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Woody Debris in Pumice-bed Streams -
how long does it last and its use by aquatic insects

Brenda Baillie, Kevin Collier[1] and Jane Halliday[1]

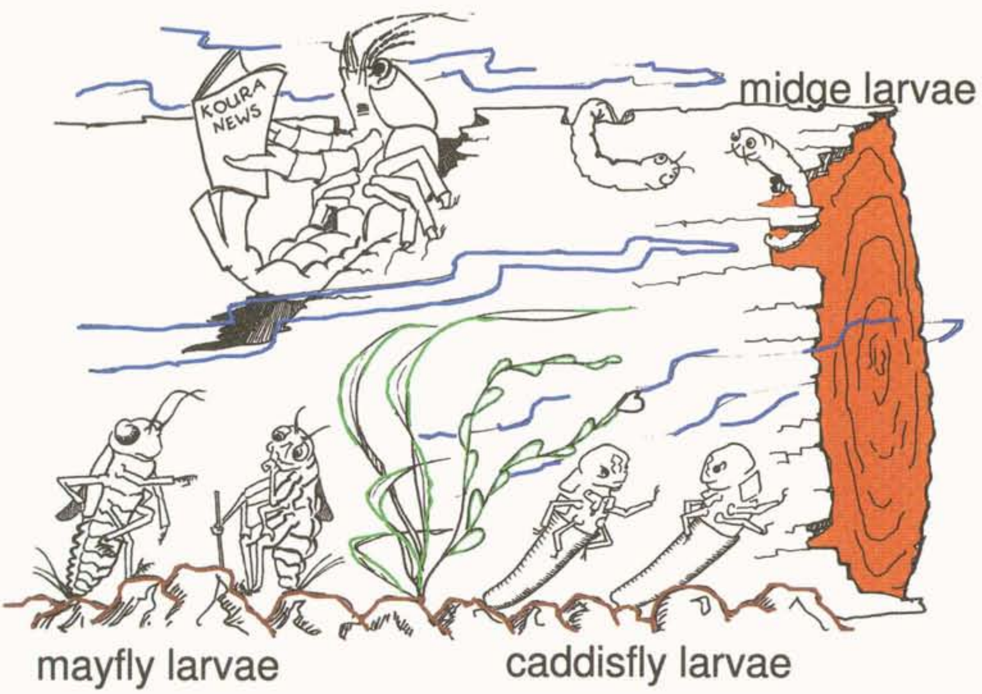

Figure 1 - Large woody debris provides a habitat for aquatic insects and other aquatic animals

Summary

- In the central North Island, streams are predominantly spring-fed with a stable flow. The small light material in these streambeds (mainly pumice sands and gravels) is very mobile.
- Aquatic insect numbers are generally low in pumice-bed streams as there is little stable substrate for the animals to live on.
- Large woody pine debris greater than 10 cm in diameter (LWD) from harvesting was still present in these streams 19 years after harvesting and is likely that some would remain in the stream channel for a full rotation (approximately 25 years).
- LWD from harvesting provides a stable long-term substrate and a food source for many aquatic insects. Aquatic insect numbers were higher on the LWD than on the pumice streambed, increasing the overall abundance of life in the stream.

[1] National Institute of Water and Atmospheric Research Limited, P.O. Box 11-115, Hamilton

Liro Forestry Solutions
Private Bag 3020, Rotorua, New Zealand
Telephone: +64 7 348 7168 Facsimile: +64 7 346 2886
Email: brenda.baillie@fri.cri.nz

Introduction

Much has been written about the importance of large woody debris (LWD) to the channel morphology and ecology of forested streams (Keller and Swanson, 1979; Mosley, 1981; Harmon et al., 1986; Sedell et al., 1988). Most of this information is based on indigenous forests, where woody debris in the stream channel is sourced predominantly from windthrow, bank collapses and earthflows (Swanson et al., 1976). In indigenous forests, these processes occur at natural rates.

