Flow optimisation benefits fish and crayfish in refuge pools

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Key Points

- Fluctuating environmental entitlement volumes often prevent the full range of recommended watering actions.
- Small amounts of environmental water can maintain important populations of small-bodied fish and crayfish.
- Rapid surveys can be used to cost effectively detect and monitor aquatic fauna persistence in refuge pools.
- Maintenance of refuge pools in intermittent systems is particularly important for enhancing long distance dispersal and recolonisation potential.

Abstract

Limited environmental water entitlement during summer/autumn 2018/19 prevented delivery of recommended flows for the mid and lower MacKenzie River and upper Burnt Creek. Previously, this scenario resulted in 'system resets' where refuge pools were presumed to have dried out and aquatic fauna lost (e.g. 2012/13 and 2014/15). Environmental watering in 2016/17 and 2017/18 re-established important fish and crayfish populations.

Ecology Australia worked with the Wimmera Catchment Management Authority to identify key refuge pools, rapidly collect baseline fish and crayfish data, workshop optimal autumn/summer environmental watering regimes based on limited water availability, and to establish minimum depth thresholds and depth monitoring regime for refuge pools. This was followed by post-implementation rapid surveys to assess population persistence in years where the watering regime was implemented (2020, 2022) and post significant flooding events (2023).

The environmental watering regime prioritised conserving refuge pools through periodic low flows, followed by provision of winter/spring releases for obscure galaxias spawning when enough water is available. This took precedence over summer and autumn 'freshes' previously considered a high priority. Self-sustaining populations of important fish and crayfish persisted at all refuge sites in 2019 and subsequent monitoring years. Realistic potential now exists for some of these species to recolonise the Wimmera River and for river blackfish to be reintroduced to Burnt Creek, where a population existed until 2002.

Fluctuating environmental entitlement volumes often prevent the full range of recommended watering actions. When water availability is limited, maintaining refuges is critical for the persistence of aquatic values.

Keywords

Environmental flows, refuge habitats, fish, crayfish, drought

Introduction

Burnt Creek and the lower MacKenzie River are flow-stressed systems and were thought to have dried out completely during the millennium drought, resulting in extirpation of fish populations including river blackfish (*Gadopsis marmoratus*) from Burnt Creek. The upper and mid MacKenzie River have more reliable flow regimes and contain some of the most intact fish communities remaining in the Wimmera River basin, including populations of river blackfish, southern pygmy perch (*Nannoperca australis*) and obscure galaxias (*Galaxias oliros*).

The MacKenzie River originates above Lake Wartook, and runs through the Grampians, joining the Wimmera River south-west of Horsham (Figure 1). The upper and mid MacKenzie River are separated by Dad and Dave Weir. The lower and mid MacKenzie River are separated by Distribution Heads Weir. Burnt Creek is an anabranch or distributary of the MacKenzie River, which originates from the Distribution Heads Weir and terminates at the Wimmera River confluence in the Horsham Weir Pool. Upper and lower Burnt Creek are separated by the Toolondo Channel (Figure 1). Upper MacKenzie River receives near continuous flows due to operational water transfers to Horsham via the Mount Zero Channel. Flows in the mid MacKenzie River are more intermittent but it receives operational transfers en route to Toolondo Channel and any environmental flows en route to Burnt Creek or the lower MacKenzie River (Figure 1). Flow stress is higher in the lower MacKenzie River than upper Burnt Creek because the latter also receives operational flows en route to Toolondo Channel.

