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Estimation and application of indicator values for common macroinvertebrate genera and families of the United States

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Abstract

Tolerance of macroinvertebrate taxa to chemical and physical stressors is widely used in the analysis and interpretation of bioassessment data, but many estimates lack empirical bases. Our main objective was to estimate genus- and family-level indicator values (IVs) from a data set of macroinvertebrate communities, chemical, and physical stressors collected in a consistent manner throughout the United States. We then demonstrated an application of these IVs to detect alterations in benthic macroinvertebrate assemblages along gradients of urbanization in New England and Alabama. Principal components analysis (PCA) was used to create synthetic gradients of chemical stressors, for which genus- and family-level weighted averages (WAs) were calculated. Based on results of PCA, WAs were calculated for three synthetic gradients (ionic concentration, nutrient concentration, and dissolved oxygen/water temperature) and two uncorrelated physical variables (suspended sediment concentration and percent fines). Indicator values for each stress gradient were subsequently created by transforming WAs into ten ordinal ranks based on percentiles of values across all taxa. Mean IVs of genera and families were highly correlated to road density in Alabama and New England, and supported the conclusions of independent assessments of the chemical and physical stressors acting in each geographic area. Family IVs were nearly as responsive to urbanization as genus IVs. The limitations of widespread use of these IVs are discussed.
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Keywords: Macroinvertebrates; Indicator values; Tolerance values; Biological assessment; National scale

1. Introduction

Most ecological assessments of streams include measures of benthic macroinvertebrate assemblages (USEPA, 2002; Hering et al., 2004). Biotic indices (sensu Johnson et al., 1993) are often used to describe the structure of biological assemblages based on known or hypothesized tolerances of taxa to pollution. Taxon tolerance estimates are often simplified to ordinal scales or ranks known as indicator values (hereafter IVs). Macroinvertebrate IVs for organic pollution and acidification have been developed and modified throughout Europe (Sandin and Hering, 2004; Sandin et al., 2004). In the U.S., macroinvertebrate IVs for

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organic pollution were developed in the upper Midwest (Hilsenhoff, 1987) and widely applied elsewhere, but IVs for other pollutants (e.g., acidification, sedimentation) are limited.

Macroinvertebrate IVs for a wide range of pollutants offer several potential benefits to biological assessments. First, they provide a quantitative basis for assigning taxa to general tolerance classes (e.g., intolerant, intermediate, tolerant), which is required for calculating some biological metrics (Barbour et al., 1999; Hering et al., 2004) and defining gradients of biological condition (sensu Gerritsen and Leppo, 2005). Second, if unique sets of taxa are sensitive to specific pollutants, IVs may facilitate diagnosing potential causes of biological impairment (e.g., Norton et al., 2000). Last, IVs could be used to expand the geographic relevance of existing biotic indices (e.g., Hilsenhoff, 1987) and create new ones for additional pollutants.

The widespread application of IVs is complicated by at least two methodological issues. First, few biological and pollutant data have been collected using the same methods across large spatial scales. As a consequence, IVs have been estimated for limited geographic areas and for ''general'' pollution (e.g., Barbour et al., 1999). Although some regional classifications have recently emerged (Yuan, 2004), IVs for specific pollutants that are potentially relevant at a variety of spatial scales are clearly needed. Second, the importance of taxonomic resolution in the application of IVs is unclear. Indicator values for coarsely resolved taxa (e.g., family and genus) may be

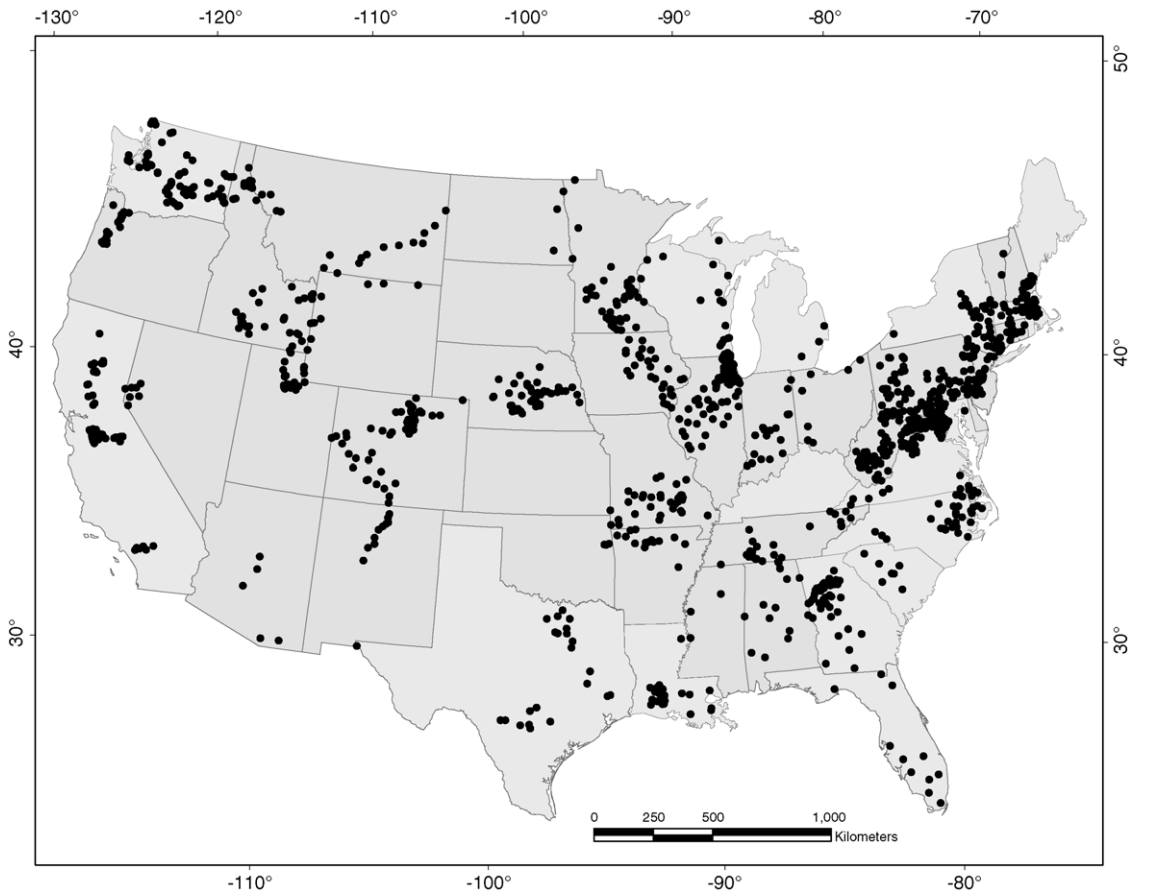

Fig. 1. Locations in the contiguous Unites States where the U.S. Geological Survey National Water-Quality Assessment Program collected macroinvertebrate and environmental data, 1993–2003, used in this report.