Department of Sustainability and Environment

Assessment of the post-fire status and distribution of the Dargo Galaxias (*Galaxias* sp. 6), affected by the White Timber Spur fire, upper Dargo River system

Black Saturday Victoria 2009 – Natural values fire recovery program

Tarmo Raadik and Michael Nicol

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Assessment of the post-fire status and distribution of the Dargo Galaxias (*Galaxias* sp. 6), affected by the White Timber Spur fire, upper Dargo River system.

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Front cover photograph: (main) Lightbound Creek and (inset) Dargo Galaxias (T.A. Raadik).

Contents

List of tables and figures

Tables

Figures

Acknowledgements

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Summary

The Dargo Galaxias (Galaxias sp. 6) was recently differentiated from the closely related Mountain Galaxias (*Galaxias olidus*) and is currently being formally described. Prior to this study, its global distribution was thought to be confined to two small headwater tributaries in the upper Dargo River system in the coastal Gippsland region of Victoria. Dargo Galaxias is a member of the Mountain Galaxias complex of cryptic species (i.e. species that are reproductively isolated from each other but whose morphology is similar). Importantly, it only persists in locations where predatory exotic Brown Trout (*Salmo trutta*) and Rainbow Trout (*Oncorhynchus mykiss*) are absent. The habitat of Dargo Galaxias was previously affected by bushfires in 2003 and 2006–7, and more recently by the White Timber Spur bushfire in February 2009.

Field investigation in late 2010 and early 2011 determined that one of the two previously known locations for this species is attributable to Mountain Galaxias. This reduces the likely distribution of Dargo Galaxias to a 4 km section of a single, small headwater stream called Lightbound Creek. This population of Dargo Galaxias was reconfirmed during this study as a viable, abundant population, with evidence of significant recent recruitment. Thirty one additional sites were sampled in the upper Dargo River system in an attempt to clarify the distribution of this species, however, no additional populations were discovered. This confirms its conservation status, based on IUCN criteria, as Critically Endangered. Extensive post-fire scouring of stream channels was only observed in Twenty Five Mile Creek and Frosty Creek and impacts of instream sedimentation were not evident at other sites surveyed, probably due to effective flushing from recent high rainfall events.

Of the additional 31 sites surveyed, two were dry at the time of sampling, 11 lacked fish, seven contained Mountain Galaxias only, eight contained exotic trout only, one contained trout and Shortfin Eel (*Anguilla australis*), one contained trout and Mountain Galaxias, and Dargo Galaxias were sampled at a second site further downstream in Lightbound Creek. The relatively widespread but fragmented presence of Mountain Galaxias in the upper Dargo River system was previously unknown. Trout were found at one location actively impacting on the resident Mountain Galaxias population, and this was also highly suspected at an additional site where the galaxiids remained in the last 300–500 m of a small, shallow headwater tributary. Otherwise, Mountain Galaxias and trout (mainly Brown Trout) had largely, mutually exclusive distributions, with the galaxiids confined to the headwater reaches of small tributaries, most likely upstream of movement barriers, such as waterfalls.

To reduce the risk of extinction for Dargo Galaxias, translocation of fish to establish additional populations is recommended. Two potential translocation catchments were identified during this study which provide habitat free from trout and the closely related Mountain Galaxias. Targeted sampling for remnant populations of Dargo Galaxias is also strongly recommended for headwater reaches of the upper west of the Mitchell River system (Wonangatta and Wongungarra River systems). These surveys also have the potential to clarify whether additional undescribed species of upland galaxiids occur in these areas.

1 Introduction

The Dargo Galaxias (*Galaxias* sp. 6) (Figure 1) is a small, endemic, scaleless native freshwater fish, which was recently taxonomically differentiated from the closely related Mountain Galaxias (*Galaxias olidus*) and is currently being formally described (Raadik 2011). Previous survey work had defined the range of this species to two sites in very short and narrow headwater reaches of the remote upper Dargo River system, Gippsland, where, being the only native fish species present, it is thought to represent 100% of the native fish diversity in those streams. A significant factor in the distribution of this species is that it only persists in locations where predatory exotic Brown Trout (*Salmo trutta*) and Rainbow Trout (*Oncorhynchus mykiss*) do not occur. When formally described, Dargo Galaxias will be nominated as a nationally threatened species, satisfying the criteria for the IUCN (2010) conservation status of Critically Endangered (see later).

The species is known from Lightbound Creek, a tributary of the Dargo River, on the Dargo High Plains where it was recorded for the first time (as Mountain Galaxias) in May 1962 (Museum of Victoria Collection NMV A.12405) and on subsequent occasions (1963, 1974, 2002 and 2008) (Raadik 2011). It has also been recorded from 3 km further south, in Twenty Five Mile Creek, a tributary of Thirty Mile Creek, draining the west side of Gow Plain, Dargo High Plains. This second record is based on the preliminary identification of a young adult specimen, 59.5 mm long, collected at White Timber Spur Track, in November 1974 (NMV A.489). This identification is considered tentative as Dargo Galaxias is very similar in appearance to the closely related native species Mountain Galaxias (Raadik 2011) and accurate morphological identification between the two taxa relies on comparison of measurements from a number of adults.

The restricted area in which the Dargo Galaxias occurs, was impacted by bushfires in 2003 and 2006–7, and more recently in the February 2009 White Timber Spur bushfire. This non-migratory freshwater species (Raadik 2011) is susceptible to the post-fire impacts of sediment influx, which can potentially affect spawning success (and hence recovery), and instream food and habitat availability (Lyon and O'Connor 2008). Pre-emptive conservation management is therefore required to ensure that this taxon does not become extinct. Consequently, an assessment of the survival and status of Dargo Galaxias was undertaken, with an initial objective of implementing appropriate instream actions to aid recovery if needed. Following the initial survey in November 2010, 21 months after the fire event, post-fire impacts on habitat or water quality were not detected at sites containing Dargo Galaxias possibly due to recent high rainfalls events which may have flushed residual instream sediment from the catchments. Consequently, recovery actions shifted to a broader and longer term objective of reducing the risk of extinction of the Dargo Galaxias population by undertaking additional surveys and locating potentially suitable translocation sites free of predatory species or other galaxiids.

Native freshwater spiny crayfish of the genus *Euastacus* are relatively widespread in lowland to upland areas of Victoria but appear to be absent from headwater reaches of the upper Mitchell, Macalister and Thomson river catchments in central to western Gippsland (Morgan 1986). Spiny crayfish are often found with species of galaxiids in headwater reaches (Raadik, T, unpublished data) and sampling for Dargo Galaxias therefore provided an opportunity to confirm their apparent absence in the upper Mitchell River catchment.