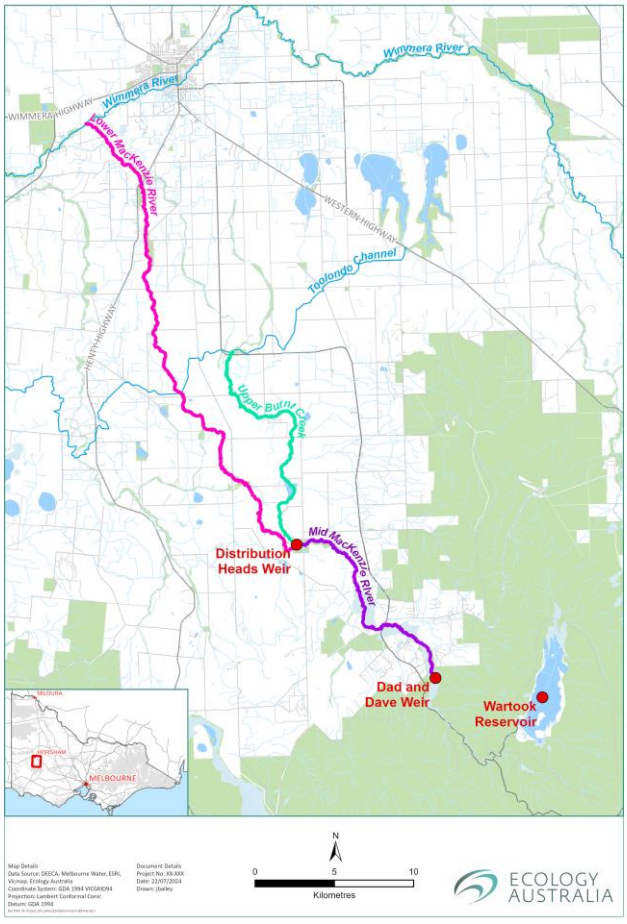

Figure 1. The location of upper Burnt Creek and the lower MacKenzie River.

Environmental watering of Burnt Creek and the lower MacKenzie Rivers commenced in 2012 when sufficient water was available; however, the systems were considered 'highly intermittent' and the watering targets for fish were accordingly focused on fish dispersal and recolonisation during wet and average years, rather than maintenance of drought refugia in dry years (Alluvium 2013). Extensive downstream recolonisation and recruitment of southern pygmy perch, obscure galaxias, and a newly discovered population of western swamp crayfish (*Gramastacus insolitus*) was first documented in Burnt Creek and the lower MacKenzie River in December 2012 following winter/spring environmental watering (Bloink 2013). However, these gains were lost in early 2013 when refuge habitats could not be maintained, resulting in the loss of aquatic fauna values, i.e. a 'system reset'.

Similar environmental watering gains were documented in subsequent years (e.g. Bloink 2014); however, system resets continued to erase these gains due to a lack of summer/autumn environmental water (e.g. 2014/15) or substantially reduced environmental water (e.g. 2015/16). Summer/autumn environmental watering in 2016/17 and 2017/18 was expected to have maintained refuge pools over two successive years for the first time since the millennium drought. The population gains made in 2016/17 (see: Stevenson and Bloink 2017) were expected to be lost again in 2018/19 due to substantially less water being available for environmental watering compared with previous years, well below recommended flows (Alluvium 2013).

This project was initiated to understand how a reduced volume of environmental water could best be used to protect and enhance fish and crayfish populations in these systems.

Methods

We undertook a review of all available fish and crayfish information for the lower MacKenzie River and upper Burnt Creek, focusing on reports and data collected over the 2012–2018 period. We examined available aerial imagery from summer 2005, 2010 and 2017, together with LiDAR imagery from 2010, to identify the location of potential refuge pools. The best available pools from the lower, mid and upper sections of the lower MacKenzie River and upper Burnt Creek were prioritised for ground truthing. Two established sites and four new sites (three sites in each waterway) were selected and rapidly surveyed for fish and crayfish in early January 2019 (Figure 2).

