Prepared in cooperation with the Illinois River Watershed Partnership

Effects of Land Use, Stream Habitat, and Water Quality on Biological Communities of Wadeable Streams in the Illinois River Basin of Arkansas, 2011 and 2012

Scientific Investigations Report 2014–5009

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

Cover:

Top, Section of Osage Creek in an urban area upstream from a wastewater-treatment plant.

Bottom, Section of Osage Creek in an agriculture area downstream from a wastewater-treatment plant.

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By James C. Petersen, B.G. Justus, and Bradley J. Meredith

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square foot (ft^2)	0.09290	square meter (m^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
cubic inch (in^3)	16.39	cubic centimeter (cm^3)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F=(1.8×°C)+32

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

°C=(°F-32)/1.8

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD83).

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (μS/cm at 25 °C).

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

Effects of Land Use, Stream Habitat, and Water Quality on Biological Communities of Wadeable Streams in the Illinois River Basin of Arkansas, 2011 and 2012

By James C. Petersen, B.G. Justus, and Bradley J. Meredith

Abstract

The Illinois River Basin includes an area of diverse land use in northwestern Arkansas. Land-use data collected in 2006 indicate that most of the land in the basin is agricultural. The agricultural land is used primarily for production of poultry and cattle.

Eighteen sites were selected from the list of candidate sites based on drainage area, land use, presence or absence of an upstream wastewater-treatment plant, water quality, and other information gathered during the reconnaissance. An important consideration in the process was to select sites along gradients of forest to urban land use and forest to agricultural land use. Water-quality samples were collected for analysis of nutrients, and a multiparameter field meter was used to measure water temperature, specific conductance, pH, and dissolved oxygen. Streamflow was measured immediately following the water-quality sampling. Macroalgae coverage was estimated and periphyton, macroinvertebrate, and fish communities were sampled at each site. Stream habitat also was assessed.

Many types of land-use, water-quality, and habitat factors affected one or more aspects of the biological communities. Several macroinvertebrate and fish metrics changed in response to changes in percent forest; sites that would be considered most disturbed, based on these metrics, are sites with the highest percentages of urban land use in their associated basins.

The presence of large mats of macroalgae was one of the most noticeable biological characteristics in several streams within the Illinois River Basin. The highest macroalgae percent cover values were recorded at four sites downstream from wastewater-treatment plants. Macroalgae percent cover was strongly correlated only with bed substrate size, canopy closure, and specific conductance.

Periphyton metrics were most often and most strongly correlated with riparian shading, specific conductance, substrate turbidity, percent agriculture, poultry house density, and unpaved road density; some of these factors were strongly correlated with percent forest, percent urban, or percent agriculture. Total biovolume of periphyton was not strongly correlated with any of the land use, habitat, or water-quality factors assessed in the present study. Although algal growth typically increases with higher nutrient concentrations and less shading, the standing crop of periphyton on rocks can be reduced by herbivorous macroinvertebrates and fish, which may explain why total biovolume in Ozark streams was not strongly affected by water-quality (or other habitat) factors.

A macroinvertebrate index and several macroinvertebrate metrics were adversely affected by increasing urban and agricultural land use and associated environmental factors. Factors most commonly affecting the index and metrics included factors associated with water quality, stream geometry, sediment, land-use percentages, and road density. In general, the macroinvertebrate index was higher (indicative of least disturbance) at sites with greater percentages of forest in their basins, lower percentages of urban land in their basins, and lower paved road density. Upstream wastewater-treatment plants affected several metrics. For example, three of the five lowest macroinvertebrate index scores, two of the five lowest percent predator values, and two of the five highest percent gatherer-collector values were at sites downstream from wastewater-treatment plants.

The Ozark Highlands fish index of biotic integrity and several fish metrics were adversely affected by increasing urban and agricultural land use and associated factors. Factors affecting these metrics included factors associated with nutrients, sediment, and shading. In general, the fish index of biotic integrity was higher at sites with higher percentages of forest in their basins, lower percentages of urban land in their basins, higher unpaved road density, and lower paved and total road density. Upstream wastewater-treatment plants seemed to affect some fish community metrics substantially but had little effect on other metrics. For example, three of the five lowest relative abundances of lithophilic spawner minus stonerollers and four of the five highest stoneroller abundances were at sites downstream from wastewater-treatment plants.

Interpretations of the results of the study described in this report are limited by a number of factors. These factors individually and collectively add to uncertainty and variability in the responses to various environmental stresses. Notwithstanding the limiting factors, the biological responses

of macroalgae cover and periphyton, macroinvertebrate, and fish metrics to environmental variables provide multiple lines of evidence that biological communities of these streams are affected by recent and ongoing land-use practices.

For several biological metrics there appears to be a threshold of about 40 to 50 percent forest where values of these metrics change in magnitude. However, the four sites with more than 50 percent forest in their basins were the four sites sampled in late May–early June of 2012 (rather than July–August of 2011). The relative influence of season and forest percentage on the biological communities at these sites is unknown.

Introduction

The Illinois River Basin (fig. 1) is an area of Arkansas undergoing substantial and rapid land-use changes, rapid population growth, and associated changes in water-quality and stream-habitat conditions (FTN Associates, Ltd., 2012); these changes can affect the biological communities in streams. The Ozark Plateaus province (which includes the Springfield Plateau and the Boston Mountains physiographic sections and contains the Illinois River Basin) is an area of relatively high biological diversity of aquatic species (Master and others, 1998; Petersen and others, 2008), The Illinois River Basin is 1of 87 similarly-sized watersheds in the United States with 10 or more at-risk fish or mussel species (Master and others, 1998).

Purpose and Scope

The purpose of this report is to describe the biological communities (periphyton, macroinvertebrates, and fish) of wadeable streams (table 1) and effects of land use in the Illinois River Basin in Arkansas. Macroalgae (the algae with visible structure, rather than the typically microscopic algal structure of periphyton) cover also is described. Relations are shown between the biological communities and macroalgae, and environmental factors such as basin land use (for example, percent forest, poultry house density, and road density), stream habitat, and water quality. (These factors generally will be referred to as “environmental factors.”)

The scope of this report is determined by several factors. The study area is limited to the part of the Illinois River Basin in Arkansas. Drainage area of sites was limited to a range of about 11 to 37 square miles (mi^2) to minimize the effect of stream size on the biological communities. Biological communities, macroalgae cover, and stream-habitat measures were sampled or measured once per site during 2011–12. Water-quality sampling was limited to a single base-flow sample per site that was analyzed for nutrients. Samples were not collected during storm events and were not analyzed for suspended sediment. Suspended sediment effects were estimated by measuring substrate embeddedness and turbidity caused by disturbance of gravel substrate. Samples were not analyzed for trace metals, pharmaceutical compounds, or other organic compounds.

Description of Study Area

The Illinois River Basin includes an area of diverse land use in northwestern Arkansas. Land-use data collected in 2006 indicate that most of the land in the basin is agricultural (46 percent, mostly pasture or poultry production) or urban (13 percent) (FTN Associates, Ltd., 2012). From 1992 to 2006 there was a shift from agricultural land use (which decreased from 64 to 46 percent) to urban land use (which increased from 6 to 13 percent) as the cities of Fayetteville, Springdale, and Rogers grew in area and in population (FTN Associates, Ltd., 2012). Forest plus herbaceous land use increased from 29 to 41 percent during the same period. Northwestern Arkansas (Benton and Washington Counties) more than doubled in population from approximately 210,900 in 1990 (U.S. Census Bureau, 2013a) to approximately 424,400 in 2010 (U.S. Census Bureau, 2013b).

The northern part of the basin lies in the Springfield Plateau and the southern part of the basin lies in the Boston Mountains physiographic section (Adamski and others, 1995). The gently rolling karst topography of the Springfield Plateau is underlain mostly by limestone. The geology associated with the karst topography results in a number of springs, sinkholes, caves, and gaining and losing streams and, therefore, a substantial connection between the surface water and the groundwater. The more rugged topography of the Boston Mountains is underlain mostly by sandstone and shale.

Activities related to the mixed land use in Illinois River Basin have affected water-quality and other hydrologic and biological conditions. Agricultural activities (as measured by percent agricultural land upstream from sites) have been related to higher concentrations of nutrients in streams in the basin or nearby parts of the Ozarks (Petersen and others, 1998; Davis and Bell, 1998; Justus and others, 2010; FTN Associates, Ltd., 2012). Agricultural activities also can cause increases in bacteria concentrations (Davis and Bell, 1998) and suspended sediment. Riparian (forested) corridors often are narrowed or eliminated in agricultural and urban areas, which can increase bank erosion and increase the amount of sunlight reaching the stream. Construction activities and general disturbance in urban areas also can be a source of suspended sediment. Wastewater-treatment plants (WWTPs) can be sources of nutrients, trace metals, pharmaceutical and personal care products, and other organic compounds. Several WWTPs (including plants serving Lincoln, Fayetteville, Rogers, Springdale, and Siloam Springs) discharge into streams in the basin (FTN Associates, Ltd., 2012). Finally, the increased impervious cover (such as roads, parking lots, and roof tops) causes increased runoff from precipitation, thus altering the natural streamflow patterns downstream from urban areas. Paul and Meyer (2001) and Coles and others (2012) provide overviews of the effects of urbanization on streams.

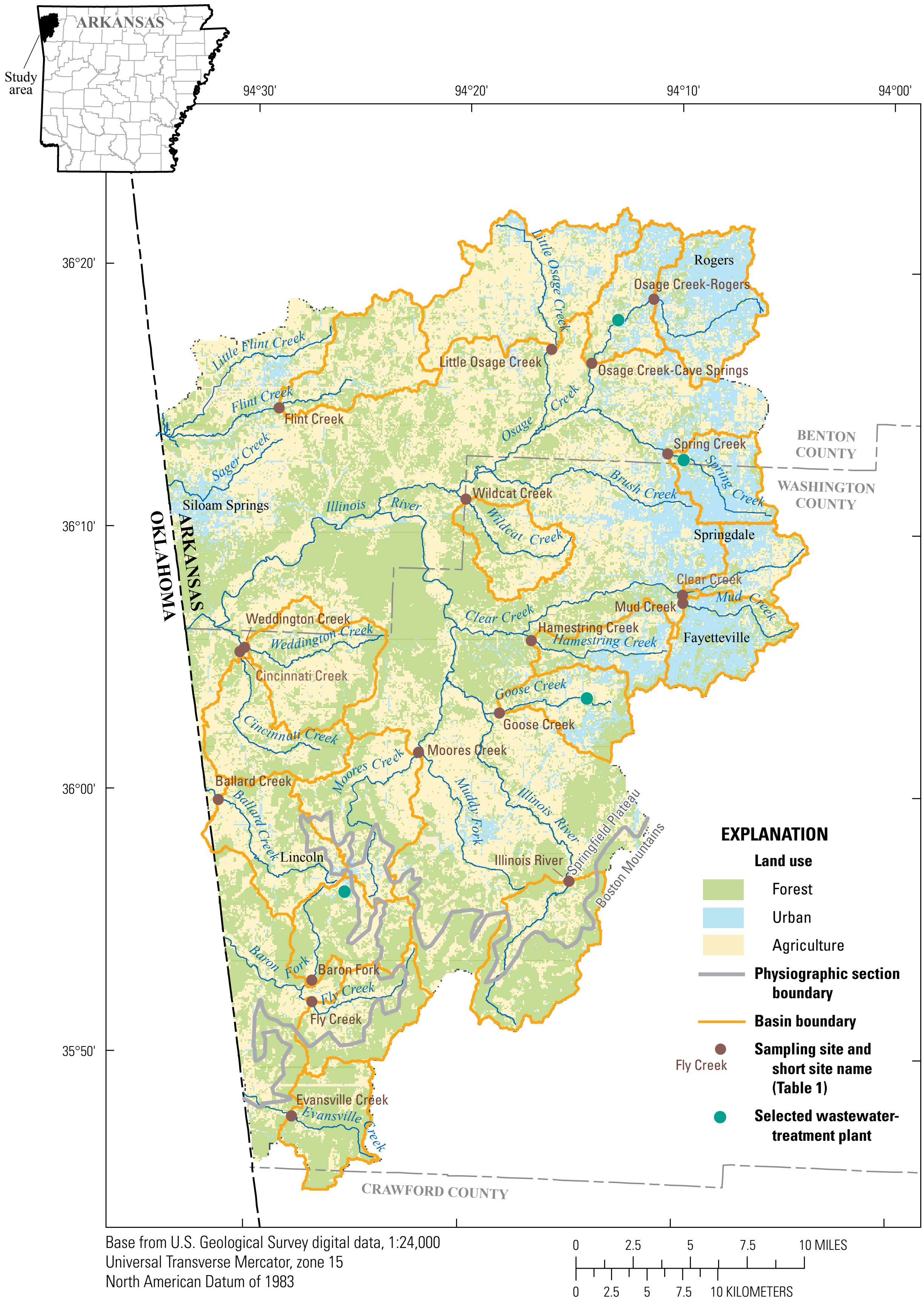

Figure 1. Map showing Illinois River Basin study area and sampling sites.

Table 1. List of sampling sites and related information for the Illinois River Basin study area.

[USGS, U.S. Geological Survey; mi^2, square mile; WWTP, wastewater-treatment plant; mi, mile; NA, not applicable]

USGS station name	Short site name	USGS station identification number	Latitude	Longitude	Drainage area (mi^2)	Forest site	Agriculture site	Urban site	Agriculture gradient site	Urban gradient site	WWTP upstream	Distance downstream from WWTP (mi)
Ballard Creek near Summers, Arkansas	Ballard Creek	07195452	355938.22	0943126.69	21.6	No	Yes	No	Yes	No	No	NA
Baron Fork near Morrow, Arkansas	Baron Fork	07196880	355241.73	0942702.64	17.3	No	Yes	No	No	No	Yes	4.9
Cincinnati Creek near Cincinnati, Arkansas	Cincinnati Creek	07195427	360517.16	0943032.76	19.8	No	Yes	No	Yes	No	No	NA
Clear Creek near Johnson, Arkansas	Clear Creek	07194812	360739.97	0940946.55	10.6	No	No	Yes	No	Yes	No	NA
Evansville Creek near Evansville, Arkansas	Evansville Creek	07196940	354743.24	0942757.98	15.8	Yes	No	No	Yes	Yes	No	NA
Flint Creek near Gentry, Arkansas	Flint Creek	07195820	361435.66	0942852.14	20.2	No	Yes	No	Yes	No	No	NA
Fly Creek near Morrow, Arkansas	Fly Creek	07196890	355201.18	0942702.88	17.5	No	Yes	No	Yes	No	No	NA
Goose Creek near Farmington, Arkansas	Goose Creek	07194758	360304.14	0941819.19	14.3	No	Yes	No	No	No	Yes	4.8
Hamestring Creek near Wheeler, Arkansas	Hamestring Creek	07194811	360551.86	0941652.1	13.4	No	No	Yes	No	Yes	No	NA
Illinois River near Hogeye, Arkansas	Illinois River	07194735	355646.56	0941504.95	25.7	Yes	No	No	Yes	Yes	No	NA
Little Osage Creek near Osage Mills, Arkansas	Little Osage Creek	07194945	361658.48	0941604.87	35.4	No	Yes	No	Yes	No	No	NA
Moores Creek northeast of Rhea, Arkansas	Moores Creek	071947888	360132.81	0942204.84	24.7	No	Yes	No	Yes	No	No	NA
Mud Creek near Johnson, Arkansas	Mud Creek	071948095	360722.11	0940945.22	16.0	No	No	Yes	No	Yes	No	NA
Osage Creek northwest of Cave Springs, Arkansas	Osage Creek-Cave Springs	07194887	361627.66	0941410.79	37.4	No	No	Yes	No	No	Yes	3.1
Osage Creek at Rogers, Arkansas	Osage Creek-Rogers	07194852	361855.84	0941118.17	22.8	No	No	Yes	No	Yes	No	NA
Spring Creek upstream from I-540 near Springdale, Arkansas	Spring Creek	071949063	361303.36	0941032.77	13.1	No	No	Yes	No	No	Yes	1.1
Weddington Creek near Cincinnati, Arkansas[1]	Weddington Creek	07195425	360526.92	0943019.51	23.2	No	Yes	No	Yes	No	No	NA
Wildcat Creek near Robinson, Arkansas	Wildcat Creek	07195223	361113.09	0942001.54	14.0	No	Yes	No	Yes	No	No	NA

[1] Often locally referred to as Wedington Creek.

Thirteen stream segments within the study area are listed as impaired water bodies by the Arkansas Department of Environmental Quality and the U.S. Environmental Protection Agency (FTN Associates, Ltd., 2012). These stream segments are listed as impaired because they do not meet water-quality standards or criteria or do not support designated beneficial uses; constituents or contaminants causing impairment include phosphorus, nitrate, suspended sediment, pathogenic bacteria, and metals. Potential sources of contaminants include surface erosion, agricultural and urban land use (including municipal point sources), failing septic systems, and unknown sources (FTN Associates, Ltd., 2012). The 13 stream segments are located on Osage Creek, Little Osage Creek, Spring Creek, Sager Creek, Clear Creek, Muddy Fork, Baron Fork, and Illinois River (fig. 1). All of the impaired stream segments were sampled as part of this study, with the exception of Sager Creek, which has a very small drainage area.

Weather Conditions During the Sampling Periods

Weather conditions preceding and during the July–September 2011 and the May–June 2012 sampling periods were abnormally hot and dry. Mean daily high temperatures near Fayetteville, Ark. (Drake Field), were 6.8, 9.1, and 5.6 degrees Fahrenheit (°F) warmer than the normal (1981–2010) temperatures of 83.6, 88.6, and 89.1 °F in June, July, and August 2011, respectively (National Climatic Data Center, 2013). Precipitation was 4.00 and 2.61 inches lower than the normal (1981–2010) of 4.95 and 3.24 inches in June and July of 2011. August was wetter than normal, but most of the rainfall occurred on August 10–12, after the last day of sampling in August 2011. Almost no precipitation occurred between August 12 and September 13, the last day of sample collection in 2011. Warmer than normal temperatures and low precipitation also occurred in April and May of 2012. April and May mean temperatures were 4.2 and 6.4 °F warmer than the normal temperatures of 69.3 and 76,1 °F, respectively. April and May precipitation values were 2.45 and 4.86 inches lower than normal precipitation values of 4.60 and 5.91 inches, respectively.

Previous Investigations

Four previous studies of the effects of land use on stream biota in the Illinois River Basin of Arkansas have been published. The studies provide a framework for the current study.

Water quality (31 sites), periphyton (15 sites), benthic macroinvertebrates (18 sites), fish (10 sites), and fish habitat (9 sites) were sampled in 1995 and 1996 by the Arkansas Department of Environmental Quality (Arkansas Department of Environmental Quality, 1997). Most sites were on the main stems of the Illinois River, Osage Creek, Spring Creek, Mud Creek, Clear Creek, or Muddy Fork. The objective of the study was to quantify and determine the impacts of four WWTPs on the Illinois River. The ADEQ sampling occurred prior to improvements in effluent quality at many of the WWTPs in the basin. An attempt was made to compare results from the 1995–96 study with the current (2011–12) study. However, the small number of sites in common between the two studies and differences in site location, sampling methods, and laboratory analysis methods precluded any rigorous assessment of changes in stream condition between the two studies.

From August 2003 through January 2004 and at 11 sites in the Illinois River Basin, Parsons and the University of Arkansas (2004) sampled water quality (nutrients, chlorophyll, total organic carbon, dissolved solids, turbidity, and field measurements); habitat; periphyton, macroinvertebrates, and fish communities; and periphyton algal production. The study focused on the effects of WWTPs. Sites were characterized as unimpacted to severely impacted based on a range of factors including point sources and nonpoint sources of water-quality constituents, urbanization, and agricultural activities.

A study by Stevenson (undated) included more than 50 sites in Arkansas and Oklahoma. Sites were sampled for water quality, algae, macroinvertebrates, and fish.

Most recently, McGoodwin, Williams, and Yates, Inc. (2009) sampled 10 sites in the Illinois River Basin in Arkansas. With the exception of two “reference” sites, all sites were on Osage Creek and Spring Creek. Sites were sampled for water quality, algae, macroinvertebrates, and fish.

Methods

Methods for collection and analysis of data are described below. Data-collection methods generally follow U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Program biological sampling methods. Data-analysis methods generally were limited to approaches for aggregating data, calculating biological metrics and indices, and describing relations between biological metrics and indices and environmental factors (table 2).

Data-Collection Methods

During April of 2011, a reconnaissance of approximately 40 candidate sites was conducted. Candidate sites were selected based on drainage area and qualitative land-use estimates. During the reconnaissance a field test kit was used to measure nutrient (phosphorus and nitrate) concentrations; qualitative information related to local land use, habitat factors, and access also was obtained.

Eighteen sites (table 1) were selected from the list of candidate sites based on drainage area, land use, presence or absence of an upstream WWTP, water-quality, and other information gathered during the reconnaissance. An important

Table 2. List of environmental factors compared to biological metrics and indices.

[NA, not applicable]

Factor	Source	Reference
Dissolved nitrite plus nitrate	Laboratory analysis	NA
Total phosphorus[1]	Laboratory analysis	NA
Water temperature	Field measurement	NA
Specific conductance	Field measurement	NA
Dissolved oxygen	Field measurement	NA
pH	Field measurement	NA
Instantaneous streamflow	Field measurement	NA
Bankfull width	Mean from 11 transects	Fitzpatrick and others (1998)
Bankfull width divided by drainage area	Mean from 11 transects	Fitzpatrick and others (1998)
Depth	Mean from 3 measurements at each of 11 transects	Fitzpatrick and others (1998)
Water velocity	Mean from 3 measurements at each of 11 transects	Fitzpatrick and others (1998)
Bed substrate class	Mean from 3 locations at each of 11 transects	Fitzpatrick and others (1998)
Embeddedness	Mean from 3 locations at each of 11 transects	Fitzpatrick and others (1998)
Open canopy angle	Mean from 11 transects	Fitzpatrick and others (1998)
Combined canopy closure	Mean from each edge of water at 11 transects	Fitzpatrick and others (1998)
Bank height	Mean from two locations at each of 11 transects	Fitzpatrick and others (1998)
Bank angle	Mean from two locations at each of 11 transects	Fitzpatrick and others (1998)
Substrate turbidity	Mean from five locations in stream reach	See methods of this report
Drainage area	For basin	NA
Percent forest	For basin from 2006	Arkansas Geographic Information Office (2006)
Percent agriculture	For basin from 2006	Arkansas Geographic Information Office (2006)
Percent urban	For basin from 2006	Arkansas Geographic Information Office (2006)
Poultry house density	For basin from 2006	Arkansas Geographic Information Office (2006)
Total unpaved road density	For basin from 2006	Arkansas Geographic Information Office (2006)
Total paved road density	For basin from 2006	Arkansas Geographic Information Office (2006)
Total road density	For basin from 2006	Arkansas Geographic Information Office (2006)

[1] Total phosphorus, rather than orthophosphorus, was selected because the State of Oklahoma's water-quality standard (Oklahoma Water Resources Board, 2013) is for total phosphorus, and total phosphorus and orthophosphorus are strongly correlated (rho=0.96).

consideration in the process was to select sites along gradients of forest to urban land use (hereafter, the urban gradient) and forest to agricultural land use (hereafter, the agricultural gradient). Most sites along both land-use gradients had a mix of all three land-use types in the part of the basin upstream from the site.

Most sites were sampled in July or August of 2011. Four sites (Evansville Creek, Illinois River, Fly Creek, and Baron Fork) were not sampled in 2011 because of low streamflow conditions; these sites were sampled in late May or early June of 2012. Water-quality samples were collected from each site prior to biological sampling. Samples were collected using standard USGS methods (U.S. Geological Survey, variously dated) for analysis of nutrients (dissolved ammonia, dissolved nitrite plus nitrate, dissolved nitrite, organic nitrogen, orthophosphorus, and total phosphorus). A multiparameter field meter was used to measure water temperature, specific conductance, pH, and dissolved oxygen. Streamflow was measured immediately following the water-quality sampling. Water-quality samples were submitted to the USGS National Water Quality Laboratory, Denver, Colorado, for analysis (Fishman, 1993; Patton and Kryskalla, 2003). A duplicate sample was collected at two sites and analyzed in 2011 and in 2012. Relative percent differences between the primary sample and the duplicate generally were less than 5 percent (table 3). Water-quality data were stored in the USGS National Water Information System water-quality database (http://waterdata.usgs.gov/nwis/qw/).

Table 3. Relative percent differences between primary and duplicate water-quality samples collected in 2011 and 2012 in the Illinois River Basin study area.

[N, nitrogen; P, phosphorus; relative percent difference is absolute value of primary sample minus duplicate sample divided by average of the two samples and multiplied by 100. All concentrations are in milligrams per liter; <, less than; ND is not determinable]

	Ammonia as N	Nitrite plus nitrate as N	Nitrite as N	Organic nitrogen as N	Total nitrogen as N	Orthophos-phorus as P	Total phosphorus as P
Fly Creek	0.017	3.2	0.0196	0.003	3.2	0.027	0.040
Fly Creek (duplicate)	0.017	3.2	0.0205	0.166	3.4	0.027	0.036
Relative percent difference	0.0	0.0	2.3	96.4	3.0	0.0	5.3
Osage Creek-Cave Springs	<0.010	2.6	0.0058	<0.259	2.9	0.158	0.171
Osage Creek-Cave Springs (duplicate)	<0.010	2.7	0.0054	<0.237	2.9	0.158	0.179
Relative percent difference	ND	1.9	3.6	ND	0.0	0.0	2.3

Periphyton and macroinvertebrate communities were sampled from five riffles within a stream reach at each site using USGS NAWQA Program methods (Moulton and others, 2002); methods are briefly described herein. Periphyton samples were collected from five rocks at each of five riffle locations at each site. To clean each rock, a 2-inch diameter polyvinyl chloride (PVC) cylinder was placed on the surface of each rock, and all the periphyton outside the cylinder was removed using a wire brush. After the rock surface was cleaned, the remaining periphyton from the area inside the PVC cylinder was removed with a wire brush, rinsed into a sample container, and preserved with formalin. Total sample area, sample volume, and preservative volume were recorded and used to calculate periphyton density (cells per area) and periphyton biomass (cell volume per area). Periphyton samples were submitted to the BSA Environmental Services, Inc. (http://www.bsaenv.com/index.html/) for identification and analysis.

Macroinvertebrates were collected from areas immediately adjacent to the areas where periphyton samples were collected using a Slack sampler with an area of 0.5 × 0.5 meter. Macroinvertebrate samples were sieved through a 500-micron sieve and preserved with formalin. Macroinvertebrate samples were submitted to Versar, Inc. (http://www.esm.versar.com/) for identification and analysis.

Fish were collected using a backpack electrofisher. Two passes were made in the stream reach, one along each bank and extending to the centerline of the stream in an upstream direction. Segments of three riffles in the stream reach also were sampled using the electrofisher and a seine; the substrate upstream from the seine was disturbed by kicking while electrofishing in a downstream direction. Fish were counted, identified in the field when possible, and released. Fish that could not be identified in the field were preserved in formalin for laboratory identification.

Stream habitat in the stream reach was assessed using NAWQA Program protocols (Fitzpatrick and others, 1998); methods are briefly described herein. Habitat measurements were made along 11 equally spaced transects spanning the length of the sampling reach. The length of the sampling reach was approximately 20 times the wetted width of the stream and typically was about 200 meters in length.

During the habitat measurement, macroalgae cover was visually estimated. Macroalgae cover was estimated at each of five quadrats (two edges of water and three locations spaced at equal intervals across the transect) at the 11 transects within each reach. Each quadrat was approximately 1 meter × 1 meter.

One additional habitat measurement that qualitatively estimated the degree of intergravel sedimentation at each sampling site was not part of the NAWQA Program protocols. At each of five locations in runs or shallow pools of the stream reach, a 3-foot section of 8-inch inside diameter PVC pipe with a foam lip was pressed into the gravel substrate so that a seal was formed. The shallow water inside the pipe and just above the substrate was agitated for 30 seconds using a stirrer constructed of a 4-inch wide × 3-inch tall paddle secured to a 40-inch section of 1-inch PVC pipe. The multiparameter field meter was used to measure turbidity (in nephelometric turbidity units) within the PVC pipe at 30-second intervals for 2 minutes. The turbidity measured after 60 seconds is termed “substrate turbidity” in this report. The depth of the water within the pipe was recorded (but for consistency, locations with a depth of approximately 1.0 foot were targeted.)

Geographic information system (GIS) data were used to describe the characteristics of the basin upstream from each of the 18 sites. The characteristics of interest were basin size, land-use percentage, number of poultry houses per square mile, and density of several road types per square mile Characteristics were estimated using data from the Arkansas Geographic Information Office (2006).

Data-Analysis Methods

Sites were grouped into site categories and ultimately into two land-use gradient groups based on basin land use. The categories were forest, agriculture, urban, agriculture with upstream WWTP, and urban with upstream WWTP (table 1). The two forest sites and the agriculture sites (not including the two with an upstream WWTP) were combined into the agriculture gradient group (table 1). The two forest sites and the urban sites (not including the two with an upstream WWTP) were combined into the urban gradient group (table 1).

Spearman's rho correlation and scatterplots were used to examine relations between selected water quality, habitat, and land-use factors (listed in table 2) and biological metrics. These examinations generally were conducted among sites chosen for each gradient. The two sites with the highest percentage of forest land use are in both gradient groups. Spearman's rho correlations are reported without reporting associated p-values because a table of exact p-values (such as table 13 in Bhattacharyya and Johnson, 1977) should be used with sample sizes of less than 20 (Helsel and Hirsch, 2002). Many statistical software packages do not report exact p-values for small sample sizes. Correlations are characterized in this report as strong or moderately strong (or moderate) based on the values of rho, the sample size, and, when given in table 13 of Bhattacharyya and Johnson (1977), the p-value:

- Sample size of 6—strong, absolute values of rho greater than or equal to 0.80; moderately strong, absolute values of rho greater than or equal to 0.65;
- Sample size of 10—strong, absolute values of rho greater than or equal to 0.60; moderately strong, absolute values of rho greater than or equal to 0.45; and
- Sample sizes of 14 and 18—strong, absolute values of rho greater than or equal to 0.50; moderately strong, absolute values of rho greater than or equal to 0.40.

The values of rho used to characterize correlation strength for sample sizes of 6 and 10 approximate values associated with p-values of 0.05 and 0.10, respectively, in Bhattacharyya and Johnson (1977). The values of rho used for sample sizes of 14 and 18 were arbitrarily selected because p-values for this sample size are not given in Bhattacharyya and Johnson (1977).

Biological metrics were chosen based on one or more criteria—previous use in other investigations; relevance based on previous use in the literature; expected relations to one or more characteristics expected to be affected by nutrients, suspended sediment, or other disturbances; or perceived patterns of differences in biological metrics related to various site categorizations. Macroinvertebrate data were processed using the Invertebrate Data Analysis System (Cuffney and Brightbill, 2011); metrics were calculated based on a series of macroinvertebrate attribute tables in the Invertebrate Data Analysis System. Periphyton metrics were calculated using methods similar to those used for macroinvertebrates (Thomas F. Cuffney, U.S. Geological Survey, written commun., 2013) and using algal attributes from Porter (2008). Fish metrics were calculated based on attributes reported in Dauwalter and others (2003) and Petersen and others (2008).

A macroinvertebrate index was developed specifically for this study. The first step in the process used to develop the macroinvertebrate index involved comparing a large number of biological metrics to potential chemical and physical stressors (or associated surrogates). More than 100 macroinvertebrate metrics that included measures and classes of behavior, feeding, tolerance (to water pollution and habitat degradation), and taxonomic relative abundance and richness were compared to potential explanatory environmental variables. Values for richness, percent richness, abundance, and percent relative abundance were evaluated for all but a few metrics (for which percentages were not beneficial to the analysis, for example, diversity indices).

Macroinvertebrate metrics were selected for the macroinvertebrate index based primarily on correlations to the percentage of forest in the basins of the 18 sites, but correlations to water quality and habitat variables also were considered. Five metrics that (1) had strong correlations to the amount of forest, (2) were ecologically relevant, and (3) were not autocorrelated (absolute value of rho greater than 0.70) were selected for inclusion in the macroinvertebrate index. Approximately 20 macroinvertebrate metrics were correlated to a number of the test variables; however, many of those metrics had taxa that overlapped with other metrics resulting in a high incidence of autocorrelation. Other macroinvertebrate metrics had spurious relations to environmental variables and were not considered because they lacked ecological relevance. Eventually, five macroinvertebrate metrics that generally had moderately strong to strong correlations to percent forest or percent urban (five metrics, none of these five were strongly correlated to percent agriculture), specific conductance or total phosphorus (four metrics), riparian cover variables (two metrics), and total road density (five metrics) were selected for the macroinvertebrate index. Those five metrics included number of taxa belonging to Ephemeroptera, Plecoptera, Trichoptera; percentage of total richness composed of predators; percentage of total abundance composed of gatherer-collectors; percentage of total abundance composed of Baetidae; and Margalef diversity (Margalef, 1958).

Scores for the macroinvertebrate index were calculated by combining values for the five metrics using a centering method (Justus, 2003). An advantage of the centering method is that it is more robust than other scoring methods (for example, scores range from 0 to 100 rather than tiered, preassigned metric classes of 1, 3, or 5). A disadvantage of the centering method is that it does not facilitate comparison of sites from independent data sets because metric scores are based on the range of sampling conditions that may not include least- or most-impaired sites. Given that only 18 sites were sampled, the application of this index is probably limited to the current study and may not be applicable to studies in other basins.

The centering method uses one of two scoring procedures depending on if high or low metric values represent least-disturbed conditions. If a high metric value indicated least-degraded conditions, the metric value was first divided by the maximum metric value (for all 18 sites), and the resulting quotient was multiplied by 100 to obtain a metric score. To obtain a metric score if low metric values indicated least-disturbed conditions, the metric value was again divided by the maximum metric value, but the resulting quotient was subtracted from 1 before being multiplied by 100. Scores for the five metrics were averaged to obtain an index score. Sites having the highest macroinvertebrate index scores were assumed to have the least-disturbed conditions. Natural breaks in the index score values were used to distinguish between the four classes: poor (less than 40), fair (greater than or equal to 40 but less than 50), good (greater than or equal to 59 but less than 67), and least disturbed (greater than or equal to 81).

Classes of Environmental Factors Affecting Biological Communities

There are three classes of environmental factors that affect the biological communities in small streams in the Illinois River Basin of Arkansas—land use, stream habitat, and water quality. Values for selected factors in each of these classes are described below.

Land-Use Factors Associated With Stream Basins

Basin land-use percentages varied substantially among the 18 sites (fig. 2, table 4). Forest land use ranged from 11.9 to 79.4 percent. Agricultural land use (which is pasture or grassland) ranged from 12.2 to 69.5 percent. Urban land use ranged from 0.4 to 65.5 percent.

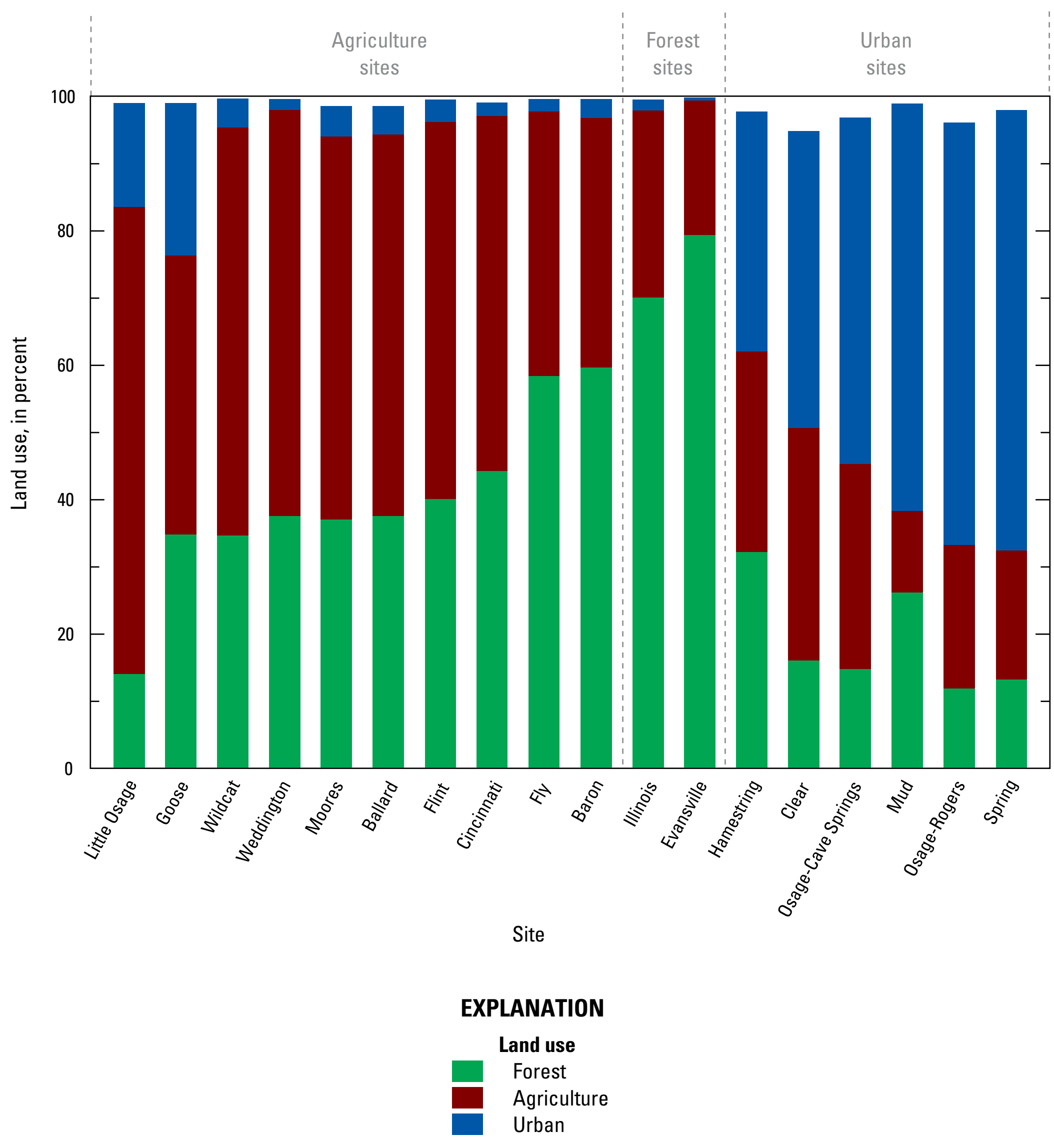

Figure 2. Land-use variation among sites along land-use gradients in the Illinois River Basin study area.

