Trial Monitoring Program for a River Restoration Project: Ovens De-willowing

Ben Gawne, Helen Gigney and Rob Cook

Murray-Darling Freshwater Research Centre
Wodonga Laboratory
PO Box 991 Wodonga Vic 3689

Report prepared for the North East Catchment Management Authority

1 June 2005

The Murray-Darling Freshwater Research Centre

COOPERATIVE RESEARCH CENTRE FOR FRESHWATER ECOLOGY

MONITORING WATER TEMPERATURES AND MACROINVERTEBRATE COMMUNITIES IN THE OVENS RIVER TO ASSESS THE EFFECT OF A DE-WILLOWING OPERATION

Introduction

Riparian zones represent the boundary between aquatic systems and the surrounding landscape and are often areas of high productivity and diversity. Riparian vegetation is also a major determinant of stream condition influencing water quality, habitat availability and productivity of the river (Schulze and Walker 1997, Pusey and Arthington 2003, Baxter et al., 2005).

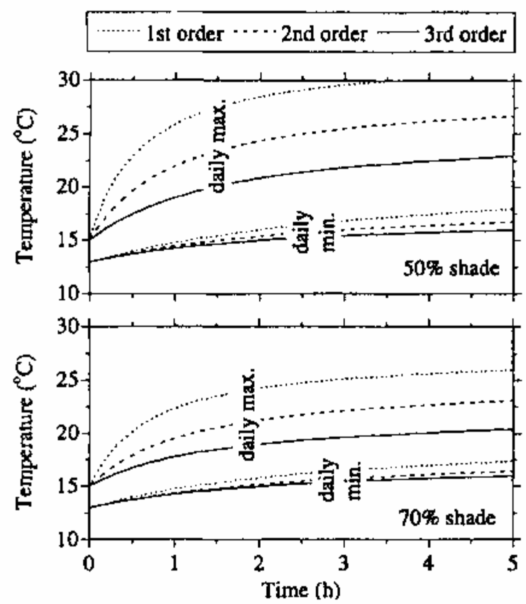

Figure 1: Changes of daily maximum and minimum water temperatures in 1st-, 2nd-, and 3rd-order stream flowing out of native bush into pasture predicted using the STREAMLINE model. From Rutherford et. al 1997

It is, therefore not surprising that changes in the amount or type of riparian vegetation may have a major impact on the river community including the invertebrate fauna with loss of riparian vegetation being associated with changes in community trophic structure (Thompson and Townsend, 2003, Danger and Robson, 2004).

One of the major impacts of changing riparian vegetation can be to influence stream temperature. This can occur in a number of ways; Firstly, incoming shortwave radiation is absorbed by the canopy reducing daily maximum temperatures; Secondly, long wave radiation emitted by the canopy reaches the water and offsets the outgoing radiation emitted by the water; and thirdly, the canopy provides a buffer to air movement, reducing the effect of evaporation and conduction and therefore increasing the daily minimum temperature. (Rutherford et. al 1997).

Rutherford et. al (2004) found maximum daily temperature changes of ± 4°C immediately downstream (600 to 960m) from 40 to 70% changes in riparian shading, in small slow flowing second order streams. Temperature changes of this magnitude are likely to be ecologically significant. Water temperature influences growth, reproduction and disease resistance in adult fish and hatching and development of fish larvae (Pusey and Arthington 2003), and also affects growth and development of aquatic insects (Butler 1984).

The effect of canopy shading is maximised in smaller streams with greater surface area to volume ratios. Figure 1 shows the predictions from the STREAMLINE model (Rutherford et al 1997). With increasing stream size the rate of heating from incoming solar radiation decreases (the rate of change of water temperature is inversely proportional to mean stream depth). Similarly, the equilibrium water temperature varied inversely with stream order (Rutherford et. al 1997).

This project undertook an examination of the short term effects of willow removal on both the stream temperature and the macroinvertebrate community in the Ovens River.