More specifically, the project objectives were to:

1. Assess the impact of the 2009 fires on the survival and status of Dargo Galaxias;
2. Undertake sampling in nearby catchments to locate additional remnant populations of Dargo Galaxias and to identify potential translocation sites; and
3. Assess the presence and distribution of spiny freshwater crayfish of the genus *Euastacus* at sites sampled for Dargo galaxias.

Figure 1. Dargo Galaxias, *Galaxias* sp. 6, from Lightbound Creek, 17 November 2010 (T.A. Raadik).

2 Methods

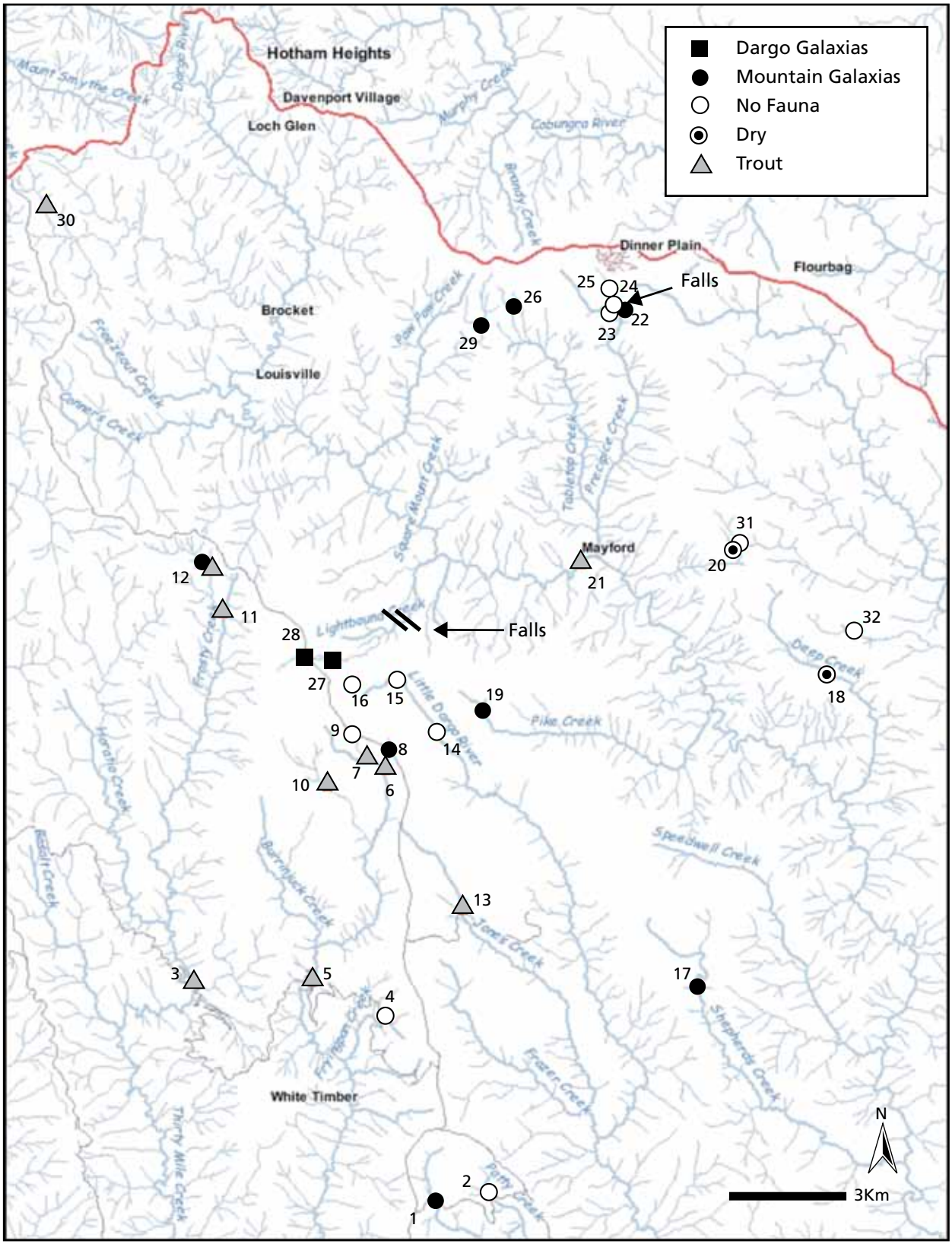
2.1 Site Selection

The primary sampling sites were the two locations from where Dargo Galaxias had previously been recorded (Lightbound Creek and Twenty Five Mile Creek).

The majority of the catchment of the upper Dargo River system, including the sub catchments of the Little Dargo River and Thirty Mile Creek, is extremely steep, remote and difficult to access (Figure 2), containing few roads or tracks. The main access to this area is via the Dargo High Plains Road which bisects this area but generally keeps to the ridgeline and therefore does not cross tributary streams (except at Lankey Plain). Other secondary tracks generally follow ridgelines (Dinner Plain Track, Long Spur Track, White Timber Spur Track), though some extend into valleys (Ritchie Road, Noones Road, Jones Creek Logging Road, King Spur Track and Frosty Creek Road). Consequently, selection of additional sampling sites in nearby catchments was limited, being restricted to those accessible by 4WD vehicle or by foot from nearby tracks. This excluded large areas of the upper (north of the Dargo High Plains) and eastern Dargo River catchment (Figure 3), although a walking track did provide access near Dinner Plain. Access to additional remote areas would have entailed carrying equipment down steep slopes from ridgelines and over long distances, significantly reducing the number of sites able to be assessed during this project.

Figure 2. The steep and remote catchment of the upper Dargo River system, looking north towards Mount Hotham from King Spur Track, 5 April 2011 (T.A. Raadik).

Figure 3 Distribution of fish species sampled at 32 survey sites in the upper Dargo River system, November 2010 and April 2011.



2.2 Fish Surveys/Site Assessment

Fish and decapod crustacea population assessments were undertaken using a fully portable, 24V Smith-Root® LR20B backpack electrofishing unit. At each site, the operator sampled in an upstream direction, stunning and retrieving fish, while an assistant followed with a bucket to carry collected fish and a dipnet to retrieve any missed by the operator. All fishing was undertaken during daylight hours and fish collected were identified and measured for length and weight. Stream width, maximum and average depth, and length of reach sampled was recorded. Water quality parameters, including electrical conductivity, water temperature, pH, turbidity and dissolved oxygen levels were recorded using a portable water quality meter (TPS 90-FL).

2.3 Galaxiid Identification

Dargo Galaxias (Figure 1) are closely related to the native Mountain Galaxias and are therefore very similar in external appearance with both species belonging to the recently resolved Mountain Galaxias cryptic species complex (Raadik 2011). They can be separated genetically, based on allozymes, or by the use of the following preliminary morphological key, adapted from Raadik (2011), though currently this requires the collection of voucher specimens for careful examination in the laboratory to verify field identifications. Previous expertise in galaxiid identification is useful, particularly in the measurement of various body proportions and internal examination of the number of pyloric caecae.

