BIOASSESSMENT METRICS AND DEPOSITED SEDIMENTS IN TRIBUTARIES OF THE CHATTOOGA RIVER WATERSHED

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Abstract. Excessive sedimentation places waters of the Chattooga River network at risk of biological impairment. Monitoring efforts could be improved by including metrics that are responsive to changes in levels of fine sediments. We sampled three habitats (riffle, depositional, bedrock outcrop) for benthic macroinvertebrates at four sites in three low-order, tributary reaches of the Chattooga River in winter and spring, 2001. We determined levels of deposited fine sediments in each sampled reach by visually estimating % surface cover. Benthic macroinvertebrate data were used to calculate five commonly used bioassessment metrics (density, richness, % EPT, NCBI, and EPT richness), which were used to assess Chattooga River waters (USEPA 1999). Of the five metrics, only % EPT was found to be significantly negatively correlated with deposited sediments.

INTRODUCTION

Elevated levels of fine, inorganic sediments within stream reaches of the Chattooga River network puts this system at risk of ecological impairment. Many stream reaches of the Chattooga River Watershed contain unnaturally high levels of fine, inorganic sediments (USEPA 1999). As part of the southern Appalachians, the Chattooga River watershed harbors a great diversity of plants and animals. The river's Wild and Scenic designation underscores the importance of maintaining the ecological integrity of its waters.

Deposited sediments most likely do not act upon benthic macroinvertebrates in the same way as organic pollution and it has recently been shown that it is possible to monitor specifically for the effects of deposited sediment (Zweig and Rabeni 2001). The objective of this paper is to present the relationship between some bioassessment metrics used to determine impairment in the Chattooga River watershed and levels of deposited, fine sediments present in tributaries of the Chattooga River watershed. The ultimate purpose of this study is to contribute to the development of effective monitoring techniques for the Chattooga River Watershed with the goal of contributing information that will help to preserve the ecological integrity of the area.

METHODS

Study sites

We sampled benthic macroinvertebrates at four sites that were chosen based upon an assessment of waters of the Chattooga River watershed (USA: GA, NC, SC) performed by the USEPA in 1999 and designations made therein. Sampling was conducted in one reference tributary, Addie Creek, and two disturbed tributaries, Roach Mill Creek and Law Ground Creek (we sampled two separate reaches on Roach Mill Creek). Disturbance is mainly attributed to elevated levels of fine sediments within stream channels (USEPA 1999).

Macroinvertebrate sampling

Sampling occurred in two seasons, winter (February 2001) and spring (April 2001). Nine benthic samples (three samples from each of three mesohabitats: depositional, riffle, bedrock outcrop) were collected from each stream reach on each sampling date. A Surber sampler was used for collection from riffle habitat, a corer was used for depositional habitat, and a knife was used to scrape samples from 100 cm^2 areas from bedrock outcrop habitats (see Huryn and Wallace 1987 for specific sampling procedures). Samples were preserved in formalin containing Phloxine B and brought back to the laboratory for further processing.

Taxonomic identification

For all samples, invertebrates were removed in the laboratory, identified to lowest possible taxonomic level (with the exception of Chironomidae, which were identified to sub-familial level) using Merritt and Cummins (1996) and Wiggins (1996), and counted.

Deposited sediment

Sediment levels and habitat proportions were calculated for each reach based upon visual estimates of deposited sediments. Sediments were characterized based on Cummins and Lauff (1968) and split into the following sizes: boulder (>256 mm, phi – 8), cobble (64-256 mm, phi – 6, – 7), pebble (64–16 mm, phi – 5, – 4), gravel (16-2mm, phi – 3, – 2, – 1), sand (<2 mm, phi 0). Each reach was divided into five meter transects and estimates of sediment proportion were made for each transect simultaneously by two investigators. Total proportion occupied by sediment types were calculated from individual transect observations after observations made by both individuals were averaged. Deposited sediments the size of sand and finer were considered as fine.

