A Method For Evaluating Stream Bioassessment Protocols

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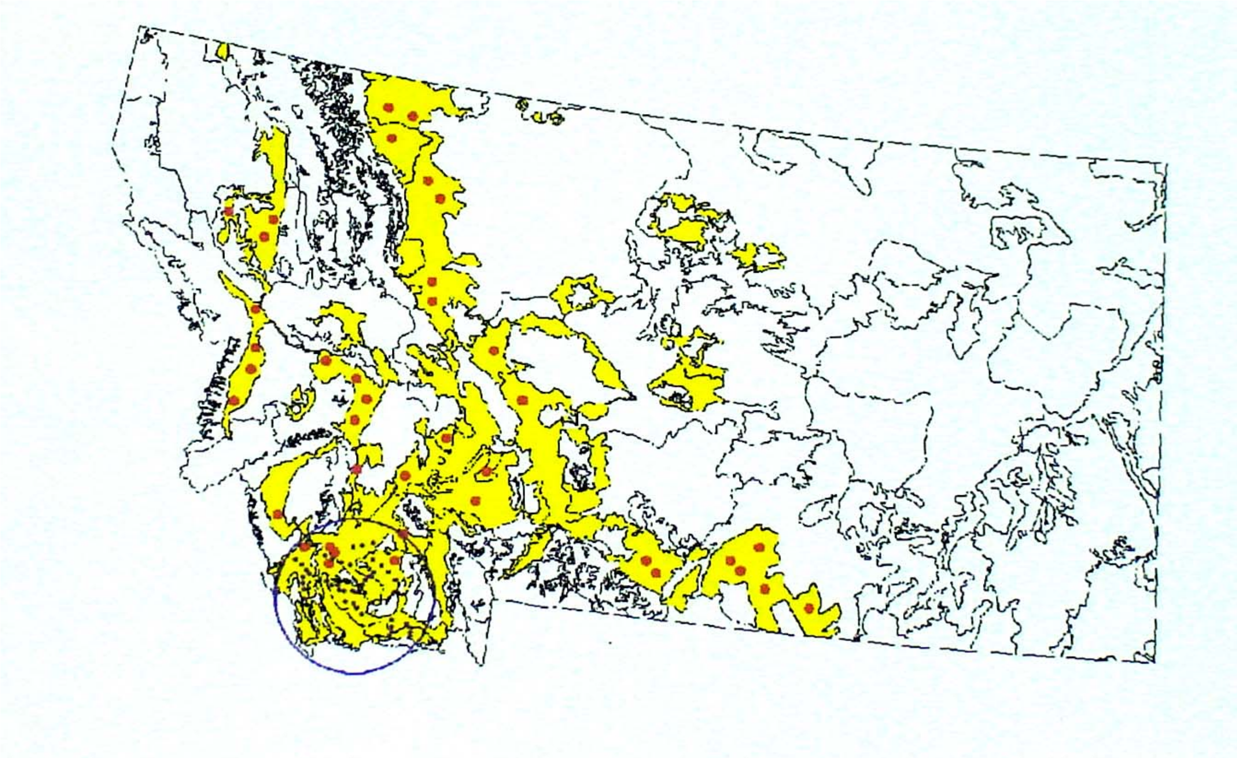
Benthic macroinvertebrate assemblages have become part of the arsenal of tools used to assess and monitor biological health or integrity of surface waters. These communities are particularly well suited for such uses, since their relatively long lives, complex life cycles, and varying sensitivities mean that there is ample time for an interpretable response to environmental perturbations to occur. Typically, bioassessment protocols translate the taxonomic data collected at stream sites into metrics, or biological attributes that change predictably when pertubations of water or habitat quality are present. These protocols are termed "multimetric" indices.

Effective and defensible bioassessment protocols are based on a foundation of three elements. The first element is an appropriate stratification or classification of stream sites. This is usually done in terms of ecoregions, though some ecoregions are diverse enough that other classifications are appropriately applied. The second element is the establishment of a battery of metrics which individually and together are able to distinguish between impaired and unimpaired conditions. To be relevant, metrics should be associated with degrees of disturbance, or with symptoms of disturbance. Symptoms of disturbance may be discerned by assessing habitat parameters and by simple water quality measures. The third element is a partitioning of the variability of metrics into that associated with natural environmental variation and that associated with human-caused impairment.

