

Stream biological research at Warra

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Abstract

An active program of stream biological research is being pursued in the Warra – Southern Forests area, with several aims: characterisation of instream biological communities and processes, quantification of forestry-related impacts, development of aquatic bioassessment of forest sustainability, and development of methods to mitigate impacts. Several aspects and results of this research are described.

Introduction

A number of stream studies are being conducted at Warra, or have a key focus within the Warra Long-Term Ecological Research (LTER) Site. Most of these studies focus on stream habitats, macroinvertebrates and fish, evaluating changes associated with forest activities like clearfell harvesting and roading, as well as developing methods to ameliorate impacts. This paper briefly summarises these studies.

Streams in the Warra Site are generally steep, fast flowing over bedrock and cobble-boulder substrates. Their catchments often have significant contributions from groundwater and subsurface flows, particularly in dolerite. They vary in colour from clear to tannin coloured, are low in nutrients and dissolved salts (conductivity), and are generally near-neutral to slightly acidic in pH. These streams are tributaries of two larger river systems: the Huon, a blackwater river, and the Weld, a limestone-influenced, semi-blackwater river.

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Aquatic fauna

Macroinvertebrates

Recent sampling by us (between 1995 and 2001) has allowed a general characterisation of the macroinvertebrate fauna of streams in this area. Amphipods, stoneflies, mayflies and chironomids, beetles and blackflies occur at all the undisturbed stream sites at Warra and in the Southern Forests. The macroinvertebrate fauna in these streams is numerically dominated by paramelitid amphipods (*Antipodeus mortoni*), leptophlebiid or prong-gill mayflies (10 species recorded from this study to date), gripopterygid stoneflies (19 species recorded) and eustheniid and austroperlid stoneflies (two species each). Two groups of Diptera (simuliids and orthoclad midges), at present with an unknown species diversity, are also abundant and widespread.

The most diverse group is the caddisflies (Trichoptera), with 63 species recorded from the area, dominated by the hydrobiosids (20 species recorded from the area) and conoesucids (10 species recorded). Of the Trichoptera, only the hydrobiosids and helicophids are occasionally relatively abundant at any one site.

Macroinvertebrate communities of undisturbed streams in the Warra LTER area all follow a similar pattern, with all sites containing and being dominated by the amphipod *Antipodeus mortoni*, the mayfly *Nousia* sp. AV7 and the stonefly *Cardioperla media/lobata*. Sixty per cent or more of 30 stream sites sampled within the LTER Site also contain *Eusthenia spectabilis* and

E. costalis, the austroperlid *Tasmanoperla thalia*, the telephlebiid dragonfly *Austroaeschna hardyi* and the grypopterygids *Leptoperla varia* and *Trinotoperla zwicki*.

This fauna is characteristic of fast flowing, cool forest streams with little fine sediment and a food web supported largely by input of organic material (leaves, twigs, bark etc) from the bankside or riparian vegetation.

The Huon and lower Weld Rivers in the vicinity of the Warra Site are dominated by the following taxa, which occur at all sample sites, listed here in their order of relative abundance: notonemourid stoneflies, helicopsychid caddisflies, chironomids, worms, caenid mayflies and austroperlid stoneflies. This is a fauna characteristic of large rivers, and distinctly different from the smaller tributary streams flowing through Warra and the Southern Forests.

Fish and others

Fish in the Warra streams are typical of most southern Tasmanian catchments. The upper reaches are frequently devoid of fish due to the presence of substantial barriers to their upstream movement (falls, or sequences of chutes and rapids). In these fish-free sections, several macroinvertebrate species which are normally vulnerable to fish predation are able to live, including baetid mayflies and the Tasmanian mountain shrimp *Anaspides tasmaniae* (known from four locations within Warra).

Downstream of these barriers, the steeper sections generally contain one or more of three native fish species—*Galaxias truttaceus* (mountain galaxias), *G. brevipinnis* (climbing galaxias) and *Anguilla australis* (shortfin eel)—while some larger lower sections also contain the introduced brown trout (*Salmo trutta*). The larger rivers adjacent to Warra (Weld, Huon, Picton) contain all of these species as well as *Pseudaphritis urvillii* (the sandy), *Prototroctes maraena* (grayling) and *Geotria australis* (lamprey), and three more introduced

species, rainbow trout, atlantic salmon and *Gadopsis marmoratus* (river blackfish). The former two have become established from escapees from marine aquaculture facilities in the lower Huon, while the native blackfish was introduced from northern Tasmania early this century.