The cyclical nature of wood management in pine plantations results in intermittent inputs of woody debris into the stream ecosystem. Most of the woody debris enters the stream channel during harvesting (Collier et al., 1998). Some additional woody debris enters the stream channel from thinning operations and windthrow, particularly in mature stands prior to harvesting. It is the input at harvesting, which is likely to have the most significant and long lasting effect on the stream ecosystem. As a result, most of the studies on stream ecosystems in pine plantations have focused on the harvesting phase of the rotation, usually to determine whether harvesting operations are causing any adverse effects.

The purpose of this study was to expand beyond the immediacy of the harvesting operation, to determine how long LWD lasts in the stream channel and the effect it has on aquatic insects.

The central North Island was chosen for the study because these streams are predominantly spring-fed and are relatively stable (Figure 2). Wood from harvesting was likely to remain in the stream channel, rather than being swept away in floods. To estimate how long LWD lasts in the stream channel, wood samples were collected from 13 stream sites in radiata pine stands, covering a time range of one to 19 years since harvest. Table 1 describes the characteristics of the sites sampled.

Site No	Years since harvest	Water temp (°C)	Dissolved oxgyen* ($g.m^{-3}$, (%))	Conductivity** ($\mu S.cm^{-1}$ @ 25°C)	Mean depth (m)	Mean width (m)
1	1	11.7	7.27 (67.1)	74.1	ND	1.14
2	1	11.7	9.70 (90.1)	78.2	0.29	1.05
3	3	11.9	9.44 (87.4)	82.0	0.25	1.05
4	5	11.8	10.10 (93.3)	63.4	0.65	1.96
5	6	10.8	10.40 (94.0)	82.0	0.74	3.30
6	10	11.7	10.49 (96.6)	72.9	0.50	1.92
7	10	11.2	10.20 (93.0)	50.7	0.62	2.07
8	11	12.6	10.25 (95.8)	60.9	0.28	1.40
9	11	13.5	10.20 (96.2)	67.6	0.30	1.51
10	12	13.8	10.15 (97.9)	89.4	0.41	2.88
11	17	10.8	10.54 (94.6)	53.3	0.41	1.42
12	18	11.3	9.41 (95.0)	83.6	0.61	4.50
13	19	11.8	8.80 (90.7)	65.1	0.35	1.33

Table 1 - Characteristics of the stream sites at sampling. Measurements were taken in November/December except for Site 1 which was measured in February. ND = no data.

* The amount of oxygen dissolved in the water; dissolved oxygen saturation of 80% recommended for fish spawning (3rd schedule of Resource Management Act, 1991), below 5-6 $g.m^{-3}$ is considered adverse for some sensitive fish species.

** Conductivity measures the ability of the water to conduct an electrical current and is affected by water temperature and the concentration of dissolved ions. It is sometimes used as an indicator of nutrient levels. The average conductivity measured in 96 New Zealand rivers was 100 $\mu S.cm^{-1}$ (Close and Davies-Colley, 1990)

Figure 2 - A typical spring-fed pumice-bed stream in the central North Island

At each site, (except one site where LWD was scarce in the stream channel) 50 pieces of LWD encountered in the stream channel were measured for decay rate, orientation to stream flow and diameter. This was repeated for 50 pieces of wood along the banks of the streams to compare the decay rate of LWD in-stream with decay rates of LWD on land. The decay scale used was adapted from the decay grades in AWPA (1997) and is described Table 2.

Scale	Description
1	sound
2	slight decay (up to 3%)
3	lightly established decay (3-10%)
4	well established decay (10-30%)
5	established and deepening decay (30-50%)
6	severe decay (50-70%)
7	failure (breaks under pressure)

Table 2 - Decay scale used to determine decay rates of LWD

At each site, aquatic insects were collected from five pieces of LWD in the stream channel and each piece of wood was measured for diameter, depth below the water surface and decay rate. The percentage of wood circumference sampled was estimated so that numbers of invertebrates could be expressed per m^2 of wood surface. Five samples of aquatic insects were also taken from the streambed, using a Surber net, adjacent to the wood sampling locations, to compare aquatic insect communities on the two substrates.