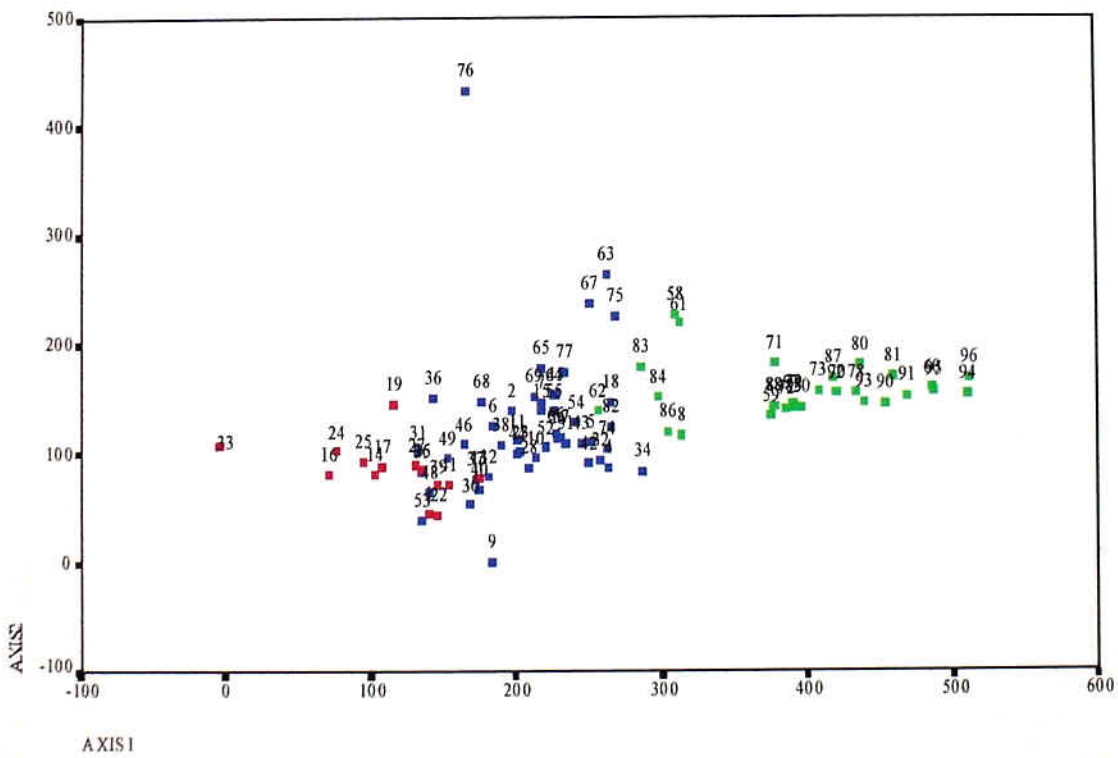
This poster demonstrates a proposed method by which multimetric bioassessment protocols might be evuated and improved. The demonstration utilizes straightforward graphical displays and simple statistical analyses to test various macroinvertebrate metrics and to assemble a battery of these attributes that can be effective for assessing ecological condition in a variety of management settings.

1) Stratification

A) All sites in this demonstration are located in the Montana Valley and Foothill Prairies ecoregion, illustrated in yellow in the map. Sampling sites are indicated by red dots. The circled area in southwestern Montana represents an area that was more intensively sampled. A total of 93 sites were samples for macroinvertebrates in 1992 and 1993.