Platypus are frequently observed in the larger rivers, and are seen occasionally in the larger tributary streams, such as at the Warra weir site. The crayfish *Astacopsis franklinii* has also been recorded from several of the smaller Warra streams and from the Huon, Weld and Picton Rivers.

Ongoing studies of forest operation impacts

What then are the impacts of forest operations on these stream systems? Recent studies at Warra have demonstrated localised impacts from road crossings, as well as impacts from increased sediments and changes to flow regimes in small (Class 3 and 4) streams following logging operations. The overall impact on the aquatic conservation values of the Huon, Weld, Picton, Arve and Esperance drainages is as yet unknown, and a number of studies are underway to evaluate the effects of forestry-associated activities on stream values. These have focussed on:

1. Road crossings – impacts and mitigation
 - Effects of road drainage into streams on macroinvertebrates (Risdon 1998);
 - Effects of culverts and culvert design on fish passage in streams (Walker 1999);
 - Designing methods for restoring fish passage through existing culverts.
2. Harvesting and silviculture
 - Effects of harvesting operations on stream macroinvertebrates and their habitats;
 - Effects of harvesting and plantation establishment on Class 4 stream channels, habitats and macroinvertebrates.

3. Assessment of impacts

- Refinement and development of techniques for the assessment of stream macroinvertebrate communities as an indicator of 'forest sustainability'.

Some examples of this work are described below.

CULVERT STUDY 1

Fish swimming speeds, for both sustained and burst swimming, were quantified in a flume for three native fish species, *Galaxias maculatus*, *G. truttaceus* and *Pseudaphritis urvillii*, as well as brown trout (Walker 1999). Predictions were then made of fish passage success through culverts at varying water velocities for *G. truttaceus* and brown trout, after developing plots of distance swum against water velocity, for a range of fish swimming performance observed within the test populations. These predictions were field-validated by conducting trials at a double culvert on Riveaux Road, near the

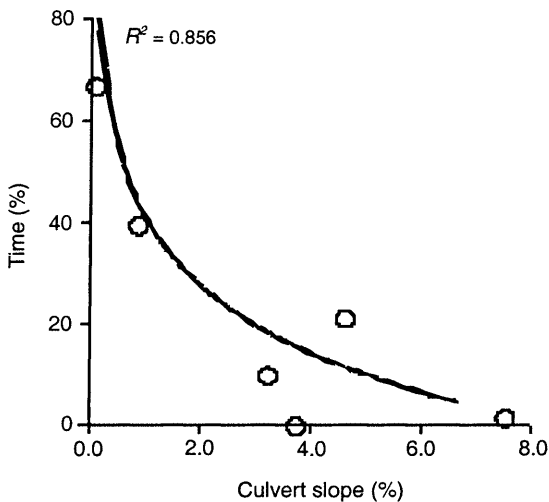


Figure 1. Relationship between per cent of time available during 1999 for the best performing 10% of brown trout to pass through culverts, and per cent culvert slope.

Warra LTER area. Passage success rates predicted from the laboratory flume trials were not significantly different from those measured at the test culvert, over a wide range of velocities (by χ^2 test).

Having established fish swimming speeds, and developed validated relationships between distances swum at differing water velocities, conditions under which culverts would prevent fish passage were then explored. Hydrological data from the Warra Creek weir site were used to develop velocity time-series for a set of six culverts in the Warra – Southern Forests area, for which velocity-discharge relationships had been developed. Relationships were developed between the proportion of time in the 1999 calendar year for which fish passage could occur, for the upper 10% and median of fish performance, and culvert slope (e.g. in Figure 1). These indicated that culverts of slopes substantially less than 2% would be required to allow a degree of fish passage.

A second issue preventing fish passage through culverts is the degree to which culverts become suspended above the downstream stream-water surface, or 'perch'. Fifty per cent of the 20 culverts surveyed in the Warra – Southern Forests region had a perch with greater than 10 cm height (Figure 2), which effectively prevents native fish passage into the culvert mouth from downstream.