Study Sites

This study was conducted on the Ovens River at Selzers Lane near Ovens, upstream of Myrtleford in autumn 2005. The site was characterised by a stream width of approximately 8 to 20m and average depth of approximately 1.2m. Stream velocity was 0.36 to 0.4ms^{-1}. Channel width was estimated to be 25 to 30m. Bottom sediments of primarily cobble and gravel were clearly visible. Grazing and irrigated cropping (tobacco and fodder) were the primary land use and the banks were lined with crack willows and cotton wood poplar. Native eucalypts were only a minor component of the riparian zone. Banks have been fortified in places with rock to prevent erosion.

The study reach was ~1000m long with a dense canopy of willows. This reach was divided into two parts. The upstream part of the reach (identified for de-willowing works by NECMA) was left intact to act as a reference site. The downstream part of the willowed reach was de-willowed during the first two weeks of April 2005. Willow canopy and trunks were cut and removed, leaving the stumps and roots intact in the river channel. The remaining stumps were then poisoned using glyphosate.

Sampling

Both upstream and downstream reaches were sampled prior to (16th to 23rd March 2005) and following the de willowing operation (14th to 21st April 2005). A 200m section in each reach was selected for sampling. Four star pickets were installed in the river channel at heavily shaded locations within each reach. These pickets were used to mark the sites for temperature and light logging for the four week monitoring period.

One temperature logger and one light logger were attached to each of the 8 star pickets (Figure 2). Temperature loggers were attached to the star picket at a depth of approximately 15cm beneath the surface of the water and the light loggers were attached proud of the star picket approximately 30 to 60cm above the surface of the water. Light was measured using "Odyssey" photosynthetic irradiance sensor/recorders (Dataflow Systems Pty Ltd, New Zealand). Temperature was measured using "HOBO™ XT" temperature loggers in water proof housings (Hastings Data Loggers, Australia). Light and temperature loggers were programmed for 10min logging intervals and deployed for a period of one week.

The four loggers from each section of the reach were treated as replicates. For each replicate descriptive statistics were used to summarise the data. These summary statistics were used to compare the reference and de-willow reaches.

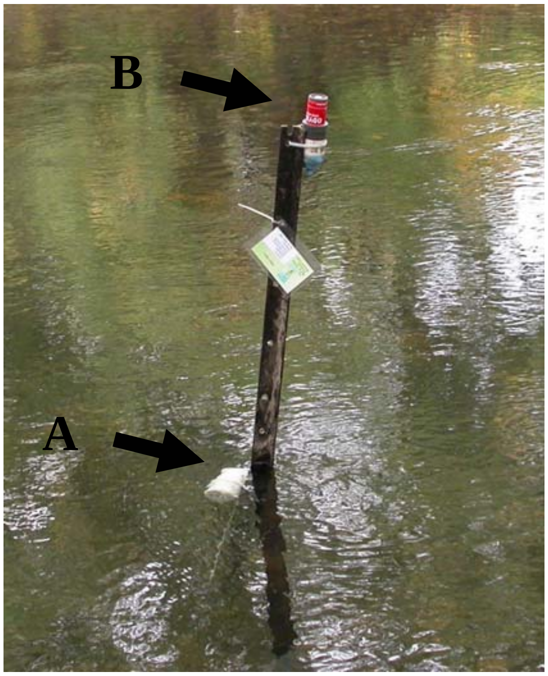

Figure 2: Water temperature logger (A) and light logger (B) deployed in the Ovens River at Selzers Lane.

Air temperatures were obtained from www.australianweathernews.com/data for the nearest weather station at Wangaratta Aero Club.

Macroinvertebrates were sampled within each reach using AUSRIVAS rapid assessment methodology on 23rd March and 21st April 2005. Kick samples were used to dislodge benthic animals from the substrate in flowing sections and edge sweeps were used to sample the slow or non flowing edge habitats. One 10m kick sample and one 10m sweep sample were collected from each reach using an "A" frame net with a mesh size of 250um. The samples were live picked in the field and identified to Family level in the laboratory. Community composition was analysed using presence absence data and cluster analysis in "Primer 5" (v 5.2.1). Taxa richness and environmentally sensitive taxa (Plafkin et al 1989) were identified and graded (Chessman 2001) to indicate the overall water quality and community health.