How long does the LWD from harvesting last in the stream?

Figure 3 compares the average decay rate of harvested LWD in-stream to the decay rates of LWD on land. Thinnings were excluded from this analysis. Site 7 was also excluded as large amounts of windthrow made it difficult to distinguish the harvesting material. After 19 years, LWD was still present in the stream channel and it is likely that some LWD would still remain 25 years after harvest (average rotation length).

Decay rates were faster on land than in water. LWD on land was severely decayed (average decay score 6) approximately 13 years after harvest. Decay rates on land are faster because there is more oxygen available for microbes, warmer temperatures, and a greater variety and diversity of fungi and insect communities to break the material down. Conversely, in the water, oxygen levels and temperatures are lower, and wood eating insect communities are less diverse (Sedell et al., 1988).

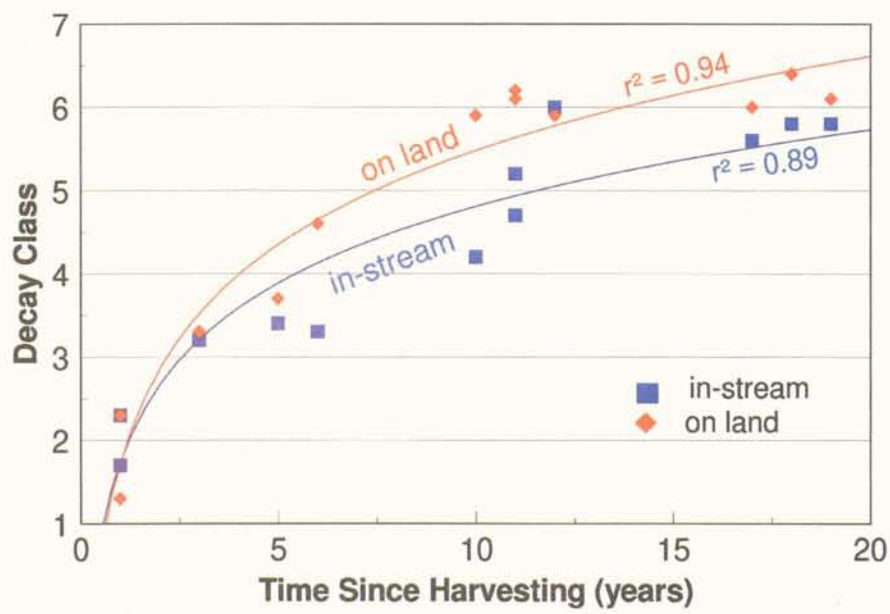

Figure 3 - Decay scores of LWD in-stream and on land against time since harvesting (lines indicate line of best fit)

What did the aquatic insects think of it all?

Most aquatic insects prefer coarse gravel and cobble substrates rather than the smaller gravels and sands (Jowett et al., 1991). The larger substrates provide them with a habitat to live on, shelter from predators and floods, and a place to find food (algae, detritus, each other). Pumice-bed streams have sand and fine gravel substrates which are very mobile and do not provide an ideal habitat for aquatic insects. In this study, LWD provided an important stable substrate for the aquatic insects, as well as a source of food for some. The numbers of aquatic insects on submerged LWD were significantly higher than the numbers on the streambed. Mayflies, caddisflies and midge larvae were most common on the wood (Figure 1), whereas caddisflies were relatively uncommon on the streambed. Many of the caddisflies on the LWD belonged to one species which fed extensively on wood in laboratory feeding experiments.

