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Recreational Fishing Grant Program – Research Report

Response of brown trout (*Salmo trutta*) to willow management and habitat improvements in the Rubicon River.

May 2009

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Table of Contents

Executive Summary

Willows were widely used for waterway erosion control in northeast Victoria but are now considered as some of the most invasive riparian and wetland plant species in temperate Australia. River management agencies are now actively managing willows through a variety of control strategies including removal.

Concern has been raised that willow removal may impact on stream ecology and have detrimental impacts on recreation trout populations.

The response of a localised brown trout population to willow removal and concurrent in-stream habitat enhancement in the Rubicon River indicated a 33% increase in brown trout numbers, over an untreated control.

Willow removal—in combination with in-stream habitat construction—did not negatively impact on trout numbers.

Introduction

Willows were introduced to Australia in the 1800s and 1900s for a variety of purposes but were widely used for waterway erosion control in northeast Victoria. Advancements in river management techniques reduced the use of willows as a stream stabilisation tool by the late 1980s but willows have continued to spread and now line many stretches of Victorian streams.

Willows of the Genera *Salix* are now considered some of the most invasive riparian and wetland plant species in temperate Australia. The Salix genus are declared Weeds of National Significance (ARMCANZ 2001). River management agencies are now actively managing willows through a variety of control strategies.

Willow management is not unanimously accepted by the whole community and willow control has caused varying levels of controversy in areas where removal and herbicide treatment have been undertaken. One vocal community sector that has shown public opposition to willow removal is the recreational trout angling community. This group claim excessive willow removal impacts on the stream, is detrimental to trout and diminishes recreational fishing opportunities. Generally the trout anglers don't want protection for willows but object to the impact of large-scale willow removal on riparian zone functions such as shading. Willows can provide conditions such as dense shade that result in lower stream water temperatures and conditions that favour introduced sport species such as trout (Hunter 1990, Caruso 2006).

The initial impact of willow removal in the riparian zone landscape is often stark as people notice the loss of large trees. This can be seen as degradation of riparian vegetation and contradictory to the generally accepted doctrine of the importance of a riparian zone maintaining ecological function, contributing to stream health and benefiting recreational fisheries.

Degradation of riparian vegetation has been identified by the Murray Darling Basin Commission's Native Fish Strategy as a Key Threatening Process to the continuing survival of several species of native fish. Stream mangers are quick to point out that effects of the removal of streamside willows are short term and willow control is often undertaken in conjunction with a native vegetation replacement program that ultimately retains the ecological and geomorphic values provided by willows (SRCMA).

The Rubicon River, a tributary of the Goulburn River, is a popular recreational angling stream in north-east Victoria (Douglas 2004). Willows are present along much of the lower reaches of the river and willow management has been undertaken in some areas by the Goulburn Broken Catchment Management Authority. This has involved the removal of willows from the streamside.

Much of the information in the willow management and trout debate is speculative and does not assist in moving forward. A trout radio-tracking study on the nearby Goulburn River showed that in-stream habitat rather than riparian willows was relatively more important in structuring trout behaviour on a mid-sized stream (Stoessel and Douglas 2007). These authors suggested that riparian vegetation may become relatively more important on a smaller stream. To investigate this theory, the current project investigated the response of a localised brown trout population to willow removal and in-stream habitat enhancement in the smaller sized Rubicon River.

Objectives

The objectives of the study were to:

- determine the response of brown trout to willow management and habitat rehabilitation works on a 200 meter section of the Rubicon River using two primary indicators:
  a. population estimates of brown trout pre and post management works at both the willow management site and a 'control' where no management works are undertaken
  b. locations and movements of individual tagged (using acoustic tags) brown trout pre, during and post management works at the willow management site.

Study Area

The study was conducted on the Rubicon River near Thornton, Victoria (**Figure *1***).

Two sample sites were selected that included:

- a 'treatment' site where willow management and artificial habitat rehabilitation would be undertaken
- a 'control' site where no management works were to be conducted.