Table 4. Land-use percentages, poultry house density, and road density associated with sampling sites in the Illinois River Basin study area.

[WWTP, wastewater-treatment plant; mi^2, square mile]

Short site name	Agri-culture gradient site	Agri-culture site	Urban gradient site	Urban site	Forest site	WWTP upstream	Percent forest	Percent agriculture	Percent urban	Poultry house density (per mi^2)	Total unpaved road density (miles per mi^2)	Total paved road density (miles per mi^2)	Total road density (miles per mi^2)
Evansville Creek	Yes	No	Yes	No	Yes	No	79.4	20.0	0.4	1.7	2.2	0.4	2.6
Illinois River	Yes	No	Yes	No	Yes	No	70.1	27.8	1.6	1.9	1.6	0.7	2.3
Ballard Creek	Yes	Yes	No	No	No	No	37.6	56.8	4.2	6.7	2.0	1.5	3.5
Cincinnati Creek	Yes	Yes	No	No	No	No	44.2	52.8	2.1	6.6	2.2	0.5	2.7
Flint Creek	Yes	Yes	No	No	No	No	40.1	56.1	3.4	6.1	3.0	0.9	3.9
Fly Creek	Yes	Yes	No	No	No	No	58.4	39.5	1.8	4.9	2.2	0.8	3.0
Little Osage Creek	Yes	Yes	No	No	No	No	14.1	69.5	15.4	4.4	2.0	2.5	4.4
Moores Creek	Yes	Yes	No	No	No	No	37.0	57.0	4.5	5.2	2.5	1.5	4.0
Weddington Creek	Yes	Yes	No	No	No	No	37.6	60.3	1.6	2.5	1.9	1.0	2.8
Wildcat Creek	Yes	Yes	No	No	No	No	34.7	60.7	4.3	3.7	2.3	1.3	3.6
Baron Fork	No	Yes	No	No	No	Yes	59.7	37.1	2.7	5.2	1.8	1.1	2.9
Goose Creek	No	Yes	No	No	No	Yes	34.8	41.5	22.7	0.8	2.1	3.8	6.0
Clear Creek	No	No	Yes	Yes	No	No	16.0	34.5	44.2	4.3	1.7	6.2	7.9
Hamestring Creek	No	No	Yes	Yes	No	No	32.2	29.9	35.7	0.9	1.4	7.2	8.6
Mud Creek	No	No	Yes	Yes	No	No	26.1	12.2	60.6	0.2	0.9	12.2	13.1
Osage Creek-Rogers	No	No	Yes	Yes	No	No	11.9	21.4	62.8	0.1	0.6	10.9	11.4
Osage Creek-Cave Springs	No	No	No	Yes	No	Yes	14.8	30.4	51.6	0.1	0.7	9.6	10.3
Spring Creek	No	No	No	Yes	No	Yes	13.2	19.2	65.5	0.5	0.6	11.9	12.5

Several environmental factors (table 2) were strongly or moderately correlated with percent forest, percent agriculture, or percent urban land use (table 5). Correlations of four environmental factors probably were substantially affected by the low streamflow at the most-forested sites (negative correlations of streamflow, depth, and velocity with percent forest; positive correlation of bankfull width with percent forest; and opposite correlations of these factors with percent urban). Each of the road density factors was strongly correlated with percent forest and percent urban. Total unpaved road density also was strongly correlated with percent agriculture. Poultry house density was strongly correlated with percent forest, percent agriculture, and percent urban. Specific conductance was strongly correlated with percent forest and percent urban, possibly largely the result of geologic differences at the least forested sites and point-source and nonpoint-source contributions of WWTPs and urban activities. Nutrients were moderately correlated with percent agriculture. Embeddedness was moderately correlated with percent urban. In summary, sites with higher percentages of forest land use tended to be associated with lower streamflow, lower specific conductance, higher poultry house density, higher unpaved road density, and lower paved road density. Sites with higher percentages of agriculture land use were associated with higher nutrient concentrations, higher poultry house density, and higher unpaved road density. Sites with higher percentages of urban land use were associated with higher streamflow, higher specific conductance, more embeddedness, lower poultry house density, lower unpaved road density, and higher paved road density.

Table 5. Correlations between land-use percentages and selected environmental factors in the Illinois River Basin study area.

[Red font denotes absolute value of rho is greater than or equal to 0.50]

	Percent forest	Percent agriculture	Percent urban
Percent forest	1.00	0.11	−0.93
Percent agriculture	0.11	1.00	−0.33
Percent urban	−0.93	−0.33	1.00
Nitrite plus nitrate	−0.26	0.48	0.14
Total phosphorus	−0.17	0.41	0.17
Temperature	0.16	−0.00	−0.12
Specific conductance	−0.68	−0.19	0.68
Dissolved oxygen	0.09	0.34	−0.06
pH	−0.03	0.19	0.06
Streamflow	−0.67	0.21	0.57
Bankfull width	0.55	−0.07	−0.46
Drainage area	0.08	0.33	−0.23
Bankfull width/drainage area	0.21	−0.28	−0.08
Depth	−0.63	−0.00	0.53
Velocity	−0.67	0.07	0.57
Bed substrate	0.36	−0.23	−0.33
Embeddedness	−0.28	−0.19	0.40
Substrate turbidity	0.25	−0.27	−0.12
Open canopy angle	−0.13	−0.09	0.07
Combined canopy closure	−0.12	0.16	0.16
Bank height	0.23	−0.33	0.02
Bank angle	−0.03	−0.05	−0.07
Poultry house density	0.52	0.66	−0.55
Total unpaved road density	0.57	0.64	−0.61
Total paved road density	−0.89	−0.35	0.96
Total road density	−0.89	−0.35	0.97

Poultry house density varied greatly among the 18 sites and ranged from 0.1 to 6.7 per mi^2 (table 4). The mean for forest sites (1.8 per mi^2) was slightly higher than the mean for urban sites and substantially lower than the mean for the agriculture category sites. Means for urban and urban with WWTP sites (1.0 per mi^2) and agriculture and agriculture with WWTP sites (4.6 per mi^2) were substantially different from each other.

Total road density varied greatly among the 18 sites and ranged from 2.3 to 13.1 mi per mi^2 (table 4). The mean total road density for forest sites (2.4 mi per mi^2) was substantially lower than the mean for any other land-use category. Means for urban and urban with WWTP sites (10.6 mi per mi^2) and agriculture and agriculture with WWTP sites (3.7 mi per mi^2) were substantially different from each other.

Paved road density varied greatly among the 18 sites and ranged from 0.4 to 12.2 mi per mi^2 (table 4). The mean for forest sites (0.5 mi per mi^2) was substantially lower than the mean for any other land-use category. Means for urban and urban with WWTP sites (9.7 mi per mi^2) and agriculture and agriculture with WWTP sites (1.5 mi per mi^2) were substantially different from each other.

Unpaved road density was less variable than paved road density among the 18 sites and ranged from 0.6 to 3.0 mi per mi^2 (table 4). The mean unpaved road densities for forest sites (1.9 mi per mi^2) and agriculture and agriculture with WWTP sites (2.2 mi per mi^2) were similar. The mean for urban and urban with WWTP sites (1.0 mi per mi^2) was substantially different from the other land-use categories.

Habitat Factors Associated With Stream Reaches

Several habitat factors, including measures of streamflow, channel geometry, substrate quality (substrate class, embeddedness, and substrate turbidity), and riparian shading (open canopy angle and canopy closure), were measured as part of the habitat field effort (tables 2 and 6). A subset of those factors (one streamflow, one channel geometry, one substrate quality, one shading factor) is described below.

Table 6. Habitat factor values associated with sampling sites in the Illinois River Basin study area.

[WWTP, wastewater-treatment plant; ft^3/s, cubic feet per second; ft, feet; ft/mi^2, feet per square mile; deg, degrees; s, second]

Short site name	Agri-culture gradient site	Urban gradient site	WWTP upstream	Stream-flow (ft^3/s)	Wetted channel width (ft)	Bankfull width (ft)	Bankfull width/drain-age area (ft/mi^2)	Bank height (ft)	Bank angle (deg)	Open canopy angle (deg)	Canopy closure (per-cent)	Depth (ft)	Velocity (ft/sec)	Bed sub-strate class	Embed-dedness (per-cent)	Substrate turbidity (neph-elometric turbidity units at 60 s)
Evansville Creek	Yes[1]	Yes[1]	No	0.21	16.9	99.9	6.3	9.5	53.4	60.0	52.9	0.6	0.45	5.9	28	308
Illinois River	Yes[1]	Yes[1]	No	0.12	18.5	153.3	6.0	9.5	65.3	82.7	30.3	0.7	0.03	6.1	13	209
Ballard Creek	Yes[2]	No	No	4.15	30.2	105.7	4.9	8.3	37.7	50.0	70.9	0.5	0.12	3.2	19	98
Cincinnati Creek	Yes[2]	No	No	1.62	19.0	111.3	5.6	7.9	62.0	90.9	35.6	0.9	0.46	4.3	35	108
Flint Creek	Yes[2]	No	No	9.16	26.9	70.7	3.5	9.5	48.4	65.0	83.7	0.9	0.68	3.8	36	154
Fly Creek	Yes[2]	No	No	0.37	31.0	94.8	5.4	9.5	67.3	50.9	63.1	0.5	0.11	4.8	29	210
Little Osage Creek	Yes[2]	No	No	14.6	28.6	61.7	1.7	9.5	62.0	52.7	75.1	1.0	1.08	4.2	15	138
Moores Creek	Yes[2]	No	No	0.94	17.0	69.2	2.8	12.3	60.2	30.9	81.3	1.0	0.32	3.7	84	590
Weddington Creek	Yes[2]	No	No	4.30	31.0	83.2	3.6	7.6	54.3	80.0	49.7	1.1	0.44	4.2	26	64
Wildcat Creek	Yes[2]	No	No	5.71	28.6	111.8	8.0	9.5	56.1	131.8	21.7	0.7	0.56	4.2	49	156
Baron Fork	No[2]	No	Yes	2.44	30.4	86.2	5.0	9.5	47.3	54.5	68.4	0.6	0.45	5.2	44	288
Goose Creek	No[2]	No	Yes	7.93	27.1	95.4	6.7	11.0	49.1	90.0	39.4	0.9	0.74	5.3	22	94
Clear Creek	No	Yes[3]	No	1.74	17.7	81.4	7.7	6.9	36.8	36.4	74.3	1.1	0.46	6.1	42	104
Hamestring Creek	No	Yes[3]	No	3.04	27.7	85.0	6.3	10.6	67.0	48.2	72.7	1.2	0.45	4.1	44	117
Mud Creek	No	Yes[3]	No	1.03	33.5	110.8	6.9	10.3	47.3	68.2	68.4	0.8	0.18	3.2	48	353
Osage Creek-Rogers	No	Yes[3]	No	5.72	28.9	44.7	2.0	9.5	49.1	97.3	55.3	1.3	0.93	3.2	63	229
Osage Creek-Cave Springs	No	No[3]	Yes	19.2	35.2	89.2	2.4	9.5	61.6	120.9	15.8	1.3	0.96	4.2	7	87
Spring Creek	No	No[3]	Yes	24.9	39.7	68.9	5.3	9.5	73.9	74.5	61.0	0.8	0.95	4.9	60	108

[1] Forest site.

[2] Agriculture site.

[3] Urban site.

Streamflow varied greatly among the 18 sites and ranged from 0.12 to 24.9 cubic feet per second (ft^3/s) (table 6). The mean streamflow for forest sites (0.164 ft^3/s) was substantially lower than the mean for any other land-use category Means for urban and urban with WWTP sites (9.27 ft^3/s) and agriculture and agriculture with WWTP sites (5.12 ft^3/s) were substantially different from each other. The mean for the urban with WWTP sites was 22.0 ft^3/s.

Bankfull width varied substantially among the 18 sites and ranged from 44.7 to 153.3 ft (table 6). Mean bankfull widths for urban and urban with WWTP sites (80.0 ft) and agriculture and agriculture with WWTP sites (89.0 ft) were similar but were substantially less than the mean bankfull width for the two forest sites (126.6 ft).

Substrate embeddedness also varied substantially among the 18 sites and ranged from 7 to 84 percent (table 6). Mean substrate embeddedness for urban and urban with WWTP sites (36 percent) and agriculture and agriculture with WWTP sites (44 percent) were similar but were substantially greater than the mean for forest sites (20 percent).

Open canopy angle varied substantially among the sites and ranged from 30.9 to 131.8 degrees (table 6). However, mean open canopy angles for urban and urban with WWTP sites (69.7 degrees), agriculture and agriculture with WWTP sites (74.2 degrees), and forest sites (71.4 degrees) were similar.

Water-Quality Factors Associated With Stream Reaches

Nutrient concentrations varied substantially among the 18 sites. Concentrations of nitrite plus nitrate and total phosphorus generally were within the range of reported concentrations in small agricultural Ozark streams (Justus and others, 2010) and in small to large agricultural, and urban Ozark streams (Davis and Bell, 1998; Petersen and others, 1998).

Total nitrite plus nitrate (hereafter referred to as nitrate) concentrations varied greatly among the 18 sites, and ranged from 0.17 to 7.4 mg/L as nitrogen (table 7). The mean nitrate concentration for forest sites (0.38 mg/L) was substantially lower than the mean for any other land-use category . Means for urban and urban with WWTP sites (1.82 mg/L) and agriculture and agriculture with WWTP sites (3.28 mg/L) were substantially different from each other.

Total phosphorus concentrations varied greatly among the 18 sites and ranged from 0.010 to 0.483 mg/L as phosphorus (table 7). The mean total phosphorus concentration for forest sites (0.01 mg/L) was substantially lower than the mean for any other land-use category . Means for urban and urban with WWTP sites (0.13 mg/L) and agriculture and agriculture with WWTP sites (0.08 mg/L) were substantially different from each other, but the difference was because of the 0.483 mg/L concentration at the site on Spring Creek.

Specific conductance varied greatly among the 18 sites and ranged from 103 to 672 microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C) (table 7). Lowest values occurred at sites with substantial parts of their basins in the Boston Mountains; surficial geology of the Boston Mountains is dominated by relatively insoluble sandstones and shales (Adamski and others, 1995). The mean specific conductance for forest sites (120 µS/cm at 25 °C) was substantially lower than the mean for any other land-use category. Highest specific conductance occurred at sites downstream from WWTPs and in urban basins although some high specific conductivity values may also indicate groundwater influence. Means for urban and urban with WWTP sites (429 µS/cm at 25 °C) and agriculture and agriculture with WWTP sites (305 µS/cm at 25 °C) were substantially different from each other.

Dissolved oxygen concentrations (typically measured in midmorning) varied greatly among the 18 sites and ranged from 1.6 to 10.0 mg/L (table 7). The mean dissolved oxygen concentration for forest sites (3.9 mg/L) was somewhat lower than the mean for any other land-use category. Means for urban and urban with WWTP sites (4.7 mg/L) and agriculture and agriculture with WWTP sites (6.9 mg/L) were substantially different from each other. Concentrations were less than 5 mg/L (the critical season standard for the Ozark Highland streams that were sampled; Arkansas Pollution Control and Ecology Commission, 2011) at 5 of the 18 sites; these 5 sites included 2 agricultural sites, 2 urban sites, and 1 forest site.

Table 7. Water-quality data associated with sampling sites in the Illinois River Basin study area.

[WWTP, wastewater-treatment plant; mg/L, milligrams per liter; N, nitrogen; P, phosphorus; deg C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; ND is not determined; <, less than]

Short site name	Agri-culture gradi-ent site	Urban gradi-ent site	WWTP up-stream	Date	Local time	Ammonia (mg/L as N)	Nitrite plus nitrate (mg/L as N)	Nitrite (mg/L as N)	Organic nitrogen (mg/L as N)	Total nitrogen (mg/L as N)	Ortho-phos-phorus (mg/L as P)	Total phos-phorus (mg/L as P)	Temper-ature (deg C)	Specific conduc-tance (µS/cm)	Dis-solved oxygen (mg/L)	pH (stan-dard units)
Evansville Creek	Yes[1]	Yes[1]	No	5/29/2012	1147	<0.010	0.58	ND	<0.037	0.62	0.005	0.010	28.3	137	2.5	7.29
Illinois River	Yes[1]	Yes[1]	No	5/30/2012	1040	0.011	0.17	<0.0010	0.028	0.21	0.006	0.012	25.1	103	5.3	7.28
Ballard Creek	Yes[2]	No	No	7/19/2011	1030	0.058	0.78	0.0374	0.418	1.3	0.042	0.079	29.0	302	9.8	7.47
Cincinnati Creek	Yes[2]	No	No	7/27/2011	830	<0.010	2.2	0.0071	<0.279	2.4	0.067	0.074	27.4	310	3.1	7.15
Flint Creek	Yes[2]	No	No	8/9/2011	1145	0.011	3.7	0.0047	0.279	4.0	0.057	0.064	25.2	252	8.7	7.64
Fly Creek	Yes[2]	No	No	5/31/2012	920	0.017	3.2	0.0196	0.003	3.2	0.027	0.040	20.8	373	7.2	6.98
Little Osage Creek	Yes[2]	No	No	8/3/2011	830	0.012	5.2	0.0112	ND	5.1	0.035	0.045	20.6	345	6.6	7.35
Moores Creek	Yes[2]	No	No	7/26/2011	800	0.116	0.81	0.0384	0.578	1.5	0.184	0.271	26.3	273	2.2	7.21
Weddington Creek	Yes[2]	No	No	7/28/2011	830	<0.010	2.9	0.0025	<0.052	2.9	0.077	0.077	25.9	321	5.1	7.43
Wildcat Creek	Yes[2]	No	No	8/2/2011	900	0.011	3.8	0.0036	0.092	3.9	0.060	0.059	26.9	292	7.3	7.66
Baron Fork	No[2]	No	Yes	6/1/2012	934	0.020	2.8	0.0235	0.325	3.2	0.052	0.071	17.7	137	9.0	7.88
Goose Creek	No[2]	No	Yes	7/18/2011	1130	0.015	7.4	0.0130	0.644	8.0	0.045	0.052	25.5	445	10.0	7.36
Hamestring Creek	No	Yes[3]	No	7/25/2011	930	<0.010	1.5	0.0063	<0.156	1.6	0.026	0.030	22.9	337	6.8	7.26
Mud Creek	No	Yes[3]	No	7/20/2011	ND	0.031	0.79	0.0133	0.158	0.98	0.012	0.018	27.0	439	2.0	7.42
Osage Creek-Rogers	No	Yes[3]	No	9/13/2011	730	0.013	3.3	0.0039	0.269	3.6	0.013	0.019	17.8	387	6.5	6.50
Clear Creek	No	Yes[3]	No	7/21/2011	900	0.015	0.45	0.0018	0.180	0.65	0.039	0.049	26.1	252	1.6	7.34
Osage Creek-Cave Springs	No	No[3]	Yes	8/4/2011	830	<0.010	2.6	0.0058	<0.259	2.9	0.158	0.171	24.4	487	5.9	7.30
Spring Creek	No	No[3]	Yes	8/2/2011	800	0.020	2.3	0.0052	0.489	2.8	0.433	0.483	26.4	672	5.6	7.66

[1] Forest site.

[2] Agriculture site.

[3] Urban site.

Description of Biological Communities and Relations to Land Use, Stream Habitat, and Water Quality

Macroalgae

The presence of large macroalgae mats was one of the most noticeable biological characteristics in several streams within the Illinois River Basin. Macroalgae were present in the water along the banks of many of the streams during the 2011 and 2012 sampling seasons, usually floating on the surface or attached to rocks or macrophytes.

The highest macroalgae percent cover values were recorded at four sites downstream from WWTPs (fig. 3). The mean percent cover at these four sites downstream from WWTPs was 21.0 percent and ranged from 13.8 to 30.9 percent (table 8, table 1).The mean macroalgae percent cover at these four sites was considerably higher than the mean macroalgae percent cover of the urban and agriculture sites not influenced by WWTPs (4.8 and 5.3 percent, respectively) or the forest sites (2.9 percent) (table 8, table 1).

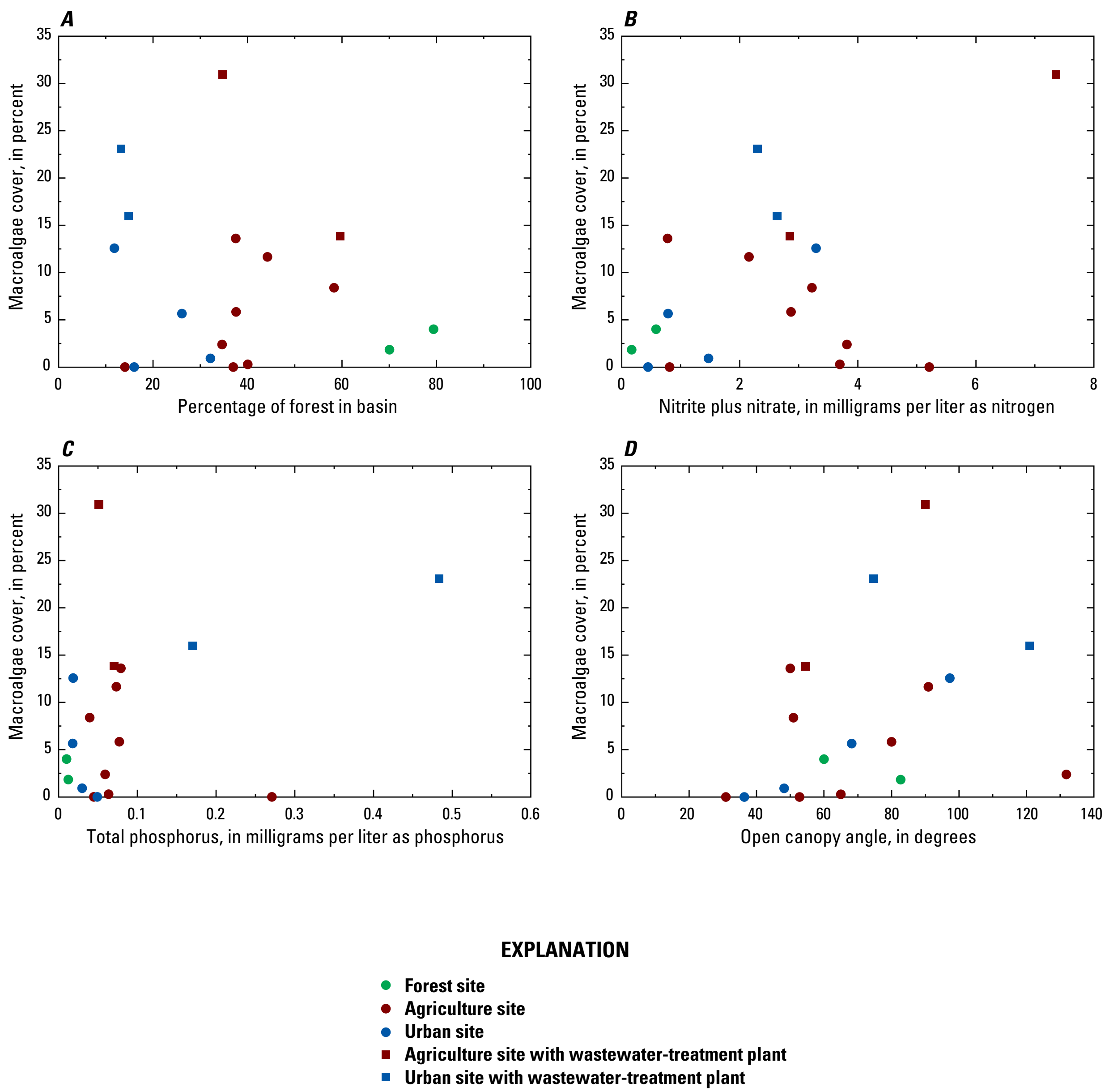

Figure 3. Scatterplots showing relation between macroalgae percent cover and selected environmental factors in the Illinois River Basin study area.

Table 8. Macroalgae percent cover and values for selected environmental factors for sampling sites in the Illinois River Basin study area.

[Sites are sorted by macroalgae cover value; mg/L, milligrams per liter; N, nitrogen; P, phosphorus; mi^2, square mile]

Short site name	Macroalgae cover (percent)	Nitrite plus nitrate (mg/L as N)	Total phosphorus (mg/L as P)	Open canopy angle (degrees)	Percent forest	Percent agriculture	Percent urban	Poultry house density (per mi^2)
Goose Creek[1]	30.9	7.4	0.052	90.0	34.8	41.5	22.7	0.8
Spring Creek[1]	23.1	2.3	0.483	74.5	13.2	19.2	65.5	0.5
Osage-Cave Springs[1]	16.0	2.6	0.171	120.9	14.8	30.4	51.6	0.1
Baron Fork[1]	13.8	2.8	0.071	54.5	59.7	37.1	2.7	5.2
Ballard Creek	13.6	0.78	0.079	50.0	37.6	56.8	4.2	6.7
Osage-Rogers	12.5	3.3	0.019	97.3	11.9	21.4	62.8	0.1
Cincinnati Creek	11.6	2.2	0.074	90.9	44.2	52.8	2.1	6.6
Fly Creek	8.4	3.2	0.040	50.9	58.4	39.5	1.8	4.9
Weddington Creek	5.8	2.9	0.077	80.0	37.6	60.3	1.6	2.5
Mud Creek	5.6	0.79	0.018	68.2	26.1	12.2	60.6	0.2
Evansville Creek	4.0	0.59	0.010	60.0	79.4	20.0	0.4	1.7
Wildcat Creek	2.4	3.8	0.059	131.8	34.7	60.7	4.3	3.7
Illinois River	1.8	0.17	0.012	82.7	70.1	27.8	1.6	1.9
Hamestring Creek	0.9	1.5	0.030	48.2	32.2	29.9	35.7	0.9
Flint Creek	0.3	3.7	0.064	65.0	40.1	56.1	3.4	6.1
Clear Creek	0.0	0.45	0.049	36.4	16.0	34.5	44.2	4.3
Little Osage Creek	0.0	5.2	0.045	52.7	14.1	69.5	15.4	4.4
Moores Creek	0.0	0.81	0.271	30.9	37.0	57.0	4.5	5.2

[1] Wastewater-treatment plant located upstream from site.

Macroalgae percent cover was strongly correlated only with bed substrate size (rho=0.89), canopy closure (rho=−0.54), and specific conductance (rho=0.52) (table 9). Specific conductance probably was affected by the WWTP effluent. Macroalgae percent cover was not strongly correlated with nutrient concentrations or with land use. Despite the lack of strong correlations, total phosphorus (means of 0.19 and 0.06 mg/L associated with upstream WWTP and no upstream plant, respectively) and nitrate (means of 3.78 and 2.10 mg/L associated with upstream WWTP and no upstream plant, respectively) concentrations in streams downstream from WWTPs were considerably higher than concentrations at sites that did not have an upstream WWTP (fig. 3, table 8).

Table 9. Correlations between macroalgae percent cover and selected environmental factors in the Illinois River Basin study area.

[Red font denotes absolute value of rho is greater than or equal to 0.50; number of sites equals 18]

	rho
Nitrite plus nitrate	0.22
Total phosphorus	0.32
Temperature	0.01
Specific conductance	0.52
Dissolved oxygen	0.39
pH	0.20
Streamflow	0.33
Bankfull width	0.16
Drainage area	−0.08
Bankfull width/drainage area	−0.05
Depth	−0.21
Velocity	0.15
Bed substrate	0.89
Embeddedness	−0.12
Substrate turbidity	−0.33
Open canopy angle	0.49
Combined canopy closure	−0.54
Bank height	0.09
Bank angle	0.00
Poultry house density	−0.31
Percent agriculture	−0.28
Percent urban	0.18
Percent forest	−0.05
Total unpaved road density	−0.35
Total paved road density	0.21
Total road density	0.12

Periphyton Communities

Periphyton communities in Illinois River Basin streams almost always were dominated (highest biovolume) by diatoms or blue-green algae (also commonly referred to as "cyanobacteria") (tables 10–11, at the end of the report). Total, diatom, and blue-green algae biovolumes at the Illinois River Basin sites generally were somewhat greater than typical reported biovolumes from sites with a wide range of land uses and basin size in the Ozarks (Petersen and Femmer, 2003). However, percentages of total biovolume composed of diatoms and blue-green algae were similar to those reported by Petersen and Femmer (2003). Green algae were more dominant than diatoms and blue-green algae in two of the Illinois River Basin communities. The highest green algae biovolume occurred in a sample from Ballard Creek, where approximately 97 percent of the biovolume of the sample was composed of a single green algae genus (*Pediastrum*).

At the genus and species level, the Illinois River Basin periphyton communities differ substantially from communities sampled previously by USGS in the Ozarks (Petersen and Femmer, 2003; Justus and others, 2010).Taxa that often were among the most dominant taxa (highest biovolumes) at the Illinois River sites were *Gloeocapsopsis* (nutrient affinity not described—nutrient and trophic information in following parentheses from Porter, 2008), *Phormidium* (affinity for high phosphorus concentrations), *Psammothidium curtissimum* (affinity for low organic nitrogen, low nutrient concentrations), *Cocconeis placentula* (generally indicative of high nutrient concentrations), *Nitzschia amphibia* (generally indicative of high nutrient concentrations, nitrogen heterotroph with affinity for high organic nitrogen concentrations), *Achnanthidium rivulare* (generally indicative of low nutrient concentrations), and *Heteroleibleinia* (nutrient affinity not described). *Gloeocapsopsis*, *Heteroleibleinia, Phormidium, Psammothidium curtissimum,* and *Achnanthium rivulare* were completely absent from samples collected in the study described in Petersen and Femmer (2003). Conversely, the diatom *Cymbella delicatula* and the blue-green alga *Calothrix*, two common taxa found in many Ozark streams (Petersen and Femmer, 2003; Justus and others, 2010) were found at 0 and 1 of the 18 Illinois River Basin sites, respectively. *Cymbella delicatula* previously has been associated with low-nutrient streams, whereas *Calothrix* is an abundant and nearly ubiquitous blue-green algal taxon (Petersen and Femmer, 2003).

Relations Between Periphyton Communities and Land Use, Stream Habitat, and Water-Quality Factors

Biomass of periphyton frequently is of interest to water-resources managers and the public because nuisance growths of attached algae provide visible evidence of nutrient enrichment (eutrophication) and water-quality degradation (Petersen and Femmer, 2003). Total biovolume, which is a surrogate for algal biomass, was not strongly correlated with any of the land use, stream-habitat, or water-quality factors assessed in the present study (table 12, at the end of the report). The absence of strong correlations corroborates results from Petersen and Femmer (2003), who reported that embeddedness (p=0.040) and alkalinity(p=0.079) were the only factors significantly correlated with total periphyton biovolume. Furthermore, there was little indication that total biovolume consistently was affected by the presence of an upstream WWTP. Although algal growth typically increases with higher nutrient concentrations and less shading, the standing crop of periphyton on rocks can be reduced by grazing by herbivorous macroinvertebrates and fish, which may explain why total biovolume in Ozark streams is not strongly affected by water-quality (or other habitat) factors (Petersen and Femmer, 2003).

Percent land use was not strongly correlated with biovolume or percent biovolume of blue-green algae, diatoms, or green algae (table 12). There was a moderately strong inverse correlation between percent agriculture and biovolume and percent biovolume of diatoms.

There were no strong correlations between total biovolume of blue-green algae, green algae, diatoms, *Gloeocapsopsis*, *Phormidium*, *Heteroleibleinia, Nitzschia amphibia,* and *Cocconeis placentula* and percent forest (fig. 4, table 12). Although the correlation between percent forest and the biovolume metrics was not strong, the highest total biovolume, diatom biovolume, and biovolumes of *Phormidium*, *Cocconeis placentula*, and *Nitzschia amphibia* occurred at sites with less than 50 percent forest (fig. 4).

The selected periphyton metrics listed in table 12 were most often and most strongly correlated with specific conductance, substrate turbidity, open canopy angle (a measure of riparian shading), percent agriculture, poultry house density, and unpaved road density; some of these factors were strongly correlated with percent forest, percent urban, or percent agriculture (table 5). Three strong or moderately strong correlations were detected between blue-green algae biovolume and nitrate, blue-green algae percent biovolume and nitrate, and *Nitzschia amphibia* biovolume and total phosphorus. Comparisons of total biovolume with nutrients, embeddedness, bank height, and total road density generally did not indicate effects of these factors on total biovolume (fig. 5). Total biovolume did increase somewhat (rho=0.45) as open canopy angle increased (fig. 5) and canopy closure decreased (rho=−0.46). The lack of correlation of total biovolume with nutrients and lack of a stronger correlation with canopy angle may be the result of periphyton grazing by herbivorous macroinvertebrates and fish.

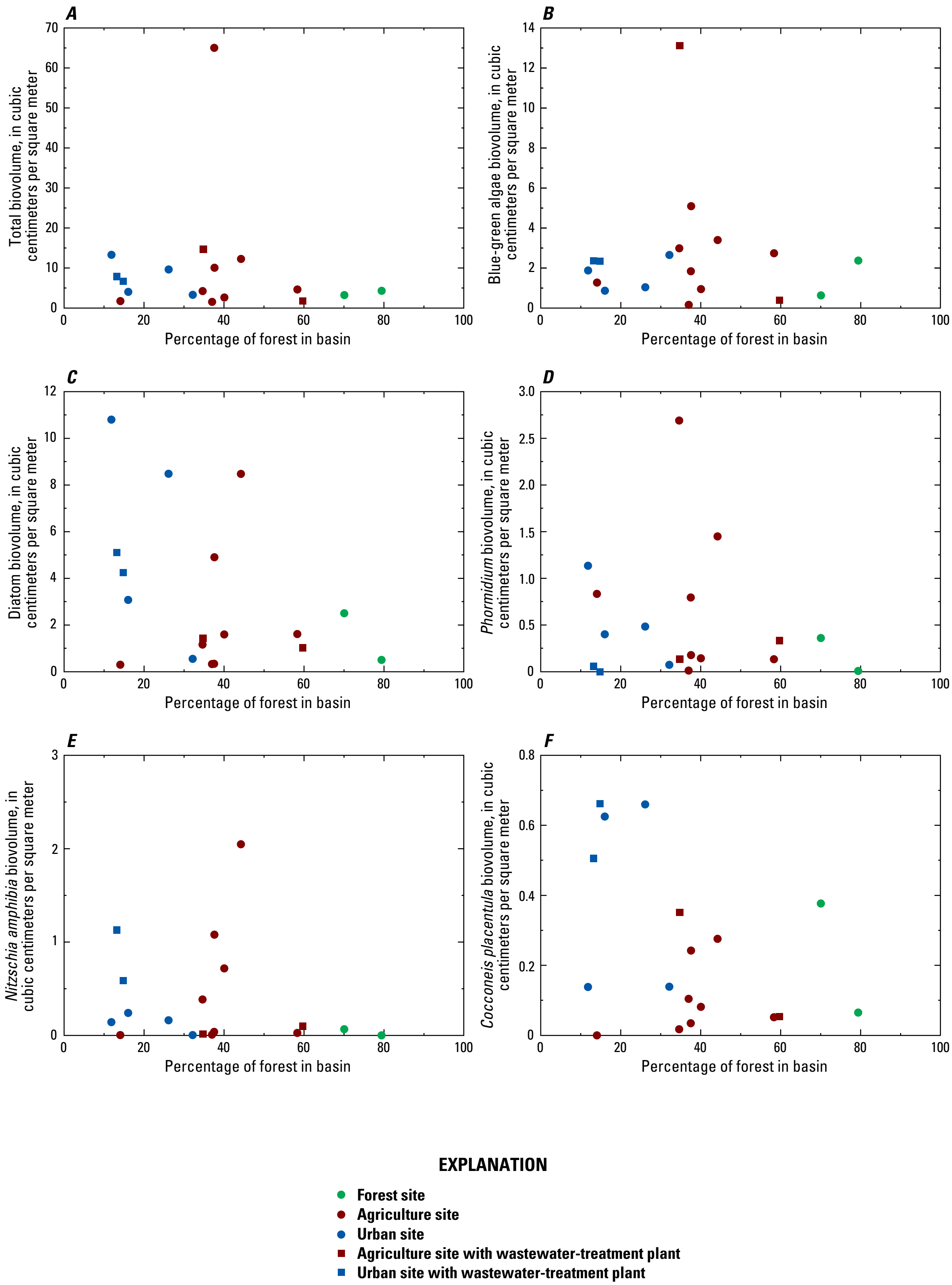

Figure 4. Scatterplots showing relations between periphyton metrics and percent forest in the Illinois River Basin study area.

