Fishing	No
Wild pig	Low

Euastacus suttoni

AUSTRALIAN CRAYFISH PROJECT "Conservation & Research"

Euastacus suttoni is also known as the New England Crayfish. It is a true giant spiny crayfish with sharp spines and a thick, strong shell that protects it in a harsh environment. (McCormack 2012)

DISTRIBUTION

They are a mountain crayfish found over 600 m a.s.l. and most common at 1000 m in the granite and sandy country. Once reasonably common but not easy to find, especially large adult males. Juveniles are more common. This species is widespread from the Stanthorpe area in Queensland in the north to Glenn Innes in New South Wales to the south. They occur in both eastern and western drainages in tributaries of Dumaresq, Severn (both northern and southern), Deepwater, Timbarra and Clarence rivers.

Total of 29 historic sites were surveyed during thi survey. Extinct at 52%, 10% we could not confirm the species presence, and only 38% of sites we confirmed the species exists.

ABUNDANCE

Populations vary widely between stream, typical good sites 2-3/lm and best site documented in this project up to 10/lm

Species specific points of note:

- **Climate refuge**
- **Cool water species**
- **Permanent water species**
- **Highland species over 600 m a.s.l., best populations over 1000 m.**
- **Small AOO = 84 km²**
- **Critical maximum water temp = 22˚C**
- **Type 1 & 2 Burrows**
- **Easily captured in traps**

Current IUCN Assessment

Previously listed as Vulnerable under criterion B1ab(iii) on the IUCN Red List

Reassessment as part of this project indicates: ENDANGERED is appropriate, based on B1ab(iii,v)+2ab(iii,v); EOO: 2719 km^{2}and AOO: 84 km^2; major population declines due to impacts of land clearing, warming water, climate change, illegal fishing, altered hydrology and competitive species.

NOTE: Predicted to go extinct within Qld within 20 years.

GIANT GROUP

Maximum size by Morgan 1988, OCL 86.3 mm. The largest specimen collected in this survey was 104.83 grams 58.78 mm OCL.

CONSERVATION FACTORS

A climate refuge restricted to cool water over 600 m a.s.l. under 22˚C in the uppermost catchment.

Recent surveys dramatically reduced original EOO with most of the historical sites now unsuitable habitat for the species. Anthropogenic change over the last 40 years has devastated *E. suttoni's* distribution. Widespread land clearing, farming chemicals, urban and mine runoff, heavy siltation and sedimentation, climate change, proliferation of pest species like plague minnows, carp , plus competitive *Cherax* have dramatically impacted this species.

Breed May-June and release young Dec-Jan. Nearly all mature females breed every year. Reasonably fecund with large eggs. Small female 70 g, 54.9 mm OCL, 192 eggs.

CURRENT THREATS

Habitat alteration	High
Cherax destructor	High
Climate Change	High
Drought	High
Illegal Fishing	High
No protection/enforcement/	High
Exotic species	High
Water harvesting	High

Euastacus spinichelatus

Euastacus spinichelatus is a small, shy and elusive dwarf group crayfish from northern New South Wales. Although the species name means 'spiny clawed' this species is anything but spiny, but it does have numerous small spines above the chelae cutting edges that distinguish it from other similar species (McCormack 2012)

DISTRIBUTION

Known from the headwaters of the Namoi, Manning, Hastings and Macleay basins. Generally over 1000 m and up to 1327 m a.s.l.; previously documented from 744-938 m. In this project the lowest we found the species was 897 m and every site below this it is now extinct.

The species has only been found in streams with permanently flowing or seeping water, this is a water dependent species.

NEW KNOWLEDGE

As part of this project molecular taxonomy analyses of Austin et al. (2022) confirmed its validity as a distinct taxon, and also confirmed the distribution in the Namoi River drainage, plus 2 divergent linages.

ABUNDANCE

Populations can be high in suitable areas, with 3–5 per lineal metre of stream; other more marginal sections of the stream may only have one per every 6 lm .

Species specific points of note:

- **Subterranean habit**
- **Climate refuge**
- **Cool water species**
- **Permanent water species**
- **Highland species over 700 m a.s.l.**
- **Small AOO = 44 km²**
- **Critical maximum water temp = 23˚C**
- **Type 2 Burrows**

Current IUCN Assessment

Euastacus spinichelatus satisfies the IUCN Red List criteria for listing as Endangered B1 & B2, ab(iii)(iv) based on a EOO 295 km^2 and AOO 44 km^2; single location threatened by climate change, bushfire, drought, land clearing/forestry practices, exotic species and illegal fishing.

DWARF GROUP

Morgan (1997) indicated that the species reaches at least 38.8 mm occipital carapace length (OCL); surveys during the present study captured an male crayfish, 28 grams, 39.69 m OCL (ACP 585) from Fenwick Creek in the upper Hastings River Basin that extend the maximum recorded size of the species. Further ACP surveys 2022 document 48.22 grams, 41.82 mm OCL as max.

CONSERVATION FACTORS

A climate refuge restricted to cool water over 700 m a.s.l. in the uppermost catchment.

The species only occurs where permanent water is available. Surface water is not a prerequisite but permanent subsurface ground water is. Of the 25 documented locations, at 9 of those locations the species is now locally extinct. This species is being critically impacted, by drought, bushfire, land clearing and domestic stock.

Females mature from 28 mm OCL. A very small female breeding pool, low fecundity (16-69 eggs) and large egg size (3.10 x 2.59 mm dia) similar to that noted for other dwarf spiny crayfish species of *Euastacus*.

CURRENT THREATS

Mega Bushfires	High
Future bushfires	High
Climate Change	High
Drought	High
Land clearing/domestic stock	High
No protection/enforcement	High
Anthropogenic damage	High
Illegal Fishing	Med

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Euastacus gamilaroi

Euastacus gamilaroi is an intermediate group crayfish, found in the high altitude streams ranging from 960-1345 m along the top of a small section of the Great Divide, with distributions in both the eastern and western drainage.

DISTRIBUTION

Euastacus gamilaroi is restricted to headwater reaches of three highland streams (Dungowan, Duncans & Burrows creeks) draining to the Peel River (western drainage) and Barnard River (eastern drainage), at elevations ranging from 960-1345 m a.s.l. The species inhabits pools and riffles in small permanent streams with pools <1.2 m deep. Populations are only established in permanently flowing streams that have catchments starting above 1300 m a.s.l. and flow for at least 2 km above 1000 m.

NEW KNOWLEDGE

As part of this project molecular taxonomy analyses of Austin et al. (2022) confirmed its validity as a distinct taxon, and also confirmed the distribution in the Manning River drainage.

ABUNDANCE

Populations can be high in suitable areas, with typically 2–3 per lineal metre of stream. Best streams can hold up to 10/lm.

Species specific points of note:

- **Very high intensity bushfire extinction level event**
- **Subterranean habit**
- **Climate refuge**
- **Cool water species**
- **Permanent water species**
- **Highland species over 900 m a.s.l.**
- **Small AOO = 68 km²**
- **Critical maximum water temp = 23°C**
- **Type 1 Burrows**

Current IUCN Assessment

Euastacus gamilaroi satisfies the IUCN Red List criteria for listing as Endangered. B1ab (iii). Based on an Extent of Occurrence of 211 km^2 and Area of Occupancy 68 km^2. A climate refugee restricted to one site, threatened by drought, warming water temperatures, high intensity bushfire, exotic trout, competitive *Cherax destructor,* poor forestry practices, land clearing and altered hydrology.

INTERMEDIATE GROUP

Maximum size of 50.14 g and 46.83 mm OCL (ACP 6091) were collected, exceeding the maximum size that was originally documented (41.8 mm OCL) Morgan 1997.

CONSERVATION FACTORS

A climate refuge restricted to cold water over 900 m a.s.l.

This project examined consequences of the 2019/2020 mega bushfires. We discovered, that low to medium bushfire had little to no impact on the species but high severity bushfire was an extinction level event.

This survey together with previous surveys identified a number of other serious threats to this endangered species, especially, current poor forestry practices & *Cherax destructor*.

Female sexual maturity starts at >34 mm OCL. Our surveys of *E. gamilaroi* suggests a small female breeding pool, low-medium fecundity (26-87 eggs) .

CURRENT THREATS

Mega Bushfires	High
Future bushfires	High
Climate Change	High
Drought	High
Exotic trout	High
Cherax destructor	High
No protection/enforcement	High
Land clearing	High

AUSTRALIAN CRAYFISH PROJECT "Conservation & Research"

Euastacus simplex

Euastacus simplex is a medium-sized intermediate group crayfish from the high country of the Great Divide in the New England region, New South Wales. (McCormack 2012).

Often confused with *E. suttoni* that occur to the north.

DISTRIBUTION

A greatly reduced distribution with the species now locally extinct at Type Location and throughout most of its previous western distribution. Currently found in upper catchment Macleay and Clarence rivers generally over 1000 m a.s.l.

NEW KNOWLEDGE

Morgan (1997) documents as occurring Fenwicks Creek, Hastings drainage. McCormack (2015) removed it indicating the species present was *E. maccai.* As part of this project molecular taxonomy analyses of Austin et al. (2022) confirmed its validity as a distinct taxon, and also confirmed the distribution in upper Maacleay River drainage (Kunderang Ck) was *E. clarkae.*

ABUNDANCE

Typically 1-2/lm when present. Highest populations 3-4/lm.

