AQUATIC MACROINVERTEBRATE MONITORING AT THE VERMONT FOREST ECOSYSTEM MONITORING RESEARCH SITE UNDERHILL, VERMONT

by the
Vermont Department of Environmental Conservation

Summary

Aquatic macroinvertebrates have been sampled by the Vermont Department of Environmental Conservation at two sites in the upper Brown's River drainage basin using standardized sampling methods. 1996 marked the sixth year of sampling. Samples are collected once annually during the fall period. Long-term sampling is undertaken at these sites, which are essentially unimpacted by land-based human activity, in order to gather data describing the natural variability of macroinvertbrate communities from year to year. Data show that macroinvertbrate community characteristics show considerable variability between years and that natural forces exert a great deal of influence on those measures of variability. This report describes sampling methods in some detail and some observations are made from the data collected over the past six years.

INTRODUCTION:

The Vermont Department of Environmental Conservation (DEC) maintains a Statewide biological monitoring program which samples aquatic biological communities in rivers and streams at 50-70 sites annually. There is a core of sites that are sampled every year during the late summer/fall period for the purpose of evaluating temporal variability and tracking long-term trends in biological integrity at those sites. Other sites are sampled for the purpose of making site-specific water quality evaluations related to the effects of watershed disturbance. In 1991, DEC initiated sampling at two sites at the Vermont Forest Ecosystem Monitoring (VForEM) research area in Underhill, on the western slope of Mt. Mansfield. These two sites, located on the Browns River and Stevensville Brook, have been sampled every fall since 1991. This report will discuss some observations related to temporal variability in aquatic macroinvertebrate communities at these two sites.

BACKGROUND

The two sites are located in the upper reaches of the Brown's River watershed - one on Stevensville Brook and one on the Brown's River upstream of its confluence with Stevensville Brook. Both sampling sites are located at an elevation of 1400 feet. The Stevensville Brook site is located about 50 m above the bridge at the parking lot for the Nebraska Notch trail and drains approximately 5.2 km^2 of forested watershed. The Brown's River site is located about 100 m

above the last bridge before the State park gate and drains approximately 6.1 km^2 of forested watershed. Physical characteristics of the two sites are very similar: stream substrate composition is similar with 35% boulder, 30% cobble, 20% course gravel, 10% gravel, and 5% sand; canopy cover (shading) is approximately 80% at both sites; sampling depth averages 0.2 m at both sites.

METHODS

All field methods used to collect aquatic macroinvertebrates for this project are documented in the Vermont Department of Environmental Conservation Field Methods Manual (DEC, 1989). All macroinvertebrate samples are collected during the late-Summer, early-Fall index period, from September to mid-October. A two-person field crew selects a representative stream section in the area to be sampled. The preferred habitat if present is "riffle". Physical characteristics recorded at the selected site include: stream width, depth, water velocity, water temperature, specific conductance, weather conditions, substrate composition, substrate embeddedness (riffle sites only), canopy cover, stream bank condition and immediate upstream land use. All data are entered onto a field sheet with appropriate site and sampling event identifiers, along with additional comments that may be pertinent to the site evaluation. A water sample is collected for pH and alkalinity determination and placed on ice for return to the laboratory.

Samples are collected using an 18 inch wide x 12 inch high D-frame net with a 500 u mesh size. One person operates the net while the second operates a stop watch. The net is placed in the riffle at an appropriate location and an area immediately upstream of the net is thoroughly disturbed by hand, ensuring that all pieces of substrate are moved and rubbed clean of attached organisms. Moving up-stream, this is repeated at 4-5 different locations within the riffle, representing a range of velocity and substrate type characteristic of that riffle. Actual sampling activity, ie substrate disturbance, is timed with the stop watch. Each specific location is actively sampled for about 30 seconds, and active sampling is terminated at the end of two minutes. Time spent relocating to a new location within the riffle is not counted as part of the two minutes. The contents of the net are washed into a quart mason jar and preserved with 75% ethanol. The process is repeated, being careful to avoid areas previously disturbed. This "composite" sampling methodology effectively collects samples representative of the macroinvertebrate community of that riffle [1]. This sampling protocol is most comparable to the riffle/run sampling portion of Rapid Bioassessment Protocol III (RBPIII) as described in Plafkin et al, 1989.