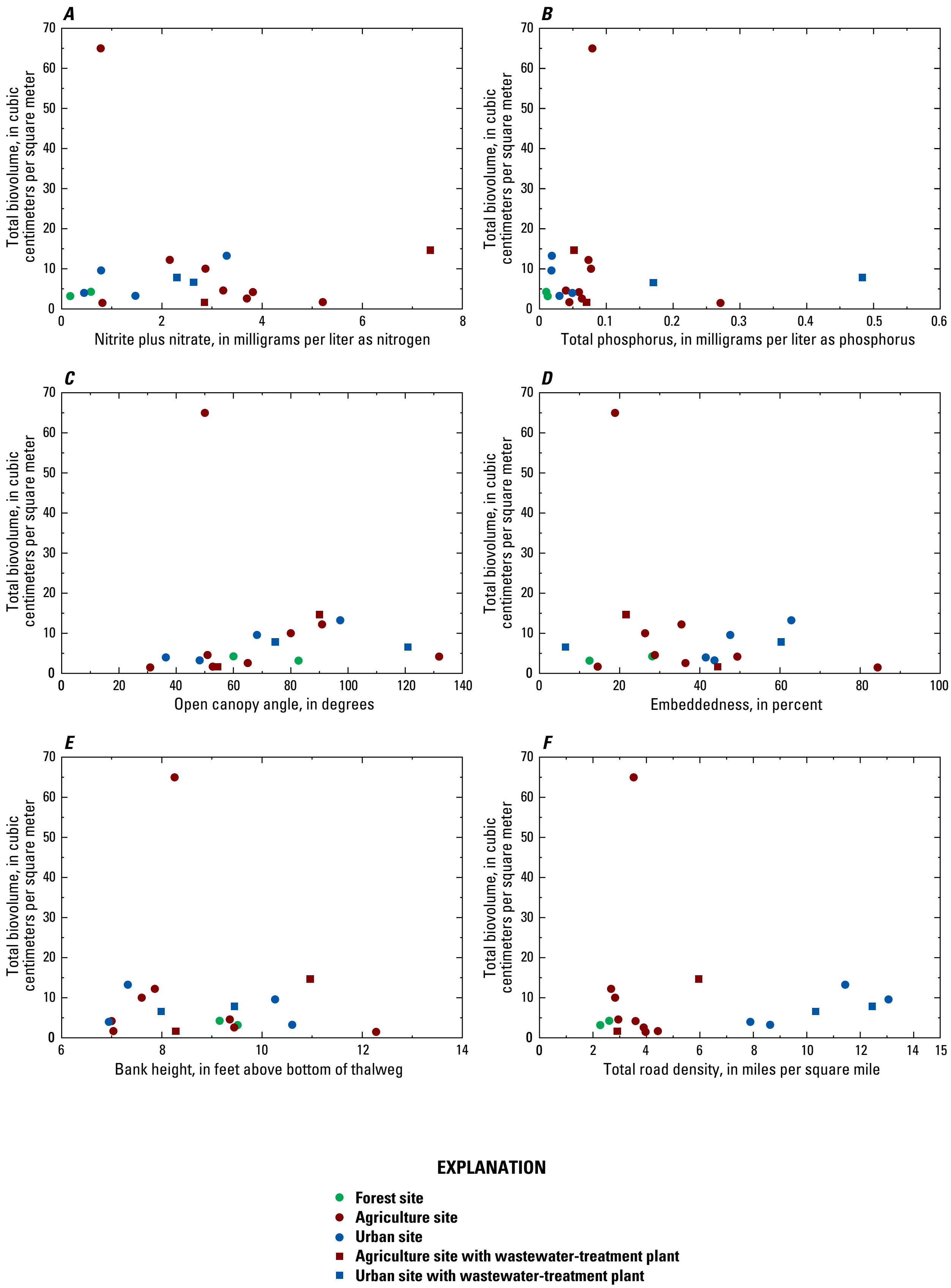

Figure 5. Scatterplots showing relations between periphyton total biovolume and selected environmental factors in the Illinois River Basin study area.

Macroinvertebrate Communities

The most common and abundant macroinvertebrate taxa were in the orders Diptera (true flies), Trichoptera (caddisflies), Ephemeroptera (mayflies), Plecoptera (stoneflies), and Coleoptera (beetles). Macroinvertebrate taxa richness (number of taxa) for the 18 study sites ranged from 31 to 73 (table 13, at the end of the report). Taxa collected at the most sites include they mayfly *Baetis*, the caddisfly *Cheumatopsyche*, the crayfish *Orconectes*, the true flies (both Chironomidae) *Polypedilum flavum* and *Rheotanytarsus*, and the beetle *Psephenus herricki*. One of the least common taxa was the scud *Gammarus*, collected only at Little Osage.

Similar to the Ozark Highlands fish index of biotic integrity (described in the "Relations Between Fish Communities and Land Use, Stream Habitat, and Water-Quality Factors" section), sites with the lowest (indicative of most-disturbed conditions) macroinvertebrate index scores generally were sites with higher percentages of urban land use (or urban land use and WWTPs) in their basins (table 1; table 14, at the end of the report). Scores for the macroinvertebrate index ranged from 13 at Osage Creek-Rogers to 86 at Fly Creek (table 14). There were four sites in the poor classification (13–35), six sites in the fair classification (40–49), four sites in the good classification (59–66), and four sites in the least-impaired classification (81–86). The four sites with the lowest index scores were urban sites, two of which were downstream from WWTPs. The four sites with the highest index scores were sites with the highest percentages of forest in their basins; however, one of the sites is also downstream from a WWTP (Baron Fork, the site farthest downstream from its associated WWTP, table 1).

Relations Between Macroinvertebrate Communities and Land Use, Stream Habitat, and Water-Quality Factors

Relations between the macroinvertebrate community metrics and land use, stream habitat, and water-quality factors were evaluated using four groups of sites. The four groups are based on land-use information in table 1. The analysis of the data from the group of 14 sites not downstream from WWTPs was intended to evaluate the strength of effects of the land-use and other environmental factors across that entire range of sites in small Illinois River Basin streams. Four sites are downstream from WWTPs, and analyses of data for these sites were intended to evaluate the unique effects of WWTP effluent on downstream water quality. There are 10 agriculture gradient sites and 6 urban gradient sites. The analyses of the data for the 10 agriculture gradient sites and the 6 urban gradient sites were performed to focus on the strength of the effects of the environmental factors at sites representing small streams affected primarily by agriculture or urban land use (and without the effects of WWTPs) in the Illinois River Basin. The low number of sites in the agriculture and urban gradients limits the confidence in these evaluations.

The macroinvertebrate index and several macroinvertebrate metrics were adversely affected by increasing urban and agricultural land use and associated environmental factors. These include metrics associated with tolerance to habitat degradation, taxonomic groups, diversity, behavior preference, and feeding preference. Factors most commonly affecting these metrics include factors associated with water quality, stream geometry, sediment, land-use percentages, and road density. The macroinvertebrate index and, in many cases, macroinvertebrate metric values indicated urban sites were more disturbed than agriculture and forest sites. However, many of the sites in the urban gradient also have a relatively high percentage (typically about 20 to 30 percent) of agriculture land use in the associated basins. Consequently, the percent of forest land use in most of the urban gradient basins is less than 30 percent and biological responses of the macroinvertebrate communities at the urban gradient sites probably were the result of the combined effects of urban and agricultural land use. Upstream WWTPs may have affected some macroinvertebrate metrics but had little effect on other metrics.

Correlations were calculated between more than 100 metrics (table 15, at the end of the report) and the environmental factors at the 18 sites. Correlations for the 21 metrics strongly correlated with at least three environmental factors, 2 additional metrics included in the macroinvertebrate index, and the macroinvertebrate index are reported in tables 16–18, at the end of the report. The following discussions will be limited to discussions of the macroinvertebrate index and metrics listed in tables 16–18.

Combined-Gradient Sites

Analysis of relations to environmental factors for all sites except the four WWTP sites, which were not included because of the somewhat unique effects of WWTPs, indicated that macroinvertebrate metrics were affected by several environmental factors. Twenty-three macroinvertebrate metrics (several of which are probably correlated with each other) and the macroinvertebrate index were strongly correlated with one or more of 16 of the 26 environmental factors (table 16). There were no strong correlations with most water-quality factors, drainage area, bankfull width, substrate turbidity, canopy angle, and percent agriculture. The strongest correlations with the largest number of macroinvertebrate metrics were with percent forest, percent urban, and road densities; correlations between macroinvertebrate metrics and percent agriculture were generally weak. In general (based on the correlations), the macroinvertebrate index was higher at sites with greater percentages of forest in their basins, lower percentages of urban land in their basins, and lower paved road density. The correlations with depth and water velocity probably were partially affected by the sampling of the most forested sites during a period of relatively low streamflow.

Relations Between Selected Macroinvertebrate Metrics and Percent Forest

The relations between the macroinvertebrate index and the five index metrics and percent forest were selected for further analysis. As a group, these metrics are associated with, and likely respond to, factors related to water quality, substrate quality, and riparian shading. The relation between the index and these metrics and percent forest (and indirectly the urban and agriculture site class) is analyzed and discussed using scatterplots (fig. 6).

In general, values for the macroinvertebrate index increased as percent forest increased (rho=0.86) (fig. 6, table 16); however, this is to be expected for the macroinvertebrate index and the associated metrics because correlation with percent forest was one of the criteria used for selecting metrics for the macroinvertebrate index. The four sites with the highest index values (the least-disturbed category) are sites with percent agriculture ranging from approximately 20 to 40 percent and less than 4 percent urban in the basin. The four sites with the lowest index values (the poor category) are sites with low percentages of forest in their basins.

The indication that urban land use may influence macroinvertebrates more than agriculture land use may be the result of the differences in the land-use proportions between the sites in the urban gradient and sites in the agriculture gradient. Most sites in the agriculture gradient are associated with basins with almost entirely forest and agriculture land use (fig. 2, table 1). However, many of the sites in the urban gradient also have a relatively high percentage (typically about 20 to 30 percent) of agriculture land use in the associated basins.

The relation between Margalef diversity and the percent forest in the basin was strong (rho=0.82). Macroinvertebrate samples collected at urban sites were associated with lower percentages of forest and were generally less diverse than macroinvertebrate samples collected at agriculture sites. Margalef diversity was most variable at sites with approximately 40 percent forest, whereas four of the five sites with the highest diversity had more than 55 percent forest in the basin.

Measures related to Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa are perhaps among the most popular metrics used for macroinvertebrate indicators (Barbour and others, 1999), and EPT richness had a strong correlation to percent forest (rho=0.72) in the present study. The metric also varied a great deal across both land-use gradients. Two of the four sites with the fewest EPT taxa were downstream from WWTPs, whereas one of the sites with the highest number of EPT taxa was a forest site.

The percent predator richness (percent of total richness composed of predators) was strongly correlated with percent forest (rho=0.73). For the seven sites that had less than 10 percent predator taxa in the macroinvertebrate community, five sites had less than 20 percent forest in the basin and five were urban sites. The metric was variable for the agriculture sites, ranging from 9 to 29 percent where 35 to 45 percent of the basin was forest land use.

The percentage of gatherer-collectors was strongly inversely correlated with percent forest (rho=−0.50). Gatherer-collector macroinvertebrate taxa have a wide range of feeding habits and specialized or generalist feeding taxa may predominate depending on the ecological conditions (Osborne and others, 1980). In the present study, the metric may be most associated with generalists that were more successful as ecological conditions declined. Five sites with more than 41 percent forest had less than 24 percent gatherer-collectors, whereas gatherer-collectors composed 35 to 45 percent of the community at four urban sites with less than 20 percent forest.

The percent Baetidae (a family of Ephemeroptera) was strongly inversely correlated with percent forest (rho=−0.52). Baetidae generally were less than about 10 percent of the macroinvertebrate community at sites where percent forest was more than about 50 percent (fig. 6) and was typically higher and more variable at sites with lower percentages of forest. The percent Baetidae generally increases with increasing nutrient concentrations in small Ozark streams (Justus and others, 2010).

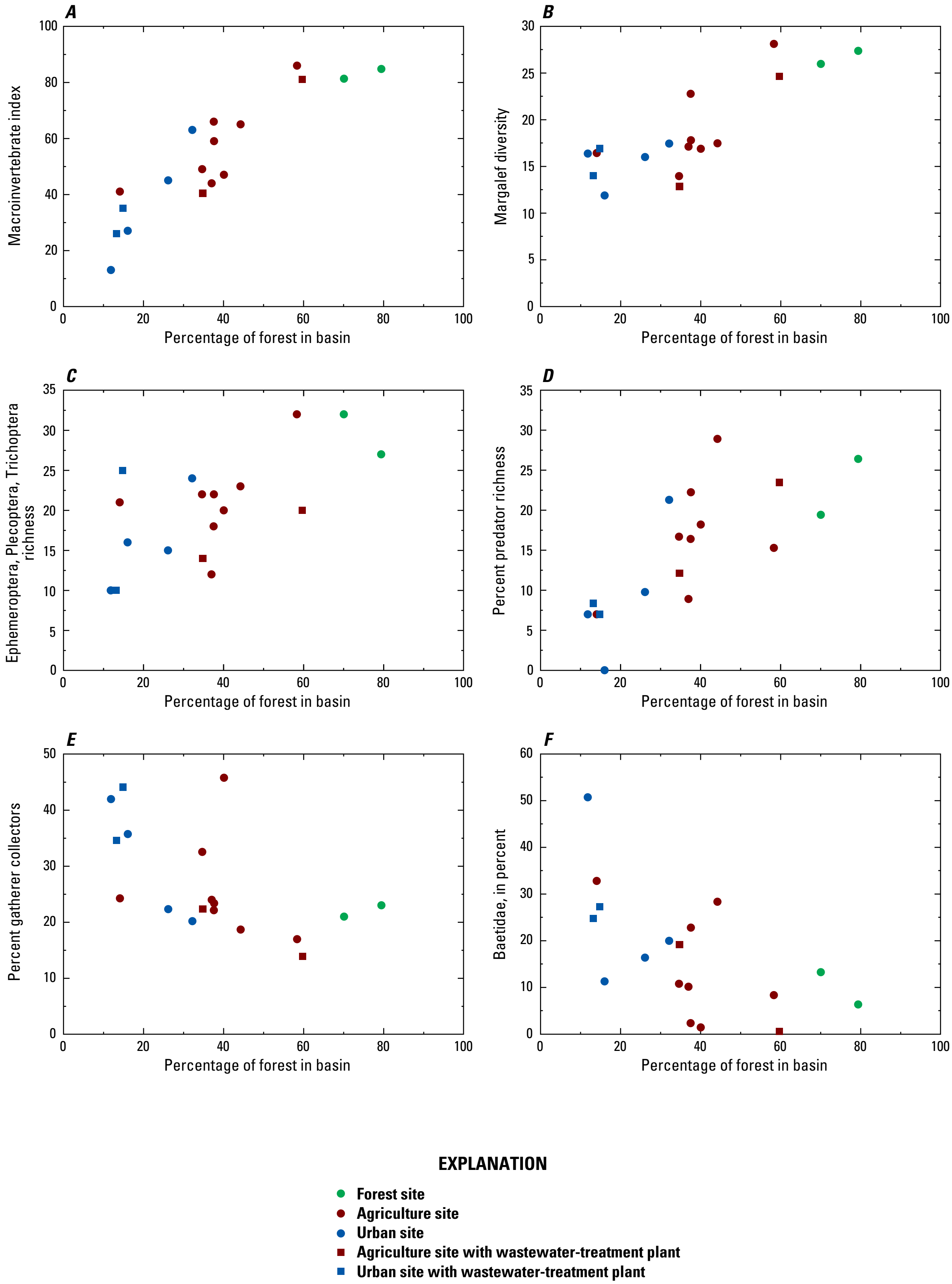

Figure 6. Scatterplots showing relations between percent forest, the macroinvertebrate index, and selected macroinvertebrate metrics in the Illinois River Basin study area.

Relations Between the Macroinvertebrate Index and Selected Environmental Factors

The macroinvertebrate index was compared graphically to six environmental factors (two nutrients [nitrate and total phosphorus], a measure of substrate quality [embeddedness], a measure of riparian shading [open canopy angle], a measure of stream geometry [bank height], and total road density). Correlations with these six factors were moderate or strong for embeddedness, open canopy angle, bank height, and total road density (fig. 7, table 16). There were strong correlations between the index and about one-third of the 26 environmental factors (table 16); most of the strong correlations were with environmental factors directly related to land use or streamflow.

The macroinvertebrate index scores generally did not decrease with increasing nitrate concentrations (fig. 7), and the inverse correlation between the index and nitrate concentration is weak (rho=−0.30) (table 16). Nitrate concentrations at the 18 sites ranged from 0.17 to 7.4 mg/L; however, most urban sites had low macroinvertebrate index scores even at sites where nitrate concentrations were near the bottom of that range. When only the two forest sites and the eight agriculture sites without upstream WWTPs were considered for the agriculture gradient, correlations between the macroinvertebrate index and nitrate strengthened considerably (rho=−0.66, table 17, at the end of the report). Correlations between the macroinvertebrate index and total phosphorus also were low (rho=−0.16, table 16). Highest index scores occurred at sites with total phosphorus concentrations less than 0.1 mg/L, but many of the lowest index scores were associated with sites with total phosphorus concentrations less than 0.1 mg/L. The high variability of index scores at sites where total phosphorus was less than 0.1 mg/L indicates that other environmental factors were more important than total phosphorus for determining macroinvertebrate index scores and macroinvertebrate community composition. Consistent with the fish index (see below), for both nitrate and phosphorus, macroinvertebrate index values almost always were lower at urban sites than at agriculture sites with similar nutrient concentrations.

Embeddedness was strongly inversely correlated with the macroinvertebrate index (rho=−0.53, table 16). The lowest index scores and the highest embeddedness generally occurred at sites with the highest percentages of urban land use (fig. 7). Open canopy angle was moderately correlated with the macroinvertebrate index (rho=−0.45, table 16) and index scores often were lower at urban sites than at agriculture sites with similar canopy angles. Bank height was moderately correlated with the macroinvertebrate index (rho=0.44, table 16). In general, for a given range of bank heights, index scores were lower at urban gradient sites than at agriculture gradient sites. Bank height may be an indication of channel incision.

Higher total road density was strongly correlated with lower macroinvertebrate index scores (rho=−0.77, table 16). Index scores decreased most substantially as road density increased from about 2 to 5 mi per mi^2 (fig. 7). Although variable, index scores generally decreased as road density increased from about 6 to 13 mi per mi^2. Highest total road densities and lowest index scores were associated with urban gradient sites.

Agriculture Gradient Sites

Analysis of data for the 10 agriculture gradient sites indicated that macroinvertebrate metrics were affected by several factors. Twenty-one macroinvertebrate metrics and the macroinvertebrate index were strongly correlated with one or more of 21 of the 26 factors (table 17). The environmental factors included measures of water quality, streamflow, water velocity, channel geometry, substrate quality, riparian shading, percent agriculture, percent forest, percent urban, and road densities. The strongest correlations with the largest number of macroinvertebrate metrics were with percent agriculture, percent forest, percent urban, streamflow, and total road density.

The macroinvertebrate index was strongly correlated with percent agricultural land use (rho=−0.83) and several other environmental factors for the 10 agriculture gradient sites; several of the metrics used to calculate the index also were strongly correlated with percent agriculture and other environmental factors (table 17). Most of these factors were related to land use, substrate quality, channel geometry, and road density. In general (based on the correlations), the macroinvertebrate index was higher at sites with higher percentages of forest in their basins (percent forest was a major criteria for selecting metrics used in the index), lower percentages of agricultural land in their basins, lower percentages of urban land in their basins, lower nutrient concentrations, wider bankfull widths, shallower depths, lower streamflow and water velocity, larger substrate size, and lower road density. The correlations with streamflow, depth, and velocity may result from sampling sites with highest percentages of forest in their associated basins during a period of relatively low streamflow.

Urban Gradient Sites

In general, macroinvertebrate index and macroinvertebrate metric values at urban gradient sites were more indicative of disturbed communities than values at agriculture gradient sites (figs. 6–7, table 14, table 1). The lowest index scores and several of the lowest Margalef diversity scores were at urban sites. Moreover, urban sites tended to have lower index scores for a given range of nutrient concentrations, lower index scores for a given range of canopy angles and a given range of bank heights, higher percentages of gatherer-collectors, lower values of EPT richness, and lower percent predator richness (figs. 6–7). This apparently larger effect of urban factors on the macroinvertebrate index may partly be the result of the differences in land-use proportions (substantially lower percentages of forest at urban gradient sites, fig. 2) between sites in the urban gradient and sites in the agriculture gradient.

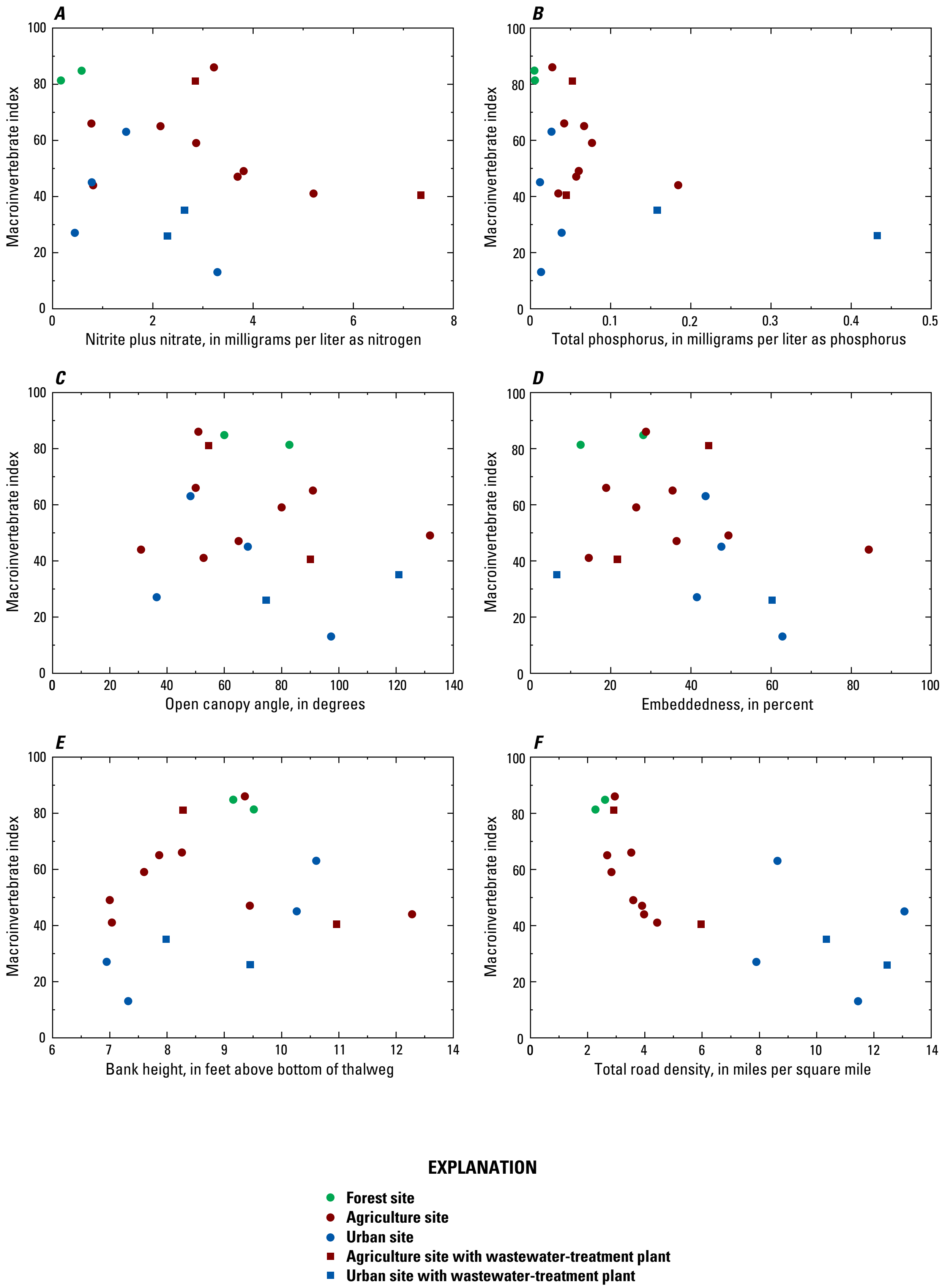

Figure 7. Scatterplots showing relations between the macroinvertebrate index and selected environmental factors in the Illinois River Basin study area.

Analysis of data for the six urban gradient sites indicated that macroinvertebrate metrics were affected by several factors. Twenty-one macroinvertebrate metrics and the macroinvertebrate index were strongly correlated with one or more of 17 of the 26 environmental factors (table 18). The environmental factors included measures of land use, water quality, channel geometry, riparian shading, substrate quality, and road density. The macroinvertebrate index and most macroinvertebrate metrics were strongly or moderately correlated with percent urban and percent forest. The index and nearly two-thirds of the metrics were strongly or moderately correlated with total and paved road density.

The macroinvertebrate index was strongly and inversely correlated with percent urban land use (rho=−0.94) and several other environmental factors for these six sites; several of the metrics used to calculate the index also were strongly correlated with percent urban and other environmental factors (table 18). Most of these factors were related to water quality, land use, and road densities. In general, the macroinvertebrate index was higher at sites with higher percentages of forest in their basins (percent forest was a major criteria for selecting metrics used in the index), lower percentages of urban land in their basins, lower nutrient concentrations, lower specific conductance, wider bankfull widths, shallower depths, lower streamflows, lower water velocities, larger substrate size, less embeddedness, higher bank angles, and lower road density. The correlations with streamflow, depth, and velocity probably were partly affected by the sampling of the most forested sites during a period of lower streamflow. Macroinvertebrate index scores generally were lower at urban sites than at agriculture sites. Scores often were lower at urban sites than at agriculture sites for a given range of environmental factors.

Wastewater-Treatment Plant Sites

Upstream WWTPs affected several metrics (figs. 6–7). For example, three of the five lowest macroinvertebrate index scores, two of the five lowest percent predator values, and two of the five highest percent gatherer-collector values were at sites downstream from WWTPs. For given values of embeddedness, canopy angle, and bank height, sites downstream from WWTPs tended to have lower macroinvertebrate index values than other sites. Also, macroinvertebrate index values at the two urban WWTP sites tended to be lower than values at sites with similar concentrations of nitrate. The sum of these results may indicate that some component of the effluent, other than nutrients, may have an effect on the macroinvertebrate communities.

Fish Communities

As for most Ozark streams, fish communities typically were dominated by the minnow, darter, and sunfish taxa (table 19, at the end of the report). Suckers were relatively infrequently collected. The most common fish collected were stoneroller (presumably two species), cardinal shiner, orangethroat darter, and slender madtom. The rarest fish were brook silverside, black bullhead, golden redhorse, golden shiner, redear sunfish, striped shiner, and white crappie. No common carp were collected. Species richness ranged from 14 in Clear Creek and Spring Creek to 28 in Fly Creek.

Scores for the Ozark Highlands fish index of biotic integrity (Dauwalter and others, 2003) (table 20, at the end of the report) ranged from 36 (Spring Creek) to 89 (Cincinnati Creek) (table 21, at the end of the report). Based on these scores, the sites were classified (Dauwalter and others, 2003) as poor (less than 40), fair (40 to less than 60), good (60 to less than 80), and reference (80 to 100; the reference class will be referred to herein as "least disturbed"). Lowest scores (in the poor or fair classes) were associated with sites with higher percentages of urban land use (or urban land use and WWTPs) in their basins. Most of the highest scores (that is, those in the least disturbed class) were associated with sites with some of the highest percentages of agriculture land use in their basins. Scores associated with the two sites with the highest percentages of forest land use in their basins (Evansville Creek and Illinois River) were lower than scores associated with many of the agriculture sites. Low streamflows (including the two lowest streamflows in the study) that occurred during the sampling of Evansville Creek and Illinois River may have lowered the fish index of biotic integrity scores of those two sites.

Relations Between Fish Communities and Land Use, Stream Habitat, and Water-Quality Factors

The relations between fish communities and land use, stream habitat, and water-quality factors were evaluated using four groups of data (the 14 sites that were not downstream from a WWTP, the 4 WWTP sites, the 10 agriculture gradient sites, and the 6 urban gradient sites). The low number of sites in the agriculture and urban gradients somewhat limits the confidence in these evaluations.

The results indicate that the Ozark Highlands fish index of biotic integrity and several fish metrics associated with feeding preference, spawning preference, and tolerance to habitat degradation were adversely affected by increasing urban and agricultural land use and associated factors. Factors affecting these metrics included factors associated with nutrients, sediment, and riparian shading. The Ozark Highlands fish index of biotic integrity and several fish metrics were most indicative of some disturbance of the fish community at urban sites. However, many of the sites in the urban gradient also have a relatively high percentage (typically about 20 to 30 percent) of agriculture land use in the associated basins. Consequently, the percent of forest land use in most of the urban gradient basins is less than 30 percent and biological responses of the fish communities at the urban gradient sites probably were the result of the combined effects of urban and agricultural land use. Upstream WWTPs seem to have affected some fish metrics while having little effect on other metrics.

Combined Gradient Sites

Fish metrics were affected by several environmental factors at the 14 sites not downstream from WWTPs. Fifteen fish metrics and the index of biotic integrity were strongly correlated with one or more of 24 of the 26 environmental factors (table 22, at the end of the report). The fish metrics included measures of feeding preference, spawning preference, tolerance to habitat degradation, taxonomic relative abundance, and the Ozark Highlands fish index of biotic integrity. The environmental factors included measures of water quality, streamflow, channel geometry, substrate quality, riparian shading, basin land use (forest, agriculture, urban), density of poultry houses, and road density. In general (based on the correlations), the fish index of biotic integrity was higher at sites with higher percentages of forest in their basins, lower percentages of urban land in their basins, higher unpaved road density, and lower paved and total road density.

Relations Between Fish Index of Biotic Integrity, Selected Fish Metrics, and Percent Forest

The associations between the Ozark Highlands fish index of biotic integrity and five metrics and percent forest were selected for additional analysis and discussion. The metrics include three metrics included in the calculation of the fish index, or very similar to metrics included in the fish index (percent darter plus madtom plus sculpin individuals, number of lithophilic spawner species, and percent invertivore individuals), one metric related to tolerance of habitat degradation (percent tolerant individuals), and one metric (percent smallmouth bass individuals) that is related to a fish index metric and likely is important to a relatively large percentage of the general public because of its recreational fishing and economic importance. As a group, these metrics are associated with, and likely respond to, factors related to water quality, substrate quality, and riparian shading. The relation between the fish index and these metrics and percent forest (and indirectly the urban and agriculture site class) is analyzed and discussed using scatterplots (fig. 8).

In general, values for the Ozark Highlands fish index of biotic integrity increased as percent forest increased (rho=0.61) (fig. 8, table 22). The five sites with the highest index values (in the least-disturbed class) are sites with percent agriculture ranging from approximately 37 to 61 percent and less than 5 percent urban in the basin (table 1). The five sites with the lowest index values are sites in the urban gradient or an urban site with an upstream WWTP.

This apparent effect of urban land use and associated activities on the fish index may partly be the result of the differences in the land-use proportions between the sites in the urban gradient and sites in the agriculture gradient. Most sites in the agriculture gradient (agriculture sites without upstream wastewater-treatment plants plus forest sites) are in basins with almost entirely forest and agriculture land use (fig. 2, table 1). However, many of the sites in the urban gradient (urban sites without upstream wastewater-treatment plants plus forest sites) also have a relatively high percentage (typically about 20 to 30 percent) of agriculture land use in the associated basins.

The relative abundance of darter plus madtom plus sculpin individuals had a strong inverse correlation with percent forest (rho=−0.54) (fig. 8, table 22). Two of the lowest relative abundances occurred at the two sites with the highest percent of forest in their associated basins. The lithophilic spawners richness generally increased as percent forest increased (rho=0.85) (fig. 8). However, many of the largest numbers of lithophilic spawner species (12 to 14) occurred at agriculture sites with about 40 to 60 percent forest. The smallest number of lithophilic spawner species (six) occurred at urban sites with less than 20 percent forest.

The relative abundance of invertivores was not correlated with percent forest (rho=−0.11) (fig. 8), and variability was high when percent forest was less than approximately 40 percent. The lowest relative abundance (less than 10 percent) occurred at urban sites with less than 20 percent forest. Relative abundance of invertivores exceeded 30 percent at the two sites with more than approximately 70 percent forest. The variability consistently decreased, and the minimum percent invertivores for a given range of percent forest increased as percent forest increased (fig. 8).

Relative abundance of tolerant individuals did not change substantially with percent forest (rho=−0.15) (fig. 8). The lowest relative abundances of tolerant individuals occurred at a number of agriculture sites with forest land-use percentages of approximately 30 to 50 percent.

Relative abundance of smallmouth bass was strongly correlated with percent forest (rho=0.67). Smallmouth bass were not collected at six sites. Four of the six sites were urban sites (fig. 8) with greater than 35 percent urban land use in the basin. The four sites with the highest relative abundances of smallmouth bass were agriculture sites with approximately 40 percent forest. Two of the four urban sites where no smallmouth bass were collected had drainages areas of less than 14 mi^2; the other two urban sites had drainage areas of 16.0 and 22.8 mi^2.

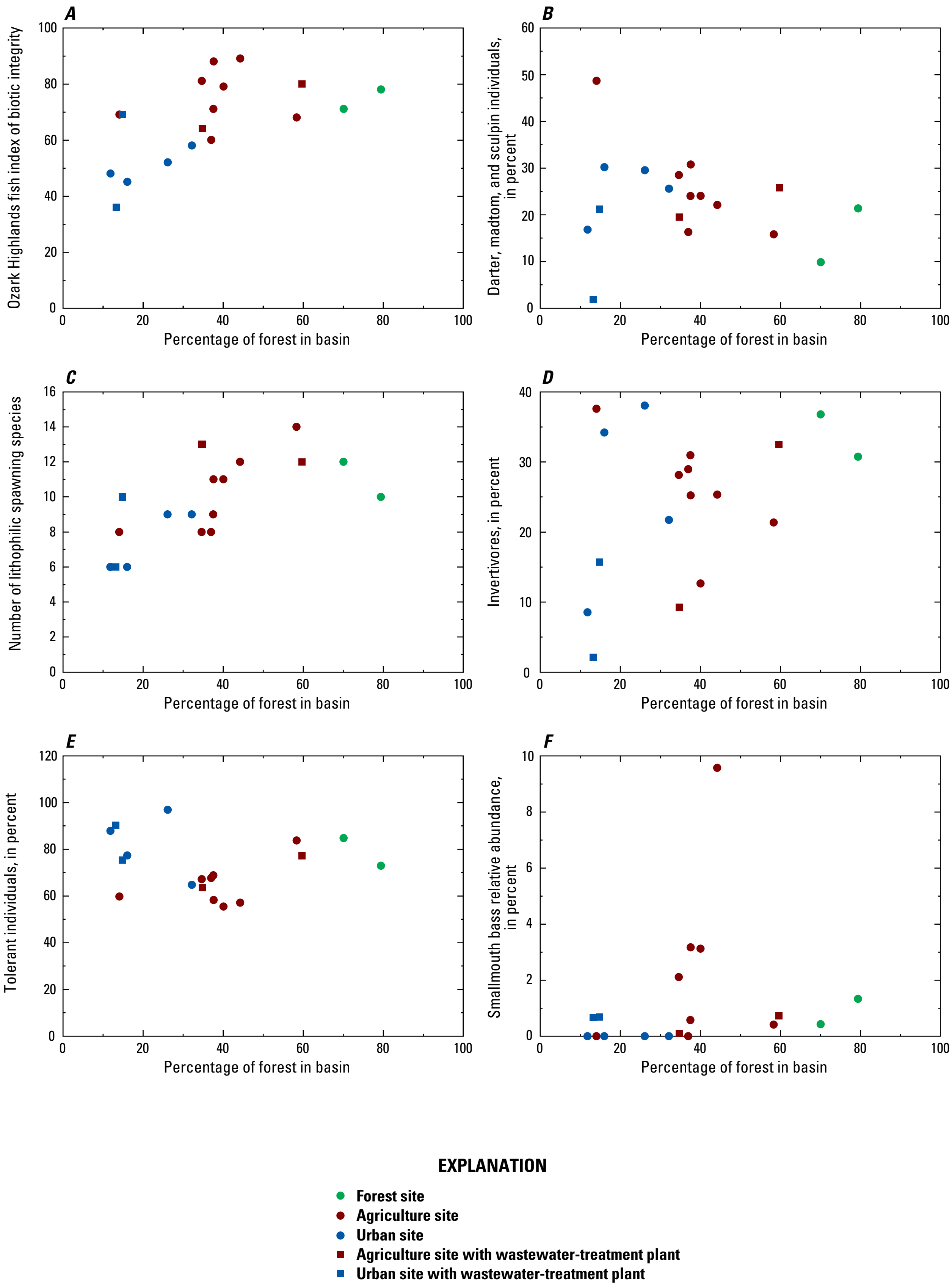

Figure 8. Scatterplots showing relations between percent forest in basin and the Ozark Highlands fish index of biotic integrity and selected fish metrics in the Illinois River Basin study area.

Relations Between the Fish Index and Selected Environmental Factors

The Ozark Highlands fish index of biotic integrity also was compared graphically to six environmental factors using scatterplots (fig. 9). These factors include two nutrients, a measure of substrate quality, a measure of riparian shading, a measure of stream geometry, and a measure of road density. Correlations with these six factors were moderate or strong for embeddedness, open canopy angle, bank height, and total road density (fig. 9, table 22). Of the 26 environmental factors, there was a strong correlation only between the fish index and five environmental factors (percent forest, percent urban, and three measures of road density; table 22).

Correlations between nutrient concentrations and the Ozark Highlands fish index of biotic integrity were weak (nitrate, rho=0.26; total phosphorus, rho=0.37) (fig. 9, table 22). For both nutrients, fish index values almost always were lower at urban sites than at agriculture sites with similar nutrient concentrations. Embeddedness was moderately correlated with the fish index (rho=−0.41) (fig. 9). The lowest fish index values and the highest embeddedness generally occurred at sites with the highest percentages of urban land use. Increases in open canopy angle were moderately correlated with increases in the fish index value (rho=0.46) (fig. 9). Fish index values almost always were lower at urban sites than at agriculture sites with similar canopy angles. Bank height was not correlated with the fish index (rho=0.36) (fig. 9). In general, for a given range of bank heights, fish index values were lower at urban sites (urban sites without upstream wastewater-treatment plants plus forest sites) than at agriculture sites (agriculture sites without upstream wastewater-treatment plants plus forest sites). Total road density was strongly and inversely correlated with the fish index (rho=−0.74) (fig. 9). Although there was variability throughout the range of total road density, fish index values decreased with increasing road density. Highest road densities were associated with urban sites.

Agriculture Gradient Sites

Analysis of data for the 10 agriculture gradient sites indicated that fish metrics were affected by several factors. Seventeen fish metrics and the Ozark Highlands fish index of biotic integrity were strongly correlated with one or more of 21 of the 26 environmental factors (table 23, at the end of the report). The fish metrics included measures of density, feeding preference, spawning preference, tolerance to habitat degradation, taxonomic relative abundance and richness, and the fish index. The environmental factors included measures of land use, road density, water quality, channel geometry, riparian shading, bed sediment quality, water velocity, and stream size. The fish index was strongly correlated only with open canopy angle, but in general (based on the stronger correlations) the fish index of biotic integrity was higher at sites with less shading, smaller drainage areas, and lower substrate turbidity.

Although there was no correlation (rho=0.02) between the Ozark Highlands fish index of biotic integrity and percent agriculture land use for the 10 agriculture gradient sites, the fish index and metrics used to calculate the index were moderately to strongly correlated with several other factors (table 23); few factors were strongly correlated with more than one of the metrics that are part of the fish index. Most of these factors were related to land use, substrate quality, channel geometry, and riparian shading. For example the number of lithophilic spawning species was strongly correlated with percent agriculture and the fish index was strongly correlated with canopy angle.

Relations between selected fish metrics and percent forest for the agriculture gradient sites sometimes differed substantially from the same relations for the complete set of sampled sites (fig. 8). For example, there was an overall strong positive correlation between the fish index and forest land use (rho=0.61) for the set of 14 sites, but that correlation was much lower for agriculture gradient sites (rho=0.13). At most agriculture gradient sites, the relation between forest land use and the relative abundance of darters plus madtoms plus sculpins seemed to be much stronger than the same relation among all sites. In contrast with the set of 14 sites (rho=0.67), relative abundance of smallmouth bass did not consistently increase with increasing percent forest (rho=0.25), and the highest relative abundances were associated with four agriculture gradient sites with percent forest values of approximately 35 to 45 percent.