Species specific points of note:

- **Climate refuge**
- **Cold water species**
- **Permanent ground water species**
- **Highland species**
- **Small AOO = 36 km²**
- **Critical maximum water temp = 23˚C**
- **Type 2 Burrows**
- **Nocturnal**
- **Populations/ distribution in decline**

Current IUCN Assessment

Euastacus simplex satisfies the IUCN Red List criteria for listing as Endangered, B1ab (iii,iv)+B2ab(iii,iv). Based on an EOO: 297 km^2 and AOO: 36 m^2. A climate refugee restricted to uppermost catchment, threatened by drought, warming water temperatures, land clearing, exotic trout, invasive *Cherax destructor,* and altered hydrology.

INTEREMEDIATE GROUP

An intermediate group crayfish maximum size of 108 g and 58.47 mm OCL The largest specimen collected in this survey was from Bullock Creek, Ebor (Nymboida-Mann-Clarence River drainage). 36.99 gram, 40.68 mm OCL.

CONSERVATION FACTORS

A climate refuge restricted to cool water over 1000 m a.s.l. in the uppermost catchment. A very robust species that can survive regular droughts and bushfires in its deep Type 2 burrows beside cold flowing streams. If the stream temperature raise over 23˚C the species disappears. Land clearing and farming practices over much of the former distribution has allowed invasive *Cherax* to displace this species in the warm waters.

Females mature over 39 mm OCl , breeding commences May to June with release juveniles late December. Reasonably fecund with a 42 mm female carrying 128 eggs.

CURRENT THREATS

Land clearing	High
Warming water	High
Climate Change	High
Drought	High
Cherax destructor	High
No protection/enforcement	High
Exotic species	High
Illegal fishing	High
Altered hydrology	High

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AUSTRALIAN CRAYFISH PROJECT "Conservation & Research"

Euastacus morgani

Euastacus morgani is an intermediate group crayfish from a highland rainforest area of eastern New South Wales. (McCormack 2012)

DISTRIBUTION

Euastacus morgani is only known from two creeks in the upper Little Nymboida River near Ulong, NSW.

NEW KNOWLEDGE

As part of this project molecular taxonomy analyses of 3 samples confirmed its validity as a distinct taxon. For *E. morgani*, two samples show little divergence (0.7%), but the third sample was surprisingly divergent given the close proximity of all samples (mean divergence: 4.9%), indicating the possibility of the presence of a separate species. As a consequence, further studies of the relationships within and between *E. morgani* and *E. neohirsutus* and a review of morphological variation are required (Austin et al. 2022).

ABUNDANCE

Little information is available on the species abundance. Rough estimates would indicate that in the Type location it occurred at 1-4/lm of stream length.

Species specific points of note:

- **Subterranean habit**
- **Forested stream species**
- **Cool water species**
- **Permanent water species**
- **Small AOO = 4km²**
- **Type 2 Burrows**
- **Nocturnal**
- **Little knowledge on the species**

Current IUCN Assessment

Euastacus morgani satisfies and IUCN listing of Critically Endangered B1ab(iii,v)+2ab (iii,v); based EOO of 4 km^2 and AOO of 4 km^2; only known from a single, small location and the area, extent and quality of its habitat is anticipated to decline due to the impacts of climate change and any local adverse events.

INTERMEDIATE GROUP

Largest specimen collected is 32 g and 40 mm OCL. The largest specimen collected in this project was 17.67 grams and 31.91 mm OCL (ACP 6606). Please note: A mature adult female has never been captured so maximum size remains unknown.

CONSERVATION FACTORS

A climate refuge restricted to cool water over 570 m a.s.l. in the uppermost catchment.

Known from clear flowing rainforest streams, also sympatric with *E. dangadi* and *E. neohirsutus,* plus 3rd species. An extensive burrowing species spending the majority of time within their burrow systems. Burrows start along the stream edges just below water level. They extend horizontally both directly back into the bank and parallel to the bank. From there they branch both up into the forest floor, usually 1 metre high or down into ground over 1 metre deep. They can have multiple entrances and multiple exits.

Fecundity unknown.

CURRENT THREATS

Mega Bushfires	High
Future bushfires	Med
Climate Change	High
Drought	High
Competitive species	Med
Lack of knowledge	Med
Land clearing	Med

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AUSTRALIAN CRAYFISH PROJECT "Conservation & Research"

Euastacus guwinus

Euastacus guwinus is a small intermediate group crayfish known only from an extremely small area in the upper catchment of Tianjara Creek, NSW.

DISTRIBUTION

Known from Tianjara Creek above Tianjara Falls (a significant local tourist attraction), a tributary of the Shoalhaven River on the southern edge of Morton National Park, New South Wales. Distributed throughout the creek from 460 m to 625 m a.s.l.

Both *E. yanga* and *E. guwinus* occur together in Tianjara Creek. McCormack (2012) also indicated *E. guwinus* occurred in the adjacent Wandandian Creek, however the one specimen sequenced (CA217) as part of this project returned as *E. yanga.*

NEW KNOWLEDGE

Austin et al. (2022) confirmed the species validity but recommended further research on the definition of *E. guwinus* and its relationship with *E. yanga* is required by sequencing a greater range of samples and an examination of variation in diagnostic taxonomic characters for both species.

ABUNDANCE

Wide variation between different sections of the stream, but generally 2-3/lm and the very best sections of stream with wider deep pool supported populations of 6-10/lm of stream length.

Species specific points of note:

- **Climate refuge**
- **Cool water species**
- **Permanent water species**
- **Type 1 Burrows**
- **Easily captured in traps**
- **Illegal fishing major threat**

Current IUCN Assessment

Critically Endangered on the IUCN Red List: B1ab(iii, v), based on: an Extent of Occurrence (EOO) of 3.207 km^2 and an Area of Occupancy (AOO) of 12 km^2. One site with continuing decline projected in EOO and quality of habitat due to climate change, increasing water temperatures and droughts, plus continuing threats from illegal fishing and lack of protection within the National Parks where it occurs. Plus the potential threat from invasive *Cherax* currently proliferating in adjacent catchments

INTERMEDIATE GROUP

During surveys by the ACP (2005-2022) mature adults attaining a maximum size of 79 g and 55.05 mm OCL were collected.

CONSERVATION FACTORS

A species restricted to one small creek system in the uppermost catchment.

Found in Type 1 burrows in permanently flowing streams, they have little-capacity to survive extreme drought. They are attracted to traps and illegal fishing is a major concern as is jurisdictional issues with NSW National Park Rangers unable to protect this species. Within the Parks that it occurs in.

Moderate fecundity (20-120 eggs) and large egg size (3.35 x 2.5 mm diameter), similar to that noted for other intermediate crayfish. Smallest berried female 36.1 mm OCL had 96 eggs. A 46.92 mm OCL female had only 21 eggs, and a 49.88 mm OCL female had 119 eggs.

CURRENT THREATS

Climate change	High
Drought	High
Competitive species	High
Easily captured in traps	High
Illegal Fishing	High
No protection/enforcement	High

Euastacus clarkae

AUSTRALIAN CRAYFISH PROJECT "Conservation & Research"

5-10/lm of stream length.

Euastacus clarkae is a medium-sized intermediate group crayfish with a small distribution in north -eastern New South Wales. A climate refugee species restricted to permanent, cool flowing streams in Type 1 burrows. E. *reductus, E. spinifer* and E. *maccai* can occur within close proximity to *E. clarkae*.

DISTRIBUTION

The species is known from the upper catchment of the Forbes and Hastings rivers over 600 m a.s.l. Also know known from the upper catchment of Kunderang Brook a tributary of the Macleay River.

A cold water mountain crayfish restricted to high altitude permanently flowing streams.

NEW KNOWLEDGE

As a result of this project the molecular taxonomy analyses by Austin et al. (2022) confirmed *E. clarkae* as a distinct taxon, and also identifying the species distribution in the adjoining Macleay River drainage

ABUNDANCE

Wide variation between streams, but best streams maintain a population of

Species specific points of note:

- **Climate refuge**
- **Cool water species**
- **Permanent water species**
- **Highland species over 600 m a.s.l. and best populations over 1000 m.**
- **Critical maximum water temp = 23˚C**
- **Type 1 Burrows**
- **Easily captured in traps**

Current IUCN Assessment

Currently listed as Critically Endangered on the IUCN Red List . Reassessment as part of this project indicates: Euastacus clarkae satisfies the IUCN Red List criteria for listing as Endangered: B1ab (iii, v)+2ab(iii, v) based on: an Extent of Occurrence (EOO) of 207 km^2 and an Area of Occupancy (AOO) of 72 km^2. Continuing decline projected in EOO, EOO and quality of habitat due to climate change, increasing water temperatures and droughts, plus increase in very high intensity bushfires. Continuing threats from illegal fishing and lack of protection within the National Parks where it occurs.

INTERMEDIATE GROUP

During surveys by the ACP (2005-2014) mature adults attaining a maximum size of 65 g and 50.59 mm OCL were collected.

CONSERVATION FACTORS

A climate refuge restricted to cool water over 600 m a.s.l. under 23C in the uppermost catchment.

Found in both small creeks and larger streams. Found in Type 1 burrows in permanently flowing streams, they have no capacity to survive drought, very intense bushfire is fatal in the shallow streams. They are attracted to traps and illegal fishing is a major concern as is jurisdictional issues with NSW National Park Rangers unable to protect this species. Within the Parks that it occurs in.

Nearly all mature females breed May-June every year keyed by dropping water temps. Reasonably fecund with standard eggs. Batches range from 75-288 .