All methods used to process aquatic macroinvertebrate samples for this project are documented in the Vermont Department of Environmental Conservation Field Methods Manual

---

[1] This sampling methodology is nominally identified as a kick net sample. This is technically a mis-nomer as no "kicking" is actually done. All substrate manipulation is done by hand. It is our opinion that this method of substrate manipulation, combined with the moving to different locations within the riffle, increases the representativeness of the sample and the precision of the sampling method. Sampling effort is extremely reproducible. It has been our experience that it is very unusual for the percent standard error of total organism abundance and taxa richness estimates using this methodology (combined with associated sample processing methods) to exceed 40% and 20% respectively. Data precision will be discussed separately.

(DEC, 1989). All sample processing is done in a laboratory setting. Processing includes picking organisms from the sample, sorting organisms into taxonomic groups, identifying organisms to lowest possible taxonomic level, and entering data into the data management system.

An entire sample is thoroughly washed through a 30-mesh (560 micron) brass sieve. The sample is then backwashed into a 12 x 18 inch white enamel tray that has been marked so as to delineate 24 numbered equal squares. The sample is spread evenly over the tray surface. A random number between 1 and 24 is selected and picking is started on that tray square. All organisms are removed from that square. Picking continues into subsequently numbered squares until a minimum of six squares (25 percent of the sample) have been picked. If less than 300 organisms have been picked at this point, picking continues until a total of 300 organisms have been removed or the entire sample has been picked, whichever comes first. Sub-sampling details are recorded on bench sheets. Removed organisms are sorted to order and placed in appropriately labeled vials in alcohol for further identification. If the sample has not been totally picked, the remaining sample is qualitatively examined for Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa not found in the sub-sample. Organisms are removed, labeled, and stored separately from the sub-sampled organisms.[2]

All organisms are subsequently identified to the lowest practicable taxonomic level by staff specializing in specific order taxonomy. Identifications are recorded on laboratory bench sheets. Raw counts and sub-sampling details are entered into the PARADOX data management system. The data management system normalizes all abundance data to a standard sampling effort to account for variations in sub-sampling procedures. The data management system uses scripts to calculate and report out the mean percent composition and density of all taxa, the standard error (based on the minimum of two replicates) of all taxon abundance estimates, the functional group percent composition, and a wide range of community biometrics for each sampling event in a sample summary report. Taxa richness is manually adjusted for each sample to account for differing levels of taxonomic identification within a sample[3]. The biometrics are electronically transferred to a macroinvertebrate metrics data table and the adjusted taxa richness values are inserted. From this table a site summary report is generated, which includes all sampling events from a site over time.

The following practices provide a means of evaluating the precision, accuracy, comparability, and representativeness of the macroinvertebrate data used in this project. These activities are documented in"Vermont DEC Ambient Biomonitoring Activities - Work/QA

---

[2] Organisms removed from the sample as part of the EPT scan are not used in subsequent calculations of organism abundance or associated metrics calculated from abundance estimates. They are used in calculations of taxonomic richness and the family of metrics derived from measures of taxonomic rishness.

[3] For example, the taxonomic bench sheet may list *Baetis tricaudata* and *Baetis* immature. The management system script will count two taxa when calculating taxa richness, whereas it is more likely that the immature organisms are of the same taxon as the identified species; counting two species would overestimate the real taxonomic richness. We haven't figured out how to make this correction electronically yet as some judgement is required.

Project Plan" (DEC, 1994).

- Precision is determined by field replication. All samples are collected, at a minimum, in duplicate. The mean of replicate samples is the value used for incorporation into the working data base. Samples with a relative standard error (RSE) of greater than 40% for abundance estimates and 20% for taxa richness are eliminated from the data base.

- Accuracy in the field is assured through standardized sampling effort conducted by experienced aquatic biologists. All field methods used to collect aquatic macroinvertebrates for this project are documented in the Vermont Department of Environmental Conservation Field Methods Manual (DEC, 1989). In the lab, all samples picked are checked for completeness by a second biologist. Standard taxonomic keys are used for all identifications and each ID is assigned a confidence level. A reference collection of all species identified is maintained and all samples are archived in their entirety forever. ID's are corroborated in-house as well as through external experts when appropriate. A random sub-sample of completed samples are re-identified to check consistency.

- Comparability and representativeness are assured by maintaining consistent standardized sampling and processing methods, and always sampling only during the fall index period.

