Changes in macroinvertebrate communities following timber harvest

E. Wilkerson and J.M. Hagan

Manomet Center for Conservation Sciences, 14 Maine St., Brunswick, ME 04011, 207-721-9040

Introduction

Headwater streams can account for 65-75 percent of the cumulative length of all stream and river channels in a watershed (Leopold et al 1964). Nevertheless, small headwater streams have often escaped both scientific research and regulatory scrutiny.

In Maine, streams draining watersheds of less than 300 acres have no buffer or shade requirements under state law (Maine Department of Conservation 1999). Our study was conducted to better understand small headwater streams and their sensitivity to biological following commercial timber harvest.

Methods

Design: Before and after controlled experiment

Experimental Units: 15 headwater streams draining watersheds with mature closed-canopy cover forest (>85%) at least 15 m tall forest were located in the industrial forests of western Maine.

Experimental Treatments: In the fall/winter of 2001, 200m x 300m blocks of forest on both sides of the study streams were harvested to the following specifications:

0m buffer: clearcut harvest zone (<6.8m^2/hectare residual basal area) without retention buffers

11m buffer: clearcut harvest zone with 11m buffers on both sides of stream

23m treatment: clearcut harvest zone with 23m buffers on both sides of stream

Partial Harvest: selectively cut harvest zone (> 13.7 m^2/hectare residual basal area) without specified buffers

Control: no harvest

Figure 1 Harvest Layout

Results

- At the lower boundary of the harvest zone (100-m station, Figure 1), macroinvertebrate communities were dominated by the order Diptera in all treatment groups (Figure 2). There were no statistical differences (α<0.05) in relative abundance among treatment groups.
- A CCA analysis showed that macroinvertebrate community structure was statistically related to environmental variables collected from the study streams (p=0.01). The strength of correlations between environmental variables and CCA axes are shown in Table 1. Axis 1 was strongly related to stream temperature (R^2=0.94) while axis 2 was related to variables describing water depth (R^2=0.64) and flow regime (R^2=0.64).
- Comparison of macroinvertebrate community structure between harvested and unharvested portions of a single stream showed variability along axis 1 and axis 2 (Figure 3). Differences in community structure along axis 1 (stream temperature) were largest in the 0-m treatment group (p=0.05), while differences along axis 2 (water depth/flow regime) did not vary significantly among treatment groups (p=0.15).
- At the 100-m station (Figure 1), post-harvest temperature increased 2.7-3.4^{o}C in the 0-m treatment group (Figure 4). Based on the CCA analysis, it appears this magnitude of temperature change can alter macroinvertebrate community composition.

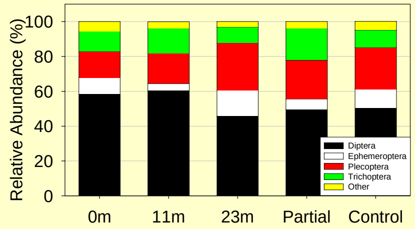

Figure 2 Relative abundance of macroinvertebrate orders at the 100-m station in the first two years following the timber harvest (2002-2003). Years were combined because of statistical similarity between samples collected in 2002 and 2003.

Table 1 Environmental variables used in the CCA analysis of macroinvertebrate communities.

Variable	Axis 1	Axis 2
Percentage of rock bag covered with water	0.310	0.636
Diurnal flux	0.476	0.217
Gradient	-0.026	-0.583
Mean Weekly Maximum stream temperature	0.943	0.074
Percentage of days with flowing water	0.027	0.636
Turbidity	0.175	0.388

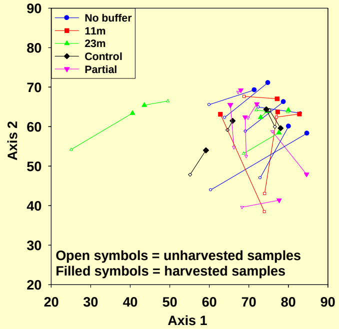

Figure 3. CCA ordination of streams for macroinvertebrate community data in the first and second post-harvest years (2002 and 2003).

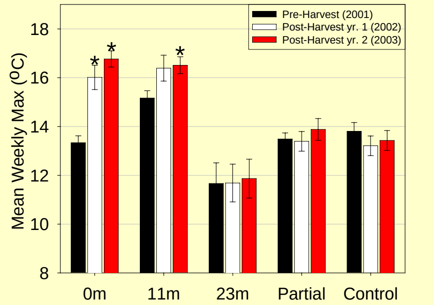

Figure 4 Average stream temperature at the 100-m station in the pre-harvest year (2001) and two post-harvest years (2002-2003). An asterisk indicates a significant (α<0.05) difference from the pre-harvest value.

Discussion

- The macroinvertebrate community was dominated by the order Diptera. Taxa in the order Diptera are less sensitive to stresses including habitat and flow modification than other orders (VT DEC 2003) and therefore may not be sensitive to observed post-harvest temperature increases.
- Stream temperature was strongly related to macroinvertebrate community composition. Aquatic organisms have adapted to living in systems within a particular temperature range in which survival and fitness are optimized (Vannote and Sweeney 1980).
- In the 0-m treatment group, significant temperature increases were observed following the timber harvest. Increases in stream temperature has been shown to alter the life history and ecology of macroinvertebrates (Murphy et al. 1981). This suggests that the 2.7-3.4^{o}C post-harvest increase in temperature may alter macroinvertebrate communities within the harvest zone.

Conclusions

- Macroinvertebrate communities of headwater streams in Maine are dominated by the order Diptera.
- Macroinvertebrate community structure is influenced by stream temperature, water depth, and flow regime.
- Harvesting without buffers results in significant increases in stream temperature and alteration of macroinvertebrate community structure within the harvest zone.

References

Leopold, L.B., M.G. Wolman, and J.P. Miller. 1964. Fluvial processes in geomorphology. Wlt. Freeman, S.F. pp:134-150.

Maine Department of Conservation. 1999. The state of the forest and forest sustainability standards: final report to the joint standing committee of the 119th legislature on agriculture, conservation, and forestry. Maine Department of Conservation. Augusta, ME 39pp.

Murphy, M. 1998. Primary production. Pages 114-168 in R.J. Naiman and R.E. Bilby (editors). River ecology and management. Springer-Verlag, New York.

Vannote, R.L. and B.W. Sweeney. 1980. Geographic analysis of thermal equilibrium: A conceptual model for evaluating the effect of natural and modified thermal regimes on aquatic insect communities. Am. Nat. 115(5):667-695.

Vermont Department of Environmental Conservation. 2003. Methods for determining aquatic life use status in selected wadeable streams pursuant to applicable water quality management objectives and criteria for aquatic biota found in Vermont Water Quality Standards. Water Quality Division, Biomonitoring and Aquatic Studies Section, Waterbury, VT, 85 pp.

Project Funders: National Council of Air and Stream Improvement, Cooperative Forest Research Unit at the University of Maine, Plum Creek Timber Company, National Fish and Wildlife Foundation