1 One or more black, very dark grey or dark brown, distinct, vertical bars (as opposed to diffuse and irregular shaped brown, brownish grey to dark brown blotches), usually longer than wide and not centred inside a mid-lateral blotch, present along the lateral midline ..... *Galaxias olidus* Günther, 1866 (in part)

– Mid-lateral bars absent..... 2

2 Length of dorsal fin base usually equal or greater than length of anal fin base; postorbital head length usually > 58% head length; no pattern usually present on sides of back; body usually a dark chocolate colour, particularly above the lateral line; usually one pyloric caecum or absent..... *Galaxias* sp. 6 (Dargo)

– Length of dorsal fin base usually less than (< 97%) length of anal fin base; postorbital head length usually < 57% head length; often pattern on sides and back, sometimes faded; colour not as above; usually 2 or 1 pyloric caecae, occasionally absent ..... *Galaxias olidus* Günther, 1866 (in part)

Voucher specimens of galaxiids from sites other than Lightbound Creek were collected in the field, preserved in 10% formalin solution and brought back to the laboratory for further identification. Each individual was subjected to a number of morphometric and meristic measurements (see Raadik 2011 for detailed methodology), and then compared against preserved individuals from other sites and previously verified preserved Dargo Galaxias and Mountain Galaxias samples, including museum specimens.

3 Results

3.1 Dargo Galaxias Sites

Both sites previously known to contain Dargo Galaxias (Lightbound Creek – site 28, and Twenty Five Mile Creek – site 6) (Table 1, Figure 3) were sampled in mid November 2010, with the former being re-sampled in April 2011.

Dargo Galaxias was found to be present and abundant in Lightbound Creek (Table 2, Figure 4). On the first sampling occasion, the population was represented by a high abundance of individuals of a broad range of sizes (Table 3), indicating the presence of multiple age classes. Fish of less than 40 mm in length, corresponding to 0+ age fish, were present. This site was re-sampled in April 2011, with results indicating a 7 fold increase in fish abundance. The majority of these individuals were represented by 0+ age fish, indicating successful spawning and recruitment during the previous spawning season. This creek was also sampled 700 m further downstream (site 27) and an abundant population of Dargo Galaxias was found (Table 2 and Table 3, Figure 5).

Figure 4. Lightbound Creek (site 28), Dargo High Plains Road, 16 November 2010 (T.A. Raadik).

Table 1. Details of 32 survey sites sampled in the upper Dargo River system during November 2010 and April 2011 (* Site No. 3 sampled outside of this sampling period).

Site No.	Waterbody	Latitude	Longitude	Altitude (m)	Date
1	Eighteen Mile Creek	-37.22353	147.19873	1280	16/11/2010; 5/04/2011
2	Patty Creek	-37.22115	147.21297	1250	16/11/2010
3*	Thirty Mile Creek	-37.17979	147.13459	930	17/02/2010
4	Frying Pan Creek	-37.18485	147.18398	1260	16/11/2010
5	Twenty Five Mile Creek	-37.17735	147.16479	1130	16/11/2010
6	Twenty Five Mile Creek	-37.13143	147.18268	1480	16/11/2010
7	Twenty Five Mile Creek	-37.13134	147.18105	1480	16/11/2010
8	Twenty Five Mile Creek	-37.12821	147.18380	1500	16/11/2010
9	Twenty Five Mile Creek	-37.12485	147.17336	1530	16/11/2010
10	Twenty Five Mile Creek	-37.13633	147.16755	1500	18/11/2010
11	Frosty Creek	-37.10006	147.13907	1320	18/11/2010
12	Frosty Creek	-37.09099	147.13511	1410	18/11/2010; 5/04/2011
13	Jones Creek	-37.16156	147.20399	1310	16/11/2010
14	Little Dargo River	-37.12462	147.19618	1415	6/04/2011
15	Little Dargo River	-37.11364	147.18525	1500	17/11/2010
16	Little Dargo River	-37.11443	147.17354	1550	17/11/2010
17	Shepherds Creek	-37.17704	147.26634	1230	17/11/2010
18	Deep Creek	-37.11026	147.29893	1200	18/11/2010
19	Pike Creek	-37.11957	147.20790	1390	6/04/2011
20	Dargo River, trib.	-37.08384	147.27319	1310	18/11/2010
21	Dargo River	-37.08809	147.23302	820	5/04/2011
22	Precipice Creek	-37.03450	147.24166	1380	4/04/2011
23	Precipice Creek	-37.03395	147.24006	1400	4/04/2011
24	Precipice Creek	-37.03432	147.24007	1400	4/04/2011
25	Precipice Creek	-37.03025	147.23884	1470	18/11/2010
26	Tabletop Creek	-37.03440	147.21376	1460	7/04/2011
27	Lightbound Creek	-37.11013	147.16848	1560	17/11/2010
28	Lightbound Creek	-37.10892	147.16127	1570	17/11/2010; 5/04/2011
29	Paw Paw Creek	-37.03850	147.20515	1410	7/04/2011
30	Dargo River	-37.01550	147.09016	1320	17/11/2010
31	Victoria River	-37.08301	147.27504	1325	18/11/2010
32	Spring Creek	-37.10062	147.30567	1230	18/11/2010

No galaxiids were recorded from Twenty Five Mile Creek at either site on White Timber Spur North Track (sites 6 and 7), with both sites dominated by Brown Trout (Table 1 and Table 2, Figure 3). Galaxiids were, however, recorded from this system in the headwaters of a tributary at the Dargo High Plains Road crossing (site 8), though no fish were recorded from the headwaters of an additional tributary further upstream (site 9) (Table 1 and Table 2, Figure 3). Careful examination of fish from site 8 (including comparison of larger individuals with preserved specimens of Dargo Galaxias in the laboratory), confirmed that the galaxiids present in Twenty Five Mile Creek were Mountain Galaxias. Additional sampling further downstream in the Twenty Five Mile Creek system (sites 4, 5 and 10, see also Figure 6, Figure 7, Figure 8 and Figure 9), which had been burnt in the 2009 fire, failed to locate additional populations of any galaxiids (Table 2, Figure 3).

Given this result, Dargo Galaxias is confirmed as occurring in a single stream, Lightbound Creek (Figure 3 site 28, Figure 4 and Figure 5), which is located outside the area impacted by the 2009 White Timber Spur bushfire. This stream, though, was impacted earlier by bushfires in 2003 and 2006/7 (Figure 6). Consequently, the population was unaffected by the 2009 fires, and appears to have recovered following the earlier fire events.

