REPLY TO DISCUSSION
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"Urbanization Influences on Aquatic Communities in Northeastern Illinois Streams"[2]

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The authors wish to thank the discussants for furthering the discussion of three important issues: indices based on different aquatic communities may indicate conflicting water quality conditions; an understanding of the metrics that make up an index and the methods used to compute the metrics may help to explain variability in index response to watershed scale land use change; and historical land use impacts may affect the range in responses of the indices to urbanization. Fitzpatrick *et al.* (2004) examined the relations of historic biotic indices (one based on fish and another based on macroinvertebrate data) and sediment trace element concentrations with the amount of urbanization in watersheds of northeastern Illinois streams (Chicago area). The two indices showed similar decreases in biotic integrity in streams with greater than 10 percent watershed urban land.

Incorporating redundancy in a biological assessment program or water quality study by sampling multiple biological communities (e.g., fish, macroinvertebrates, and algae) can be a powerful tool. In the United States, 45 of 65 states, tribes, territories, and interstate commissions utilize monitoring programs that incorporate more than one biotic assemblage for stream assessment (U.S. Environmental Protection Agency, 2002). Response patterns of structural and functional aspects of aquatic communities differ as a function of stressor types, temporal and spatial scales, and biological characteristics. Although assessments derived from each assemblage may be similar, there is however, even greater utility when examining the differences between indices allows the identification of specific stressors (Karr and Chu, 1999). For example in agricultural streams in eastern Wisconsin, fish indices of biotic integrity (IBI) scores were most related to riparian land cover along the entire stream network, whereas invertebrate and algae metrics were most related to nutrient concentrations and flow variability (Fitzpatrick *et al.,* 2001).

Nevertheless, it is true that confusing or confounding results from biological indices using different, or even the same, organisms can result from the artifacts of the indices themselves rather than underlying aspects of stream quality. Understanding the underlying metrics that define an index is critical in stream assessments.

In Fitzpatrick *et al.* (2004) it was suggested that pollutants in streambed sediment may affect benthic invertebrates more than fish. Further statistical analysis of the initial dataset of the macroinvertebrate index (MBI), the alternative index of biotic integrity (AIBI), watershed urban land, and copper concentrations in sediment indicates that copper concentrations in sediment are more closely linked with the MBI than the AIBI. This is apparent in the standardized residual plots of AIBI and MBI scores against copper concentrations (Figure 1). The standardized residuals for AIBI, MBI, and copper concentrations are from linear regressions of the three variables with watershed urban land. The plot shows that the amount of variability accounted for by watershed urban land is more similar between copper and the MBI than between copper and the AIBI.

It should be noted that the Illinois Department of Natural Resources and the Illinois Environmental Protection Agency have recently developed new multimetric fish and macroinvertebrate indices of biotic

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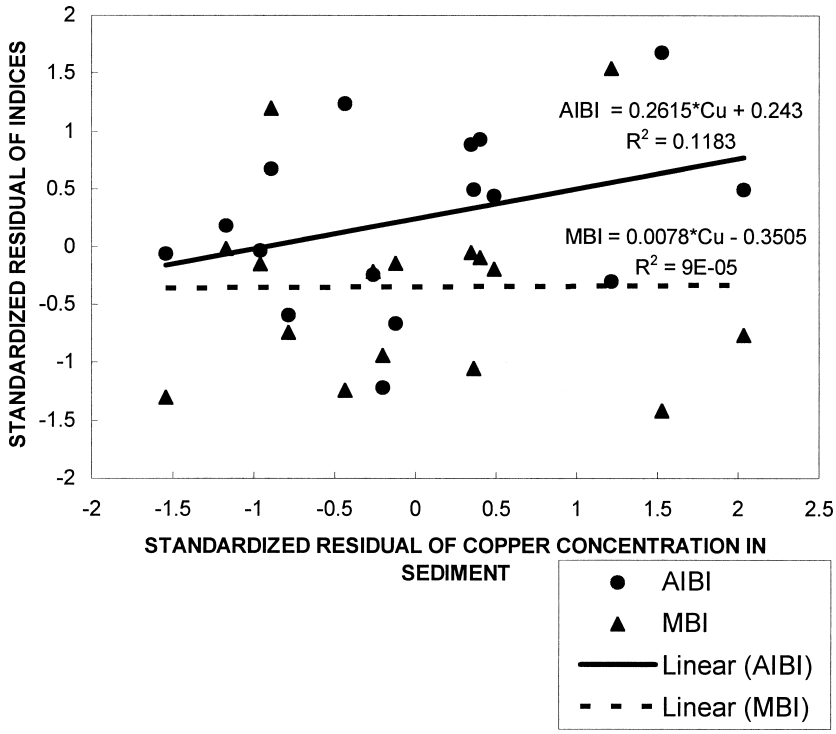

Figure 1. Relations Between Residuals From AIBI and Watershed Urban Land, MBI and Watershed Urban Land, and Copper Concentrations in Sediment and Watershed Urban Land.

integrity based on taxonomic structure and ecological function to the replace the historic AIBI and MBI. They are encouraged by the behavior of the new indices as assessment tools.

A comparison of National Water Quality Assessment Program findings of a study of urban effects in major metropolitan areas of Boston, Philadelphia, Dayton/Cincinnati, and Chicago from 1999 to 2001 indicated that the number of intolerant invertebrate taxa (Ephemeroptera, Plecoptera, and Trichoptera) (EPT) generally decreased with increasing urbanization, with the steepest decline in EPT taxa from 0 to about 20 percent urban land (Groschen *et al.,* 2004). Streams in the Boston area had the least amount of variability in their response to increased watershed urban land (urban development of forested land), whereas streams in Dayton/Cincinnati and Chicago had more variability in their response to increased watershed urban land (urban development of agricultural land). At 20 percent urban land, the percentage of EPT taxa remaining ranged from 35 percent in the Dayton/Cincinnati area to 60 percent in the Philadelphia area. These important regional differences are most likely a reflection of both spatial and temporal characteristics at a variety of scales. These differences are further evidence that local spatial and historical data are needed to be able to better address the causes for variability among index scores based on a variety of aquatic assemblages.

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