The stream morphology at both sites was shallow riffles interspersed with some deeper pools (to 250cm) and a substrate of cobble, gravel, clay and sand.

The treatment site was located upstream from the control site on the first bend of Rubicon Road. Prior to the management works, willows dominated the majority of the riparian zone vegetation at the treatment site. Following the management works, this site retained some willows in the riparian zone and in-stream artificial fish habitat structures were added. Land use on both sides was primarily cattle grazing.

The control site was downstream from the management site. Land use varied on both sides of the site. One bank was a picnic area with a riparian zone vegetation composed of grass and sparse willow trees back from the river. Willows dominated the riparian zone vegetation of the other side.

On-ground Works

The Goulburn Broken Catchment Management Authority carried out the on-ground works at the treatment site. The primary objectives/activities of the management works were to:

- improve angler access
- delineate and mark with fencing the Crown and private land boundary to clarify public (angler) passage rights to the crown land and eliminate impacts of stock within the riparian zone (Crown Water Frontage)
- improve river health and aquatic habitat through removal of exotic vegetation and revegetation with indigenous species
- introduce some artificial in-stream habitat structures.

The on ground works entailed removal of several willow trees along the banks, fencing to exclude stock with stile and car parking provision for angler access, revegetation works along both banks and the installation of LUNKERs.

LUNKERs are an artificial undercut banks constructed of wood. Their introduction to some streams in the United States of America has shown considerable improvement in trout numbers (Brown 2001).

Figure 1. Diagram of study site locations.

Methods

Population Assessments

Fish population estimates of the two sites were made using the generalised removal method technique (Zippin 1958). This method is suitable for estimation of fish population size (Cowx 1983). Backpack mounted electrofishing was used to capture fish. The validity of this method depends on certain assumptions, (e.g. a minimum of three fishing passes, a high average probability of capture, and equal catchability[1]) and these requirements necessitated a fishing procedure that was slow, methodical and consistent (Jones and Stockwell 1995).

To sample a site, the stream was blocked at either end of the site with stop nets (30 mm knot-to-knot mesh size). Repeated passes (N=4) were made with two backpack electrofishing units (Smithroot) operated concurrently. Captured fish were removed from the stream, anaesthetised (Aqui-s ®) to Stage 1 then counted, weighed (nearest gram) and measured (length measurements were fork length (FL) to nearest millimetre) and then held in an aerated fish bin to recover, and keep them out of the stream during subsequent passes of the electrofisher. Fish were released back to the site at the conclusion of the sampling.

Calculations to obtain the population estimates were undertaken using the computer program Microfish 3.0 (Van Deventer and Platts 1989). This program performs the maximum likelihood calculations based on the number of fish captured from each electrofishing pass (Van Deventer and Platts 1989). Two population estimates were calculated: a population estimate based on removal method for all brown trout, and a population estimate based on removal method for large (>250 FL) brown trout.

Trout population data from an earlier study in the Rubicon River were available and used in this study as historical "before data". Data in the current investigation were collected using the same method as these previous data to ensure compatible and comparable in the analysis.

Acoustic Tagging & Tracking

A total of 9 brown trout were collected using backpack electrofishing as subjects for acoustic tagging and tracking. Details of these fish is given in Table 1.