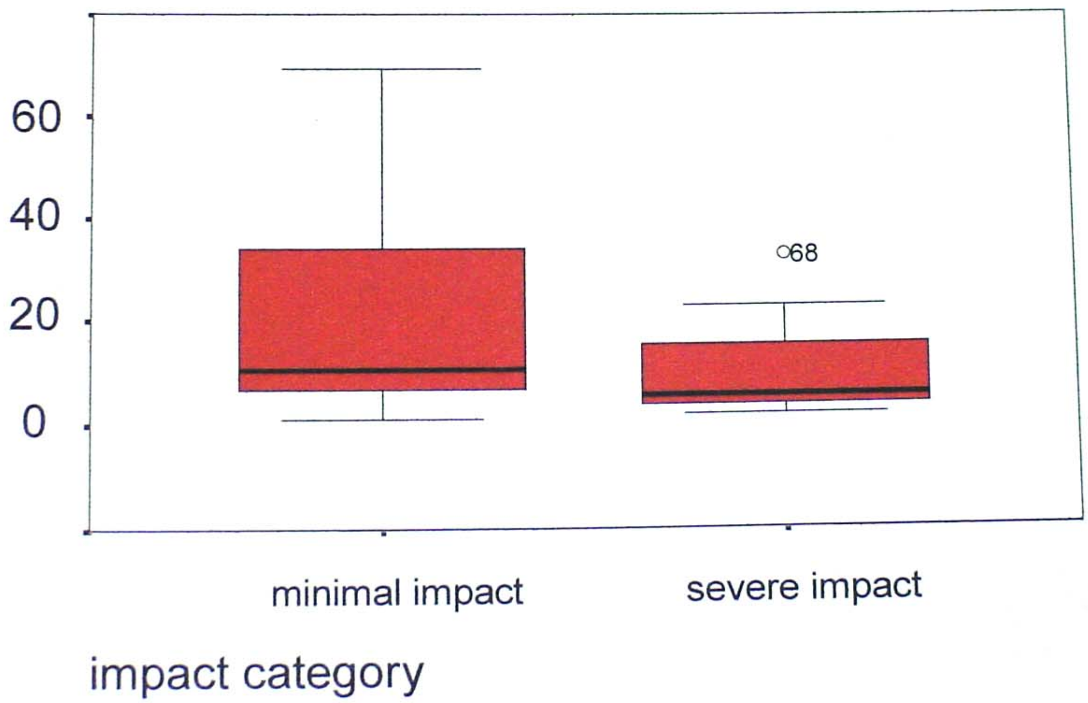
B) The Montana Valley and Foothill Prairies ecoregion might well be a cohesive unit in some respects, but it is highly variable in geology, land use and elevation. To further stratify sites, an ordination of taxonomic data (DECORANA) was used to discern patterns in macroinvertebrate communities that could be attributed to natural variation in the environment. Correlations between ordination axes and environmental variables indicated that site elevation was the major determinant of the taxomonic composition of benthic assemblages in this ecoregion. In the plot, colors were assigned to groups of sites by a classification procedure (TWINSPAN).