3.2 Broader Survey

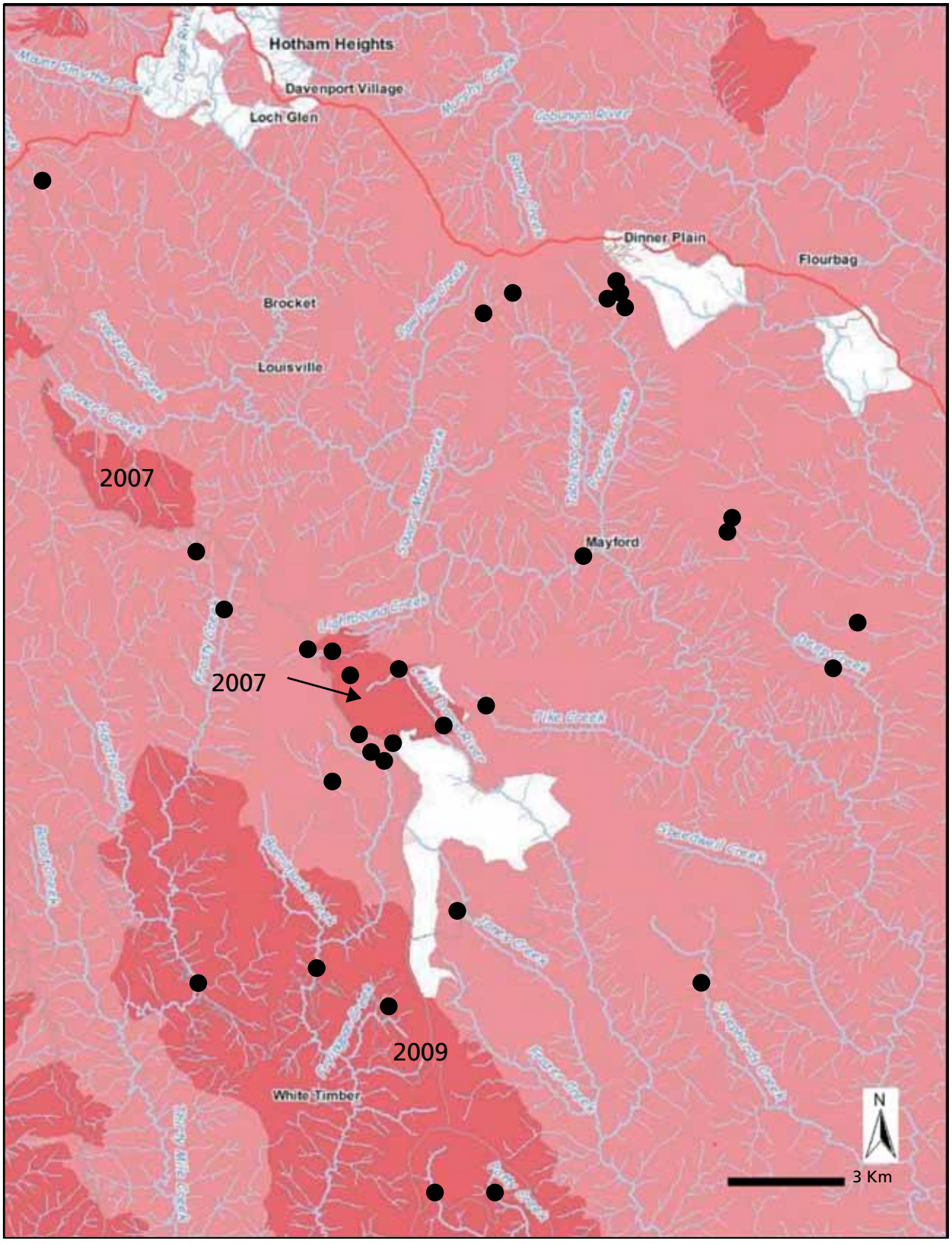
A total of 32 sites in the upper Dargo River system were surveyed (Table 1, Figure 3), with their site characteristics and water quality data provided in Appendix 1. This data includes one site initially selected for sampling during this study (site 3) that was recently surveyed during February 2010 using a similar sampling technique (Justin O'Connor, pers. comm. 2011) and was therefore not resampled.

Figure 5. Lightbound Creek (site 27), off Kings Spur Track, 700 m downstream from Dargo High Plains Road, 18 November 2010 (T.A. Raadik).

Table 2. Summary of the diversity and abundance of fish sampled at each survey site (# exotic predatory species).

Site No.	Waterbody	Date sampled	Scientific Name	Common Name	Number collected
1	Eighteen Mile Crk	16/11/2010	*Galaxias olidus*	Mountain Galaxias	28
		5/04/2011	*Galaxias olidus*	Mountain Galaxias	13
2	Patty Crk	16/11/2010	No Catch		
3	Thirty Mile Crk	17/02/2010	*Salmo trutta* #	Brown Trout	231
			Anguilla australis	Shortfin Eel	1
4	Frying Pan Crk	16/11/2010	No Catch		
5	Twenty Five Mile Crk	16/11/2010	*Salmo trutta* #	Brown Trout	10
6	Twenty Five Mile Crk	16/11/2010	*Salmo trutta* #	Brown Trout	13
7	Twenty Five Mile Crk	16/11/2010	*Salmo trutta* #	Brown Trout	4
8	Twenty Five Mile Crk	16/11/2010	*Galaxias olidus*	Mountain Galaxias	12
9	Twenty Five Mile Crk	16/11/2010	No Catch		
10	Twenty Five Mile Crk	18/11/2010	*Salmo trutta* #	Brown Trout	3
11	Frosty Crk	18/11/2010	*Salmo trutta* #	Brown Trout	1
12	Frosty Crk	18/11/2010;	No Catch		
		5/04/2011	*Galaxias olidus*	Mountain Galaxias	22
			Salmo trutta #	Brown Trout	2
13	Jones Crk	16/11/2010	*Oncorhynchus mykiss* #	Rainbow Trout	6
14	Little Dargo River	6/04/2011	No Catch		
15	Little Dargo River	17/11/2010	No Catch		
16	Little Dargo River	17/11/2010	No Catch		
17	Shepherds Crk	17/11/2010	*Galaxias olidus*	Mountain Galaxias	22
18	Deep Crk	18/11/2010	DRY		
19	Pike Crk	6/04/2011	*Galaxias olidus*	Mountain Galaxias	27
20	Dargo River	18/11/2010	DRY		
21	Dargo River	5/04/2011	*Salmo trutta* #	Brown Trout	7
22	Precipice Crk	4/04/2011	*Galaxias olidus*	Mountain Galaxias	43
23	Precipice Crk	4/04/2011	No Catch		
24	Precipice Crk	4/04/2011	No Catch		
25	Precipice Crk	18/11/2010	No Catch		
26	Tabletop Crk	7/04/2011	*Galaxias olidus*	Mountain Galaxias	24
27	Lightbound Crk	17/11/2010	*Galaxias* sp. 6	Dargo Galaxias	33
28	Lightbound Crk	17/11/2010	*Galaxias* sp. 6	Dargo Galaxias	65
		5/04/2011	*Galaxias* sp. 6	Dargo Galaxias	141
29	Paw Paw Crk	7/04/2011	*Galaxias olidus*	Mountain Galaxias	13
30	Dargo River	17/11/2010	*Salmo trutta* #	Brown Trout	19
31	Victoria River	18/11/2010	No Catch		
32	Spring Crk	18/11/2010	No Catch		

Figure 6. Fire history of the study area (pink – 2003; red – as marked; black circles – surveyed sites).