Results

Light

The willow canopy in the reference reach continued to shade the water despite some autumn leaf fall (Figure 3) but shading was reduced in the de-willow reach (Figure 4) after the de-willowing operation. Mean incident photosynthetic irradiance (Figure 5) in the de-willow reach in April (after the de-willowing treatment) was more than 5 times greater than that the light in the reference reach in April. Whereas, in March (before the de- willowing treatment) light was similar in both reaches. An example of the change in incident radiation at one site (d2) within the de-willow reach during five days of monitoring in March and in April is given in Figure 6. This clearly shows the overall daily patterns of light peaking towards midday. The ragged nature of most of the peaks is evidence of radiation being intercepted to different degrees on different days. The most likely cause of these interceptions are clouds.

Figure 3: Reference reach in March (top) and April (bottom) 2005, temperature and light logging site W4 indicated with the arrow.

Figure 4: De-willow reach in March (top) and April (bottom) 2005, temperature and light logging site D4 indicated with the arrow.

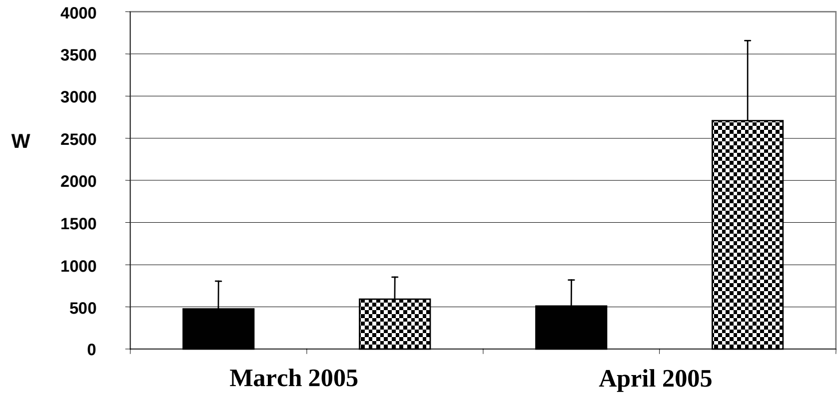

Figure 5: Incident photosynthetic irradiance in the reference and de-willow sites in March and April 2005.

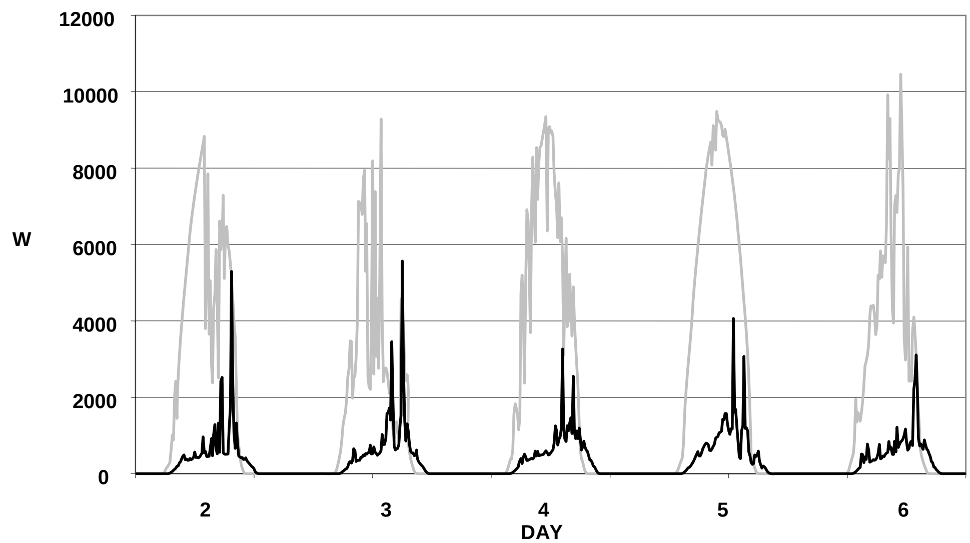

Figure 6: Light reaching the water at site (D2) over 5 days in the de-willow reach before (March) and after (April) de-willowing treatment.