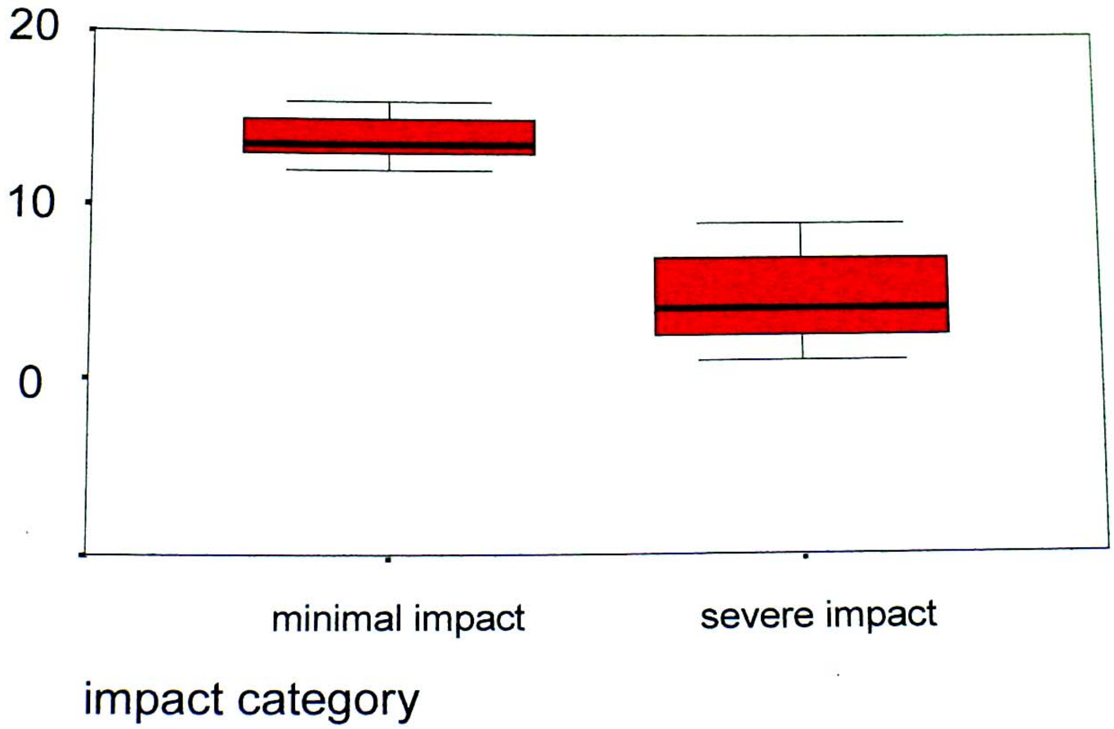
2) Assessing the relevance of metrics

Visual evaluation of a variety of habitat parameters at each site allowed for a selection of a group of sites which were least impacted by human-caused pertubations and a second group which were severely impacted. More than twenty different bioassessment metrics were tested for the ability to discriminate between the groups of sites. Ranges of metric values within each site grouping were compared using simple graphical displays, as in the following examples. Statistical tests (Mann-Whitney U tests) were used to validate the easily observed results from the graphs.

This metric, "Percent scrapers plus shredders", is a measure of the proportion of animals at each site that feed by either scraping algae off of the surfaces of cobbles or by shredding leaves and woody debris. The metric clearly does an inadequate job of distinguishing between impact categories; mean values are not widely separated, and value ranges completely overlap. This metric is not sensitive to impairment.



This metric, "EPT richness", is a measure of the number of mayfly, stonefly and caddisfly taxa collected at a site. It is apparent from the ranges of the metric value that it makes clear distinction between the two impact categories. Mean values for each range are widely separates, and the ranges do not overlap. This metric is sensitive to impairment.



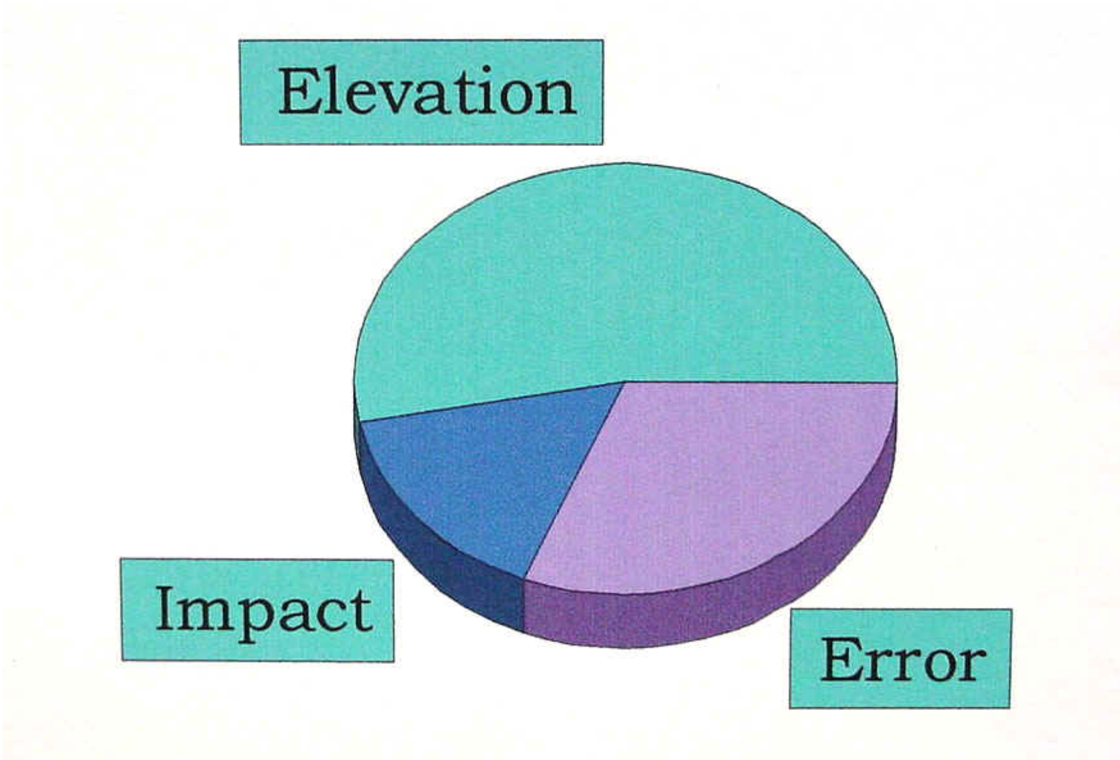
3) Partitioning the variability of metric values

