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A Trial of Wood Decomposition Rates as an Ecological Assessment Tool in Large Rivers

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A Trial of Wood Decomposition Rates as an Ecological Assessment Tool in Large Rivers

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EXECUTIVE SUMMARY

Traditional approaches to assessing river ecosystem health have tended to focus on structural components of the ecosystem such as the abundance and composition of invertebrate and periphyton communities. However, the value of incorporating measurements of ecosystem function (*i.e.* the rates of certain ecological processes) into regular monitoring programmes is increasingly being recognised. One of the potential advantages of using functional measures is that they allow some flexibility in the types of habitats that can be assessed and may be helpful in situations where habitat differences between control and impact sites make interpretations of invertebrate community data problematic. This report describes the results of a test/demonstration of the use of wood decomposition rates as a functional indicator of river ecosystem health in the lower reaches of the Hokitika River in the vicinity of a dairy effluent discharge. Monitoring of invertebrate community composition and periphyton growth is regularly conducted above and below this discharge. However, the results of these monitoring efforts are sometimes difficult to interpret due to tidal fluctuations influencing the river just downstream of the discharge, thus making it hard to separate any effects of the discharge from effects associated with tidal fluctuations.

Replicate sets of birchwood sticks were deployed at one site upstream of the dairy factory and two sites downstream of the dairy factory for three months during off-season and production season periods. A temperature logger was also deployed throughout the study to allow decay rates to be standardised between the two deployment periods. Any differences in decomposition rates among upstream and downstream sites, or in the pattern of decay rates at the sites between production season and off-season could be associated with an effect of the milk factory discharge.

Only two sets of sticks out of 24 were lost during the three months deployment periods, which demonstrates that with careful site selection and deployment it is possible to use this technique in large rivers with variable flow regimes. During the off-season, wood decay rates were similar at all the sites. However, during the production season wood decay rates at the site immediately downstream of the discharge were significantly lower than at the other two sites. When considering all the data together after temperature compensation, however, there was no interaction between site and season which suggests that inherent differences among sites were larger than any effect occurring during the production season at the site just downstream of the discharge. Organic pollution generally increases microbial activity and was expected to increase wood decay rates. Therefore, the pattern of decay rates among sites that was observed in the production season was the opposite of what was expected. The lower decay rates at the site downstream of the discharge during the production season were probably related to the sticks being buried by deposited sediment during the deployment period rather than a direct effect of the discharge.

It appears that wood decomposition is affected by site-specific habitat factors, such as sediment deposition, and so doesn't overcome the issues that are faced by invertebrate community analysis. Nevertheless, this method does provide insight into aspects of river ecosystem health that are not considered by invertebrate sampling alone. Wood decomposition should be considered as a tool alongside others for assessing river ecosystem health, especially if effects on microbial community activity are suspected.

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1. INTRODUCTION

Traditional approaches to assessing river ecosystem health have tended to focus on structural components of the ecosystem such as the abundance and composition of invertebrate and periphyton communities. However, the value of incorporating measurements of ecosystem function (*i.e.* the rates of certain ecological processes) into regular monitoring programmes is increasingly being recognised (Bunn 1995; Gessner & Chauvet 2002). The rates of wood decomposition and ecosystem metabolism appear to have promise as suitable functional indicators (Young & Huryn 1999; Bunn & Davies 2000; Gessner & Chauvet 2002; Young *et al.* 2004; Young & Collier in review).

One of the potential advantages of using functional measures is that they allow some flexibility in the types of habitats that can be assessed (Young *et al.* 2004). For example, ecosystem metabolism can be measured relatively easily in large rivers where traditional sampling of invertebrate communities is either difficult or dangerous. It may also be possible to monitor ecosystem health in transition zones, like the lower reaches of tidal rivers, where interpretations of invertebrate community composition are often problematic and confounded by natural differences in species composition and abundance between sites.