CURRENT THREATS

Mega Bushfires	High
Future bushfires	High
Climate Change	High
Drought	High
Illegal Fishing	Med
No protection/enforcement	Med

Euastacus polysetosus

AUSTRALIAN CRAYFISH PROJECT "Conservation & Research"

Populations vary greatly between streams. Typically 1-2/lm but best habitat areas can have 3 -4/lm of stream length

Current IUCN Assessment

Coughran et al. 2010 originally listed this species as Endangered. IUCN Status: EN B1(a),(b)iii based on EOO <5,000 km^2, fragmented distribution, and anticipated decline in area, extent and/or quality of habitat and EOO due to climate change.

This listing is in doubt as much further research required on species distribution and genetic variation.

EOO: 700 km^2 AOO: 90km^2

INTEREMEDIATE GROUP

An small intermediate group crayfish. Maximum size by Morgan 1997, OCL 56.6 mm. The largest specimen collected in this survey was 45.03 mm OCL and 42.65grams from Polblue Creek

Euastacus polysetosus is an intermediate group crayfish that is found in the Barrington Tops region of New South Wales. It is called the many-bristled crayfish by some because of its fine hairy appearance (McCormack 2012).

DISTRIBUTION

Euastacus polysetosus is found in permanent flowing streams, usually over 750 m a.s.l., of the Mt Royal Range, New South Wales (a spur off the Great Dividing Range). Tributaries of the Manning River (Dilgry, Mopy, Barrington and Gloucester rivers) and Hunter River (Allyn River and Paddys, Polblue and Glennes creeks).

NEW KNOWLEDGE.

The molecular taxonomic analyses of Austin et al. (2022) did not confirmed its validity as a distinct taxon. *Euastacus polysetosus* also requires additional survey work and sample collection to better document the taxonomic relationships and geographic variability for this species.

ABUNDANCE

Species specific points of note:

- **Climate refuge**
- **Cool water species**
- **Permanent water species**
- **Highland species**
- **Small AOO = 90 km^2**
- **Critical maximum water temp = 23˚C**
- **Type 1 Burrows**
- **Nocturnal**

CONSERVATION FACTORS

A climate refuge restricted to permanently flowing cool water over 750 m a.s.l. in the uppermost catchment. They construct Type 1 burrows that are fully flooded. They have no capacity to survive drought and very high intensity bushfire in the shallow streams would result in mass mortality.

Threatened by exotic trout, illegal fishing and jurisdictional issues as National Park Rangers cannot enforce recreational fishing rules. A looming threat is the proliferation of brumbies in the area.

Sexual maturity is reached at about 32.5 mm OCL with small females having clutches of 30 –60 eggs.

CURRENT THREATS

Climate Change	High
Drought	High
Illegal Fishing	High
No protection/enforcement	High
Exotic trout	High
High intensity bushfire	High
Land clearing	High
Brumbies	Low
Wild pigs	Low

Euastacus claytoni

AUSTRALIAN CRAYFISH PROJECT "Conservation & Research"

Euastacus claytoni is an intermediate group crayfish from southern New South Wales and northern Victoria that lives in an area of climatic extremes, with hot summers, freezing cold winters, periodic droughts and then floods. A robust species surviving climate extremes within its Type 2 burrow system.

DISTRIBUTION

The species is now known from the upper catchment of the Snowy and Genoa rivers in southern NSW and northern Victoria. Tributaries of MacLaughlin, Undowah, Bombala, Genoa, Little Plains, and Bendoc rivers.

A cold water mountain crayfish restricted to upper catchment in high altitude streams.

NEW KNOWLEDGE

As a result of this project the molecular taxonomy analyses by Austin et al. (2022) confirmed *E. claytoni* as a distinct taxon, and also identifying divergent lineage occurring across the northern extent of the range (e.g. Murrumbidgee and Shoalhaven River basins)

ABUNDANCE

Wide variation between streams, but best streams maintain a population of 4-5/lm of stream length. Many streams now absent due to drought and land

Species specific points of note:

- **Locally extinct across much of former range**
- **Climate refuge**
- **Cool water species**
- **Permanent water species**
- **Highland species over 800 m a.s.l. and best populations over 1000 m.**
- **Critical maximum water temp = 23˚C**
- **Type 1 & 2 Burrows**
- **Easily captured in traps**
- **Where *Cherax* occur *E. claytoni* absent**

Current IUCN Assessment

Euastacus claytoni meets the thresholds for listing as Endangered (EN) under criteria B1ab(i,ii,iii)+B2ab(i,ii,iii) EOO 1500 km^2 and AOO 40 Km^2 based on a single location threatened by climate change, bushfire, drought, land clearing/forestry practices, exotic species and illegal fishing. *E. claytoni's* original EOO has greatly reduced due to anthropogenic change over the last 50 years. Add further declines due to future bushfires, heat waves, droughts, floods, illegal fishing, exotic species, the long term future for this montane species remains

INTERMEDIATE GROUP

A maxi size of 120 grams and 59 mm OCL was recorded during previous surveys. The maximum size collected in this survey was 57.9 grams and 47.76 mm OCL.

CONSERVATION FACTORS

A climate refuge restricted to cool water over 800 m a.s.l. under 23˚C in the highland catchment.

Found in flowing creeks and swampy bog areas. Extensive Type 1 & 2 burrows that provide good protection from normal climate extremes , surviving in deep burrows into water table when surface flows dry out. Extreme high intensity bushfire no impact but extreme drought that dries water table is fatal. Land clearing, invasive *Cherax* and exotic trout are all major threats as is illegal fishing .

Mature females >36 mm OCL breed April-June 2-3 times/5 years keyed by dropping water temps. Reasonably fecund with standard eggs. Batches range from 66-170 .

CURRENT THREATS

Land clearing	High
Stock grazing	High
Climate Change	High
Drought	High
Exotic Trout	High
Invasive *Cherax*	High
Illegal Fishing	Med

AUSTRALIAN CRAYFISH PROJECT
"Conservation & Research"

Euastacus bidawalus

Euastacus bidawalus is an intermediate group crayfish from the far south coast of New South Wales and eastern Victoria. A robust species surviving both drought and bushfires in its type 2 burrows. A shy species, preferring to be hidden away out of sight during the day. Both *Engaeus orientalis & Engaeus laevis* plus *Euastacus yanga* occur within its distribution area.

DISTRIBUTION

A relatively small distribution low altitude species, Found from 28 m. a.s.l. to 796 m.a.s.l in streams and tributaries of the Wallagaraugh, Genoa, Wingan, Cann and Bemm Rivers.

ABUNDANCE

Populations can be high in suitable areas, with 6–10 per lineal metre of stream; other more marginal sections of the stream may only have one per every lineal metre.

NEW KNOWLEDGE

As a result of this project the molecular taxonomy analyses by Austin et al. (2022) confirmed *E. Bidawalus* as a distinct taxon, but also identifying two divergent lineages *E. cf. bidawalus 1* and *E. cf. bidawalus 2.* It is recommended that further field surveying of the sites of the divergent sequences are strongly recommended to investigate the unexpected diversity within *E. bidawalus*.

Species specific points of note:

- **Robust species**
- **Subterranean habit**
- **Reliant on permanent subsurface water**
- **Low land species**
- **Type 2 Burrows**
- **Requires forested stream or intact riparian zones**
- **Land clearing and stock grazing a major threat**

Current IUCN Assessment

Euastacus bidawalus satisfies the IUCN Red List criteria for listing as Endangered, E : B1ab(i,ii,iii)+2ab(i,ii,iii) based on: an Extent of Occurrence (EOO) of 2609 km^2 and an Area of Occupancy (AOO) of 248 km^2. Continuing decline projected in EOO, EOO and quality of habitat due to ongoing land clearing, domestic stock grazing together with farm dam construction, water extraction for agriculture and groundwater harvesting, plus climate change and drought.

INTERMEDIATE GROUP

The largest specimen documented in our research project was ACP 3791, 58 grams and 50.56 mm OCL (berried female). From a tributary of Tongi Creek, Cann River drainage.

CONSERVATION FACTORS

A lowland species found in the lower creeks and valleys. These are the areas most heavily developed and the species does not occur where riparian zones have been removed and the stream sides and bed grazed by domestic stock

The species occurs in both permanent and intermittent streams. Surface water is not a prerequisite but permanent subsurface ground water is essential for survival in its type 2 burrows.

Euastacus bidawalus is an intermediate crayfish with females reaching maturity at > 40 mm OCL. Breeding commences April—May as water temperatures drop with batches of 80-110 eggs, with release of juveniles December.

CURRENT THREATS

Land clearing	High
Domestic stock	High
Climate Change	High
Extreme Drought	High
Water extraction from creeks	High
Illegal Fishing	Low
Groundwater harvesting	Low

Euastacus diversus

AUSTRALIAN CRAYFISH PROJECT "Conservation & Research"

Euastacus diversus is a small intermediate group species found only in small numbers across a wide area of East Gippsland, Victoria. It's a small, rare and elusive crayfish.

DISTRIBUTION

The species is now known from the eastern catchment of the Snowy River, in East Gippsland, Victoria: Found in the Brodribb, Yalmy, Rodger and Bonang river drainages at elevations ranging from 350 – 950 m a.s.l. Restricted to heavily forested, permanently flowing streams in Type 1 burrows. All burrows are fully flooded and constructed below water level.

ABUNDANCE

Wide variation between streams, but best streams maintain a population of 1-2/lm of stream length. In the larger streams at lower altitudes full of fish, eels and the giant group crayfish *Euastacus kershawi* the species is rare and restricted to very shallow marginal habitats. Higher up the catchment in the permanently flowing small streams where predators are few they are more abundant. Many streams now absent due to both the preceding drought and then high intensity mega bushfire impacts.