Urban Gradient Sites

In general, Ozark Highlands fish index of biotic integrity and fish metric values at urban gradient (urban sites without upstream wastewater-treatment plants plus forest sites) sites were more indicative of disturbed communities than values at agriculture gradient sites (agriculture sites without upstream wastewater-treatment plants plus forest sites) (figs. 8–9, table 1, table 21). The lowest fish index scores were at urban gradient sites. In addition, urban gradient sites tended to have fewer lithophilic spawner species (richness), fewer smallmouth bass, and lower fish index values for a given range of nutrient concentrations (fig. 9). Lower fish index values occurred at sites with higher embeddedness and paved road densities, which are typical of urban sites (table 5). The indication that urban land use may influence fish more than agriculture land use may partly be the result of the differences in the land-use proportions (substantially lower percentages of forest at urban gradient sites, fig. 2) between the sites in the urban gradient and sites in the agriculture gradient.

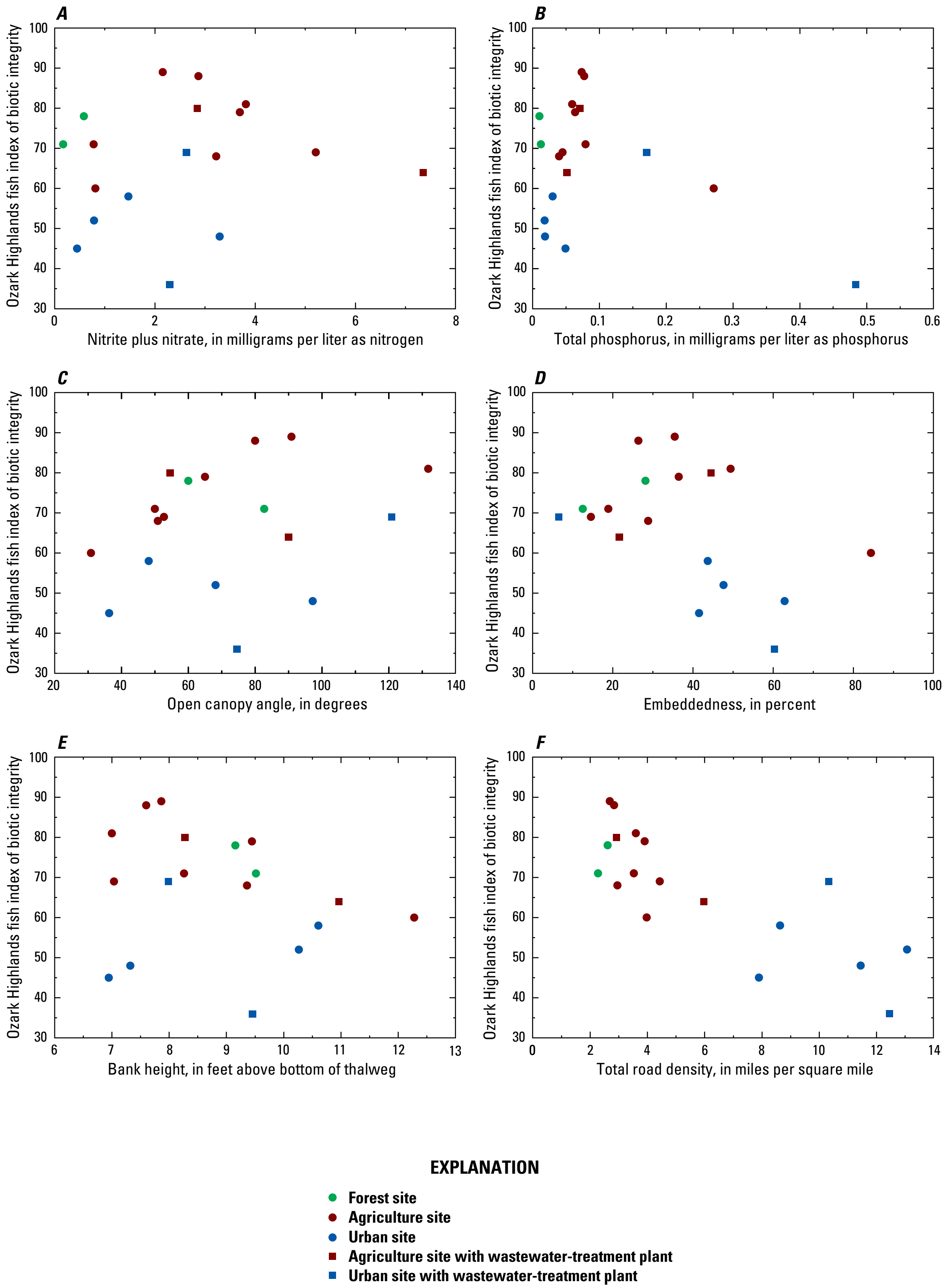

Figure 9. Relations between the Ozark Highlands fish index of biotic integrity and selected environmental factors in the Illinois River Basin study area.

Analysis of data for the six urban gradient sites indicated that fish metrics were affected by several factors. Thirteen fish metrics and the fish index were strongly correlated with one or more of 22 of the 26 environmental factors (table 24, at the end of the report). The fish metrics included measures of feeding preference, spawning preference, taxonomic relative abundance and richness, and the Ozark Highlands fish index of biotic integrity. The environmental factors included measures of land use, road density, water quality, channel geometry, riparian shading, substrate quality, water velocity, and streamflow. In general (based on the correlations), the fish index was higher at sites with higher percentages of forest in their basins, lower percentages of urban land in their basins, lower nutrient concentrations, shallower depths, lower streamflows, and lower velocities. The correlations with streamflow, depth, and velocity may be affected by the sampling of the sites with the highest percentages of forest during a period of relatively low streamflow.

There was a strong inverse correlation (rho=−0.83) between the fish index and percent urban land use for these six sites; the fish index and metrics used to calculate the index were strongly correlated with several other factors (table 24). Most of these factors were related to land use, water quality, streamflow, channel geometry, and riparian shading. For example, the relative abundance of top carnivores, species richness of lithophilic spawners, and the fish index were negatively correlated with total phosphorus.

Wastewater-Treatment Plant Sites

Upstream WWTPs appear to have substantially affected some fish community metrics but had little effect on other metrics (figs. 8–9, table 21). For example, three of the five lowest relative abundances of lithophilic spawner minus stonerollers and four of the five highest stoneroller relative abundances were at sites downstream from WWTPs. The relative abundance of darters plus madtoms plus sculpins at one site (Spring Creek) was substantially lower than at any other site, and the number of darter plus madtom plus sculpin species tended to be somewhat lower for a given percentage of forest at these sites. An unusually high relative abundance of yellow bullheads (a tolerant species) occurred at Spring Creek (table 19). However, the fish index, relative abundance of tolerant fish species, relative abundance of invertivores, and relative abundance of smallmouth bass do not appear to be strongly influenced by the upstream WWTPs.

Limitations and Implications

Interpretations of the results of the study are limited by a number of factors. These include the drought that occurred during the sampling period, the necessity to sample some of the sites in 2012 because of low streamflows in 2011, the absence of sites of appropriate drainage area with percent forest exceeding 80 percent (limited to least-disturbed sites rather than “reference” sites), the large number of environmental settings (which are determined by the interaction of land use, land-use intensity, instream and riparian habitat quality, and groundwater influence), rapid land-use changes in some parts of the Illinois River Basin, incomplete characterization of land-use intensity based on the available data, and the relatively low number of sites.These factors individually and collectively add to uncertainty and variability in the responses to various environmental stresses (including, but not limited to, nutrients, sediment, habitat degradation, and streamflow alteration). Notwithstanding the limiting factors, the biological responses of macroalgae cover and periphyton, macroinvertebrate, and fish metrics to environmental variables provide multiple lines of evidence that biological communities of these streams are being affected by recent and ongoing land-use practices.

Many types of land-use, water-quality, and habitat factors affected one or more aspects of the biological communities. For example, percent macroalgae cover uniformly was highest at the four sites downstream from WWTPs, but the strongest correlation among the 18 sites was to open canopy angle. Nitrate was moderately correlated with biovolume of blue-green algae periphyton and strongly correlated with percent biovolume of blue-green algae periphyton. Several macroinvertebrate and fish metrics change in response to changes in percent forest; sites that would be considered most disturbed, based on these metrics, are sites with the highest percentages of urban land use in their associated basins. However, many of the sites in the urban gradient also have a relatively high percentage (typically about 20 to 30 percent) of agriculture land use in the associated basins. Consequently, the percent of forest land use in most of the urban gradient basins is less than 30 percent and biological responses of the fish communities at the urban gradient sites probably were the result of the combined effects of urban and agricultural land use. For some metrics (notably macroalgae cover, for example), sites downstream from WWTPs tended to have values indicative of more disturbed communities, but other metrics did not indicate disturbance.

For several biological metrics (for example, percent macroalgae cover; diatom biovolume; *Phormidium* biovolume; macroinvertebrate index; macroinvertebrate Margalef diversity; Ephemeroptera, Plecoptera, Trichoptera richness; percent macroinvertebrate gatherer-collectors; and relative abundance of smallmouth bass), there appears to be a threshold of about 40 to 50 percent forest where values of these metrics change in magnitude (figs. 3, 4, 6, and 8). However, the four sites with more than 50 percent forest in their basins were the four sites sampled in late May–early June of 2012. The relative influence of season and forest percentage on the biological communities at these sites is unknown. The high number of metrics that show this pattern is evidence that biological communities in small Illinois River Basin streams change where percent forest decreases to less than about 50 percent.

Summary

The Illinois River Basin includes an area of diverse land use in northwestern Arkansas. Land-use data collected in 2006 indicate that most of the land in the basin is agricultural. From 1992 to 2006, there was a shift from agricultural land use to urban land use as the cities of Fayetteville, Springdale, and Rogers grew in area and in population. Forest plus herbaceous land use increased from 29 to 41 percent during the same period. The agricultural land is used primarily for production of poultry and cattle.

Eighteen sites were selected from the list of candidate sites based on drainage area, land use, presence or absence of an upstream WWTP, water quality, and other information gathered during the reconnaissance. An important consideration in the process was to select sites along gradients of forest to urban land use and forest to agricultural land use. Water-quality samples were collected for analysis of nutrients, and a multiparameter field meter was used to measure water temperature, specific conductance, pH, and dissolved oxygen. Streamflow was measured immediately following the water-quality sampling. Periphyton, macroinvertebrate, and fish communities were sampled at each site. Stream habitat also was assessed.

Many types of land-use, water-quality, and habitat factors affected one or more aspects of the biological communities. Several macroinvertebrate and fish metrics change in response to changes in percent forest; sites that would be considered most disturbed, based on these metrics, are sites with the highest percentages of urban land use in their associated basins. However, many of the sites in the urban gradient also have a relatively high percentage (typically about 20 to 30 percent) of agriculture land use in the associated basins. Consequently, the percent of forest land use in most of the urban gradient basins is less than 30 percent and biological responses of the macroinvertebrate communities at the urban gradient sites probably were the result of the combined effects of urban and agricultural land use.

The presence of large mats of macroalgae (the algae with visible structure, rather than the typically microscopic algal structure of periphyton) was one of the most noticeable biological characteristics in several streams within the Illinois River Basin. The highest macroalgae percent cover values were recorded at four sites downstream from wastewater-treatment plants. Macroalgae percent cover was strongly correlated only with bed substrate size, canopy closure, and specific conductance.

Total biovolume of periphyton, which is a surrogate for algal biomass, was not strongly correlated with any of the land-use, habitat, or water-quality factors assessed in the present study. Although algal growth typically increases with higher nutrient concentrations and less shading, the standing crop of periphyton on rocks can be reduced by grazing by herbivorous macroinvertebrates and fish, which may explain why total biovolume in Ozark streams is not strongly affected by water-quality (or other habitat) factors. Other periphyton metrics were most often and most strongly correlated with riparian shading, specific conductance, substrate turbidity, percent agriculture, poultry house density, and unpaved road density; some of these factors are strongly correlated with percent forest, percent urban, or percent agriculture. Three strong or moderately strong correlations were detected between blue-green algae biovolume and blue-green algae percent biovolume and nitrate, and *Nitzschia amphibia* biovolume and total phosphorus. *Cymbella delicatula*, a diatom associated with low-nutrient streams, was not found at any sites in the present study.

A macroinvertebrate index and several macroinvertebrate metrics were adversely affected by increasing urban and agricultural land use and associated environmental factors. These include metrics associated with tolerance to habitat degradation, taxonomic groups, diversity, behavior preference, and feeding preference. Factors most commonly affecting these metrics included factors associated with water quality, stream geometry, sediment, land-use percentages, and road density. Correlations with the macroinvertebrate index were moderate or strong for embeddedness, open canopy angle, bank height, total road density, and other factors. The macroinvertebrate index and, in many cases, macroinvertebrate metric values were most indicative of some disturbance of the macroinvertebrate community at urban sites. However, many of the sites in the urban gradient also have a relatively high percentage (typically about 20 to 30 percent) of agriculture land use in the associated basins. The four sites with the highest index scores (indicative of least disturbance) were sites with the highest percentages of forest in their basins; however, one of the sites is also downstream from a wastewater-treatment plant (the site farthest downstream from its associated wastewater-treatment plant). The four sites with the lowest index scores were urban sites, two of which were downstream from wastewater-treatment plants. In general (based on the correlations), the macroinvertebrate index was higher at sites with greater percentages of forest in their basins, lower percentages of urban land in their basins, and lower paved road density. The correlations with depth and water velocity probably are partially affected by the sampling of the most forested sites during a period of relatively low streamflow. Correlations with the macroinvertebrate index were moderate or strong (absolute value of rho greater than or equal to 0.40) for embeddedness, open canopy angle, bank height, total road density, and other factors. Upstream wastewater-treatment plants affect several metrics. For example, three of the five lowest macroinvertebrate index scores, two of the five lowest percent predator values, and two of the five highest percent gatherer-collector values are at sites downstream from wastewater-treatment plants.

The Ozark Highlands fish index of biotic integrity and several fish metrics associated with feeding preference, spawning preference, and tolerance to habitat degradation were adversely affected by increasing urban and agricultural land use and associated factors. Factors affecting these metrics include factors associated with nutrients, sediment, and riparian shading. Correlations with the fish index of biotic integrity were moderate or strong (absolute value of rho greater than or equal to 0.40) for total road density, embeddedness, open canopy angle, and other factors; correlations were weak for nitrate, total phosphorus, and bank height. The Ozark Highlands fish index of biotic integrity and several fish metrics were most indicative of some disturbance of the fish community at urban sites. However, many of the sites in the urban gradient also have a relatively high percentage (typically about 20 to 30 percent) of agriculture land use in the associated basins. Most of the highest scores (that is, those in the least-disturbed class) were associated with sites with some of the highest percentages of agriculture land use in their basins. Lowest scores (in the poor or fair classes) were associated with sites with high percentages of urban land use (or urban land use and wastewater-treatment plants) in their basins. In general (based on the correlations), the fish index of biotic integrity was higher at sites with higher percentages of forest in their basins, lower percentages of urban land in their basins, higher unpaved road density, and lower paved and total road density. Upstream wastewater-treatment plants appear to affect some fish community metrics substantially but have little effect on other metrics. For example, the relative abundance of darters plus madtoms plus sculpins at one site (Spring Creek) was substantially lower than at any other site. However, the fish index, relative abundance of tolerant individuals, relative abundance of invertivores, and relative abundance of smallmouth bass do not appear to be strongly influenced by the upstream WWTPs.For example, three of the five lowest relative abundances of lithophilic spawner minus stonerollers and four of the five highest stoneroller abundances were at sites downstream from wastewater-treatment plants.

Interpretations of the results of the study described in this report are limited by a number of factors. These factors individually and collectively add to uncertainty and variability in the responses to various environmental stresses (including, but not limited to, nutrients, sediment, habitat degradation, and streamflow alteration). Notwithstanding the limiting factors, the biological responses of macroalgae cover and periphyton, macroinvertebrate, and fish metrics to environmental variables provide multiple lines of evidence that biological communities of these streams are being affected by recent and ongoing land-use practices.

For several biological metrics, there appears to be a threshold of about 40 to 50 percent forest where values of these metrics change in magnitude. However, the four sites with more than 50 percent forest in their basins were the four sites sampled in late May–early June of 2012 (rather than July–August of 2011). The relative influence of season and forest percentage on the biological communities at these sites is unknown. The high number of metrics that show this pattern is evidence that biological communities in small Illinois River Basin streams change where percent forest decreases to less than about 50 percent.

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Table 10. List of algal taxa and biovolumes for sampling sites in the Illinois River Basin study area.

[Biovolume is in cubic centimeters per square meter, values are rounded to seven decimal places]

Short site name	Algae group	Scientific name	Biovolume
Ballard Creek	Green algae	*Pediastrum duplex clathratum*	62.6826409
Ballard Creek	Green algae	*Kirchneriella lunaris*	0.0047094
Ballard Creek	Green algae	*Monoraphidium arcuatum*	0.0077706
Ballard Creek	Green algae	*Scenedesmus*	0.0565133
Ballard Creek	Green algae	*Tetrastrum glabrum*	0.0281311
Ballard Creek	Diatoms	*Achnanthidium minutissimum*	0.0003231
Ballard Creek	Diatoms	*Cocconeis neothumensis*	0.0086344
Ballard Creek	Diatoms	*Cocconeis placentula*	0.0343615
Ballard Creek	Diatoms	*Psammothidium curtissimum*	0.0764763
Ballard Creek	Diatoms	*Caloneis bacillium*	0.0012482
Ballard Creek	Diatoms	*Cymbella affinis*	0.1101950
Ballard Creek	Diatoms	*Gomphonema cf. parvulum*	0.0087218
Ballard Creek	Diatoms	*Gomphonema minutum*	0.0011970
Ballard Creek	Diatoms	*Navicula capitatoradiata*	0.0035977
Ballard Creek	Diatoms	*Navicula cf. cryptotenella*	0.0011748
Ballard Creek	Diatoms	*Navicula subminuscula*	0.0347286
Ballard Creek	Diatoms	*Nitzschia amphibia*	0.0362343
Ballard Creek	Diatoms	*Nitzschia inconspicua*	0.0007011
Ballard Creek	Diatoms	*Nitzschia palea*	0.0045433
Ballard Creek	Diatoms	*Stephanocyclus meneghiniana*	0.0071366
Ballard Creek	Blue-green algae	*Heteroleibleinia*	0.1104658
Ballard Creek	Blue-green algae	*cf. Scytonema*	0.0864653
Ballard Creek	Blue-green algae	*Gloeocapsopsis*	0.8359255
Ballard Creek	Blue-green algae	*Merismopedia*	0.0097139
Ballard Creek	Blue-green algae	*Phormidium*	0.7934464
Ballard Creek	Total biovolume		64.9450558
Baron Fork	Green algae	*Stigeoclonium*	0.2277784
Baron Fork	Green algae	*Cosmarium*	0.0101435
Baron Fork	Green algae	*Scenedesmus dimorphus*	0.0084269
Baron Fork	Diatoms	*Achnanthidium minutissimum*	0.0030491
Baron Fork	Diatoms	*Achnanthidium rivulare*	0.0089484
Baron Fork	Diatoms	*Cocconeis pediculus*	0.0145825
Baron Fork	Diatoms	*Cocconeis placentula*	0.0536902
Baron Fork	Diatoms	*Psammothidium curtissimum*	0.3267810
Baron Fork	Diatoms	*Amphora pediculus*	0.0016880
Baron Fork	Diatoms	*Cymbella affinis*	0.1542039
Baron Fork	Diatoms	*Cymbella tumida*	0.0557075
Baron Fork	Diatoms	*Gomphonema*	0.0094802
Baron Fork	Diatoms	*Gomphonema cf. parvulum*	0.0075842
Baron Fork	Diatoms	*Navicula antonii*	0.0092798
Baron Fork	Diatoms	*Navicula capitatoradiata*	0.1802930
Baron Fork	Diatoms	*Navicula subminuscula*	0.0342469
Baron Fork	Diatoms	*Reimeria sinuata*	0.0291650
Baron Fork	Diatoms	*Nitzschia amphibia*	0.0974770

Table 10. List of algal taxa and biovolumes for sampling sites in the Illinois River Basin study area.—Continued

[Biovolume is in cubic centimeters per square meter, values are rounded to seven decimal places]

Short site name	Algae group	Scientific name	Biovolume
Baron Fork	Diatoms	*Nitzschia inconspicua*	0.0042760
Baron Fork	Diatoms	*Nitzschia palea*	0.0141785
Baron Fork	Diatoms	*Stephanocyclus meneghiniana*	0.0111357
Baron Fork	Blue-green algae	*Chlorogloea*	0.0019447
Baron Fork	Blue-green algae	*Aphanocapsa*	0.0052818
Baron Fork	Blue-green algae	*Heteroleibleinia*	0.0276125
Baron Fork	Blue-green algae	*Gloeocapsopsis*	0.0030731
Baron Fork	Blue-green algae	*Phormidium*	0.3308639
Baron Fork	Blue-green algae	*Leptolyngbya*	0.0076346
Baron Fork	Heterokonts	*Phaeothamnion*	0.0146931
Baron Fork	Total biovolume		1.6532193
Cincinnati Creek	Green algae	*Chaetophora*	0.1301971
Cincinnati Creek	Green algae	*Characium*	0.0123446
Cincinnati Creek	Green algae	*Cosmarium*	0.1512219
Cincinnati Creek	Green algae	*Kirchneriella lunaris*	0.0007715
Cincinnati Creek	Green algae	*Monoraphidium*	0.0034719
Cincinnati Creek	Green algae	*cf. Phacotus lenticularis*	0.0062495
Cincinnati Creek	Green algae	*Scenedesmus*	0.0166652
Cincinnati Creek	Diatoms	*Cocconeis placentula*	0.2753414
Cincinnati Creek	Diatoms	*Psammothidium*	0.4871424
Cincinnati Creek	Diatoms	*Psammothidium curtissimum*	1.2936780
Cincinnati Creek	Diatoms	*Cymbella excisa*	3.4490412
Cincinnati Creek	Diatoms	*Gomphonema cf. parvulum*	0.4289855
Cincinnati Creek	Diatoms	*Gomphonema pumilum*	0.0261134
Cincinnati Creek	Diatoms	*Luticola mutica*	0.0267693
Cincinnati Creek	Diatoms	*Navicula capitatoradiata*	0.1809134
Cincinnati Creek	Diatoms	*Navicula subminuscula*	0.0794254
Cincinnati Creek	Diatoms	*Reimeria sinuata*	0.0150026
Cincinnati Creek	Diatoms	*Aulacoseira*	0.0252249
Cincinnati Creek	Diatoms	*Nitzschia amphibia*	2.0459621
Cincinnati Creek	Diatoms	*Nitzschia palea*	0.1359605
Cincinnati Creek	Blue-green algae	*cf. Heteroleibleinia*	0.1056766
Cincinnati Creek	Blue-green algae	*Gloeocapsopsis*	1.7624829
Cincinnati Creek	Blue-green algae	*Phormidium*	1.4484861
Cincinnati Creek	Blue-green algae	*Pseudanabaena*	0.0804618
Cincinnati Creek	Total biovolume		12.1875893
Clear Creek	Green algae	*Scenedesmus dimorphus*	0.0059850
Clear Creek	Diatoms	*Achnanthidium eutrophilum*	0.0098894
Clear Creek	Diatoms	*Achnanthidium rivulare*	1.7648855
Clear Creek	Diatoms	*Cocconeis placentula*	0.6248101
Clear Creek	Diatoms	*Psammothidium curtissimum*	0.2698043
Clear Creek	Diatoms	*Gomphoneis olivacea*	0.0450466
Clear Creek	Diatoms	*Gomphonema kobayasii*	0.1152590
Clear Creek	Diatoms	*Nitzschia amphibia*	0.2395641
Clear Creek	Blue-green algae	*cf. Komvophoron*	0.0136374

Table 10. List of algal taxa and biovolumes for sampling sites in the Illinois River Basin study area.—Continued

[Biovolume is in cubic centimeters per square meter, values are rounded to seven decimal places]

Short site name	Algae group	Scientific name	Biovolume
Clear Creek	Blue-green algae	*Planktothrix*	0.0166103
Clear Creek	Blue-green algae	*Trichodesmium*	0.2360745
Clear Creek	Blue-green algae	*Heteroleibleinia*	0.0458839
Clear Creek	Blue-green algae	*Lyngbya*	0.1028647
Clear Creek	Blue-green algae	*Phormidium*	0.3986007
Clear Creek	Blue-green algae	*Leptolyngbya*	0.0449643
Clear Creek	Total biovolume		3.9338798
Evansville Creek	Green algae	*Cosmarium*	0.0237618
Evansville Creek	Green algae	*Bulbochaete*	0.5868226
Evansville Creek	Green algae	*Scenedesmus*	0.0342171
Evansville Creek	Diatoms	*Achnanthidium gracillimum*	0.0882290
Evansville Creek	Diatoms	*Achnanthidium minutissimum*	0.0602949
Evansville Creek	Diatoms	*Achnanthidium reimeri*	0.0026459
Evansville Creek	Diatoms	*Achnanthidium rivulare*	0.0968280
Evansville Creek	Diatoms	*Cocconeis placentula*	0.0648234
Evansville Creek	Diatoms	*Planothidium lanceolatum*	0.0048338
Evansville Creek	Diatoms	*Psammothidium curtissimum*	0.0035617
Evansville Creek	Diatoms	*Cymbella turgidula*	0.0945932
Evansville Creek	Diatoms	*Encyonema minutum*	0.0374914
Evansville Creek	Diatoms	*Encyonema silesiacum*	0.0142537
Evansville Creek	Diatoms	*Gomphonema cf. americobtusatum*	0.0005936
Evansville Creek	Diatoms	*Gomphonema grovei lingulatum*	0.0009097
Evansville Creek	Diatoms	*Navicula antonii*	0.0028833
Evansville Creek	Diatoms	*Navicula capitatoradiata*	0.0030275
Evansville Creek	Diatoms	*Reimeria sinuata*	0.0198948
Evansville Creek	Diatoms	*Rhoicosphenia abbreviata*	0.0013222
Evansville Creek	Diatoms	*Nitzschia palea*	0.0003077
Evansville Creek	Blue-green algae	*Chlorogloea*	0.0131522
Evansville Creek	Blue-green algae	*Aphanocapsa*	0.0016158
Evansville Creek	Blue-green algae	*Heteroleibleinia*	0.3132999
Evansville Creek	Blue-green algae	*Gloeocapsopsis*	1.1828944
Evansville Creek	Blue-green algae	*Lyngbya*	0.2053024
Evansville Creek	Blue-green algae	*Phormidiochaete*	0.0572601
Evansville Creek	Blue-green algae	*Phormidium*	0.0056538
Evansville Creek	Blue-green algae	*Leptolyngbya*	0.5870364
Evansville Creek	Heterokonts	*cf. Phaeothamnion*	0.6950340
Evansville Creek	Total biovolume		4.2025443
Flint Creek	Green algae	*Scenedesmus*	0.0049353
Flint Creek	Green algae	*Tetrastrum glabrum*	0.0014806
Flint Creek	Diatoms	*Cocconeis placentula*	0.0809752
Flint Creek	Diatoms	*Psammothidium curtissimum*	0.3835667
Flint Creek	Diatoms	*Cymbella excisa regulare*	0.0223957
Flint Creek	Diatoms	*Cymbella tumida*	0.0755633
Flint Creek	Diatoms	*Cymbella turgidula*	0.1424519
Flint Creek	Diatoms	*Gomphonema*	0.0305516

Table 10. List of algal taxa and biovolumes for sampling sites in the Illinois River Basin study area.—Continued

[Biovolume is in cubic centimeters per square meter, values are rounded to seven decimal places]

Short site name	Algae group	Scientific name	Biovolume
Flint Creek	Diatoms	*Gomphonema cf. angustatum*	0.0064055
Flint Creek	Diatoms	*Gomphonema kobayasii*	0.0048707
Flint Creek	Diatoms	*Navicula antonii*	0.0094978
Flint Creek	Diatoms	*Navicula capitatoradiata*	0.0701379
Flint Creek	Diatoms	*Navicula cryptotenella*	0.0060884
Flint Creek	Diatoms	*Navicula subminuscula*	0.0018265
Flint Creek	Diatoms	*Reimeria sinuata*	0.0292241
Flint Creek	Diatoms	*Nitzschia amphibia*	0.7160764
Flint Creek	Diatoms	*Nitzschia palea*	0.0103101
Flint Creek	Blue-green algae	*Heteroleibleinia*	0.4817273
Flint Creek	Blue-green algae	*Gloeocapsopsis*	0.2587624
Flint Creek	Blue-green algae	*Merismopedia*	0.0001047
Flint Creek	Blue-green algae	*Oscillatoria*	0.0610748
Flint Creek	Blue-green algae	*Phormidium*	0.1415824
Flint Creek	Total biovolume		2.5396094
Fly Creek	Green algae	*Scenedesmus*	0.2048052
Fly Creek	Diatoms	*Achnanthidium alpestre*	0.0036669
Fly Creek	Diatoms	*Achnanthidium minutissimum*	0.0013096
Fly Creek	Diatoms	*Achnanthidium rivulare*	0.8761290
Fly Creek	Diatoms	*Cocconeis placentula*	0.0513367
Fly Creek	Diatoms	*Psammothidium curtissimum*	0.0361452
Fly Creek	Diatoms	*Gomphoneis olivacea*	0.0337301
Fly Creek	Diatoms	*Cymbella affinis*	0.1829017
Fly Creek	Diatoms	*Cymbella excisa*	0.0748043
Fly Creek	Diatoms	*Encyonema minutum*	0.0135091
Fly Creek	Diatoms	*Gomphonema*	0.0067460
Fly Creek	Diatoms	*Gomphonema kobayasii*	0.0180721
Fly Creek	Diatoms	*Navicula capitatoradiata*	0.1492955
Fly Creek	Diatoms	*Reimeria sinuata*	0.0061879
Fly Creek	Diatoms	*Rhoicosphenia abbreviata*	0.1145226
Fly Creek	Diatoms	*Nitzschia amphibia*	0.0240113
Fly Creek	Diatoms	*Nitzschia frustulum*	0.0078787
Fly Creek	Diatoms	*Nitzschia inconspicua*	0.0048721
Fly Creek	Blue-green algae	*Aphanocapsa*	0.0393167
Fly Creek	Blue-green algae	*Heteroleibleinia*	0.1115791
Fly Creek	Blue-green algae	*Gloeocapsopsis*	1.9352067
Fly Creek	Blue-green algae	*Phormidium*	0.1318609
Fly Creek	Blue-green algae	*Leptolyngbya*	0.5176241
Fly Creek	Total biovolume		4.5455115
Goose Creek	Green algae	*cf. Characium*	0.0024950
Goose Creek	Green algae	*Scenedesmus*	0.0403041
Goose Creek	Diatoms	*Achnanthidium minutissimum*	0.0032888
Goose Creek	Diatoms	*Achnanthidium rivulare*	0.1189107
Goose Creek	Diatoms	*Cocconeis neothumensis*	0.0422851
Goose Creek	Diatoms	*Cocconeis pediculus*	0.1452214

Table 10. List of algal taxa and biovolumes for sampling sites in the Illinois River Basin study area.—Continued

[Biovolume is in cubic centimeters per square meter, values are rounded to seven decimal places]

Short site name	Algae group	Scientific name	Biovolume
Goose Creek	Diatoms	*Cocconeis placentula*	0.3516067
Goose Creek	Diatoms	*Planothidium lanceolatum*	0.0207581
Goose Creek	Diatoms	*Psammothidium curtissimum*	0.2171915
Goose Creek	Diatoms	*Caloneis bacillium*	0.0093967
Goose Creek	Diatoms	*Cymbella affinis*	0.0313274
Goose Creek	Diatoms	*Encyonema minutum*	0.0046229
Goose Creek	Diatoms	*Encyonema reichardtii*	0.0004895
Goose Creek	Diatoms	*Gomphonema truncatum*	0.0650557
Goose Creek	Diatoms	*Navicula antonii*	0.0205018
Goose Creek	Diatoms	*Navicula lanceolata*	0.1537639
Goose Creek	Diatoms	*Navicula subminuscula*	0.1025092
Goose Creek	Diatoms	*Reimeria uniseriata*	0.0106780
Goose Creek	Diatoms	*Rhoicosphenia abbreviata*	0.0107948
Goose Creek	Diatoms	*Nitzschia amphibia*	0.0122362
Goose Creek	Diatoms	*Nitzschia dissipata*	0.0462255
Goose Creek	Diatoms	*Nitzschia inconspicua*	0.0616702
Goose Creek	Cryptophytes	*Cryptomonas*	0.0126670
Goose Creek	Cryptophytes	*Rhodomonas*	0.0056298
Goose Creek	Blue-green algae	*Aphanocapsa*	0.0529231
Goose Creek	Blue-green algae	*Heteroleibleinia*	0.0723854
Goose Creek	Blue-green algae	*Chroococcus*	0.0159937
Goose Creek	Blue-green algae	*Gloeocapsopsis*	12.8072238
Goose Creek	Blue-green algae	*Phormidium*	0.1351146
Goose Creek	Blue-green algae	*Leptolyngbya*	0.0297962
Goose Creek	Total biovolume		14.6030666
Hamestring Creek	Green algae	*Characium*	0.0030895
Hamestring Creek	Green algae	*Scenedesmus cf. opoliensis*	0.0140572
Hamestring Creek	Diatoms	*Achnanthidium minutissimum*	0.0142758
Hamestring Creek	Diatoms	*Achnanthidium rivulare*	0.1359502
Hamestring Creek	Diatoms	*Cocconeis neothumensis*	0.0033046
Hamestring Creek	Diatoms	*Cocconeis placentula*	0.1387921
Hamestring Creek	Diatoms	*Planothidium lanceolatum*	0.0039655
Hamestring Creek	Diatoms	*Psammothidium curtissimum*	0.1175107
Hamestring Creek	Diatoms	*Cymbella affinis*	0.0589092
Hamestring Creek	Diatoms	*Cymbella turgidula*	0.0063117
Hamestring Creek	Diatoms	*Geissleria decussis*	0.0099137
Hamestring Creek	Diatoms	*Gomphonema cf. pumilum*	0.0140890
Hamestring Creek	Diatoms	*Navicula capitatoradiata*	0.0098697
Hamestring Creek	Diatoms	*Navicula cryptotenella*	0.0076005
Hamestring Creek	Diatoms	*Navicula menisculus*	0.0060804
Hamestring Creek	Diatoms	*Navicula subminuscula*	0.0023793
Hamestring Creek	Diatoms	*Reimeria sinuata*	0.0110152
Hamestring Creek	Diatoms	*Nitzschia amphibia*	0.0017672
Hamestring Creek	Diatoms	*Nitzschia palea*	0.0009257
Hamestring Creek	Diatoms	*Stephanocyclus meneghiniana*	0.0039985

Table 10. List of algal taxa and biovolumes for sampling sites in the Illinois River Basin study area.—Continued

[Biovolume is in cubic centimeters per square meter, values are rounded to seven decimal places]

Short site name	Algae group	Scientific name	Biovolume
Hamestring Creek	Blue-green algae	*cf. Homeothrix*	0.0032955
Hamestring Creek	Blue-green algae	*Komvophoron*	0.0206803
Hamestring Creek	Blue-green algae	*Chlorogloea*	0.1351651
Hamestring Creek	Blue-green algae	*Heteroleibleinia*	0.1587225
Hamestring Creek	Blue-green algae	*Chroococcus*	0.0018537
Hamestring Creek	Blue-green algae	*Gloeocapsopsis*	1.6627458
Hamestring Creek	Blue-green algae	*Phormidiochaete nordstedtii*	0.3552912
Hamestring Creek	Blue-green algae	*Phormidium*	0.0716761
Hamestring Creek	Blue-green algae	*Leptolyngbya*	0.2391264
Hamestring Creek	Total biovolume		3.2123623
Illinois River	Green algae	*Scenedesmus dispar*	0.0036280
Illinois River	Diatoms	*Achnanthidium gracillimum*	0.2829572
Illinois River	Diatoms	*Achnanthidium minutissimum*	0.5353202
Illinois River	Diatoms	*Cocconeis placentula*	0.3766422
Illinois River	Diatoms	*Planothidium lanceolatum*	0.0023250
Illinois River	Diatoms	*Psammothidium curtissimum*	0.0380447
Illinois River	Diatoms	*Rossithidium pusillum*	0.0887709
Illinois River	Diatoms	*Cymbella affiniformis*	0.2992538
Illinois River	Diatoms	*Cymbella cf. excisa procera*	0.4049283
Illinois River	Diatoms	*Cymbella cf. parviformis*	0.0215333
Illinois River	Diatoms	*Cymbella excisa*	0.2143131
Illinois River	Diatoms	*Encyonema minutum*	0.0113058
Illinois River	Diatoms	*Gomphonema*	0.0380447
Illinois River	Diatoms	*Gomphonema cf. lateripunctatum*	0.0110673
Illinois River	Diatoms	*Gomphonema grovei lingulatum*	0.0297570
Illinois River	Diatoms	*Navicula capitatoradiata*	0.0416114
Illinois River	Diatoms	*Reimeria sinuata*	0.0313869
Illinois River	Diatoms	*Nitzschia amphibia*	0.0640485
Illinois River	Diatoms	*Nitzschia sinuata tabellaria*	0.0093112
Illinois River	Blue-green algae	*Komvophoron*	0.0009070
Illinois River	Blue-green algae	*Heteroleibleinia*	0.0460208
Illinois River	Blue-green algae	*Phormidiochaete nordstedtii*	0.0382641
Illinois River	Blue-green algae	*Phormidium*	0.3599656
Illinois River	Blue-green algae	*Leptolyngbya*	0.0233080
Illinois River	Blue-green algae	*Limnothrix*	0.0107139
Illinois River	Blue-green algae	*Calothrix*	0.1451200
Illinois River	Total biovolume		3.1285489
Little Osage Creek	Green algae	*Monoraphidium arcuatum*	0.0010272
Little Osage Creek	Green algae	*Scenedesmus*	0.0029583
Little Osage Creek	Green algae	*Klebsormidium*	0.0851269
Little Osage Creek	Diatoms	*Achnanthidium rivulare*	0.2042759
Little Osage Creek	Diatoms	*Cocconeis neothumensis*	0.0107784
Little Osage Creek	Diatoms	*Planothidium lanceolatum*	0.0038494
Little Osage Creek	Diatoms	*Psammothidium curtissimum*	0.0217564
Little Osage Creek	Diatoms	*Rossithidium pusillum*	0.0004220