This report describes the results of a test/demonstration of the use of wood decomposition rates as a functional indicator of river ecosystem health in the lower reaches of the Hokitika River in the vicinity of a dairy effluent discharge. Monitoring of invertebrate community composition and periphyton growth is regularly conducted above and below this discharge (Crowe 2005; Olsen 2006). However, the results of these monitoring efforts are sometimes difficult to interpret due to tidal fluctuations influencing the river just downstream of the discharge, thus making it hard to separate any effects of the discharge from effects associated with tidal fluctuations. Therefore, this site was considered a good test to determine if wood decomposition rates could help to overcome some of these difficulties. This work was funded by a small Envirolink grant (WCRC11).

2. METHODS

Four sets of birchwood coffee stirrer sticks were deployed at three sites along a side-arm of the Hokitika River (Figure 1). The wooden sticks were prepared, deployed and processed according to the protocol listed in Young *et al.* (2006). Two three-month deployments were made to represent the period when the factory was discharging little effluent (off-season - July to November) and the period when the factory was in full production mode (production season - November to February). A temperature logger was deployed at the upstream site throughout the study and recorded water temperatures every hour.

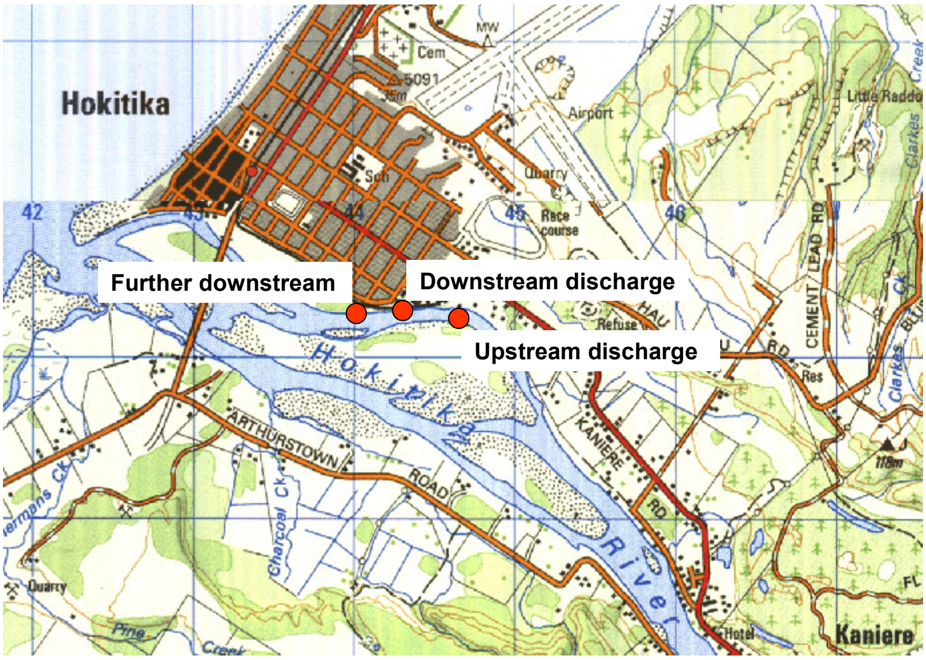

Figure 1. Location of the stick deployment sites on the Hokitika River.

Decomposition was reported as the % mass remaining after the deployment period (Young *et al.* 2006). Any differences in decomposition among the three sites were assessed using one-way ANOVA for each season. Data based on percentages were arcsine transformed before analysis. Decomposition rates are closely linked to water temperature (Webster & Benfield 1986). Therefore, comparisons of decay rates between the production season and off-season were made using exponential decay rates calculated using degree days rather than days as the time variable. The number of degree days was determined by multiplying the number of days of deployment by the average temperature during the deployment period. For example, if the average water temperature over a five day deployment period was 12°C then 60 degree days would have been accumulated. A 2-way ANOVA using site and season as factors was used to analyse the temperature-corrected decay rates.

3. RESULTS AND DISCUSSION

All groups of sticks were retrieved successfully after the off-season period, while two sets of sticks were lost during the production season period. The relatively low number of lost sticks was quite an achievement considering the size and flow variability of the Hokitika River and demonstrates that this technique is feasible in rivers of this size. After the production season deployment, all sticks at the upstream site were clear of obstructions and fully exposed to the current. Unfortunately, the three sets of sticks that were retrieved from just downstream of the discharge were buried by sediment, which may have affected the decay rates.