Effective bioassessment metrics should vary more with impairment than with natural sources of variability, sources such as elevation, which was demonstrated to be the largest source of variability in the taxonomic composition of benthic assemblages. To partition the sources of variability in metrics, a Type II (random effects) ANOVA model was employed, and that portion of metric variability attributable to impairment was compared to those portions attributable to elevation and to error, or other sources of variability. The results of these comparisons can be displayed in pie charts.

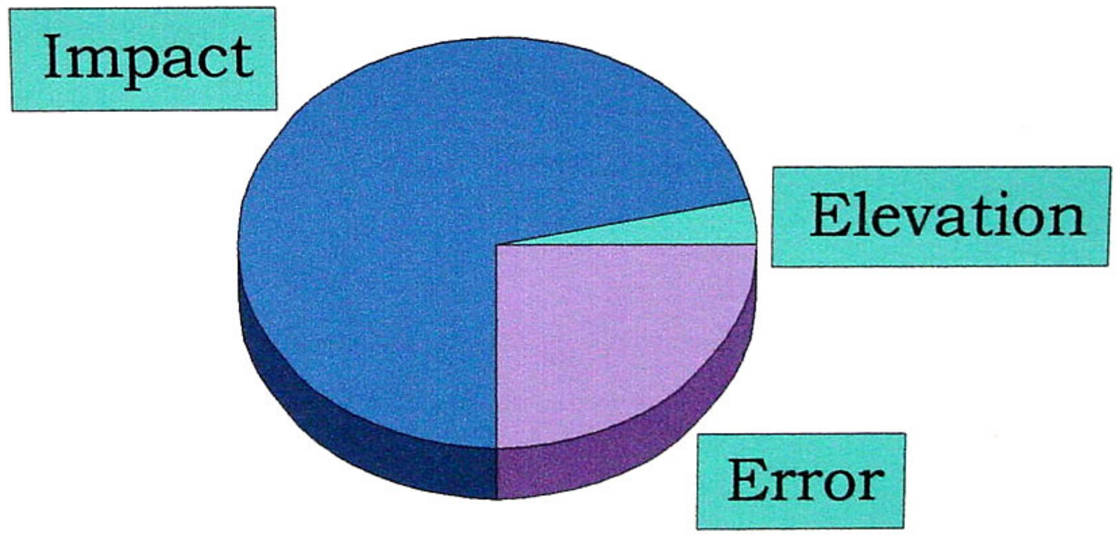
Why use metrics at all?

One effect of translating taxonomic composition of communities into bioassessmnt metric can be demonstrated by partitioning the variability of benthic community taxonomy. The result is illustrated in the pie chart.

Ordination axis 1 scores are, simply, the position of each benthic community on the ordination graph; thus scores represent the taxonomic composition of the assemblages sampled. This chart illustrates that the major variation of benthic assamblage composition is due to elevation. Impact contributes little.



Impact accounts for an estimated 71% of the variation in the EPT richness of macroinvertebrate communities, while elevation makes very little contribution to variability. Error accounts for about 25% of metric variability; error variability can be thought of as being due to sampling error or to other natural environmental variability besides elevation. Metrics which vary more with elevation or error than with impact are not effective bioassessment tools.

