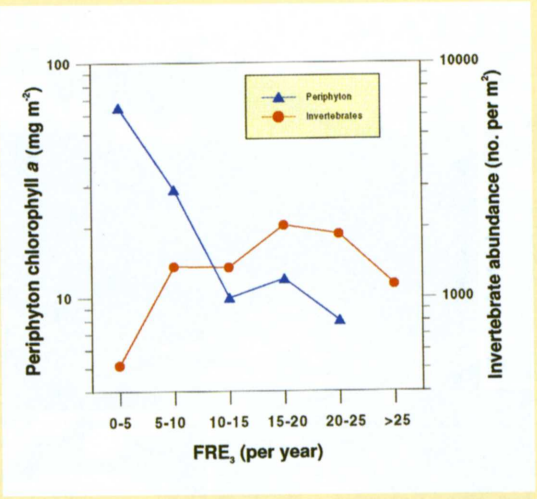

Figure 2. Geometric means of periphyton biomass and invertebrate abundance in 83 rivers classified according to the flood frequency FRE_3 where a flood is defined as flows higher than three times the median flow.

factors such as whether the substrate is cobbly or silty, and levels of nutrient concentrations. However, FRE_3 does indicate some trends.

Figure 2 shows the geometric means of periphyton biomass and invertebrate abundance found in the 83 study rivers with FRE_3 in six classes (0–5, 5–10, 10–15, 15–20, 20–25, >25 floods per year). The figure shows that as the number of floods per year increases, periphyton chlorophyll *a* decreases. This means that there is a high chance of finding more periphyton in rivers with fewer floods. However, for invertebrates, numbers tend to increase with FRE_3 up to 15–20 floods per year, but decrease for higher values.

Our study showed that not only did periphyton biomass decrease with increasing FRE_3, but also the taxonomic richness and diversity of periphyton decreased significantly. For invertebrates it was less clear how taxonomic richness and diversity varied with changing FRE_3. These were more related to the average flow conditions, for example the median flow.

The conclusion was that FRE_3 is the most useful of the 35 flow variables for classifying rivers according to habitat for benthic biota. It explained 20% of the variance of periphyton biomass, richness and diversity, and invertebrate abundance.

We suggest that FRE_3 can be used as a basis for interrogating flow records by using the following procedure:

- Obtain daily flow data from the site and period of interest.
- Calculate the median value and multiply it by three.
- Count how many times the flow exceeds this value and divide by the number of years in the period. This value is the FRE_3.
- Place the river in one of the six categories of flood frequency then read off from Figure 2 whether it is likely to have high or low biomass/abundance of benthic biota. ■

Bente Clausen carried out this study under the NIWA post-doctoral scholarship scheme; she is based at Aarhus University, Denmark. Barry Biggs is based at NIWA in Christchurch.

Chewing up the woody debris: enzymes for all seasons

Christopher Hickey
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Studies of enzyme activity are helping us to understand how organic matter is processed in streams.

YOU MAY HAVE SEEN THEM on television advertisements ... colourful little spheres with huge mouths munching out those "impossible" stains. Chances are your laundry contains one of the numerous enzyme-containing detergents. The reason those enzymes are so good is that they work on such a wide range of organic muck and they do it at room temperature.

Have you ever stopped to think of what happens to all the organic debris produced by plants (e.g., grass, leaves, wood) going into the environment? Well, the enzymes produced by microorganisms, primarily bacteria and fungi, are responsible for the breakdown and natural recycling of most of that organic matter. In turn, the microorganisms that grow on the simple organic compounds produced by enzymatic breakdown form the basis of the food chain to support invertebrates and higher consumers.

We have been using enzyme "fingerprints" to trace the basis of organic matter processing in streams.

The principle of this technique is to deduce what types of compounds are important to stream microbes by comparing the activities of a suite of enzymes associated with microbial communities exposed to differing environmental conditions.

The microbial communities studied are those living in "biofilms" – the often slimy layer of living material attached to the rocky streambed or attached to decaying vegetation. These sessile organisms adapt their individual metabolism and community structure to their food sources from either the overlying flowing water or the adjacent vegetation. While they are responsible for the production of thousands of enzymes, only a few specific enzymes digest food compounds such as carbohydrates and proteins. Specific reagents are commercially available to measure the metabolic activity of a wide range of enzymes. Many have been used for studying environmental processes, largely litter decay in soil. Some of these reagents were chosen for this preliminary study (see panel). The measurement process involves either incubation of whole rocks, or homogenisation of leaf material, with enzyme substrates.

We have investigated biofilms from streams draining catchments having different vegetation cover – pasture, pine and native bush. The results have been encouraging. Measurable activity has been present for each of the enzyme groups and