Temperature

In the two weeks prior to the end of the study period average maximum and minimum air temperatures at Wangaratta fell, resulting in drop of 3.3 degrees overall.

Mean average (Figure 7) and mean maximum (Figure 8) water temperatures in both the reference and de-willow sites were similar in March and again in April but the temperatures recorded in April were approximately two degrees lower than those recorded in March.

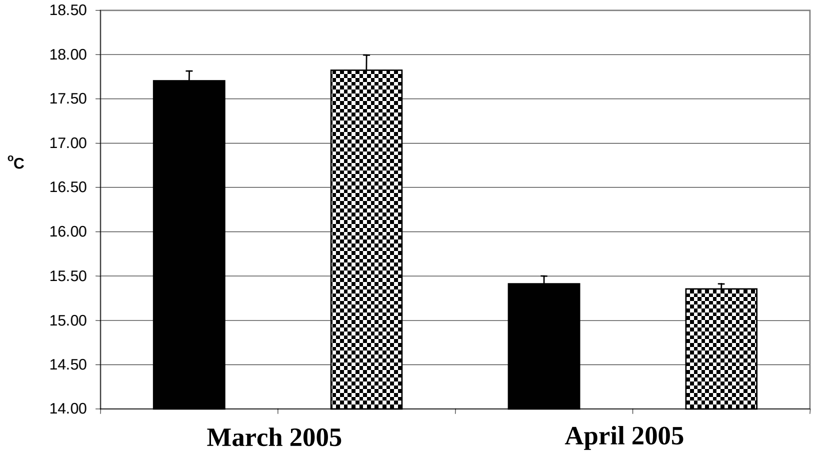

Figure 7: Mean average water temperature in the reference [black] and de-willow [checked] sites in March and April 2005.

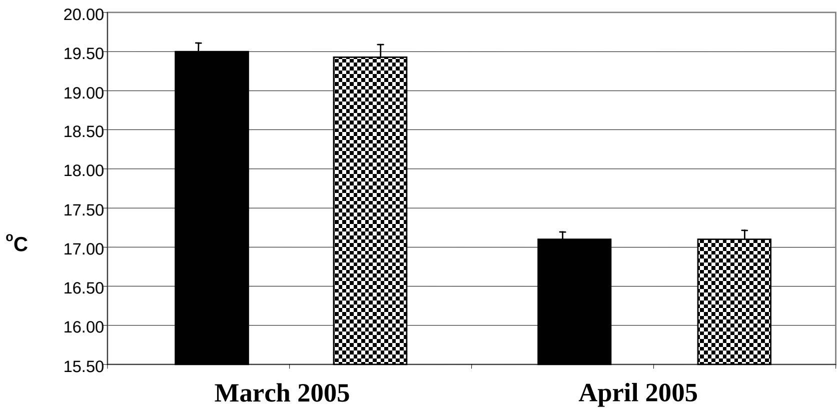

Figure 8: Mean maximum water temperature in the reference [black] and de-willow [checked] sites in March and April 2005.

Macroinvertebrates

Total taxonomic richness and sensitive taxa (Ephemeropter, Plecoptera Trichoptera) in the reference and de-willow reaches was not different before or after the de-willowing operation (kick and sweep samples combined), (Figure 9). Edge sweep samples from both reaches in April contained the most taxa (27) and the kick sample from the reference reach in April contained the least taxa (20) (Figure 10). Taxa that were abundant in the reference reach were also abundant in the de-willow reach. All samples were dominated by insect larvae from two Orders; Ephemeroptera and Trichoptera. Five families of Ephemeroptera and nine families of Trichoptera accounted for 53% to 74% of the total number of animals collected. One family of Plecoptera was also present. A full taxonomic list (family level) including abundance and sensitivity grades for the combined kick and sweep samples is attached in appendix 1.

