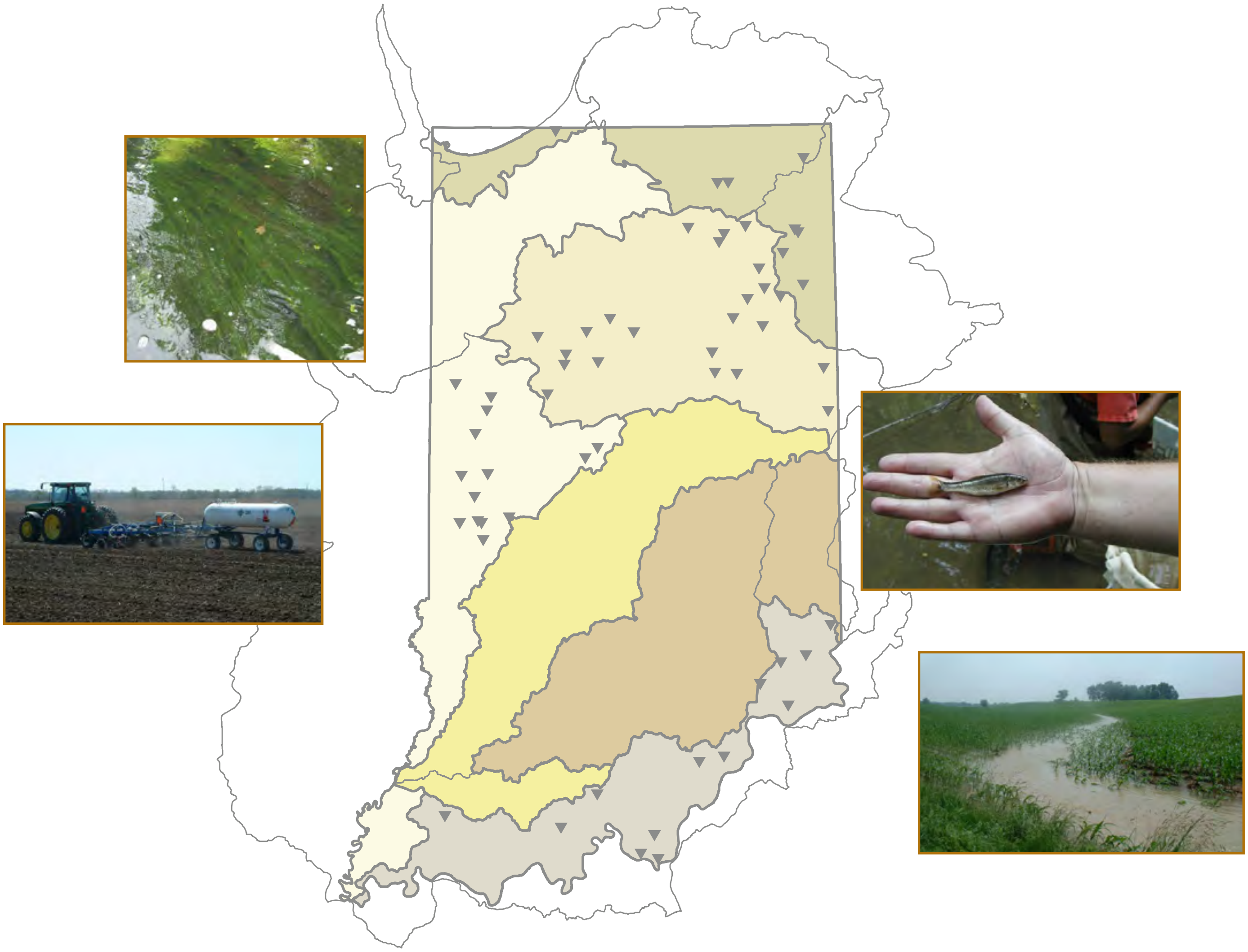
Prepared in cooperation with the Indiana Department of Environmental Management, Division of Water, Assessment Branch

Nutrient, Habitat, and Basin-Characteristics Data and Relations with Fish and Invertebrate Communities in Indiana Streams, 1998–2000



Scientific Investigations Report 2007–5076

U.S. Department of the Interior
U.S. Geological Survey

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By Jeffrey W. Frey and Brian J. Caskey

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Conversion Factors and Datum

Multiply	By	To obtain
	Area	
meters (m)	3.28	feet (ft)
square kilometer (km^2)	0.3861	square mile (mi^2)
meters per kilometer (m/km)	5.28	feet per mile (ft/mi)

Horizontal coordinate information used in the maps is referenced to the North American Datum of 1927 (NAD 27). Sampling site coordinate information used a Global Positioning System (GPS) referenced to North American Datum of 1983 (NAD 83), which then was converted to NAD 27.

Concentrations of chemical constituents in water are given in milligrams per liter (mg/L).

Abbreviations

TKN	total Kjeldahl nitrogen
N	nitrogen
P	phosphorus
CWA	Clean Water Act
USEPA	U.S. Environmental Protection Agency
IBI	Index of Biotic Integrity
TN	total nitrogen
TP	total phosphorus
CHLa	chlorophyll *a*
IDEM	Indiana Department of Environmental Management
USGS	U.S. Geological Survey
WMP	Watershed Monitoring Program
NLCD	National Land Cover Dataset
STATSGO	State Soil Geographic Database
CA	correspondence analysis
CCA	canonical correspondence analysis
CA1	correspondence analysis first axis site score
SAS	Statistical Analysis System
r	Pearson correlation coefficient
c_j	regression/canonical coefficient for normalized parameters
QHEI	Qualitative Habitat Evaluation Index

Nutrient, Habitat, and Basin-Characteristics Data and Relations with Fish and Invertebrate Communities in Indiana Streams, 1998–2000

By Jeffrey W. Frey and Brian J. Caskey

Abstract

An analysis of existing nutrient, habitat, basin-characteristics, and biological-community (fish and invertebrate) data assessed significant relations between nutrients and biological data. Data from 1998 through 2000 for 58 sites in the Upper Wabash River Basin, Lower Wabash River Basin, and tributaries to the Great Lakes and Ohio River Basins were analyzed. Correspondence analysis was used to assess significant relations among nutrients, habitat, basin-characteristics, and biological-community data. Canonical correspondence analysis was used to identify which environmental parameters most influenced the biological communities. When all 58 sites were assessed, six biological-community attributes, metric scores, or site scores were statistically sigificant but weak. When a subset of data was analyzed for eight headwater streams in one ecoregion to minimize the naturally occurring variability associated with the 58 sites, the strength of the relations increased and 24 attributes, metric scores, or site scores were significantly related. Fish-community composition in the 58 sites was most influenced by habitat and land use but not by nutrients. The invertebrate-community composition in the 58 sites was most influenced by habitat, land use, soils, and one nutrient (total Kjeldahl nitrogen [TKN]).

Introduction

Excessive inputs of nutrients into streams have human-health, economic, and ecological consequences. Eutrophication, or excess amounts of the nutrients, primarily nitrogen (N) and phosphorus (P), in aquatic ecosystems have been linked to fish kills, shifts in species composition, taste and odor in drinking-water supplies, and harmful algal blooms (Munn and Hamilton, 2003; U.S. Environmental Protection Agency, 2000).

The Clean Water Act (CWA) of 1972 established a national goal of achieving water-quality levels for the protection and propagation of aquatic organisms and wildlife and for human recreation in and on the water. In 1996, the U.S. Environmental Protection Agency's (USEPA) National Water Quality Inventory identified nutrients as the second leading cause (first was siltation) of impairment in rivers and streams across the United States (U.S. Environmental Protection Agency, 1997). The excess amounts of nutrients found in many rivers and streams have resulted in waters that do not meet the goal of the CWA.

USEPA drinking-water criteria (maximum contaminant levels) are 10 mg/L for nitrate as nitrogen and 1 mg/L nitrite as nitrogen. In addition, aquatic-life criteria to protect aquatic organisms have been set for ammonia as nitrogen (pH, temperature, and life-stage dependent) (U.S. Environmental Protection Agency, 2005). The current criteria do not address concerns associated with the effects on the biological communities resulting from increased nutrients in rivers and streams. Typically, nutrient concentrations must be extremely high to be toxic to biological communities; such concentrations rarely are found in the environment. For example, nitrate as nitrogen concentrations below 90 mg/L would not have direct effects on warmwater fish (Ohio Environmental Protection Agency, 1999). Exceptions are concentrations of ammonia after accidental discharges from wastewater-treatment facilities, combined-sewer overflows, or confined-animal feedlots (Ohio Environmental Protection Agency, 1999). Previous analysis of the effects of nutrients on biological communities in Ohio found few relations between nutrients and fish and invertebrate-community data (Miltner and Rankin, 1998). Only total phosphorus was significantly correlated with any of the fish or invertebrate attributes or metrics (fish Index of Biotic Integrity [IBI] scores in headwater streams).

Because algae directly use nutrients, several confounding issues could affect this lack of relations between nutrients and biological communities, these include

- seasonal changes in nutrient concentrations because of evapotranspiration, in-stream algal uptake, and decreased loadings from rainfall and surface runoff;
- differences in light attenuation from shading and turbidity that can influence algal uptake;

- frequency of storms that scour periphyton algae and reduce algal uptake of nutrients;
- grazers that feed on algae and reduce algal uptake of nutrients;
- differences in nutrient and algal-biomass concentrations in wet and dry years; and
- differences between nutrient levels in streams (increased nutrient loadings in oligotrophic streams can increase fish- and invertebrate-community productivity, but negative impacts on species composition and productivity have been linked to eutrophication).

Many streams have been placed on the CWA Section 303(d) list of impaired water bodies because of excess nutrients. In 2000, the USEPA proposed nutrient water-quality criteria for two causal parameters—total nitrogen (TN) and total phosphorus (TP) and three response parameters—seston and periphyton chlorophyll *a* (CHL*a*) and turbidity. The USEPA based the proposed nutrient water-quality criteria on Aggregate Nutrient Ecoregions (U.S. Environmental Protection Agency, 2000), areas with similar geographic features that include topography, soils, geology, land use, and biogeography. The USEPA reviewed existing data and set the proposed nutrient water-quality criteria for TN, TP, CHL*a*, and turbidity at the 25th-percentile value for each parameter.

USEPA mandated that states either accept the proposed nutrient water-quality criteria or provide their own criteria more appropriate to the waters within each state by 2004. An extension was given to states, including Indiana, that adopted plans describing the data needs and process to develop nutrient water-quality criteria. As part of the process, states need to review existing data, in addition to collecting new data. The review of existing data includes analysis of the relations between nutrients, habitat, and biological communities (fish and invertebrates).

The Indiana Department of Environmental Management (IDEM) and the U.S. Geological Survey (USGS) are cooperating on studies to assist the State of Indiana in developing the nutrient water-quality criteria as mandated by the USEPA. When the USEPA proposed nutrient water-quality criteria in 2000, few CHLa data existed. Between 2001 and 2005, the USGS augmented the IDEM Watershed Monitoring Program (WMP) by including algal-biomass (periphyton CHL*a* and ash-free-dry mass and seston CHL*a* and particulate organic carbon) data. The algal-biomass data are in addition to the nutrient, habitat, and fish- and invertebrate- community data collected as part of the WMP. These collaborative studies were conducted in the West Fork White River (2001), Whitewater River and East Fork White River Basins (2002), Upper Wabash River Basin (2003), Lower Wabash River and Kankakee River Basins (2004), and Ohio River and Michigan Basins (2005).

Purpose and Scope

The purpose of this report is to identify the statistically significant relations between nutrient, habitat, and biological-community (fish and invertebrate) parameters, using existing data from 58 sites collected by IDEM between 1998 and 2000. Additionally, the USGS determined basin characteristics (drainage area, land use, and soils) for these 58 sites to enhance the analysis. Fish- and invertebrate-community composition was assessed to determine if they indicated nutrient enrichment.

Description of the Study Area

The 58 sampling sites selected from the IDEM WMP for this report are in the Upper Wabash River, Lower Wabash River, Great Lakes, and Ohio River Basins in Indiana (fig. 1 and appendix 1). Most of the sites are in the Upper and Lower Wabash River Basin (37 sites), 13 sites are in the Ohio River Basin, and 8 sites are in the Great Lakes Basins. The Great Lakes Basins are comprised of tributaries to Lake Michigan, the St. Joseph River, and the Maumee River Basins. Reflective of much of the State of Indiana, most of the sampling sites are in agriculturally dominated areas (fig. 2).

The Upper Wabash River Basin drains 18,738 km^2 of central Indiana and parts of western Ohio before draining into the Lower Wabash River Basin (Steeves and Nebert, 1994). The area of the Upper Wabash River Basin in Indiana is 18,023 km^2 (Hoggatt, 1975). The dominant land use of the Upper Wabash River Basin is 88.8 percent agriculture, primarily row crops of corn and soybeans (table 1). The basin is 6.9 percent forested; 1.8 percent urban, and 2.5 percent other land uses. Streams in the Upper Wabash River can be characterized as having low relief and velocities. Soils are clayey glacial till and the region is primarily till plain interspersed with narrow looping belts of rolling, hummocky, ridged, moraine upland (Clark, 1980).

The Lower Wabash River Basin drains more than 85,339 km^2 of central and southern Indiana, parts of western Ohio, and eastern Illinois (Steeves and Nebert, 1994) before it flows into the Ohio River. The Lower Wabash River Basin drains the Upper Wabash River (18,738 km^2), the East Fork White River (14,814 km^2), the White River and West Fork White River (14,566 km^2), and Patoka River (2,225 km^2) Basins (Steeves and Nebert, 1994). The area of the Lower Wabash River Basin (not including the upstream basins) is 34,994 km^2 (Steeves and Nebert, 1994). The land use for this area is 81.3 percent agriculture, 12.4 percent forested, 1.5 percent urban, and 4.9 percent other land uses (table 1). The streams in the northern Lower Wabash River Basin have low relief and low velocities. In the southern Lower Wabash River Basin, the landscape shows greater dissection by streams with steeper gradients and

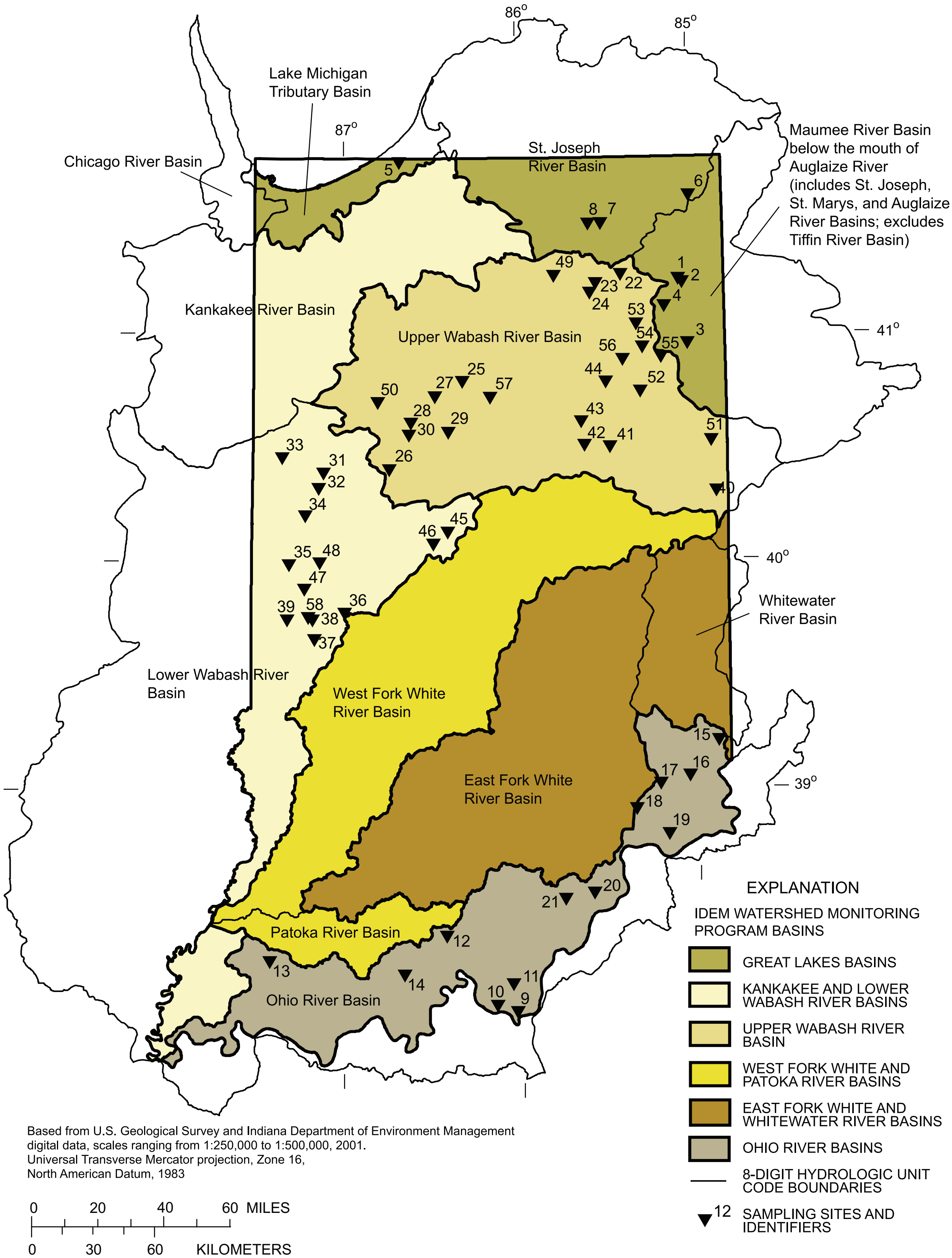

Figure 1. Location of the Indiana Department of Environmental Management (IDEM) Watershed Monitoring Program major basins and the 58 sampling sites, 1998–2000. (Site list and description in appendix 1.)