Bioassessment metrics

Five commonly used bioassessment metrics were calculated. EPT richness, percent EPT, and the North Carolina Biotic Index (NCBI, Lenat 1993) were previously determined to be sensitive to general impairment when used to analyze benthic macroinvertebrate data from waters of the Chattooga River Watershed (USEPA 1999). Two other metrics—density, and richness were included because they have been consistently reported as significantly correlated to deposited sediment (Zweig and Rabeni 2001, Angradi 1999). Richness, EPT richness and percent EPT scores are based upon total number of taxa found in all samples taken from each reach. NCBI and density results represent habitat-weighted abundances.

Statistical analysis

Proportional data sets (i.e. % reach covered by fine sediments, and % EPT) were arcsine transformed before analysis. T-tests were performed on metric results from the two sample dates and if there was no significant difference between dates (at $\alpha = .05$), results were combined for analysis. Metrics and deposited sediment levels were compared using regression analysis with a general linear model.

RESULTS

Deposited fine sediments ranged from 20% cover at the reference reach, Addie Creek, and 60% cover at Law Ground Creek. Differences in estimations made by the two investigators ranged between 0 and 7.25 % for all transects and the average difference was 2.66%.

No significant difference existed between any metric results for any stream between sample dates (at α = 0.05). Therefore, results from seasons were combined for analysis in all cases.

Only percent EPT was significantly (negatively) correlated with deposited sediment levels (at $\alpha = .05$).

EPT richness and richness slightly declined with increases in deposited sediment. NCBI scored lowest (best biological rating) for the reference stream, but the stream with the highest level of deposited sediment and poorest biological condition (USEPA 1999) (Law Ground Creek) did not have the worst biological rating.

Table 1. Stream Use Support Status, Sediment Characterization and Metric Scores

	Addie	Roach 1	Roach 2	Law
Designations*	Ref	Par	Par	Par
Pollutant of Concern*	N/A	Sed	Sed	Bio
Sediment Characterization				
% Deposited Sediments	20	47	37	60
% Cobble	37	25	48	32
% Bedrock Outcrop	43	28	15	8
Metric Scores†				
NCBI	4.94	5.36	6.04	5.31
	4.07	5.80	5.26	5.17
%EPT	55	49	52	42
	51	48	48	41
EPT richness	42	32	30	22
	32	29	30	22
Density	14072	50197	30391	27078
	47652	17603	42985	30514
Richness	76	65	58	53
	65	56	63	54

Notes: Ref = reference; Par = partial support; Sed = excessive sedimentation; Bio = biological community and habitat impairment.

* Designations and pollutant information from USEPA (1999).

†Two values for each metric score represent separate collection dates. Top value = February 2001, bottom value = April 2001.

Benthic macroinvertebrate density did not display any trends in relation to the level of deposited sediments within stream reaches.

DISCUSSION

We averaged estimates made simultaneously by two people for sediment estimations because we thought that this method would provide us with a more objective characterization of stream sediments.

Contrary to results from Missouri streams (Zweig and Rabeni 2001), density and richness were not significantly correlated with levels of deposited sediments in the Chattooga River watershed. Zweig and Rabeni (2001) consistently found density to be significantly negatively correlated to deposited sediments, and richness to be significantly negatively correlated to deposited sediments in some cases. Another study examining the relationship between fine sediments and benthic macroinvertebrates in the southern Appalachians (Angradi 1999) found weak correlations between density, and EPT richness metrics and deposited sediments. Angradi's (1999) study was experimental, however, and deposited sediment levels ranged from 0 to 30%. Our lowest level of sedimentation is 20%. In the upper Piedmond of North Carolina, Lenat et al. (1991) found benthic macroinvertebrate density to decline with fine sediment addition in general, but found that areas containing stable-sand sediments could support (through periphyton production) high densities of rapidly reproducing, small-bodied, grazing invertebrates. Similarly, in the North Carolina Appalachians, Wallace et al. (1995) found increases in the densities of small, multivoltine, collector invertebrates where log additions to streams created areas that had slowed current velocity and increases in fine sediments and coarse and fine particulate organic matter. We suspect that macroinvertebrate densities in this study are also being driven by organic matter dynamics. Organic matter has been collected with each benthic macroinvertebrate sample, but has not yet been processed sufficiently to be included in this analysis.

As with the NCBI in this study, other studies have found biotic indices (BI) to be poorly correlated with deposited sediments (Zweig and Rabeni 2001, Angradi 1999).