Table 1. Details of acoustically tagged brown trout

Fish	Length (mm)	Weight (g)	Date released
Brown trout	246	172.5	02-Nov-06
Brown trout	257	213.0	02-Nov-06
Brown trout	312	410.0	10-Nov-06
Brown trout	324	400.0	10-Nov-06
Brown trout	283	279.0	10-Nov-06
Brown trout	293	306.0	10-Nov-06
Brown trout	273	293.0	10-Nov-06
Brown trout	267	237.0	02-Nov-06
Brown trout	292	297.5	02-Nov-06

A coded acoustic transmitter [2]("V9" model from Vemco, Canada) was surgically inserted into the abdomen and each fish released. Upon capture, the trout were anaesthetised with a solution of clove oil and the acoustic transmitters were surgically inserted into the abdominal cavity via a 2.5 cm incision on the ventral side of the fish. The incision was closed by sutures and sealed with a cyanoacrylate based adhesive. Total surgery time averaged two to three minutes. Fish were kept moist during surgery with constant spraying of water via an atomiser over the gills and body. After surgery, anaesthetised fish were allowed to recover in an aerated fish box full of river water prior to release. Fish were released at their capture site. The trout were not examined to determine sex, so no differentiation is made between sexes.

[1] Equal catchability – all the trout are equally available to be caught, none are in areas inaccessible to the gear etc

[2] Acoustic transmitter – a type of tag, each one emits a chain of sound 'pings' unique to that particular tag every few seconds

Listening devices (“VR2” Single Channel Monitoring Receivers from Vemco, Canada) located as sentinels, two at each end of the willow removal site, were used to monitor if acoustic-tagged fish moved out of the study site (**Figure 2**). Tagged fish were also monitored on an ‘ad hoc’ basis with a hand held hydrophone and receiver (“VR60” model from Vemco, Canada) to determine if they could be located within the willow management site.