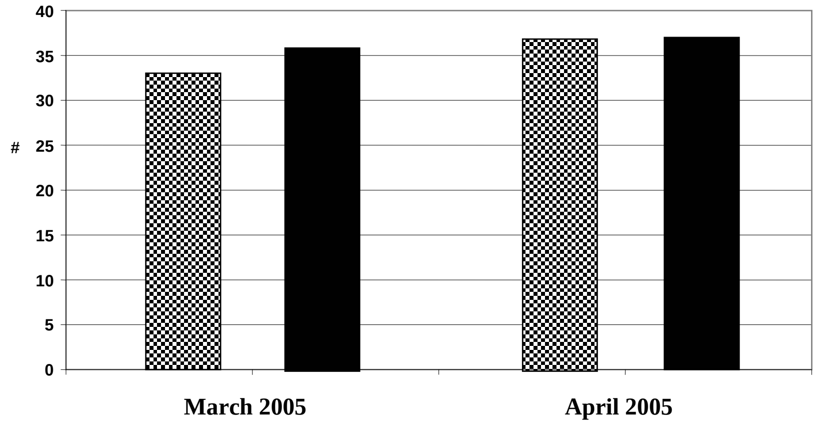

Figure 9: Total taxonomic richness for edge and riffle macroinvertebrate assemblages collected from the reference and de-willow reach sections in March and April 2005.

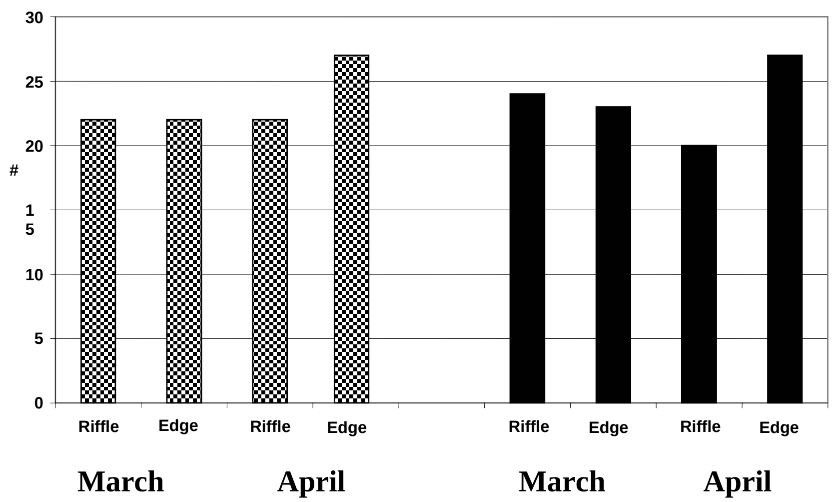

Figure 10: Taxonomic richness for macroinvertebrate assemblages collected from edge and riffle habitats in de-willow and reference reach sections in March and in April 2005.

Community composition analysis of similarity, based on presence absence data, showed two distinct groups separating due to habitat (riffle or edge) (Figure 11). Within these two major groups the samples separated out further based on sampling date. There was no evidence of altered community composition due to the de-willowing treatment.