Whilst all of the sampling sites were located in areas previously burnt by fire since 2003, five of these (sites 1–5) were within the immediate area of the 2009 White Timber Spur fire, five occurred in areas burnt in 2007, and 22 occurred in areas burnt in 2003 (Figure 6). Two sites, located on relatively flat, upland plateaus, were found to be dry in mid November (Deep Creek, site 18 and Dargo River tributary, site 20). Electrofishing was undertaken at the remaining 30 sites (excluding the previously sampled site 3), with fish (both native and exotic) recorded at 19 sites (Table 1 and Table 2, Figure 3). No aquatic fauna (fish or decapod crustacea) were recorded from the remaining 11 non-dry sites.

Of the 19 sites recorded with fish, 10 (53%) contained trout (Figure 3, sites 3, 5, 6, 7, 10, 11, 12, 13, 21 and 30), with Brown Trout found at all but one of these (site 13). Rainbow Trout was only recorded from the upper reaches of Jones Creek, a tributary of the Little Dargo River (Table 2, site 13).

Trout had an extensive distribution, being found in all larger stream systems (Thirty Mile Creek, Twenty Five Mile Creek, Little Dargo River), including the Dargo River almost to its headwaters at an elevation of 1320 m (Figure 3, site 30). Trout were the only species recorded at each of these sites, except for Thirty Mile Creek (site 3), where a single native Shortfin Eel (*Anguilla australis*) was recorded, and Frosty Creek (site 12), where Mountain Galaxias was also collected.

A total of nine sites (47%) were surveyed where galaxiids (either Mountain Galaxias or Dargo Galaxias) represented the only fish species present (Table 2, Figure 3, sites 1, 8, 17, 19, 22, 26–29). Images of Mountain Galaxias collected from 18 Mile Creek (site 1), Precipice Creek (site 22) and Paw Paw Creek (site 29) are provided (Figure 10, Figure 11 and Figure 12 respectively) for comparison with that of Dargo Galaxias (Figure 1).

Table 3. Density and length range of galaxiids at survey sites at which they were recorded. (LCF – length to caudal fork; * site surveyed twice).

Site No.	Waterbody	Scientific Name	Fish Density (fish/m²)	Length Range (mm LCF))
1*	Eighteen Mile Creek	*Galaxias olidus*	0.9 0.2	60–98 54–109
8	Twenty Five Mile Creek	*Galaxias olidus*	0.1	62–68
12	Frosty Creek	*Galaxias olidus*	0.2	39–93
17	Shepherds Creek	*Galaxias olidus*	0.3	45–100
19	Pike Creek	*Galaxias olidus*	0.5	31–107
22	Precipice Creek	*Galaxias olidus*	0.9	55–110
26	Tabletop Creek	*Galaxias olidus*	0.2	45–112
27	Lightbound Creek	*Galaxias* sp. 6	0.7	58–118
28*	Lightbound Creek	*Galaxias* sp. 6	0.8 5.9	35–100 27–96
29	Paw Paw Creek	*Galaxias* olidus	0.2	37–114

Figure 7. Twenty Five Mile Creek valley, from Ritchie Road, post-2009 fires, 16 November 2010 (T.A. Raadik).

Figure 8. Twenty-Five Mile Creek (site 5), Ritchie Road, 16 November 2010 (T.A. Raadik).

One site in the headwaters of Frosty Creek (Table 2, Figure 3, site 12) contained Mountain Galaxias and Brown Trout. Notably, this was the only location at which both species were found together. At this site, two adult trout were found in the lower section of the 0.8 m wide sample reach, upstream of a head erosion instream barrier, in the absence of galaxiids. Mountain Galaxias appeared in low abundance 2 m above the point where the last trout was recorded, increasing in abundance with further distance upstream, suggesting a lack of trout in this higher zone. Data suggests that trout had recently invaded the lower reach of this section of stream and were in the early phase of extirpating the resident Mountain Galaxias population. The two trout, a developing female and a running ripe male, were found relatively close to each other and could potentially have bred and established a larger population in this portion of the catchment.

Of note is the almost mutually exclusive distribution of galaxiids and exotic trout (Figure 3), with the exception of the trout-impacted site in Frosty Creek (site 12). Also, the remnant populations of galaxiids were restricted to the very upper, headwater reaches of small tributaries, either known, or presumed (based on sections of steep catchment further downstream indicated by a dense concentration of altitude contours on topographic survey maps), to be upstream of significant instream barriers.

Freshwater Shrimp (*Paratya australiensis*), a native decapod crustacean found further downstream in the Dargo River system, was not recorded during the surveys, nor were any species of crayfish.

Significant channel scouring resulting from high flow events was evident in the 2009 fire zone at Twenty Five Mile Creek at Ritchie Road (site 5, Figure 8), however, scouring was not evident in Patty Creek (site 2), Frying Pan Creek (site 4, Figure 13) or Eighteen Mile Creek (site 1). Of these sites, Mountain Galaxias occurred at Eighteen Mile Creek, whilst no fish were collected at Patty and Frying Pan Creeks. All catchments had similar amounts of vegetation regrowth, thus channel scouring at Twenty Five Mile Creek at Ritchie Road (site 5) was assumed to be due, in part, to greater stream discharge associated with its larger catchment. The degree of stream scouring may also be related to stream gradient. The upper Frosty Creek (site 12), burnt in the 2003 fires, also experienced significant scour from recent high flows in late 2010 and possessed a far steeper gradient than the similar sized Eighteen Mile, Patty and Frying Pan Creeks which did not exhibit scouring. This was also despite greater vegetation regrowth in the catchment of Frosty Creek compared to the others, which would potentially have retarded the rate of water runoff into the creek. Impacts of instream sedimentation were not evident at all sites surveyed, probably due to effective flushing from recent high rainfall events.

Figure 9. Twenty Five Mile Creek, tributary (site 10), White Timber Spur North Track, 18 Nov 2010 (T.A. Raadik).

