Evaluating the Hilsenhoff Biotic Index as a Biological Monitoring Indicator in Stream Ecosystems

Evelyn Boardman[1], Declan J. McCabe[2]

[1]Environmental Science, Rubenstein School of Environmental Resources, University of Vermont
[2]Department of Biology, Saint Michael's College

Abstract:

Many metrics have been developed using benthic macroinvertebrates as biological monitoring indicators for stream ecosystems. This project examined the ability of the Hilsenhoff Biotic Index (HBI), a metric developed to measure organic pollution in streams, to accurately describe variance in stream properties based on watershed land use. Through analysis of macroinvertebrate and geospatial land use data, HBI values were plotted against a gradient of catchment land use. Additionally, the effect of increased sample size on site HBI values was analyzed for a mixed land use and forested catchment stream in order to determine the number of samples necessary to discern between the sites. Significance and standardized effect size were established for samples at Potash Brook and Snipe Island Brook. HBI values were significantly related to the percentage of a catchment in urban and forested catchment land use, supporting the importance of watershed-level controls on stream ecological conditions.

Introduction:

• Macroinvertebrates have been identified as organisms useful to biological monitoring for their measurable and variable susceptibility to in-stream disturbance over long life cycles (Resh et al. 1996).

• The EPA currently has 14 metrics recommended for assessing disturbance using macroinvertebrate assemblage information and a number of other metrics to assess stream condition (Barbour et al. 1999).

• The ability of any particular metric to accurately describe variance in stream properties may vary based on changes in land use, geographic location, stream continuum, etc.

• This project examined the relationship between the Hilsenhoff Biotic Index (HBI), a metric developed to measure organic pollution in streams, and land use (Barbour et al. 1999).

• The effect of increased sample size on site HBI values was analyzed for a mixed land use and forested catchment stream in order to determine the number of samples necessary to discern between the sites.

Methods:

• 2008-2010 macroinvertebrate data collected by St. Michael's College, through its affiliation with the Vermont EPSCoR Streams Project, was analyzed using the Hilsenhoff Biotic Index (Barbour et al. 1999). GIS land use data for each stream site was extracted from the Streams Project online database.

• Linear regressions of land use and composite site HBI were performed with JMP 9.

• HBI for individual samples at Potash Brook and Snipe Island Brook from 2009 and 2010 was calculated and used to produce a running average with increasing number of samples.

• ANOVA of HBI values was performed with JMP 9 on samples from Potash and Snipe Island Brooks using 3 samples, then adding samples one by one to 30 samples per site.

• Cohen's D effect size with 95% confidence intervals was calculated from ANOVA results (Cohen 1988, Smithson 2003).

Figure 1. Land Use at Potash Brook and Snipe Island Brook.

Regression Results:

• Regression analyses are based on 13,808 invertebrates with HBI scores, collected during 69 separate sampling events at over 50 sites between 2008 and 2010.

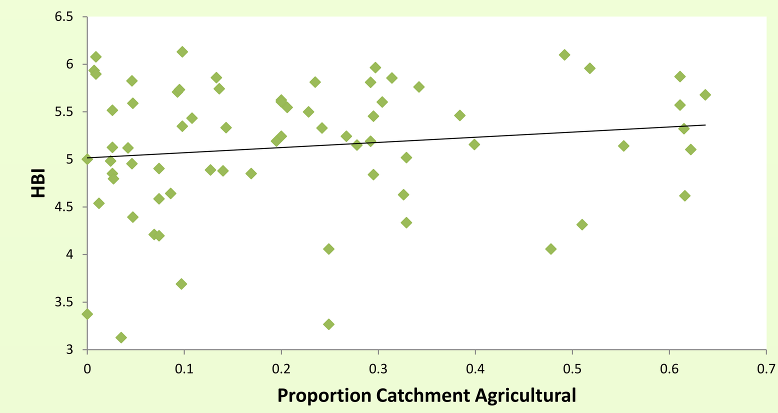

Figure 2. Proportion Catchment Agricultural and HBI

	Agricultural	Urban	Forested
R Squared	0.0215	0.1827	0.1934
F 2	0.0219	0.2235	0.2398
P Value	0.2262	0.0002	0.0001

Table 1. Land Use and HBI Regression Results

• No relationship observed between Proportion Catchment Agricultural and HBI scores.