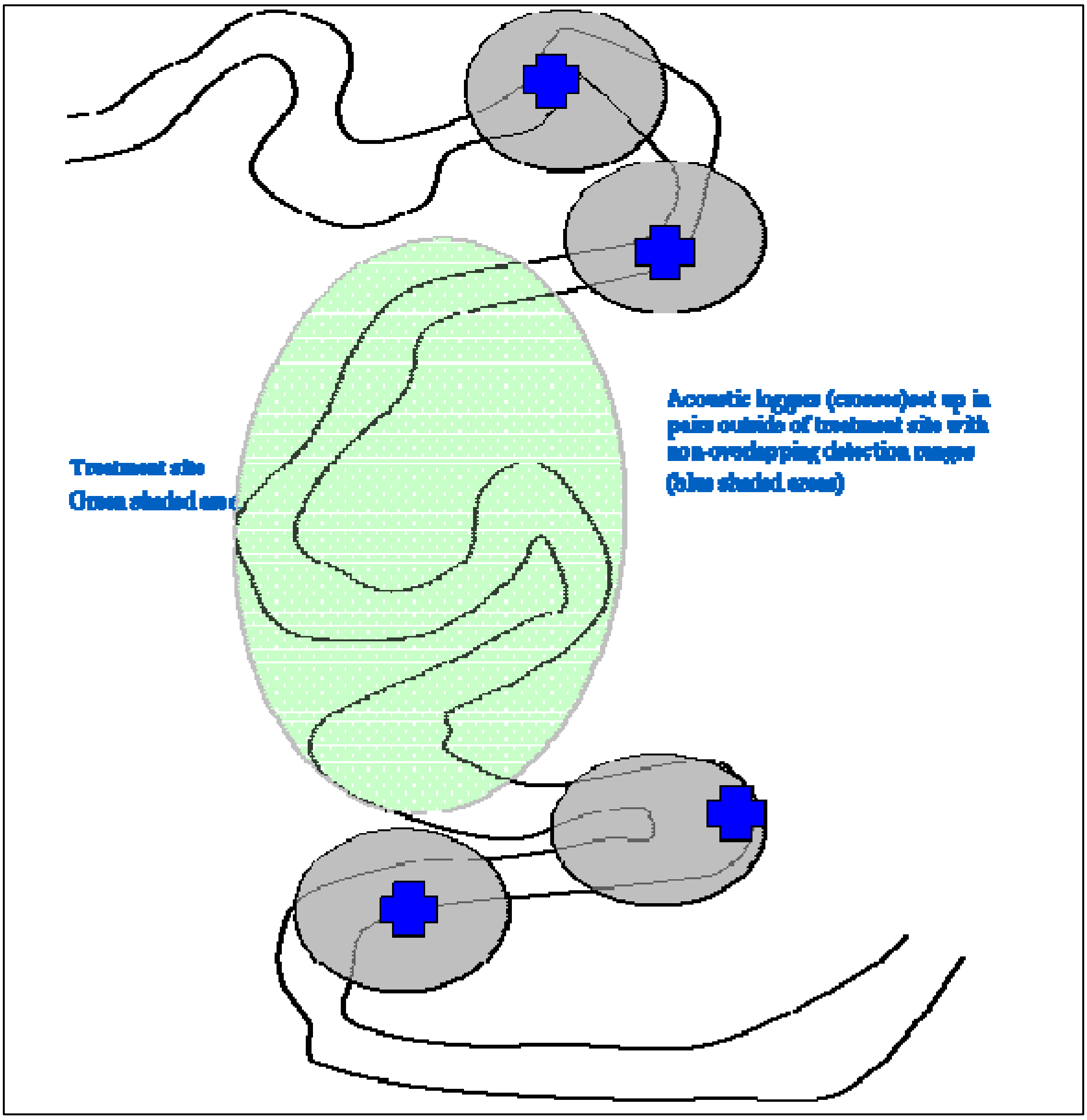

Figure 2 Schematic of sentinel concept to monitor acoustically tagged brown trout movement in and out of treatment site

Results

Population Assessments

All brown trout

Population estimates from the historical and pre-treatment samples and the post-treatment sampling indicated that the current population was within the range of variation seen in the historical population in both sites (Table 1). Figure 3 presents a graphical depiction. There is no indication that the willow removal and LUNKER installation was detrimental to the trout population at the treatment site. There was a general decline in trout numbers at both sites between samples in 2006 and 2008. At the control site, the trout population in November 2008 had declined by 50% from levels measured in May 2006 but at the treatment site the population was only reduced to 83% of its prior abundance. The 'net benefit' observed for the treatment was ~33% of populations size for all brown trout.

Table 2. Details of historical and current (in bold text) Rubicon fish-down samples and the resulting population estimates with their 95% confidence[3] limits, for brown trout of all sizes. Site lengths were 210 m and 160 m for treatment and control sites respectively

Site	Date	Pass 1	Pass 2	Pass 3	Pass 4	Pop^n estimate	lwr 95% confidence	uppr 95% confidence
Rubicon treatment	Dec-01	8	5	0	1	14	13	15
	Feb-02	18	8	3	3	32	29	37
	Jun-02	11	14	2	1	29	21	37
	Dec-02	4	2	3	0	9	7	11
	Mar-03	21	18	3	9	60	46	74
	May-06	17	7	5	1	30	28	32
	Nov-08	10	6	6	1	26	20	32
Rubicon control	Dec-01	12	5	8	0	26	22	30
	Feb-02	21	18	4	2	47	42	52
	Jun-02	18	7	5	2	33	29	37
	Dec-02	8	9	7	1	29	19	39
	Mar-03	12	7	0	4	24	20	28
	May-03	23	14	7	8	62	47	77
	May-06	28	15	12	6	69	57	81
	Nov-08	12	8	8	2	35	24	46

[3] 95% Confidence limits – the population estimate is just that, an estimate; but statistically we can be 95% confident that the 'true' population lies between these limits

Table 3. Details of historical and current (in bold text) Rubicon fish-down samples and the resulting population estimates with their 95% confidence[4] limits, for trout over 250mm . Site lengths were 210 m and 160 m for treatment and control sites respectively

