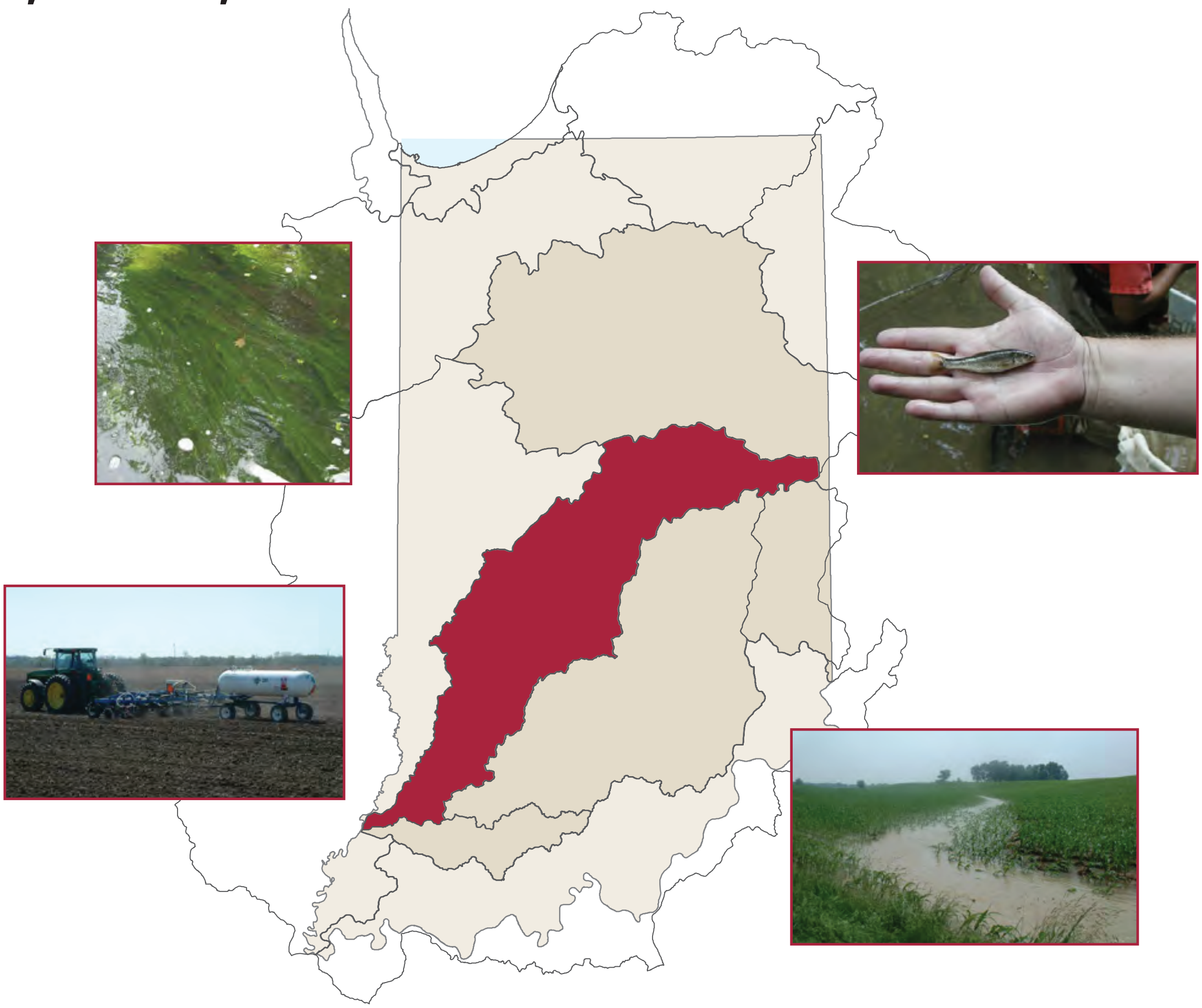
Prepared in cooperation with the Indiana Department of Environmental Management, Division of Water, Assessment Branch

Relations of Principal Components Analysis Site Scores to Algal-Biomass, Habitat, Basin-Characteristics, Nutrient, and Biological-Community Data in the West Fork White River Basin, Indiana, 2001



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U.S. Department of the Interior
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By Jeffrey W. Frey, Brian J. Caskey, and B. Scott Lowe

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Conversion Factors and Datum

Multiply	By	To obtain
centimeter (cm)	0.3937	inch (in.)
square kilometer (km^2)	0.3861	square mile (mi^2)
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
liter (L)	0.2642	gallon (gal)

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

$$°F=(1.8×°C)+32$$

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

Concentrations of chemical and algal-biomass constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L). Concentrations of periphyton algal biomass are given in milligrams per meter squared (mg/m^2).