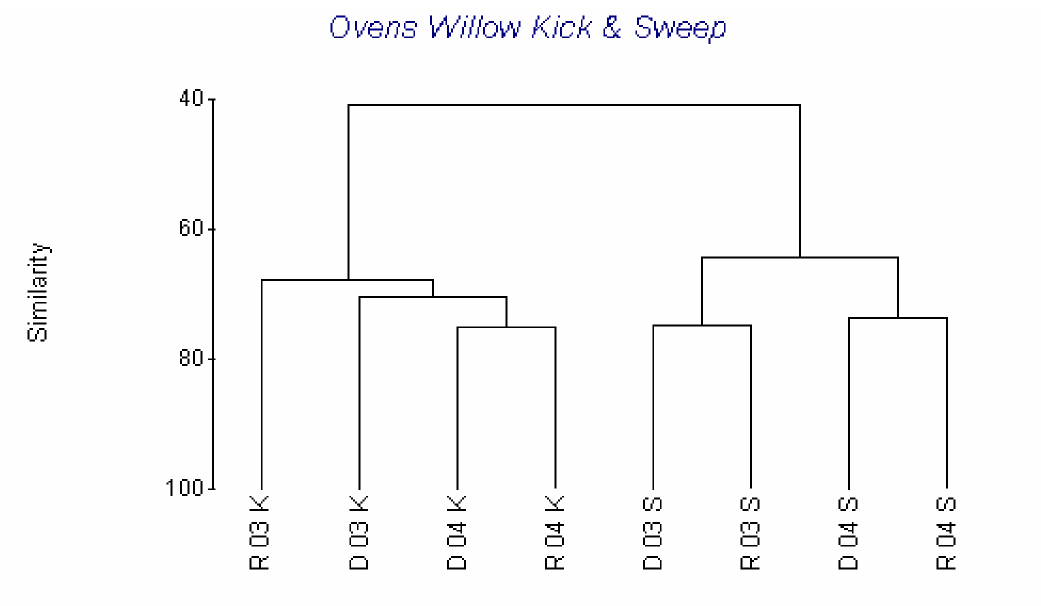

Figure 11: MDS of macroinvertebrate community structure from riffle kick (K) and edge sweep (S) samples taken in March (03) and April (04) 2005 at the reference (R) and de-willow (D) reach sections.

Discussion

Light and Temperature

In this study, both the reference (shaded) and de-willow (unshaded) reaches experienced a two degree fall in temperature between the March and April sampling periods as a result of changes in ambient temperature. There was no evidence of a change in water temperature due to the de-willowing operation despite a significant loss of shade in the de-willow reach. This is contrary to the findings of Rutherford et al. (1997), however their studies were conducted in summer, whereas, this study was conducted in autumn. Also, the Ovens River upstream of Myrtleford is a higher order stream than those studied by Rutherford. Its greater size, depth and flow velocity provide greater buffering against any localised temperature changes. Water travelling at $0.4ms^{-1}$ will travel 200m in a little over 8 minutes. Therefore, large changes in riparian canopy over much greater distances would be required to induce any significant changes in local water temperature.

The timing of sampling for this study was constrained by the timing of the de-willowing operation and may have limited the capacity of this study to detect the impact of the operation. Although the AUSRIVAS macroinvertebrate bio-assessment protocol requires sampling in autumn or spring, the potential changes to water temperatures, light and primary productivity would be greatest in mid summer when solar radiation and ambient temperatures are at a maximum and the effect of shading and the contrast between the reference and de-willowed reach of the stream are greatest.

Macroinvertebrates

This study found no significant difference in the macroinvertebrate assemblage following the de-willowing operation. The macroinvertebrates sampled in this study were typical of an upland stream and the taxa that were abundant in the reference reach were also abundant in the de-willow reach after the de-willowing operation. The dominant taxonomic classes found (*Ephemeroptera* and *Trichoptera*) were those that are known to be sensitive to environmental stress (Plafkin et al. 1989, Chessman 2001). Taxonomic richness at the family level was high, 32 to 37 out of the possible 40 used by Chessman (2001).

Apart from the loss of shading and willow canopy trailing in the stream, the structure of the edges and riffle remained relatively unchanged. The willow root mats were still in place providing complex habitat for macroinvertebrates at the edges, leaf litter/coarse organic material was still abundant and the channel was largely unchanged. Consequently, little immediate change in macroinvertebrate taxa might be expected as the samples for this study were collected only weeks after the de-willowing operation.

However, there is the potential for increased light to induce other biological changes within the river system; for example, changes in periphyton composition and increased biomass (primary production) could lead to changes in macroinvertebrate abundance or community structure in the longer term (Pusey and Arthington 2003, Feminella et al 1989, Plafkin et al. 1989, Behmer and Hawkins 1986) and the relative abundance of taxa from particular functional feeding groups, for example, the ratio of scrapers to filterers (Plafkin et al. 1989).