Site	Date	1st pass	2nd Pass	3rd Pass	4th Pass	Popn est	lwr 95% confidence	uppr 95% confidence
Rubicon treatment	Dec-01	5	3	0	1	9	8	10
	Feb-02	5	6	2	1	15	11	19
	Jun-02	7	11	2	1	22	13	31
	Dec-02	2	1	2	0	5	3	7
	Mar-03	6	0	0	1	7	6	8
	May-06	5	4	2	1	12	9	15
	Nov-08	8	5	3	1	17	14	20
Rubicon control	Dec-01	8	3	2	0	13	12	14
	Feb-02	8	7	0	2	17	15	19
	Jun-02	6	3	2	1	12	10	14
	Dec-02	5	0	0	0	5	5	5
	Mar-03	2	0	0	1	3	0	6
	May-03	2	1	2	0	5	3	7
	May-06	4	2	3	1	11	6	16
	Nov-08	4	4	5	0	15	8	22

[4] 95% Confidence limits – the population estimate is just that, an estimate; but statistically we can be 95% confident that the 'true' population lies between these limits

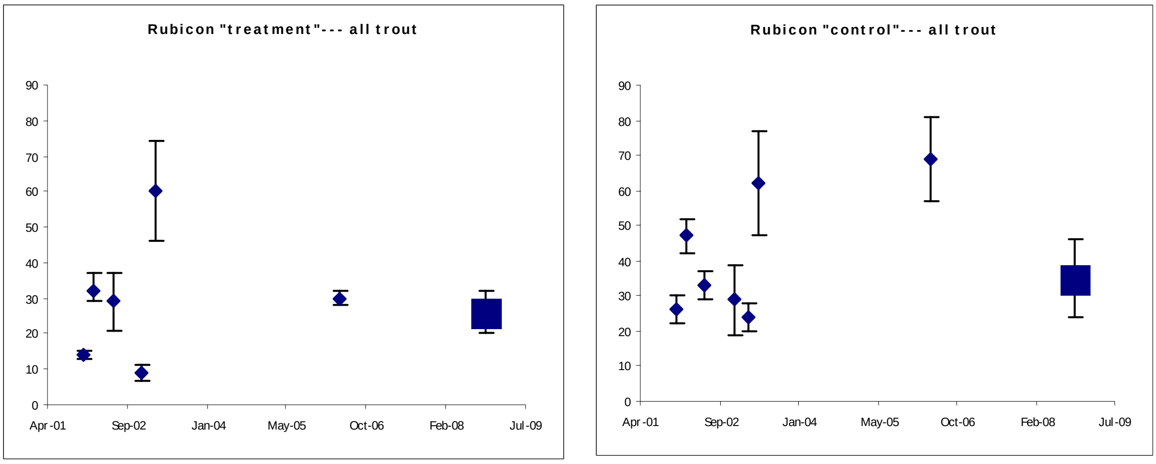

Figure 3. Comparison of post treatment brown trout population estimates with historical pre-treatment brown trout population estimates (with 95% confidence limits) for all brown trout from the Rubicon River treatment and control sites. The large square highlights post-works sample. Y-axis is number of fish, X-axis is sample date.

Large brown trout

When trout larger than 25 cm are considered separately, population estimates from the historical and pre-treatment samples and the post-treatment sampling also indicated that the current population was within the range of variation seen in the historical population in both sites. The population estimate for large trout in the treatment site is statistically similar to that of the control site. Figure 4 presents a graphical representation. There is no indication that the willow removal and LUNKER installation was detrimental to the large trout population at the treatment site.