RESULTS AND DISCUSSION

The watersheds of these two sites are essentially undisturbed by significant human activity. The six years of data collected from these two sites present an opportunity to examine the variability in biological communities and in the various measures of community structure and function as influenced by the forces of nature. Information regarding natural variability is critical when using biological data to evaluate water quality impacts related to watershed activities. Without natural variability information, it can be difficult to determine if observed biological conditions at a particular site are a result of watershed perturbation or are within the bounds of natural variability. This report will discuss observations in temporal variability of the following measures of macroinvertebrate community structure and function, which DEC uses on a regular basis to evaluate water quality condition:

- *Relative density*: a measure of the number of organisms collected during a standardized sampling effort; density can be affected by a number of chemical, physical, and biological conditions and can be a good indicator of general trophic status.

- *Mean Taxa Richness*: a measure of the number of "species" per sample; a simple diversity indicator that is a good indicator of general biological health.

- *Percent Mayflies and Stoneflies*: these are the dominant organisms in these streams and are generally very intolerant of environmental disturbance; good indicators of general biological health.

- *Percent Shredder Functional Group*: a measure of the percent of organisms in a sample that process detrital material originating outside the stream banks (eg heterotrophic materials such as leaf litter) as their primary source of energy; a good indicator of the primary source of energy in the stream system.

Relative density at the two sites over the six years of sampling is shown in Figure 1. As can be seen, there was a considerable degree of variability from year to year in the estimate of relative density. The relative density of aquatic organisms is particularly sensitive to annual or seasonal variations in hydrological and meteorological events. Heavy precipitation and high flows can scour streams and dislodge many of the organisms less adapted to finding refuge during stressful hydrological periods. Other factors, such as temperature, level of predation, food availability, and recruitment success can strongly affect faunal density on a year to year basis. Outstanding recruitment in any given year by a particular species can influence annual estimates of faunal density. As can be seen in **Figure 1**, density ranges are within the ranges of similar sites located in different areas of the state. With the exception of 1994, macroinvertebrates have been more abundant and show greater abundance variability in the Brown's River than in Stevensville Brook. In 1992, a year of relatively high abundance for both streams, the mayfly *Baetis sp.* and the dipteran *Micropsectra sp.* were quite abundant. *Micropsectra sp.* Made up 38% of the community in Brown's River and nearly 10% in Stevensville Brook; since that time, this organism has not exceeded 1% of the community composition in either stream.

Figure 1: Macroinvertebrate Density

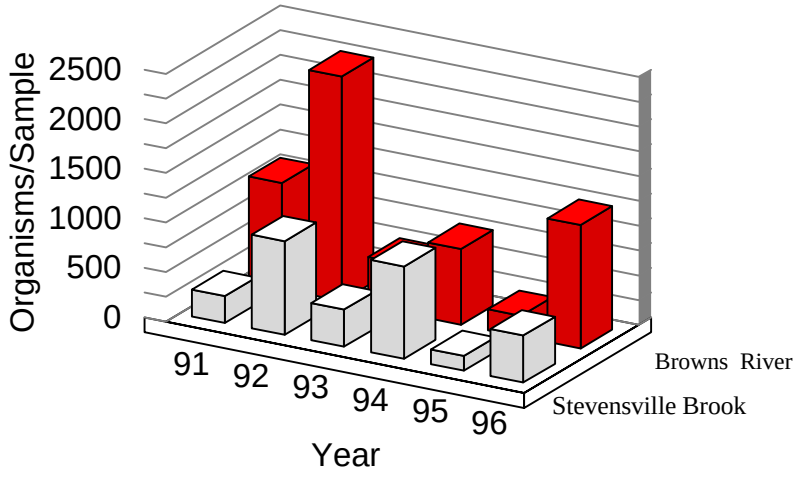


Table 1: Range of macroinvertebrate measurements at the two study sites and at a number of similar undisturbed sites statewide.

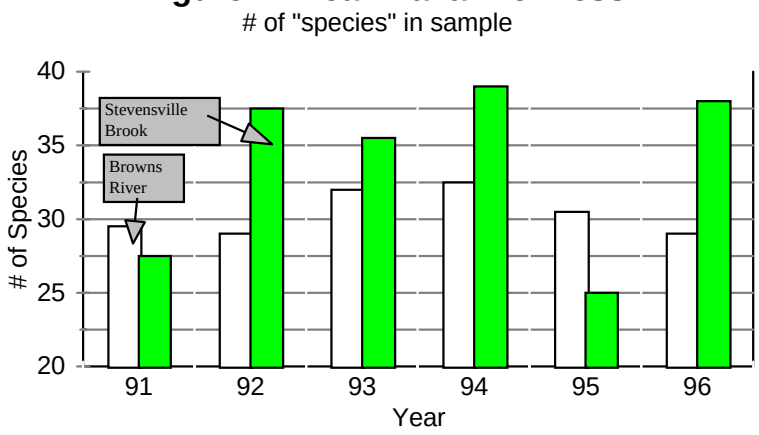
Attribute	Statewide Range	Stevensville 1991-1996	Relative Standard Deviation	Brown's 1991-1996	Relative Standard Deviation
Relative Density	100-2400	151-945	65%	208-2262	72%
Mean Taxa Richness	21-48	25-39	18%	29-32.5	6%
% Stoneflies	13-79	38-76	36%	13-55	36%
% Mayflies	0-45	1-40	123%	11-29	41%
% Shredders	3-55	20-70	45%	7-40	46%