Species specific points of note:

- **Mass mortality from very high intensity bushfire**
- **Mass mortality from extreme drought**
- **Type 1 burrows**
- **Permanent water species**
- **Exotic trout a major threat**
- **Invasive *Cherax* a looming threat**

Current IUCN Assessment

Currently listed as Endangered on the IUCN Red List Endangered: B1ab(iii)+2ab (iii) based on: an Extent of Occurrence (EOO) of 1850 km^2 and an Area of Occupancy (AOO) of 260 km^2. Continuing decline projected in EOO, and quality of habitat due to climate change, increasing water temperatures, bushfire, droughts, plus continuing threats from land clearing, illegal fishing invasive *Cherax* and exotic trout.

INTERMEDIATE GROUP

A maximum size of 47 grams and 44.54 mm Occipital Carapace Length was recorded during ACP previous surveys, The maximum size collected in this survey was 22.59 grams and 34.86 mm OCL.

CONSERVATION FACTORS

A widespread but rare species that occurs at highest densities in small shallow flowing streams in Type 1 burrows. *E. diversus* is one of an number of intermediate crayfish occurring in Type 1 burrows which are vulnerable to mass mortality from very high intensity bushfire. It requires permanently flowing water and has no capacity to survive drought which is another mass mortality event. Land clearing, invasive *Cherax* and exotic trout are all major threats as is illegal fishing .

Fecundity is unknown as only one female with 30 eggs ever captured. However we predict as a typical intermediate crayfish females can physically hold 50-170 eggs

CURRENT THREATS

High Intensity Bushfire	High
Extreme Drought	High
Climate Change	High
Illegal fishing	High
Land clearing	High
Exotic Trout	High
Invasive *Cherax*	Med

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Euastacus coughrani

AUSTRALIAN CRAYFISH PROJECT "Conservation & Research"

Euastacus coughrani sp.nov. is a small intermediate group species found only in small numbers across a wide area of East Gippsland, Victoria. It's a small, rare and elusive crayfish.

DISTRIBUTION

The species is currently known from the Bemm River basin and the Queenbourough River drainage (Snowy River), in East Gippsland, Victoria: at elevations ranging 251 – 1050m a.s.l. Restricted to heavily forested, permanently clear flowing streams in Type 1 burrows. Found in streams with an understory of tree ferns and higher tree canopy with all streams heavily shaded from sunlight.

ABUNDANCE

Wide variation between streams, but best streams maintain a population of 1-2/lm of stream length. In the larger streams at lower altitudes full of fish, eels and the giant group crayfish *Euastacus kershawi* the species is rare and restricted to very shallow marginal habitats. Higher up the catchment in the permanently flowing small streams where predators are few they are more abundant. Many streams now absent due to drought and mega bushfire impacts.

Species specific points of note:

- **Mass mortality from very high intensity bushfire**
- **Mass mortality from extreme drought**
- **Type 1 burrows**
- **Permanent water species**
- **Exotic trout a major threat**
- **Invasive *Cherax* a looming threat**
- **Deer and foxes potential threat**

Current IUCN Assessment

Euastacus coughrani satisfies a listing as Endangered on the IUCN Red List Endangered, E : : B1ab(iii)+2ab(iii) based on: an Extent of Occurrence (EOO) of 176 km^2 and an Area of Occupancy (AOO) of 68 km^2. Continuing decline projected in EOO, and quality of habitat due to climate change, increasing water temperatures, bushfire, droughts, plus continuing threats from land clearing, illegal fishing invasive Cherax and exotic trout.

INTERMEDIATE GROUP

A maximum size of 55.56 mm OCL (ACP 5721) Arte River. The largest specimen collected in this survey was ACP 6819 38.46 grams, 44.22 mm OCL from a tributary Arte River, crossing Glenn Arte Road, Arte River Forest Reserve, Victoria

CONSERVATION FACTORS

A widespread but rare species that occurs at highest densities in small shallow flowing streams in Type 1 burrows. *E. coughrani* is one of an number of intermediate crayfish occurring in Type 1 burrows which are vulnerable to mass mortality from very high intensity bushfire. It requires permanently flowing water and has no capacity to survive drought which is another mass mortality event. Exotic trout are a major threat as is illegal fishing .

Female sexual maturity generally starts at >39 mm OCL. Breeding commences late March –June dependent on water temperature/elevation. A female 43.62 mm OCL had 97 eggs late April. Eggs are very large 3.78 x 2.76 mm.

CURRENT THREATS

High Intensity Bushfire	High
Extreme Drought	High
Climate Change	High
Drought	High
Illegal Fishing	Med
Exotic Trout	High
Invasive *Cherax*	Low

Survey Results & Discussion

The scope of Project 100086 encompassed evaluating the effects of the 2019/2020 mega bushfires on 18 *Euastacus* species distributed from southeast Queensland to East Gippsland in Victoria.

Initial estimations regarding the impact of the 2019-20 mega bushfires on our spiny crayfish projected a decade for taxa to exhibit signs of recovery (Legge *et al*., 2021b). However, our comprehensive surveys have revealed a more prolonged recovery trajectory. It is now projected that many *Euastacus* species, particularly those within the dwarf group characterized by small population numbers and limited habitat areas with low fecundity, may require approximately 30 years to fully restore their population levels to pre-fire conditions.

The 2019-20 mega bushfires weren't an isolated incident; they marked the culmination of seven years of preceding drought, including three extreme years. Many *Euastacus* species within the dwarf and intermediate groups inhabit small flowing streams, and the prolonged drought had desiccated numerous streams or significantly reduced their flow rates. This not only impacted the crayfish directly by diminishing or eradicating suitable habitat areas but also affected the terrestrial vegetation along the riparian zones. Species within the dwarf group, such as *Euastacus girurmulayn, Euastacus spinichelatus*, and *Euastacus dalagarbe,* experienced substantial population declines due to the combination of drought and habitat loss. In the case of *Euastacus spinichelatus*, detailed in Report 8 (McCormack, 2020f), the drought was categorized as an extinction-level event for the species. These findings underscore the profound and multifaceted impact of prolonged drought and subsequent bushfires on the vulnerable *Euastacus* species, necessitating extended recovery periods for their populations to rebound.

Figure 17 Looking upstream. An *E. Girurmulayn* creek in Whian Whian State Forest NSW

In Figure 17, the visual representation illustrates the aftermath of the drought-induced drying of the creek, accompanied by the devastating effect of the ensuing rainforest fire. The burnt landscape reveals the remnants of the rainforest, with the surviving palms shedding their fronds after the fire.

Figure 18 Looking downstream, burnt timber, a dry creek bed, abandoned burrows with no sign of the species when conditions return to normal it will take 30 years for this creek to be back to pre-drought and pre-fire population numbers

With the dwarf group species that occur in the smaller streams at the top of the catchment we noticed that although conditions had returned to normal with flows returning from February 2020, many upper catchment streams even 2 years on had still not started flowing.

The loss of vegetation cover had exposed the soils to sun and wind drying them, when it did rain it did not soak in and just flowed straight off with the creeks flash flooding, then rapidly drying out after the rain event. Most of these creeks are groundwater fed, this change in hydrology has seen the groundwater resources not rapidly recharging, further delaying any species recovery. This was not only a major concern for the dwarf group, but both the intermediates and giants.

Figure 19 *Euastacus clarkae* (intermediate group) stream in Werrikimbe National Park, still dry October 2021

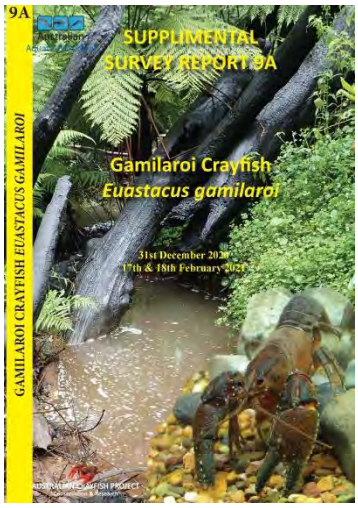
Euastacus clarkae is an intermediate group, cold water crayfish inhabiting "Type 1" burrows restricted to permanently flowing streams. McCormack (2015) first reported a mass mortality event for *E. clarkae* after a high intensity bushfire. In this Project we identified another similar intermediate group, cold water crayfish inhabiting "Type 1" burrows restricted to permanently flowing streams *E. gamilaroi* that was also subject to a mass mortality event as the result of very high intensity bushfire.

These high altitude climate refugee intermediate group crayfish are highly susceptible to mass mortality after very high intensity bushfire. Normal medium to high intensity bushfires have little impact but very high intensity fire has the ability to rapidly heat the water to a level that the crayfish cannot tolerate forcing the species to abandon its hot water filled burrow to die of exposure on the surface surrounding the creek.

McCormack (2015) found *E. clarkae* dead along the stream margins after a very high intensity bushfire. *Euastacus clarkae* inhabits both the shallow flowing streams and the deeper streams. Water depth seems to be the critical factor, if the water is deep enough it provides a level of protection from extreme fire heat, however, in the shallow water streams no protection is provided and the water rapidly heats to intolerable levels.

In Supplemental Survey Report 9A *Euastacus gamilaroi* we document very high intensity bushfire as an extinction level event. In that report we study *E. gamilaroi* and the impacts of a very high intensity bushfire that devastated two *E. gamilaroi* habitat streams. The research

site is Washpool Gully as well as the unnamed tributary of Washpool Gully, Hanging Rock State Forest, Back-Barnard-Manning River drainage.