Abbreviations

Abbreviations and acronyms used in this report:

PC1	Principal components analysis first axis site score
EPT	Ephemeroptera, Plecoptera, and Trichoptera
USEPA	U.S. Environmental Protection Agency
N	nitrogen
P	phosphorus
CWA	Clean Water Act
IBI	Index of Biotic Integrity
TN	total nitrogen
TP	total phosphorus
CHLa	chlorophyll *a*
TKN	total Kjeldahl nitrogen
IDEM	Indiana Department of Environmental Management
USGS	U.S. Geological Survey
WMP	Watershed Monitoring Program
PCA	Principal components analysis
AFDM	ash-free dry mass
POC	particulate organic carbon
IN	Indiana
NAWQA	National Water-Quality Assessment Program
NWQL	National Water Quality Laboratory
QHEI	Qualitative Habitat Evaluation Index
NLCD	National Land Cover Dataset
r_s	Spearman’s rho statistic

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By Jeffrey W. Frey, Brian J. Caskey, and B. Scott Lowe

Abstract

Data were gathered from July through September 2001 at 34 randomly selected sites in the West Fork White River Basin, Indiana for algal biomass, habitat, nutrients, and biological communities (fish and invertebrates). Basin characteristics (drainage area and land use) and biological-community attributes and metric scores were determined for the basin of each sampling site. Yearly Principal Components Analysis site scores were calculated for algal biomass (periphyton and seston). The yearly Principal Components Analysis site scores for the first axis (PC1) were related, using Spearman's rho, to the seasonal algal-biomass, basin-characteristics, habitat, seasonal nutrient, biological-community attribute and metric score data.

The periphyton PC1 site score, which was most influenced by ash-free dry mass, was negatively related to one (percent closed canopy) of nine habitat variables examined. Of the 43 fish-community attributes and metric scores examined, the periphyton PC1 was positively related to one fish-community attribute (percent tolerant). Of the 21 invertebrate-community attributes and metric scores examined, the periphyton PC1 was positively related to one attribute (Ephemeroptera, Plecoptera, and Trichoptera (EPT) index) and one metric score (EPT index metric score). The periphyton PC1 was not related to the five basin-characteristic or 12 nutrient variables examined. The seston PC1 site score, which was most influenced by particulate organic carbon, was negatively related to two of the 12 nutrient variables examined: total Kjeldahl nitrogen (July) and total phosphorus (July). Of the 43 fish-community attributes and metric scores examined, the seston PC1 was negatively related to one attribute (large-river percent). Of the 21 invertebrate-community attributes and metric scores examined, the seston PC1 was negatively related to one attribute (EPT-to-total ratio). The seston PC1 was not related to the five basin-characteristics or nine habitat variables examined.

To understand how the choice of sampling sites might have affected the results, an analysis of the drainage area and land use was done. The 34 randomly selected sites in the West Fork White River Basin in 2001 were skewed to small streams. The dominant mean land use of the sites sampled was agriculture, followed by forest, and urban.

The values for nutrients (nitrate, total Kjeldahl nitrogen, total nitrogen, and total phosphorus) and chlorophyll *a* (periphyton and seston) were compared to published U.S. Environmental Protection Agency (USEPA) values for Aggregate Nutrient Ecoregions VI and IX and Level III Ecoregions 55 and 72. Several nutrient values were greater than the 25th percentile of the published USEPA values. Chlorophyll *a* (periphyton and seston) values were either greater than the 25th percentile of published USEPA values or extended data ranges in the Aggregate Nutrient Ecoregions and Level III Ecoregions. If the proposed values for the 25th percentile were adopted as nutrient water-quality criteria, many samples in the West Fork White River Basin would have exceeded the criteria.

Introduction

Excessive inputs of nutrients into streams have human-health, economic, and ecological consequences. Excess amounts of nutrients—nitrogen (N) and phosphorus (P)—have been shown to be a source of eutrophication in aquatic ecosystems, which sometimes has been linked to fish kills, shifts in species composition, taste and odor in drinking-water supplies, and blooms of harmful algae in freshwater and estuaries (Munn and Hamilton, 2003; U.S. Environmental Protection Agency, 2000a,b).