CULVERT STUDY 2

The second study on fish passage at culverts is in progress, and is developing a cost-effective method to alter existing culverts in order to restore a degree of native fish passage while not reducing the culvert's hydraulic capacity under high flows. This is being approached by evaluating the success of fish passage through a culvert fitted with a series of small baffles. Different baffle sizes and spacings are being trialled, and passage of *Galaxias truttaceus* and

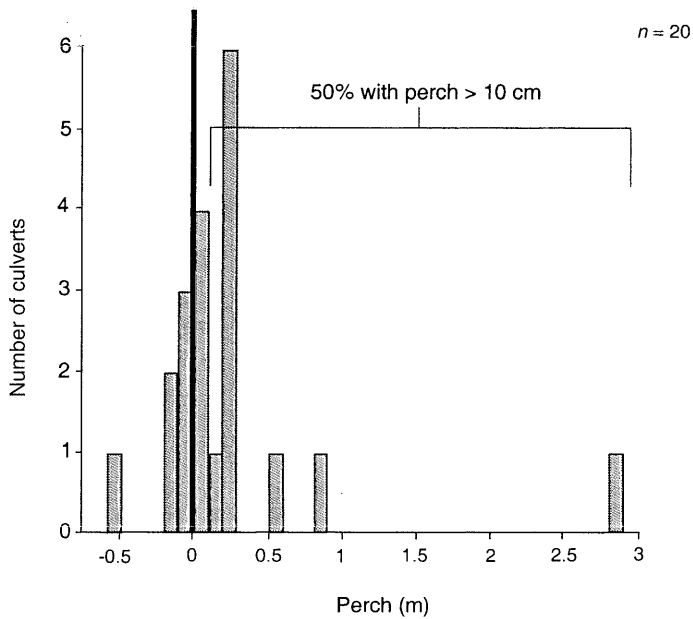


Figure 2. Perch (height above water surface) for 20 culverts surveyed in the Warra –Southern Forests road network. Solid line indicates 0 slope.

G. maculatus is being assessed over a range of water velocities. The trial is taking place at the Riveaux Road double culvert during 2001/2002. A risk assessment survey methodology will also be developed to determine priority culverts for fish passage restoration within a catchment, and will be trialled in the lower Weld, Picton, Arve and Huon catchments.

STREAM CROSSING IMPACT STUDY

Macroinvertebrates and sediments were sampled upstream and downstream of road crossings in 1999 (Risdon 1998). Changes in macroinvertebrate abundance and community composition were related to variables describing the characteristics of the road crossings, road surface and road drainage at each site. Drainage gradient was strongly positively correlated with the proportion of instream sediment deposits that were coarse-grained. Low drainage slopes apparently assist trapping of coarser material, so that only finer

sediments (< 63 μm) are deposited in the stream channel.

Biological responses varied between taxa, with worms (oligochaetes) having significantly greater abundance downstream than upstream of road crossings (by 300%, $t = 2.7$, $df = 10$, $P = 0.022$), and more sensitive taxa such as austroperlid and eustheniid stoneflies having significantly reduced abundance downstream of the crossing (by 50–60%, $t = 2.6$ and 2.3 , $df = 10$, $P < 0.05$; see Figure 3). In addition, the number of taxa was significantly negatively correlated with the proportion of fine sediments (< 250 and < 63 μm , both $P < 0.025$) at upstream and downstream sites.

The difference in number of taxa downstream compared to upstream of crossings was also negatively correlated with mean drainage gradient ($R^2 = 0.37$, $P = 0.028$), suggesting that steeper drainage channels lead to greater input of coarser (c. 1 mm) road sediment material which has