3.3 Potential Translocation Sites

Only two areas were identified as potential translocation sites: the upper Little Dargo River (Figure 3, sites 14–16 and Figure 14); and upper Precipice Creek upstream of Precipice Falls (Figure 3, sites 23–25). These appeared to be the only sites without trout or Mountain Galaxias that also have sufficient catchment upstream of barriers and a reliable stream baseflow to support a translocated population of Dargo Galaxias. The remaining fishless sites (Figure 3, sites 2, 31 and 32) had relatively small catchments upstream of barriers and therefore potentially unreliable stream baseflows.

Figure 10. *Galaxias olidus*, Eighteen Mile Creek, Noones Road, 16 November 2010 (T.A. Raadik).

Figure 11. *Galaxias olidus*, Precipice Creek, 4 April 2011 (T.A. Raadik).

Figure 12. *Galaxias olidus*, Paw Paw Creek, 7 April 2011 (T.A. Raadik).

4 Discussion

4.1 Distribution of Dargo Galaxias

The previously known, restricted distribution of Dargo Galaxias was redefined in this study from two locations to a single, small tributary of the upper Dargo River. The previous record from Twenty Five Mile Creek (Thirty Mile Creek catchment) was found to be erroneous, referrable to the Mountain Galaxias. This was confirmed by comparing morphometric and meristic measurements of preserved specimens collected from Twenty Five Mile Creek during this study with those of the single *Galaxias* sp. individual previously collected from this stream (NMV A.489), Mountain Galaxias voucher material collected from elsewhere in the catchment (this study and previously), and previously collected Dargo Galaxias voucher material (Raadik 2011). Dargo Galaxias were not recorded during this study at any of the other sampling sites located in the upper Dargo River system.

Figure 13. Frying Pan Creek (site 4), Ritchie Road, post 2009 fires, 16 Nov 2010 (T.A. Raadik).

The Lightbound Creek Dargo Galaxias population is known to extend from the top of the catchment, where it is found in an alpine meadow, over 2 km of stream to approximately 700 m downstream of the Dargo High Plains Road (a catchment area of around 4 km^2) (Raadik 2011). Their downstream distribution is unconfirmed, but is believed to extend a further 2 km downstream to a set of waterfalls at Devils Hollow, approximately 2 km upstream from the junction with the Dargo River. Trout are abundant throughout the Dargo River system, and are most likely present within the lower Lightbound Creek upstream to these falls. Therefore, the maximum extent of the known global distribution of Dargo Galaxias is probably restricted to a 4 km length of small creek in a small area of catchment of 9 km^2.

When assessed against IUCN (2010) Red List Categories, Dargo Galaxias meets the following criteria for the conservation status of Critically Endangered: B1a,b (i, ii, iii, iv, v). This is based on being a single population; the extent of occupancy (EOO) being less than 100 km^2; the area of occupancy (AOO) being less than 10 km^2; and, undergoing an anticipated decline in occurrence and area of occupancy, area, extent and or quality of habitat, number of populations and number of mature individuals, due to climate change and impacts from exotic species (IUCN 2010).

Dargo Galaxias appear to be relatively resilient to the impacts of fire and ongoing drought, having successfully survived two fires in relatively short succession (2003 and 2007), while simultaneously surviving a long period of drought (1997–2009). The most critical threat to the survival of this species is from the deliberate or accidental introduction of predatory species such as trout which, once established in the upper Lightbound Creek, could cause rapid extinction of Dargo Galaxias. Lightbound Creek is a small, shallow creek (approximately 1.0 m average width and 0.1 m average depth), which would be unable to sustain a population of large fish suitable for recreational angling. This creek is, however, at some risk of being illegally stocked and subsequently colonised by trout as it is a highly visible and accessible site, being the only creek crossing on the Dargo High Plains Road for a distance of 63 km from north of Dargo to the Great Alpine Road.

Figure 14. Little Dargo River (site 15), off Kings Spur Track, Alpine National Park, 17 November 2010 (T.A. Raadik).

Another important threat to the species is increased sediment input from eroded banks or trampled alpine bogs within the catchment caused by cattle (Anon 2009). Sediment can smother the stream bed, asphyxiating the demersal eggs laid by Dargo Galaxias and also altering the abundance and diversity of aquatic macroinvertebrates which are eaten by the species. An additional threat from cattle grazing is an increase in nutrient input to the relatively nutrient-poor, pristine alpine ecosystem, potentially leading to increased algal growths which may cause lowered dissolved oxygen levels during summer when stream flows are reduced.

4.2 Impacts from Fires

On-going impacts of the 2009 fire on populations of Mountain Galaxias were not evident at the time of this study, probably due to significant rainfall in late 2010 which elevated stream flows and flushed residual instream sediment further downstream. This may also be a result of natural catchment recovery since the time of fire, as riparian vegetation at all impacted sites had significantly recovered in the 21+ months post-fire.

4.3 Galaxiid Distribution

Results from this study indicate that the distribution of galaxiids was fragmented and isolated into headwater reaches of sub catchments, most likely upstream of significant instream barriers which prevent the upstream colonisation of trout. This distribution is typical of that found at sites where trout and galaxiids occur in the same general area (McDowall 2006). Generally, galaxiids do not occur at sites further downstream in the mid to lower reaches of mainstream creeks and side tributaries where trout are abundant. As a result, targeted sampling of headwater reaches of tributaries is required to locate remnant galaxiid populations. This needs to be conducted in a systematic fashion, fishing in an upstream direction until habitat without trout populations are encountered or until the watercourse becomes too small to sustain fish.

Remnant populations of galaxiids were found in the headwater reaches of a number of streams in the upper Dargo River system, with Dargo Galaxias restricted to Lightbound Creek, and Mountain Galaxias to Eighteen Mile, Twenty Five Mile, Frosty, Shepherds, Pike, Precipice, Tabletop and Paw Paw Creeks. The relatively widespread but fragmented presence of Mountain Galaxias in this part of the upper Dargo River system was previously unknown. These sites are either known, or presumed, to be upstream of instream barriers which prevent the upstream colonisation of trout, except Frosty Creek, where trout appear to be currently impacting the galaxiid population. The long-term persistence of these small and isolated populations is reliant on a range of factors, including: the continued exclusion of trout from these stream reaches; sufficient aquatic habitat to maintain appropriate levels of genetic diversity and population viability; and suitable instream conditions to support ecological function. It is presumed that prior to the introduction of trout, these fragmented populations were connected. The longer-term impacts of genetic isolation on these numerous small Mountain Galaxias populations (e.g. King and Wallis 1998), is unknown.

Unfortunately, two Mountain Galaxias populations identified in this study are at imminent risk of extinction from trout predation. The population in the upper Frosty Creek catchment (site 12) is located in the uppermost 1.6 km of the catchment and was observed to be impacted by trout at its downstream end. The second population, situated in the headwaters of a tributary of Twenty Five Mile Creek on Omeo/Gows Plain (site 8), is in a more perilous situation. This population is located in the uppermost 300 m of stream. Trout were collected 300 m further downstream although they probably occur much closer as instream barriers are unlikely in the low gradient stream between these two points. This galaxiid population is probably being reduced in abundance and distribution by trout impacts at its downstream extent.