The Clean Water Act (CWA) established a national goal of achieving water quality that provides for the protection and propagation of aquatic organisms and wildlife, and recreation in and on the water. In 1996, the U.S. Environmental Protection Agency's (USEPA) National Water Quality Inventory identified excess amounts of nutrients as the second leading cause of impairment in rivers and streams across the United States (the first cause was siltation) (U.S. Environmental

Protection Agency, 1997a). The excess amounts of nutrients that have been documented in many rivers and streams have resulted in streams that do not meet the goal of the CWA in Indiana and the nation.

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

Many streams have been placed by the USEPA on the CWA Section 303(d) list of impaired water bodies because of excess amounts of nutrients. In 2000, the USEPA proposed nutrient water-quality criteria for causal variables—total nitrogen (TN) and total phosphorus (TP)—and for response variables—periphyton and seston chlorophyll *a* (CHLa) and turbidity. Criteria also have been proposed for nitrate and total Kjeldahl nitrogen (TKN) because TN is the sum of nitrate and TKN. These proposed nutrient water-quality criteria are based on Aggregate Nutrient Ecoregions, areas with similar geographic features (topography, soils, geology, land use, and biogeography) (U.S. Environmental Protection Agency, 2000a,b). USEPA reviewed selected data and set the proposed nutrient water-quality criteria for nitrate, TKN, TN, TP, CHLa (periphyton and seston), and turbidity at the 25th-percentile value of all data for each parameter.

USEPA mandated that by 2004 states either accept the proposed nutrient water-quality criteria or provide their own set of criteria that are more appropriate to the waters within each state (U.S. Environmental Protection Agency, 2000a,b). An extension was given to Indiana and other states that adopted plans describing the data needs and the process to develop nutrient water-quality criteria. Beginning in 2001, the Indiana Department of Environmental Management (IDEM) and the U.S. Geological Survey (USGS) are cooperating on several studies that will assist the State of Indiana in developing nutrient water-quality criteria as mandated by the USEPA. The multivariate approach used in this report should allow the results to be used in similar ecoregions in Illinois and Ohio.

Purpose and Scope

Data in this report were collected as part of an ongoing cooperative effort between IDEM and the USGS in which similar studies have been conducted as part of the IDEM probabilistic Watershed Monitoring Program (WMP) in the Whitewater River and East Fork White River Basins (2002), Upper Wabash River Basin (2003), Lower Wabash River and Kankakee River Basins (2004), and Ohio River and Great Lakes Basins (2005) (Indiana Department of Environmental Management, 2001). In all of these yearly WMP studies, IDEM collected habitat and biological-community data and the nutrient data from 2001 through 2003; to augment the IDEM WMP studies and better understand nutrient enrichment in streams, the USGS collected algal biomass during all years of the study and also collected nutrients in 2004 and 2005. The long-term goal of these studies is to provide data and analysis to aid IDEM in the development of nutrient water-quality criteria. An objective of this report was to develop a preliminary understanding of how algal biomass relates to biological community and environmental variables in the West Fork White River Basin in 2001. In this report, the environmental vari ables included nutrients, habitat, and basin characteristics. An additional purpose of this report was to compile a list of the most statistically significant relations between algal biomass, nutrients, habitat, and biological attributes and metrics that may be helpful in future investigations.

Two approaches were used for the preliminary analysis of the data sets. The first approach included ordination and regression analyses of the algal biomass, nutrient, and environmental data. The second approach compared the CHLa and nutrient values collected by IDEM and USGS personnel to USEPA published values. The purpose of this preliminary analysis was to investigate all potential relations and identify those relations that were the strongest and warrant further investigation.

This report discusses the relations of yearly Principal Components Analysis (PCA) site axis scores, which represent algal biomass (periphyton and seston), to habitat, basin characteristics, nutrient, and biological-community (fish and invertebrates) attributes and metric scores (appendix 1; Dufour, 2002). Data were collected at 34 randomly selected sites in the West Fork White River Basin in 2001. A discussion of the basin characteristics of the 34 sites describes how drainage area and land use affect the analysis. This report also compares nutrient values (nitrate plus nitrite as N, TKN as N, TN as N, TP as P) and CHLa (periphyton and seston) collected by IDEM and USGS for the West Fork White River Basin to values published by the USEPA for both Aggregate Nutrient Ecoregions (VI, Corn Belt and Northern Great Plains; IX, Southeastern Temperate Forested Plains and Hills) (U.S. Environmental Protection Agency, 2000a,b) and for Level III

Ecoregions (55, Eastern Corn Belt Plains; 71, Interior Plateau; and 72, Interior River Lowland) (U.S. Environmental Protection Agency, 1997b). Aggregate Nutrient Ecoregions consist of one or more Level III Ecoregions (U.S. Environmental Protection Agency, 2000a,b).