A fire break had been created beside a road through the forest, one side of the road is unburnt (upstream side) and the species is at natural population levels. The other side of the road (downstream side) is severely burnt.

The unnamed tributary of Washpool Gully was surveyed at 2 sites in late December 2020.

The first site was upstream within an unburnt area and surveyed on the 31st December 2020. This site is upstream of the road/firebreak with the *E. gamilaroi* population at normal levels approximately 1-2/lm of stream length and unimpacted by the mega bushfires (Fig. 20A).

Downstream across the road and firebreak, had been severely impacted by a very high severity bushfire and on the 31st December 2020 we were unable to find any indication that the species still existed within this section of stream. To confirm our initial alarming results of the 31st December we revisited the site on the 17th February 2021.

Figure 20 A, upstream unimpacted by fire; B. Downstream, burnt timber, sediment and weeds in stream bed. C. Downstream, open sky conditions

In February 2021 one year after the fires and with the stream flowing at normal levels, we more intensively surveyed the area at 2 sites within the severely burnt area. A 150 metre section of the unnamed tributary (Fig. 20B&C) and a 150 metre section of Washpool Gully (Fig. 21). We set baited box traps overnight and intensively examined each 150 m section. We searched for active crayfish burrows and lifted every rock and log we could in our search for crayfish.

At site B the unnamed tributary we captured nothing in the traps but surprisingly we found an immature female (29.26 mm OCL) *E. gamilaroi* sheltering under a rock within the stream. There was no burrow as such just directly under a rock in the middle of the stream. We would expect this is a travelling/migrating animal using the rock for shelter during the day and it would move along at night. It is unknown if this is an animal that has come from further downstream and moving upstream, or one from upstream and moving downstream.

The second site was Washpool Gully, this site had been previously surveyed in 2006 with the species being abundant within the stream and easily collected from under rocks. Back in 2006 the stream was flowing at much the same capacity as it is today and flowed under a complete lower canopy of tree ferns and a higher canopy of eucalyptus trees.

Today the flow is good but the higher canopy from the eucalyptus trees is gone with many of those trees fallen across the creek. The tree ferns have recovered nicely and did provide an intermittent canopy over the creek which is an incised stream with very steep banks. Burnt and fallen timber clogged much of the creek bed (Fig. 21).

Figure 21 Washpool Gully, tree ferns regenerating, with burnt timber clogging the stream

An intensive survey of 150 metres of stream failed to find even one crayfish. For all intents and purposes the species seemed locally extinct as a result of the high severity bushfire. Burnt timber clogged the stream and sedimentation was a serious issue. However, the baited traps resulted in a surprise. Of the 3 largest deepest pools, one returned a surprising result with 4 crayfish captured. Three adult and one immature crayfish captured overnight in one trap. Unfortunately, *E. gamilaroi* is an aggressive/territorial species and the juvenile did not survive the capture within a confined space of the trap and it had been killed and half eaten by the larger crays.

The pool was approximately 3m long, up to 1 m at its widest and 400mm deep. This was the largest pool in the 150 m section surveyed, it is unknown if these 4 crayfish are new migrants

that have grabbed the best habitat or survivors of the fire. What we do know is that the stream population that once occurred at 1-2/lm of stream length had been eliminated from the other 147 m of stream.

Both *E. gamilaroi* and *E. clarkae* are climate refugees restricted to the cool permanently flowing water at high altitudes. These crayfish and others like them are extremely vulnerable to high intensity bushfire which is an extinction level event for the species. Our research indicates that only a very high severity bushfire is an extinction level event in shallow flowing streams and low to medium severity bushfires or controlled burns are not a concern for *E. gamilaroi* (McCormack & Whiterod, in prep b).

Over the duration of the project, we noticed a large number of impacts from the bushfires on the streams, firstly, sedimentation was not a major problem at the top of the catchment as flow rates are fast and the sediment tends to be moved further downstream. It's generally lower down the catchment where the flows spread and slow that the sediment is deposited and builds up filling the deeper pools. These deep pools are the main habitat areas for many adult *Euastacus* species and when they are filled, they become unsuitable displacing the crayfish.

One of the most noticeable impacts from the bushfires was the regrowth of weeds. They seemed to be the first thing to grow and the long term consequences of their growth remains unknown.

The loss of riparian vegetation and raised water temperatures downstream constrict distributions and allow invasive *Cherax destructor* to proliferate and we found vast areas of previously *Euastacus* distribution areas now infested with *Cherax*. Once *Cherax* become established, *Euastacus* are unwilling or unable to displace them.

Extinction Level Threats to *Euastacus*

The following are the threats to the *Euastacus* genera that have been proven as extinction level events and we have documented evidence as to their veracity.

1. Drought

Euastacus generally are permanent water species, they have little capacity to survive extended droughts. Most *Euastacus* are deep burrowing species enabling them to burrow below the surface into the creek's groundwater flow. Surface water is not essential for survival, but groundwater is. Results of our surveys indicate that drought has dramatically altered the distributions of numerous species. For example, *E. dalagarbe* no longer occurs in many of the streams it occurred in 10 years ago as these streams are no longer flowing.

Surveys *of E. gumar* shows the species is suffering from drought with dramatically reduced populations and those few survivors are only just surviving in deep burrows within otherwise dry creek beds.

Of significance is *E. spinichelatus*. Its Holotype and Paratype locations were surveyed in October 2019 just before the mega bushfires. Drought had completely dried these 2 streams and the species had expired in the streams. After the bushfires devastated the area, flows returned in February 2020 and have remained at normal flow ever since, but the species has not returned. Two years later in February 2022 the species has just started to return in very low numbers of 1/100m of stream length (McCormack & Whiterod. in prep a). Drought is a documented extinction level event for this *Euastacus* species with a prediction of 30 year for creeks populations to return to normal pre-extinction event levels.

NOTE: *Euastacus* crayfish take 7-9 years to reach sexual maturity. For example, when drought occurs and streams dry, the very largest animals may have the size and stamina to dig a deep burrow to water table and potentially survive a prolonged drought if some groundwater at depth remains. All the small immature and small adults die out. When conditions return to normal, this remnant of a remnant population can emerge, breed, incubate the eggs for 7-10 months and 7-9 years later their offspring if they survive can breed and boost the creeks population. Any recovery from drought takes 10-30 years for a recovery to occur and that will greatly depend on the species group and its capacity to recover (see Fecundity; page 53).

2. High Intensity Bushfire

Bushfires are a natural part of the Australian environment and many *Euastacus* species have evolved with bushfire over thousands of years and a fire has little or no impact on the species. Lowland species like *E. australasiensis, E. guwinus, E. pilosus, E. spinifer* or *E. reductus* for example are generally unimpacted by very high intensity bushfire.

However, for many of the high altitude climate refugee species bushfire in their high altitude eucalypt or rainforests are not something that they have evolved with and for many species that only occur in small areas, their forests have never previously burnt.

The most vulnerable *Euastacus* species are the high altitude climate refugee species restricted to cool/cold water in the uppermost catchment and utilizing Type 1 burrows. Two good examples are *Euastacus clarkae* and *Euastacus gamilaroi.* Both are intermediate group crayfish, restricted to high altitude cool water streams in Type 1 burrows connected directly to the stream.

McCormack (2015) first documented a mass mortality event for *Euastacus clarkae* after a very high severity bushfire. In this project we document a mass mortality event for *E. gamilaroi* after a high severity bushfire. McCormack (2021d) documents a mass mortality

event for *E. gamilaroi*. The research site is within Hanging Rock State Forest NSW. A fire break had been created to stop the mega bushfires that raged throughout the area. One side of the fire break (upstream) was native forest with *E. gamilaroi* population at normal natural levels. The other side of the firebreak (downstream) suffered a very high severity bushfire and *E. gamilaroi* was absent from the two streams surveyed. This report documents very high severity bushfire as an extinction level event for *E. gamilaroi*.

3. Anthropogenic impacts

This project documents a huge number of sites where *Euastacus* species no longer occur due to anthropogenic changes. For example, *Euastacus suttoni* (McCormack 2021b) and *Euastacus simplex* (McCormack 2022a) were species traditionally with very large distribution areas. Unfortunately, these large distributions were based on historic collection records. Because they were supposedly such widespread and abundant species over the last 16 years the Australian Crayfish Project had not intensively researched them. That was a major mistake.

This project did research all the historical record sites of occurrence and the results are very, very concerning. Over the last 40-50 years rampant land clearing and removal of riparian zones had dramatically altered thousands of square kilometres making an uncalculatable number of creeks and rivers now unsuitable habitat for *Euastacus*. *Euastacus* crayfish are dependent on intact riparian zones, providing shade and shelter from sunlight impacts on their habitat streams. The widespread alteration of these environments has resulted in an immeasurable loss of suitable habitat for *Euastacus* species across thousands of square kilometres.

Weirs and dams on small creeks are also a major contributor to altering downstream water temperatures. A weir creates a large surface area of shallow static water behind it. This shallow water is impacted by the sun which raises its surface water temperature. Weirs overflow from the top, it is hot surface water that overflows. For many of our cold water *Euastacus* species this hot water makes the downstream habitat uninhabitable. Additionally, the weirs are usually constructed for water storage and extraction for agriculture. The weir halts the streams flow, with the water being extracted for agriculture nothing flows downstream making the habitat downstream unsuitable for permanent water species like *Euastacus* crayfish. This projects documents *E. gamilaroi* and *E. suttoni* as good examples of dam/weir impacts.