These results support USEPA's (1999) suggestion that the biological index used to monitor stream conditions in the Chattooga River watershed could be

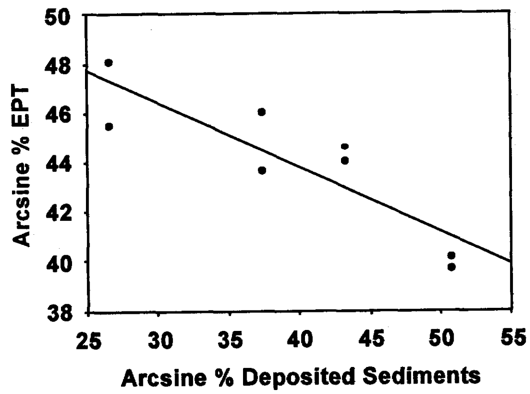

Figure 1. Relationship of % EPT to deposited sediments: R2 = 0.7667, p = 0.0387.

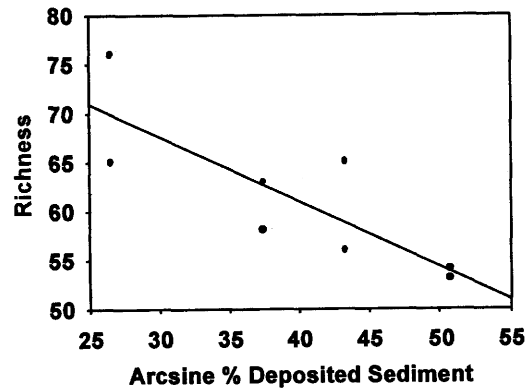

Figure 2. Relationship of richness to deposited sediments: $R^2 = 0.6808$, p = 0.2643

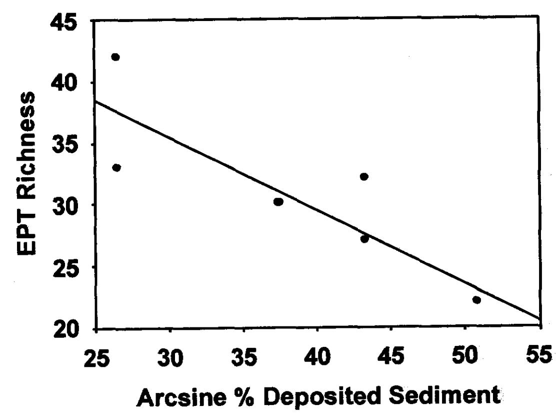

Figure 3. Relationship of EPT richness to deposited sediments: $R^2 = 0.7786$, p = 0.1711

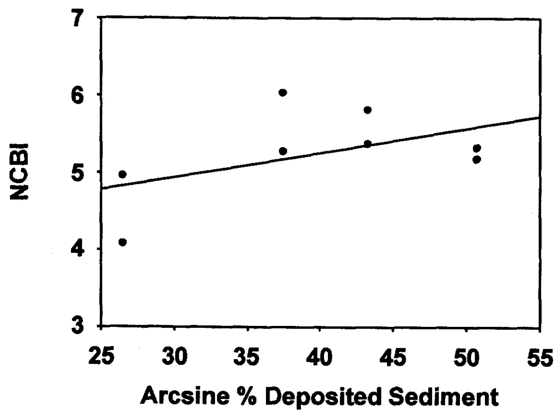

Figure 4. Relationship of NCBI to deposited sediments: $R^2 = 0.26$, $p = 0.1750$

more effective if supplemented by the addition of metrics that are more responsive to levels of deposited sediments. It is important to begin development of such a biological index because parts of this watershed are experiencing sustained sediment loading and this sedimentation is probably resulting in the impairment of benthic macroinvertebrate communities. As bioassessment requires a great deal of time and effort to implement, it is important to develop improved methods of assessing sediments.

This paper represents an initial step towards the refinement of a biological index for use in the Chattooga River watershed (USEPA 1999). We will add more tributaries, more metrics, and more environmental variables to this study and analyze metrics for each mesohabitat separately. Lastly, we intend to work toward the development of tolerance values based on deposited sediments, as suggested by Zweig and Rabeni (1999).

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