Studies of populations of *Galaxias vulgaris* in New Zealand (Woodford and McIntosh 2010) indicate that a viable population occurring in trout-free waters upstream of habitat in which trout exist, acts as a 'source' population, contributing juvenile fish downstream to a non-reproducing ('sink') population that persists amongst trout. Conversely, the Mountain (and Dargo) Galaxias populations in the upper Dargo River system may be acting as important 'source' populations only. It is highly likely that 'sink' populations of galaxiids further downstream do not exist in this area, or are potentially only present for short periods of time during decreases in trout abundances or temporary contractions in range (Closs and Lake 1996). Consequently, the conservation management of fragmented and genetically isolated galaxiid populations in south-eastern Australia requires greater research and management effort.

4.4 Potential Translocation Sites

Dargo Galaxias is currently restricted to a short section in the headwater reaches of one small stream. This species is therefore highly susceptible to extinction from stochastic events including trout predation following colonisation and increasing impacts from drought and fire due to climate change. This extinction risk can be reduced by establishing additional populations at other sites in separate streams, i.e. translocation (the intentional movement of organisms from one location to another). Translocation, however, is dependant on several factors, such as the availability of suitable translocation sites, source fish and funding. Captive breeding of Dargo Galaxias may be considered if not enough wild source individuals are available for translocation. Detailed examination of population genetics should precede translocation. In order to increase chances of translocated

individuals surviving and establishing, all known threats to Dargo Galaxias must be absent or mitigated at the translocation site. Therefore, translocation sites must be free of predatory fish and lack other closely related native species (e.g. other galaxiids of the Mountain Galaxias cryptic species complex) to avoid the potential risk of hybridisation. These sites must also meet a number of additional physical and physico-chemical criteria, for example, provision of suitable breeding habitat and water quality.

Trout predation appears to be the major threat to the Dargo Galaxias. Unfortunately, trout are widely distributed throughout most cooler, upland catchments in Victoria. The identification of trout-free upland streams of reasonable size, and with high water security (i.e. permanent flow during drought conditions), is problematic. Trout were found to be widespread in the upper Dargo River system (Figure 3). Only two areas were identified as potential translocation sites, namely, the upper Little Dargo River (Figure 3, sites 14–16) and upper Precipice Creek upstream of Precipice Falls (Figure 3, sites 23–25). Both locations lack trout and appear to have relatively permanent stream flow, although a number of issues with these sites need to be resolved.

One such issue at the Precipice Creek site is the potential for hybridisation between Dargo Galaxias and Mountain Galaxias as hybridisation between some pairs of the closely related taxa in the Mountain Galaxias species complex has been previously confirmed (Raadik 2011). Although a significant natural instream barrier (falls) occurs downstream of this site, Mountain Galaxias are present immediately below the falls. Whilst Mountain Galaxias appear to be unable to naturally migrate upstream above the falls to the potential translocation site, they may hybridise with any Dargo Galaxias that potentially survive downstream displacement over the falls. In addition, there may be water quality issues, as, at the time of sampling in April, the left (or western) tributary upstream of the falls had high levels of filamentous algae, suggesting nutrient enrichment. Furthermore, the headwater reaches of the right (eastern) tributary drains from Dinner Plain and flows through an area that is undergoing extensive housing development, which may lead to future water quality impacts. The upper Little Dargo River was similarly devoid of trout and requires further investigation to clarify why fish (both native and exotic) are absent from this relatively large system. Trout may be absent due to an instream barrier further downstream, and similarly, native fish may be absent as they have historically been unable to colonise this part of the catchment. Alternatively, native fish may have been present historically but have been extirpated as a result of poor water quality, stream drying, or by predation following trout colonisation (with trout subsequently eliminated by poor water quality). The location of instream barriers and their efficacy in preventing fish movement, and an understanding of water permanency in the upper Little Dargo River is needed to fully assess the suitability of this site for Dargo Galaxias translocation.

Whilst the Little Dargo River appears potentially more suitable as a translocation site than Precipice Creek, it is geographically located 1 km south-east of the Lightbound Creek catchment. Though it would, importantly, enable a second population of Dargo Galaxias to be established, populations at both these sites are more likely to be exposed to similar threatening processes or events. In this respect, the Precipice Creek location is more favourable, as it is located 11 km north-east.

Given the extremely restricted range of Dargo Galaxias and associated high risk of extinction, the establishment of additional populations is considered critical for its survival and should be addressed as a matter of urgency. Both potential sites identified in this study should be considered and proceed with development of detailed translocation plans. A trial translocation should be undertaken in the Little Dargo River as a priority, and if successful, translocation of fish to Precipice Creek should also be undertaken.

Further survey work is required to identify additional potential translocation sites in the upper Dargo River catchment, though this may be problematic due to the difficulty of access. Investigation should also extend further west to include the Wongungarra and Wonnangatta river systems (Mitchell River catchment), as these areas are also poorly surveyed. This work would also have additional important biodiversity benefits, including potentially locating other remnant populations of Dargo Galaxias as well as other, unrecognised species within the Mountain Galaxias cryptic species complex which may be similarly threatened. This information will be extremely useful in documenting the distribution of other native fish and crayfish species as well as defining our knowledge of the distribution of trout in these catchments and their impact on native aquatic fauna.

4.5 Identification

The preliminary identification key used to distinguish Dargo Galaxias from Mountain Galaxias was adapted from one developed to discriminate between 15 species in the Mountain Galaxias cryptic species complex across south-eastern mainland Australia (Raadik 2011). As such, it is based on comparison of one population of Dargo Galaxias with multiple populations of Mountain Galaxias from across their broad geographic range (southern Queensland to South Australia) (Raadik 2011). To potentially improve the level of accuracy distinguishing Dargo from Mountain Galaxias, this key requires refinement to make it more applicable at the regional level of the Mitchell River catchment. This can by achieved by limiting the data for Mountain Galaxias used in the key (Raadik, 2011) to those few individuals from the Mitchell River catchment and supplementing this with new morphological data gathered from voucher specimens collected in this study.

4.6 Spiny Freshwater Crayfish

Spiny Freshwater Crayfish of the genus *Euastacus* are widespread in Victoria (Morgan 1986, 1997). Some members of this genus have broad ranges (e.g. Murray Spiny Crayfish *Euastacus armatus* and the Gippsland Spiny Crayfish *Euastacus kershawi*), whilst others have small, restricted ranges and are consequently classified as threatened (e.g. Orbost Spiny Crayfish *Euastacus diversus* and the South Gippsland Spiny Crayfish *Euastacus neodiversus*). In the Gippsland region, spiny crayfish are found in all major river systems from South Gippsland, eastward to the New South Wales (NSW) border near Genoa, and have been recorded in headwater reaches in all systems except in the Mitchell River catchment (Morgan 1986, AFD 2011, ARI unpublished data).