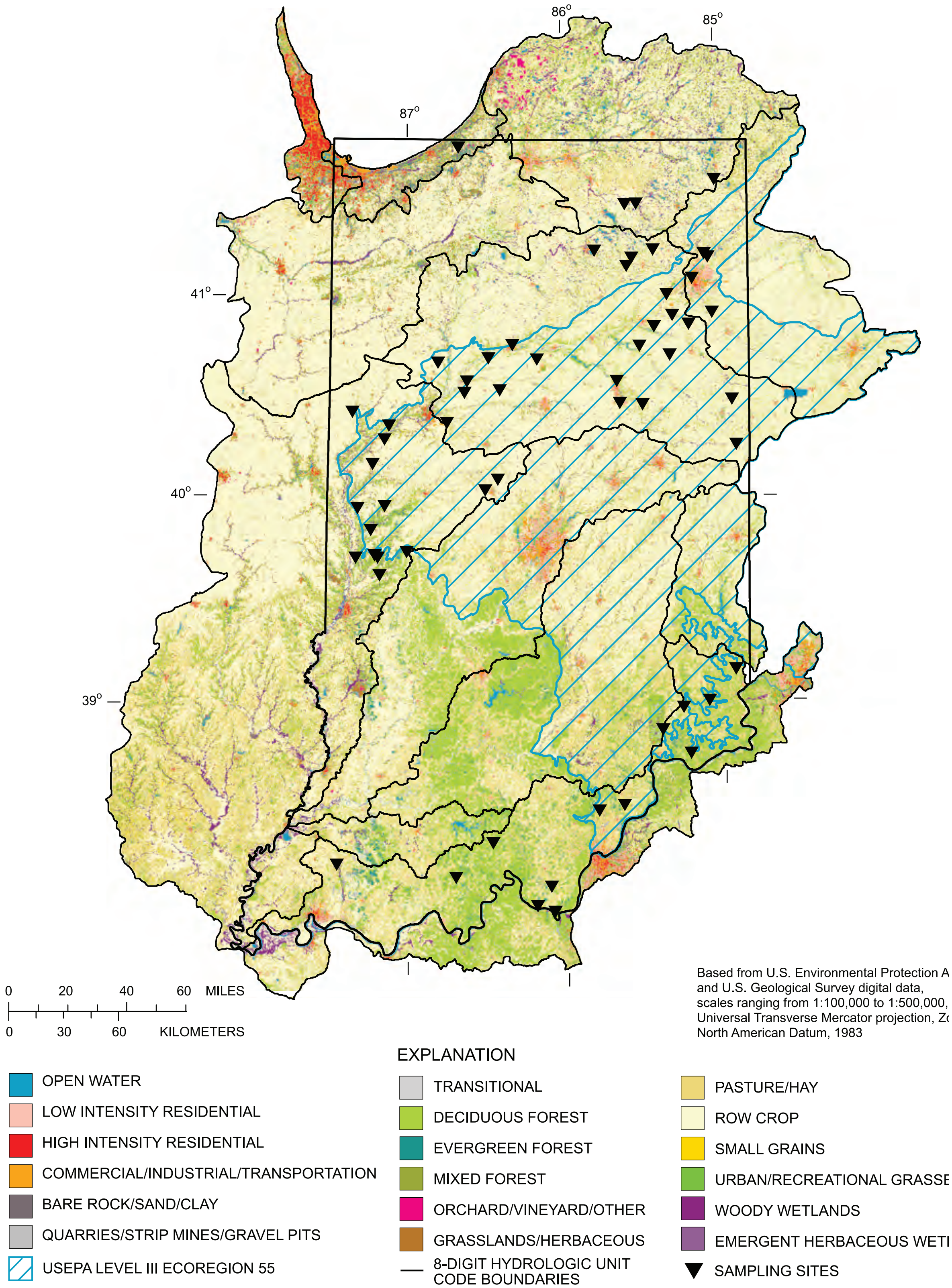

Figure 2. Land use for the Indiana Department of Environmental Management Watershed Monitoring Program major basins and the 58 sampling sites, 1998–2000. (Data from U.S. Environmental Protection Agency [USEPA], 1997b and U.S. Geological Survey, 2000; site identifiers on figure 1; site list and description in appendix 1.)

Table 1. Land use associated with the major basins of the Indiana Department of Environmental Management Watershed Monitoring Program.

Basin[1]	Land use (percent)[2]			
	Agriculture	Forest	Urban	Other
Upper Wabash River	88.8	6.9	1.8	2.5
Lower Wabash River	81.3	12.4	1.5	4.9
Great Lakes				
Lake Michigan tributaries	39.9	27.4	18.1	14.7
St. Joseph River	71.7	16.4	3.5	8.4
Maumee River	86.6	8.1	3.2	2.2
Ohio River	51.0	38.5	5.8	4.7

[1] Indiana Department of Environmental Management (1999).

[2] As compiled by the U.S. Geological Survey (2000). See Basin-Characteristics Data section and appendix 3 for details.

higher stream velocities. The soils are formed in thin loess to moderately thick loess over loamy glacial till. Alluvial and outwash deposits are present along the main stem of the Wabash River. The topography south of the main stem of the river is till plain and moraines of loam till. To the north of the river, the topography is characterized by morainic ridges and plain, with interspersed ice-disintegration forms, dunes, and lake flats (Clark, 1980).

The Great Lakes Basins include the tributaries to Lake Michigan Basin (1,873 km^2), the St. Joseph River Basin (12,157 km^2), and the Maumee River Basin (10,218 km^2) (Steeves and Nebert, 1994). The St. Joseph River drains into Lake Michigan and the Maumee River drains into Lake Erie.

Tributaries to the Lake Michigan Basin include small streams draining portions of northwestern Indiana, northeastern Illinois, and southwestern Michigan. Within Indiana the drainage area of the tributaries to the Lake Michigan Basin is 1,422 km^2 (Steeves and others, 1994). The land use is 39.8 percent agriculture, 27.4 percent forest, 14.6 urban, and 18.1 percent other (table 1). This part of Indiana is more industrialized than the other basins. The soils are sandy and loamy lacustrine deposits and eolian sand. The topography ranges from low, flat, poorly drained clay and till to rolling, hummocky, clayey till on uplands (Clark, 1980).

The Maumee River Basin drains portions of northeastern Indiana and northwestern Ohio. In Indiana the drainage area of the Maumee River Basin is approximately 5,715 km^2 (Steeves and Nebert, 1994). Much of the drainage for this basin is in Ohio. Land use in the basin is 86.6 percent agriculture, 8.1 percent forest, 3.2 percent urban, and 2.2 percent other land uses (table 1). The soils are silty and clayey lacustrine deposits adjacent to the Maumee River and clayey glacial till adjacent to the St. Joseph and St. Marys Rivers. The topography in the Maumee River Basin is flat, poorly drained till-plain bed of glacial deposits (Clark, 1980).

The St. Joseph River Basin drains portions of northern Indiana and southern Michigan. Within Indiana the St. Joseph River Basin drains approximately 9,485 km^2 (Hoggatt, 1975). In this study, while the sample sites were located within Indiana, the basin included the streams that originated in Michigan and flow into Indiana and streams that flowed into the main stem of the St. Joseph River at the Michigan/Indiana state line. Land use in the basin is 71.7 percent agriculture, 16.4 percent forest, 3.5 percent urban, and 8.4 percent other land uses (table 1). Lakes and wetlands are scattered throughout the area. Most of the soils are from alluvial and outwash deposits. The rest of the soils in the area are loamy glacial till in origin. The topography is complex interlobate loam till and outwash moraine topography with interspersed lakes, bogs, and glacial-drainage troughs and plains (Clark, 1980).

The Ohio River Basin drains an area of 18,023 km^2 of small unconnected streams that drain directly into the Ohio River (Steeves and Nebert, 1994). The area is 51.0 percent agricultural; however, unlike the rest of Indiana, more agricultural acreage in the basin is dedicated to pasture and hay than to corn and soybean row crops (table 1). Forested land covers 38.5 percent of the area, urban 5.8 percent, and other land uses 4.7 percent of the area. The soils are formed in discontinuous loess over weathered bedrock (limestone and shale in the east and sandstone and shale in the west). In this region, hilltop deposits of glacial till may be only a few feet thick and the larger valley-till deposits may reach 30 m or more. The eastern part of the basin is characterized by steep hills of strong to moderate relief and greater dissected streams than the other parts of the Basin. The central part of the basin is characterized by broad plains and uplands with thin, patchy till. The western part of the basin is characterized by rolling plains and more-moderate relief. Broad valley flats are underlain by thick deposits of alluvium, outwash, and lake deposits (Clark, 1980).

Overall, the basin areas of the 58 IDEM sampling sites ranged from 1.3 to 1,668 km^2, with a median of 63.4 km^2 (appendix 2). Almost half of the sites were headwater (< 52 km^2) or close to headwater in size. The land use in the 58 sampling-site basins was heavily agricultural, with little forest, urban, or other land uses. The agricultural land use ranged from 26.8 to 99.1 percent agriculture and had a median of 84.5 percent agriculture (appendix 2). The forest land use ranged from 0.4 to 69.3 percent forest and had a median of 9.6 percent forest. The urban land use ranged from 0.0 to 35.4 percent urban and had a median of 0.5 percent urban.

Site Selection and Study Methods

Data from one IDEM surface-water monitoring program was used in this report—the Watershed Monitoring Program (WMP) (Indiana Department of Environmental Management, 1998). IDEM has collected nutrient, habitat, and biological-community data through other programs; however, this program was selected because the WMP data represent assessments of nutrients, habitat, and concurrent biological-community data.

Watershed Monitoring Program of the Indiana Department of Environmental Management

The WMP data-set contains the largest number of sites in the IDEM data base that have, with the exception of basin characteristics, all of the parameters of interest for this study: nutrient, habitat, basin-characteristics, and fish- and invertebrate-community data. The WMP began in 1996 as a result of the Surface Water Quality Monitoring Program developed by IDEM in assessing the State's waters (Indiana Department of Environmental Management, 1998). The WMP works on a 5-year rotating basin cycle, focusing on selected basins each year of the cycle, with a complete assessment of the State completed at the end of each 5-year cycle. The 5-year rotating cycle divides the basins in Indiana into five groups (Indiana Department of Environmental Management, 1999):

– West Fork White River and Patoka River Basins
– East Fork White River and Whitewater River Basins
– Upper Wabash River Basin
– Lower Wabash River and Kankakee River Basins
– Great Lakes and Ohio River Basins

For this study, data were used from the Upper Wabash River Basin collected in 1998, the Lower Wabash River in 1999, and the Great Lakes and Ohio River Basins in 2000.

Each year of the cycle, sampling sites within the targeted basins are selected randomly by the USEPA. Each selected sampling site represents a specific stream order; therefore, statistically valid extrapolations can be made from the randomly sampled streams to the entire class of streams in each basin. For statistical purposes, approximately 50 sites are sampled in each basin; some streams go dry during the summer, reducing the total number of samples collected.

Typically, the WMP collects samples during stable flow for nutrients three times from May through October. These samples represent seasonal changes; the first sampling is in May and June, the second sampling in July and August, and the third sampling in September and October. Water samples are analyzed for anions, metals, nutrients, organics, and physical parameters. The WMP also includes biological-community assessments one time at the same sites; these typically are completed between June and September. Depending on weather and number of sites sampled, the biological-community assessment may extend into October.

Field Methods of the Indiana Department of Environmental Management

The nutrient, habitat, and biological-community data used in this report was collected by IDEM between 1998 and 2000. The following methods were used by IDEM personnel.

Nutrients

Nutrient samples (ammonia, TKN, nitrate, and TP) were collected three times per sampling site between May and October by IDEM personnel following approved IDEM methods (Beckman, 2000). Nutrient quality-assurance methods followed approved IDEM methods (Bowren and Ghiasuddin, 1999). The nutrient samples were preserved by an IDEM scientist, placed on wet ice, and taken to an independent laboratory (Test America in Indianapolis) for analysis.

Biological Communities

Fish- and invertebrate-community assessments followed IDEM methods (Indiana Department of Environmental Management, 1992 and 1999). Biological communities (fish and invertebrate) were assessed one time from mid summer to early fall (June through October) as part of the WMP. After the assessments were completed, community attributes and metric scores were calculated for the fish- and invertebrate-community data and metrics scores were determined by IDEM personnel (Simon, 1991; Dufour, 2002). Approximately 10 percent of the sites were sampled a second time during the same year as part of the quality-assurance plan. The community attributes and metric scores describing the fish- and invertebrate-community data are listed in appendix 5.

Habitat

Habitat was assessed by IDEM following approved methods (Indiana Department of Environmental Management, 2002). Habitat assessments were made each time fish communities were sampled. Habitat assessments include in-stream and riparian measurements that are incorporated into the Qualitative Habitat Evaluation Index (QHEI). The habitat parameters are listed in appendix 7.

Basin-Characteristics Data

The basin-characteristic data included drainage area, land use, and soils and were determined by the USGS for this study. Drainage area was derived from the basin boundaries. Basin boundaries for each site were generated following the method outlined by Ries, III, and others (2004). This method combines the National Elevation Dataset, Digital Elevation Model data, and the National Hydrography Dataset, which is a comprehensive set of digital surface-water features. The basin boundaries were used to extract land-use and soil information from the National Land Cover Dataset (NLCD) (U.S. Geological Survey, 2000) and a raster-data version of the State Soil Geographic (STATSGO) Database (Schwartz and Alexander, 1995) for each sampling site.