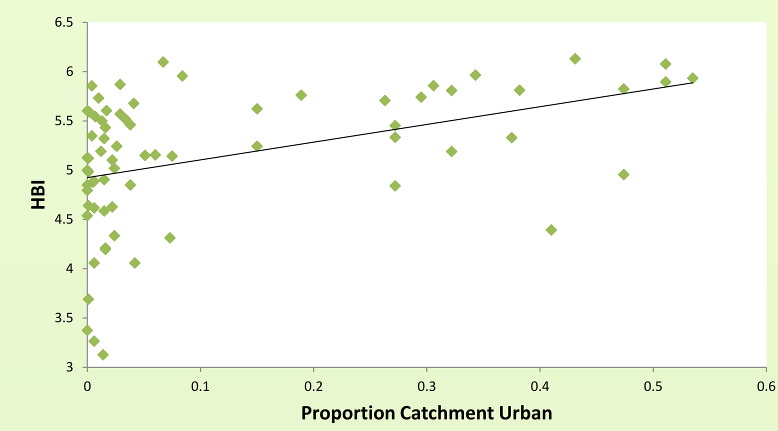

Figure 3. Proportion Catchment Urban and HBI

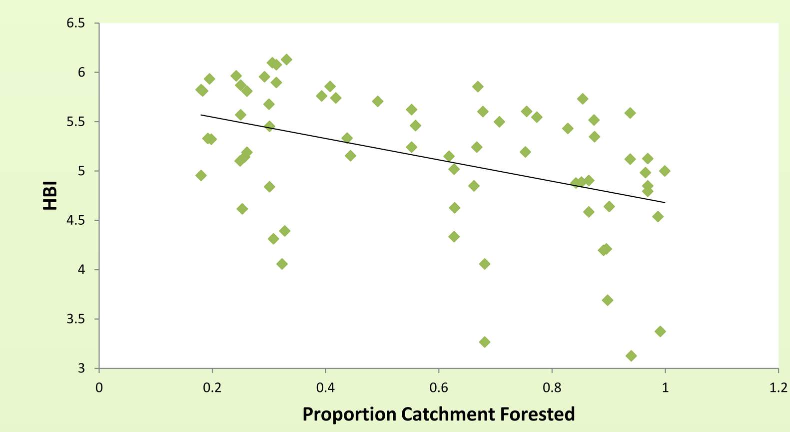

Figure 4. Proportion Catchment Forested and HBI

• Significant relationship observed between Proportion Catchment Urban and HBI scores and between Proportion Catchment Forested and HBI scores.

ANOVA Results:

• ANOVA results are based on 60 samples from 2009 and 2010, 30 from each site.

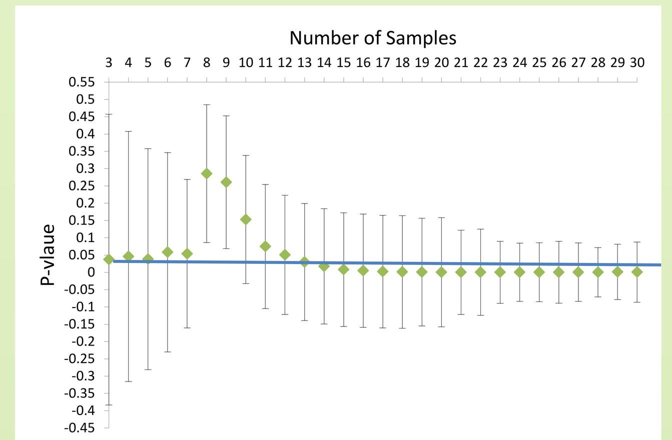

Figure 5. P-value for ANOVA of HBI scores for Potash Brook and Snipe Island Brook with increasing sample size

• HBI scores for Potash and Snipe Island Brooks were discernibly different for 24 of the 27 Analysis of Variance tests run.

• The other three tests were within a interval of a p-value of 0.05.

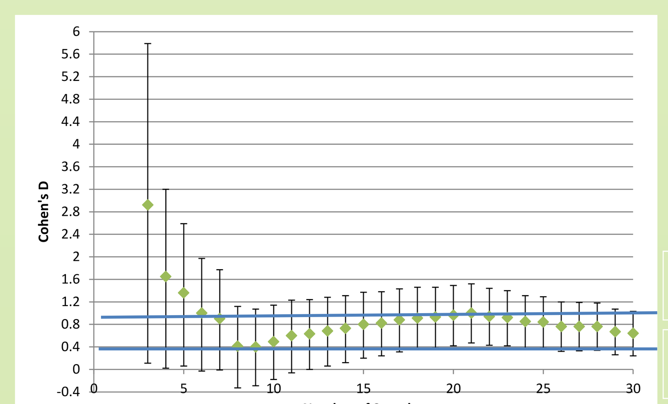

Figure 6. Cohen's D for ANOVA of HBI scores for Potash Brook and Snipe Island Brook with increasing sample size.

• The graph to the left plots Cohen's D as a way of measuring the magnitude of difference between mean HBI scores at Potash and Snipe Island Brooks with increasing sample size.

• Cohen's D stabilizes and confidence intervals narrow with increasing sample size. An effect size at or above 0.2 to 0.3 is considered small, at or above 0.5 is considered medium and at or above 0.8 is considered large (Cohen 1988).

Discussion:

• Proportion Catchment Urban and Proportion Catchment Forested are significantly related to HBI scores. High HBI scores are associated with a greater number of tolerant macroinvertebrates than those with low HBI scores.

• Forested areas may allow for more infiltration of organic pollutants, leading to lower HBI scores because of the presence of sensitive invertebrates.

• Impervious surfaces and impactful land use in urban areas may lead to increased levels of organic pollutants and higher HBI score because of the presence of tolerant invertebrates.

• The proportion of agricultural land use in a catchment did not have a significant relationship with HBI score, possibly owing to the diversity of agricultural practices and farm types.

• P-value for the analysis of variance mostly showed a difference between the Potash Brook and Snipe Island Brook sites, but for sample sizes of 8 and 9 did not.

• Using the magnitude of effect expressed with Cohen's D shows the possibility of difference of varying magnitude in all of the samples, along with greater confidence in the result with greater sample size.

• HBI was a relatively reliable way to look at the relative effect of urban and forested land use on stream macroinvertebrates. When the categorization is unclear, using an effect size statistic makes it possible to discern how different sites are.

Acknowledgements:

Funding for this internship and project provided by NSF EPS Grant #0701410 through ESPCoR Vermont. Thanks to the Streams Project participants that contributed to the collection of this data and Alan Howard for his statistics support.

Works Cited:

• Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment
• Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.
• Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (Second ed.). Hillsdale, New Jersey: Lawrence Erlbaum Associates.
• Resh, V. H., Meyers, M. J., & Hannaford, M. J. (1996). Macroinvertebrates as Biotic Indicators of Environmental Quality. *Methods in Stream Ecology* (pp. 647-667). San Diego: Academic
• Smithson, M.J. (2003). Confidence Intervals, Quantitative Applications in the Social Sciences Series, No. 140. Thousand Oaks, CA: Sage.