The Alpine Spiny Crayfish (*Euastacus crassus*) is considered threatened in Victoria (van Praagh 2003) and is listed under the Victorian *Flora and Fauna Guarantee Act 1988*. Its Victorian distribution encompasses a narrow band of headwater streams along the northern side of the Great Dividing Range, extending from the NSW border to the Ovens River system (Morgan 1997). Its distribution on the south side of the Great Dividing Range was recently confirmed, extending from the Deddick River system (Snowy River catchment), westward to the headwaters of the Tambo River system (ARI unpublished data). The study area in the upper Dargo River system is just to the west and south of the distribution of Alpine Spiny Crayfish, and further east of other species of spiny crayfish in coastal catchments in Victoria (Morgan 1986, 1997, ARI unpublished data).

Spiny crayfish are regularly collected from small streams using electrofishing techniques. The electrical current disturbs the animals, causing them to move out from cover (e.g. from under rocks or timber debris), where they are more easily visible and can be netted. Their capture is also aided by the small size of these streams and the usually high water clarity. The absence of any species of spiny crayfish in this survey is surprising, given that spiny crayfish are present in the upper reaches of all other river systems in the Gippsland area.

Until this study, the upper reaches of the Mitchell River system had been poorly sampled for fish and decapod crustaceans, particularly in smaller streams (AFD, 2011). This is most likely due to the remote nature of this catchment and the relative difficulty of access. Currently it appears that spiny crayfish are absent from at least the eastern portion of the upper Mitchell River catchment. Intensive sampling in the western portion, particularly in headwaters of the Wongungarra and Wonnangatta rivers, is required before they can be confidently stated as absent from this catchment.

5 Recommendations

The following actions are urgently required to reduce the risk of extinction of Dargo Galaxias (listed from highest to lowest priority):

- Plan and undertake a trial translocation to establish a second population in the headwater reaches of the Little Dargo River.
- If the trial translocation is successful, undertake an additional translocation to establish a third population in Precipice Creek, upstream of Precipice Falls.
- Undertake detailed population genetic analysis to inform conservation management of the species.
- Investigate the security of the falls on Lightbound Creek near Devils Hollow with respect to their ability to prevent the upstream colonisation of trout.
- Locate other suitable translocation sites for Dargo Galaxias.
- Undertake targeted sampling in the headwater tributaries of the Wongungarra and Wonangatta Rivers to search for additional, remnant populations, including remnant populations of other, currently unrecognised, galaxias species.
- Research the breeding biology of Dargo Galaxias, including captive breeding options.

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Appendix 1

Site characteristics and environmental variables recorded at sampling sites (excluding sites 18 and 20 which were dry). (EC – electrical conductivity at 25 °C; DO – dissolved oxygen).

Site No.	Waterbody	Survey length (m)	Average width (m)	Max. depth (m)	Ave depth (m)	EC	Water temp (°C)	DO mg/L	DO %Sat.	pH	Turbidity (NTU)
1	Eighteen Mile Crk	100 70	0.3 0.8	0.4 0.3	0.15 0.1	54.2 92.0	10.0 8.0	8.7 10.4	92 0 90.0	7.47 7.7	< 5 7
2	Patty Crk	70	0.75	0.4	0.2	57.0	10.0	9.7	85.0	7.9	< 5
3	Thirty Mile Crk	152	–	–	0.4	37.4	13.9	11.0	105.7	7.2	< 5
4	Frying Pan Crk	50	0.4	0.3	0.2	19.2	11.4	9.8	90.0	7.3	< 5
5	Twenty Five Mile Crk	70	3.5	0.8	0.2	19.4	12.4	9.8	92.7	7.6	< 5
6	Twenty Five Mile Crk	50	1	0.5	0.2	13.7	16.3	7.7	74.3	7.1	< 5
7	Twenty Five Mile Crk	30	1.2	0.6	0.2	13.7	16.3	7.7	74.3	7.1	< 5
8	Twenty Five Mile Crk	60	1.5	1.0	0.1	34.3	16.4	7.7	78.0	7.3	< 5
9	Twenty Five Mile Crk	40	0.3	0.3	0.2	7.0	10.6	9.7	84.7	7.0	< 5
10	Twenty Five Mile Crk	30	2	0.5	0.2	4.8	16.8	7.7	78.0	7.3	< 5
11	Frosty Crk	40	1.25	1.2	0.3	–	–	–	–	–	–
12	Frosty Crk	50 100	3.0 1.0	1.2 0.3	0.25 0.15	3.1 10.0	9.5 8.4	10.2 10.8	85.0 88.0	7.0 7.2	< 5 < 5
13	Jones Crk	60	2.5	0.4	0.2	22.1	9.7	10.3	92.0	7.6	< 5
14	Little Dargo River	100	1.3	0.4	0.2	38.0	12.0	10.4	100.0	7.2	< 5
15	Little Dargo River	200	1.25	0.3	0.2	6.7	15.7	8.2	80.0	6.6	< 5
16	Little Dargo River	50	1	0.2	0.1	–	–	–	–	–	–
17	Shepherds Crk	70	1	0.8	0.2	23.8	11.1	8.6	74.0	7.0	< 5
19	Pike Crk	50	1	0.3	0.1	43.0	8.5	10.7	96.0	7.3	< 5
21	Dargo River	70	12	0.4	0.3	18.3	11.4	11.1	101.0	7.5	< 5
22	Precipice Crk	25	1.8	0.4	0.2	27.0	7.0	8.5	72.0	6.8	< 5
23	Precipice Crk	40	1.1	0.4	0.1	27.0	7.0	8.5	72.0	6.8	< 5
24	Precipice Crk	50	1.5	0.3	0.1	27.0	7.0	8.5	72.0	6.8	< 5
25	Precipice Crk	50	1	0.5	0.3	–	–	–	–	–	–
26	Tabletop Crk	50	2.5	0.4	0.2	58.0	9.3	8.8	100.0	7.0	<5
27	Lightbound Crk	45	1	1.1	0.4	8.4	16.9	73.0	80.0	6.9	<5
28	Lightbound Crk	40 60	2 0.4	1.2 1.0	0.2 0.1	8.4 12	16.9 13.2	7.3 10.1	80.0 98.6	6.9 7.5	< 5 < 5
29	Paw Paw Crk	70	1	0.4	0.2	43.0	10.0	9.0	100.0	6.6	<5
30	Dargo River	50	1.5	0.4	0.2	–	–	–	–	–	–
31	Victoria River	20	0.5	0.1	0.0	–	–	–	–	–	–
32	Spring Crk	50	0	0.0	0.0	33.0	18.5	6.8	70.0	6.7	< 5

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