Land-use parameters, generated from the NLCD extraction, comprise 21 individual land-use categories; 19 of these categories were found in Indiana, and 18 of these categories were in sampling-site basins. Major land-use categories in the NLCD include water, developed, barren, forested upland, shrubland, non-natural woody, herbaceous upland natural/semi-natural vegetation, herbaceous planted/cultivated, and wetlands. All of the major and individual land-use categories were included as parameters for this analysis (appendix 3). STATSGO, a generalized soil database, was used for soils information because more detailed, digitized county-level soil data were not universally available for Indiana. From the STATSGO database, soil parameters were extracted for each sampling site (appendix 4). Some of the soil parameters include available-water capacity, bulk density, clay content, drainage quality, organic-material content, soil-erodibility factor, and soil permeability.

Nutrient Data

As part of the IDEM WMP, water samples are collected and analyzed for chemical and physical parameters. The nutrients include dissolved ammonia as nitrogen, dissolved nitrate plus nitrite as nitrogen, total Kjeldahl nitrogen as nitrogen (TKN), total nitrogen as nitrogen (TN), and total phosphorus as phosphorus (TP). Because concentrations of nitrate typically are two orders of magnitude greater than nitrite and because nitrite usually does not exceed 0.5 mg/L in surface water (National Research Council, 1978), concentrations of nitrite plus nitrate are referred to as nitrate in this report. Concentrations of total nitrogen (TN) were calculated as the sum of TKN and nitrate. Almost all of the ammonia data were censored below the reporting levels. For nutrient analyses, the scope of this report is narrowed to nitrate, TKN, TN, and TP.

In most cases, the WMP data set contains nutrient values from three periods. In general, these three periods represent spring (May and June), summer (July and August), and fall (September and October). For this study, the single discrete samples from each sampling site representing the summer data were selected for analysis (appendix 6). The selection provided several benefits. Excluding data collected from spring and fall allowed removal of some of the seasonal variability that could confound relations with the biological data. Also, the water-quality data collected in the summer produced 58 sites with complete nitrate, TKN, and TP data; the spring and fall yielded only 33 and 28 sites, respectively, with complete nitrate, TKN, and TP data.

Another approach could have been to analyze only those sites where complete nutrient data were available for all three seasons—spring, summer, and fall. A review of the WMP data, however, revealed there were only 22 sites that met these criteria. These 22 sites did not provide a broad enough geographical distribution or a robust enough data set to justify this approach.

Data Analysis

In large environmental datasets, natural variability often masks the relations between parameters. Multivariate techniques, including ordination analysis, are often used to identify relations among parameters. An objective of this report was to develop an understanding of the relations among biological-community and environmental parameters from historical data collected by IDEM. In this report, the environmental parameters include the nutrient, habitat, and basin-characteristics data. The environmental parameters and biological-community data were analyzed using ordination and regression techniques. Multivariate techniques used in this report included correspondence analysis (CA) and canonical correspondence analysis (CCA). The CA explored patterns in the community data from site to site and species to species, the CCA examined patterns between the community data and selected environmental parameters. Regression methods examined the relations among CA site scores to nutrient data.

The purpose of this preliminary analysis was to determine which relations require further investigation. In the preliminary analysis of these data, the goal is to investigate all potential relations and identify which relations were the strongest. In this report, for a relation to be considered statistically significant using CA, the Pearson correlation coefficient (r) was required to be greater than the absolute value of 0.27 at a 95 percent significance level based on the sample size. Although a Pearson correlation coefficient of 0.27 is considered significant, it has a greater probability of introducing a Type I error. For this report, Pearson correlation coefficients greater than an absolute value of 0.45 are considered strong relations and between 0.27 and 0.45 are considered weak relations.

The multivariate analysis was completed on two biological-community data sets (fish and invertebrates) and

64 environmental parameters that included basin characteristics (appendix 2), habitat (appendix 7), nutrients (appendix 6), and soils (appendix 8). The two biological-community (invertebrate and fish) datasets were square-root transformed and the environmental dataset was normalized to a z-score prior to use in the data analyses, allowing for comparison of parameters that were recorded in different units.

Correspondence Analysis

A CA is an indirect gradient analysis based on the unimodal response of biological-community data among the sites and species (Gauch, 1982; Jongman and others, 1995; McCune and Grace, 2002). CA uses weighted averages of the species and site data to calculate site scores. The site scores determined by CA are a theoretical numeric representation of how the sites and species relate to one another. The site scores for similar species are close together and dissimilar species are far apart; similar sites are close together and dissimilar sites are far apart. The unimodal response means that large positive or negative species scores imply favorable conditions to the species at either end of the CA axis. One shortcoming with CA is the potential effects of rare species. The effects of reciprocal averaging can have adverse results on the site scores. For example, sites with a few rare species and overall similar communities could have site scores that are very different. This would place them on opposite ends of a community gradient even though the sites are more biologically similar than dissimilar. Either rare species need to be removed, or their influence reduced using a technique termed downweighting. Because this was a preliminary analysis, rare species were not removed in order to retain the most data in the analysis. Instead, rare species were downweighted. Another shortcoming with CA is the second axis may be a quadratic distortion of the first axis, termed the “arch effect”; to counter this possibility only the first axis was related to the nutrients data (Gauch, 1982).

The CA site scores often are related to environmental data because it is an indirect gradient analysis. Consequently, the biological response on a CA axis is inferred from ecological knowledge of the biological community composition. In some cases these relations are quite obvious. For example, if the gradient on the first axis was influenced by basin or stream size, the fish community would have headwater species (minnows or darters) with negative species scores and large river species (suckers or gars) with positive species scores. In some cases these patterns may not be clear; relating the CA site scores shows which parameter has the strongest relation to the site scores and other relations that are influencing the biological community (Jongman and others, 1995). Only the CA sites scores from the first axis (CA1) were related to the environmental data because the CA1 best explains the biological (fish and invertebrate) data.

The CA site scores were related to four nutrients, 32 fish and 21 invertebrate-community attributes/metric scores, using Statistical Analysis System (SAS) (Statistical Analysis System, version 9.1.3, 2003). Prior to the regression analysis, data were normalized, so the Pearson correlation (r) was chosen as the regression analysis because of the large sample size and the normally distributed dataset. The regression analysis in this report is intended as an exploratory technique to determine multiple lines of evidence for future nutrient and biological community studies; the relations presented are uncorrected Pearson correlation coefficients.

Bonferroni, or other correction techniques, are often recommended when presenting regression results with multiple correlations. This adjustment reduces the chance of a Type I error (the relation is declared present when the relation is not present) at a specific alpha level. This technique, although useful, has a drawback. If the chance of producing a Type I error is reduced, the chance of producing a Type II error (no relation declared when relation is present) is increased. Because this is a preliminary analysis and there were a limited number of significant relations, Bonferroni corrections were not applied.

Canonical Correspondence Analysis

Because the CA only accounts for variation within the biological communities and the regression analysis accounts for variations between two parameters, a third multivariate procedure, CCA was completed. The CCA relates the biological-community data to the environmental parameters by using a direct gradient analysis that identifies linear combinations of environmental parameters; it maximizes the majority of variation within the data to show which environmental parameters are most related to the biological community (Jongman and others, 1995; McCune and Grace, 2002). The relations between the biological communities and environmental parameters with the highest CCA regression/canonical coefficients (c_j) are most influential in explaining the composition of the biological structure (ter Braak and Smilauer, 2002). One requirement with the CCA is that the number of environmental parameters must be one less than the number of samples (sites); in this study, 64 environmental parameters were evaluated. The automatic forward selection procedure in CANOCO 4.5 (ter Braak and Smilauer, 2002) was used to decrease the number of environmental parameters. This procedure used a Monte Carlo Permutation Test with unrestricted permutations to determine the top 5 of the 64 environmental parameters that accounted for the majority of the variation (had the highest c_j values) within the environmental data as they relate to the biological-community data.

Eigenvalues and species-environment correlations were determined for the first two axes. Eigenvalues of each CCA axis determine the relative importance of each axis to explain the data set; when compared to the sum of all eigenvalues, they indicate how much of the total dispersion of all data is explained by the CCA axis. For example, sites with high eigenvalues will be distributed along a wide range on an axis and sites with low eigenvalues will be distributed along a narrow range. Higher eigenvalues equates to greater diversity, for example, the biological data among the sites are dissimilar; lower eigenvalues indicate the majority of the biological communities are similar among the sites. Species-environment correlation indicates how well the recorded environmental data explain the structure of the data set (ter Braack and Smilauer, 2002). Higher species-environment correlations indicate a greater explanation of the dispersion of the biological community data to the environmental parameters.

Nutrient, Habitat, and Basin-Characteristics Data and Relations with Fish and Invertebrate Communities

This section will describe the fish- and invertebrate-community composition at the 58 sites used in the analysis. Next, this section will show the significant relations between nutrients and the biological-community data and then assess which nutrients, basin characteristics, and habitat parameters most influence the biological communities.

In the fish- and invertebrate-community composition sections two analyses were done. First, taxa were classified on frequency of collection; taxa were labeled as rare if collected at 1 to 3 sites, common if collected at 4 to 28 sites, and very common if collected at greater than 29 sites. Second, the taxa most often found at sites were assessed as to whether they indicated nutrient enrichment. In this report the term taxa is used as the lowest taxonomic level defined, for example generally fish are identified to species and invertebrates to family level.

Fish-Community Composition

A total of 13,253 individuals and 88 taxa (appendix 9) were collected at the 58 sites, representing 86 species and two hybrids. Of the 88 taxa collected, 40 taxa were rare. Of the rare species collected, 21 species and 1 hybrid (orangethroat/rainbow darter) were collected at one site, 7 species were collected at two sites, and 10 species and 1 hybrid (hybrid sunfish) were collected at three sites. Of the 88 taxa collected, 39 species were common, and 9 species were very common.

At the 58 sites where fish communities were assessed, three species accounted for nearly half of the total number of fish collected. Creek chubs (*Semotilus atromaculatus*) were most abundant with 1,992 individuals collected at 48 sites (15.0 percent of the total number of individuals), followed by bluntnose minnow (*Pimephales notatus*) with 1,437 individuals collected at 42 sites (10.8 percent of the total number of individuals) and central stonerollers (*Campostoma anomalum*) with 1,395 individuals collected at 31 sites (10.5 percent of the total number of individuals). At least one fish was collected at all 58 sites but no single fish specie was collected at all 58 sites. The majority of rare species were collected from small headwater sites, < 52 km^2, or from large river sites. The three most-abundant fish species are indicators of stressed habitats (Simon, 1991) and suggest the majority of sites were impacted streams. All three species are omnivores (creek chubs and bluntnose minnows) or algavores (central stonerollers) and benefit from increased algal growth (Petersen and Femmer, 2002).

Invertebrate-Community Composition

A total of 10,449 individuals and 62 taxa (appendix 10) were collected at the 58 sites. Of the 62 identified taxa, 31 taxa were rare. Of the rare species collected, 15 taxa were collected at one site, 11 of the rare taxa were collected at two sites, and 5 of the rare taxa were collected at three sites. Of the 62 identified taxa, 22 taxa were common and 9 taxa were very common.

At the 58 sites where invertebrate communities were assessed, three families accounted for 62 percent of the total number of invertebrates collected. *Chironomidae* taxa were the most abundant with 3,230 individuals collected at 58 sites (30.9 percent of the total number of individuals), followed by *Hydropsychidae* taxa with 2,110 individuals collected at 56 sites (20.2 percent of the total number of individuals), and *Elmidae* taxa with 1,098 individuals collected at 55 sites (10.5 percent of the total number of individuals). The only family collected at all 58 sites was *Chironomidae* taxa. The invertebrate-community composition was typical of nutrient-rich agriculturally dominated streams.

Nutrient Relations to the Biological-Community Attributes, Metric Scores, and Site Scores

When the 58 sites were analyzed, there were six statistically significant but weak relations among the nutrient concentrations and the biological-community attributes, metric scores, and CA site scores. Nitrate was related to two fish parameters, carnivore percent ($r = -0.3017$), sucker species count ($r = -0.3031$). Nitrate was not related to the invertebrate parameters. TKN was not related to the fish parameters; however, it was related to one invertebrate parameter, ephemeroptera, plecoptera, and trichoptera (EPT) to chironomid ratio ($r = -0.3023$). TN was related to three fish parameters, carnivore percent ($r = -0.2981$), sucker species count ($r = -0.3200$), and tolerant percent metric score ($r = -0.2758$). TN was not related to the invertebrate parameters. TP was not related to the fish and invertebrate parameters.

Strong relations between nutrients and biological-community attributes and metrics were not observed. Because the Bonferroni corrections were not applied, the weak relations, although significant, may be Type I errors. Given this limitation in the analysis, several generalizations can be made, including (1) other factors, such as basin size, habitat, land use, or soil (which were not included in the preliminary analysis) are driving the community response; (2) the biological communities are statistically related to nutrients; and (3) both fish- and invertebrate-community attributes/metrics could be important parameters when assessing nutrients.

Relations of the Biological Community to the Environmental Parameters

The strength of the fish CCA regression/canonical coefficient for normalized parameters (c_j) of the first axis for the 58 sites (table 2) showed that of the selected environmental parameters used in the analysis, the fish community was most influenced by habitat (reach gradient, c_j = –0.6695) and land use (drainage area, c_j = 0.5903; transitional area, c_j = 0.3079). The eigenvalues for the fish CCA were 0.301 (axis 1) and 0.226 (axis 2), and the species-environment correlation was 0.873 for the first axis. Based upon the strength of these CCA regression/canonical coefficientss, the findings suggest that the fish-community composition is influenced mainly by habitat and land use rather than nutrients.

Table 2. Summary of the regression/canonical coefficients for the first axis canonical correspondence analysis of nutrient, habitat, basin-characteristics relations to the fish and invertebrate communities for the Indiana Department of Environmental Management Watershed Management Program 58 sampling sites, 1998–2000.

[c_j, regression/canonical coefficient for normalized parameters[1]; QHEI, Qualitative Habitat Evaluation Index; —, no parameters chosen in the Canoco forward selection procedure]

Category	Parameter	c_j
	Fish	
Habitat	Reach gradient	–0.6695
	Segment gradient	.0159
Nutrients	—	—
Land use	Drainage area	.5903
	Transitional area	.3079
	Commercial area	.0546
Soils	—	—
	Invertebrates	
Habitat	QHEI score	–.5129
Nutrients	Total Kjeldahl nitrogen	.3276
Land use	Small grains	–.2473
Soils	Percent hydrogroup CD	.6577
	High percent clay	.4761

[1](ter Braak and Smilauer, 2002)

The invertebrate CCA of the 58 sites (table 2) showed that of the selected environmental parameters used in the analysis, the invertebrate community was influenced by land use (small grains, c_j = –0.2473), soils (percent hydrogroup CD, c_j = 0.6577; high percent clay, c_j = 0.4761), habitat (Qualitative Habitat Evaluation Index [QHEI] score, c_j = –0.5129), and one nutrient (TKN, c_j = 0.3276). The eigenvalues for the invertebrate CCA were 0.118 (axis 1) and 0.083 (axis 2), and the species-environment correlation was 0.828 for the first axis. The low eigenvalues suggest the invertebrate-community composition is similar from site to site and the differences are most influenced by habitat, land use, soils, and the nutrient TKN. The strongest influences to the invertebrate community can be attributed to habitat, land use, and soils with low permeability (high clay content) and high runoff potential (hydrogroup CD); however, the invertebrate communities also had a significant but weak relation with the nutrient TKN. It is possible that the strongest relations of nutrients and biological-community parameters could be observed on the second or third CCA axes; future analysis might look at more than the first CCA axis.

The lack of relations or the presence of weak relations of nutrients to the biological-community parameters were found in the CA and CCA analyses. The CCA (fish and invertebrate) showed the biological communities were driven more by physical characteristics of the sites than by nutrient concentrations. A subset of the 58 sites was used to try to improve the strength of relations between nutrients and biological communities. Both of the CCAs suggested that stream size (or basin size) and physical characteristics (habitat) were strongly influencing the biological communities. To reduce the variability associated with habitat and basin size in the analysis, a subset of eight headwater sites (drainage area, <52 km^2) from the same ecoregion were analyzed, following the same methods as the 58 site analysis. Other studies that used multivariate techniques have shown that naturally occurring variability (such as stream size, latitude, and ecoregion) within biological communities can mask the effects of environmental parameters (such as nutrients) (Wang and others, 1997; Carpenter and Waite, 2000).