Table 10. List of algal taxa and biovolumes for sampling sites in the Illinois River Basin study area.—Continued

[Biovolume is in cubic centimeters per square meter, values are rounded to seven decimal places]

Short site name	Algae group	Scientific name	Biovolume
Little Osage Creek	Diatoms	*Cymbella affinis*	0.0133400
Little Osage Creek	Diatoms	*Cymbella excisa*	0.0050114
Little Osage Creek	Diatoms	*Cymbella excisa angusta*	0.0029415
Little Osage Creek	Diatoms	*Gomphonema cf. pumilum*	0.0056510
Little Osage Creek	Diatoms	*Navicula capitatoradiata*	0.0152836
Little Osage Creek	Diatoms	*Navicula cryptotenella*	0.0028229
Little Osage Creek	Diatoms	*Reimeria sinuata*	0.0021386
Little Osage Creek	Diatoms	*Reimeria uniseriata*	0.0016681
Little Osage Creek	Diatoms	*Nitzschia amphibia*	0.0012662
Little Osage Creek	Diatoms	*Nitzschia fonticola*	0.0027002
Little Osage Creek	Blue-green algae	*Chlorogloea*	0.0525912
Little Osage Creek	Blue-green algae	*Heteroleibleinia*	0.0691800
Little Osage Creek	Blue-green algae	*Gloeocapsopsis*	0.1472554
Little Osage Creek	Blue-green algae	*Phormidium*	0.8320092
Little Osage Creek	Blue-green algae	*Leptolyngbya*	0.1709625
Little Osage Creek	Total biovolume		1.6550161
Moores Creek	Green algae	*cf. Stigeoclonium farctum*	0.9713308
Moores Creek	Green algae	*Characium*	0.0006445
Moores Creek	Diatoms	*Achnanthidium eutrophilum*	0.0001903
Moores Creek	Diatoms	*Achnanthidium minutissimum*	0.0003382
Moores Creek	Diatoms	*Achnanthidium rivulare*	0.0033543
Moores Creek	Diatoms	*Cocconeis neothumensis*	0.0032063
Moores Creek	Diatoms	*Cocconeis placentula*	0.1041809
Moores Creek	Diatoms	*Planothidium frequentissimum*	0.0025369
Moores Creek	Diatoms	*Psammothidium*	0.0035516
Moores Creek	Diatoms	*Psammothidium curtissimum*	0.0483415
Moores Creek	Diatoms	*Meridion circulare*	0.0003709
Moores Creek	Diatoms	*Amphora pediculus*	0.0002871
Moores Creek	Diatoms	*cf. Geissleria lateropunctata*	0.0008033
Moores Creek	Diatoms	*Cymbella turgidula*	0.0016515
Moores Creek	Diatoms	*Gomphonema cf. lateripunctatum*	0.0057217
Moores Creek	Diatoms	*Gomphonema minutum*	0.0018961
Moores Creek	Diatoms	*Navicula capitatoradiata*	0.0086254
Moores Creek	Diatoms	*Navicula cryptocephala*	0.0032979
Moores Creek	Diatoms	*Navicula schroeteri*	0.0025897
Moores Creek	Diatoms	*Navicula subminuscula*	0.0002819
Moores Creek	Diatoms	*Navicula viridula linearis*	0.0662758
Moores Creek	Diatoms	*Reimeria uniseriata*	0.0012050
Moores Creek	Diatoms	*Rhoicosphenia abbreviata*	0.0351033
Moores Creek	Diatoms	*Aulacoseira ambigua*	0.0036996
Moores Creek	Diatoms	*Bacillaria paxillifer*	0.0156119
Moores Creek	Diatoms	*Nitzschia amphibia*	0.0055988
Moores Creek	Diatoms	*Nitzschia palea*	0.0022251
Moores Creek	Blue-green algae	*Aphanocapsa*	0.0000175
Moores Creek	Blue-green algae	*cf. Planktothrix*	0.0233141

Table 10. List of algal taxa and biovolumes for sampling sites in the Illinois River Basin study area.—Continued

[Biovolume is in cubic centimeters per square meter, values are rounded to seven decimal places]

Short site name	Algae group	Scientific name	Biovolume
Moores Creek	Blue-green algae	*cf. Jaaginema*	0.0000574
Moores Creek	Blue-green algae	*Heteroleibleinia*	0.0092400
Moores Creek	Blue-green algae	*Gloeocapsopsis*	0.0058995
Moores Creek	Blue-green algae	*Oscillatoria*	0.0224637
Moores Creek	Blue-green algae	*Phormidium*	0.0107122
Moores Creek	Blue-green algae	*Leptolyngbya*	0.0671553
Moores Creek	Blue-green algae	*Pseudanabaena*	0.0183522
Moores Creek	Total biovolume		1.4501325
Mud Creek	Green algae	*Kirchneriella lunaris*	0.0059436
Mud Creek	Green algae	*Oocystis parva*	0.0038423
Mud Creek	Diatoms	*Achnanthidium eutrophilum*	0.0224748
Mud Creek	Diatoms	*Achnanthidium minutissimum*	2.9228529
Mud Creek	Diatoms	*Achnanthidium rivulare*	0.9439433
Mud Creek	Diatoms	*cf. Rossithidium petersenii*	0.0123612
Mud Creek	Diatoms	*Cocconeis neothumensis*	0.0449497
Mud Creek	Diatoms	*Cocconeis placentula*	0.6592620
Mud Creek	Diatoms	*Planothidium frequentissimum*	0.0224748
Mud Creek	Diatoms	*Psammothidium curtissimum*	2.1216249
Mud Creek	Diatoms	*Amphora pediculus*	0.0209874
Mud Creek	Diatoms	*Caloneis bacillium*	0.0404547
Mud Creek	Diatoms	*Cymbella excisa*	0.1960190
Mud Creek	Diatoms	*Cymbella turgidula*	0.4868653
Mud Creek	Diatoms	*Gomphonema cf. parvulum*	0.1080537
Mud Creek	Diatoms	*Gomphonema parvulum*	0.0796749
Mud Creek	Diatoms	*Navicula capitatoradiata*	0.2494707
Mud Creek	Diatoms	*Navicula subminuscula*	0.0494446
Mud Creek	Diatoms	*Nupela impexiformis*	0.0194782
Mud Creek	Diatoms	*Reimeria sinuata*	0.0421403
Mud Creek	Diatoms	*Nitzschia amphibia*	0.1609643
Mud Creek	Diatoms	*Nitzschia inconspicua*	0.0171695
Mud Creek	Diatoms	*Nitzschia palea*	0.1888648
Mud Creek	Diatoms	*Nitzschia sinuata tabellaria*	0.0629549
Mud Creek	Blue-green algae	*cf. Trichodesmium lacustre*	0.0423616
Mud Creek	Blue-green algae	*Heteroleibleinia*	0.4652616
Mud Creek	Blue-green algae	*cf. Scytonema*	0.0204243
Mud Creek	Blue-green algae	*Chroococcus*	0.0197850
Mud Creek	Blue-green algae	*Phormidium*	0.4812012
Mud Creek	Blue-green algae	*Pseudanabaena*	0.0107593
Mud Creek	Total biovolume		9.5220649
Osage Creek-Cave Springs	Diatoms	*Achnanthidium alpestre*	0.0102856
Osage Creek-Cave Springs	Diatoms	*Achnanthidium eutrophilum*	0.0061714
Osage Creek-Cave Springs	Diatoms	*Achnanthidium minutissimum*	0.0246855
Osage Creek-Cave Springs	Diatoms	*Achnanthidium rivulare*	0.2343195
Osage Creek-Cave Springs	Diatoms	*Cocconeis neothumensis*	0.0385711
Osage Creek-Cave Springs	Diatoms	*Cocconeis placentula*	0.6618804

Table 10. List of algal taxa and biovolumes for sampling sites in the Illinois River Basin study area.—Continued

[Biovolume is in cubic centimeters per square meter, values are rounded to seven decimal places]

Short site name	Algae group	Scientific name	Biovolume
Osage Creek-Cave Springs	Diatoms	*Planothidium frequentissimum*	0.0205713
Osage Creek-Cave Springs	Diatoms	*Planothidium lanceolatum*	0.0061714
Osage Creek-Cave Springs	Diatoms	*Psammothidium curtissimum*	1.1108481
Osage Creek-Cave Springs	Diatoms	*Psammothidium didymum*	0.0092571
Osage Creek-Cave Springs	Diatoms	*Meridion circulare*	0.0338752
Osage Creek-Cave Springs	Diatoms	*Synedra cf. ulna*	0.1619987
Osage Creek-Cave Springs	Diatoms	*Gomphoneis olivacea*	0.0047452
Osage Creek-Cave Springs	Diatoms	*Amphora pediculus*	0.0007640
Osage Creek-Cave Springs	Diatoms	*Cymbella affinis*	0.0185764
Osage Creek-Cave Springs	Diatoms	*Cymbella excisa*	0.0120354
Osage Creek-Cave Springs	Diatoms	*Cymbella tumida*	0.1714288
Osage Creek-Cave Springs	Diatoms	*Encyonema brehmii*	0.0138360
Osage Creek-Cave Springs	Diatoms	*Gomphonema*	0.0344989
Osage Creek-Cave Springs	Diatoms	*Gomphonema cf. parallelistriatum*	0.0172494
Osage Creek-Cave Springs	Diatoms	*Gomphonema cf. pumilum*	0.0335167
Osage Creek-Cave Springs	Diatoms	*Gomphonema angustatum*	0.0211080
Osage Creek-Cave Springs	Diatoms	*Navicula antonii*	0.0102856
Osage Creek-Cave Springs	Diatoms	*Navicula subminuscula*	0.2185697
Osage Creek-Cave Springs	Diatoms	*Reimeria sinuata*	0.4252466
Osage Creek-Cave Springs	Diatoms	*Rhoicosphenia abbreviata*	0.0160115
Osage Creek-Cave Springs	Diatoms	*Nitzschia amphibia*	0.5878504
Osage Creek-Cave Springs	Diatoms	*Nitzschia fonticola*	0.0638434
Osage Creek-Cave Springs	Diatoms	*Nitzschia inconspicua*	0.1355445
Osage Creek-Cave Springs	Diatoms	*Nitzschia palea*	0.1424199
Osage Creek-Cave Springs	Blue-green algae	*Chlorogloea*	0.6650790
Osage Creek-Cave Springs	Blue-green algae	*Aphanocapsa*	0.0248296
Osage Creek-Cave Springs	Blue-green algae	*Planktothrix*	0.1489413
Osage Creek-Cave Springs	Blue-green algae	*Heteroleibleinia*	0.8133917
Osage Creek-Cave Springs	Blue-green algae	*Chroococcus*	0.0033670
Osage Creek-Cave Springs	Blue-green algae	*Gloeocapsopsis*	0.5334488
Osage Creek-Cave Springs	Blue-green algae	*Lyngbya*	0.1527603
Osage Creek-Cave Springs	Total biovolume		6.5879832
Osage Creek-Rogers	Green algae	*cf. Stigeoclonium*	0.0859070
Osage Creek-Rogers	Green algae	*Stauridium tetras*	0.2813974
Osage Creek-Rogers	Green algae	*Kirchneriella lunaris*	0.0037384
Osage Creek-Rogers	Green algae	*Coelastrum microporum*	0.0018692
Osage Creek-Rogers	Green algae	*Botryococcus*	0.1691707
Osage Creek-Rogers	Diatoms	*Achnanthidium minutissimum*	0.4044105
Osage Creek-Rogers	Diatoms	*Achnanthidium rivulare*	6.3593558
Osage Creek-Rogers	Diatoms	*Cocconeis placentula*	0.1378672
Osage Creek-Rogers	Diatoms	*Planothidium frequentissimum*	0.0306372
Osage Creek-Rogers	Diatoms	*Psammothidium curtissimum*	0.1158085
Osage Creek-Rogers	Diatoms	*Fragilaria bidens*	0.2328424
Osage Creek-Rogers	Diatoms	*Fragilaria vaucheriae*	0.0980389
Osage Creek-Rogers	Diatoms	*Meridion circulare*	0.0675528

Table 10. List of algal taxa and biovolumes for sampling sites in the Illinois River Basin study area.—Continued

[Biovolume is in cubic centimeters per square meter, values are rounded to seven decimal places]

Short site name	Algae group	Scientific name	Biovolume
Osage Creek-Rogers	Diatoms	*Amphora pediculus*	0.0073689
Osage Creek-Rogers	Diatoms	*Cymbella affinis*	0.2767090
Osage Creek-Rogers	Diatoms	*Cymbella turgida*	1.4065743
Osage Creek-Rogers	Diatoms	*Encyonema minutum*	0.5268470
Osage Creek-Rogers	Diatoms	*Gomphonema cf. angustatum*	0.5649127
Osage Creek-Rogers	Diatoms	*Gomphonema kobayasii*	0.1515046
Osage Creek-Rogers	Diatoms	*Rhoicosphenia abbreviata*	0.0150764
Osage Creek-Rogers	Diatoms	*Nitzschia amphibia*	0.1404305
Osage Creek-Rogers	Diatoms	*Nitzschia palea*	0.2574560
Osage Creek-Rogers	Blue-green algae	*Aphanocapsa*	0.0012084
Osage Creek-Rogers	Blue-green algae	*Heteroleibleinia*	0.0636090
Osage Creek-Rogers	Blue-green algae	*Gloeocapsopsis*	0.0101956
Osage Creek-Rogers	Blue-green algae	*cf. Lyngbya*	0.5202000
Osage Creek-Rogers	Blue-green algae	*Phormidium*	1.1328398
Osage Creek-Rogers	Blue-green algae	*Leptolyngbya*	0.1501296
Osage Creek-Rogers	Total biovolume		13.2136578
Spring Creek	Green algae	*cf. Stigeoclonium*	0.3266177
Spring Creek	Green algae	*Tetraedron minimum*	0.0028879
Spring Creek	Green algae	*Monoraphidium tortile*	0.0032662
Spring Creek	Green algae	*Scenedesmus*	0.0052259
Spring Creek	Diatoms	*Achnanthidium cf. exiguum*	0.0102187
Spring Creek	Diatoms	*Achnanthidium minutissimum*	0.0333268
Spring Creek	Diatoms	*cf. Rossithidium petersenii*	0.0167215
Spring Creek	Diatoms	*Cocconeis placentula*	0.5053601
Spring Creek	Diatoms	*Psammothidium curtissimum*	2.2889838
Spring Creek	Diatoms	*Psammothidium didymum*	0.0177666
Spring Creek	Diatoms	*Melosira*	0.1962451
Spring Creek	Diatoms	*Amphora pediculus*	0.0078858
Spring Creek	Diatoms	*Encyonema minutum*	0.0212981
Spring Creek	Diatoms	*Navicula capitatoradiata*	0.0947550
Spring Creek	Diatoms	*Navicula cf. veneta*	0.0209018
Spring Creek	Diatoms	*Navicula subminuscula*	0.2424613
Spring Creek	Diatoms	*Nitzschia amphibia*	1.1283943
Spring Creek	Diatoms	*Nitzschia inconspicua*	0.4790353
Spring Creek	Diatoms	*Nitzschia palea*	0.0425809
Spring Creek	Cryptophytes	*Chroomonas*	0.0050323
Spring Creek	Blue-green algae	*cf. Planktothrix*	0.0037742
Spring Creek	Blue-green algae	*Heteroleibleinia*	0.5064751
Spring Creek	Blue-green algae	*Gloeocapsopsis*	1.7899615
Spring Creek	Blue-green algae	*Phormidium*	0.0571581
Spring Creek	Total biovolume		7.8063339
Weddington Creek	Diatoms	*Achnanthidium minutissimum*	0.0322778
Weddington Creek	Diatoms	*Achnanthidium rivulare*	0.0332000
Weddington Creek	Diatoms	*Cocconeis neothumensis*	0.3117116
Weddington Creek	Diatoms	*Cocconeis placentula*	0.2420837

Table 10. List of algal taxa and biovolumes for sampling sites in the Illinois River Basin study area.—Continued

[Biovolume is in cubic centimeters per square meter, values are rounded to seven decimal places]

Short site name	Algae group	Scientific name	Biovolume
Weddington Creek	Diatoms	*Planothidium frequentissimum*	0.0332000
Weddington Creek	Diatoms	*Psammothidium curtissimum*	1.8592027
Weddington Creek	Diatoms	*Cymbella tumida*	0.1190836
Weddington Creek	Diatoms	*Cymbella turgidula*	0.4070506
Weddington Creek	Diatoms	*Gomphonema cf. lateripunctatum*	0.0653869
Weddington Creek	Diatoms	*Gomphonema parvulum*	0.2494030
Weddington Creek	Diatoms	*Navicula subminuscula*	0.4233006
Weddington Creek	Diatoms	*Reimeria sinuata*	0.0129111
Weddington Creek	Diatoms	*Nitzschia amphibia*	1.0779271
Weddington Creek	Diatoms	*Nitzschia palea*	0.0317037
Weddington Creek	Blue-green algae	*Chlorogloea*	0.1380240
Weddington Creek	Blue-green algae	*Planktothrix*	0.0365212
Weddington Creek	Blue-green algae	*Heteroleibleinia*	4.3817940
Weddington Creek	Blue-green algae	*Gloeocapsopsis*	0.2120049
Weddington Creek	Blue-green algae	*Lyngbya*	0.0351961
Weddington Creek	Blue-green algae	*Phormidium*	0.1751525
Weddington Creek	Blue-green algae	*Leptolyngbya*	0.1132349
Weddington Creek	Total biovolume		9.9903702
Wildcat Creek	Diatoms	*Achnanthidium rivulare*	0.0152836
Wildcat Creek	Diatoms	*cf. Achnanthidium*	0.0043419
Wildcat Creek	Diatoms	*Cocconeis placentula*	0.0173678
Wildcat Creek	Diatoms	*Psammothidium curtissimum*	0.1907367
Wildcat Creek	Diatoms	*Psammothidium scoticum*	0.0023157
Wildcat Creek	Diatoms	*Synedra ulna*	0.0421458
Wildcat Creek	Diatoms	*Cymbella excisa*	0.2434476
Wildcat Creek	Diatoms	*Gomphonema cf. ventricosum*	0.0740645
Wildcat Creek	Diatoms	*Gomphonema parvulum*	0.1239697
Wildcat Creek	Diatoms	*Navicula antonii*	0.0065998
Wildcat Creek	Diatoms	*Navicula capitatoradiata*	0.0243149
Wildcat Creek	Diatoms	*Reimeria sinuata*	0.0222886
Wildcat Creek	Diatoms	*Nitzschia amphibia*	0.3837895
Wildcat Creek	Diatoms	*Nitzschia inconspicua*	0.0004423
Wildcat Creek	Diatoms	*Nitzschia palea*	0.0025430
Wildcat Creek	Diatoms	*Cyclotella*	0.0046314
Wildcat Creek	Blue-green algae	*Komvophoron*	0.0213020
Wildcat Creek	Blue-green algae	*Heteroleibleinia*	0.1478824
Wildcat Creek	Blue-green algae	*Gloeocapsopsis*	0.1043364
Wildcat Creek	Blue-green algae	*Phormidium*	2.6893802
Wildcat Creek	Blue-green algae	*Leptolyngbya*	0.0154331
Wildcat Creek	Blue-green algae	*Pseudanabaena*	0.0022461
Wildcat Creek	Total biovolume		4.1388631

Table 11. Periphyton metric values at sampling sites in the Illinois River Basin study area.

[Biovolume is in cubic centimeters per square meter, values shown are rounded to one decimal place, percent biovolumes calculated from raw values]

Short site name	Total biovolume	Blue-green algae biovolume	Blue-green algae percent biovolume	Green algae biovolume	Green algae percent biovolume	Diatom biovolume	Diatom percent biovolume	*Gloeo-capsopsis* biovolume	*Hetero-leibleinia* biovolume	*Phor-midium* biovolume	*Nitzschia amphibia* biovolume	*Cocconeis placentula* biovolume
Ballard Creek	64.9	1.8	2.8	62.78	96.7	0.3	0.5	0.84	0.11	0.79	0.04	0.03
Baron Fork	1.7	0.4	22.8	0.25	14.9	1.0	61.4	0.00	0.03	0.33	0.10	0.05
Cincinnati Creek	12.2	3.4	27.9	0.32	2.6	8.5	69.5	1.76	0.00	1.45	2.05	0.28
Clear Creek	3.9	0.9	21.8	0.01	0.2	3.1	78.0	0.00	0.05	0.40	0.24	0.62
Evansville Creek	4.2	2.4	56.3	0.64	15.3	0.5	11.8	1.18	0.31	0.01	0.00	0.06
Flint Creek	2.5	0.9	37.1	0.01	0.3	1.6	62.6	0.26	0.48	0.14	0.72	0.08
Fly Creek	4.5	2.7	60.2	0.20	4.5	1.6	35.3	1.94	0.11	0.13	0.02	0.05
Goose Creek	14.6	13.1	89.8	0.04	0.3	1.4	9.8	12.81	0.07	0.14	0.01	0.35
Hamestring Creek	3.2	2.6	82.4	0.02	0.5	0.5	17.0	1.66	0.16	0.07	0.00	0.14
Illinois River	3.1	0.6	20.0	0.00	0.1	2.5	79.9	0.00	0.05	0.36	0.06	0.38
Little Osage Creek	1.7	1.3	76.9	0.09	5.4	0.3	17.8	0.15	0.07	0.83	0.00	0.00
Moores Creek	1.5	0.2	10.8	0.97	67.0	0.3	22.1	0.01	0.01	0.01	0.01	0.10
Mud Creek	9.5	1.0	10.9	0.01	0.1	8.5	89.0	0.00	0.47	0.48	0.16	0.66
Osage Creek-Rogers	13.2	1.9	14.2	0.54	4.1	10.8	81.7	0.01	0.06	1.13	0.14	0.14
Osage Creek-Cave Springs	6.6	2.3	35.5	0.00	0.0	4.2	64.5	0.53	0.81	0.00	0.59	0.66
Spring Creek	7.8	2.4	30.2	0.34	4.3	5.1	65.4	1.79	0.51	0.06	1.13	0.51
Weddington Creek	10.0	5.1	51.0	0.00	0.0	4.9	49.0	0.10	0.15	2.69	1.08	0.24
Wildcat Creek	4.1	3.0	72.0	0.00	0.0	1.2	28.0	0.21	4.38	0.18	0.38	0.02

Table 12. Correlations between periphyton metrics and selected environmental factors in the Illinois River Basin study area.

[Red font denotes absolute value of rho is greater than or equal to 0.50; number of sites equals 18]

	Nitrite plus nitrate	Total phosphorus	Temperature	Specific conductance	Dissolved oxygen	pH	Streamflow	Bankfull width	Drainage area	Bankfull width/drainage area	Depth	Velocity	Bed substrate
Total periphyton biovolume	0.07	0.07	0.38	0.55	0.10	−0.07	0.19	0.24	−0.10	0.12	−0.02	0.04	−0.19
Blue-green algae biovolume	0.41	0.02	0.19	0.46	0.22	−0.08	0.22	0.25	−0.26	0.26	0.01	0.19	0.06
Blue-green algae percent biovolume	0.59	−0.18	−0.26	0.22	0.38	0.06	0.31	−0.02	−0.26	0.19	0.09	0.40	0.30
Green algae biovolume	−0.18	0.10	0.20	−0.02	0.04	−0.23	−0.18	−0.22	−0.03	−0.26	−0.30	−0.13	−0.20
Green algae percent biovolume	−0.13	0.08	0.03	−0.18	0.16	−0.15	−0.20	−0.26	0.03	−0.31	−0.37	−0.16	−0.07
Diatom biovolume	−0.03	−0.03	0.01	0.41	−0.36	−0.14	0.10	0.03	−0.08	0.09	0.26	0.11	0.00
Diatom percent biovolume	−0.22	−0.13	−0.14	0.07	−0.50	−0.13	−0.07	−0.04	0.06	0.01	0.24	0.04	0.05
Gloeocapsopsis biovolume	0.33	0.22	0.13	0.46	0.40	−0.11	0.27	0.03	−0.22	−0.01	−0.13	0.21	0.10
Heteroleibleinia biovolume	0.16	0.09	0.12	0.42	0.06	0.36	0.42	−0.05	−0.06	−0.03	0.11	0.17	−0.17
Phormidium biovolume	0.17	−0.18	0.08	−0.13	0.10	0.10	0.01	0.21	0.02	0.12	−0.10	0.02	−0.26
Nitzschia amphibia biovolume	0.09	0.49	0.19	0.18	−0.15	0.32	0.35	0.03	−0.05	−0.01	0.16	0.22	−0.05
Cocconeis placentula biovolume	−0.38	0.06	0.11	0.34	−0.52	−0.12	0.03	0.06	−0.12	0.22	0.43	0.09	0.25

	Embeddedness	Substrate turbidity	Open canopy angle	Combined canopy closure	Bank height	Bank angle	Percent forest	Percent urban	Percent agriculture	Poultry house density	Total unpaved road density	Total paved road density	Total road density
Total periphyton biovolume	−0.16	−0.47	0.45	−0.46	−0.12	−0.15	−0.19	0.19	−0.17	−0.29	−0.27	0.23	0.16
Blue-green algae biovolume	−0.19	−0.49	0.46	−0.55	−0.12	0.32	−0.01	−0.10	0.13	−0.22	0.09	−0.10	−0.08
Blue-green algae percent biovolume	−0.27	−0.29	0.16	−0.18	−0.03	0.40	0.01	−0.13	0.24	−0.16	0.24	−0.15	−0.06
Green algae biovolume	0.29	0.37	−0.39	0.35	0.23	−0.03	0.09	0.00	−0.12	0.27	0.13	−0.05	−0.04
Green algae percent biovolume	0.14	0.37	−0.58	0.48	0.19	−0.00	0.20	−0.15	0.05	0.43	0.25	−0.18	−0.18
Diatom biovolume	0.18	−0.16	0.56	−0.42	−0.15	0.02	−0.27	0.32	−0.49	−0.47	−0.55	0.28	0.30
Diatom percent biovolume	0.27	0.16	0.35	−0.17	−0.17	−0.03	−0.23	0.29	−0.49	−0.32	−0.53	0.23	0.25
Gloeocapsopsis biovolume	−0.22	−0.41	0.09	−0.19	0.22	0.44	0.08	−0.07	0.05	0.01	0.20	−0.12	−0.04
Heteroleibleinia biovolume	−0.17	−0.31	0.24	−0.16	0.07	0.12	−0.18	0.14	−0.18	−0.44	−0.17	0.23	0.27
Phormidium biovolume	0.10	0.01	0.26	−0.06	−0.57	−0.29	−0.13	0.01	0.31	0.25	−0.01	−0.02	−0.09
Nitzschia amphibia biovolume	0.16	−0.39	0.52	−0.32	−0.33	−0.03	−0.16	0.16	−0.01	−0.01	−0.20	0.09	0.10
Cocconeis placentula biovolume	−0.03	−0.29	0.26	−0.29	0.24	0.01	−0.28	0.42	−0.59	−0.56	−0.59	0.43	0.41

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Ballard Creek	Annelida	Oligochaeta	Branchiobdellida		Branchiobdellida	0.5
Ballard Creek	Annelida	Oligochaeta	Tubificida	Naididae (Pristininae)	*Pristina leidyi*	1.1
Ballard Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	0.5
Ballard Creek	Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Enochrus*	0.2
Ballard Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	4.1
Ballard Creek	Arthropoda	Insecta	Diptera	Ceratopogonidae	*Atrichopogon*	0.9
Ballard Creek	Arthropoda	Insecta	Diptera	Ceratopogonidae	*Ceratopogoninae*	0.2
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Chironomini*	0.5
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Corynoneura*	0.7
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus absurdus*	2.8
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Dicrotendipes*	0.5
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Microtendipes pedellus* group	0.2
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Nanocladius*	0.2
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Nanocladius crassicornus/ rectinervis*	0.2
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Nanocladius spiniplenus*	0.2
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Nilotanypus fimbriatus*	3.4
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Pentaneurini*	0.2
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum*	0.2
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	20.2
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum illinoense*	1.8
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum obtusum*	1.1
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum scalaenum* group	0.5
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	1.8
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsini*	0.2
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	0.5
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. C	5.1
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. M	0.9
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. T	0.2
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella taurocapita*	0.7
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	9.4
Ballard Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Zavrelimyia*	1.6
Ballard Creek	Arthropoda	Insecta	Diptera	Empididae	*Hemerodromia*	0.9
Ballard Creek	Arthropoda	Insecta	Diptera	Tabanidae	*Tabanus* genus group	0.2
Ballard Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna*	0.5
Ballard Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna pygmaea*	0.5
Ballard Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	0.5
Ballard Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis flavistriga*	0.5
Ballard Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	0.5
Ballard Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis*	5.5
Ballard Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis diminuta* group	0.2
Ballard Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis latipennis*	1.1
Ballard Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptageniidae	0.2

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Ballard Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium*	0.2
Ballard Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenacron interpunctatum*	0.5
Ballard Creek	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	*Tricorythodes*	0.7
Ballard Creek	Arthropoda	Insecta	Lepidoptera	Crambidae	*Petrophila*	0.7
Ballard Creek	Arthropoda	Insecta	Megaloptera	Corydalidae	Corydalidae	1.4
Ballard Creek	Arthropoda	Insecta	Megaloptera	Corydalidae	*Corydalus cornutus*	1.6
Ballard Creek	Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	0.7
Ballard Creek	Arthropoda	Insecta	Trichoptera	Helicopsychidae	*Helicopsyche*	0.5
Ballard Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	6.2
Ballard Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche*	0.2
Ballard Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsychidae*	3.9
Ballard Creek	Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptilidae	0.2
Ballard Creek	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra aterrima*	0.9
Ballard Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes neglectus neglectus*	1.8
Ballard Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes* sp.	3.2
Ballard Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes virilis*	0.2
Ballard Creek	Mollusca	Gastropoda	Lymnophila	Ancylidae	*Ferrissia rivularis*	0.5
Ballard Creek	Mollusca	Gastropoda	Mesogastropoda	Pleuroceridae	*Pleurocera potosiensis*	4.8
Ballard Creek	Mollusca	Gastropoda			Gastropoda	0.2
Baron Fork	Annelida	Oligochaeta	Tubificida	Naididae (Naidinae)	*Slavina appendiculata*	0.3
Baron Fork	Arthropoda	Arachnida	Acariformes	Lebertidae	*Lebertia*	1.1
Baron Fork	Arthropoda	Arachnida	Acariformes	Sperchontidae	*Sperchon*	0.3
Baron Fork	Arthropoda	Arachnida	Acariformes	Sperchontidae	*Sperchonopsis*	0.3
Baron Fork	Arthropoda	Arachnida	Acariformes		Acariformes	0.3
Baron Fork	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	0.3
Baron Fork	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis crenata*	0.8
Baron Fork	Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Tropisternus*	0.3
Baron Fork	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	1.7
Baron Fork	Arthropoda	Insecta	Coleoptera	Ptilodactylidae	Ptilodactylidae	0.3
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus*	0.3
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus absurdus*	0.3
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus bicinctus* group	0.3
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus triannulatus/ infuscatus*	0.6
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Dicrotendipes*	3.6
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Microtendipes pedellus* group	1.9
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Nilotanypus fimbriatus*	0.3
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Paratanytarsus*	0.6
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	6.7
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Pseudochironomus*	0.3
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	9.7
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Stempellinella fimbriata*	0.6
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsini*	0.3
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	0.3
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. C	0.6

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. M	0.6
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella* sp. B	0.6
Baron Fork	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	2.5
Baron Fork	Arthropoda	Insecta	Diptera	Empididae	Empididae	0.3
Baron Fork	Arthropoda	Insecta	Diptera	Empididae	*Hemerodromia*	0.3
Baron Fork	Arthropoda	Insecta	Diptera	Tabanidae	Tabanidae	0.3
Baron Fork	Arthropoda	Insecta	Diptera	Tabanidae	*Tabanus* genus group	0.3
Baron Fork	Arthropoda	Insecta	Diptera	Tipulidae	Tipulidae	0.3
Baron Fork	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acentrella parvula*	0.3
Baron Fork	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna pygmaea*	0.3
Baron Fork	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis*	1.7
Baron Fork	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis amica*	3.1
Baron Fork	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis punctata*	0.3
Baron Fork	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptageniidae	0.3
Baron Fork	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta*	1.1
Baron Fork	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta/Nixe*	0.6
Baron Fork	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium terminatum/ pulchellum*	14.2
Baron Fork	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenacron*	3.6
Baron Fork	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenacron interpunctatum*	3.1
Baron Fork	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenonema femoratum*	0.3
Baron Fork	Arthropoda	Insecta	Ephemeroptera	Isonychiidae	*Isonychia*	0.6
Baron Fork	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	*Tricorythodes*	3.6
Baron Fork	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	*Choroterpes basalis*	0.3
Baron Fork	Arthropoda	Insecta	Hemiptera	Gerridae	*Rheumatobates*	0.3
Baron Fork	Arthropoda	Insecta	Lepidoptera	Crambidae	*Parapoynx*	7.8
Baron Fork	Arthropoda	Insecta	Lepidoptera	Crambidae	*Synclites*	0.3
Baron Fork	Arthropoda	Insecta	Megaloptera	Corydalidae	*Corydalus cornutus*	0.3
Baron Fork	Arthropoda	Insecta	Odonata	Gomphidae	*Hagenius brevistylus*	0.6
Baron Fork	Arthropoda	Insecta	Plecoptera	Perlidae	*Neoperla harpi*	0.6
Baron Fork	Arthropoda	Insecta	Trichoptera	Helicopsychidae	*Helicopsyche limnella*	4.4
Baron Fork	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	8.9
Baron Fork	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychidae	0.3
Baron Fork	Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Hydroptila*	2.2
Baron Fork	Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Hydroptila*	0.6
Baron Fork	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes* sp.	0.6
Baron Fork	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes* sp.	0.6
Baron Fork	Mollusca	Gastropoda	Basommatophora	Ancylidae	*Ferrissia*	1.4
Baron Fork	Mollusca	Gastropoda	Basommatophora	Ancylidae	*Ferrissia fragilis*	0.3
Baron Fork	Mollusca	Gastropoda	Basommatophora	Lymnaeidae	Lymnaeidae	0.6
Baron Fork	Mollusca	Gastropoda	Basommatophora	Physidae	*Physa*	0.6
Baron Fork	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	*Cura*	0.3
Cincinnati Creek	Annelida	Oligochaeta	Lumbriculida	Sparganophilidae	*Sparganophilus*	0.3
Cincinnati Creek	Annelida	Oligochaeta	Tubificida	Naididae (Tubificinae)	Naididae (Tubificinae) Unid.	0.3
Cincinnati Creek	Arthropoda	Arachnida	Acariformes	Hygrobatidae	*Atracides*	0.3

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Cincinnati Creek	Arthropoda	Arachnida	Acariformes	Lebertidae	*Lebertia*	0.3
Cincinnati Creek	Arthropoda	Arachnida	Acariformes	Sperchonidae	*Sperchon* sp. 1	0.3
Cincinnati Creek	Arthropoda	Arachnida	Acariformes	Sperchonidae	Sperchonidae	0.3
Cincinnati Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	0.3
Cincinnati Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	4.8
Cincinnati Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus absurdus*	3.0
Cincinnati Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus patens*	0.3
Cincinnati Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus politus*	2.4
Cincinnati Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	4.8
Cincinnati Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	1.2
Cincinnati Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella similis*	1.5
Cincinnati Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella taurocapita*	0.6
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna*	3.6
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna pygmaea*	6.6
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetidae	0.6
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	8.1
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis flavistriga*	1.5
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	7.8
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis hilaris* group	5.1
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptageniidae	4.8
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta*	3.9
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta/Nixe*	13.6
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium*	1.5
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium bednariki*	3.9
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium mediopunctatum*	1.5
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium pulchellum*	1.2
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium terminatum*	0.3
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Isonychiidae	*Isonychia*	2.7
Cincinnati Creek	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	*Tricorythodes*	0.9
Cincinnati Creek	Arthropoda	Insecta	Megaloptera	Corydalidae	*Corydalus cornutus*	0.9
Cincinnati Creek	Arthropoda	Insecta	Megaloptera	Corydalidae	*Nigronia*	0.6
Cincinnati Creek	Arthropoda	Insecta	Megaloptera	Corydalidae	*Nigronia serricornis*	0.3
Cincinnati Creek	Arthropoda	Insecta	Odonata	Gomphidae	Gomphidae	0.3
Cincinnati Creek	Arthropoda	Insecta	Plecoptera	Perlidae	*Neoperla*	0.3
Cincinnati Creek	Arthropoda	Insecta	Plecoptera	Perlidae	*Perlidae* sp.	0.6
Cincinnati Creek	Arthropoda	Insecta	Plecoptera	Perlidae	*Perlidae* sp. 1	1.8
Cincinnati Creek	Arthropoda	Insecta	Plecoptera		Plecoptera	0.3
Cincinnati Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	3.9
Cincinnati Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychidae	0.6
Cincinnati Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes neglectus neglectus*	1.2
Cincinnati Creek	Mollusca	Gastropoda	Mesogastropoda	Pleuroceridae	*Pleurocera potosiensis*	0.3
Cincinnati Creek	Nemertea	Enopla	Hoplonemertea	Tetrastemmatidae	*Prostoma*	0.3
Clear Creek	Annelida	Oligochaeta	Tubificida	Naididae (Naidinae)	*Slavina appendiculata*	0.6
Clear Creek	Annelida	Oligochaeta	Tubificida	Naididae (Tubificinae)	Naididae (Tubificinae)	0.3