Large numbers of *Euastacus* species are now locally extinct at numerous sites across their distribution. For example, for *Euastacus suttoni* in this project we surveyed a total of 29 historic sites of occurrence. Of these the species is now extinct at 52% of these sites. At 10% of the sites, we could not confirm the species presence, and only 38% of sites the species still exists. In this report we also state: *Unfortunately, unless something is done immediately to*

reverse the current downward population trajectory; Euastacus suttoni will be the first Euastacus species to become extinct in Queensland!

In the *E. suttoni* report we state: *Leckie et al., 2005 in their study noted a maximum yearly stream temperature of 22˚C and warned not to exceed that temperature. McCormack 2008 in aquarium experiments documented noticeable lethargy occurring at 23˚C with mortality occurring at 25˚C. This survey confirms both Leckie & McCormack, no E. suttoni were captured in waters exceeding 22˚C, the maximum recorded for species present was 20.3˚C for this extensive survey. Results of our survey indicate that today water temperatures at the historic sites where the species is now locally extinct exceed the maximum of 22˚C. Our surveys were conducted during very mild conditions; during hot weather (2017/2018/2019) these temperatures would have been much-much higher. The current high water temperatures are probably reflective of the upstream land clearing resulting in the streams becoming uninhabitable for this species, with climate change (reduced rainfall and higher air temperatures, bushfires) accelerating the species decline. Water temperature is a good indicator of suitable E. suttoni habitat areas.*

Anthropogenic change is a documented extinction level event for *Euastacus* crayfish. This dramatic transformation highlights the critical dependence of Euastacus crayfish on healthy riparian ecosystems. Preservation and restoration efforts focused on conserving these zones are crucial to safeguarding the habitats necessary for the survival and conservation of *Euastacus* populations.

Major Threats to *Euastacus* identified by this project

Invasive Cherax destructor

The negative impacts from translocated populations of *Cherax destructor* Clark, 1936 in other parts of Australia have been discussed by various authors (Austin, 1985; Horwitz, 1990; Horwitz and Knott, 1995; Merrick, 1995; Elvey *et al*., 1996; Bradsell *et al*., 2002; Beatty *et al*., 2005; Coughran *et al*., 2009; McCormack, 2014). In this project we found that as stream conditions change and where the riparian zone has been completely cleared for cattle grazing, that *Cherax destructor* becomes the dominant species in residence.

Cherax destructor is a species that prefers warm water and open sky environments, it is a prolific, robust species that has the capacity to rapidly establish populations, all indications are that stream conditions have changed to suit *C. destructor* to the detriment of *Euastacus* crayfish.

For example, in this study we found the presence of *Cherax destructor* in large numbers a clear indication that species like *E. suttoni* (McCormack 2021b), *E. simplex* (McCormack

2022a) or *E. claytoni* (McCormack 2022d) were no longer present within the area and had been replaced with *C. destructor*.

Morgan in his 1988 redescription of *E. suttoni* was based on his field surveys in 1981; he did not capture *Cherax destructor* and *E. suttoni* together during those surveys. He states that; *"C. destructor was frequently collected downstream of E. suttoni".* At the majority of those 1981 sites that Morgan documents *E. suttoni* as occurring, now in this project when we surveyed those sites only *C. destructor* was abundant, and I surmise this species has displaced/replaced *E. suttoni*.

The impact on *Euastacus* species by invasive *C. destructor* in eastern NSW has been documented by Coughran *et al*. (2009); McCormack (2014). *Cherax destructor* is a prolific, robust species that has the capacity to rapidly establish populations: they only take 6 months to reach sexual maturity compared to *Euastacus* species that takes 7-9 years. Female *C destructor* breed up to 3 times per year compared to once/year for the giant group crayfish like *E. suttoni* or once every second year for dwarf group crayfish like *E. spinichelatus*. *Cherax destructor* has 100-1000 offspring per breeding compared to *E. suttoni* with 200-400 or *E. spinichelatus* that has 20-70 offspring per batch (McCormack & Whiterod, in prep A). *Cherax destructor* grow to 350 grams in weight, whilst *E. suttoni* also reaches 350 gram and dwarf groups like *E. spinichelatus* only reach 41 grams in weight. Once *C. destructor* becomes established it will continue to spread with ongoing negative impacts for endemic *Euastacus* species.

The common yabby *Cherax destructor* is a predator and cannibalistic (McCormack 2005). Larger animals actively seek out and consume smaller animals. Crayfish are most susceptible to predation when they moult, leaving them soft and vulnerable unable to defend themselves. For any crayfish to grow, it must moult regularly, be it *Cherax* or *Euastacus*. Large adult *E. suttoni* may be invulnerable to *C. destructor* predation but juvenile *E. suttoni* are highly susceptible. As the *C. destructor* population numbers increase the likelihood of *E. suttoni* juveniles being consumed greatly increases. In the *E. suttoni* report ((McCormack 2021b) Site 12 Paling Yard Creek, Girraween National Park, Qld, where an adult *E. suttoni* was captured in amongst a swarm of *C. destructor* is a site/creek that in another 10 years or so *E. suttoni* will be extinct. Those large remnant adults may breed each year for the next 10 or 15 years, but if none of their juveniles survive to replace them, then the writing is on the wall and eventually the species will become extinct in that stream.

The ecological dynamics within streams involving both *Euastacus* crayfish and *Cherax destructor* are complex and pivotal to the survival of these species. Euastacus crayfish, particularly the adults, play a crucial role in maintaining the equilibrium of their habitat. They are long-lived, territorial, and defend their territory against invaders. This territorial behaviour contributes to a balanced population structure within the streams, where adult numbers remain relatively static while the juvenile population fluctuates. However, this

balance can be significantly disrupted by various factors such as habitat destruction, drought, or other stressors, leading to potential irreparable damage to the stream's ecology.

Cherax destructor is a warm-water species that prefer intermittent, open-sky environments, it is a prolific, robust species that has the capacity to rapidly establish populations. *Euastacus* crayfish are cold-water species, and highly active and very aggressive at a water temperature of 16 °C. However, at 22 °C they are very slow and lethargic and unable to defend themselves, whereas *C. destructor* are highly active and aggressive and able to harass the incapacitated *Euastacus* and/or consume them. All indications are that stream conditions over tens of thousands of square kilometres of NSW have changed (open sky conditions, warm water, intermittent flow) to suit *C. destructor* to the detriment of species such as *E. gamilaroi, E simplex* and *E. Suttoni.*

For example, Coughran & Furse 2010 assessed *Euastacus simplex* as vulnerable based on historic records. IUCN Status: VU B1(a), (b)iii based on EOO <20,000 km^2. McCormack 2022a documents an EOO in 2022 as to have declined since 1954 to only 300 km^2 today, the rest is invasive *Cherax destructor* habitat.

One particularly concerning aspect is the dispersal rate of *Cherax destructor*, which significantly contrasts with the limited dispersal capability of *Euastacus* crayfish. The former can migrate extensively, covering considerable distances upstream and downstream. This characteristic makes *Cherax destructor* highly invasive and able to quickly fill gaps or niches left by declining *Euastacus* populations. This rapid dispersal capability contributes to its expanding dominance across various drainage systems, representing a substantial threat to native crayfish populations.

The ecological equilibrium and viability of *Euastacus* crayfish are significantly influenced by a myriad of factors, encompassing anthropogenic interventions, ecological disturbances, and the proliferation and swift spread of invasive species such as *Cherax destructor*. The ramifications of these interplays on indigenous species underscore an urgent imperative for conservation endeavours targeting the safeguarding and rehabilitation of habitats crucial for sustaining *Euastacus* populations while mitigating conditions favourable to invasive *Cherax* proliferation.

Illegal Fishing and collection

During this project we identified illegal fishing occurring at numerous sites*, E. guwinus* (McCormack, 2021f), *E. jagabar* (McCormack, 2020b), *E, dalagarbe* (McCormack, 2020a)*., E. suttoni* (McCormack, 2021b) and also other non priority species, *E. valentulus* and *E. sulcatus* were all being illegally taken.

For example, *Euastacus suttoni*; Leckie *et al.* (2005); Coughran *et al*. (2010); and McCormack (2012), all identified illegal fishing as a threat to this species. All giant spiny group crayfish are the dominant invertebrate predator within their streams, they are active in

the streams day and night and readily attracted to and captured in traps, they are extremely vulnerable to illegal fishing. Despite *E. suttoni* being protected in both States the species is heavily illegally fished, in this study we observed people illegally fishing for crayfish. Most of these people have no idea of the fishing regulations, no idea as to what species occur where, and no idea of any protected species. It's all just yabbies and they are happy to catch and eat whatever they can get, wherever they can get them. Lack of education, lack of any signage in National Parks and camping area is a key threatening process to this species that is actively attracted to traps and easily captured. Loss of adult crayfish that take 10 years to replace does irreparable damage to that stream's ecology. Those large giant adults are the front line troops that protect the stream from invasion by *Cherax destructor* and other predators, once they are illegally poached, the battle is lost.

Illegal fishing and collection are a major threat to *Euastacus* crayfish.

Climate change

General climate change predictions indicate a general rise in temperatures. Any rise in general air temperature equates to a general rise in water temperature. Many *Euastacus* species are climate refuges, restricted to the cool waters of the upper catchment. Their distribution downstream is restricted by the water temperatures downstream. Those crayfish living at the lowest altitude sites are at the limit of their water temperature tolerance, even a small change of 1˚C can make that water uninhabitable.

In this project we saw a general reduction of the downstream distributions of crayfish species due to increased water temperatures. For example, *E. jagara* Qld (McCormack 2021a) seemed to no longer occur at the lower altitude sites compared to its abundance at these sites 10 years ago. Rising water temperatures are a major threat to *Euastacus*.