The subset of the 58-site data set collected in 1998 by IDEM consisted of eight headwater streams within the Upper Wabash River Basin and USEPA Level III Ecoregion 55 (appendix 1). First, CA site scores were calculated for the eight sites, and Pearson correlations then were calculated from the subset. This task was completed to determine if the subset would increase relations of nutrients to the biological communities. Because of the small sample size, for a relation to be considered statistically significant, the absolute value of the Pearson correlation coefficients were required to be greater than 0.67 (p-value <0.05).

The Pearson correlations from the eight Upper Wabash River Basin sites showed more statistically significant relations than the 58-site analysis did (table 3). Nitrate was related to three fish parameters, CA axis 2 site score (r = 0.6962), simple lithophil percent (r = 0.8061), and simple lithophil percent metric score (r = 0.8474); nitrate was not related to the invertebrate parameters. TKN was related to two fish parameters, tolerant percent (r = –0.7036) and tolerant percent metric score (r = 0.7522) and three invertebrate parameters, EPT to total ratio (r = 0.8422), EPT count metric score (r = 0.6871), EPT to total ratio metric score (r = 0.8438). TN was related to three fish parameters, CA axis 1 score (r = –0.7257), simple lithophil percent (r = 0.8000), and simple lithophil percent metric score (r = 0.8815); TN was not related to the invertebrate parameters. TP was not related to the fish parameters but was related to several invertebrate parameters, dominant taxa percent (r = –0.6985), EPT index (r = 0.7882), EPT to

Table 3. Significant[1] Pearson correlations of nutrients to the biological-community attributes, metric scores, and site scores at eight headwater sites, Upper Wabash River Basin, Indiana, 2000.

[r, Pearson correlation coefficient; EPT, ephemeroptera, plecoptera, and trichoptera; MIBI, macroinvertebrate Index of Biotic Integrity; HBI, Hilsenhoff Biotic Index; CA, correspondence analysis; —, no significant relations]

Nutrient	Attribute/metric	r
	Fish	
Nitrate	CA axis 2 site score	0.6962
	Simple lithophil percent	.8061
	Simple lithophil percent metric score	.8474
Total Kjeldahl nitrogen	Tolerant percent	–.7036
	Tolerant percent metric score	.7522
Total nitrogen	CA axis 1 site score	.7257
	Simple lithophil percent	.8000
	Simple lithophil percent metric score	.8815
Total phosphorus	—	—
	Invertebrates	
Nitrate	—	—
Total Kjeldahl nitrogen	EPT to total ratio	.8422
	EPT to total ratio metric score	.8438
	EPT count metric score	.6871
Total nitrogen	—	—
Total phosphorus	Dominant taxa percent	–.6985
	EPT index	.7882
	EPT index metric score	.7086
	HBI score	–.8336
	HBI metric score	.7999
	EPT to total ratio	.7821
	EPT to total ratio metric score	.8400
	EPT to chironomid ratio	.7198
	EPT to chironomid ratio metric score	.7495
	MIBI metric score	.7801
	CA axis 1 site score	–.7658

[1]Absolute Pearson correlation coefficients greater than 0.67 are considered significant with a sample size of 8.

chironomid ratio (r = 0.7198), EPT to total ratio (r = 0.7821), Hilsenhoff Biotic Index (HBI) score (r = –0.8336), CA axis 1 score (r = –0.7658), EPT index metric score (r = 0.7086), EPT to chironomid ratio metric score (r = 0.7495), EPT to total ratio metric score (r = 0.8400), HBI metric score (r = 0.7999), and Macroinvertebrate Index of Biotic Integrity (MIBI) metric score (r = 0.7801). The findings from the subset of headwater streams suggest the relations between nutrients and biological communities can be strengthened by removing the naturally occurring variability in the data associated, in this case, with basin size and ecoregion. Both fish- and invertebrate-communities show the effects of nutrients in headwater streams of the Upper Wabash River Basin within USEPA Level III Ecoregion 55. In this analysis, TP was related to more attributes and metric scores than other nutrients and the invertebrate community was related to more nutrients than the fish community.

When the eight-site fish CCA was evaluated (table 4), it showed that of the 64 environmental parameters used in the analysis, the fish community was most influenced by land use (agriculture, c_j = –0.7127) and soils (percent hydrogroup A, c_j = 0.2798; percent hydrogroup B, c_j = 0.1871); two nutrients became significant (total phosphorus, c_j = –0.2167; nitrate, c_j = 0.0573). The eigenvalues for the fish CCA improved to 0.620 (axis 1) and 0.535 (axis 2), and the species-environment correlation was 0.997 for the first axis. These findings suggest that when the naturally occurring variation is removed (in this case drainage area and ecoregion), the effects of nutrients can be seen in the fish-community composition.

When the eight-site invertebrate CCA was evaluated (table 4), it showed that of the 64 environmental parameters used in the analysis, the invertebrate community was most influenced by soils (percent hydrogroup BD, c_j = 0.7054; percent hydric soils, c_j = – 0.4788), habitat (riffle/run percent score, c_j = –0.5125), land use (woody wetlands, c_j = –0.4788), and nutrients (TKN, c_j = –0.6769). The eigenvalues for the invertebrate CCA improved to 0.344 (axis 1) and 0.258 (axis 2), and the species-environment correlation was 0.972 for the first axis. The majority of the influences to the invertebrate community still were attributed to habitat, land use, and soils. The strength of the nutrient relation (TKN), however, improved from a c_j of 0.3276 to –0.6769.

Table 4. Summary of the regression/canonical coefficients for the first axis canonical correspondence analysis of nutrient, habitat, basin-characteristics relations to the fish and invertebrate communities for the Indiana Department of Environmental Management Watershed Management Program of the eight headwater sites, Upper Wabash River Basin, Indiana, 1998.

[c_j, regression/canonical coefficient for normalized parameters[1]; QHEI, Qualitative Habitat Evaluation Index; —, no parameters chosen in the Canoco forward selection procedure]

Category	Parameter	c_j
	Fish	
Habitat	—	—
Nutrients	Total phosphorus	–.2167
	Nitrate	.0573
Land use	Agriculture	–.7127
Soils	Percent hydrogroup A	.2798
	Percent hydrogroup B	.1871
	Invertebrates	
Habitat	Riffle/run percent score	–.5125
Nutrients	Total Kjeldahl nitrogen	–.6769
Land use	Woody wetlands	–.4788
Soils	Percent hydrogroup BD	.7054
	Percent hydric soils	–.4788

[1](ter Braak and Smilauer, 2002)

Summary

The water-quality criteria for nutrients proposed by USEPA established TN and TP as causal parameters and periphyton and seston CHLa and turbidity as response parameters. Few CHL*a* data, however, were available when the proposed criteria were developed. Because of the lack of CHL*a* data, this analysis focused on the relations of nutrients and biological communities, using existing data. A previous study by the Ohio Environmental Protection Agency of the effects of nutrients on biological communities in Ohio found few relations between nutrients and fish- and invertebrate- community data. Only TP was significantly correlated with any of the fish- or invertebrate attributes or metrics (fish IBI scores in headwater streams).

This study found that although nutrients may be affecting stream-water quality, most variation in the biological communities is explained by habitat, land use, and drainage-basin size. When all the data are assessed, the naturally occurring variability associated with habitat, land use, and drainage-basin size masks the relations between nutrients and the biological communities. In the 58-site analysis, no nutrients were in the top five parameters (had the highest c_j) in explaining the variability in the fish community; in the invertebrate community only TKN was weakly related. When the 8-site subset of headwater streams from one ecoregion was assessed, habitat and land use still explained the most variability. TP and nitrate, however, became two of the top five parameters for the fish community and the relation for TKN was strengthened. Future studies need to take into account naturally occurring parameters such as habitat, land use, and drainage-basin size that can mask the relations of nutrients on biological communities.

Of all the environmental parameters, drainage-basin size appears to have a significant impact on the biological-community data. Multivariate analysis showed that drainage-basin size was one of the most statistically significant parameters affecting fish-community composition. There were no statistically significant relations between drainage-basin size and invertebrate-community attributes, metric scores, or site scores. Habitat parameters such as gradient and the pool to glide metric score also were significantly related to the fish-community data but not to the invertebrate-community data.

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Appendixes 1–10

1. Description of the 58 Indiana Department of Environmental Management Watershed Monitoring Program Sampling Sites, 1998–2000
2. Basin Characteristics of the 58 Sampling Sites
3. Land-Use Categories Used for the 58 Sampling Sites
4. Soil Parameters Used for Basin Characteristics of the 58 Sampling Sites
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10. Invertebrate-Community Data for the 58 Sampling Sites

Appendix 1. Description of the 58 Indiana Department of Environmental Management Watershed Monitoring Program Sampling Sites, 1998–2000.

[IDEM, Indiana Department of Environmental Management; Rd, road; Ave, avenue; CR, county road; SR, state road; St, street; Ln, Lane; Mt, mount; bold text indicates sites that were used in subset data analysis; RR, railroad; US, U.S. highway; D/S, downstream; I-65, Interstate-65; IN, Indiana]

Site number	IDEM site number (LSITE)	Stream name	Location short description	Latitude	Longitude
1	LEJ090-0001	Cedar Creek	Hursh Rd — Probabalistic	41.22277	–85.06806
2	LEJ090-0003	Cedar Creek	Hardisty Rd	41.20693	–85.04629
3	LES050-0001	Unnamed Tributary of St. Marys River	Brunson Rd	40.938	–85.01929
4	LES060-0002	Spy Run Creek	Mildred Ave	41.10329	–85.15143
5	LMG100-0001	South Branch Galena River	CR 900 N	41.73992	–86.68486
6	LMJ110-0001	Pigeon Creek	CR 400 S	41.58624	–84.99785
7	LMJ170-0001	North Branch Elkhart River	CR 450 W	41.46932	–85.51299
8	LMJ190-0002	Elkhart River	SR 5 Pigeon St	41.46629	–85.5869
9	OBS010-0001	West Branch Mosquito Creek	Brittany Ln	38.0132	–86.03892
10	OBS050-0001	Buck Creek	Lou Miller Rd	38.04149	–86.14941
11	OBS050-0002	Buck Creek	Lake Rd	38.13555	–86.06142
12	OBS180-0004	Camp Fork Creek	East Temple Rd	38.34688	–86.43075
13	OHP020-0002	Smith Fork Pigeon Creek	CR 800 E	38.23649	–87.41785
14	OLP060-0001	Middle Fork Anderson River	CR 37	38.17616	–86.66677
15	OML030-0001	Salt Fork	Mt Pleasant Rd	39.19599	–84.88794
16	OML040-0002	South Hogan Creek	Windsor Cemetery	39.04273	–85.05546
17	OML070-0002	Laughery Creek	Signor Hill Rd	39.01086	–85.22053
18	OSK030-0002	West Fork Indian Kentuck Creek	Camp Meeting Ground Rd	38.90065	–85.35699
19	OSK030-0003	Dry Fork	Run Rd	38.78859	–85.17805
20	OSK070-0002	Fourteenmile Creek	Dickey Rd	38.53416	–85.60299
21	OSK140-0002	Miller Fork	Caney Rd	38.50696	–85.7627
22	**WAE020-0006**	**Mud Run**	**CR 450 E**	**41.24472**	**–85.4025**
23	**WAE030-0001**	**Spring Creek**	**Scheckler Rd**	**41.20583**	**–85.54639**
24	**WAE030-0008**	**Schuman Ditch**	**Pennsylvania RR**	**41.16333**	**–85.58028**
25	**WAE070-0002**	**Tributary of Tick Creek**	**CR 300 E**	**40.77944**	**–86.3225**
26	**WAW040-0057**	**Unnamed Tributary of St. Marys River**		**40.39472**	**–86.74694**
27	**WDE020-0010**	**Keeps Creek**	**CR 600 W**	**40.71194**	**–86.48083**
28	WDE050-0003	Deer Creek	CR 300 N	40.59861	–86.61972
29	WDE050-0005	Little Deer Creek	CR 600 E	40.5575	–86.40667
30	**WDE050-0018**	**Bridge Creek**	**SR 18**	**40.545**	**–86.63306**

Appendix 1. Description of the 58 Indiana Department of Environmental Management Watershed Monitoring Program Sampling Sites, 1998–2000.—Continued

[IDEM, Indiana Department of Environmental Management; Rd, road; Ave, avenue; CR, county road; SR, state road; St, street; Ln, Lane; Mt, mount; bold text indicates sites that were used in subset data analysis; RR, railroad; US, U.S. highway; D/S, downstream; I-65, Interstate-65; IN, Indiana]

Site number	IDEM site number (LSITE)	Stream name	Location short description	Latitude	Longitude
31	WLV030-0004	Little Pine Creek	CR 450 N	40.3796	–87.12372
32	WLV030-0014	Opossum Hollow	CR 600 E	40.31158	–87.14952
33	WLV050-0007	Mud Pine Creek	Near SR 26 and US 41	40.44563	–87.36045
34	WLV100-0002	Turkey Run	CR 200 E	40.19087	–87.22613
35	WLV120-0003	Mill Creek	Tangier Rd	39.97744	–87.31958
36	WLV160-0003	Tributary of Big Raccoon Creek	CR 880 W	39.76463	–87.00142
37	WLV170-0014	Big Raccoon Creek	Bridgeton Covered Bridge	39.6492	–87.17348
38	WLV180-0029	Little Raccoon Creek	CR 200 S	39.73517	–87.18427
39	WLV190-0009	Big Raccoon Creek	1/2 mile D/S Mecca Covere	39.73398	–87.32942
40	WMI010-0008	Mississinewa River	CR 900 N	40.29139	–84.87139
41	WMI050-0003	Walnut Creek	CR 400 S	40.49	–85.47611
42	WMI050-0013	Mississinewa River	First St	40.49667	–85.62306
43	WMI060-0015	Hummel Creek	Bocock Rd	40.60139	–85.64111
44	WSA040-0012	Majenica Creek	CR 200 W	40.77472	–85.49528
45	WSU010-0007	Browns Wonder Creek	CR 250 E	40.11982	–86.41273
46	WSU020-0005	Prairie Creek	I-65	40.06727	–86.49432
47	WSU060-0005	Roaring Creek	SR 41	39.86974	–87.23127
48	WSU060-0017	Sugar Mill Creek	Lutheran Church Rd	39.98609	–87.14492
49	WTI020-0012	Deeds Creek	CR 300 E	41.24028	–85.78917
50	WTI150-0002	Big Creek	CR 300 E	40.68861	–86.80972
51	WUW050-0009	Limberlost Creek	185 E RD	40.51167	–84.895
52	WUW080-0006	Rock Creek	CR 400 W	40.73111	–85.2975
53	WUW100-0005	Aboite Creek	W Hamilton Rd	41.025	–85.31556
54	WUW110-0001	Witzgall Ditch	Feighner Rd	40.925	–85.28028
55	WUW110-0006	Eightmile Creek	CR 950 N , Ossian, IN	40.88	–85.17333
56	**WUW120-0010**	**Mud Creek**	**CR 300 E**	**40.87039**	**–85.39772**
57	WUW170-0003	Pipe Creek	CR 400 S	40.70806	–86.16278
58	WWE020-0014	Williams Creek	CR 80 E, 200 Meters N CR	39.74619	86.79199

Appendix 2. Basin Characteristics of the 58 Indiana Department of Environmental Management Watershed Monitoring Program Sampling Sites, 1998–2000.