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Clear Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	3.0
Clear Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	6.2
Clear Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus absurdus*	0.6
Clear Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	4.2
Clear Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum obtusum*	1.2
Clear Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	0.3
Clear Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Stempellinella fimbriata*	1.5
Clear Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	1.2
Clear Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna*	0.6
Clear Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna pygmaea*	0.3
Clear Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetidae	2.4
Clear Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	5.0
Clear Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	3.0
Clear Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis hilaris* group	15.1
Clear Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptageniidae	2.1
Clear Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium*	12.5
Clear Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium pulchellum*	0.6
Clear Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium terminatum*	5.6
Clear Creek	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	*Choroterpes*	5.0
Clear Creek	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebiidae	3.9
Clear Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	17.8
Clear Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychidae	1.8
Clear Creek	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra aterrima*	0.6
Clear Creek	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra obscura*	0.3
Clear Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes neglectus neglectus*	0.3
Clear Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes* sp.	2.4
Clear Creek	Mollusca	Gastropoda	Mesogastropoda	Pleuroceridae	*Pleurocera potosiensis*	0.3
Clear Creek	Mollusca	Pelecypoda	Eulamellibranchia	Corbiculidae	*Corbicula fluminea*	0.6
Clear Creek	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	Dugesiidae	0.9
Evansville Creek	Annelida	Oligochaeta	Branchiobdellida		Branchiobdellida	0.2
Evansville Creek	Arthropoda	Arachnida	Acariformes	Hygrobatidae	*Atractides*	0.7
Evansville Creek	Arthropoda	Arachnida	Acariformes	Lebertidae	*Lebertia*	0.5
Evansville Creek	Arthropoda	Arachnida	Acariformes	Sperchontidae	*Sperchon*	0.2
Evansville Creek	Arthropoda	Arachnida	Acariformes	Sperchontidae	*Sperchonopsis*	0.5
Evansville Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Dubiraphia*	0.5
Evansville Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	0.7
Evansville Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis crenata*	0.2
Evansville Creek	Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Enochrus*	0.9
Evansville Creek	Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Laccobius*	0.2
Evansville Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	0.7
Evansville Creek	Arthropoda	Insecta	Coleoptera	Ptilodactylidae	Ptilodactylidae	0.5
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Dicrotendipes*	0.2
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Labrundinia*	0.2
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Microtendipes pedellus* group	2.3

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Nilotanypus fimbriatus*	0.2
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Parametriocnemus*	0.7
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Paratanytarsus*	0.2
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Paratendipes albimanus* group	0.2
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum*	0.2
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	1.2
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum illinoense*	0.7
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Pseudochironomus*	0.2
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	1.6
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Stempellinella fimbriata*	0.2
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	0.5
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. C	12.4
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. M	0.9
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella* sp. B	0.9
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	3.5
Evansville Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Zavrelimyia*	1.2
Evansville Creek	Arthropoda	Insecta	Diptera	Empididae	*Hemerodromia*	1.2
Evansville Creek	Arthropoda	Insecta	Diptera	Stratiomyidae	*Odontomyia*	0.5
Evansville Creek	Arthropoda	Insecta	Diptera	Tabanidae	*Tabanus* genus group	0.2
Evansville Creek	Arthropoda	Insecta	Diptera	Tipulidae	*Dicranota*	0.2
Evansville Creek	Arthropoda	Insecta	Diptera	Tipulidae	*Hexatoma*	0.5
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna*	0.5
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna pygmaea*	1.4
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetidae	2.3
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	0.7
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis flavistriga*	1.2
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	0.2
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis*	7.5
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis*	0.2
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptageniidae	0.5
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta*	0.5
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta/Nixe*	1.2
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium*	0.5
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium mediopunctatum*	0.2
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenonema femoratum*	0.9
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Isonychiidae	*Isonychia*	0.2
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	*Tricorythodes*	0.5
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebiidae	1.6
Evansville Creek	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	*Paraleptophlebia*	0.2
Evansville Creek	Arthropoda	Insecta	Hemiptera	Veliidae	*Microvelia paludicola*	1.2
Evansville Creek	Arthropoda	Insecta	Megaloptera	Corydalidae	*Corydalus cornutus*	0.2
Evansville Creek	Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	0.2
Evansville Creek	Arthropoda	Insecta	Plecoptera	Perlidae	*Neoperla*	0.2

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Evansville Creek	Arthropoda	Insecta	Plecoptera	Perlidae	*Neoperla osage*	0.7
Evansville Creek	Arthropoda	Insecta	Plecoptera	Perlidae	Perlidae	0.5
Evansville Creek	Arthropoda	Insecta	Trichoptera	Helicopsychidae	*Helicopsyche limnella*	3.0
Evansville Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	10.5
Evansville Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche (H.) instabilis* group, depravata complex	1.2
Evansville Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychidae	7.9
Evansville Creek	Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Hydroptila*	1.2
Evansville Creek	Arthropoda	Insecta	Trichoptera	Polycentropodidae	*Polycentropus*	0.5
Evansville Creek	Arthropoda	Insecta+C796	Ephemeroptera	Heptageniidae	*Stenacron interpunctatum*	0.2
Evansville Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes*	0.9
Evansville Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes* sp.	0.5
Evansville Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes virilis*	0.2
Evansville Creek	Arthropoda	Malacostraca	Isopoda	Asellidae	*Lirceus*	0.5
Evansville Creek	Mollusca	Gastropoda	Basommatophora	Ancylidae	*Ferrissia fragilis*	0.2
Evansville Creek	Mollusca	Gastropoda	Basommatophora	Physidae	*Physa*	11.9
Evansville Creek	Mollusca	Gastropoda	Mesogastropoda	Pleuroceridae	*Pleurocera potosiensis*	1.6
Flint Creek	Annelida	Oligochaeta	Branchiobdellida		Branchiobdellida	1.1
Flint Creek	Arthropoda	Arachnida	Acariformes	Hygrobatidae	*Atracides*	0.3
Flint Creek	Arthropoda	Arachnida	Acariformes	Hygrobatidae	*Hygrobates*	0.3
Flint Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Optioservus*	2.8
Flint Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	0.6
Flint Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	15.8
Flint Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus absurdus*	0.3
Flint Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	2.5
Flint Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	0.8
Flint Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	0.3
Flint Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Stempellinella fimbriata*	0.6
Flint Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. M	0.6
Flint Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	0.6
Flint Creek	Arthropoda	Insecta	Diptera	Empididae	*Hemerodromia*	0.6
Flint Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna pygmaea*	0.3
Flint Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	1.1
Flint Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis hilaris* group	41.5
Flint Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptageniidae	3.7
Flint Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta*	0.8
Flint Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta/Nixe*	1.1
Flint Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium*	1.7
Flint Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium bednariki*	2.5
Flint Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium mediopunctatum*	1.7
Flint Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenacron interpunctatum*	0.8
Flint Creek	Arthropoda	Insecta	Ephemeroptera	Isonychiidae	*Isonychia*	0.3
Flint Creek	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	*Tricorythodes*	1.1
Flint Creek	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	*Choroterpes*	0.3

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Flint Creek	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebiidae	0.6
Flint Creek	Arthropoda	Insecta	Hemiptera	Veliidae	*Microvelia americana/ paludicola*	0.3
Flint Creek	Arthropoda	Insecta	Megaloptera	Corydalidae	*Corydalus cornutus*	0.8
Flint Creek	Arthropoda	Insecta	Megaloptera	Corydalidae	*Nigronia serricornis*	0.3
Flint Creek	Arthropoda	Insecta	Odonata	Coenagrionidae	*Coenagrionidae*	0.3
Flint Creek	Arthropoda	Insecta	Odonata	Gomphidae	*Gomphidae*	2.0
Flint Creek	Arthropoda	Insecta	Odonata	Gomphidae	*Stylogomphus albistylus*	0.3
Flint Creek	Arthropoda	Insecta	Plecoptera	Leuctridae	*Leuctra*	0.3
Flint Creek	Arthropoda	Insecta	Trichoptera	Helicopsychidae	*Helicopsyche*	0.8
Flint Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	3.7
Flint Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche*	0.3
Flint Creek	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra aterrima*	1.7
Flint Creek	Arthropoda	Insecta	Trichoptera	Psychomyiidae	*Psychomyia flavida*	0.6
Flint Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes neglectus neglectus*	0.8
Flint Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes* sp.	0.8
Flint Creek	Mollusca	Gastropoda	Lymnophila	Ancylidae	*Ferrissia rivularis*	1.7
Flint Creek	Mollusca	Gastropoda	Mesogastropoda	Pleuroceridae	*Pleurocera potosiensis*	0.3
Flint Creek	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	*Cura*	0.3
Fly Creek	Annelida	Hirudinea	Arhynchobdellida	Erpobdellidae	*Erpobdella fervida*	0.6
Fly Creek	Annelida	Oligochaeta	Branchiobdellida		Branchiobdellida	0.3
Fly Creek	Annelida	Oligochaeta	Opisthopora	Lumbricidae	Lumbricidae	0.3
Fly Creek	Arthropoda	Arachnida	Acariformes	Rhynchohydracaridae	*Clathrosperchon*	0.3
Fly Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	0.6
Fly Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis exilis*	0.3
Fly Creek	Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Enochrus*	0.3
Fly Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	0.3
Fly Creek	Arthropoda	Insecta	Coleoptera	Staphylinidae	Staphylinidae	0.3
Fly Creek	Arthropoda	Insecta	Diptera	Ceratopogonidae	*Bezzia/Palpomyia*	0.3
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Ablabesmyia*	0.3
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Microtendipes pedellus* group	2.4
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Nilotanypus fimbriatus*	0.6
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Orthocladius*	0.3
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Parametriocnemus*	0.6
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Phaenopsectra obediens*	0.3
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum*	0.3
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	4.8
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum scalaenum* group	0.3
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	2.7
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	0.6
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Stempellinella fimbriata*	0.6
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	0.3
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. C	0.6

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. M	0.3
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. T	0.3
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella*	0.3
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella* sp. B	0.3
Fly Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	5.1
Fly Creek	Arthropoda	Insecta	Diptera	Simuliidae	*Simulium*	0.3
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acentrella turbida*	0.3
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna*	2.7
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna pygmaea*	1.8
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetidae	0.3
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	0.9
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis flavistriga*	1.5
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	0.6
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Fallceon quilleri*	0.3
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis*	2.1
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis punctata*	1.2
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta*	5.1
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta/Nixe*	8.0
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta/Nixe*	1.2
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium*	3.6
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium mediopunctatum*	0.3
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium terminatum/ pulchellum*	0.3
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenacron*	4.8
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenacron interpunctatum*	2.4
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenonema femoratum*	0.3
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Isonychiidae	*Isonychia*	0.9
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	*Tricorythodes*	1.2
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	*Choroterpes basalis*	0.3
Fly Creek	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebiidae	0.3
Fly Creek	Arthropoda	Insecta	Lepidoptera	Crambidae	Crambidae	0.3
Fly Creek	Arthropoda	Insecta	Lepidoptera	Crambidae	*Parapoynx*	0.6
Fly Creek	Arthropoda	Insecta	Odonata	Aeshnidae	*Boyeria vinosa*	0.3
Fly Creek	Arthropoda	Insecta	Odonata	Calopterygidae	Calopterygidae	0.3
Fly Creek	Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	1.8
Fly Creek	Arthropoda	Insecta	Plecoptera	Leuctridae	*Leuctra*	0.3
Fly Creek	Arthropoda	Insecta	Plecoptera	Perlidae	*Neoperla*	0.6
Fly Creek	Arthropoda	Insecta	Plecoptera	Perlidae	*Neoperla harpi*	2.4
Fly Creek	Arthropoda	Insecta	Trichoptera	Helicopsychidae	*Helicopsyche limnella*	0.6
Fly Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	14.0
Fly Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	0.6
Fly Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche (H.) bronta* group	0.6
Fly Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche (H.) instabilis* group	4.8

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Fly Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychidae	1.5
Fly Creek	Arthropoda	Insecta	Trichoptera	Polycentropodidae	*Polycentropus*	2.1
Fly Creek	Arthropoda	Insecta	Trichoptera	Psychomyiidae	*Psychomyia flavida*	0.3
Fly Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes*	0.3
Fly Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes* sp.	1.5
Fly Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes virilis*	0.3
Fly Creek	Arthropoda	Malacostraca	Isopoda	Asellidae	*Lirceus*	0.9
Fly Creek	Mollusca	Gastropoda	Basommatophora	Physidae	*Physa*	0.9
Fly Creek	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	*Cura*	0.3
Goose Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	1.3
Goose Creek	Arthropoda	Insecta	Diptera	Ceratopogonidae	*Atrichopogon*	0.3
Goose Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Ablabesmyia mallochi*	0.3
Goose Creek	Arthropoda	Insecta	Diptera	Chironomidae	Chironomidae	1.0
Goose Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus triannulatus/ infuscatus*	0.3
Goose Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus trifascia*	1.6
Goose Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Nilotanypus fimbriatus*	0.3
Goose Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	25.2
Goose Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum obtusum*	1.6
Goose Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	16.6
Goose Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Stempellinella fimbriata*	0.6
Goose Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	0.3
Goose Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. C	0.6
Goose Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella taurocapita*	0.6
Goose Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	3.8
Goose Creek	Arthropoda	Insecta	Diptera	Simuliidae	*Simulium tuberosum*	0.6
Goose Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna*	0.6
Goose Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetidae*	1.9
Goose Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	10.2
Goose Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis flavistriga*	2.2
Goose Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	4.2
Goose Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis*	1.0
Goose Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium*	1.3
Goose Creek	Arthropoda	Insecta	Ephemeroptera	Isonychiidae	*Isonychia*	0.6
Goose Creek	Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	1.0
Goose Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	11.5
Goose Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche depravata complex*	1.3
Goose Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychidae	1.6
Goose Creek	Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Hydroptila*	3.8
Goose Creek	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra aterrima*	1.9
Goose Creek	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra socia*	0.3
Goose Creek	Nemertea	Enopla	Hoplonemertea	Tetrastemmatidae	*Prostoma*	0.3
Goose Creek	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	Dugesiidae	1.0

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Hamestring Creek	Annelida	Hirudinea	Arhynchobdellida	Erpobdellidae	*Erpobdella fervida*	0.2
Hamestring Creek	Annelida	Oligochaeta	Branchiobdellida		Branchiobdellida	4.6
Hamestring Creek	Arthropoda	Arachnida	Acariformes	Hygrobatidae	*Atracides*	1.1
Hamestring Creek	Arthropoda	Arachnida	Acariformes	Limnesiidae	*Limnesia*	0.2
Hamestring Creek	Arthropoda	Arachnida	Acariformes	Sperchonidae	*Sperchonopsis*	0.2
Hamestring Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	0.7
Hamestring Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	23.6
Hamestring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Helopelopia*	0.2
Hamestring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	0.9
Hamestring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	1.1
Hamestring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	0.2
Hamestring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Stempellinella fimbriata*	0.5
Hamestring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsini*	0.2
Hamestring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella taurocapita*	0.2
Hamestring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	1.4
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna*	0.9
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna pygmaea*	3.0
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	2.8
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis flavistriga*	4.4
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	8.7
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Procloeon*	0.2
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis*	10.8
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptageniidae	2.3
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta*	1.6
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta/Nixe*	2.1
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium*	2.1
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium mediopunctatum*	0.2
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium pulchellum*	1.1
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium terminatum*	0.2
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenacron interpunctatum*	0.2
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Isonychiidae	*Isonychia*	0.9
Hamestring Creek	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebiidae	0.2
Hamestring Creek	Arthropoda	Insecta	Hemiptera	Veliidae	*Rhagovelia*	0.2
Hamestring Creek	Arthropoda	Insecta	Lepidoptera	Crambidae	*Petrophila*	0.5
Hamestring Creek	Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	2.5
Hamestring Creek	Arthropoda	Insecta	Plecoptera	Leuctridae	*Leuctra*	0.2
Hamestring Creek	Arthropoda	Insecta	Trichoptera	Helicopsychidae	*Helicopsyche*	0.2
Hamestring Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	10.6
Hamestring Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychidae	1.1
Hamestring Creek	Arthropoda	Insecta	Trichoptera	Polycentropodidae	*Cernotina*	0.2
Hamestring Creek	Arthropoda	Insecta	Trichoptera	Polycentropodidae	*Polycentropus*	0.2
Hamestring Creek	Arthropoda	Insecta	Trichoptera	Psychomyiidae	*Psychomyia flavida*	0.7
Hamestring Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes neglectus neglectus*	0.9

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Hamestring Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes* sp.	3.0
Hamestring Creek	Mollusca	Gastropoda	Mesogastropoda	Pleuroceridae	*Pleurocera potosiensis*	0.9
Hamestring Creek	Nemertea	Enopla	Hoplonemertea	Tetrastemmatidae	*Prostoma*	0.2
Hamestring Creek	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	*Cura*	0.7
Hamestring Creek	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	*Girardia*	0.5
Illinois River	Annelida	Hirudinea	Arhynchobdellida	Erpobdellidae	*Erpobdella fervida*	0.6
Illinois River	Annelida	Oligochaeta	Tubificida	Naididae (Naidinae)	*Nais communis*	2.0
Illinois River	Annelida	Oligochaeta	Tubificida	Naididae (Naidinae)	*Slavina appendiculata*	0.6
Illinois River	Annelida	Oligochaeta	Tubificida	Naididae (Tubificinae)	*Limnodrilus hoffmeisteri*	0.3
Illinois River	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	0.9
Illinois River	Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Enochrus*	0.6
Illinois River	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	3.4
Illinois River	Arthropoda	Insecta	Diptera	Ceratopogonidae	*Atrichopogon*	6.3
Illinois River	Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogonidae	0.3
Illinois River	Arthropoda	Insecta	Diptera	Ceratopogonidae	*Dasyhelea*	1.4
Illinois River	Arthropoda	Insecta	Diptera	Ceratopogonidae	*Mallochohelea*	0.3
Illinois River	Arthropoda	Insecta	Diptera	Chironomidae	*Conchapelopia*	0.3
Illinois River	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus*	1.1
Illinois River	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus absurdus*	2.0
Illinois River	Arthropoda	Insecta	Diptera	Chironomidae	*Dicrotendipes*	0.3
Illinois River	Arthropoda	Insecta	Diptera	Chironomidae	*Helopelopia*	0.3
Illinois River	Arthropoda	Insecta	Diptera	Chironomidae	*Microtendipes pedellus* group	0.6
Illinois River	Arthropoda	Insecta	Diptera	Chironomidae	*Parametriocnemus*	0.3
Illinois River	Arthropoda	Insecta	Diptera	Chironomidae	*Phaenopsectra obediens*	0.6
Illinois River	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	1.4
Illinois River	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum illinoense*	0.3
Illinois River	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	0.3
Illinois River	Arthropoda	Insecta	Diptera	Chironomidae	*Stempellinella fimbriata*	0.3
Illinois River	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. C	0.6
Illinois River	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella* sp. B	0.6
Illinois River	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	4.3
Illinois River	Arthropoda	Insecta	Diptera	Empididae	*Hemerodromia*	2.3
Illinois River	Arthropoda	Insecta	Diptera	Tabanidae	*Tabanus* genus group	0.6
Illinois River	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acentrella*	0.3
Illinois River	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acentrella parvula*	0.3
Illinois River	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna*	1.1
Illinois River	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna pygmaea*	4.9
Illinois River	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetidae	0.3
Illinois River	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	0.9
Illinois River	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis flavistriga*	2.6
Illinois River	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	2.6
Illinois River	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Diphetor hageni*	0.3
Illinois River	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis*	4.3
Illinois River	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis amica*	2.3

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Illinois River	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis punctata*	0.6
Illinois River	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptageniidae	1.7
Illinois River	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta*	4.3
Illinois River	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta/Nixe*	2.6
Illinois River	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium*	1.4
Illinois River	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium mediopunctatum*	0.6
Illinois River	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium terminatum/ pulchellum*	4.0
Illinois River	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenacron*	1.4
Illinois River	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenacron interpunctatum*	3.2
Illinois River	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenonema femoratum*	3.4
Illinois River	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenonema femoratum*	0.3
Illinois River	Arthropoda	Insecta	Ephemeroptera	Isonychiidae	*Isonychia*	1.7
Illinois River	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	*Tricorythodes*	0.3
Illinois River	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	*Choroterpes basalis*	1.4
Illinois River	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebiidae	0.6
Illinois River	Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	0.9
Illinois River	Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia moesta*	0.9
Illinois River	Arthropoda	Insecta	Plecoptera	Perlidae	*Neoperla*	0.3
Illinois River	Arthropoda	Insecta	Plecoptera	Perlidae	*Neoperla harpi*	1.7
Illinois River	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	7.2
Illinois River	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychidae	0.6
Illinois River	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra*	0.9
Illinois River	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra obscura*	1.1
Illinois River	Arthropoda	Insecta	Trichoptera	Polycentropodidae	*Polycentropus*	0.3
Illinois River	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes* sp.	0.3
Illinois River	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes virilis*	1.1
Illinois River	Arthropoda	Malacostraca	Isopoda	Asellidae	*Lirceus*	0.3
Illinois River	Mollusca	Gastropoda	Basommatophora	Physidae	*Physa*	0.6
Illinois River	Mollusca	Gastropoda	Mesogastropoda	Pleuroceridae	*Pleurocera potosiensis*	3.7
Little Osage Creek	Annelida	Oligochaeta	Tubificida	Naididae (Naidinae)	*Slavina appendiculata*	0.3
Little Osage Creek	Arthropoda	Arachnida	Acariformes	Hygrobatidae	*Atracides*	0.3
Little Osage Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Optioservus*	5.2
Little Osage Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Optioservus sandersoni*	1.7
Little Osage Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	0.8
Little Osage Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	1.4
Little Osage Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus absurdus*	0.3
Little Osage Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cryptochironomus*	0.3
Little Osage Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Parametriocnemus*	0.3
Little Osage Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	4.4
Little Osage Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum obtusum*	1.9
Little Osage Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	0.6
Little Osage Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Stempellinella fimbriata*	1.4
Little Osage Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	0.6

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Little Osage Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acentrella turbida*	0.3
Little Osage Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna pygmaea*	2.2
Little Osage Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetidae	2.8
Little Osage Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	10.2
Little Osage Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis flavistriga*	3.0
Little Osage Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	10.7
Little Osage Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Diphetor hageni*	3.6
Little Osage Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis hilaris* group	0.8
Little Osage Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptageniidae	2.2
Little Osage Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium*	8.5
Little Osage Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium mediopunctatum*	0.8
Little Osage Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium terminatum*	2.2
Little Osage Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenacron interpunctatum*	0.8
Little Osage Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenonema femoratum*	0.3
Little Osage Creek	Arthropoda	Insecta	Ephemeroptera	Isonychiidae	*Isonychia*	0.3
Little Osage Creek	Arthropoda	Insecta	Odonata	Gomphidae	Gomphidae	0.3
Little Osage Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	14.0
Little Osage Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche bronta*	2.8
Little Osage Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychidae	1.4
Little Osage Creek	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra*	0.6
Little Osage Creek	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra aterrima*	5.0
Little Osage Creek	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra socia*	1.1
Little Osage Creek	Arthropoda	Malacostraca	Amphipoda	Gammaridae	*Gammarus*	0.3
Little Osage Creek	Arthropoda	Malacostraca	Amphipoda	Gammaridae	*Gammarus minus*	0.3
Little Osage Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes neglectus neglectus*	1.9
Little Osage Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes* sp.	1.9
Little Osage Creek	Mollusca	Gastropoda	Lymnophila	Ancylidae	*Ferrissia rivularis*	0.6
Little Osage Creek	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	*Cura*	0.8
Little Osage Creek	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	Dugesiidae	1.1
Moores Creek	Annelida	Oligochaeta	Lumbriculida	Lumbriculidae	*Lumbriculus variegatus*	0.3
Moores Creek	Annelida	Oligochaeta	Tubificida	Naididae (Naidinae)	*Bratislavia unidentata*	0.3
Moores Creek	Annelida	Oligochaeta	Tubificida	Naididae (Tubificinae)	*Limnodrilus hoffmeisteri*	0.3
Moores Creek	Annelida	Oligochaeta	Tubificida	Naididae (Tubificinae)	*Limnodrilus udekemianus*	0.3
Moores Creek	Annelida	Oligochaeta	Tubificida	Naididae (Tubificinae)	Naididae (Tubificinae) Unid.	12.3
Moores Creek	Arthropoda	Arachnida	Acariformes	Hygrobatidae	*Hygrobates*	0.5
Moores Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	23.7
Moores Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis crenata*	2.4
Moores Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis decorata*	0.5
Moores Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Ectopria cf. leechi*	0.3
Moores Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	0.5
Moores Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cladotanytarsus* cf. *daviesi*	0.5
Moores Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Corynoneura*	0.3
Moores Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Nilotanypus fimbriatus*	0.3

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Moores Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	2.4
Moores Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum obtusum*	0.3
Moores Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum scalaenum* group	6.1
Moores Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	0.8
Moores Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Stempellinella fimbriata*	0.3
Moores Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. C	0.8
Moores Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. M	0.8
Moores Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	0.5
Moores Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna*	2.4
Moores Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna pygmaea*	1.3
Moores Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	3.2
Moores Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	3.2
Moores Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis latipennis*	0.3
Moores Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptageniidae	0.3
Moores Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium*	0.8
Moores Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium pulchellum*	0.5
Moores Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium terminatum*	2.7
Moores Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenacron interpunctatum*	0.5
Moores Creek	Arthropoda	Insecta	Megaloptera	Corydalidae	Corydalidae	0.3
Moores Creek	Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	0.5
Moores Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	4.5
Moores Creek	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra obscura*	0.5
Moores Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes neglectus neglectus*	2.9
Moores Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes* sp.	1.1
Moores Creek	Arthropoda	Malacostraca	Isopoda	Asellidae	*Caecidotea*	0.5
Moores Creek	Mollusca	Gastropoda	Lymnophila	Ancylidae	*Ferrissia rivularis*	2.1
Moores Creek	Mollusca	Gastropoda	Lymnophila	Ancylidae	*Laevapex fusca*	0.5
Moores Creek	Mollusca	Pelecypoda	Eulamellibranchia	Corbiculidae	*Corbicula fluminea*	9.3
Moores Creek	Mollusca	Pelecypoda	Eulamellibranchia	Sphaeriidae	*Sphaerium striatinum*	2.4
Moores Creek	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	*Cura*	0.5
Moores Creek	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	Dugesiidae	5.1
Mud Creek	Annelida	Oligochaeta	Tubificida	Naididae (Naidinae)	*Nais communis*	0.3
Mud Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	0.9
Mud Creek	Arthropoda	Insecta	Coleoptera	Lutrochidae	*Lutrochus*	0.3
Mud Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	0.6
Mud Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus absurdus*	0.3
Mud Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus bicinctus*	0.3
Mud Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus triannulatus/ infuscatus*	0.3
Mud Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Paramerina*	0.3
Mud Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	9.1
Mud Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum illinoense*	0.6
Mud Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum obtusum*	1.3

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Mud Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	2.5
Mud Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Stempellinella fimbriata*	0.6
Mud Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus*	0.6
Mud Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. C	1.3
Mud Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Tanytarsus* sp. D	0.3
Mud Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	4.4
Mud Creek	Arthropoda	Insecta	Diptera	Tipulidae	*Hexatoma*	0.3
Mud Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna*	0.3
Mud Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna pygmaea*	0.3
Mud Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	6.6
Mud Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis flavistriga*	0.3
Mud Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	8.8
Mud Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis hilaris group*	2.2
Mud Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium*	2.8
Mud Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium pulchellum*	0.6
Mud Creek	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	*Tricorythodes*	6.3
Mud Creek	Arthropoda	Insecta	Hemiptera	Veliidae	*Rhagovelia*	0.6
Mud Creek	Arthropoda	Insecta	Lepidoptera	Crambidae	*Petrophila*	0.3
Mud Creek	Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	0.3
Mud Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	29.9
Mud Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche*	0.3
Mud Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychidae	9.1
Mud Creek	Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Hydroptila*	0.9
Mud Creek	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra aterrima*	1.3
Mud Creek	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra socia*	1.3
Mud Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes neglectus neglectus*	0.3
Mud Creek	Mollusca	Gastropoda	Lymnophila	Planorbidae	Planorbidae	0.6
Mud Creek	Mollusca	Pelecypoda	Eulamellibranchia	Corbiculidae	*Corbicula fluminea*	0.3
Mud Creek	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	*Cura*	0.3
Mud Creek	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	Dugesiidae	1.6
Osage Creek-Cave Springs	Annelida	Oligochaeta	Tubificida	Naididae (Pristininae)	*Pristina leidyi*	1.1
Osage Creek-Cave Springs	Arthropoda	Arachnida	Acariformes	Hygrobatidae	*Hygrobates*	0.3
Osage Creek-Cave Springs	Arthropoda	Arachnida	Acariformes	Sperchonidae	*Sperchon* sp. 1	0.3
Osage Creek-Cave Springs	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	0.3
Osage Creek-Cave Springs	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis exilis*	0.3
Osage Creek-Cave Springs	Arthropoda	Insecta	Coleoptera	Hydrophilidae	*Enochrus*	0.6
Osage Creek-Cave Springs	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	3.4
Osage Creek-Cave Springs	Arthropoda	Insecta	Diptera	Chironomidae	*Microtendipes pedellus* group	0.6

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Osage Creek-Cave Springs	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum*	0.3
Osage Creek-Cave Springs	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	1.4
Osage Creek-Cave Springs	Arthropoda	Insecta	Diptera	Chironomidae	*Stempellinella fimbriata*	1.7
Osage Creek-Cave Springs	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	1.4
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna*	4.3
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna pygmaea*	2.9
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetidae	1.7
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	5.2
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis flavistriga*	1.1
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	9.8
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Fallceon quilleri*	2.3
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis*	4.0
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis hilaris* group	20.1
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptageniidae	3.2
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta*	0.3
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta/Nixe*	0.3
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium*	4.0
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium bednariki*	1.4
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium mediopunctatum*	2.6
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium pulchellum*	3.2
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenacron interpunctatum*	0.3
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Isonychiidae	*Isonychia*	1.1
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	*Tricorythodes*	2.3
Osage Creek-Cave Springs	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebiidae	0.3
Osage Creek-Cave Springs	Arthropoda	Insecta	Lepidoptera	Crambidae	*Petrophila*	0.6

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Osage Creek-Cave Springs	Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	0.3
Osage Creek-Cave Springs	Arthropoda	Insecta	Plecoptera	Perlidae	Perlidae	0.3
Osage Creek-Cave Springs	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	9.2
Osage Creek-Cave Springs	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychidae	1.7
Osage Creek-Cave Springs	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra aterrima*	0.3
Osage Creek-Cave Springs	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra socia*	0.6
Osage Creek-Cave Springs	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes neglectus neglectus*	0.3
Osage Creek-Cave Springs	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes* sp.	0.6
Osage Creek-Cave Springs	Arthropoda	Malacostraca	Isopoda	Asellidae	*Caecidotea*	0.3
Osage Creek-Cave Springs	Mollusca	Gastropoda	Mesogastropoda	Pleuroceridae	*Pleurocera potosiensis*	2.0
Osage Creek-Cave Springs	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	Dugesiidae	1.7
Osage Creek-Rogers	Annelida	Oligochaeta	Branchiobdellida		Branchiobdellida	3.8
Osage Creek-Rogers	Annelida	Oligochaeta	Tubificida	Naididae (Naidinae)	*Slavina appendiculata*	0.5
Osage Creek-Rogers	Annelida	Oligochaeta	Tubificida	Naididae (Pristininae)	*Pristina leidyi*	0.3
Osage Creek-Rogers	Arthropoda	Arachnida	Acariformes	Hygrobatidae	*Hygrobates*	0.5
Osage Creek-Rogers	Arthropoda	Insecta	Coleoptera	Elmidae	*Optioservus*	0.8
Osage Creek-Rogers	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis*	3.0
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	Chironomidae	0.3
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	*Chironomini*	0.3
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus*	2.2
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus absurdus*	12.0
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus bicinctus*	0.3
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus triannulatus/ infuscatus*	1.4
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	*Dicrotendipes*	0.3
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	*Eukiefferiella claripennis* group	0.3

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	*Nilotanypus fimbriatus*	0.5
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	*Parametriocnemus*	0.3
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	*Paratanytarsus*	0.3
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	0.3
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	0.5
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	*Stempellinella fimbriata*	0.3
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella*	0.5
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus	0.5
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Ephydridae	*Scatella*	0.8
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Simuliidae	*Simulium*	0.5
Osage Creek-Rogers	Arthropoda	Insecta	Diptera	Simuliidae	*Simulium vittatum*	1.6
Osage Creek-Rogers	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetidae	4.9
Osage Creek-Rogers	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	6.8
Osage Creek-Rogers	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis flavistriga*	0.3
Osage Creek-Rogers	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	20.4
Osage Creek-Rogers	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Fallceon quilleri*	18.3
Osage Creek-Rogers	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis hilaris* group	0.3
Osage Creek-Rogers	Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	0.5
Osage Creek-Rogers	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	1.1
Osage Creek-Rogers	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychidae	0.5
Osage Creek-Rogers	Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Oxyethira*	0.8
Osage Creek-Rogers	Arthropoda	Insecta	Trichoptera	Psychomyiidae	*Psychomyia flavida*	2.7
Osage Creek-Rogers	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes neglectus neglectus*	0.3
Osage Creek-Rogers	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes* sp.	0.8
Osage Creek-Rogers	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes virilis*	0.5

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Osage Creek-Rogers	Arthropoda	Malacostraca	Isopoda	Asellidae	*Caecidotea*	0.3
Osage Creek-Rogers	Mollusca	Gastropoda	Mesogastropoda	Pleuroceridae	*Pleurocera potosiensis*	1.4
Osage Creek-Rogers	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	*Cura*	1.4
Osage Creek-Rogers	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	Dugesiidae	6.5
Spring Creek	Arthropoda	Arachnida	Acariformes	Hygrobatidae	*Atracides*	0.3
Spring Creek	Arthropoda	Insecta	Coleoptera	Elmidae	Elmidae	0.3
Spring Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Microcylloepus*	0.3
Spring Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	0.3
Spring Creek	Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae	0.3
Spring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cardiocladius obscurus*	0.6
Spring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Chironomini*	0.3
Spring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus absurdus*	1.0
Spring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus triannulatus/ infuscatus*	0.6
Spring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Dicrotendipes neomodestus*	0.6
Spring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Parachironomus carinatus*	0.3
Spring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	17.5
Spring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum illinoense*	0.3
Spring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum obtusum*	1.0
Spring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	5.7
Spring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella*	0.3
Spring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemanniella similis*	0.3
Spring Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	1.3
Spring Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetidae	15.9
Spring Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	3.8
Spring Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis flavistriga*	0.6
Spring Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	4.4
Spring Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis diminuta* group	0.3
Spring Creek	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	*Tricorythodes*	7.3
Spring Creek	Arthropoda	Insecta	Lepidoptera	Crambidae	*Petrophila*	0.6
Spring Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	24.4
Spring Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychidae	2.5
Spring Creek	Arthropoda	Insecta	Trichoptera	Hydroptilidae	*Hydroptila*	1.0
Spring Creek	Arthropoda	Insecta	Trichoptera		Trichoptera	0.3
Spring Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes neglectus neglectus*	0.3
Spring Creek	Arthropoda	Malacostraca	Isopoda	Asellidae	*Lirceus*	0.3
Spring Creek	Mollusca	Gastropoda	Lymnophila	Physidae	*Physa*	0.3
Spring Creek	Mollusca	Gastropoda	Lymnophila	Planorbidae	Planorbidae	1.0
Spring Creek	Nemertea	Enopla	Hoplonemertea	Tetrastemmatidae	*Prostoma*	1.6
Spring Creek	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	*Cura*	1.0
Spring Creek	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	Dugesiidae	2.9

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Weddington Creek	Annelida	Oligochaeta	Tubificida	Naididae (Naidinae)	*Nais variabilis*	0.3
Weddington Creek	Annelida	Oligochaeta	Tubificida	Naididae (Naidinae)	*Slavina appendiculata*	0.6
Weddington Creek	Annelida	Oligochaeta	Tubificida	Naididae (Pristininae)	*Pristina leidyi*	0.3
Weddington Creek	Arthropoda	Arachnida	Acariformes	Hygrobatidae	*Atracides*	0.3
Weddington Creek	Arthropoda	Arachnida	Acariformes	Hygrobatidae	*Hygrobates*	0.6
Weddington Creek	Arthropoda	Arachnida	Acariformes	Limnocharidae	*Rhyncholimnochares*	0.3
Weddington Creek	Arthropoda	Arachnida	Acariformes	Sperchonidae	*Sperchon* sp. 1	0.3
Weddington Creek	Arthropoda	Arachnida	Acariformes	Sperchonidae	*Sperchon* sp. 2	0.3
Weddington Creek	Arthropoda	Insecta	Coleoptera	Elmidae	*Stenelmis exigua*	0.3
Weddington Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Ectopria* cf. *leechi*	0.9
Weddington Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	11.2
Weddington Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus absurdus*	2.4
Weddington Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	2.7
Weddington Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	3.3
Weddington Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Stempellinella fimbriata*	0.3
Weddington Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	0.9
Weddington Creek	Arthropoda	Insecta	Diptera	Empididae	*Hemerodromia*	0.3
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna pygmaea*	4.4
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetidae	0.6
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	5.3
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis flavistriga*	2.7
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	9.8
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis hilaris* group	10.1
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptageniidae	2.4
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta*	4.1
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta/Nixe*	11.8
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium*	0.6
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium bednariki*	1.8
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium mediopunctatum*	0.6
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium pulchellum*	1.2
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Stenacron interpunctatum*	0.3
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Isonychiidae	*Isonychia*	3.0
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	*Tricorythodes*	1.5
Weddington Creek	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	*Choroterpes*	0.6
Weddington Creek	Arthropoda	Insecta	Megaloptera	Corydalidae	Corydalidae	0.3
Weddington Creek	Arthropoda	Insecta	Megaloptera	Corydalidae	*Corydalus cornutus*	2.4
Weddington Creek	Arthropoda	Insecta	Odonata	Coenagrionidae	*Argia*	0.3
Weddington Creek	Arthropoda	Insecta	Plecoptera	Perlidae	Perlidae	1.2
Weddington Creek	Arthropoda	Insecta	Plecoptera	Perlodidae	Perlodidae	0.3
Weddington Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	5.6
Weddington Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Chimarra*	0.3
Weddington Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Helicopsyche*	0.3
Weddington Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes neglectus neglectus*	0.3

Table 13. List of macroinvertebrate taxa and relative abundances for sampling sites in the Illinois River Basin study area.—Continued

Short site name	Phylum	Class	Order	Family	Genus and species or other taxonomic group	Relative abundance (percent)
Weddington Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes* sp.	1.2
Weddington Creek	Mollusca	Gastropoda	Lymnophila	Ancylidae	*Ferrissia rivularis*	0.3
Weddington Creek	Mollusca	Gastropoda	Mesogastropoda	Pleuroceridae	*Pleurocera potosiensis*	1.8
Wildcat Creek	Annelida	Hirudinea	Arhynchobdellida	Erpobdellidae	*Erpobdella fervida*	0.3
Wildcat Creek	Arthropoda	Arachnida	Acariformes	Hygrobatidae	*Atracides*	1.0
Wildcat Creek	Arthropoda	Arachnida	Acariformes	Lebertidae	*Lebertia*	0.3
Wildcat Creek	Arthropoda	Insecta	Coleoptera	Psephenidae	*Psephenus herricki*	4.5
Wildcat Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Cricotopus absurdus*	2.4
Wildcat Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Polypedilum flavum*	3.4
Wildcat Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Rheotanytarsus*	0.3
Wildcat Creek	Arthropoda	Insecta	Diptera	Chironomidae	*Thienemannimyia* genus group	1.0
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna*	3.9
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Acerpenna pygmaea*	3.1
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetidae	0.8
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*	2.1
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis intercalaris*	0.8
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Caenidae	*Caenis hilaris* group	26.0
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptageniidae	1.6
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta*	1.8
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Leucrocuta/Nixe*	1.8
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium*	5.0
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium bednariki*	4.5
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium mediopunctatum*	1.6
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	*Maccaffertium pulchellum*	1.6
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Isonychiidae	*Isonychia*	9.7
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	*Tricorythodes*	1.6
Wildcat Creek	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebiidae	0.3
Wildcat Creek	Arthropoda	Insecta	Megaloptera	Corydalidae	*Corydalus cornutus*	0.5
Wildcat Creek	Arthropoda	Insecta	Odonata	Gomphidae	Gomphidae	0.3
Wildcat Creek	Arthropoda	Insecta	Plecoptera	Perlidae	Perlidae	2.4
Wildcat Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	10.8
Wildcat Creek	Arthropoda	Insecta	Trichoptera	Hydropsychidae	*Hydropsyche bronta*	0.3
Wildcat Creek	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra*	0.3
Wildcat Creek	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra aterrima*	0.8
Wildcat Creek	Arthropoda	Insecta	Trichoptera	Philopotamidae	*Chimarra obscura*	0.3
Wildcat Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes neglectus neglectus*	1.6
Wildcat Creek	Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes* sp.	1.8
Wildcat Creek	Mollusca	Gastropoda	Mesogastropoda	Pleuroceridae	*Pleurocera potosiensis*	1.3
Wildcat Creek	Nemertea	Enopla	Hoplonemertea	Tetrastemmatidae	*Prostoma*	0.3
Wildcat Creek	Platyhelminthes	Turbellaria	Tricladida	Dugesiidae	*Cura*	0.3

Table 14. Macroinvertebrate metric and index scores for sampling sites in the Illinois River Basin study area.