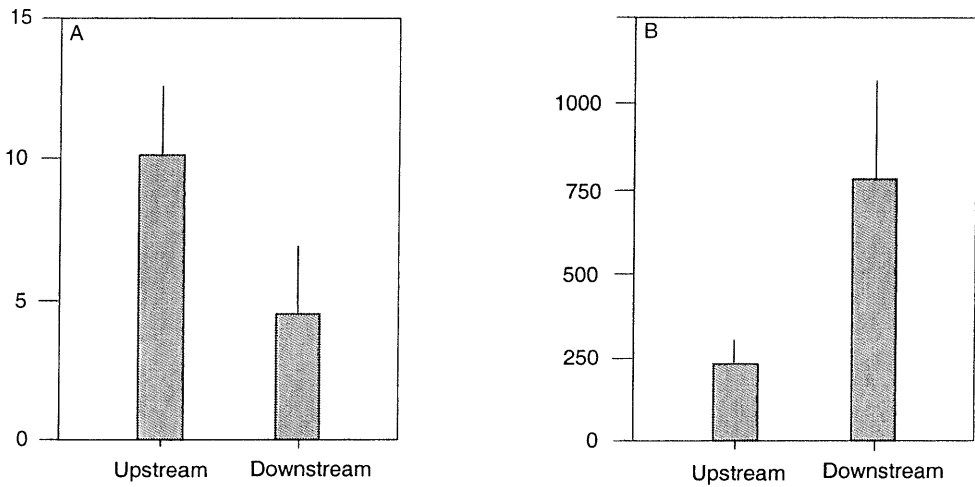


Figure 3. Abundance (n/m^2) of eustheniid stoneflies (A) and freshwater worms (B) upstream and downstream of ten road crossings in the Warra – Southern Forests region. Vertical lines are one standard error above the mean.

a subsequent negative impact on stream habitat quality and macroinvertebrates.

BIOASSESSMENT—THE MONTREAL INDICATOR STUDY

This study, funded under the Montreal Indicators Program is being conducted to:

- Evaluate the utility of AUSRIVAS (Australian River Assessment Scheme) bioassessment as one among several indicators of forest sustainability;
- Propose alterations to the AUSRIVAS protocols which would optimise their sensitivity for forested streams and for assessing changes in stream fauna associated with current forest practices;
- Collect baseline pre-logging data on stream macroinvertebrates for the Warra LTER forest hydrology study;
- Develop a baseline dataset on stream macroinvertebrates from streams within both the Warra LTER Site and adjacent Southern Forests for future assessments, and as the basis of a possible audit of stream conditions associated with forest operations in the area.

Eighty-nine stream sites have been sampled, on up to five occasions, for macroinvertebrates and environmental variables since the study commenced in 1999.

AUSRIVAS bioassessment is based on the development and use of 'predictive' bioassessment models which allow the direct comparison of the list of macroinvertebrate taxa found (or 'observed') at a stream site with the list of taxa predicted (or 'expected') to occur at that site if it were undisturbed. It has become a nationally accepted methodology for rapid assessment of riverine ecological health using macroinvertebrate data (Davies 2000).

The models are developed using data from minimally disturbed (reference) sites of similar stream types within the catchment and region. They are then used to predict the occurrence of macroinvertebrate taxa at a site, against which the actual observed fauna (collected using the same sampling technique) is compared by the use of the observed/expected, or 'O/E', ratio. O/E is the proportion of taxa predicted to occur at a site which are actually found or observed there. It ranges from 0 to 1, with values near 1 that fall within the range calculated for reference sites being deemed