In the text, the Aggregate Nutrient Ecoregions are referred to as Ecoregion VI or IX; Level III Ecoregions are referred to as Ecoregion 55, 71, or 72. The nutrients are described as concentrations of nitrate, TKN, TN, and TP. In this report, periphyton CHLa, ash-free dry mass (AFDM), seston CHLa, and particulate organic carbon (POC) are considered measures of algal biomass.

This report provides data from the West Fork of the White River. The White River drains a substantial area of central Indiana (fig. 1). The White River is joined by the East Fork White River near Petersburg, Indiana, before flowing into the Wabash River. The White River is labeled as such on USGS maps above the confluence with the East Fork White River but commonly is referred to as the “West Fork” of the White River. The IDEM Probabilistic Watershed Program refers to the West Fork White River Basin. In this report, the “West Fork White River Basin” will be used.

Description of the West Fork White River Basin

The West Fork White River Basin drains more than 12,414 km^2 (Hogatt, 1975) of central and southern Indiana and is joined by the East Fork White River at Petersburg, Ind., before flowing into the Wabash River. In water year 2001, the annual mean streamflow at the USGS streamflow-gaging station West Fork White River at Newberry, IN (03360500) (fig. 1), was 119.6 m^3/s, which was below the annual mean long-term streamflow (1929-2001) of 137.7 m^3/s at Newberry (Stewart and others, 2002).

The climate in the West Fork White River Basin is characterized as humid continental with well-defined winter and summer seasons. The mean monthly temperature ranges from -2.78°C in winter to 23.9°C in summer (Schnoebelen and others, 1999). The mean annual precipitation ranges from about 96.5 cm in the northern part of the basin to 111.8 cm in the south (Schnoebelen and others, 1999).

The dominant land use is agriculture (71 percent), primarily row crops such as corn and soybeans. Nineteen percent of the basin area is forested (Baker and Frey, 1997). Typical of many streams in the state, most streams in the West Fork White Rive Basin have low gradients and velocities. The largest urban areas are Indianapolis (population about 791,930), Muncie (population about 67,430), and Anderson (population about 59,730) (U.S. Census Bureau, 2000) (fig. 1).

Study Methods

This study used field and analytical methods from the IDEM and the USGS. The following sections describe the site selection and sampling strategies; field and laboratory methods used in collecting, processing, and analyzing algal-biomass, habitat, basin-characteristics, nutrients, and biological-community data; and data analysis used in this report.

Site Selection and Sampling Strategies

Sampling sites were selected randomly by the USEPA as part of the IDEM probabilistic Watershed Monitoring Program (WMP) (Indiana Department of Environmental Management, 1999, 2001). Each selected sampling site (table 1) represents a specific stream order; therefore, statistically valid extrapolations can be made from the randomly sampled streams to the entire class of streams of that order in a particular basin. The IDEM WMP works on a 5-year rotating basin schedule, focusing on 1–2 selected basins each year, with a complete assessment of the state at the end of each 5-year cycle. In 2001, the focus was the West Fork White River. After the sampling sites were selected and prior to collection of field data, IDEM personnel completed a visual assessment of the potential sampling sites and determined the reach to be sampled at each site. At each of the USEPA randomly selected sites, the latitude and longitude was used as the middle point of the reach, with half of the reach upstream and half downstream of the middle point.

During periods of stable flow from July through September 2001, 34 sites in the West Fork White River Basin (fig. 1, table 1) were sampled two times for algal biomass and three times for nutrients. The samples were collected three times to measure seasonal changes in the algal biomass and nutrients. Round one of sampling was done in July and August (summer), and round two of sampling was done in September (fall). In this report, round one sampling will be referred to as spring or July and round two as fall or September. Water also was sampled for nutrients in May by IDEM personnel, however this data was not included in the analysis. Nutrient and algal-biomass samples were collected at roughly the same time of day. Habitat, fish, and invertebrate communities were sampled once by IDEM personnel in July and August. Sites that required a boat to collect nutrient and algal-biomass samples were not sampled for algal biomass in 2001.