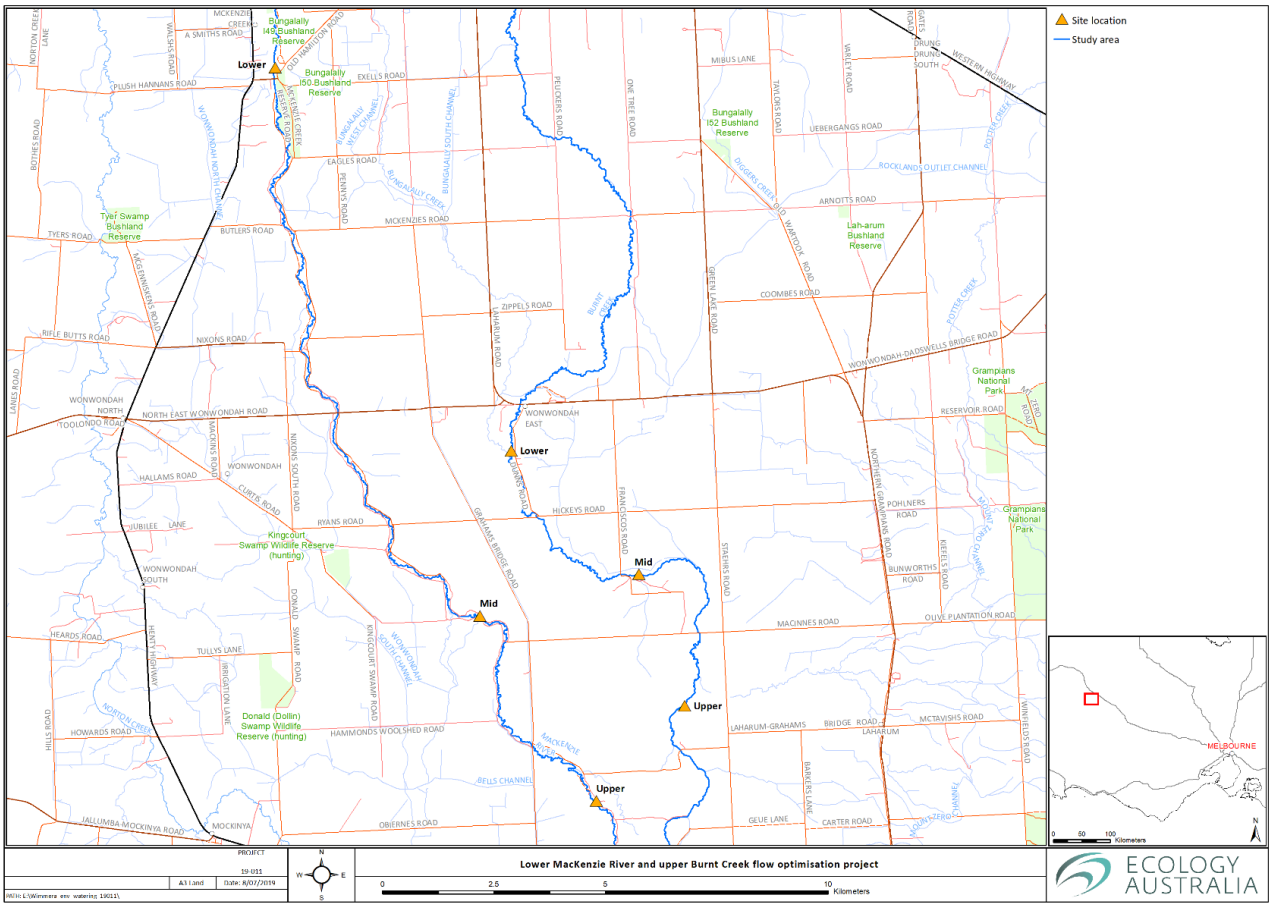

Figure 2. The location of refuge pool monitoring sites for upper Burnt Creek and lower MacKenzie River.

A workshop was held with staff from Wimmera Catchment Management Authority (WCMA), Victorian Environmental Water Holder (VEWH), Ecology Australia (EA) and Arthur Rylah Institute (ARI) to discuss the results of the survey and to use all available ecological, flow regime and flow constraint knowledge to review the suitability of existing flow recommendations (Alluvium 2013) and develop a flow and monitoring regime suited to maintaining aquatic fauna values under scenarios with much reduced environmental water availability.