Loss of riparian vegetation (native or introduced) does not only affect the amount of light or heat reaching the stream but also the amount of carbon. Streamside vegetation provides litter fall to the system. This litter provides energy and acts as a substrate for biofilm and microorganisms as well as providing nutrition and refuge for aquatic insects (Schulze and Walker 1997, Pusey and Arthington 2003). However, the timing and rate of decomposition of willow leaf material is very different from that of native species such as river red gum which may affect native species capacity to utilise the material (Schulze and Walker 1997). Willow litter fall occurs in late Autumn when the whole canopy senesces, where as river redgum retain a significant proportion of their canopy and peak litter fall occurs in late summer. (Bowen, pers. com.) Most of the common Trichopteran (Caddisfly) Families (*Leptoceridae*) are case dwelling animals that utilise sticks, twigs and leaf material to construct their portable cases. One of these, Oecetis is well adapted to willow litter and commonly found in willow root masses (J. Hawking, pers.com), but the larvae of Calamoceratidae (Trichoptera) can only use eucalypt leaves to construct their cases (J. Hawking, pers. com). So, not only altering the amount but also the type of riparian vegetation may have longer term impacts on the aquatic communities.

River restoration projects are an investment in the long term long health of the river system. There is no doubt that large scale removal of riparian canopy (including willow) would have an effect on summer stream water temperatures. The degree to which this would occur however is primarily dependent on stream size and area removed but could be predicted using remote sensing data to assess the type riparian canopy and models such as STREAMLINE (Rutherford 1997). Replacement of willow with appropriate native vegetation is an important part of restoring the river to a more natural state. To assess the effectiveness of restoration projects some long term monitoring is essential and to maximise the benefit of such a program seasonal influences on the parameters of interest need to be considered.

Acknowlegements
We would like to thank Terry McCormack at NECMA for assisting with the coordination of the study and the works program and the land holders, Colin McCormack & John Selzer for access to their properties as well as Adam Richardson, John Hawking and Kathie Le Busque from MDRFC, for their knowledge and assistance.

References:

Baxter, C.V., Fausch, K.D., and Carl Saunders, W. (2005). Tangled webs: reciprocal flows of invertebrate prey link streams and riparian zones. *Freshwater Biology* **50**:201-220.

Behmer, D.G. and Hawkins, C.P. (1986). Effect of overhead canopy on macroinvertebrate production in a Utah stream. *Freshwater Biology* **16**: 287-300.

Butler, M.G. (1984). Life Histories of Aquatic Insects. **In**, The Ecology of Aquatic Insects. Resh V.H. & Rosenberg D.M. Eds. Praeger Publishers. New York.

Chessman, B. (2001). SIGNAL 2. A scoring system for macroinvertebrates (‘waterbugs’) in Australian rivers. User Manual. NSW Department of Land and Water Conservation. Parramatta, NSW, Australia.

Danger, A.R., and Robson, B.J. (2004). The effects of land use on leaf-litter processing by macroinvertebrates in an Australian temperate coastal stream. *Aquatic Sciences* **66**:296-304.

Feminella, J.W. Power, M.E. and Resh, V.H. (1989). Periphyton responses to invertebrate grazing and riparian canopy in three northern California coastal streams. *Freshwater Biology* **22**: 445-457.

Plafkin, J.L., Barbour, T.M., Porter, K.D., Gross, S.K and Hughes, R.M. (1989). Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. USEPA, Washington, D.C.

Pusey, B, and Arthington, A. (2003). Importance of the riparian zone to the conservation and management of freshwater fish: a review. *Marine and Freshwater Research* **54**:1-16.

Rutherford, J.C., Blackett, S., Blackett, C., Saito, L., and Davis-Colley, R.J. (1997). Predicting the effects of shade on water temperature in small streams. *New Zealand Journal of Marine and Freshwater Research*, **31**:707-721.

Rutherford, J.C., Marsh, N.A., Davies, P.M. and Bunn, S.E. (2004). Effects of patchy shade on stream water temperature: how quickly do small streams heat and cool? *Marine and Freshwater Research*, **55**, 737-748.