Algal-Biomass, Habitat, Nutrient, and Biological-Community Data-Collection and Processing Methods

Algal-biomass samples were collected and processed for periphyton and seston, as described in USGS protocols, with several modifications. The National Water-Quality Assessment (NAWQA) Program algal protocols for periphyton (Porter and others, 1993) are a reach-based sampling methodology in which five periphyton subsamples are collected from five different locations within the sampling reach. At each location, the stream depth, velocity, shading, and substrate were

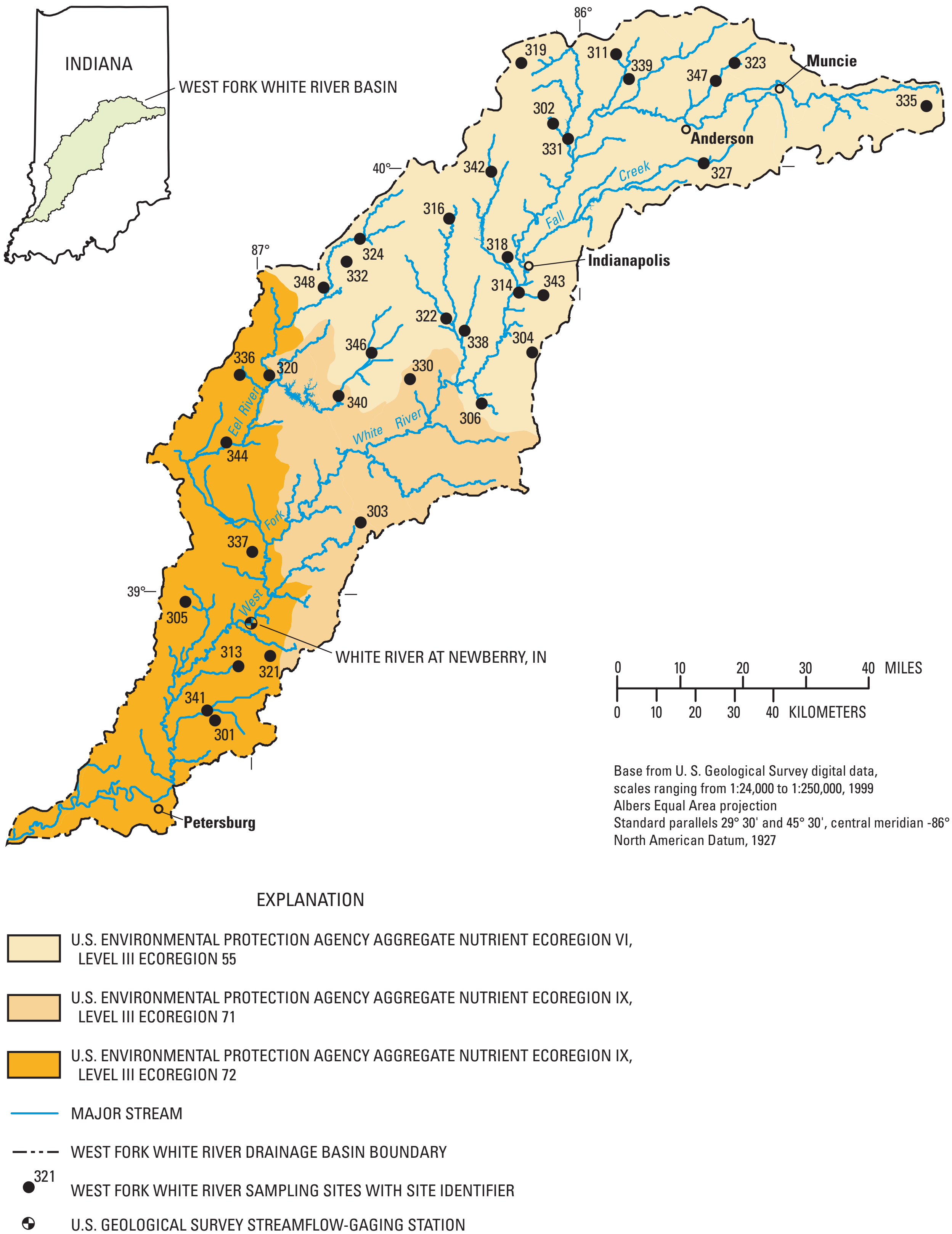

Figure 1. Location of the 34 algal-biomass sampling sites in West Fork White River Basin, Indiana, 2001.