The influence of wood on the aquatic insect community changes as the wood decays (Figure 4). When the wood is fresh, the main aquatic insects attracted to the wood appear to be those that feed on the fungi, bacteria and algae that initially colonise the wood. In this study, midge larvae were most common on fresh wood, followed by grazing and collecting mayflies. As the fungi soften the wood and the decay advances, the wood-eaters move in; most prevalent were a common species of cased caddisfly. Over time, holes develop in the wood to provide a habitat and refuge for a range of other aquatic animals (Figures 1 and 4) including a filter feeding mayfly, the carnivorous toe-biter and the native koura.

Implications for woody debris management in streams

Woody debris is often thought of in negative terms, potentially blocking fish passage, forming debris dams which can be swept downstream during floods and reducing water quality. However, woody debris impacts are not always negative, and LWD in particular, can play an important role in stable forested stream ecosystems. The impact of woody debris on the stream ecosystem at harvesting needs to be kept in perspective with its impact over the whole rotation.

This study has shown that in pumice-bed streams with a stable flow, woody debris can benefit aquatic insect density. The study also showed that the harvest material is likely to maintain this benefit over a whole rotation period as there was still residual harvesting material in the streams 19 years after harvest.

However, management of streams is site specific, depending on factors such as local geology, climate and in-stream and downstream values. Streams that are flood prone and already have a cobble substrate may not derive the same benefits from woody debris in the stream, and this debris is a risk factor which needs to be managed accordingly. However, in stable spring-fed streams with pumice beds, retention of moderate amounts of LWD has the potential to improve habitat diversity and numbers of aquatic insects in the stream ecosystem in the long term. This needs to be kept in perspective with possible short term effects where large volumes of wood entering the stream at harvesting, may cause a drop in dissolved oxygen levels (Collier et al., 1998).

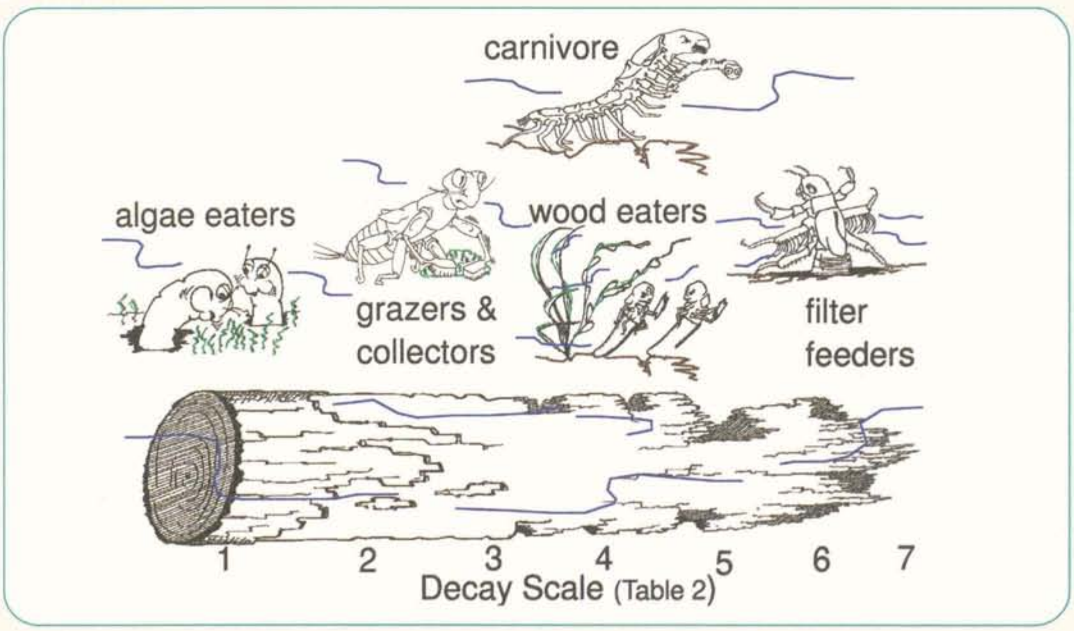

Figure 4 - Changes in the aquatic insect community as LWD decays

Acknowledgments

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