In this project we documented species distributions being dramatically reduced at the top of their distribution due to drought and being reduced at the bottom of their distributions by rising water temperatures.

Climate change is a major threat to *Euastacus.*

Domestic stock

Loss of riparian zones by clearing for stock access is a major threat. Uncontrolled stock access to creeks and rivers causes massive damage. Their hoofs trample burrows and destroy incised banks, making the area uninhabitable to *Euastacus* crayfish; their wastes create pollution that has impacts not only at the site but also further downstream.

Not only domestic stock but wild stock is also a problem. The damage created by wild brumbies in Kosciusko National Park and surrounding areas is well documented and a major

threat to species such as *E. rieki* and *E. crassus* that occur in the area and have been eliminated from large areas degraded by the brumbies.

Domestic stock is not only creating damage on private properties, this project also documents the destruction caused by cattle being grazed in State Forests of NSW. The endangered dwarf group crayfish *Euastacus spinichelatus* has undergone significant population declines due to drought and bushfire. It is currently locally extinct at its holotype (Hastings drainage) and paratype (Macleay drainage) locations (McCormack 2020f). Both sites are within Enfield State Forest and both sites are now heavily degraded by uncontrolled cattle grazing within the State Forest.

Figure 22 Sign on the gate into Enfield State Forest

Domestic stock is a major threat to *Euastacus* crayfish.

Jurisdictional lack of protection

In NSW many of our most Endangered *Euastacus* crayfish only occur within small areas within National Parks. This is generally considered a high level of protection, however, that is not the case. National Parks in NSW provide zero protection from illegal fishing or illegal collection. Aquatic resources within National Parks are not within the scope of National Park Rangers jurisdiction or protection. Typically, National Parks Rangers have no knowledge of the *Euastacus* species that occur within their Park or the fishing regulations that apply to those species, and even those that do know, have NO authority to enforce any fishing regulations which is the jurisdiction of NSW DPI Fisheries.

This is a major threat to the endangered crayfish that occur within National Parks. Rangers typically receive dozens of complaints from park users about people illegally flipping rocks in creeks and collecting crayfish, but they have no authority to do anything. NSW National Parks Rangers need to be given the authority to protect all animals in their Parks not just a few cute furry terrestrial animals.

It's promising to hear in 2023 about the increased attention and resources directed towards combating illegal inland crayfishing within National Parks and State Forests by NSW Fisheries. This move could significantly benefit the preservation of endangered *Euastacus* species.

By implementing patrols and dedicating resources to curbing illegal crayfishing activities in these protected areas, it's possible to mitigate the threats posed to these endangered species. Protecting these environments from illegal exploitation is critical for the survival and conservation of *Euastacus* crayfish populations. Efforts aimed at enforcement, education, and public awareness regarding the significance of protecting these species and their habitats are fundamental to safeguarding their future. Collaborative actions involving authorities, conservationists, and the public play a vital role in ensuring the longevity of these endangered species within these protected environments.

Poor Forestry Practices

Unfortunately, for *E. gamilaroi*, our surveys in 2019 -2021 documented bad forestry practices in action (McCormack 2021c). From the bridge crossing Forest Way, Burrows Creek had been clear felled downstream on one side. Zero riparian zone now exists on one side of the creek. Although, this section of creek was dry at the time (2019), when rainfall occurs there is nothing to stop sediment washing into the creek and impacting the downstream population, additionally, with the clear sky conditions, sunlight on the water will heat it, also impacting on the downstream populations. Additionally, much of the unwanted timber has been dumped in the creek.

Figure 23 Burrows Creek, an *E. gamilaroi* stream, clear felled to water's edge (2021)

Unfortunately, current forestry practices are far inferior to those of the past. Riparian zones to and through the creeks are being cleared (Sites 9 & 10). Timber is being pushed into the creeks. Current poor forestry practices are an immediate major threat to this species (McCormack 2021d).

Other Threats

Flash floods

For many *Euastacus* species their juvenile crayfish construct rudimentary Type 1, burrows under rocks, litter and logs in the streams. Severe weather with flash flood events places these juveniles at extreme risk. The structures they are sheltering under can easily be moved and dislodged in extreme flood events, this will expose the juvenile to the full impact of the raging flood waters, resulting in mortality. Flash floods are a major threat to *Euastacus* crayfish.

Exotic animals

Exotic pests such as cats, foxes, pigs and goats occur within the range of *Euastacus* crayfish surveyed by this project. These species have been found to impact on other crayfish species elsewhere (e.g. Green and Osbourne, 1981; Horwitz, 1990; Merrick, 1995; Eyre *et al*., 1997; ACT Government, 2007; O'Brien, 2007).

During the extent of this project, we observed the occasional cat and goat but do not consider these a current threat to any of the 18 *Euastacus* species surveyed.

Foxes

Foxes occur across the *Euastacus* distribution area and were documented in a number of our reports. Fox numbers were high in some areas (McCormack, 2022g) and we do consider these a threat to *Euastacus* crayfish.

Feral Deer

Feral deer numbers are on the rise. Large numbers of deer were observed during this project, and although we did not identify any current threat from their numbers, if left unchecked we could see a problem arising like we have with wild brumbies. We consider feral deer as an emerging threat (McCormack, 2022g).

Wild Pigs (Sus scrofa)

Predation, habitat degradation, competition and disease transmission by feral pigs has been listed by the NSW Scientific Committee as a key threatening process in NSW. Predation, habitat degradation, competition and disease transmission by feral pigs was listed as a key threatening process under section 168 of the EPBC Act in 2002.

Feral pigs have been regarded as a threat to some *Euastacus* species. In this project we did identify feral pig activity. Pigs rooting for underground parts of plants and invertebrates destroy the riparian vegetation, destroy seedlings and generally degrade the habitat.

In both the *E. jagara* (McCormack 2021a) and *E. suttoni* (McCormack 2021b) reports the crayfish create a burrow that extends into the streams riparian zone making them susceptible to the pig rooting and consumption by pigs and both species were impacted by feral pigs but only to a very minor extent and although some crayfish may have been lost the impact to their overall populations would be small. In other reports *Euastacus polysetosus* (McCormack 2022c), *Euastacus clarkae* (McCormack 2022b), *Euastacus gamilaroi* (McCormack 2021d), were also impacted by feral pigs.

We support any wild pig control programs but for our 18 *Euastacus* species surveyed they were not currently a major threat only a minor one.

However, in this project we did identify another species that occurs in the area *Euastacus maccai* (McCormack and Coughran 2008) that prefers the wet muddy, swampy areas and it is these areas that are targeted by feral pigs, this is a threat to them and their habitat. Additionally, other *Euastacus* species that occur in soft wet swampy areas such as *E. setosus*

and *E. yigara* are both being critically impacted by wild pigs and for these species wild pigs are a major threat.

Wild Horses/Brumbies (Equus caballus)

The negative environmental impact of wild horses has been formally recognised by the listing of habitat degradation and loss by feral horses as a Key Threatening Process in Schedule 4 of the NSW Biodiversity Conservation Act 2016. The impact of wild horses in Kosciusko National Park (KNP) has been well-documented in a number of scientific, peer-reviewed papers. We have observed *Euastacus rieki* and *Euastacus crassus* in KNP as being seriously impacted by wild horses.

In this project we identified growing numbers of horses in Barrington National Park, NSW as a looming threat to *Euastacus polysetosus* (McCormack 2022c). Although, the threat is small at the moment we consider wild horses as an emerging threat in Barrington Tops National Park area.

Water extraction/mining

Many of the *Euastacus* species subject to this project rely on permanently flowing creeks. Most of these creeks are groundwater fed which creates constant/permanent flows and stable temperatures. Any extraction of this groundwater that reduces that creek flow will eliminate the *Euastacus* species in those creeks.

Any groundwater mining or harvesting in their distribution area must be considered a key threatening process to *Euastacus* crayfish.

Dam and Weir construction

Typically for larger municipal dams, cold water pollution is the problem with water being released downstream that is from the bottom of the dams and 10˚C colder than the downstream waters. All research to date has been on the impacts to native fish species that prefer warm water. No research has been conducted as to the impacts to *Euastacus* crayfish that prefer cold water.

During this project we identified numerous sites where small dams and weirs were critically damaging stream ecosystems by releasing hot surface water into cold water streams. These smaller structures do not release cold water from the base of the dam but only hot surface water. These smaller dams and weirs create a large surface area of shallow, open sky, static water that rapidly heats in the sun. This hot surface water is released downstream, dramatically raising the downstream water temperatures to the detriment of *Euastacus* species.

Furthermore, the still static water of the weir or dam is typically not preferential *Euastacus* habitat that like flowing water but prime habitat for invasive species like *Cherax destructor*. This project identified a large number of *Euastacus* species that have been detrimentally impacted by dams and weirs on their streams.

For example, Bald Rock and Accommodation Creeks in Lyra, Qld have a number of small weirs created on them. These streams used to be prime habitat for *E. suttoni,* today no *E. suttoni* occur only *C. destructor* (McCormack, 2021b).

Burnt Hut Creek Hanging Rock, NSW has a number of Dams (Sheba Dams) constructed on it. Above the dams *E. gamilaroi* exists, in the dams and below, only *C. destructor* for the 2km of Creek until after it joins Burrows Creek then *E. gamilaroi* exists again (McCormack, 2021c).

Dams and Weirs are a threat to *Euastacus* crayfish.