This is a clear example of a highly successful recruitment year for a couple of species. Because these organisms feed primarily on algae, it is reasonable to conclude that at the time of sampling in 1992, there was more algal growth present than in other years. Algal populations in turbulent streams are likely to be quite ephemeral and subject to hydraulic scouring, exhibiting extreme short term variations. Fauna associated with those algal populations will be subject to the same short term variability factors, although macroinvertebrate recolonization occurs more slowly than algal recolonization.

Mean taxa richness at the two sites over the last six years is shown in **Figure 2.** Taxa richness appears to be more variable in Stevensville Brook than in the Brown's River, but is much less variable than abundance (**Table 2)**. Over the six years of sampling, nineteen taxa in Brown's River have at one time or another occurred at densities making up more than three percent of the community composition. Seven of those taxa have appeared at that level in only

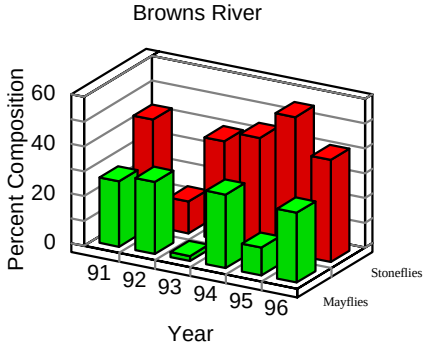
one year. Two taxa have appeared at the greater than three percent level in all six years.

Figure 2: Mean Taxa Richness



Similarly in Stevensville Brook, eighteen taxa have appeared at the three percent level, with five appearing only once at that level and three taxa at the greater than three percent level in all six years.

Figure 4: % Mayflies and Stoneflies



These two streams are dominated by mayflies and stoneflies. Recent evaluations conducted by DEC of similar streams throughout Vermont show this to be a very typical scenario for small, high elevation cold turbulent streams (**Table 1)**. **Figures 3 and 4** show the percent composition of mayflies and stoneflies at the two streams.

Figure 5: Percent Stoneflies

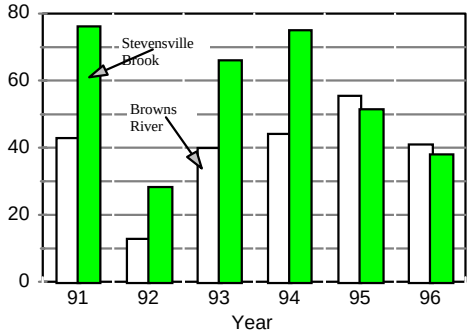
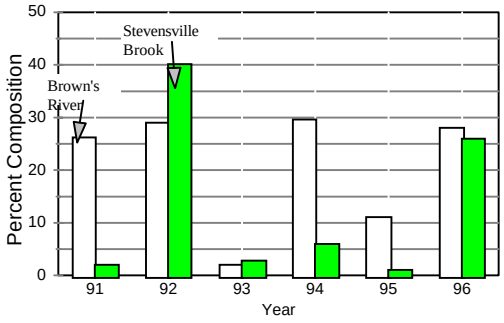
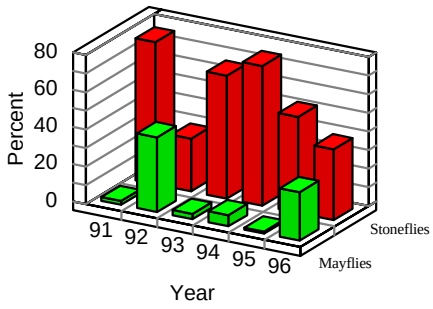


Figure 6: Percent Mayflies



1993 was a tough year for mayflies as % composition dropped sharply in both streams that year. Populations remained depressed in Stevensville Brook in subsequent years, but rebounded to previous levels in Brown's River the following year. Mayflies are a much more significant and consistent component of the Brown's River fauna than the fauna of Stevensville Brook, which is definitely a "stonefly" stream. The two orders regularly make up more than 60% of the fauna at both sites, ranging up to 80% at Stevensville Brook and 73% at Brown's River. The mayflies show somewhat greater variability between years than the stoneflies, particularly in