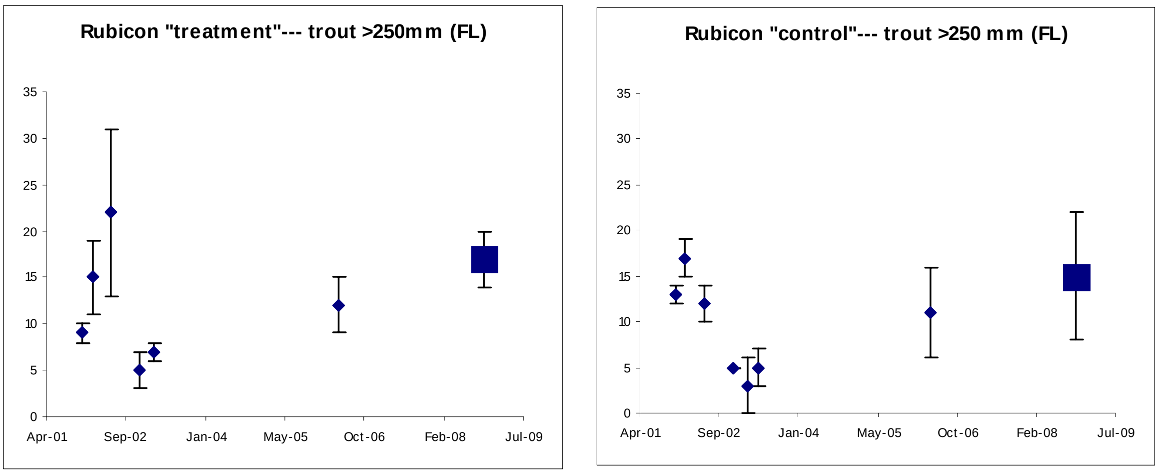

Figure 4 Comparison of post treatment brown trout population estimates with historical pre-treatment brown trout population estimates (with 95% confidence limits) for large (>250mm FL) brown trout from the Rubicon River treatment and control sites. The large square highlights post-works sample. Y-axis is number of fish, X-axis is sample date

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Acoustic Tagging & Tracking

Acoustic Tags

Inspection of the river with a hand-held hydrophone on the day after the fish were released confirmed that all tags were functioning properly. Over the course of the study five of the nine acoustically tagged fish were recorded by the sentinel listening stations; but only three of the nine trout were known to have left the treatment site. The undetected fish are assumed to have stayed within the treatment site.

Of the two detected fish that did not leave the site, one fish was regularly recorded near the upstream end of the treatment site, and the other fish was regularly detected near the downstream end of the treatment site. The CMA work removing willows began on the 12/2/2007. Two fish (BT 1442 and BT 1445) left on the 22/2/2007. This was while the CMA works were being undertaken. While these two fish may have left due to the works, there was no mass exodus of trout observed that could be attributed to willow removal .

Dart tags

In the 2006 pre treatment survey sample, all fish over 250mm total length (n=23) caught in the treatment site were tagged with an individually numbered dart tag. Three of these fish were recovered at the site in the 2008 post treatment samples indicating that at least these three fish were still associated with the their original tagging location. The remaining untagged population of large brown trout at this treatment site therefore comprised immigrants not previously encountered at this site.

Table 4. Fate of detected acoustically tagged brown trout

Trout i.d. code	Date first detection on VR2	Date last detection on VR2	Date that fish left site	Fate of fish
BT 1442	22/2/2007	22/2/2007	22/2/2007	Left site
BT 1444	17/11/2007	6/5/2007		Remained at site
BT1445	20/11/06	22/1/2007	22/1/2007	Left site
BT 1446	23/11/06	6/2/2007		Remained at site
BT 1450	9/2/2007	10/2/2007	9/2/2007*	Left site

* came back 10/2/2007 but left on same day

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Discussion

The key finding from this study is that willow thinning and subsequent installation of LUNKERS was not detrimental to the brown trout population, may have resulted in a third more trout in the treatment site, and in selected areas, is a useful management approach to willow control whilst maintaining erosion protection of the stream banks and fish habitat.