[IDEM, Indiana Department of Environmental Management; km², square kilometer; bold text indicates sites that were used in subset data analysis]

Site number	IDEM site number (LSITE)	Stream name	Drainage area (km²)	Land use (percent)[1]			
				Agriculture	Forest	Urban	Other
1	LEJ090-0001	Cedar Creek	842.2	84.6	9.4	2.3	3
2	LEJ090-0003	Cedar Creek	849.9	84.5	9.6	2.3	3
3	LES050-0001	Unnamed Tributary of St. Marys River	4.1	90.4	9.3	0	.1
4	LES060-0002	Spy Run Creek	43	53.6	8.4	35.4	2.2
5	LMG100-0001	South Branch Galena River	50.6	37.7	40.6	.9	11.8
6	LMJ110-0001	Pigeon Creek	185.9	81.3	11.2	2	4.5
7	LMJ170-0001	North Branch Elkhart River	505.3	76.5	9.7	2.5	7.1
8	LMJ190-0002	Elkhart River	916.6	77.6	10.3	1.8	7
9	OBS010-0001	West Branch Mosquito Creek	33.7	51.8	48	0	.1
10	OBS050-0001	Buck Creek	316	64	35.5	.1	.1
11	OBS050-0002	Buck Creek	93.9	59.9	39.3	.1	0
12	OBS180-0004	Camp Fork Creek	18.2	26.8	68	.1	4.9
13	OHP020-0002	Smith Fork Pigeon Creek	91.5	81.5	11.5	.4	5.9
14	OLP060-0001	Middle Fork Anderson River	62.7	29	69.3	.5	0
15	OML030-0001	Salt Fork	17.1	55.7	35.8	8.1	.2
16	OML040-0002	South Hogan Creek	109.8	59.6	37.2	2.5	.4
17	OML070-0002	Laughery Creek	557.9	67.9	29.1	2	.3
18	OSK030-0002	West Fork Indian Kentuck Creek	22.1	64.7	34.6	0	.5
19	OSK030-0003	Dry Fork	4.6	64.8	34.8	.3	0
20	OSK070-0002	Fourteenmile Creek	186.8	78.2	20.6	.4	.6
21	OSK140-0002	Miller Fork	58.8	41.6	54.3	3.3	.2
22	**WAE020-0006**	**Mud Run**	**15.1**	**81.6**	**14.1**	**0**	**3.4**
23	**WAE030-0001**	**Spring Creek**	**5.9**	**91.3**	**6.6**	**.1**	**1.1**
24	**WAE030-0008**	**Schuman Ditch**	**22.5**	**85.3**	**10.6**	**.4**	**2.7**
25	**WAE070-0002**	**Tributary of Tick Creek**	**4.1**	**83.8**	**14.4**	**.3**	**1.5**
26	**WAW040-0057**	**Unnamed Tributary of St. Marys River**	**19.2**	**95.8**	**2.6**	**.2**	**1.4**
27	**WDE020-0010**	**Keeps Creek**	**14.9**	**95**	**3.6**	**.9**	**.4**
28	WDE050-0003	Deer Creek	868.7	95.9	2.4	.9	.7
29	WDE050-0005	Little Deer Creek	117.4	97.5	1.5	.4	.6
30	**WDE050-0018**	**Bridge Creek**	**11.6**	**97.5**	**2.2**	**0**	**.2**
31	WLV030-0004	Little Pine Creek	165.1	90.7	5.9	.5	2
32	WLV030-0014	Opossum Hollow	10.7	84.3	13.9	.1	1.3

Appendix 2. Basin Characteristics of the 58 Indiana Department of Environmental Management Watershed Monitoring Program Sampling Sites, 1998–2000.—Continued

[IDEM, Indiana Department of Environmental Management; km², square kilometer; bold text indicates sites that were used in subset data analysis]

Site number	IDEM site number (LSITE)	Stream name	Drainage area (km²)	Land use (percent)[1]			
				Agriculture	Forest	Urban	Other
33	WLV050-0007	Mud Pine Creek	217.8	96.2	1.6	1.1	.5
34	WLV100-0002	Turkey Run	58.1	95.9	2	.6	1
35	WLV120-0003	Mill Creek	57.8	81.9	13.4	.6	2.8
36	WLV160-0003	Tributary of Big Raccoon Creek	1.3	51.9	48.1	0	0
37	WLV170-0014	Big Raccoon Creek	839.7	80.6	16.9	.4	.9
38	WLV180-0029	Little Raccoon Creek	325.6	71.9	23.7	.5	2.4
39	WLV190-0009	Big Raccoon Creek	1,492	72.3	23.7	.6	2.1
40	WMI010-0008	Mississinewa River	199	93	4.8	1.5	.6
41	WMI050-0003	Walnut Creek	49.1	93.6	5.4	.1	.9
42	WMI050-0013	Mississinewa River	1,668	90.9	5.7	1.9	1.2
43	WMI060-0015	Hummel Creek	25	90.4	8.7	.5	.3
44	WSA040-0012	Majenica Creek	33.2	96.8	2.6	.3	.3
45	WSU010-0007	Browns Wonder Creek	56.9	99.1	0.4	.1	.4
46	WSU020-0005	Prairie Creek	77.8	85	0.8	13.3	.8
47	WSU060-0005	Roaring Creek	36.3	82.3	12.2	1.2	2.5
48	WSU060-0017	Sugar Mill Creek	64.1	85.6	12	.1	1.9
49	WTI020-0012	Deeds Creek	79.1	85.6	9.4	1	3.7
50	WTI150-0002	Big Creek	172.7	97.8	1.4	.1	.4
51	WUW050-0009	Limberlost Creek	72.8	94.4	5	0	.5
52	WUW080-0006	Rock Creek	235.2	96.5	2.8	.2	.5
53	WUW100-0005	Aboite Creek	141	86.6	8.1	2.5	2.6
54	WUW110-0001	Witzgall Ditch	14.5	94.1	4.6	.4	.7
55	WUW110-0006	Eightmile Creek	92.4	95.2	3.2	1	.5
56	**WUW120-0010**	**Mud Creek**	**2.4**	**97.2**	**2.8**	**0**	**0**
57	WUW170-0003	Pipe Creek	540.1	94.5	3.2	1.7	.5
58	WWE020-0014	Williams Creek	36.8	61	28.4	6.5	2.2
		Minimum	1.3	26.8	.4	0	0
		Median	63.4	84.5	9.6	.5	.7
		Mean	220.9	79.3	16.5	1.8	1.7
		Maximum	1,668	99.1	69.3	35.4	11.8

[1] (U.S. Geological Survey, 2000)

Appendix 3. Land-Use Categories Used for the 58 Indiana Department of Environmental Management Watershed Monitoring Program Sampling Sites (U.S. Geological Survey, 2000).

[NLCD, National Land Cover Dataset]

Major category description[1]/ individual category description	NLCD code
Water	
Open water	11
Developed	
Low intensity residential	21
High intensity residential	22
Commercial/industrial/transportation	23
Barren	
Bare rock/sand/clay	31
Quarries/strip mines/gravel pits	32
Transitional	33
Forested upland	
Deciduous forest	41
Evergreen forest	42
Mixed forest	43
Shrubland	
Shrubland	51
Non-natural woody	
Orchards/vineyards/other	61
Herbaceous upland natural/semi-natural vegetation	
Grasslands/herbaceous	71
Herbaceous planted/cultivated	
Pasture/hay	81
Row crops	82
Small grains	83
Urban/recreational grasses	85
Wetlands	
Woody wetlands	91
Emergent herbaceous wetlands	92

[1] For the purposes of this report land use used in table 1 and in the description of the study area section, agriculture includes pasture/hay, row crops, small grains, urban/recreational grasses, and orchards/vineyards/other; forest includes deciduous forest, evergreen forest, and mixed forest; urban includes low intensity residential, high intensity residential, and commercial/industrial/transportation; and other includes open water, bare rock/sand/clay, quarries/strip mines/gravel pits, transitional, shrubland, grasslands/herbaceous, woody wetlands, and emergent herbaceous wetlands

Appendix 4. Soil Parameters Used for Basin Characteristics of the 58 Indiana Department of Environmental Management Watershed Monitoring Program Sampling Sites.

Soil parameter name	Soil parameter description	Minimum value	Average value	Maximum value
AWCH	High range of available water capacity (inches per inch)	0.16	0.18	0.21
AWCL	Low range of available water capacity (inches per inch)	.12	.14	.17
BDH	High range of bulk density in the soil (grams per cubic centimeter)	1.41	1.61	1.70
BDL	Low range of bulk density in the soil (grams per cubic centimeter)	1.18	1.39	1.49
CLAYH	High range of percent of soil consisting of clay (in percent)	22.6	33.6	47.2
CLAYL	Low range of percent of soil consisting of clay (in percent)	11.8	21.2	30.8
DRAIN	Drainage quality (1=well drained to 7=poorly drained)	3.05	4.31	5.40
HGA	Percent of hydrogroup A	.00	1.07	20.2
HGAD	Percent of hydrogroup AD	.00	2.09	22.8
HGB	Percent of hydrogroup B	.00	28.4	76.0
HGBD	Percent of hydrogroup BD	.00	10.2	36.3
HGC	Percent of hydrogroup C	9.50	48.1	86.0
HGCD	Percent of hydrogroup CD	.00	6.50	31.0
HGD	Percent of hydrogroup D	.00	3.49	40.5
HYDRIC	Percent of hydric soil	.00	20.9	42.8
KFACT	Soil erodibility factor	.26	.34	.39
NO10H	High range of soil passing sieve number 10 (percent by weight)	90.0	97.2	100
NO10L	Low range of soil passing sieve number 10 (percent by weight)	67.4	83.4	92.5
NO200H	High range of soil passing sieve number 200 (percent by weight)	60.5	84.3	92.9
NO200L	Low range of soil passing sieve number 200 (percent by weight)	34.2	60.1	72.8
NO4H	High range of soil passing sieve number 4 (percent by weight)	92.5	98.4	100
NO4L	Low range of soil passing sieve number 4 (percent by weight)	72.9	89.8	96.5
OMH	High range of organic material in the soil (percent by weight)	.54	2.92	19.7
OML	Low range of organic material in the soil (percent by weight)	.15	1.62	13.6
PERMH	High range of the permeability of the soil (inches per hour)	.94	2.20	7.73
PERML	Low range of the permeability of the soil (inches per hour)	.21	.73	2.36

Appendix 5. Table of Metrics Used by Indiana Department of Environmental Management for Habitat, Fish, and Invertebrates.

Metrics	Definition
Habitat	
SubstrateScore	A metric to evaluate substrate type, origin, silt cover, and embeddedness.
InstreamCoverScore	Instream cover types and the amount (availability) of instream cover.
ChannelMorphologyScore	Quality of the stream channel related to the creation and stability of instream habitat (channel sinuosity, channel development, channelization, stability, and modifications).
RiparianZoneandBankErosionScore	Quality of the riparian buffer zone and flood-plain vegetation, looking at riparian width, predominant surrounding land uses, and bank-erosion status.
PoolGlideQualityScore	Quality of pool/glide taking into account maximum pool depth, morphology, and velocity.
RiffleRunQualityScore	Quality of riffle/run, taking into account riffle/run depth, substrate, and embeddedness.
GradientScore	A measure of the influence of gradient and stream size on the biological community and available habitat.
Fish[1]	
SpeciesCount	Number of species, excluding hybrid species (exclude gizzard shad if in the Wabash River mainstem and drainage area is greater than 5,180 square kilometers).
DMS_SpeciesCount	Number of darter, madtom, and sculpin species, excluding hybrid species.
Darter_SpeciesCount	Number of darter species, excluding hybrid species.
Headwater_Percent	Percent of headwater individuals.
LargeRiver_Percent	Percent of large river individuals (exclude gizzard shad if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).
Sunfish_SpeciesCount	Number of sunfish species, excluding hybrid species.
Centrarchid_SpeciesCount	Number of centrarchidae species, excluding hybrid species.
Minnow_SpeciesCount	Number of minnow species, excluding hybrid species.
Sucker_SpeciesCount	Number of sucker species, excluding hybrid species.
RoundBodySucker_SpeciesCount	Number of round-body sucker species, excluding hybrid species.
Salmonid_SpeciesCount	Number of salmonid species, excluding hybrid species.
Sensitive_SpeciesCount	Number of sensitive species, excluding hybrid species.
Tolerant_Percent	Percent of tolerant individuals (exclude gizzard shad if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).
Omnivore_Percent	Percent of omnivore individuals (exclude gizzard shad if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).
Insectivore_Percent	Percent of insectivore or invertivore individuals (exclude gizzard shad if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).
Pioneer_Percent	Percent of pioneer individuals.
Carnivore_Percent	Percent of carnivore or piscivore individuals (exclude gizzard shad if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).

Appendix 5. Table of Metrics Used by Indiana Department of Environmental Management for Habitat, Fish, and Invertebrates.—Continued

Metrics	Definition
Fish[1]—Continued	
CatchPerUnitEffort	Catch per unit effort (CPUE) or total number of individuals.
CPUElessShads	Catch per Unit Effort (CPUE), excluding the number of gizzard shad individuals if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).
SimpleLithophil_Percent	Percent of simple lithophilic species (exclude gizzard shad if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).
DELT_Percent	Percent of individuals with deformities, eroded fins, lesions, and tumors (DELT), including multiple DELTs (exclude gizzard shad if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).
Invertebrates	
Family Level HBI	Summation of the tolerance value times the number of individuals for a specific family divided by the total count of individuals for families with a tolerance value.
Number of Taxa	Number of families identified in the subsample.
Number of Individuals	Total number of individuals for all families identified in the subsample.
Percent Dominant Taxa	Highest number of individuals for a given family divided by the total number of individuals in the subsample.
EPT Index	Total number of families represented in the orders ephemeroptera, plecoptera, and trichoptera.
EPT Count	Total number of individuals for orders ephemeroptera, plecoptera, and trichoptera.
EPT Count to Total Number of Individuals	Total number of individuals for orders ephemeroptera, plecoptera, and trichoptera divided by the total number of individuals in the subsample.
EPT Count to Chironomid Count	Total number of individuals for orders ephemeroptera, plecoptera, and trichoptera divided by the total number of chironomidae.
Chironomid Count	Total number of chironomids in the subsample.
Total Number of Individuals to Number of Squares Sorted	Total number of individuals in the subsample divided by the number of squares needed to reach the total number of individuals.

[1]Specific fish species associated with each metric can be found in Dufour, 2000.

Appendix 6. Summer Nutrient Data for the 58 Sampling Sites from the Indiana Department of Environmental Management Watershed Monitoring Program, 1998–2000.