The workshop recognised the maintenance of refuge pools in these waterways as an important environmental watering target to enhance population viability and facilitate more widespread dispersal and recolonisation potential, ultimately to the Wimmera River itself. A series of recommendations were developed and implemented by WCMA in summer and autumn 2019. The recommendations included:

- Reducing the emphasis on the need for summer/autumn freshes in these systems to conserve the environmental water required to maintain refuge pools.
- Reconsidering the ‘flushing’ purpose of summer/autumn freshes in favour of alternating environmental water deliveries between the two waterways at reduced flow rates and for reduced duration.

- Prioritising the watering of each of the six refuge pools based on their differences in existing aquatic fauna values and expected system losses. This meant that the most downstream MacKenzie River refuge pool was assigned the lowest priority due to the large distance required for water transfer and higher water losses in that system.
- Establishing critical depth thresholds at each refuge pool and appropriate depth monitoring frequencies, particularly throughout the December to April period.

A post implementation rapid survey was undertaken in June 2019 to determine the persistence of three target species (southern pygmy perch, obscure galaxias and western swamp crayfish). Subsequent surveys were undertaken in November 2020 following the implementation of a similar watering regime in summer/autumn 2020 (Bloink and Coates 2020) and in December 2022 (Bloink et al. 2023). The 2022 survey omitted the most downstream lower MacKenzie River refuge pool site, as this was not a target of environmental watering from summer/autumn 2020 onwards due to high system losses.

Results

A summary of the background review of the distribution and recolonisation potential of the three target species over the 2012 to 2018 period (i.e. before the 2019 pre and post optimisation surveys) is provided in Table 1, including the expected recolonisation distance from the expected source (i.e. mid MacKenzie River at Distribution Heads).

Table 1. Summary of key results from previous surveys of Burnt Creek and lower MacKenzie River undertaken by Biosis (Bloink 2013), Ecology Australia (EA) (Bloink 2014, Stevenson and Bloink 2017) and Arthur Rylah Institute (ARI) (VEFMAP data) over the 2012–2018 period. Note that a range of different sites were used for these surveys.

Target species	2012 Biosis	2014 EA	2017 EA	2017 ARI	2018 ARI
Obscure galaxias (*Galaxias oliros*)	Colonised all sites in both waterways, including to Three Bridges Rd on MacKenzie River (>33 km). Decline in Catch Per Unit Effort (CPUE) in downstream direction in MacKenzie River.		Only detected at Burnt Creek sites. Lower abundances than 2012 and 2014.	Detected at the three most upstream MacKenzie River sites in low abundance.	
Southern pygmy perch (*Nannoperca australis*)	Colonised both Burnt Creek sites and first two MacKenzie River sites (~8 km). Decline in CPUE in downstream direction in MacKenzie River.		Detected at all sites except MacKenzie River DS Wonwondah (colonised >33 km to Three Bridges Rd). Decline in CPUE in downstream direction in MacKenzie River		Detected at all sites except Three Bridges Rd (colonised >26 km to MacKenzie Creek). DS decline in CPUE in MacKenzie River.
Western swamp crayfish (*Gramastacus insolitus*)	Detected at both Burnt Creek sites and the most upstream MacKenzie River sites.	Detected at both Burnt Creek sites only.	Detected at both Burnt Creek sites and the most upstream MacKenzie River site.	Not detected.	

The results of the pre-implementation (January 2019) survey on Burnt Creek indicated that the refuge pools either do not fully dry out or have not done so for an extended period. Results included the detection of a large and well-structured population of southern pygmy perch at the 'mid' Burnt Creek site, together with detections of freshwater mussels at the 'mid' and 'lower' sites. The 'system resets' that were previously considered to have occurred (i.e. 2011/12, 2012/13, 2014/15, 2015/16) are, therefore, likely to have only been partial resets, in that the vast majority of the habitat in the system may have dried out, with the exception of the deepest refuge pools. It is expected that the mid MacKenzie River and deep refuge pools such as the 'mid' Burnt Creek site provided the source fish for the widespread recolonisation that was observed in previous years.