Brown trout movement

Trout residency was not affected in the treatment area. Brown trout exhibit a variety of movements over several spatial scales but apart from spawning migrations they have a relatively small home range that is related to the size of the fish (Ovidio 1999) and to stream size (Knouft and Spotila 2002). Season, water temperature and flows can all influence the size of trout home ranges and changes in water temperatures and flows can induce up and downstream migration (Ovidio *et al* 2002; Jonnson 1991 in Klemetsen *et al* 2003). Flow related movement is not common to all individuals as some trout will stay in a location despite changes in flows (Douglas 2004b). Brown trout home ranges can be quite small. For example, in the Aberfeldy River in Victoria, home range was estimated at 60 m (Jackson 1980), 41 m in a high altitude American stream (Young 1999), and 20 m in a southern Ireland stream (Bridcut 1993). Some trout home ranges can be larger but Knouft and Spotila (2002) reported that most brown trout territories were less than 800 m of stream. Although they have home ranges, the sites are not necessarily permanent as some trout will relocate to other areas for unknown reasons. In studies of the nearby Goulburn River, Douglas (2004) reported that in general brown trout had home ranges but some fish did change the location of this home range by up to several kilometres on occasions. The majority of trout in the present study stayed within the treatment site in their small home range, and the fish that left could be relocating for many reasons including, but not necessarily due to, the changed riparian vegetation conditions. The observations from the present study are consistent with observations of general brown trout movement patterns as reported in the literature.

Resident trout at the treatment site were exposed to considerable human activity associated with the willow removal and installation of the LUNKERs. The fact that trout stayed in the area indicates that trout are quite tolerant of human activity in the Rubicon River. Previous studies undertaken in the Rubicon River have shown that tagged brown trout remained in the Tumbling Waters site throughout the year, despite the fact that the area is adjacent to a popular river reserve. The resident trout at this site are exposed to a range of human activity (especially throughout the summer months) including increased bank activity (cars and picnics), swimming, rock-throwing, children’s “dam building” and angling—yet some individual trout remained (Douglas 2004). The recapture of three brown trout that were dart tagged in 2006 at the same site add support to these observations.

In this present study, the majority of trout stayed in the treatment area and those trout that did leave may have left for reasons other than the disturbance of the works or altered riparian conditions. The conclusion is that this behaviour is consistent with trout movement and that the works did not negatively impact on trout home ranges or movement patterns.

Brown trout distribution

Given that the physico-chemical parameters of a stream are suitable for trout, the availability of in-stream habitat may be a more important factor than riparian habitat when it comes to fish distribution in trout streams. The importance of riparian vegetation has been promoted by numerous fisheries and stream management agencies worldwide and it is generally accepted doctrine that riparian vegetation health is paramount to healthy waterways and thus fisheries. However, while riparian vegetation is important for a range of ecological functions crucial to many aquatic organisms, including fish communities, the role it plays in influencing the spatial distribution of brown trout may not be as critical as the role played by in-stream habitat. The riparian zone has important influences on the total stream ecosystem including the habitat of trout through shade, organic detritus from the riparian zone affecting stream productivity; while large woody debris from the riparian zone influences channel morphology (Meehan *et al.* 1977). The influence and role of riparian vegetation varies with size and position along “the continuum from headwaters to mouth” of the stream (Meehan *et al.* 1977). Wesche *et al.* (1987) reported that riparian vegetation was the parameter that explained the greatest variation in trout abundance but their results were clouded by incorporating additional in-stream habitat components into their analysis and thus did not specifically investigate riparian effects as a stand alone variable.

Links between trout distribution and riparian vegetation are not highlighted in the literature and this may reflect its limited influence in fish distribution. Nelson *et al.* (1992) suggested important discriminating attributes for trout location included stream width, abundance of large substrate (rubble and boulder), and stream-flow as they determined trout are principally associated with sites characterized by wider, well-watered stream reaches containing high percentages of large stream-bottom particles. Water depth, water velocity, streambed substrate type and availability of cover have been found to be important characteristics for brown trout habitat in riverine systems (Heggenes 1988), although habitat preference changes with size, age and season. Smaller fish prefer shallow riffle areas with cobble substrate, with large fish preferring deeper cobble and boulder substrate, abundant cover and higher flow rates (Cunjak and Power 1986; Heggenes 1988).