During the off-season (July - November) there was no significant difference in wood decomposition rates among the sites (Figure 2). This was expected since only a few minor discharges of effluent from the dairy factory were expected during this period. However, there were residual droplets of milk fat observed among the riverbed substrate downstream of the discharge in July when the sticks were initially deployed. Therefore, the off-season certainly doesn't constitute a perfect experimental control.

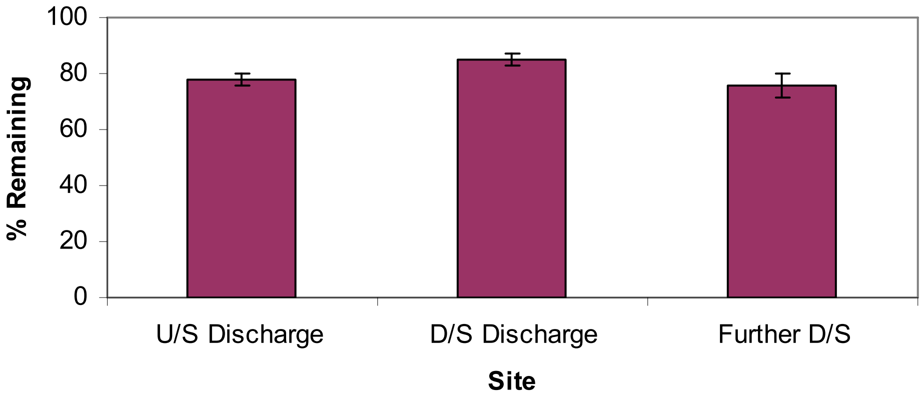

Figure 2. The percentage of mass remaining for wooden sticks deployed in the Hokitika River during the off-season (July - November) for the dairy factory.

During the production season, wood decay rates just downstream of the discharge were lower than that observed upstream or further downstream (Figure 3). Milk factory wastes may support an active microbial community downstream of the discharge point, which were expected to result in faster wood decay (Pascoal *et al.* 2003). However, the opposite trend was observed with slower wood decomposition downstream of the discharge.

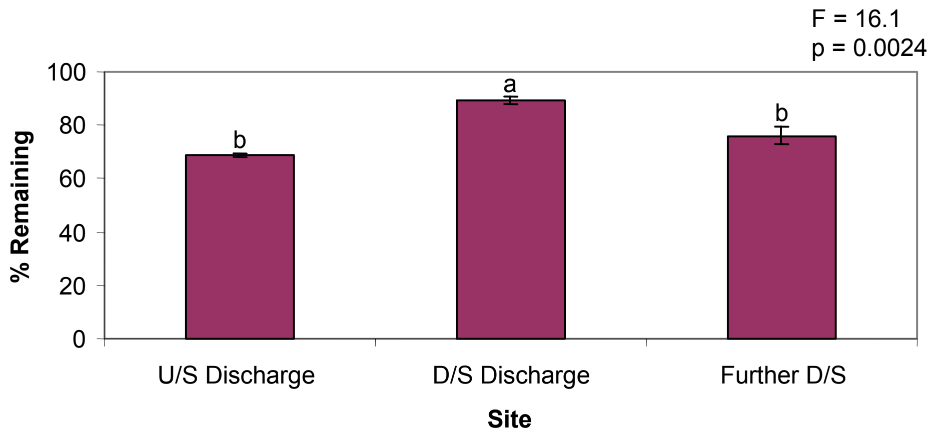

Figure 3. The percentage of mass remaining for wooden sticks deployed in the Hokitika River during the production season (November - February) for the dairy factory.

Considering all the data together after temperature compensation, there were no consistent differences in decomposition rates between production season and off-season periods (Figure 4, 2-way ANOVA, F = 0.239, p = 0.63). However, there was a significant difference among the sites with decomposition rates at the site just downstream of the discharge consistently lower than the other two sites (Figure 4, 2-way ANOVA, F = 7.15, p < 0.01). There was no significant interaction between season and site in this analysis (Figure 4, 2-way ANOVA, F = 1.96, p = 0.17), which was unexpected considering the results of the 1-way ANOVA conducted on the production season data mentioned above. This suggests that inherent differences among sites were larger than any effect occurring just downstream of the discharge during the production season.