[Sites are sorted by index score, which is rounded to nearest whole number; EPT, Ephemeroptera, Plecoptera, Trichoptera; richness, number of taxa; Metric scores are associated with metric in preceding column and range from 0 to 100, with 100 indicating least degraded condition]

Short site name	EPT richness	Metric score	Percent predator richness	Metric score	Percent gatherer-collectors	Metric score	Margalef diversity	Metric score	Percent Baetidae	Metric score	Macroinvertebrate index score[1]	Macroinvertebrate index class
Fly Creek[2]	32	100.0	15.3	52.9	17.0	90.3	28.1	100.0	8.3	84.5	86	Least impaired
Evansville Creek[3]	27	77.3	26.4	91.3	23.0	71.4	27.4	95.4	6.3	88.5	85	Least impaired
Illinois River[3]	32	100.0	19.4	67.2	21.0	77.8	26.0	86.9	13.2	74.7	81	Least impaired
Baron Fork[2]	20	45.5	23.4	81.1	13.9	100.0	24.6	78.7	0.6	100.0	81	Least impaired
Ballard Creek[2]	18	36.4	16.4	56.7	22.1	74.2	22.7	67.0	2.3	96.5	66	Good
Cincinnati Creek[2]	23	59.1	28.9	100.0	18.7	85.0	17.5	34.4	28.3	44.6	65	Good
Hamestring Creek[4]	24	63.6	21.3	73.6	20.2	80.2	17.4	34.2	20.0	61.3	63	Good
Weddington Creek[2]	22	54.6	22.2	76.9	23.4	70.3	17.8	36.5	22.8	55.7	59	Good
Wildcat Creek[2]	22	54.6	16.7	57.7	32.5	41.5	13.9	12.8	10.8	79.6	49	Fair
Flint Creek[2]	20	45.5	18.2	62.9	45.8	-0.0	16.9	30.8	1.4	98.3	47	Fair
Mud Creek[4]	15	22.7	9.8	33.8	22.3	73.5	16.0	25.4	16.4	68.5	45	Fair
Moores Creek[2]	12	9.1	8.9	30.8	24.0	68.3	17.1	32.2	10.1	80.9	44	Fair
Little Osage Creek[2]	21	50.0	7.0	24.2	24.2	67.5	16.4	28.0	32.8	35.7	41	Fair
Goose Creek[2]	14	18.2	12.1	42.0	22.4	73.4	12.8	5.9	19.2	62.9	40	Fair
Osage Creek-Cave Springs[4]	25	68.2	7.0	24.2	44.1	5.2	16.9	31.1	27.3	46.6	35	Poor
Clear Creek[4]	16	27.3	0.0	0.0	35.7	31.5	11.9	0.0	11.3	78.6	27	Poor
Spring Creek[4]	10	0.0	8.3	28.8	34.6	35.0	14.0	13.2	24.8	51.7	26	Poor
Osage Creek-Rogers[4]	10	0.0	7.0	24.2	42.0	11.9	16.4	27.8	50.7	0.0	13	Poor

[1] Index values rounded to nearest whole number.

[2] Agriculture site (Baron Fork and Goose Creek are downstream from wastewater-treatment plants).

[3] Forest site.

[4] Urban site (Osage Creek-Cave Springs and Spring Creek are downstream from wastewater-treatment plants).

Table 15. List of macroinvertebrate metrics.

[EPT, Ephemeroptera, Plecoptera, Trichoptera; EPA, U.S. Environmental Protection Agency]

Abbreviated metric name	Metric description
AbundTOL	Abundance-weighted EPA tolerance value for sample[1]
Baetidae %	Percentage of total abundance composed of Baetidae
bu_abund	Abundance of burrower taxa
bu_abundp	Percentage of abundance composed of burrower taxa
bu_richp	Percentage of richness composed of burrower taxa
cb_abundp	Percentage of abundance composed of climber taxa
cb_richp	Percentage of richness composed of climber taxa
CHp	Percentage of total abundance composed of midges
CHR	Richness composed of midges
CHRp	Percentage of total richness composed of midges
cn_abund	Abundance of clinger taxa
cn_abundp	Percentage of abundance composed of clinger taxa
cn_richp	Percentage of richness composed of clinger taxa
COLEOPp	Percentage of total abundance composed of coleoptera
COLEOPR	Richness composed of coleoptera
COLEOPRp	Percentage of total richness composed of coleoptera
DIPp	Percentage of total abundance composed of diptera
DIPR	Richness composed of diptera
DIPRp	Percentage of total richness composed of diptera
Dom1	Percentage of total abundance represented by the most abundant taxon
Dom2	Percentage of total abundance represented by the two most abundant taxa
Dom3	Percentage of total abundance represented by the three most abundant taxa
Dom4	Percentage of total abundance represented by the four most abundant taxa
Dom5	Percentage of total abundance represented by the five most abundant taxa
EPEMp	Percentage of total abundance composed of mayflies
EPEMR	Richness composed of mayflies
EPEMRp	Percentage of total richness composed of mayflies
EPT_CHp	Ratio of EPT and midge abundance
EPT_CHR	Ratio of EPT richness to midge richness
EPT_CHRp	Ratio of EPT percent richness to midge percent richness
EPTp	Percentage of total abundance composed of mayflies, stoneflies, and caddisflies
EPTR	Richness composed of mayflies, stoneflies, and caddisflies
EPTRp	Percentage of total richness composed of mayflies, stoneflies, and caddisflies
FC_abund	Total abundance composed of filtering-collectors
FC_rich	Richness composed of filtering-collectors
GASTROp	Percentage of total abundance composed of gastropods
GASTROR	Richness composed of gastropoda
GASTRORp	Percentage of total richness composed of gastropoda
GC_abund	Total abundance composed of gatherer-collectors
GC_rich	Richness composed of gatherer-collectors
Intol_abund	Total abundance in the intolerant class
Intol_abundp	Percentage of abundance in the intolerant class
Intol_rich	Number of taxa in the intolerant class
Intol_richp	Percentage of taxa richness in the intolerant class
Invertebrate index	See “Methods” section of this report
ISOPp	Percentage of total abundance composed of Isopoda
Margalef	Margalef’s diversity (Margalef, 1958)
Modtol_abund	Total abundance in the moderately tolerant class
ModTol_abundp	Percentage of abundance in the moderately tolerant class
Modtol_rich	Number of taxa in the moderately tolerant class
Modtol_richp	Percentage of taxa richness in the moderately tolerant class
MOLCRUp	Percentage of total abundance composed of molluscs and crustaceans
MOLCRUR	Richness composed of molluscs and crustaceans
MOLCRURp	Percentage of total richness composed of molluscs and crustaceans
NCHDIPp	Percentage of total abundance composed of non-midge dipterans
NCHDIPR	Richness composed of non-midge diptera
NCHDIPRp	Percentage of total richness composed of non-midge diptera
NONINSp	Percentage of total abundance composed of non-insects
NONINSR	Richness composed of non-insects
NONINSRp	Percentage of total richness composed on non-insects
ODIPNIp	Percentage of total abundance composed of non-midge diptera and non-insects
ODIPNIR	Richness composed of non-midge diptera and non-insects
ODIPNIRp	Percentage of total richness composed of non-midge diptera and non-insects
ODONOp	Percentage of total abundance composed of odonates

Table 15. List of macroinvertebrate metrics.—Continued

[EPT, Ephemeroptera, Plecoptera, Trichoptera; EPA, U.S. Environmental Protection Agency]

Abbreviated metric name	Metric description
ODONOR	Richness composed of odonates
ODONORp	Percentage of total richness composed of odonates
OLIGOp	Percentage of total abundance composed of Oligochaeta
OLIGOR	Richness composed of oligochaeta
OLIGORp	Percentage of total richness composed of Oligochaeta
OM_abund	Total abundance composed of omnivores
OM_rich	Richness composed of omnivores
pFC_abund	Percentage of total abundance composed of filtering-collectors
pFC_rich	Percentage of total richness composed of filtering-collectors
pGC_abund	Percentage of total abundance composed of gatherer-collectors
pGC_rich	Percentage of total richness composed of gatherer-collectors
PLECOp	Percentage of total abundance composed of stoneflies
PLECOR	Richness composed of stoneflies
PLECORp	Percentage of total richness composed of stoneflies
pOM_abund	Percentage of total abundance composed of omnivores
pOM_rich	Percentage of total richness composed of omnivores
pPR_abund	Percentage of total abundance composed of predators
pPR_rich	Percentage of total richness composed of predators
PR_abund	Total abundance composed of predators
PR_rich	Richness composed of predators
pSC_abund	Percentage of total abundance composed of scrapers
pSC_rich	Percentage of total richness composed of scrapers
pSH_abund	Percentage of total abundance composed of shredders
pSH_rich	Percentage of total richness composed of shredders
RICH	Total richness (number of non-ambiguous taxa)
RichTOL	Average EPA tolerance values for sample based on richness
SC_abund	Total abundance composed of scrapers
SC_rich	Richness composed of scrapers
SH_abund	Total abundance composed of shredders
SH_rich	Richness composed of shredders
sp_abund	Abundance of sprawler taxa
sp_abundp	Percentage of abundance composed of sprawler taxa
sp_richp	Percentage of richness composed of sprawler taxa
Tol_abund	Total abundace in the tolerant class
Tol_abundp	Percentage of abundance in the tolerant class
Tol_rich	Number of taxa in the tolerant class
Tol_richp	Percentage of taxa richness in the tolerant class
TRICHp	Percentage of total abundance composed of caddisflies
TRICHR	Richness composed of caddisflies
TRICHRp	Percentage of total richness composed of caddisflies

[1] EPA tolerance values from Barbour and others (1999).

Table 16. Correlations between macroinvertebrate metrics and index and selected environmental factors for sites not affected by wastewater-treatment plants.

[Macroinvertebrate metrics are sorted by absolute value of correlation with percent forest; red font denotes absolute value of rho is greater than or equal to 0.50; metric abbreviations are listed in table 15; number of sites equals 14]

	Nitrite plus nitrate	Total phosphorus	Tempera-ture	Specific conduc-tance	Dissolved oxygen	pH	Streamflow	Bankfull width	Drainage area	Bankfull width/ drainage area	Depth	Velocity
PR_rich	−0.30	−0.17	0.32	−0.32	0.17	−0.14	−0.56	0.62	−0.03	0.20	−0.58	−0.54
Macroinvertebrate index	−0.30	−0.16	0.31	−0.25	0.29	−0.07	−0.58	0.66	−0.11	0.27	−0.74	−0.66
PLECOR	−0.02	−0.16	0.11	−0.24	0.07	−0.21	−0.42	0.49	−0.14	0.23	−0.40	−0.26
Margalef diversity	−0.28	−0.09	0.09	−0.18	0.21	−0.29	−0.54	0.29	0.25	−0.16	−0.53	−0.64
SC_rich	−0.08	0.05	0.04	−0.34	0.27	0.09	−0.30	0.10	0.20	−0.18	−0.41	−0.45
pPR_abund	−0.30	−0.11	0.19	−0.27	0.42	−0.14	−0.45	0.57	0.09	0.07	−0.60	−0.61
PR_abund	−0.34	−0.14	0.22	−0.32	0.40	−0.10	−0.47	0.56	0.06	0.10	−0.57	−0.61
RICH	−0.33	−0.17	0.08	−0.22	0.22	−0.30	−0.55	0.26	0.18	−0.12	−0.47	−0.63
PLECORp	0.06	−0.03	0.11	−0.20	0.08	−0.10	−0.31	0.47	−0.08	0.19	−0.34	−0.23
pPR_rich	−0.12	−0.03	0.37	−0.30	0.13	0.07	−0.27	0.55	−0.11	0.23	−0.28	−0.24
EPTR	−0.10	−0.34	−0.05	−0.26	0.23	−0.11	−0.44	0.55	−0.12	0.30	−0.46	−0.35
PLECOp	0.15	−0.07	0.03	−0.18	0.24	−0.09	−0.31	0.57	−0.14	0.28	−0.47	−0.24
bu_richp	0.11	−0.35	−0.24	0.21	−0.16	−0.15	0.28	−0.37	−0.19	0.03	0.54	0.54
Modtol_rich	−0.50	−0.09	0.39	−0.16	−0.04	−0.17	−0.68	0.26	0.12	−0.03	−0.63	−0.77
Dom4	0.29	−0.01	−0.22	0.24	−0.07	0.18	0.53	−0.56	−0.24	−0.09	0.62	0.58
Dom3	0.28	0.08	−0.02	0.15	0.05	0.32	0.54	−0.41	−0.27	−0.00	0.39	0.54
Dom5	0.22	−0.08	−0.14	0.17	−0.10	0.16	0.45	−0.52	−0.32	−0.02	0.56	0.55
Dom2	0.31	0.04	−0.05	0.22	0.12	0.29	0.46	−0.38	−0.27	−0.01	0.27	0.42
cb_abundp	−0.10	−0.04	−0.17	−0.22	0.54	0.01	−0.24	0.24	0.22	−0.13	−0.56	−0.50
Baetidae %	0.25	−0.18	−0.45	0.54	−0.30	−0.38	0.27	−0.20	0.24	−0.21	0.64	0.36
pGC_abund	0.35	0.14	−0.18	−0.17	−0.02	0.38	0.63	−0.58	0.07	−0.22	0.46	0.70
SC_abund	−0.01	0.21	0.05	−0.25	−0.40	−0.37	−0.43	−0.03	0.18	−0.12	−0.14	−0.14
ODIPNIR	−0.26	−0.13	−0.08	−0.28	−0.00	−0.42	−0.40	−0.10	0.47	−0.38	−0.12	−0.37
pSC_abund	0.02	0.27	0.02	−0.22	−0.40	−0.35	−0.38	−0.09	0.20	−0.16	−0.08	−0.12

Table 16. Correlations between macroinvertebrate metrics and index and selected environmental factors for sites not affected by wastewater-treatment plants.—Continued

[Macroinvertebrate metrics are sorted by absolute value of correlation with percent forest; red font denotes absolute value of rho is greater than or equal to 0.50; metric abbreviations are listed in table 15; number of sites equals 14]

	Bed substrate	Embedded-ness	Substrate turbidity	Open canopy angle	Combined canopy closure	Bank height	Bank angle	Percent forest	Percent agricul-ture	Percent urban	Poultry house density	Total unpaved road density	Total paved road density	Total road density
PR_rich	0.39	−0.49	−0.05	0.18	−0.52	0.35	0.44	0.91	−0.20	−0.85	0.12	0.24	−0.80	−0.83
Macroinvertebrate index	0.39	−0.53	0.03	−0.45	0.32	0.44	−0.06	0.86	−0.15	−0.81	0.19	0.26	−0.71	−0.77
PLECOR	0.59	−0.36	−0.09	0.34	−0.58	0.09	0.53	0.82	−0.10	−0.81	0.09	0.29	−0.84	−0.78
Margalef diversity	0.31	−0.60	−0.02	−0.11	−0.26	0.39	0.47	0.82	−0.11	−0.80	0.20	0.20	−0.68	−0.75
SC_rich	0.28	−0.51	−0.04	−0.19	0.02	0.44	0.33	0.80	0.09	−0.82	0.25	0.47	−0.68	−0.64
pPR_abund	0.22	−0.53	−0.13	0.14	−0.47	0.31	0.38	0.80	−0.16	−0.75	0.18	0.13	−0.64	−0.75
PR_abund	0.21	−0.52	−0.11	0.09	−0.43	0.36	0.37	0.79	−0.18	−0.74	0.13	0.14	−0.62	−0.74
RICH	0.26	−0.53	0.05	−0.18	−0.20	0.48	0.46	0.77	−0.20	−0.74	0.09	0.16	−0.60	−0.67
PLECORp	0.54	−0.35	−0.19	0.42	−0.63	0.00	0.49	0.77	0.04	−0.80	0.11	0.30	−0.81	−0.78
pPR_rich	0.26	−0.33	−0.22	0.33	−0.51	0.25	0.32	0.73	−0.07	−0.72	0.05	0.23	−0.68	−0.68
EPTR	0.70	−0.57	−0.14	0.13	−0.49	0.13	0.68	0.72	−0.06	−0.75	0.01	0.16	−0.70	−0.71
PLECOp	0.53	−0.26	−0.09	0.45	−0.65	−0.01	0.58	0.72	0.08	−0.72	0.14	0.35	−0.77	−0.72
bu_richp	−0.25	0.45	0.28	−0.14	0.28	−0.05	−0.04	−0.70	−0.18	0.70	−0.50	−0.35	0.63	0.68
Modtol_rich	0.04	−0.33	0.32	−0.38	0.06	0.64	0.12	0.66	−0.29	−0.53	0.19	0.24	−0.41	−0.44
Dom4	−0.58	0.69	0.18	−0.06	0.53	0.04	−0.47	−0.66	−0.13	0.73	−0.33	−0.16	0.67	0.83
Dom3	−0.65	0.71	0.21	0.02	0.45	−0.07	−0.62	−0.63	−0.06	0.71	−0.19	−0.02	0.63	0.76
Dom5	−0.55	0.71	0.26	−0.07	0.51	0.08	−0.50	−0.59	−0.23	0.68	−0.36	−0.12	0.61	0.78
Dom2	−0.70	0.73	0.35	−0.05	0.49	0.11	−0.50	−0.57	−0.08	0.69	−0.19	0.04	0.63	0.78
cb_abundp	0.16	−0.46	−0.01	−0.06	0.03	0.29	0.20	0.54	−0.04	−0.46	0.37	0.22	−0.39	−0.41
Baetidae %	−0.01	0.06	−0.14	0.38	−0.25	−0.29	0.25	−0.52	−0.03	0.40	−0.45	−0.67	0.38	0.30
pGC_abund	−0.27	0.36	0.05	0.11	0.34	−0.43	−0.58	−0.50	0.23	0.40	−0.09	0.13	0.32	0.42
SC_abund	0.57	−0.13	0.14	−0.17	−0.06	0.08	0.49	0.48	0.25	−0.52	0.34	0.50	−0.64	−0.51
ODIPNIR	0.07	−0.22	0.31	−0.05	−0.18	0.35	0.29	0.48	−0.16	−0.51	−0.13	0.09	−0.42	−0.49
pSC_abund	0.55	−0.12	0.08	−0.19	−0.02	0.06	0.46	0.45	0.29	−0.49	0.36	0.49	−0.60	−0.48

Table 17. Correlations between macroinvertebrate metrics and index and environmental factors at agriculture gradient sites in the Illinois River Basin study area.

[Macroinvertebrate metrics are sorted by absolute value of correlation with percent agriculture; red font denotes absolute value of rho is greater than or equal to 0.60; metric abbreviations are listed in table 15; number of sites equals 10]

	Nitrite plus nitrate	Total phosphorus	Temperature	Specific conductance	Dissolved oxygen	pH	Streamflow	Bankfull width	Drainage area	Bankfull width/drainage area	Depth	Velocity
PR_rich	−0.68	−0.47	0.34	−0.29	−0.25	−0.41	−0.74	0.61	−0.37	0.65	−0.50	−0.47
Macroinvertebrate index	−0.66	−0.49	0.31	−0.15	−0.24	−0.50	−0.84	0.60	−0.44	0.70	−0.68	−0.64
RICH	−0.74	−0.38	0.16	−0.16	−0.25	−0.51	−0.83	0.25	−0.12	0.32	−0.53	−0.74
Margalef diversity	−0.67	−0.37	0.09	−0.04	−0.18	−0.56	−0.81	0.27	−0.13	0.31	−0.56	−0.77
PR_abund	−0.77	−0.33	0.32	−0.32	0.10	−0.22	−0.71	0.67	−0.16	0.55	−0.64	−0.71
pPR_abund	−0.71	−0.31	0.24	−0.22	0.16	−0.27	−0.70	0.66	−0.15	0.52	−0.66	−0.76
Modtol_rich	−0.72	−0.14	0.33	−0.22	−0.21	−0.46	−0.74	0.06	−0.14	0.14	−0.58	−0.66
PLECOR	−0.25	−0.47	0.08	0.02	−0.33	−0.50	−0.51	0.45	−0.51	0.59	−0.29	−0.19
EPTR	−0.23	−0.79	−0.23	−0.01	−0.16	−0.46	−0.59	0.54	−0.31	0.65	−0.41	−0.35
pGC_abund	0.54	0.20	−0.09	−0.22	0.20	0.76	0.72	−0.44	0.08	−0.33	0.52	0.71
Dom4	0.53	0.41	0.01	−0.12	0.05	0.58	0.67	−0.60	0.01	−0.45	0.52	0.67
ODIPNIR	−0.80	−0.15	0.14	−0.42	−0.59	−0.41	−0.76	−0.02	0.23	0.05	−0.07	−0.64
SC_rich	−0.29	−0.25	−0.16	−0.14	−0.07	−0.15	−0.35	−0.22	−0.06	−0.08	−0.09	−0.35
Dom3	0.43	0.43	0.25	−0.19	0.33	0.71	0.65	−0.37	−0.15	−0.28	0.19	0.59
pPR_rich	−0.43	−0.19	0.45	−0.36	−0.30	−0.03	−0.32	0.54	−0.38	0.58	−0.03	−0.02
Dom2	0.47	0.32	0.14	−0.13	0.42	0.62	0.58	−0.39	−0.21	−0.27	0.02	0.49
PLECORp	−0.14	−0.28	0.06	0.18	−0.33	−0.40	−0.36	0.40	−0.42	0.50	−0.09	−0.17
Dom5	0.38	0.28	0.15	−0.27	−0.02	0.54	0.52	−0.52	−0.15	−0.30	0.36	0.64
Baetidae %	0.24	−0.03	−0.35	0.39	−0.39	−0.26	0.15	0.01	0.41	−0.09	0.54	0.20
PLECOp	0.04	−0.40	−0.10	0.19	−0.03	−0.36	−0.35	0.58	−0.56	0.66	−0.37	−0.23
bu_richp	0.17	−0.13	0.08	−0.27	−0.21	0.22	0.24	−0.22	0.11	−0.08	0.18	0.53
SC_abund	−0.15	0.05	−0.09	0.21	−0.84	−0.83	−0.43	−0.27	0.01	−0.12	0.18	−0.15
pSC_abund	−0.10	0.14	−0.15	0.27	−0.81	−0.81	−0.36	−0.33	0.09	−0.22	0.28	−0.15
cn_abundp	−0.10	0.37	0.50	−0.12	−0.12	0.29	0.16	−0.15	−0.32	−0.04	0.22	0.22

Table 17. Correlations between macroinvertebrate metrics and index and environmental factors at agriculture gradient sites in the Illinois River Basin study area.—Continued

[Macroinvertebrate metrics are sorted by absolute value of correlation with percent agriculture; red font denotes absolute value of rho is greater than or equal to 0.60; metric abbreviations are listed in table 15; number of sites equals 10]

	Bed substrate	Embed-dedness	Substrate turbidity	Open canopy angle	Combined canopy closure	Bank height	Bank angle	Percent forest	Percent agricul-ture	Percent urban	Poultry house density	Total unpaved road density	Total paved road density	Total road density
PR_rich	0.67	−0.28	0.09	0.27	−0.47	0.22	0.09	0.93	−0.88	−0.90	−0.27	−0.26	−0.88	−0.95
Macroinvertebrate index	0.65	−0.24	0.26	0.09	−0.49	0.21	0.21	0.84	−0.83	−0.82	−0.32	−0.24	−0.76	−0.87
RICH	0.51	−0.39	0.28	−0.30	−0.10	0.46	0.09	0.81	−0.80	−0.78	−0.30	−0.29	−0.57	−0.71
Margalef diversity	0.53	−0.39	0.22	−0.27	−0.13	0.43	0.18	0.81	−0.79	−0.77	−0.22	−0.32	−0.56	−0.71
PR_abund	0.43	−0.49	−0.02	0.07	−0.37	0.31	−0.02	0.77	−0.78	−0.76	−0.13	−0.41	−0.56	−0.83
pPR_abund	0.42	−0.48	−0.03	0.04	−0.36	0.32	0.06	0.75	−0.76	−0.72	−0.07	−0.42	−0.53	−0.79
Modtol_rich	0.17	−0.14	0.42	−0.60	0.22	0.60	−0.11	0.62	−0.71	−0.49	−0.02	0.04	−0.36	−0.41
PLECOR	0.73	0.00	0.07	0.48	−0.53	0.01	0.35	0.79	−0.68	−0.77	−0.28	−0.12	−0.91	−0.78
EPTR	0.93	−0.34	0.20	0.46	−0.65	−0.01	0.59	0.73	−0.63	−0.74	−0.56	−0.38	−0.75	−0.77
pGC_abund	−0.53	0.35	−0.03	0.08	0.35	−0.21	−0.49	−0.61	0.62	0.53	−0.05	0.47	0.49	0.67
Dom4	−0.66	0.59	0.05	−0.12	0.52	−0.09	−0.50	−0.61	0.60	0.59	0.14	0.66	0.48	0.76
ODIPNIR	0.32	−0.27	0.44	−0.40	0.06	0.61	−0.01	0.55	−0.55	−0.57	−0.46	−0.20	−0.34	−0.48
SC_rich	0.25	−0.14	0.16	−0.25	0.28	0.49	−0.16	0.65	−0.55	−0.68	−0.28	0.03	−0.44	−0.35
Dom3	−0.79	0.56	0.01	−0.15	0.48	−0.12	−0.67	−0.61	0.53	0.64	0.33	0.71	0.53	0.73
pPR_rich	0.42	−0.04	−0.22	0.65	−0.54	−0.07	−0.18	0.65	−0.53	−0.75	−0.25	−0.14	−0.79	−0.79
Dom2	−0.75	0.58	0.15	−0.27	0.54	−0.03	−0.57	−0.56	0.45	0.64	0.33	0.77	0.53	0.77
PLECORp	0.61	−0.01	−0.15	0.56	−0.60	−0.15	0.31	0.62	−0.45	−0.72	−0.28	−0.24	−0.77	−0.73
Dom5	−0.58	0.64	0.21	−0.13	0.49	−0.01	−0.57	−0.44	0.41	0.45	0.07	0.77	0.31	0.64
Baetidae %	0.35	−0.28	−0.30	0.39	−0.43	−0.48	0.58	−0.28	0.39	0.15	−0.24	−0.59	0.10	−0.04
PLECOp	0.58	0.13	0.06	0.61	−0.69	−0.14	0.54	0.48	−0.39	−0.50	−0.20	−0.09	−0.64	−0.57
bu_richp	−0.11	0.13	0.35	−0.09	0.15	−0.18	−0.09	−0.46	0.34	0.53	−0.16	0.27	0.33	0.46
SC_abund	0.32	0.33	0.43	−0.20	0.05	0.28	0.51	0.24	−0.22	−0.13	−0.07	0.12	−0.35	−0.12
pSC_abund	0.26	0.31	0.32	−0.20	0.09	0.28	0.50	0.20	−0.16	−0.12	−0.02	0.07	−0.30	−0.09
cn_abundp	−0.30	0.30	−0.34	0.10	0.15	−0.04	−0.70	0.20	−0.09	−0.32	0.12	0.29	−0.27	−0.16

Table 18. Correlations between macroinvertebrate metrics and index and selected environmental factors at urban gradient sites in the Illinois River Basin study area.

[Macroinvertebrate metrics are sorted by absolute value of correlation with percent urban; red font denotes absolute value of rho is greater than or equal to 0.80; metric abbreviations are listed in table 15; number of sites equals 6]

	Nitrite plus nitrate	Total phosphorus	Tempera-ture	Specific conduc-tance	Dissolved oxygen	pH	Streamflow	Bankfull width	Drainage area	Bankfull width/ drainage area	Depth	Velocity
Dom3	0.71	0.49	−0.31	0.89	−0.09	−0.03	0.77	−0.66	−0.09	0.03	0.71	0.66
Macroinvertebrate index	−0.49	−0.71	0.54	−0.66	0.09	0.14	−0.77	0.71	0.09	0.03	−0.83	−0.71
SC_rich	−0.49	−0.71	0.54	−0.66	0.09	0.14	−0.77	0.71	0.09	0.03	−0.83	−0.71
PLECORp	−0.39	−0.70	0.33	−0.76	0.27	−0.15	−0.64	0.52	0.15	−0.21	−0.70	−0.52
SC_abund	−0.75	−0.38	0.64	−0.84	−0.35	0.32	−0.70	0.38	−0.29	0.38	−0.78	−0.38
Dom4	0.89	0.43	−0.43	0.94	0.20	−0.20	0.83	−0.60	−0.03	−0.14	0.77	0.60
Dom5	0.89	0.43	−0.43	0.94	0.20	−0.20	0.83	−0.60	−0.03	−0.14	0.77	0.60
PLECOp	−0.52	−0.64	0.15	−0.82	0.33	−0.21	−0.70	0.64	0.33	−0.33	−0.64	−0.64
Dom2	0.77	0.37	−0.20	1.00	0.03	0.09	0.66	−0.37	−0.09	0.09	0.60	0.37
PR_rich	−0.26	−0.83	0.37	−0.54	0.31	−0.09	−0.66	0.66	0.31	−0.26	−0.71	−0.66
pSC_abund	−0.71	−0.26	0.66	−0.77	−0.43	0.37	−0.60	0.26	−0.43	0.49	−0.71	−0.26
ODIPNIR	−0.20	−0.70	0.12	−0.70	0.46	−0.41	−0.46	0.35	0.29	−0.46	−0.52	−0.35
Margalef diversity	−0.14	−0.77	0.14	−0.60	0.49	−0.37	−0.49	0.43	0.37	−0.49	−0.54	−0.43
pPR_rich	−0.03	−0.66	0.31	−0.37	0.43	−0.14	−0.43	0.49	0.09	−0.20	−0.54	−0.49
RICH	−0.14	−0.77	0.14	−0.60	0.49	−0.37	−0.49	0.43	0.37	−0.49	−0.54	−0.43
PLECOR	−0.18	−0.74	0.09	−0.68	0.44	−0.44	−0.44	0.29	0.38	−0.53	−0.50	−0.29
Baetidae %	0.77	0.37	−0.83	0.66	0.66	−0.60	0.71	−0.37	0.31	−0.60	0.83	0.37
pPR_abund	−0.26	−0.71	−0.03	−0.66	0.54	−0.43	−0.54	0.54	0.54	−0.60	−0.49	−0.54
PR_abund	−0.26	−0.71	−0.03	−0.66	0.54	−0.43	−0.54	0.54	0.54	−0.60	−0.49	−0.54
Modtol_rich	−0.35	−0.88	0.71	−0.35	−0.09	0.35	−0.79	0.79	0.26	0.09	−0.88	−0.79
cn_abundp	−0.13	−0.65	0.65	−0.39	−0.13	0.13	−0.39	0.13	−0.13	0.13	−0.65	−0.13
EPTR	−0.31	−0.60	−0.14	−0.77	0.43	−0.54	−0.43	0.26	0.54	−0.66	−0.37	−0.26
pGC_abund	0.20	0.14	−0.03	0.20	−0.37	−0.03	0.37	−0.66	−0.03	0.03	0.26	0.66
bu_richp	0.88	0.52	−0.52	0.58	0.58	−0.52	0.88	−0.70	−0.39	−0.21	0.76	0.70

Table 18. Correlations between macroinvertebrate metrics and index and selected environmental factors at urban gradient sites in the Illinois River Basin study area.—Continued

[Macroinvertebrate metrics are sorted by absolute value of correlation with percent urban; red font denotes absolute value of rho is greater than or equal to 0.80; metric abbreviations are listed in table 15; number of sites equals 6]

	Bed substrate	Embedded-ness	Substrate turbidity	Open canopy angle	Combined canopy closure	Bank height	Bank angle	Percent forest	Percent agriculture	Percent urban	Poultry house density	Total unpaved road density	Total paved road density	Total road density
Dom3	−0.83	0.94	0.20	0.20	0.49	−0.26	−0.60	−0.89	−0.20	0.94	−0.66	−0.71	0.83	0.89
Macroinvertebrate index	0.54	−0.77	0.20	−0.14	−0.54	0.43	0.60	1.00	−0.20	−0.94	0.37	0.66	−0.71	−0.66
SC_rich	0.54	−0.77	0.20	−0.14	−0.54	0.43	0.60	1.00	−0.20	−0.94	0.37	0.66	−0.71	−0.66
PLECORp	0.52	−0.76	0.09	−0.03	−0.64	0.27	0.70	0.94	−0.09	−0.94	0.33	0.64	−0.82	−0.76
SC_abund	0.81	−0.90	−0.20	−0.49	−0.23	−0.17	0.14	0.75	0.20	−0.90	0.81	0.99	−0.93	−0.84
Dom4	−0.94	1.00	0.26	0.26	0.43	0.03	−0.31	−0.77	−0.26	0.89	−0.83	−0.83	0.89	0.94
Dom5	−0.94	1.00	0.26	0.26	0.43	0.03	−0.31	−0.77	−0.26	0.89	−0.83	−0.83	0.89	0.94
PLECOp	0.64	−0.82	−0.03	0.09	−0.70	0.33	0.76	0.88	0.03	−0.88	0.39	0.52	−0.76	−0.82
Dom2	−0.89	0.94	0.37	0.14	0.49	0.20	−0.37	−0.66	−0.37	0.83	−0.77	−0.77	0.94	1.00
PR_rich	0.31	−0.60	0.37	0.14	−0.71	0.49	0.71	0.94	−0.37	−0.83	0.09	0.43	−0.60	−0.54
pSC_abund	0.77	−0.83	−0.26	−0.60	−0.09	−0.26	0.03	0.66	0.26	−0.83	0.83	1.00	−0.89	−0.77
ODIPNIR	0.35	−0.61	0.12	0.17	−0.72	0.20	0.75	0.81	−0.12	−0.81	0.14	0.46	−0.75	−0.70
Margalef diversity	0.26	−0.54	0.26	0.26	−0.77	0.31	0.77	0.83	−0.26	−0.77	0.03	0.37	−0.66	−0.60
pPR_rich	0.14	−0.43	0.31	−0.03	−0.49	0.60	0.77	0.89	−0.31	−0.77	−0.03	0.37	−0.49	−0.37
RICH	0.26	−0.54	0.26	0.26	−0.77	0.31	0.77	0.83	−0.26	−0.77	0.03	0.37	−0.66	−0.60
PLECOR	0.29	−0.56	0.18	0.29	−0.79	0.09	0.68	0.74	−0.18	−0.74	0.09	0.41	−0.74	−0.68
Baetidae %	−0.71	0.77	0.03	0.49	0.14	0.31	0.20	−0.60	−0.03	0.71	−0.77	−0.94	0.77	0.66
pPR_abund	0.37	−0.60	0.14	0.37	−0.83	0.37	0.83	0.77	−0.14	−0.71	0.09	0.26	−0.60	−0.66
PR_abund	0.37	−0.60	0.14	0.37	−0.83	0.37	0.83	0.77	−0.14	−0.71	0.09	0.26	−0.60	−0.66
Modtol_rich	0.26	−0.53	0.62	0.09	−0.62	0.44	0.35	0.88	−0.62	−0.71	0.09	0.44	−0.44	−0.35
cn_abundp	0.13	−0.39	0.39	−0.13	−0.39	−0.13	0.13	0.65	−0.39	−0.65	0.13	0.65	−0.65	−0.39
EPTR	0.43	−0.60	−0.03	0.43	−0.83	−0.09	0.60	0.54	0.03	−0.60	0.20	0.31	−0.71	−0.77
pGC_abund	−0.31	0.37	0.09	0.20	0.09	−0.89	−0.71	−0.60	−0.09	0.49	−0.14	−0.09	0.09	0.20
bu_richp	−0.70	0.70	−0.15	−0.15	0.52	0.21	0.21	−0.39	0.15	0.39	−0.58	−0.46	0.46	0.58

Table 19. Fish relative abundance and taxa richness for the sampling sites in the Illinois River Basin study area.