[IDEM, Indiana Department of Environmental Management; mg/L, milligrams per liter; bold text indicates sites that were used in subset data analysis]

Site number	IDEM site number (LSITE)	Nitrate as nitrogen (mg/L)	Total Kjeldahl nitrogen as nitrogen (mgL)	Total nitrogen as nitrogen (mg/L)	Total phosphorus as phosphorus (mg/L)
1	LEJ090-0001	2.2	2.1	4.3	0.34
2	LEJ090-0003	2.3	1.8	4.1	.33
3	LES050-0001	1.8	2.7	4.5	.5
4	LES060-0002	.33	2.4	2.73	.14
5	LMG100-0001	.32	.67	.99	.04
6	LMJ110-0001	3.7	1.6	5.3	.1
7	LMJ170-0001	.24	1.4	1.64	.08
8	LMJ190-0002	.2	1.1	1.3	.07
9	OBS010-0001	1.5	.33	1.83	0
10	OBS050-0001	1.3	.63	1.93	0
11	OBS050-0002	1.9	.4	2.3	0
12	OBS180-0004	2.3	.1	2.4	0
13	OHP020-0002	0	.43	.43	.04
14	OLP060-0001	.44	.65	1.09	41
15	OML030-0001	2.8	.85	3.65	1.5
16	OML040-0002	.34	.71	1.05	.11
17	OML070-0002	.45	.81	1.26	.13
18	OSK030-0002	1.3	.63	1.93	.04
19	OSK030-0003	.27	.75	1.02	.19
20	OSK070-0002	1.6	.66	2.26	.09
21	OSK140-0002	.62	.46	1.08	.04
22	**WAE020-0006**	**2.3**	**1.2**	**3.5**	**.13**
23	**WAE030-0001**	**.84**	**1**	**1.84**	**.15**
24	**WAE030-0008**	**1.7**	**1.1**	**2.8**	**.1**
25	**WAE070-0002**	**.92**	**.68**	**1.6**	**.12**
26	**WAW040-0057**	**4**	**.38**	**4.38**	**.08**
27	**WDE020-0010**	**6.1**	**.58**	**6.68**	**.12**
28	WDE050-0003	3.7	.8	4.5	.14
29	WDE050-0005	6.7	.88	7.58	.12
30	**WDE050-0018**	**6.2**	**.37**	**6.57**	**.08**
31	WLV030-0004	2.6	.37	2.97	.06
32	WLV030-0014	.95	.23	1.18	0

Appendix 6. Summer Nutrient Data for the 58 Sampling Sites from the Indiana Department of Environmental Management Watershed Monitoring Program, 1998–2000.—Continued

[IDEM, Indiana Department of Environmental Management; mg/L, milligrams per liter; bold text indicates sites that were used in subset data analysis]

Site number	IDEM site number (LSITE)	Nitrate as nitrogen (mg/L)	Total Kjeldahl nitrogen as nitrogen (mgL)	Total nitrogen as nitrogen (mg/L)	Total phosphorus as phosphorus (mg/L)
33	WLV050-0007	.04	.51	.55	.06
34	WLV100-0002	.22	2.1	2.32	.17
35	WLV120-0003	.25	1.4	1.65	.13
36	WLV160-0003	.42	4.2	4.62	.08
37	WLV170-0014	2	0.37	2.37	.04
38	WLV180-0029	.95	.22	1.17	.04
39	WLV190-0009	1.4	.4	1.8	0
40	WMI010-0008	2.8	1.1	3.9	.23
41	WMI050-0003	3.5	1	4.5	.33
42	WMI050-0013	1.3	.52	1.82	.17
43	WMI060-0015	1.7	.5	2.2	.17
44	WSA040-0012	13	1	14	.19
45	WSU010-0007	.06	.69	.75	.08
46	WSU020-0005	1.8	1.3	3.1	.74
47	WSU060-0005	.02	.23	.25	.03
48	WSU060-0017	1.2	.83	2.03	.07
49	WTI020-0012	2	.69	2.69	.1
50	WTI150-0002	6.3	.45	6.75	.03
51	WUW050-0009	1.1	.65	1.75	.06
52	WUW080-0006	.63	.61	1.24	.12
53	WUW100-0005	6	1.5	7.5	.18
54	WUW110-0001	13	.31	13.3	.17
55	WUW110-0006	7.2	1.5	8.7	.15
56	**WUW120-0010**	**2.2**	**.71**	**2.91**	**.06**
57	WUW170-0003	1.6	.39	1.99	.13
58	WWE020-0014	11	.64	11.6	1.3
	Samples	58	58	58	58
	Minimum	0	.1	.25	0
	Mean	2.48	.91	3.38	.16
	Median	1.6	.69	2.31	0.1
	Maximum	13	4.2	14	1.5
	Standard deviation	2.97	.71	2.99	.266

Appendix 7. Habitat Data for the 58 Sampling Sites from the Indiana Department of Environmental Management Watershed Monitoring Program[1], 1998–2000.

[IDEM, Indiana Department of Environmental Management; m/km, meters per kilometer; m, meters; nd, no data; bold text indicates sites that were used in subset data analysis]

Site number	IDEM site number (LSITE)	Gradient (m/km)	Stream width avg (m)	Distance fished (m)	Water depth avg (m)	Water depth max (m)	Total score	Substrate score	Instream cover score
1	LEJ090-0001	1.04	22	330	0.5	1.5	80	17	14
2	LEJ090-0003	.40	24.3	360	.5	1.4	77	17	15
3	LES050-0001	.79	3	50	.1	0.3	55	12	10
4	LES060-0002	1.52	6.2	95	.4	0.7	69	16	13
5	LMG100-0001	2.50	3	50	.5	1.3	63	13	9
6	LMJ110-0001	.79	8	120	.25	.5	63	15	10
7	LMJ170-0001	.52	14	210	.5	1.3	81	15	16
8	LMJ190-0002	.30	12	180	.7	1.5	72	18	14
9	OBS010-0001	5.00	7.7	120	.1	.5	73	17	11
10	OBS050-0001	.44	10	150	.75	1	65	12	13
11	OBS050-0002	1.85	13	195	.15	.3	60	12	7
12	OBS180-0004	4.88	nd	nd	nd	nd	nd	nd	nd
13	OHP020-0002	.28	6.7	105	.3	.5	38	8	12
14	OLP060-0001	1.47	11	165	1	2	56	6	13
15	OML030-0001	11.11	5.8	90	.2	.5	68	17	11
16	OML040-0002	4.55	6.5	98	.3	.5	71	16	12
17	OML070-0002	2.22	18.2	270	.4	1.3	79	14	13
18	OSK030-0002	6.25	5	75	.2	.5	69	14	10
19	OSK030-0003	16.67	3.5	60	.2	.6	60	17	7
20	OSK070-0002	.83	17.4	255	.5	.85	66	16	7
21	OSK140-0002	1.28	6	90	.5	1	67	13	14
22	**WAE020-0006**	**4.12**	**3**	**50**	**.15**	**.3**	**58**	**11**	**11**
23	**WAE030-0001**	**3.21**	**2.3**	**50**	**.1**	**.2**	**47**	**12**	**6**
24	**WAE030-0008**	**2.46**	**3**	**50**	**.2**	**.5**	**62**	**16**	**12**
25	**WAE070-0002**	**7.19**	**2**	**50**	**.1**	**.3**	**60**	**13**	**11**
26	**WAW040-0057**	**3.95**	**3**	**50**	**.2**	**.4**	**59**	**14**	**12**
27	**WDE020-0010**	**5.56**	**4.3**	**60**	**.3**	**.7**	**74**	**16**	**14**
28	WDE050-0003	1.87	19.4	285	.7	1	81	16	17
29	WDE050-0005	2.64	10.1	150	.3	1.7	87	16	20
30	**WDE050-0018**	**3.08**	**1**	**50**	**.1**	**.15**	**49**	**12**	**6**
31	WLV030-0004	5.36	8.7	135	.25	1.5	66	14	7
32	WLV030-0014	15.00	4	60	.1	.3	52	11	5

Appendix 7. Habitat Data for the 58 Sampling Sites from the Indiana Department of Environmental Management Watershed Monitoring Program[1], 1998–2000.—Continued

[IDEM, Indiana Department of Environmental Management; m/km, meters per kilometer; m, meters; nd, no data; bold text indicates sites that were used in subset data analysis]

Site number	IDEM site number (LSITE)	Pool glide score	Riffle run score	Gradient score	Percent pool	Percent riffle	Percent run	Percent glide	Canopy cover percent open
1	LEJ090-0001	10	4	10	40	20	20	20	24
2	LEJ090-0003	9	6	8	25	10	65		30
3	LES050-0001	6	2	4	40	10	50	0	5
4	LES060-0002	6	3	10	40	20	40	0	15
5	LMG100-0001	10	1	8	40	0	60	0	27
6	LMJ110-0001	6	6	6	15	25	60	0	30
7	LMJ170-0001	12	5	8	25	10	65	0	30
8	LMJ190-0002	9	8	4	30	25	45	0	80
9	OBS010-0001	5	4	8	60	40	0	0	4
10	OBS050-0001	12	5	4	40	10	50	0	25
11	OBS050-0002	5	4	10	20	10	0	70	35
12	OBS180-0004	nd	nd	nd	nd	nd	nd	nd	nd
13	OHP020-0002	4	0	4	0	0	0	100	97
14	OLP060-0001	10	2	10	70	5	25	0	60
15	OML030-0001	5	4	4	40	30	30	0	15
16	OML040-0002	7	4	8	35	25	40	0	35
17	OML070-0002	11	6	8	30	20	20	30	36
18	OSK030-0002	5	6	6	25	25	50	0	20
19	OSK030-0003	4	4	4	60	20	20	0	2
20	OSK070-0002	8	4	10	10	10	80	0	42
21	OSK140-0002	11	3	10	25	25	50	0	40
22	**WAE020-0006**	**5**	**2**	**10**	**10**	**30**	**60**	**0**	**16**
23	**WAE030-0001**	**0**	**0**	**10**	**20**	**20**	**60**	**0**	**56**
24	**WAE030-0008**	**5**	**2**	**8**	**30**	**50**	**20**	**0**	**15**
25	**WAE070-0002**	**3**	**2**	**8**	**30**	**15**	**55**	**0**	**nd**
26	**WAW040-0057**	**4**	**0**	**6**	**0**	**0**	**0**	**0**	**1**
27	**WDE020-0010**	**6**	**4**	**10**	**20**	**40**	**40**	**0**	**26**
28	WDE050-0003	11	6	10	25	30	45	0	65
29	WDE050-0005	12	5	8	30	30	40	0	42
30	**WDE050-0018**	**0**	**2**	**10**	**0**	**50**	**50**	**0**	**7**
31	WLV030-0004	6	4	8	30	30	40	0	nd
32	WLV030-0014	5	4	4	20	80	0	0	nd

Appendix 7. Habitat Data for the 58 Sampling Sites from the Indiana Department of Environmental Management Watershed Monitoring Program[1], 1998–2000.—Continued

[IDEM, Indiana Department of Environmental Management; m/km, meters per kilometer; m, meters; nd, no data; bold text indicates sites that were used in subset data analysis]

Site number	IDEM site number (LSITE)	Gradient (m/km)	Stream width avg (m)	Distance fished (m)	Water depth avg (m)	Water depth max (m)	Total score	Substrate score	Instream cover score
33	WLV050-0007	1.78	7.1	105	0.6	1.5	80	18	14
34	WLV100-0002	1.67	5	75	.3	1.2	72	14	13
35	WLV120-0003	3.31	7	105	.25	.6	77	19	11
36	WLV160-0003	13.88	1	50	.1	.3	66	17	12
37	WLV170-0014	1.17	36.1	500	1	2	64	12	9
38	WLV180-0029	0.93	7.6	125	.2	1	58	12	9
39	WLV190-0009	0.70	18	300	.8	1.75	71	14	11
40	WMI010-0008	0.68	11.5	84	.2	2.5	64	13	15
41	WMI050-0003	1.54	5	75	.3	.5	67	13	12
42	WMI050-0013	.39	33	495	.8	1.4	85	16	20
43	WMI060-0015	1.79	4.5	60	.3	.5	71	17	13
44	WSA040-0012	1.23	2.8	50	.5	.7	55	15	10
45	WSU010-0007	1.14	4	60	.1	.3	50	12	6
46	WSU020-0005	.93	8.1	120	.3	.7	63	13	15
47	WSU060-0005	4.62	5.1	75	.3	.7	63	13	10
48	WSU060-0017	2.42	7	105	.2	.7	76	17	12
49	WTI020-0012	.86	4.1	60	.3	.5	51	11	13
50	WTI150-0002	.69	6.9	120	.4	.7	66	17	12
51	WUW050-0009	.70	8	120	.1	.45	57	13	11
52	WUW080-0006	.41	9	137	.4	.5	55	13	11
53	WUW100-0005	1.00	15.2	175	.7	1.1	74	16	13
54	WUW110-0001	1.79	2.8	50	.1	.2	42	13	4
55	WUW110-0006	.34	8.5	120	.5	1	48	7	11
56	**WUW120-0010**	**4.17**	**2.2**	**50**	**.15**	**.25**	**60**	**14**	**12**
57	WUW170-0003	1.62	24.1	360	.3	.7	85	18	18
58	WWE020-0014	2.18	4	60	.3	.8	74	15	13
	Samples	58.00	57	57	57	57	57	57	57
	Minimum	.28	1.0	50.0	.1	.2	38.0	6.0	4.0
	Mean	2.95	9.0	135.0	.4	.8	65.3	14.2	11.6
	Median	1.72	6.9	105.0	.3	.7	66.0	14.0	12.0
	Maximum	16.67	36.1	500.0	1.0	2.5	87.0	19.0	20.0
	Standard deviation	3.54	7.57	108.05	.23	.53	11.05	2.71	3.35

Appendix 7. Habitat Data for the 58 Sampling Sites from the Indiana Department of Environmental Management Watershed Monitoring Program[1], 1998–2000.—Continued

[IDEM, Indiana Department of Environmental Management; m/km, meters per kilometer; m, meters; nd, no data; bold text indicates sites that were used in subset data analysis]

Site number	IDEM site number (LSITE)	Pool glide score	Riffle run score	Gradient score	Percent pool	Percent riffle	Percent run	Percent glide	Canopy cover percent open
33	WLV050-0007	10	5	10	33	33	33	0	nd
34	WLV100-0002	8	3	10	50	30	20	0	nd
35	WLV120-0003	6	5	10	50	50	0	0	nd
36	WLV160-0003	5	0	4	34	33	33	0	0
37	WLV170-0014	9	1	10	50	5	45	0	90
38	WLV180-0029	6	2	6	0	0	0	0	nd
39	WLV190-0009	10	7	8	20	35	40	5	50
40	WMI010-0008	6	5	6	20	10	70	0	30
41	WMI050-0003	5	3	10	25	15	60	0	32
42	WMI050-0013	10	5	10	20	20	50	0	45
43	WMI060-0015	5	3	6	0	0	0	0	7
44	WSA040-0012	5	6	6	40	10	50	0	99
45	WSU010-0007	3	3	6	0	10	90	0	nd
46	WSU020-0005	6	3	6	10	20	40	30	38
47	WSU060-0005	8	0	8	30	20	50	0	nd
48	WSU060-0017	8	5	10	40	40	20	0	nd
49	WTI020-0012	6	0	4	20	0	80	0	15
50	WTI150-0002	7	5	6	70	10	20	0	29
51	WUW050-0009	4	6	6	10	20	70	0	55
52	WUW080-0006	5	4	4	10	10	80	0	50
53	WUW100-0005	10	4	10	70	20	10	0	78
54	WUW110-0001	0	3	6	10	10	80	0	95
55	WUW110-0006	6	5	4	50	10	40	0	23
56	**WUW120-0010**	**3**	**2**	**10**	**10**	**20**	**70**	**0**	**98**
57	WUW170-0003	9	7	10	40	30	30	0	31
58	WWE020-0014	10	2	8	50	30	20	0	nd
	Samples	57	57	57	57	57	57	56	46
	Minimum	.0	.0	4.0	.0	.0	.0	.0	.0
	Mean	6.7	3.6	7.5	28.9	21.2	40.0	4.6	37.9
	Median	6.0	4.0	8.0	30.0	20.0	40.0	0.0	30.5
	Maximum	12.0	8.0	10.0	70.0	80.0	90.0	100.0	99.0
	Standard deviation	2.99	1.99	2.30	18.35	15.30	24.41	17.04	27.82

[1] (Indiana Department of Environmental Management, 2002)

Appendix 8. Soils Data Used for 58 Indiana Department of Environmental Management Watershed Monitoring Program Sampling Sites, 1998–2000.