Figure 3: % Mayflies and Stoneflies
Stevensville Brook

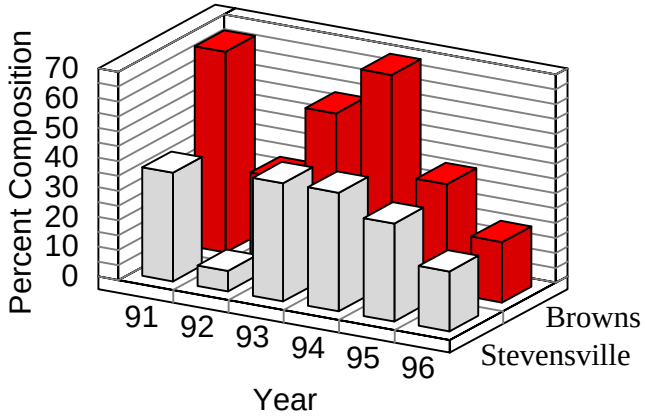


Stevensville Brook (see **Table 1**) where relative standard deviation exceeds 100%. **Figures 5 and 6** compare stonefly and mayfly percent composition across streams.

The **detrital shredder functional group** makes up a significant portion of both stream macroinvertebrate communities, although some variability between years is indicated. **Figure 7** shows the percent composition of detrital shredders in the two streams from 1991 to 1996. A dominance by

Figure 7: % Detrital Shredders

Brown's River/Stevensville Brook



detrital shredders is a general indication of the extent to which heterotrophic, rather than autotrophic energy sources dominate the aquatic food chain. Heterotrophic means that the energy source originates outside the aquatic system. An example of a heterotrophic energy source is leaf litter that falls into the stream and is consumed by detrital shredders. Autotrophic means that the primary energy for the system is derived from instream processes, an example being periphyton growth in the stream that is consumed by algal grazers. It is typical for small mountain streams to be dominated by heterotrophic processes as primary production in the stream is often limited by various chemical and physical constraints and there is usually a good supply of organic material from the watershed falling into the streams. In comparing these two streams, Stevensville Brook appears to have a more significant detrital

shredder component than the Brown's River. Stevensville is consistently dominated by the shredding *Leuctridae* and *Peltoperlidae* stoneflies and less by the algal-grazing mayflies (*Baetis spp* and *Epeorus sp*) and caddisflies (*Lepidostoma spp*) of the Brown's River. As with other measurements evaluated at these sites, the percent shredders indicate that 1992 was an unusual year, with a low percentage of shredders in both streams.

Observations of six years of macroinvertebrate monitoring data from these two streams can lead to a number of inferential conclusions regarding the character of these two streams:

- The macroinvertebrate communities of these two streams appear to be typical of similar streams throughout the state, although some of the community characteristics border on the extreme range for their stream type.

- The measured characteristics of the macroinvertebrate communities show considerable variability from year to year. Individual species show high variability in relative abundance from year to year. Because these streams are relatively unimpacted by human activity, this variability can be assumed to be due to natural causes.

- The data indicate some differences between the two streams. Stevensville appears to have a more hydraulically rigorous environment than the Brown's River. This is indicated by wider ranges in most measurements and an apparent lower level of primary production as indicated by relatively greater dominance by detrital shredders. In addition, the dominant species are those able to resist hydraulic scouring to a greater extent some of those common to the Brown's River.

The Vermont Forest Ecosystem Monitoring Research Area offers a unique opportunity to investigate the factors that influence variability in these streams and to validate the inferences that can be made from the biological data. Additional data being gathered by cooperating researchers on the site, including streamflow, stream chemistry, precipitation quantity and chemistry, the timing of leaf litter inputs to the streams, and land typing and use mapping will be integrated into further investigations regarding the forces which shape natural variability in the biological components of aquatic systems.

Acknowledgments: The staff of the Biological Monitoring and Aquatic Studies Section of the Vermont DEC - Steve Fiske, Rick Levey, Jim Kellogg, Rich Langdon, Heather Pembrook, Jessica Rykken - are responsible for the gathering and analysis of the stream monitoring data presented in this report. Much appreciated encouragement and assistance from Tim Sherbatskoy, Sandy Wilmot, and Phil Girton of VForEM.