Further support that riparian vegetation may not be a critical habitat component can be seen in the many examples of world class trout streams where tree-lined riparian vegetation is not the dominant habitat feature. Fisheries such as England’s chalk streams, fisheries in New Zealand’s south island, Patagonian and North American trout streams such as Henry’s fork on the Snake River and numerous Montana rivers, often lack trees in the riparian vegetation. The riparian zone of many of these streams consists of low vegetation such as grass or only limited tall trees.

The impact of riparian willow removal on fish populations is not clear. Research monitoring trout populations in a New Zealand stream reported a general decline in trout numbers where willow removal was undertaken (Brown and Sanders 1999 in Caruso 2006). However, the authors considered that this was probably due to other factors apart from willow removal as the decline was occurring before the willows were removed, as well as in the streams where no willow removal had occurred (Brown and Sanders 1999 in Caruso 2006). In the Goulburn River, trout used areas where substantial riparian vegetation (willow) removal had occurred and it was speculated that the distribution of trout was due to the presence of sufficient and suitable in-stream cover available rather than the presence of riparian vegetation (Stoessel and Douglas 2007). The results from the present study—of the trout population remaining in the cleared areas—are similar to those found by Stoessel and Douglas (2007) in the Goulburn River, and support the theory that in-stream structure may be a very important habitat component in maintaining or influencing trout distribution in small streams.

The lack of riparian vegetation in these areas indicates that the presence of trees is possibly not critical for trout but, it is important to note, that in these areas water quality and water temperature have to be acceptable for trout. Where such climatic conditions are not ideal for trout, particularly in areas where summer air temperatures are high, then large riparian vegetation is important in shading streams and the corresponding influence on water temperatures. Barton *et al.* (1985) investigated the dimensions of riparian buffer strips required to maintain trout habitat reported that the only environmental variable which clearly distinguished trout and non-trout streams was a weekly maximum water temperature (trimean weekly maxima less than 22^0 C). Warmer streams had, “at best, only marginal trout populations” (Barton *et al.* 1985). In these situations riparian vegetation that offers shade and keeps the water temperature in the trout’s preferential range would assist in fish distribution on the stream reach scale.

In-stream habitat works such as the introduction of artificial bank overhangs have been shown to increase trout abundance in small stream with poor in-stream habitat (Brown 2001). The construction and placement of such structures in the Rubicon anecdotally increased in-stream trout habitat in the study reach as no in-stream structures were removed and willow root wads were left in place. During the sampling for this study, fish were sampled[5] from under the LUNKER structures so these artificial bank overhangs were providing in-stream habitat. The concurrent installation of such structures with willow management may be an important factor in maintaining the local trout populations where willow management is required. Further work could be conducted to investigate what happens to the local trout population if willows are removed and no in-stream structures installed.

What is clear is that densely willowed areas can reduce a streams water transporting ability and hinder recreational access (Glova and Sagar 1994).

The willow debate will not be solved easily but this study indicates that willow removal and associated in-stream habitat construction is not detrimental to recreational salmonid fisheries. Such combined actions allow for successful willow management with no detriment to trout populations and provide additional access for recreational anglers. Such actions demonstrate successful management of an environmental problem with acknowledgement of key user groups and stakeholders and should be encouraged by fisheries managers, fishers, and catchment managers alike.

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[5] On four-passes through the treatment site 15 trout were observed (not all caught) exiting from the artificial overhangs of LUNKERs

Conclusions

Willow removal and the concurrent in-stream habitat construction did not negatively impact on trout numbers.

In-stream habitat is an important factor determining trout distribution in small streams.

Brown trout use LUNKERS in Victorian streams.

Brown trout appear to be tolerant of human activity. Despite heavy machinery working along the banks and some severe habitat modification through the removal of large riparian vegetation and in-stream habitat modifications within the locale, the trout population remained largely unaffected.

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