[IDEM, Indiana Department of Environmental Management; bold text indicates sites that were used in subset data analysis]

Soil parameters														
Site number	IDEM site number (LSITE)	DRAIN[1]	HGA	HGB	HGC	HGD	HGAD	HGBD	HGCD	HYDRIC	KFACT	PERML	PERMH	AWCL
1	LEJ090-0001	4.8	0.9	36.6	26.9	0.0	12.3	16.0	7.4	35.7	0.3	1.3	4.1	0.1
2	LEJ090-0003	4.6	.0	5.0	73.0	.0	2.0	2.0	18.0	22.0	.4	.2	.9	.1
3	LES050-0001	5.0	.0	2.5	69.5	.0	1.5	2.0	24.5	28.0	.4	.2	.9	.1
4	LES060-0002	5.0	.0	2.5	69.5	.0	1.5	2.0	24.5	28.0	.4	.2	.9	.1
5	LMG100-0001	4.3	20.2	31.2	16.4	.0	15.8	8.6	7.8	32.2	.3	2.3	7.7	.1
6	LMJ110-0001	4.7	5.0	28.4	32.4	.0	19.4	7.0	7.8	34.2	.3	1.4	4.5	.2
7	LMJ170-0001	4.7	2.5	38.3	23.0	.0	22.8	8.3	5.3	36.3	.3	1.8	5.4	.2
8	LMJ190-0002	5.2	1.7	32.0	16.8	2.3	15.5	16.2	15.5	47.2	.3	2.0	5.4	.1
9	OBS010-0001	3.1	.0	46.5	23.0	26.0	.0	4.5	.0	1.0	.3	.6	2.0	.1
10	OBS050-0001	3.3	.0	50.7	26.3	18.3	.0	3.0	1.7	8.0	.3	.6	2.0	.2
11	OBS050-0002	3.5	.0	71.0	23.0	3.5	.0	.0	2.5	11.0	.3	.6	2.0	.2
12	OBS180-0004	3.1	.0	33.0	67.0	.0	.0	.0	.0	0.0	.3	.5	2.2	.1
13	OHP020-0002	3.7	.0	14.5	78.3	1.0	.0	.0	6.3	20.5	.4	.5	1.7	.1
14	OLP060-0001	3.4	.0	38.0	52.0	2.3	.0	4.3	3.3	13.7	.3	.7	2.5	.1
15	OML030-0001	3.2	.0	10.0	86.0	4.0	.0	.0	.0	.0	.3	.3	1.0	.1
16	OML040-0002	3.8	.0	7.3	65.7	27.0	.0	.0	.0	12.7	.4	.3	1.0	.1
17	OML070-0002	3.7	.0	6.3	71.5	22.3	.0	.0	.0	9.5	.4	.3	1.1	.1
18	OSK030-0002	4.2	.0	3.5	56.0	40.5	.0	.0	.0	19.0	.4	.3	1.1	.1
19	OSK030-0003	3.2	.0	10.0	86.0	4.0	.0	.0	.0	.0	.3	.3	1.0	.1
20	OSK070-0002	3.5	.0	17.2	56.5	24.8	.0	1.5	.0	7.5	.3	.4	1.4	.1
21	OSK140-0002	3.4	.0	23.4	67.4	4.6	.0	2.6	2.0	9.2	.3	.5	2.0	.1
22	**WAE020-0006**	**4.6**	**.0**	**5.0**	**73.0**	**.0**	**2.0**	**2.0**	**18.0**	**22.0**	**.4**	**.2**	**.9**	**.1**
23	**WAE030-0001**	**4.6**	**.0**	**5.0**	**73.0**	**.0**	**2.0**	**2.0**	**18.0**	**22.0**	**.4**	**.2**	**.9**	**.1**
24	**WAE030-0008**	**4.6**	**.0**	**5.0**	**73.0**	**.0**	**2.0**	**2.0**	**18.0**	**22.0**	**.4**	**.2**	**.9**	**.1**
25	**WAE070-0002**	**3.7**	**.5**	**76.0**	**11.0**	**.0**	**2.5**	**10.0**	**.0**	**12.5**	**.3**	**2.4**	**4.6**	**.1**
26	**WAW040-0057**	**4.4**	**.0**	**39.3**	**41.0**	**.0**	**.0**	**19.3**	**.3**	**19.7**	**.4**	**.5**	**1.7**	**.1**
27	**WDE020-0010**	**4.1**	**.3**	**57.0**	**34.7**	**.0**	**.0**	**7.7**	**.3**	**7.7**	**.4**	**.6**	**1.8**	**.1**
28	WDE050-0003	4.5	.1	42.8	36.9	.0	.8	15.5	4.0	20.1	.4	.8	2.1	.1
29	WDE050-0005	4.5	.0	37.7	41.7	.0	.3	20.0	.3	20.3	.4	.4	1.4	.1
30	**WDE050-0018**	**4.5**	**.5**	**39.5**	**48.5**	**.0**	**.0**	**11.0**	**.5**	**11.0**	**.4**	**.6**	**1.9**	**.1**
31	WLV030-0004	4.3	.0	41.4	40.0	.0	.8	17.6	.2	18.4	.4	.4	1.5	.1
32	WLV030-0014	4.4	2.0	59.3	9.5	.5	.0	28.8	.0	28.8	.3	1.5	3.0	.1

Appendix 8. Soils Data Used for 58 Indiana Department of Environmental Management Watershed Monitoring Program Sampling Sites, 1998–2000.—Continued

[IDEM, Indiana Department of Environmental Management; bold text indicates sites that were used in subset data analysis]

		Soil parameters—Continued												
Site number	IDEM site number (LSITE)	AWCH	BDL	BDH	OML	OMH	CLAYL	CLAYH	NO4L	NO4H	NO200L	NO200H	NO10L	NO10H
1	LEJ090-0001	0.2	1.3	1.5	7.7	11.6	16.4	27.8	89.1	99.0	44.7	73.1	79.2	97.6
2	LEJ090-0003	.2	1.5	1.7	1.7	3.1	28.2	40.4	93.7	99.9	69.8	90.1	84.9	99.9
3	LES050-0001	.2	1.5	1.7	1.4	2.8	28.4	40.5	93.6	100.0	70.4	90.2	84.9	99.9
4	LES060-0002	.2	1.5	1.7	1.4	2.8	28.4	40.5	93.6	100.0	70.4	90.2	84.9	99.9
5	LMG100-0001	.2	1.3	1.5	9.6	14.2	11.8	22.6	89.2	99.3	34.2	60.5	78.7	97.5
6	LMJ110-0001	.2	1.2	1.4	12.2	17.9	16.9	28.8	87.6	98.9	44.8	71.7	76.6	97.6
7	LMJ170-0001	.2	1.2	1.4	13.6	19.7	14.6	26.5	86.6	99.2	38.6	66.0	75.6	97.8
8	LMJ190-0002	.2	1.3	1.5	9.3	13.8	17.1	29.1	87.0	98.9	41.1	67.5	75.1	97.3
9	OBS010-0001	.2	1.3	1.5	.5	1.3	24.6	42.4	80.6	95.0	59.1	87.6	74.7	93.2
10	OBS050-0001	.2	1.3	1.5	.5	1.3	20.8	36.8	85.7	96.4	61.5	89.0	81.0	95.0
11	OBS050-0002	.2	1.3	1.5	.3	1.0	19.9	37.0	91.1	98.8	65.5	92.8	85.4	97.4
12	OBS180-0004	.2	1.3	1.6	.2	.7	15.6	32.5	72.8	94.2	48.2	82.0	67.4	92.2
13	OHP020-0002	.2	1.4	1.6	.2	.7	17.0	31.2	81.0	93.2	52.7	82.9	72.7	90.2
14	OLP060-0001	.2	1.3	1.5	.3	1.0	14.1	28.8	74.9	92.5	50.5	79.2	70.5	90.0
15	OML030-0001	.2	1.4	1.6	.2	.9	30.8	47.2	88.5	99.1	63.0	90.6	79.8	98.2
16	OML040-0002	.2	1.4	1.6	.2	.8	26.2	41.3	91.0	99.3	65.1	90.9	84.3	98.4
17	OML070-0002	.2	1.4	1.6	.2	.7	25.0	39.8	90.8	99.3	64.7	89.7	83.7	98.0
18	OSK030-0002	.2	1.4	1.6	.2	.7	21.8	35.4	94.3	99.7	67.5	89.9	90.0	98.5
19	OSK030-0003	.2	1.4	1.6	.2	.9	30.8	47.2	88.5	99.1	63.0	90.6	79.8	98.2
20	OSK070-0002	.2	1.4	1.6	.3	.8	23.2	39.2	87.6	97.8	62.8	88.5	81.3	96.1
21	OSK140-0002	.2	1.4	1.6	.2	.8	17.8	33.3	80.1	95.1	55.0	82.7	73.9	92.6
22	**WAE020-0006**	**.2**	**1.5**	**1.7**	**1.7**	**3.1**	**28.2**	**40.4**	**93.7**	**99.9**	**69.8**	**90.1**	**84.9**	**99.9**
23	**WAE030-0001**	**.2**	**1.5**	**1.7**	**1.7**	**3.1**	**28.2**	**40.4**	**93.7**	**99.9**	**69.8**	**90.1**	**84.9**	**99.9**
24	**WAE030-0008**	**.2**	**1.5**	**1.7**	**1.7**	**3.1**	**28.2**	**40.4**	**93.7**	**99.9**	**69.8**	**90.1**	**84.9**	**99.9**
25	**WAE070-0002**	**.2**	**1.4**	**1.6**	**1.4**	**2.8**	**13.1**	**24.3**	**79.3**	**95.7**	**37.4**	**69.6**	**69.4**	**93.6**
26	**WAW040-0057**	**.2**	**1.4**	**1.6**	**.6**	**1.5**	**19.0**	**29.5**	**94.0**	**99.9**	**59.3**	**87.0**	**90.7**	**99.2**
27	**WDE020-0010**	**.2**	**1.4**	**1.6**	**.3**	**1.0**	**19.9**	**29.8**	**94.0**	**99.5**	**62.2**	**85.1**	**90.2**	**98.2**
28	WDE050-0003	.2	1.4	1.6	.8	1.7	20.3	30.8	91.0	99.0	58.9	83.3	86.4	98.0
29	WDE050-0005	.2	1.5	1.7	.6	1.4	20.9	30.6	93.2	99.6	62.2	84.5	89.8	98.0
30	**WDE050-0018**	**.2**	**1.4**	**1.6**	**.4**	**1.1**	**19.3**	**29.7**	**94.6**	**99.4**	**64.1**	**84.7**	**90.5**	**98.2**
31	WLV030-0004	.2	1.4	1.6	1.0	1.9	22.2	33.2	93.2	99.5	65.4	87.2	89.3	98.5
32	WLV030-0014	.2	1.4	1.6	.7	1.9	17.9	29.0	88.8	97.9	53.8	78.9	84.0	96.3

Appendix 8. Soils Data Used for 58 Indiana Department of Environmental Management Watershed Monitoring Program Sampling Sites, 1998–2000.—Continued

[IDEM, Indiana Department of Environmental Management; bold text indicates sites that were used in subset data analysis]

Soil parameters—Continued														
Site number	IDEM site number (LSITE)	DRAIN[1]	HGA	HGB	HGC	HGD	HGAD	HGBD	HGCD	HYDRIC	KFACT	PERML	PERMH	AWCL
33	WLV050-0007	4.4	0.6	55.3	21.4	0.0	0.3	19.9	2.6	22.7	0.3	1.3	2.7	0.1
34	WLV100-0002	4.5	2.0	46.5	23.5	.3	.3	27.2	.2	27.7	.3	2.2	4.2	.1
35	WLV120-0003	4.4	2.3	46.0	29.7	.7	.0	21.3	.0	21.3	.3	1.8	3.3	.1
36	WLV160-0003	4.3	.0	54.0	34.0	.0	.0	12.0	.0	12.0	.4	.5	1.7	.2
37	WLV170-0014	4.1	.0	26.6	49.2	1.1	.1	15.6	.1	17.0	.3	.5	1.6	.1
38	WLV180-0029	4.2	.0	51.0	34.2	.2	.0	14.7	.0	14.8	.4	.5	1.7	.2
39	WLV190-0009	3.8	4.3	56.1	26.9	.4	.6	11.8	.0	13.5	.3	1.8	4.4	.1
40	WMI010-0008	4.7	.0	8.1	68.6	.0	.6	12.7	10.0	23.1	.4	.4	1.3	.1
41	WMI050-0003	5.0	.0	2.5	69.5	.0	1.5	2.0	24.5	28.0	.4	.2	.9	.1
42	WMI050-0013	4.9	.0	26.4	38.3	2.0	1.1	14.9	17.3	33.3	.4	.7	1.9	.1
43	WMI060-0015	5.0	.0	2.5	69.5	.0	1.5	2.0	24.5	28.0	.4	.2	.9	.1
44	WSA040-0012	5.4	.0	.0	66.0	.0	1.0	2.0	31.0	34.0	.4	.2	.9	.1
45	WSU010-0007	5.2	.0	10.5	59.0	.0	.5	29.5	.5	30.0	.4	.4	1.5	.1
46	WSU020-0005	5.4	.0	9.7	53.0	.0	.7	36.3	.3	37.0	.4	.5	1.8	.2
47	WSU060-0005	4.0	.0	64.3	24.0	.3	.0	11.3	.0	11.7	.4	.5	1.7	.2
48	WSU060-0017	4.1	.6	57.8	24.0	.4	.0	17.2	.0	17.2	.3	1.7	3.2	.1
49	WTI020-0012	4.3	5.8	42.8	29.6	.0	4.8	13.4	3.6	21.8	.3	1.4	3.8	.1
50	WTI150-0002	4.6	17.3	30.2	21.3	.3	4.5	26.3	.0	31.2	.3	2.0	6.7	.1
51	WUW050-0009	4.9	.0	8.8	61.8	.0	1.2	8.6	19.6	29.4	.4	.3	1.2	.1
52	WUW080-0006	5.2	.0	10.8	50.5	.8	.8	25.0	12.3	38.8	.4	.4	1.3	.1
53	WUW100-0005	4.7	.3	27.0	46.5	.0	.8	13.3	12.3	26.3	.4	.5	1.8	.1
54	WUW110-0001	5.0	.0	2.5	69.5	.0	1.5	2.0	24.5	28.0	.4	.2	.9	.1
55	WUW110-0006	5.3	.0	3.0	57.0	1.0	1.0	21.7	16.3	40.0	.4	.3	1.0	.1
56	**WUW120-0010**	**5.0**	**.0**	**2.5**	**69.5**	**.0**	**1.5**	**2.0**	**24.5**	**28.0**	**.4**	**.2**	**.9**	**.1**
57	WUW170-0003	5.0	.0	5.7	68.7	.0	1.0	8.0	16.7	25.3	.4	.3	1.2	.1
58	WWE020-0014	4.3	.0	49.0	36.0	.5	.0	14.5	.0	15.0	.4	.5	1.8	.2
	Samples	58	58	58	58	58	58	58	58	58	58	58	58	58
	Minimum	3.1	.0	.0	9.5	.0	.0	.0	.0	.0	.3	.2	.9	.1
	Mean	4.4	1.2	27.8	47.7	3.3	2.2	10.3	7.4	21.3	.3	.7	2.2	.1
	Median	4.5	.0	27.7	48.9	.0	.6	8.6	2.3	21.9	.4	.5	1.7	.1
	Maximum	5.4	20.2	76.0	86.0	40.5	22.8	36.3	31.0	47.2	.4	2.4	7.7	.2
	Standard deviation	.63	3.59	21.48	21.22	8.34	4.86	9.25	9.26	10.80	.03	.63	1.54	.01

Appendix 8. Soils Data Used for 58 Indiana Department of Environmental Management Watershed Monitoring Program Sampling Sites, 1998–2000.—Continued

[IDEM, Indiana Department of Environmental Management; bold text indicates sites that were used in subset data analysis]