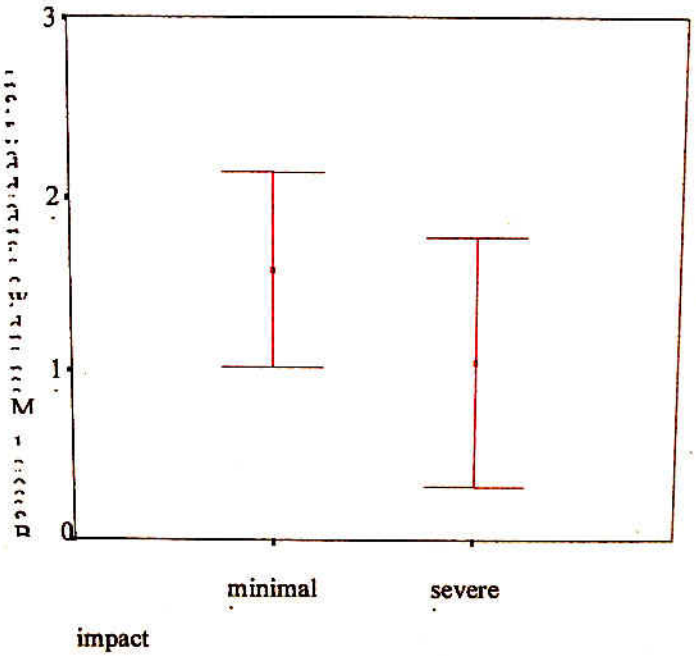


Conclusion

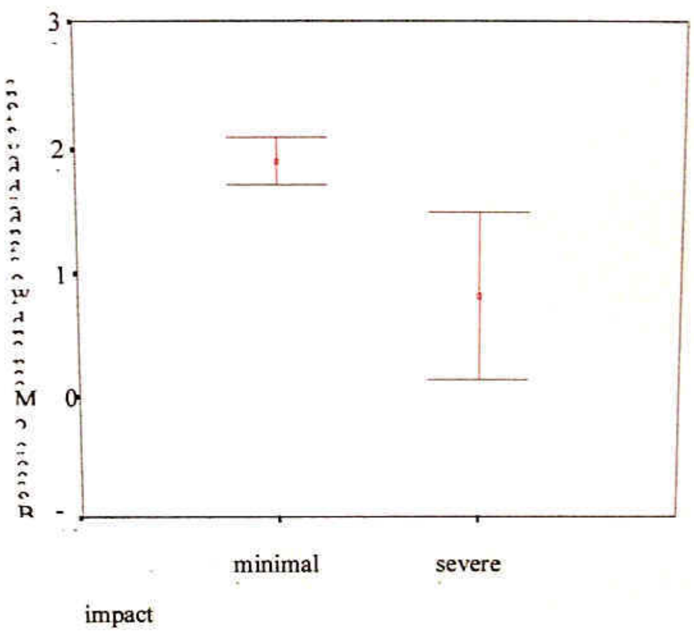
The method described here was used to evaluate the multiletric bioassessment method used by the Montana Department of Environmental Quality (MT DEQ) for assessing streams in the Valley and Foothill Prairies ecoregion. This method is based on eight macroinvertebrate metrics. As a result of the evaluation, an entirely different battery, comprised of six metrics, was proposed to replace the MT DEQ protocol. The table below lists both metric batterys.

Montana DEQ metric battery	**Proposed revision for the Montana Valley and Foothill Prairies ecoregion**
Taxa richness	Ephemeroptera richness
EPT richness	Plecoptera richness
Biotic index	Trichoptera richness
Percent dominant taxon	Number of sensitive taxa
Percent gatherers plus filterers	Percent filterers
Percent scrapers plus shredders	Percent tolerant taxa
Percent Hydropsychinae of Trichoptera	
Percent EPT	

Both metric batteries were compares for their ability to distinguish impacted sites from relatively umimpaired sites. The results of this comparison are illustrated in graphs of the ranges of total bioassessment scores. The Montana DEQ battery does not distinguish impaired from unimpaired sites well, while the revised method clearly does.



Montana DEQ metric battery



Proposed revision