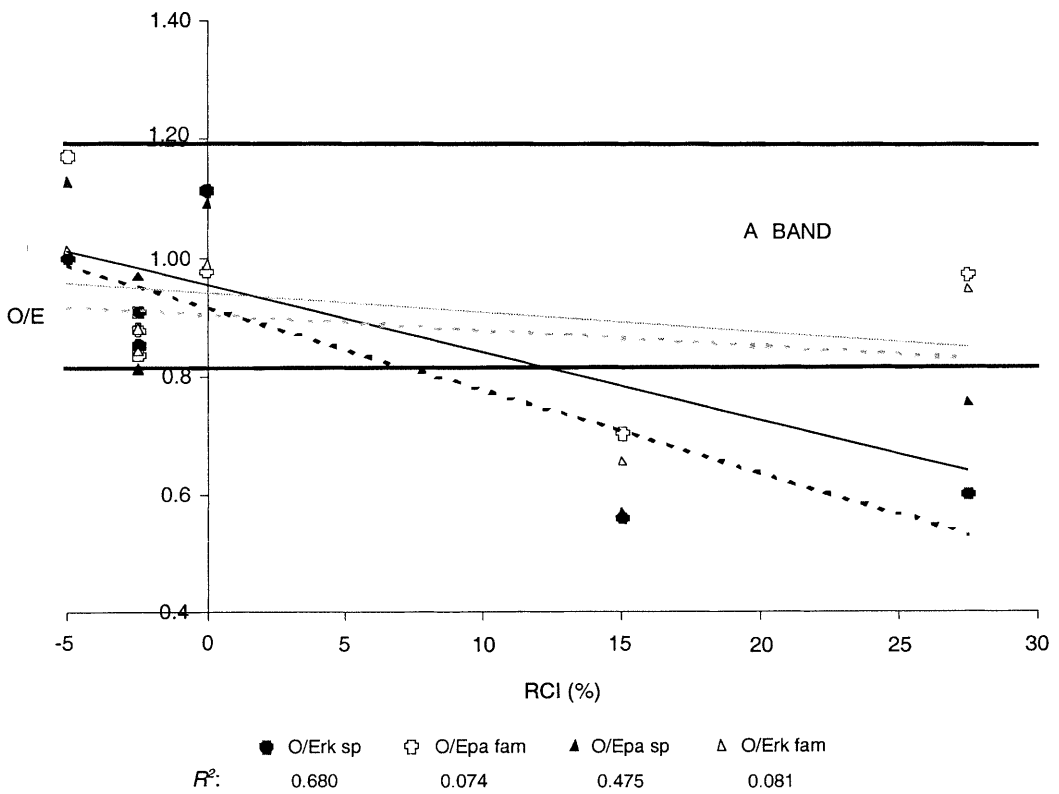


Figure 4. Plot of O/E values for sites downstream of six road crossings in the Southern Forests, derived using AUSRIVAS live-pick data models developed using species or family level data (sp and fam), transformed to presence/absence or rank abundance (pa and rk), against the Road Crossing Impact Index (RCI). R² values for each regression are shown. Both slope and R² increase in the order pa fam < rk fam < pa sp < rk sp.

undisturbed or equivalent to reference, and 0 representing the complete absence of any expected taxa—obviously a fairly extremely disturbed situation!

O/E values of 0 are rare, occurring only at a few sites downstream of highly polluting mine sites; for example, in the King River (Davies *et al.* 1996). However, the ability of AUSRIVAS models to detect an impact, and to assess departures of stream condition from reference, is dependent on the sensitivity of the model. This sensitivity is dependent on a number of factors, most importantly:

- Taxonomic level. Use of data at family level is potentially less sensitive than data at species level.
- Sampling technique. Rapid assessment techniques, such as kick netting with live-picking on site, are more prone to error than quantitative sampling and laboratory-processing techniques.
- Data transformation. Use of presence/absence data is regarded as less sensitive than rank or absolute abundance data.
- Sampling frequency. Use of data produced by combining a number of seasonal sampling events is regarded as more sensitive and reliable than single-sample datasets.
- Spatial scale. Use of local, regional models is regarded as more sensitive than broader regional or even statewide models.

All of these issues are being explored in the Warra and Southern Forests Montreal Indicator study. AUSRIVAS predictive bioassessment models are being developed using live-pick, quantitative, family level and species level data, as well as at three regional scales (Warra LTER area only, Southern Forests and Tasmania) and with two data transformations (presence/absence and rank abundance). The family of models that is being developed is being used to assess data from a common set of macroinvertebrate samples collected over two 'gradients' of forestry disturbance:

1. Road crossings. Samples have been collected upstream and downstream of 13 road crossings.
2. Harvesting. Samples have been collected upstream and downstream of 11 coupes, both before and after logging operations.

The relationship between O/E scores derived from these models will be used to assess model sensitivity to both types of disturbance. An initial example of the results is shown in Figure 4 for four models.

A road crossing impact index (RCI) has been developed which is based on the per cent change in area of fine sediments (sands and silts) between two sites upstream and downstream of each crossing. Increased

slope in the response of O/E to the degree of impact from road crossings indicates greater sensitivity, while increased R^2 of the regression indicates reduced variability in the assessment. All AUSRIVAS models developed for the Warra – Southern Forests region are being assessed using this kind of approach.

It is envisaged that a suite of recommendations for applying AUSRIVAS to regional and national assessment of forest sustainability will be developed from this work which will assure optimum sensitivity and reliability from the approach. In addition, the AUSRIVAS models developed from the project will be used as the basis for future audits of forest stream condition in the Southern Forests region in the future.

Conclusion

An active program of stream research is being pursued in the Warra LTER Site – Southern Forests, with the aim of identifying key ecosystem components and processes of Tasmanian wet forest streams and the nature and extent of forestry-associated impacts. This research is becoming increasingly focussed on methods for improving management of forest streams, as well as on methods for mitigating impacts.

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