		Soil parameters—Continued												
Site number	IDEM site number (LSITE)	AWCH	BDL	BDH	OML	OMH	CLAYL	CLAYH	NO4L	NO4H	NO200L	NO200H	NO10L	NO10H
33	WLV050-0007	0.2	1.4	1.6	0.8	1.9	19.1	29.8	89.8	98.2	56.3	82.0	84.8	97.1
34	WLV100-0002	.2	1.4	1.6	.8	1.9	16.8	27.2	87.9	97.1	51.0	74.9	82.9	95.1
35	WLV120-0003	.2	1.4	1.6	.5	1.8	17.3	28.1	87.7	97.6	57.8	79.9	83.0	95.6
36	WLV160-0003	.2	1.4	1.6	.4	1.0	19.5	29.3	93.5	99.8	66.3	89.8	89.0	98.5
37	WLV170-0014	.2	1.3	1.5	.5	1.1	18.3	28.0	87.0	92.3	60.4	81.4	83.1	91.1
38	WLV180-0029	.2	1.4	1.6	.4	1.2	19.1	29.5	94.7	99.7	67.1	90.3	91.0	98.6
39	WLV190-0009	.2	1.4	1.6	.7	1.7	15.5	26.1	89.2	97.7	50.7	76.1	83.9	96.4
40	WMI010-0008	.2	1.5	1.7	.8	1.9	23.2	34.9	91.7	99.1	65.4	86.3	86.1	98.0
41	WMI050-0003	.2	1.5	1.7	1.4	2.8	28.4	40.5	93.6	100.0	70.4	90.2	84.9	99.9
42	WMI050-0013	.2	1.4	1.7	1.1	2.3	23.5	35.2	91.1	99.1	60.7	85.6	84.4	98.5
43	WMI060-0015	.2	1.5	1.7	1.4	2.8	28.4	40.5	93.6	100.0	70.4	90.2	84.9	99.9
44	WSA040-0012	.2	1.5	1.7	1.1	2.5	28.6	40.5	93.6	100.0	71.1	90.4	84.8	100.0
45	WSU010-0007	.2	1.5	1.7	.9	1.8	20.8	31.1	93.4	99.6	64.1	83.9	89.9	97.9
46	WSU020-0005	.2	1.5	1.7	.9	1.8	20.3	30.5	93.9	99.4	63.2	84.4	90.6	97.7
47	WSU060-0005	.2	1.4	1.6	.3	.9	19.0	29.3	94.4	99.9	67.4	91.3	90.3	98.7
48	WSU060-0017	.2	1.4	1.6	.5	1.3	18.3	28.6	88.9	97.7	58.7	81.4	84.6	95.7
49	WTI020-0012	.2	1.4	1.6	3.6	5.7	15.8	26.6	88.1	98.2	43.5	70.7	78.5	96.5
50	WTI150-0002	.2	1.4	1.6	1.0	2.1	13.5	24.4	92.9	99.8	40.4	67.6	87.3	99.3
51	WUW050-0009	.2	1.4	1.7	1.4	2.8	26.2	38.3	94.4	100.0	69.4	90.6	86.9	99.9
52	WUW080-0006	.2	1.4	1.6	1.3	2.6	26.0	37.5	95.5	100.0	68.6	92.3	89.6	100.0
53	WUW100-0005	.2	1.4	1.6	1.1	2.4	21.8	33.8	94.6	99.9	61.8	88.1	87.9	99.8
54	WUW110-0001	.2	1.5	1.7	1.4	2.8	28.4	40.5	93.6	100.0	70.4	90.2	84.9	99.9
55	WUW110-0006	.2	1.4	1.6	1.4	2.5	28.8	40.1	94.8	100.0	69.7	92.3	87.8	99.9
56	**WUW120-0010**	**.2**	**1.5**	**1.7**	**1.4**	**2.8**	**28.4**	**40.5**	**93.6**	**100.0**	**70.4**	**90.2**	**84.9**	**99.9**
57	WUW170-0003	.2	1.5	1.7	1.1	2.2	25.8	37.2	93.8	99.7	69.3	88.4	86.6	99.2
58	WWE020-0014	.2	1.4	1.6	.4	.9	18.3	28.8	96.5	99.9	72.8	92.9	92.5	98.6
	Samples	58	58	58	58	58	58	58	58	58	58	58	58	58
	Minimum	.2	1.2	1.4	.2	.7	11.8	22.6	72.8	92.3	34.2	60.5	67.4	90.0
	Mean	.2	1.4	1.6	1.7	3.0	21.7	33.8	90.3	98.6	60.4	84.4	83.7	97.5
	Median	.2	1.4	1.6	.8	1.9	20.6	32.9	92.3	99.3	63.0	87.4	84.9	98.2
	Maximum	.2	1.5	1.7	13.6	19.7	30.8	47.2	96.5	100.0	72.8	92.9	92.5	100.0
	Standard deviation	.01	.07	.07	2.86	4.05	5.16	6.06	5.07	1.95	10.03	7.85	5.80	2.54

[1] Description of soil parameters is found in appendix 2.

Appendix 9. Fish-Community Data for the 58 Sampling Sites from the Indiana Department of Environmental Management Watershed Monitoring Program[1], 1998–2000.

[r, rare occurs at 3 or less sites (about 5 percent); c, common occurs at 4 to 28 sites; vc, very common occurs at 29 or more sites (50 percent); e, exotic species]

Family/common name	Status	Number of sites fish were found (n=58)	Number of individuals	Percent abundance
Amiidae				
bowfin	r	1	1	0.01
Anguillidae				
chestnut lamprey	r	1	2	.02
Aphredoderidae				
pirate perch	r	1	2	.02
Catostomidae				
bigmouth buffalo	r	1	1	.01
black redhorse	c	9	89	.67
creek chubsucker	r	3	3	.02
golden redhorse	c	14	81	.61
northern hogsucker	vc	29	352	2.66
quillback	r	2	3	.02
river carpsucker	r	1	3	.02
river redhorse	r	1	1	.01
shorthead redhorse	r	1	6	.05
silver redhorse	r	3	16	.12
spotted sucker	c	5	9	.07
white sucker	vc	36	184	1.39
Centrarchidae				
black crappie	c	5	6	.05
bluegill	vc	32	351	2.65
green sunfish	vc	37	470	3.55
hybrid sunfish	r	3	3	.02
largemouth bass	c	14	44	.33
longear sunfish	vc	31	621	4.69
orangespotted sunfish	c	5	14	.11
redear sunfish	c,e	4	19	.14
rock bass	c	21	133	1.00
pumpkinseed	c	4	25	.19
smallmouth bass	c	11	57	.43

Appendix 9. Fish-Community Data for the 58 Sampling Sites from the Indiana Department of Environmental Management Watershed Monitoring Program[1], 1998–2000.—Continued

[r, rare occurs at 3 or less sites (about 5 percent); c, common occurs at 4 to 28 sites; vc, very common occurs at 29 or more sites (50 percent); e, exotic species]

Family/common name	Status	Number of sites fish were found (n=58)	Number of individuals	Percent abundance
Centrarchidae—Continued				
spotted bass	c	17	65	.49
warmouth	r	2	9	.07
white crappie	r	1	3	.02
Clupeidae				
gizzard shad	r	2	30	.23
Cottidae				
banded sculpin	c	4	87	.66
mottled sculpin	c	13	406	3.06
Cyprinidae				
bigeye chub	r	3	245	1.85
bigeye shiner	r	1	12	.09
blacknose dace	c	22	865	6.53
bluntnose minnow	vc	42	1,437	10.8
brook silverside	r	1	1	.01
carp	c,e	17	75	.57
central stoneroller	vc	31	1,395	10.53
common shiner	r	2	8	.06
creek chub	vc	48	1,992	15.03
cypress minnow	r	1	2	.02
emerald shiner	c	4	12	.09
fathead minnow	c	4	58	.44
golden shiner	r	1	8	.06
hornyhead chub	r	3	16	.12
largescale stoneroller	c	5	249	1.88
mimic shiner	c	4	7	.05
Mississippi silvery minnow	r	3	17	.13
redfin shiner	c	7	19	.14
river chub	r	3	113	.85
river shiner	r	1	1	.01
rosyface shiner	c	5	50	.38

Appendix 9. Fish-Community Data for the 58 Sampling Sites from the Indiana Department of Environmental Management Watershed Monitoring Program[1], 1998–2000.—Continued

[r, rare occurs at 3 or less sites (about 5 percent); c, common occurs at 4 to 28 sites; vc, very common occurs at 29 or more sites (50 percent); e, exotic species]

Family/common name	Status	Number of sites fish were found (n=58)	Number of individuals	Percent abundance
Cyprinidae—Continued				
sand shiner	c	15	320	2.41
scarlet shiner	r	1	5	.04
silver chub	r	1	3	.02
silverjaw minnow	c	19	178	1.34
southern redbelly dace	r	1	3	.02
spotfin shiner	c	20	628	4.74
steelcolor shiner	c	4	71	.54
Cyprinidae—Continued				
striped shiner	c	21	101	.76
suckermouth minnow	c	9	102	.77
Cyprinodontidae				
blackstripe topminnow	c	9	143	1.08
Esocidae				
grass pickerel	c	9	21	.16
sauger	r	1	1	.01
Ictaluridae				
brindled madtom	r	3	5	.04
channel catfish	c	6	21	.16
flathead catfish	r	2	4	.03
stonecat	c	15	59	.45
tadpole madtom	r	1	2	.02
yellow bullhead	c	26	77	.58
Lepisosteidae				
longnose gar	r	2	2	.02
Percidae				
banded darter	r	2	19	0.14
blackside darter	c	7	28	.21
bluebreast darter	r	1	10	.08

Appendix 9. Fish-Community Data for the 58 Sampling Sites from the Indiana Department of Environmental Management Watershed Monitoring Program[1], 1998–2000.—Continued

[r, rare occurs at 3 or less sites (about 5 percent); c, common occurs at 4 to 28 sites; vc, very common occurs at 29 or more sites (50 percent); e, exotic species]

Family/common name	Status	Number of sites fish were found (n=58)	Number of individuals	Percent abundance
Percidae—Continued				
bluntnose darter	r	1	4	.03
dusky darter	c	7	41	.31
fantail darter	C	21	348	2.63
greenside darter	c	24	486	3.67
johnny darter	vc	34	269	2.03
logperch	c	7	22	.17
orangethroat darter	c	21	213	1.61
orangethroat rainbow hybrid	r	1	1	.01
rainbow darter	c	19	357	2.69
slenderhead darter	r	3	16	.12
slough darter	r	1	3	.02
Poecillidae				
western mosquitofish	r	1	3	.02
Sciaenidae				
freshwater drum	r	3	5	.04
Umbridae				
central mudminnow	r	3	4	.03
Total number of individuals	13,253			
Total number of species	88			
Total number of families	16			

[1] (Indiana Department of Environmental Management, 1992)

Appendix 10. Invertebrate-Community Data for the 58 Sampling Sites from the Indiana Department of Environmental Management Watershed Monitoring Program[1], 1998–2000.

[r, rare, occurs at less than 3 sites (about 5 percent); c, common, occurs at 4 to 28 sites; v, very common, occurs at 29 or more sites; (n), number of sites]

Phylum	Class	Order	Taxon/common name	Status	Number of sites invertebrates were found (n=58)	Number of individuals	Percent abundance
Annelida	Hirudinea		Hirudinid Leech	r	2	2	0.02
Annelida	Oligochaeta	Clitellata	Tubificidae	r	2	5	.05
Annelida	Oligochaeta		Oligochaeta	vc	46	970	9.28
Annelida			Annelida	r	1	6	.06
Arthropoda	Arachnida		Acari	vc	32	164	1.57
Arthropoda	Hexapoda	Lepidoptera	Pyralidae	r	2	8	.08
Arthropoda	Insecta	Coleoptera	Coleoptera	r	1	3	.03
		Coleoptera	Dryopidae	r	2	2	.02
		Coleoptera	Dytiscidae	r	1	1	.01
		Coleoptera	Elmidae	vc	55	1,098	10.5
		Coleoptera	Haliplidae	r	1	1	.01
		Coleoptera	Hydrophilidae	c	6	11	.11
		Coleoptera	Psephenidae	c	14	110	1.05
		Diptera	Ceratopagonidae	c	9	24	.23
		Diptera	Chironomidae	vc	58	3,230	30.9
		Diptera	Diptera	r	1	1	.01
		Diptera	Empididae	vc	35	121	1.16
		Diptera	Ephydridae	r	1	1	.01
		Diptera	Simuliidae	vc	35	257	2.46
		Diptera	Stratiomyidae	r	1	1	.01
		Diptera	Tabanidae	c	7	16	.15
		Diptera	Tipulidae	c	16	54	.52
		Ephemeroptera	Baetidae	vc	50	819	7.84
		Ephemeroptera	Caenidae	c	13	40	.38
		Ephemeroptera	Ephemeridae	c	4	4	.04
		Ephemeroptera	Heptageniidae	vc	39	425	4.07
		Ephemeroptera	Leptophlebiidae	r	3	8	.08
		Ephemeroptera	Oligoneuriidae	c	16	112	1.07
		Ephemeroptera	Siphlonuridae	r	1	1	.01
		Ephemeroptera	Tricorythidae	c	21	172	1.65

Appendix 10. Invertebrate-Community Data for the 58 Sampling Sites from the Indiana Department of Environmental Management Watershed Monitoring Program[1], 1998–2000.—Continued

[r, rare, occurs at less than 3 sites (about 5 percent); c, common, occurs at 4 to 28 sites; v, very common, occurs at 29 or more sites; (n), number of sites]

Phylum	Class	Order	Taxon/common name	Status	Number of sites invertebrates were found (n=58)	Number of individuals	Percent abundance
Arthropoda	Insecta—Continued						
		Hemiptera	Veliidae	r	2	3	.03
		Hexapoda	Isotomidae	r	2	3	.03
		Homoptera	Corixidae	r	2	2	.02
		Megaloptera	Corydalidae	c	10	24	.23
		Megaloptera	Sialidae	r	3	7	.07
		Odonata	Aeshnidae	r	1	1	.01
		Odonata	Corduliidae	r	1	1	.01
		Odonata	Gomphidae	r	1	1	.01
		Plecoptera	Capniidae	c	5	20	.19
		Plecoptera	Perlodidae	r	2	6	.06
		Plecoptera	Taeniopterygidae	r	3	12	.11
		Trichoptera	Glossosomatidae	r	1	3	.03
		Trichoptera	Helicopsychidae	c	8	20	0.19
		Trichoptera	Hydropsychidae	vc	56	2,110	20.2
		Trichoptera	Hydroptilidae	c	23	114	1.09
		Trichoptera	Leptoceridae	r	2	2	.02
		Trichoptera	Limnephilidae	r	1	1	.01
		Trichoptera	Philopotamidae	c	12	111	1.06
		Trichoptera	Polycentropodidae	r	3	8	.08
Arthropoda	Malcostraca	Amphipoda	Gammaridae	r	1	6	.06
		Amphipoda	Talitridae	r	3	3	.03
		Decapoda	Astacidae	c	5	7	.07
		Isopoda	Asellidae	c	10	59	.56
Mollusca	Basommatophora	Gastropoda	Physa	c	9	48	.46
		Gastropoda	Planorbidae	r	2	2	.02
Mollusca	Bivalvia	Gastropoda	Ferrissia	c	6	15	.14
		Gastropoda	Gastropoda	r	1	1	.01
		Gastropoda	Lymnea	r	2	2	.02

Appendix 10. Invertebrate-Community Data for the 58 Sampling Sites from the Indiana Department of Environmental Management Watershed Monitoring Program[1], 1998–2000.—Continued

[r, rare, occurs at less than 3 sites (about 5 percent); c, common, occurs at 4 to 28 sites; v, very common, occurs at 29 or more sites; (n), number of sites]

Phylum	Class	Order	Taxon/common name	Status	Number of sites invertebrates were found (n=58)	Number of individuals	Percent abundance
Mollusca	Bivalvia—Continued						
		Pelecypoda	Sphaeriidae	c	13	32	.31
			Corbicula	c	6	74	.71
Nematoda			Nematoda	c	6	12	.11
Platyhelminthes	Turbellaria		Turbellaria	c	11	72	.69
Total number of individuals	10,449						
Total number of taxa	88						

[1] (Indiana Department of Environmental Management, 1999)

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