Exotic Fish

Exotic Plague Minnows or mosquito fish *Gambusia holbrook*i (Girard, 1859), are generally considered tropical species impacting newly released juvenile crayfish at low altitudes. However, during this survey we encountered *Gambusia holbrooki* at 1250 m. Both Sheba Dams on Burrows Creek were infested with *Gambusia holbrooki* as were other dams in the general area. Predation by *Gambusia holbrooki* (Plague Minnow) was listed as a KEY THREATENING PROCESS on Schedule 3 of the Threatened Species Conservation Act 1995 (29 January 1999). Their impact on *Euastacus gamilaroi* juvenile crayfish remains unknown but must be of concern and considered another threatening process.

Exotic Rainbow Trout (*Oncorhynchus mykiss*) are known predators of freshwater crayfish (Horwitz, 1990; Merrick, 1995). Introduced trout and any offspring that may now occur naturally pose a serious threat. Adult crayfish are invulnerable to trout predation, but juveniles are susceptible (Merrick and Schmida, 1984). The level of threat is unknown as interactions have not been documented, but we know that trout prey on small juvenile freshwater crayfish and prefer the same upland, flowing stream environments as *Euastacus* crayfish. These trout pose no threat to the adult crayfish, however, the juveniles when released would be threatened by the trout. Unfortunately, the large adult crayfish prefer the small deeper pools in the streams; this also is the preferred habitat for exotic trout, thus creating a key threat to this species.

During our surveys we identified Rainbow Trout in pools with *E. coughrani, E. diversus, E. gamilaroi, E. polysetosus, E simplex* and *E. claytoni*. Notably, while Rainbow Trout were specifically identified, the potential presence of other exotic trout species such as *Brown Trout* and *Brook Trout* in *Euastacus* streams warrants equal concern, suggesting a significant threat to all *Euastacus* species.

Fecundity and capacity to recover.

McCormack (2012) delineated the *Euastacus* genera into three distinct groups based on shared morphological and biological characteristics, with fecundity and recovery capacity directly correlated to these groupings.

Fundamental constraints apply uniformly across all *Euastacus* species, irrespective of their group:

- *Euastacus* take 7-9 years to reach sexual maturity
- *Euastacus* breed a maximum of once/year
- Breeding is keyed to dropping water temperatures
- All *Euastacus* species breed before water temperatures drop to 7 °C (many lowland species breed at much higher temperatures, but no species breed below 7 °C)
- Generally, breeding commences May-June in El Niño years & April to May in La Niña years. (This applies to all species except *E. mirangudjin* from northern NSW & southern Queensland that displays a different pattern).
- *Euastacus* eggs are a similar size regardless of the species (Average oval 3.5 mm x 2.5 mm).

Unfortunately, measuring egg diameters is a relatively new parameter and previously we only counted eggs. However, for this report the following is offered on the current state of the knowledge base re fecundity for our 18 species surveyed.

Report No.	*Species*	Group	Egg size (mm)	Egg No.
1	*Euastacus dalagarbe*	Dwarf		35
2	*Euastacus jagabar*	Dwarf	3.12 x 2.7	2*
3	*Euastacus girurmulayn*	Dwarf	3.4 x 2.8	21-24
4	*Euastacus gumar*	Intermediate	3.39 x 2.68	50-150
5	*Euastacus pilosus*	Intermediate	3.2 x 2.76	60-100
6	*Euastacus jagara*	Dwarf		50-70
7	*Euastacus suttoni*	Giant		200-400
8	*Euastacus spinichelatus*	Dwarf	3.10 x 2.59	16-69
9	*Euastacus gamilaroi*	Intermediate	3	30-100
10	*Euastacus simplex*	Intermediate		100-150
11	*Euastacus morgani*	Intermediate	Unknown	Unknown
12	*Euastacus guwinus*	Intermediate	3.35 x 2.5	20-150
13	*Euastacus clarkae*	Intermediate	3.7	75-288
14	*Euastacus polysetosus*	Intermediate		30-60*
15	*Euastacus claytoni*	Intermediate	3.4 x 2.22	66-170
16	*Euastacus bidawalus*	Intermediate	3.4 x 2.3	88-107
17	*Euastacus diversus*	Intermediate	Unknown	30*
18	*Euastacus coughrani*	Intermediate	3.78 x 2.76	97
	Euastacus spinifer	Giant	3.5 x 2.6	200-1500

Note *E. jagabar*: * Only two berried females have ever been captured some 13 years apart, both had only 2 eggs (Fig. 24).
Note *E. polysetosus*: * Only small berried females captured to-date
Note *E. diversus*: * Only one small berried female observed with 30 eggs
Note E. spinifer: This species is added due to the under representation of Giant Group crayfish in the table.

Euastacus eggs are a similar size regardless of the species (Typically oval 3.2-3.7 mm x 2.2-2.7 mm). There is variation between egg size on each individual and between individual eggs in any given batch but basically, they are all similar sized. This is a critical factor.

- dwarf group crayfish are small in stature, they only hold a small number of eggs (generally 20–70)
- intermediate crayfish are intermediate in size, they hold a medium number of eggs (generally 50–170)
- giant group are the largest with large numbers of eggs (generally 200–1500)

The recuperative potential of a species correlates directly with the fecundity of females within their respective groups. However, reproduction rate presents another critical variable, with distinctive differences among the groups.

Based on ACP research we offer the following observations.

- dwarf group mature female crayfish will reproduce 2-3 times in 5 years
- intermediate group mature female crayfish will reproduce 3-4 times in 5 years
- giant group mature female crayfish will reproduce 4-5 times in 5 years

Notably, the dwarf group, reproducing at longer intervals with fewer offspring, exhibits the least capacity for population recovery. Conversely, the giant group, characterized by larger offspring batches and annual reproduction, demonstrates the highest potential for rapid recuperation following a mass mortality event.

Figure 24 *Euastacus jagabar* only 2 berried females ever recorded. Left 2007 and right 2020, both only 2 eggs (Extract McCormack, 2020b).

Figure 25 Rob McCormack with an *E. spinichelatus* with small clutch of eggs

Recommendations for the Conservation of Endangered *Euastacus* Crayfish:

1. **Assessment and Conservation Classification:**
   Conduct assessments of all *Euastacus* species and nominate them for suitable conservation categorization under the EPBC Act.
2. **Range Definition through Field Surveys:**
   Intensively survey *Euastacus* species to define their Extent of Occurrence (EOO) and clarify their distribution, particularly for species with limited known ranges.
3. **Fill Knowledge Gaps in Biology and Ecology:**
   Prioritize further field surveys and sampling to enhance understanding of the biology and ecology of various *Euastacus* species, addressing critical knowledge gaps.
4. **Support Molecular Taxonomy Projects:**
   Back molecular taxonomy projects to identify additional *Euastacus* species, leveraging the potential to double the known species count in Australia by surveying the numerous yet unexplored habitats.
5. **Discovery and Taxonomic Descriptions:**
   Prioritize field surveys aimed at discovering and describing new species and new Genera to prevent the unnoticed extinction of unknown and undescribed species.

6. **Implementation of Educational Signage:**
   Erect educational signage in National Parks and State Forests, especially along trails and camping areas, informing visitors about the endangered status of crayfish and the prohibition of fishing or collection. This is a priority!
7. **Enhanced Jurisdictional Protection:**
   Advocate for expanded jurisdiction and authority for NSW National Park Rangers to enforce regulations protecting aquatic species, ensuring comprehensive protection within park waterways.
8. **Comprehensive Protection Measures:**
   Lobby for the full protection of all *Euastacus* species (except *E. armatus*) in NSW and Victoria, prohibiting capture and consumption, akin to the current protection of *Euastacus bispinosus* in Victoria and all *Euastacus* in Queensland.
9. **Translocation Strategies:**
   Develop translocation plans to mitigate local extinctions and prevent the establishment of invasive species, particularly relevant for *Euastacus* species facing extinction.
10. **Temperature Baseline Data Collection:**
    Initiate the compilation of baseline water temperature data across *Euastacus* drainages by deploying data loggers, crucial for understanding and preserving their cool water habitats.
11. **Integration into Education Curriculum:**
    Advocate for the inclusion of *Euastacus* crayfish information in primary and tertiary school curriculums, raising awareness about these unique Australian species.
12. **Urgent Species-Specific Management:**
    Implement monitoring programs and formulate specific management plans to counter the rapid decline of *Euastacus* species facing heightened extinction risks.
13. **Priority on Habitat Protection and Restoration:**
    Prioritize the protection and restoration of riparian zones to reverse the decline of *Euastacus* populations and restore their habitats.
14. **Formal Description of New Species:**
    Formally describe the 27 potentially new *Euastacus* species identified under the "Save the Spinys" project to enhance understanding and conservation efforts.

Conclusions

Project 100086 conducted extensive field surveys on 18 *Euastacus* species, significantly contributing new insights into their distributions, population sizes, and overall status. The survey outcomes reveal distressing declines in distribution and population levels across all 18 species. While certain species, such as *E. jagara*, exhibit moderate declines, others like *E. simplex* or *E. suttoni* face severe and alarming reductions, raising extreme conservation concerns.

These findings underscore the urgent need for comprehensive conservation and management initiatives aimed at safeguarding our threatened freshwater *Euastacus* crayfish. By

highlighting the critical status of these species, it is anticipated that the survey results will catalyse the development of conservation strategies and management plans essential for the protection and preservation of these numerous imperilled species.

Figure 26 Rob McCormack left and Claudia Santori (Oceanwatch) right with *E. yanga* during the *E. guwinus* survey, Morton National Park NSW

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Figure 27 Camping beside the Queensborough River Victoria for the *E. coughrani* survey.