At most sites, the full suite of target species (southern pygmy perch, obscure galaxias and western swamp crayfish) was detected during the post-implementation survey (June 2019). The relatively high abundances and diverse size classes suggest that the refuge pools likely persisted through summer/autumn 2019, as opposed to these populations being the result of dispersal from the mid MacKenzie River following natural flow events over the April–May 2019 period.

Results of the November 2020 (Bloink and Coates 2021) and December 2022 (Bloink et al. 2023) surveys, indicate continued persistence of target species populations at the refuge pools over the 2019–2022 period (see Table 1), with large increases in Catch Per Unit Effort (CPUE) of southern pygmy perch evident at Burnt Creek sites, notwithstanding expected seasonal and water level (density) differences.

Table 2: Catch Per Unit Effort (CPUE) (# fish/min of backpack electrofishing) comparison between sites and sampling events. Species persistence between surveys highlighted in green. Note: CPUE intended for broad comparison only, as seasonal and water level (density) differences influence CPUE.

River/Creek	Site	Sampling event	Obscure galaxias	Southern pygmy perch	Western swamp crayfish
Upper Burnt Creek	Upper	January 2019	0.2	25.5	0.3
		June 2019	0.8	7.4	0.8
		November 2020	2.1	38.0	0.1
		December 2022	0.2	69.8	2.0
	Mid	January 2019	0.3	45.3	0.3
		June 2019		5.3	
		November 2020	1.0	18.1	0.8
		December 2022	0.5	91.7	5.2
	Lower	January 2019	0.4	9.6	2.0
		June 2019	1.0	2.9	0.1
		November 2020	0.2	2.5	0.2
		December 2022		17.5	0.4
Lower MacKenzie River	Upper	January 2019	2.4	4.2	0.1
		June 2019	0.6	2.4	0.3
		November 2020	0.3	1.4	0.1
		December 2022		1.1	
	Mid	January 2019	0.7	4.7	
		June 2019		3.9	
		November 2020		0.8	
		December 2022		5.3	0.2

Conclusions

The results indicate that the frugal watering regime used by WCMA over summer/autumn 2019 successfully maintained at least five, possibly all six, monitored refuge pools. The target species at these sites were not only provided with conditions that enabled them to survive but were suitable for some of them to successfully reproduce (southern pygmy perch, western swamp crayfish) or reach reproductive condition (obscure galaxias) where spawning was either imminent or already occurring at the time of the repeat survey.

The partial 'system resets' that likely occurred in 2012/13 and 2014/15 due to lack of environmental water, and in MacKenzie River and most of Burnt Creek in 2015/16 due to substantially reduced environmental water, were avoided in 2018/19 and 2020 by the targeted use of the much lower volume of available environmental water combined with regular water level monitoring. Successive years of habitat maintenance over summer/autumn periods have been achieved since, with indications of increases in the population size and extent of southern pygmy perch, obscure galaxias and western swamp crayfish in the lower MacKenzie River and upper Burnt Creek.

Maintenance of refuge pools in the lower MacKenzie River and throughout upper Burnt Creek, substantially reduce the dispersal distances and the likelihood of successful re-establishment of southern pygmy perch and obscure galaxias populations throughout these waterways, potentially including to the Wimmera River itself.

The results demonstrate that positive outcomes can be achieved by well-targeted and monitored environmental watering. Provided long-term security can be obtained for the minimum annual environmental water allocation volume required to achieve refuge pool persistence outcomes demonstrated by this study, realistic potential now exists to reintroduce river blackfish to the largest of the Burnt Creek refuge sites, the last known site the species was recorded from prior to extirpation by the end of the millennium drought.

A series of recommendations were made for when water availability for the lower MacKenzie River and upper Burnt Creek is very limited. Implementation of these recommendations during dry times (as occurred in summer/autumn 2019 and 2020) is expected to be critical for protecting water-dependent values in these waterways; however, the recommendations should not be considered the minimum required to maintain and protect populations in the long term. Other recommended flow components, such as winter and spring baseflows and freshes (Alluvium 2013), are required to achieve these objectives, particularly for the recruitment of obscure galaxias.

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