Schulze, D.J., and Walker, K.F. (1997). Riparian eucalypts and willows and their significance for aquatic invertebrates in the River Murray, South Australia. *Regulated Rivers: Research and Management* **13**:557-577.

Thompson, R.M., and Townsend, C.R. (2003). Impacts on stream food webs of native and exotic forest: An intercontinental comparison. *Ecology* **84**:145-161

Appendix 1: Species list, abundances and sensitivity grade (1 = low and 10 = high) for macroinvertebrates collected in autumn 2005 from the Ovens River upstream of Selzers Lane near Myrtleford, Victoria.

CLASS	FAMILY	De-willow Mar 05	Ref Mar 05	De-willow Apr 05	Ref Apr 05	Signal 2 sensitivity grade
Arachnida	Acariformes	5	11	3	5	Not determined
Collembola	Isotomidae	0	2	1	0	Not determined
Coleoptera	Dytiscidae	0	1	3	9	**2**
Coleoptera	Elmidae	9	19	3	5	**7**
Coleoptera	Gyrinidae	0	0	1	0	**4**
Coleoptera	Hydrophylidae	2	1	6	1	**2**
Coleoptera	Psephenidae	11	7	13	15	**6**
Crustacea	Atyidae	4	7	10	12	**3**
Crustacea	Parastacidae	0	0	3	2	**4**
Diptera	Aphroteninae	0	0	0	1	**8**
Diptera	Atheriscidae	1	3	0	0	**8**
Diptera	Ceratopogonidae	0	3	3	1	**4**
Diptera	Chironominae	7	14	21	12	**3**
Diptera	Chrionomid pupae	2	4	1	5	Not determined
Diptera	Dixidae	0	1	3	0	**7**
Diptera	Empididae	0	2	0	0	**5**
Diptera	Orthcladinae	4	0	1	7	**4**
Diptera	Simuliidae	0	2	0	2	**5**
Diptera	Tanypodinae	15	12	8	14	**4**
Diptera	Tipulidae	8	1	6	3	**5**
Ephememeroptera	Baetidae	39	72	18	26	**5**
Ephememeroptera	Caenidae	0	0	0	1	**4**
Ephememeroptera	Coloburiscidae	5	4	13	6	**8**
Ephememeroptera	Leptophlebiidaae	44	129	73	151	**8**
Ephememeroptera	Oniscigastridae	4	2	2	0	**8**
Bivalvia	Corbiculidae	0	0	1	1	**4**
Hemiptera	Corixidae	7	20	25	61	**2**
Hemiptera	Gerridae	1	1	3	1	**4**
Hemiptera	Notonectidae	7	3	6	5	**1**
Hemiptera	Veliidae	9	6	3	11	**3**
Megaloptera	Corydalidae	0	8	2	2	**7**
Megaloptera	Sialidae	5	0	0	0	**5**
Odonata	Gomphidae	8	5	18	10	**5**
Odonata	Isosticidae	1	0	0	0	**3**
Odonata	Synlestidae	3	1	11	2	**7**
Odonata	Synthemistidae	1	0	0	4	**2**
Odonata	Telephlebiidae	1	0	0	0	**9**
Oligochaeta	Oligochaete	4	6	3	11	Not determined
Plecoptera	Gripopterygidae	5	7	6	0	**8**
Trichoptera	Atriplectidae	0	0	2	3	**7**
Trichoptera	Calamoceratidae	3	1	7	7	**7**
Trichoptera	Conoesucidae	3	3	1	0	**7**
Trichoptera	Ecnomidae	0	8	11	16	**4**
Trichoptera	Glossomatidae	0	1	0	0	**9**
Trichoptera	Hydrobiosidae	10	16	12	11	**8**
Trichoptera	Hydropsychidae	13	16	39	32	**6**
Trichoptera	Leptoceridae	63	38	93	72	**6**
Trichoptera	Philorethridae	0	0	0	1	**8**