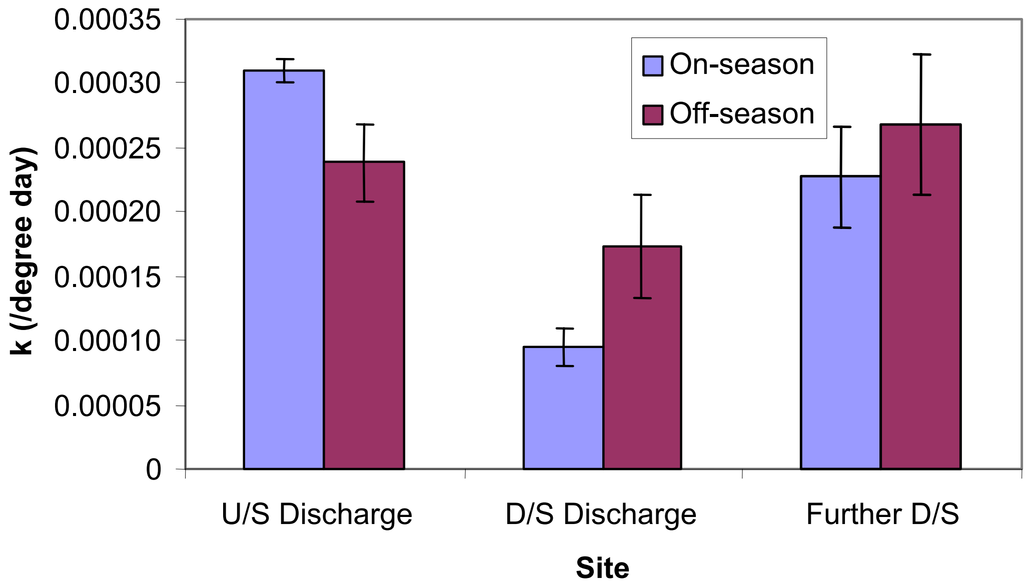

Figure 4. Temperature corrected decay rates for wooden sticks deployed in the Hokitika River during the production season (on-season) and off-season periods for the dairy factory.

Stick burial is the most likely explanation for the slower decomposition rates just downstream of the discharge during the production season period. Burial beneath fine sediment generally decreases organic matter decay rates (Meyer 1980; Rader *et al.* 1994; Niyogi *et al.* 2003), although some recent studies have showed the opposite effect (Christoph Matthaei, University of Otago, pers. comm.). Decomposition rates at the site further downstream were not affected by stick burial and were equivalent to that upstream, which provides support for the theory that stick burial rather than the discharge was responsible for the slower decomposition. It is difficult to predict where burial might occur when deploying sticks, but the best approach to avoid this happening would be to try and cover a wide range of microhabitats so that at least some of the sticks will remain unburied. Alternatively, sticks could be deliberately buried at all sites and thus measuring microbial activity within the riverbed substrate.

An alternative explanation for the slower decomposition downstream of the discharge relates to differences in the composition of the microbial community. Milk factory discharges are likely to contain fats and simple sugars that can be metabolised relatively easily, compared to the lignin and complex carbohydrates found in wood. Bacteria would be expected to be the main component of the microbial community responding to the factory discharge, whereas fungi are more suited to wood processing (Tank & Winterbourn 1995, 1996). Therefore, it is possible that the microbial community downstream of the effluent discharge was less capable of, or less inclined to, process wood than the community upstream because of the abundant sources of easily metabolised organic matter from the discharge. However, this second explanation doesn't account for the return to 'background' decomposition rates just a few hundred metres further downstream of the discharge and thus seems unlikely.

It appears that wood decomposition is affected by site-specific habitat factors, such as sediment deposition, and so doesn't overcome the issues that are faced by invertebrate community analysis. Nevertheless, this method does provide insight into aspects of river ecosystem health that are not considered if invertebrate samples alone are measured. Wood decomposition should be considered as a tool alongside others for assessing river ecosystem health, especially if effects on microbial community activity are suspected.

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