[Relative abundance in percent; NC, not collected]

Taxa	Ballard Creek	Baron Fork	Cincinnati Creek	Clear Creek	Evansville Creek	Flint Creek	Fly Creek	Goose Creek	Hamestring Creek
Banded darter	NC	NC	0.34	NC	NC	NC	0.02	0.20	0.10
Banded sculpin	NC	0.93	0.28	NC	0.11	12.66	4.16	11.19	6.66
Bigeye chub	NC	0.46	NC	NC	NC	NC	NC	NC	NC
Bigeye shiner	1.00	0.60	NC	NC	1.22	NC	1.20	0.10	NC
Black bullhead	NC	NC	0.07	NC	NC	NC	NC	NC	NC
Black redhorse	NC	NC	0.21	NC	NC	NC	0.31	0.39	NC
Blackspotted topminnow	NC	NC	0.07	NC	NC	NC	0.22	NC	0.29
Bluegill	0.14	0.20	0.55	5.45	NC	0.18	1.51	0.10	1.83
Bluntnose minnow	0.86	0.07	NC	0.98	1.88	NC	1.35	NC	0.10
Brook silversides	NC	NC	NC	NC	NC	NC	0.05	NC	NC
Cardinal shiner	9.18	2.92	16.46	2.94	6.75	9.54	3.61	18.25	20.85
Carmine shiner	NC	NC	NC	NC	NC	NC	NC	0.88	NC
Creek chub	0.36	0.46	0.62	NC	2.77	3.67	1.92	0.39	2.22
Cyprinella sp.	NC	NC	NC	NC	NC	NC	NC	0.10	NC
Fantail darter	1.29	NC	NC	8.39	2.54	NC	0.63	NC	0.87
Golden redhorse	NC	NC	NC	NC	NC	NC	NC	NC	0.10
Golden shiner	NC	NC	NC	0.11	NC	NC	NC	NC	NC
Green sunfish	5.16	0.46	0.07	9.91	3.87	0.18	9.30	1.18	10.42
Green sunfish x bluegill	NC	NC	NC	NC	NC	NC	0.36	NC	NC
Green sunfish x longear sunfish	NC	NC	NC	NC	NC	NC	NC	NC	NC
Greenside darter	0.07	0.53	0.07	NC	0.22	NC	0.10	0.69	0.68
Largemouth bass	NC	NC	NC	NC	NC	NC	NC	0.20	0.10
Logperch	NC	NC	NC	NC	NC	NC	NC	0.10	NC
Longear sunfish	5.95	6.51	2.82	4.03	8.30	1.10	7.98	0.29	2.51
Longear sunfish x redear sunfish	NC	NC	NC	NC	NC	0.18	NC	NC	NC
Mosquitofish	3.01	NC	0.69	3.38	NC	NC	0.14	NC	NC
Northern hog sucker	NC	0.07	0.07	0.11	0.77	0.37	0.34	0.49	0.87
Northern studfish	NC	NC	0.41	NC	NC	NC	NC	NC	NC
Orangethroat darter	10.75	9.23	9.44	10.57	4.31	2.39	6.49	3.14	12.45
Ozark minnow	2.15	4.12	3.72	NC	10.29	2.94	4.09	4.02	NC
Redear sunfish	NC	NC	NC	NC	NC	NC	NC	NC	NC
Redspot chub	NC	1.26	3.51	NC	NC	5.32	0.07	NC	0.39
Shadow bass	NC	0.13	NC	NC	NC	4.59	0.17	NC	NC
Slender madtom	10.04	13.88	11.78	11.22	11.84	8.07	3.37	4.22	4.63
Smallmouth bass	0.57	0.73	9.57	NC	1.33	3.12	0.41	0.10	NC
Southern redbelly dace	7.17	0.07	NC	NC	NC	NC	0.84	NC	NC
Spotted bass	NC	NC	NC	NC	NC	NC	0.05	NC	NC
Spotted sucker	NC	NC	NC	NC	NC	NC	NC	NC	NC
Stoneroller	40.00	55.98	38.84	42.59	41.26	44.59	50.02	52.99	34.65
Striped shiner	NC	NC	NC	NC	NC	NC	NC	NC	NC
Sunburst darter	1.86	1.26	0.21	NC	2.32	0.92	1.06	NC	0.19
Warmouth	NC	NC	NC	0.11	NC	NC	0.12	NC	NC
White crappie	NC	NC	NC	NC	NC	NC	NC	NC	NC
White sucker	NC	NC	NC	NC	NC	NC	NC	NC	NC
Yellow bullhead	0.43	0.13	0.21	0.22	0.22	0.18	0.17	0.98	0.10
Richness (number of taxa)[1]	18	21	22	14	17	16	28	20	20
Number of individuals	1,395	1,506	1,452	918	904	545	4,162	1,019	1,036

Table 19. Fish relative abundance and taxa richness for the sampling sites in the Illinois River Basin study area.—Continued

[Relative abundance in percent; NC, not collected]

Taxa	Illinois River	Little Osage Creek	Moores Creek	Mud Creek	Osage Creek-Cave Springs	Osage Creek-Rogers	Spring Creek	Weddington Creek	Wildcat Creek
Banded darter	NC	NC	1.58	NC	0.11	0.05	NC	0.10	NC
Banded sculpin	NC	12.25	7.92	NC	6.49	8.29	0.67	5.82	0.61
Bigeye chub	NC	NC	NC	NC	NC	NC	NC	NC	NC
Bigeye shiner	3.31	NC	1.81	1.14	NC	NC	NC	NC	NC
Black bullhead	NC	NC	NC	NC	NC	NC	NC	NC	NC
Black redhorse	1.10	0.17	2.04	NC	0.34	NC	NC	NC	NC
Blackspotted topminnow	0.76	NC	0.45	0.38	NC	NC	NC	0.10	NC
Bluegill	0.42	NC	3.39	5.82	0.57	2.79	0.15	0.41	NC
Bluntnose minnow	3.31	NC	8.37	3.81	NC	NC	NC	NC	NC
Brook silversides	NC	NC	NC	NC	NC	NC	NC	NC	NC
Cardinal shiner	5.85	9.06	17.65	0.54	8.31	0.96	7.76	13.28	14.90
Carmine shiner	NC	NC	NC	NC	NC	NC	NC	NC	NC
Creek chub	NC	5.37	NC	0.05	1.94	2.65	1.12	2.55	1.49
Cyprinella sp.	NC	NC	NC	NC	NC	NC	NC	NC	NC
Fantail darter	0.25	5.20	NC	NC	NC	NC	NC	NC	NC
Golden redhorse	NC	NC	NC	0.05	NC	NC	NC	NC	NC
Golden shiner	NC	NC	NC	NC	NC	NC	NC	NC	NC
Green sunfish	12.03	8.39	11.76	4.08	2.16	10.12	0.82	0.61	1.05
Green sunfish x bluegill	NC	NC	NC	NC	NC	0.72	NC	NC	NC
Green sunfish x longear sunfish	NC	0.17	NC	NC	NC	NC	NC	0.10	NC
Greenside darter	0.17	0.34	0.45	NC	0.23	NC	NC	0.72	0.09
Largemouth bass	NC	0.17	NC	0.38	0.11	NC	NC	NC	NC
Logperch	NC	NC	0.90	NC	0.23	NC	NC	NC	NC
Longear sunfish	21.78	NC	16.29	6.97	0.68	NC	0.97	0.10	0.18
Longear sunfish x redear sunfish	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mosquitofish	NC	0.84	2.49	2.50	0.23	0.29	0.07	0.72	0.18
Northern hog sucker	0.59	1.17	NC	0.11	1.37	NC	0.07	0.82	NC
Northern studfish	NC	NC	NC	NC	NC	NC	NC	0.10	NC
Orangethroat darter	6.27	23.15	4.52	28.14	7.06	7.56	0.75	8.58	13.76
Ozark minnow	6.53	NC	1.36	NC	0.11	NC	NC	3.88	1.93
Redear sunfish	NC	NC	NC	0.05	NC	NC	NC	NC	NC
Redspot chub	0.17	1.51	NC	NC	NC	0.05	NC	2.15	1.14
Shadow bass	0.25	NC	NC	NC	NC	0.19	NC	0.10	NC
Slender madtom	2.71	5.54	0.68	1.36	6.83	0.05	NC	15.53	12.80
Smallmouth bass	0.42	NC	NC	NC	0.68	NC	0.67	3.17	2.10
Southern redbelly dace	NC	1.85	NC	NC	NC	1.69	0.07	NC	NC
Spotted bass	0.17	NC	1.36	NC	NC	NC	NC	NC	NC
Spotted sucker	NC	NC	0.45	NC	NC	NC	NC	NC	NC
Stoneroller	32.97	21.64	15.16	44.53	62.19	63.54	78.96	41.16	48.47
Striped shiner	NC	NC	NC	NC	NC	NC	NC	NC	0.09
Sunburst darter	0.42	2.18	0.23	NC	0.23	0.87	0.45	NC	1.23
Warmouth	0.08	NC	NC	NC	NC	0.19	NC	NC	NC
White crappie	NC	NC	NC	0.05	NC	NC	NC	NC	NC
White sucker	NC	1.01	NC	NC	NC	NC	NC	NC	NC
Yellow bullhead	0.42	NC	1.13	NC	0.11	NC	7.46	NC	NC
Richness (number of taxa)[1]	22	18	21	17	20	15	14	19	15
Number of individuals	1,180	596	442	1,837	878	2,076	1,340	979	1,141

[1] Does not include hybrids or unidentified *Cyprinella*. Stonerollers considered as one species (likely to be two species at many or all sites).

Table 20. List of fish metrics.

[All metrics are for relative abundance unless otherwise noted. --, No reference; GSFYBHBGCC is green sunfish plus yellow bullhead plus bluegill plus channel catfish; PAHINP is algivorous/herbivorous, invertivorous, piscivorous; IBI, Ozark Highlands fish index of biotic integrity; NA is not applicable]

Metric	Reference	Used to calculate index	Expected response to environmental degradation
Algivores+detritivores	Dauwalter and others (2003)	No	Increases
Tolerant	Dauwalter and others (2003)	No	Decreases
Lithophilic spawners	Dauwalter and others (2003)	No	Decreases
Stonerollers	--	No	Increases
Lithophilic spawners minus stonerollers	Dauwalter and others (2003)	No	Decreases
Smallmouth bass	--	No	Decreases
Invertivores	Dauwalter and others (2003)	No	Decreases
Darters+madtoms+sculpins	Dauwalter and others (2003)	No	Decreases
Centrarchidae	--	No	Variable
Bluegill	--	No	Increases
Green sunfish (includes hybrids)	--	No	Increases
Yellow bullhead	--	No	Increases
GSFYBHBGCC	Dauwalter and others (2003)	Yes	Increases
Top carnivores	Dauwalter and others (2003)	Yes	Decreases
PAHINP	Dauwalter and others (2003)	Yes	Increases
Darters+madtoms+sculpins (richness)	Dauwalter and others (2003)	Yes	Decreases
Lithophilic spawners (richness)	Dauwalter and others (2003)	Yes	Decreases
IBI score	Dauwalter and others (2003)	NA	Decreases
IBI category	Dauwalter and others (2003)	NA	NA

Table 21. Fish metric and index of biotic integrity values for sampling sites in the Illinois River Basin study area.

[Sites are sorted by IBI score; all metrics are relative abundance values (percent individuals in sample), unless otherwise noted. GSFYBHBGCC, green sunfish plus yellow bullhead plus bluegill plus channel catfish; PAHINP, percent algivorous/herbivorous, invertivorous, piscivorous; IBI, index of biotic integrity. See table 19 for additional information about metrics. Index values were rounded to nearest whole number.]

Short site name	Algivores plus detritivores	Tolerant	Lithophilic spawners	Stonerollers	Lithophilic spawners minus stonerollers	Smallmouth bass	Invertivores	Darters plus madtom plus sculpins	Centrarchidae
Cincinnati Creek[1]	42.6	57.1	97.7	38.8	58.9	9.6	25.3	22.1	13.0
Weddington Creek[1]	45.0	58.2	91.4	41.2	50.3	3.2	25.2	30.7	4.5
Wildcat Creek[1]	50.4	67.1	98.1	48.5	49.6	2.1	28.1	28.5	3.3
Baron Fork[1]	60.2	77.2	97.7	56.0	41.7	0.7	32.5	25.8	8.0
Flint Creek[1]	47.5	55.4	86.8	44.6	42.2	3.1	12.7	24.0	9.4
Evansville Creek[2]	51.5	72.9	93.7	41.3	52.4	1.3	30.8	21.3	13.5
Ballard Creek[1]	49.3	68.8	90.3	40.0	50.3	0.6	31.0	24.0	11.8
Illinois River[2]	39.5	84.7	82.6	33.0	49.7	0.4	36.8	9.8	35.2
Osage Creek-Cave Springs[3]	62.3	75.4	90.0	62.2	27.8	0.7	15.7	21.2	4.2
Little Osage Creek[1]	23.5	59.7	77.9	21.6	56.2	0.0	37.6	48.7	8.7
Fly Creek[1]	55.0	83.7	82.5	50.0	32.5	0.4	21.4	15.8	19.9
Goose Creek[1]	57.0	63.5	85.5	53.0	32.5	0.1	9.2	19.5	1.9
Moores Creek[1]	16.5	67.6	60.6	15.2	45.5	0.0	29.0	16.3	32.8
Hamestring Creek[3]	34.7	64.8	79.7	34.7	45.1	0.0	21.7	25.6	14.9
Mud Creek[3]	44.5	96.8	83.0	44.5	38.4	0.0	38.1	29.5	17.3
Osage Creek-Rogers[3]	65.2	87.9	77.6	63.5	14.0	0.0	8.5	16.8	14.0
Clear Creek[3]	42.6	77.3	79.8	42.6	37.3	0.0	34.2	30.2	19.5
Spring Creek[3]	79.0	90.3	90.8	79.0	11.9	0.7	2.2	1.9	2.6

Short site name	Bluegill	Green sunfish (includes hybrids)	Yellow bullhead	GSFYBHBGCC	Top carnivores	PAHINP	Darters plus madtoms plus sculpins (richness)	Lithophilic spawners (richness)	IBI score	IBI category
Cincinnati Creek[1]	0.55	0.07	0.21	0.83	9.57	0.76	6	12	89	Least disturbed[4]
Weddington Creek[1]	0.41	0.72	0.00	1.12	3.27	0.41	5	11	88	Least disturbed[4]
Wildcat Creek[1]	0.00	1.05	0.00	1.05	2.10	0.00	5	8	81	Least disturbed[4]
Baron Fork[1]	0.20	0.46	0.13	0.80	0.86	0.33	5	12	80	Least disturbed[4]
Flint Creek[1]	0.18	0.18	0.18	0.55	7.71	0.37	4	11	79	Good
Evansville Creek[2]	0.00	3.87	0.22	4.09	1.33	0.22	6	10	78	Good
Ballard Creek[1]	0.14	5.16	0.43	5.73	0.57	0.57	5	9	71	Good
Illinois River[2]	0.42	12.03	0.42	12.88	0.85	0.85	5	12	71	Good
Osage Creek-Cave Springs[3]	0.57	2.16	0.11	2.85	0.80	0.68	7	10	69	Good
Little Osage Creek[1]	0.00	8.56	0.00	8.56	0.17	0.00	6	8	69	Good
Fly Creek[1]	1.51	9.66	0.17	11.35	0.63	1.68	6	14	68	Good
Goose Creek[1]	0.10	1.18	0.98	2.26	0.29	1.08	4	13	64	Good
Moores Creek[1]	3.39	11.76	1.13	16.29	1.36	4.52	7	8	60	Good
Hamestring Creek[3]	1.83	10.42	0.10	12.36	0.10	1.93	7	9	58	Fair
Mud Creek[3]	5.82	4.08	0.00	9.91	0.44	5.82	2	9	52	Fair
Osage Creek-Rogers[3]	2.79	10.84	0.00	13.63	0.19	2.79	5	6	48	Fair
Clear Creek[3]	5.45	9.91	0.22	15.58	0.00	5.66	3	6	45	Fair
Spring Creek[3]	0.15	0.82	7.46	8.43	0.67	7.61	3	6	36	Poor

[1] Agriculture site (Baron Fork and Goose Creek are downstream from wastewater-treatment plants).

[2] Forest site.

[3] Urban site (Osage Creek-Cave Springs and Spring Creek are downstream from wastewater-treatment plants).

[4] Categorized here as “least disturbed,” but score is equivalent to “reference” in Dauwalter and others (2003).

Table 22. Correlations between fish metrics and Ozark Highlands fish index of biotic integrity and selected environmental factors for sites not affected by wastewater-treatment plants in the Illinois River Basin study area.

[Fish metrics are sorted by absolute value of correlation with percent forest; red font denotes absolute value of rho is greater than or equal to 0.50; metric descriptions are listed in table 20; GSFYBHBGCC is green sunfish plus yellow bullhead plus bluegill plus channel catfish; PAHINP is algivorous/herbivorous, invertivorous, piscivorous; number of sites equals 14]

Fish metrics, relative abundance (unless otherwise noted)	Nitrite plus nitrate	Total phosphorus	Temperature	Specific conductance	Dissolved oxygen	pH	Streamflow	Bankfull width	Drainage area	Bankfull width/ drainage area	Depth	Velocity
Lithophilicspawners (richness)	−0.11	−0.07	0.09	−0.13	0.19	−0.10	−0.45	0.50	0.12	0.03	−0.53	−0.55
Smallmouth bass	0.14	0.32	0.43	−0.36	0.29	0.35	0.04	0.45	0.02	0.09	−0.40	−0.05
Top carnivores	0.21	0.42	0.38	−0.33	0.13	0.20	−0.06	0.31	0.21	−0.09	−0.35	−0.09
IBI score	0.26	0.37	0.38	−0.32	0.34	0.39	0.11	0.42	0.18	−0.02	−0.40	−0.00
Darters+madtoms+sculpins	0.30	0.20	0.04	0.25	−0.08	0.61	0.61	−0.20	−0.19	0.12	0.39	0.49
Lithophilic spawners	−0.02	0.10	0.66	−0.28	0.17	0.51	−0.05	0.70	−0.31	0.49	−0.54	−0.10
Yellow bullhead	−0.68	0.22	0.44	−0.70	−0.13	−0.16	−0.57	0.17	0.08	0.03	−0.34	−0.48
GSFYBHBGCC	−0.42	−0.22	−0.37	0.08	−0.42	−0.56	−0.35	−0.33	0.08	−0.06	0.35	−0.23
Lithophilic spawners minus stonerollers	−0.04	0.23	0.46	−0.30	0.03	0.24	−0.01	0.32	0.31	−0.08	−0.25	0.00
Bluegill	−0.34	−0.07	−0.15	0.33	−0.56	−0.49	−0.31	−0.18	−0.20	0.10	0.41	−0.22
PAHINP	−0.48	−0.12	−0.09	0.27	−0.54	−0.50	−0.40	−0.12	−0.20	0.14	0.32	−0.33
Green sunfish (includes hybrids)	−0.35	−0.30	−0.47	−0.01	−0.16	−0.52	−0.31	−0.24	0.22	−0.14	0.25	−0.26
Darters+madtoms+sculpins (richness)	0.13	0.09	−0.14	0.04	0.08	−0.53	−0.21	−0.14	0.16	−0.29	0.00	−0.05
Algivores+detritivores	0.18	−0.23	0.05	0.15	0.34	0.04	0.08	0.07	−0.28	0.12	−0.36	0.02
Tolerant	−0.47	−0.60	−0.07	0.19	−0.32	−0.34	−0.49	0.15	−0.11	0.28	−0.18	−0.42
Centrarchidae	−0.63	−0.35	−0.16	−0.11	−0.45	−0.64	−0.75	0.05	−0.02	0.13	−0.03	−0.56
Invertivores	−0.48	−0.18	0.37	−0.17	−0.42	0.30	−0.28	0.33	0.10	0.31	−0.23	−0.26
Stonerollers	0.30	−0.24	−0.11	0.28	0.21	0.07	0.20	−0.02	−0.45	0.23	−0.13	0.19
Fish per meter	−0.12	−0.00	0.30	0.41	−0.01	−0.09	−0.28	0.57	−0.54	0.56	−0.37	−0.39

Table 22. Correlations between fish metrics and Ozark Highlands fish index of biotic integrity and selected environmental factors for sites not affected by wastewater-treatment plants in the Illinois River Basin study area.—Continued

[Fish metrics are sorted by absolute value of correlation with percent forest; red font denotes absolute value of rho is greater than or equal to 0.50; metric descriptions are listed in table 20; GSFYBHBGCC is green sunfish plus yellow bullhead plus bluegill plus channel catfish; PAHINP is algivorous/herbivorous, invertivorous, piscivorous; number of sites equals 14]

Fish metrics, relative abundance (unless otherwise noted)	Bed substrate	Embed-dedness	Substrate turbidity	Open canopy angle	Combined canopy closure	Bank height	Bank angle	Percent forest	Percent urban	Percent agricul-ture	Poultry house density	Total unpaved road density	Total paved road density	Total road density
Lithophilic spawners (richness)	0.38	−0.53	−0.09	0.18	−0.33	0.39	0.46	0.85	−0.79	−0.11	0.25	0.23	−0.73	−0.71
Smallmouth bass	0.20	−0.35	−0.39	0.50	−0.50	−0.17	0.02	0.67	−0.73	0.29	0.41	0.50	−0.75	−0.74
Top carnivores	0.04	−0.05	0.01	0.45	−0.35	0.11	0.12	0.64	−0.64	0.32	0.42	0.66	−0.72	−0.63
IBI score	0.17	−0.41	−0.34	0.46	−0.45	0.36	0.17	0.61	−0.73	0.47	0.44	0.56	−0.73	−0.74
Darters+madtoms+sculpins	−0.09	−0.04	−0.52	−0.04	0.22	−0.47	−0.36	−0.54	0.36	0.38	−0.06	−0.17	0.45	0.41
Lithophilic spawners	0.19	−0.27	−0.31	0.51	−0.61	−0.24	−0.15	0.53	−0.57	0.10	0.20	0.35	−0.56	−0.59
Yellow bullhead	0.21	−0.18	0.06	−0.50	0.19	0.37	−0.06	0.51	−0.38	−0.10	0.49	0.37	−0.42	−0.44
GSFYBHBGCC	0.01	0.29	0.35	−0.48	0.27	0.21	0.07	−0.39	0.46	−0.33	−0.34	−0.46	0.47	0.41
Lithophilic spawners minus stonerollers	0.24	−0.58	−0.34	0.12	−0.26	−0.12	0.18	0.36	−0.52	0.40	0.36	0.28	−0.50	−0.59
Bluegill	−0.18	0.55	0.26	−0.28	0.25	0.33	−0.12	−0.36	0.56	−0.49	−0.27	−0.48	0.51	0.55
PAHINP	−0.19	0.49	0.28	−0.34	0.24	0.37	−0.16	−0.32	−0.56	0.53	−0.28	−0.52	0.52	0.51
Green sunfish (includes hybrids)	0.03	0.13	0.35	−0.39	0.19	0.28	0.24	−0.27	0.32	−0.28	−0.33	−0.42	0.36	0.27
Darters+madtoms+sculpins (richness)	0.11	−0.01	0.14	−0.32	0.05	0.31	0.73	0.21	−0.22	0.21	0.14	0.26	−0.27	−0.22
Algivores+detritivores	−0.15	0.07	0.11	0.40	−0.36	−0.32	−0.30	0.17	−0.15	−0.25	−0.17	0.07	−0.14	−0.12
Tolerant	−0.01	0.15	0.54	0.01	−0.19	0.11	−0.17	−0.15	0.27	−0.68	−0.54	−0.53	0.32	0.23
Centrarchidae	0.23	0.15	0.49	−0.41	0.14	0.55	0.21	0.13	0.08	−0.58	−0.18	−0.27	0.05	0.07
Invertivores	0.24	−0.34	0.06	−0.19	0.02	−0.02	−0.21	−0.11	0.06	−0.05	−0.03	−0.19	0.14	0.00
Stonerollers	−0.17	0.34	0.15	0.40	−0.21	−0.33	−0.34	−0.09	0.16	−0.28	−0.25	−0.03	0.10	0.20
Fish per meter	−0.02	0.17	−0.12	0.16	−0.42	−0.08	0.01	0.05	0.09	−0.21	0.01	0.47	0.76	0.94

Table 23. Correlation between fish metrics and Ozark Highlands fish index of biotic integrity and selected environmental factors at agriculture gradient sites in the Illinois River Basin study area.

[Fish metrics are sorted by absolute value of correlation with percent agriculture; red font denotes absolute value of rho is greater than or equal to 0.60; metric descriptions are listed in table 20; number of sites equals 10]

Fish metrics, relative abundance (unless otherwise noted)	Nitrite plus nitrate	Total phosphorus	Temperature	Specific conductance	Dissolved oxygen	pH	Streamflow	Bankfull width	Drainage area	Bankfull width/drainage area	Depth	Velocity
Darters+madtoms+sculpins	0.70	0.27	−0.03	0.39	0.31	0.69	0.92	−0.38	0.08	−0.35	0.53	0.77
Centrarchidae	−0.71	−0.21	−0.07	−0.37	−0.43	−0.76	−0.86	0.15	0.20	0.08	−0.32	−0.70
Lithophilic spawners (richness)	−0.28	−0.32	−0.22	0.09	0.00	−0.53	−0.49	0.35	−0.15	0.27	−0.29	−0.46
Tolerant	−0.58	−0.48	−0.03	−0.22	−0.08	−0.38	−0.77	0.38	−0.01	0.41	−0.64	−0.77
Yellow bullhead	−0.80	0.24	0.45	−0.56	−0.26	−0.33	−0.61	0.17	0.18	0.01	−0.28	−0.55
PAHINP	−0.51	0.29	−0.05	−0.01	−0.31	−0.72	−0.64	0.07	0.22	−0.12	−0.16	−0.77
Algivores+detritivores	0.04	−0.39	0.27	0.10	0.41	0.15	−0.15	0.32	−0.83	0.58	−0.76	−0.12
Bluegill	−0.28	0.35	−0.19	0.12	−0.36	−0.72	−0.46	−0.06	0.20	−0.22	0.06	−0.57
Fish per meter	−0.09	0.02	0.29	0.37	0.15	−0.29	−0.32	0.62	−0.58	0.59	−0.59	−0.43
Stonerollers	0.30	−0.33	0.05	0.14	0.48	0.26	0.05	0.24	−0.81	0.48	−0.54	0.04
Green sunfish (includes hybrids)	−0.33	−0.22	−0.38	−0.13	−0.13	−0.38	−0.49	−0.04	0.47	−0.12	−0.20	−0.61
IBI score	0.09	0.06	0.39	−0.06	0.04	0.37	0.26	0.41	−0.40	0.41	0.18	0.38
Smallmouth bass	0.02	0.14	0.44	−0.07	0.06	0.30	0.18	0.38	−0.47	0.38	0.10	0.27
Invertivores	−0.32	−0.20	0.04	−0.21	−0.13	0.01	−0.14	0.12	0.50	−0.01	0.01	−0.09
Lithophilic spawners	−0.03	−0.08	0.64	−0.13	0.09	0.38	0.07	0.62	−0.70	0.72	−0.22	0.25
GSFYBHBGCC	−0.37	−0.08	−0.32	−0.01	−0.30	−0.52	−0.52	−0.14	0.52	−0.21	−0.10	−0.64
Lithophilic spawners minus stonerollers	−0.16	−0.03	0.36	0.09	−0.29	−0.03	0.09	0.13	0.16	0.07	0.20	0.31
Darters+madtoms+sculpins (richness)	−0.10	0.00	−0.01	0.27	−0.70	−0.74	−0.34	−0.32	0.07	−0.16	0.01	−0.08
Top carnivores	0.07	0.30	0.27	−0.21	−0.25	0.10	0.12	0.14	−0.36	0.18	0.33	0.30

Table 23. Correlation between fish metrics and Ozark Highlands fish index of biotic integrity and selected environmental factors at agriculture gradient sites in the Illinois River Basin study area.—Continued

[Fish metrics are sorted by absolute value of correlation with percent agriculture; red font denotes absolute value of rho is greater than or equal to 0.60; metric descriptions are listed in table 20; number of sites equals 10]

Fish metrics, relative abundance (unless otherwise noted)	Bed substrate	Embed-dedness	Substrate turbidity	Open canopy angle	Combined canopy closure	Bank height	Bank angle	Percent forest	Percent urban	Percent agricul-ture	Poultry house density	Total unpaved road density	Total paved road density	Total road density
Darters+madtoms+sculpins	−0.43	−0.03	−0.66	0.20	0.12	−0.78	−0.43	−0.69	0.47	0.79	0.05	0.10	0.44	0.48
Centrarchidae	0.41	−0.09	0.64	−0.37	0.09	0.84	0.44	0.60	−0.36	−0.72	−0.02	−0.18	−0.30	−0.36
Lithophilic spawners (richness)	0.58	−0.22	−0.07	0.24	−0.25	0.32	0.41	0.78	−0.71	−0.69	−0.07	−0.20	−0.81	−0.63
Tolerant	0.44	−0.37	0.55	−0.30	−0.25	0.38	0.35	0.42	−0.37	−0.50	−0.37	−0.46	−0.12	−0.39
Yellow bullhead	−0.14	0.04	0.39	−0.46	0.24	0.74	−0.15	0.31	−0.10	−0.50	0.33	−0.02	−0.02	−0.19
PAHINP	0.04	0.12	0.31	−0.38	0.11	0.73	0.41	0.34	−0.18	−0.41	0.21	0.12	−0.52	−0.17
Algivores+detritivores	0.15	0.10	0.08	0.08	−0.21	−0.19	−0.23	0.39	−0.42	−0.37	0.01	0.04	0.07	−0.37
Bluegill	0.03	0.28	0.24	−0.24	0.12	0.63	0.49	0.25	−0.10	−0.28	0.20	0.26	−0.63	−0.07
Fish per meter	0.16	0.13	−0.15	0.29	−0.60	−0.22	0.27	0.26	−0.28	−0.24	0.14	0.03	−0.54	−0.44
Stonerollers	0.09	0.26	0.02	0.26	−0.20	−0.21	−0.16	0.29	−0.33	−0.21	−0.04	0.25	−0.20	−0.21
Green sunfish (includes hybrids)	0.20	−0.32	0.56	−0.52	0.10	0.49	0.47	0.02	0.07	−0.13	−0.30	−0.25	0.19	0.10
IBI score	0.06	0.09	−0.58	0.81	−0.52	−0.52	−0.32	0.13	−0.32	0.02	−0.06	−0.09	−0.36	−0.41
Smallmouth bass	−0.01	0.19	−0.54	0.69	−0.40	−0.35	−0.38	0.25	−0.39	−0.11	0.07	0.02	−0.45	−0.44
Invertivores	0.15	−0.60	0.07	−0.18	−0.10	−0.09	0.09	−0.20	0.19	0.10	−0.22	−0.59	0.53	0.15
Lithophilic spawners	0.08	0.15	−0.36	0.72	−0.66	−0.56	−0.37	0.18	−0.33	−0.09	−0.05	−0.12	−0.18	−0.50
GSFYBHBGCC	0.16	−0.29	0.52	−0.60	0.14	0.48	0.49	−0.01	0.08	−0.09	−0.24	−0.26	0.20	0.09
Lithophilic spawners minus stonerollers	0.20	−0.44	−0.46	0.21	−0.25	−0.50	−0.10	−0.04	−0.03	0.07	0.03	−0.56	0.17	−0.27
Darters+madtoms+sculpins (richness)	0.20	0.19	0.50	−0.45	0.15	0.14	0.47	−0.02	0.18	−0.06	0.10	−0.01	0.23	0.06
Top carnivores	−0.10	0.60	−0.15	0.58	−0.20	−0.01	−0.20	0.15	−0.19	−0.05	0.09	0.37	−0.54	−0.19

Table 24. Correlation between fish metrics and Ozark Highlands fish index of biotic integrity and selected environmental factors at urban gradient sites in the Illinois River Basin study area.

[Fish metrics are sorted by absolute value of correlation with percent urban; red font denotes absolute value of rho is greater than or equal to 0.80; metric descriptions are listed in table 20; number of sites equals 6]

Fish metrics, relative abundance (unless otherwise noted)	Nitrite plus nitrate	Total phosphorus	Tempera-ture	Specific conduc-tance	Dissolved oxygen	pH	Stream-flow	Bankfull width	Drainage area	Bankfull width/ drainage area	Depth	Velocity
Lithophilic spawners minus stonerollers	−0.49	−0.71	0.54	−0.66	0.09	0.14	−0.77	0.71	0.09	0.03	−0.83	−0.71
Yellow bullhead	−0.84	−0.41	0.32	−0.99	−0.12	0.06	−0.75	0.49	0.06	0.03	−0.70	−0.49
Smallmouth bass	−0.54	−0.85	0.51	−0.78	−0.03	0.03	−0.78	0.54	0.30	−0.14	−0.85	−0.54
Stonerollers	0.60	0.26	−0.09	0.77	−0.26	0.09	0.60	−0.60	−0.03	0.09	0.49	0.60
Bluegill	0.26	0.60	−0.09	0.77	−0.43	0.43	0.43	−0.26	−0.20	0.43	0.49	0.26
PAHINP	0.26	0.60	−0.09	0.77	−0.43	0.43	0.43	−0.26	−0.20	0.43	0.49	0.26
IBI score	−0.26	−0.83	0.37	−0.54	0.31	−0.09	−0.66	0.66	0.31	−0.26	−0.71	−0.66
Lithophilic spawners (richness)	−0.53	−0.79	0.38	−0.62	0.15	0.09	−0.85	0.88	0.44	−0.18	−0.79	−0.88
Fish per meter	0.20	0.66	−0.03	0.71	−0.37	0.49	0.37	−0.14	−0.37	0.54	0.43	0.14
Tolerant	0.09	−0.14	−0.03	0.49	−0.31	0.26	−0.03	0.14	0.60	−0.09	0.09	−0.14
Lithophilic spawners	−0.54	−0.71	0.94	−0.31	−0.54	0.71	−0.83	0.71	0.03	0.49	−0.94	−0.71
Darters+madtoms+sculpins (richness)	0.23	−0.15	−0.26	−0.38	0.75	−0.67	0.12	−0.12	−0.12	−0.46	0.03	0.12
Top carnivores	−0.26	−1.00	0.49	−0.37	0.03	0.09	−0.71	0.66	0.60	−0.26	−0.77	−0.66
GSFYBHBGCC	−0.09	0.71	−0.60	−0.03	−0.09	−0.26	0.43	−0.54	−0.09	−0.09	0.60	0.54
Algivores+detritivores	0.37	−0.31	0.14	0.31	−0.20	−0.03	0.20	−0.37	0.26	−0.14	0.03	0.37
Darters+madtoms+sculpins	0.03	0.60	0.37	0.43	−0.60	0.66	0.26	−0.26	−0.83	0.89	0.14	0.26
Green sunfish (includes hybrids)	−0.03	0.20	−0.83	−0.20	0.54	−0.66	0.14	−0.03	0.54	−0.71	0.43	0.03
Invertivores	−0.66	−0.26	0.60	−0.09	−0.66	0.83	−0.71	0.77	0.14	0.54	−0.60	−0.77
Centrarchidae	−0.66	0.26	−0.09	−0.26	−0.31	0.31	−0.37	0.43	0.14	0.20	−0.09	−0.43

Table 24. Correlation between fish metrics and Ozark Highlands fish index of biotic integrity and selected environmental factors at urban gradient sites in the Illinois River Basin study area.—Continued

[Fish metrics are sorted by absolute value of correlation with percent urban; red font denotes absolute value of rho is greater than or equal to 0.80; metric descriptions are listed in table 20; number of sites equals 6]

Fish metrics, relative abundance (unless otherwise noted)	Bed substrate	Embed-dedness	Sub-strate turbidity	Open canopy angle	Com-bined canopy closure	Bank height	Bank angle	Percent forest	Percent Urban	Percent agricul-ture	Poultry house density	Total unpaved road density	Total paved road density	Total road density
Lithophilic spawners minus stonerollers	0.54	−0.77	0.20	−0.14	−0.54	0.43	0.60	1.00	−0.94	−0.20	0.37	0.66	−0.71	−0.66
Yellow bullhead	0.93	−0.99	−0.32	−0.20	−0.46	−0.12	0.35	0.73	−0.87	0.32	0.81	0.81	−0.93	−0.99
Smallmouth bass	0.54	−0.78	0.27	0.14	−0.78	−0.03	0.37	0.85	−0.85	−0.27	0.37	0.68	−0.85	−0.78
Stonerollers	−0.77	0.83	0.37	0.26	0.31	−0.43	−0.71	−0.77	0.83	−0.37	−0.60	−0.54	0.66	0.77
Bluegill	−0.43	0.66	0.03	−0.09	0.66	−0.09	−0.71	−0.77	0.83	−0.03	−0.26	−0.54	0.83	0.77
PAHINP	−0.43	0.66	0.03	−0.09	0.66	−0.09	−0.71	−0.77	0.83	−0.03	−0.26	−0.54	0.83	0.77
IBI score	0.31	−0.60	0.37	0.14	−0.71	0.49	0.71	0.94	−0.83	−0.37	0.09	0.43	−0.60	−0.54
Lithophilic spawners (richness)	0.53	−0.74	0.29	0.18	−0.74	0.50	0.62	0.91	−0.79	−0.29	0.27	0.41	−0.56	−0.62
Fish per meter	−0.31	0.54	−0.09	−0.31	0.77	0.14	−0.54	−0.60	0.66	0.09	−0.14	−0.43	0.77	0.71
Tolerant	−0.37	0.43	0.54	0.66	−0.20	−0.14	−0.54	−0.49	0.66	−0.54	−0.43	−0.60	0.60	0.49
Lithophilic spawners	0.37	−0.54	0.54	−0.14	−0.37	0.14	−0.09	0.71	−0.60	−0.54	0.31	0.60	−0.43	−0.31
Darters+madtoms+sculpins (richness)	0.06	−0.23	−0.23	−0.12	−0.20	0.32	0.84	0.49	−0.55	0.23	−0.03	0.23	−0.46	−0.38
Top carnivores	0.14	−0.43	0.71	0.49	−0.89	0.20	0.31	0.71	−0.54	−0.71	−0.09	0.26	−0.43	−0.37
GSFYBHBGCC	0.14	0.14	−0.71	−0.03	0.37	−0.60	−0.37	−0.71	0.49	0.71	0.26	−0.20	0.14	−0.03
Algivores+detritivores	−0.54	0.43	0.60	0.49	−0.26	−0.54	−0.49	−0.31	0.37	−0.60	−0.49	−0.20	0.14	0.31
Darters+madtoms+sculpins	−0.09	0.26	−0.20	−0.77	0.89	−0.09	−0.60	−0.31	0.26	0.20	0.20	0.14	0.31	0.43
Green sunfish (includes hybrids)	0.14	−0.03	−0.43	0.49	−0.26	0.03	0.37	−0.26	0.20	0.43	−0.03	−0.43	0.09	−0.20
Invertivores	0.43	−0.37	0.26	−0.09	−0.09	0.20	−0.31	0.26	−0.14	−0.26	0.37	0.20	0.03	−0.09
Centrarchidae	0.60	−0.37	−0.43	−0.09	0.09	0.03	−0.14	−0.09	0.03	0.43	0.54	0.03	0.03	−0.26

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