Table 1. Location and basin characteristics of the 34 algal-biomass sampling sites in the West Fork White River Basin, Indiana, July through September 2001.

[IDEM, Indiana Department of Environmental Management; USGS, U.S. Geological Survey; ID, identification number; USEPA, U.S. Environmental Protection Agency; FT, feet; US, upstream; INDPLS, Indianapolis; CR, County Road; SR, State Route; DS, downstream; CK, Creek.; FK, Fork; DCH, Ditch; NR, near; AV, Avenue; ST, Street; N, North; S, South; E, East; W, West; IN, Indiana]

Short IDEM site number[1]	USGS station ID	USGS station name	USEPA Aggregate Nutrient Ecoregion[2]	Level III Ecoregion[3]	Latitude (degrees)	Longitude (degrees)
301	384211087065501	EAGAN DITCH 1000 FT US CR 350N NR WASHINGTON, IN	IX	72	38.70314	-87.11519
302	400620086050901	HINKLE CK 1500 FT US EAST 216TH ST AT DEMING, IN	VI	55	40.10550	-86.08569
303	391009086403001	RICHLAND CREEK 2200 FT US SR 43 AT WHITEHALL, IN	IX	71	39.16925	-86.67497
304	393410086085901	HONEY CR 2300 FT US SR 135 AT STONES CROSSING, IN	VI	55	39.56947	-86.14986
305	385847087123301	BREWER DCH 2000 FT DS CR 1450W NR PLEASANTVILLE, IN	IX	72	38.97981	-87.20928
306	392659086181801	SOUTH PRONG STOTTS CK 1200 FT US SR 44 AT COPE, IN	VI	55	39.44967	-86.30492
311	401606085532301	POLYWOG CK 3000 FT US CR 300S AT NEW LANCASTER, IN	VI	55	40.26842	-85.88969
313	384949087024201	KANE DITCH 1200 FT DS CR 700E NR EPSOM, IN	IX	72	38.83017	-87.04497
314	394234086112801	LICK CREEK 1200 FT DS SOUTH HARDING ST AT INDPLS	VI	55	39.70931	-86.19117
316	395256086242601	BEAMAN DITCH 3800 FT US CR 800N NR BROWNSBURG, IN	VI	55	39.88219	-86.40722
318	394734086133501	LITTLE EAGLE CREEK 2100 FT US WEST 16TH ST INDPLS	VI	55	39.79292	-86.22642
319	401451086110701	KIGIN DITCH 300 FT US CR 900W NR EKIN, IN	VI	55	40.24744	-86.18542
320	393046086573501	BIG WALNUT CK 3700 FT US 1-70 NR PLEASANT GARDENS	IX	72	39.51281	-86.95969
321	385116086565701	UNNAMED CREEK 3500 FT DS CR 1100E NR FARLEN, IN	IX	72	38.85442	-86.94911
322	393855086245601	W FK WHITE LICK CK 1500 FT US I-70 NR PLAINFIELD	VI	55	39.64856	-86.41567
323	401449085311801	JAKES CREEK 600 FT DS CR 700W AT BETHEL, IN	VI	55	40.24683	-85.52169
324	395003086410401	BIG WALNUT CREEK 1600 FT US CR 900E NR BARNARD, IN	VI	55	39.83422	-86.68439
327	400046085370901	FALL CREEK 1300 FT DS CR 300E NR EMPORIA, IN	VI	55	40.01286	-85.61917
330	393022086313401	LAMBS CREEK 1600 FT DS BEREAN RD NR WILBUR,IN	IX	71	39.50614	-86.52622

Table 1. Location and basin characteristics of the 34 algal-biomass sampling sites in the West Fork White River Basin, Indiana, July through September 2001.—Continued

[IDEM, Indiana Department of Environmental Management; USGS, U.S. Geological Survey; ID, identification number; USEPA, U.S. Environmental Protection Agency; FT, feet; US, upstream; INDPLS, Indianapolis; CR, County Road; SR, State Route; DS, downstream; CK, Creek.; FK, Fork; DCH, Ditch; NR, near; AV, Avenue; ST, Street; N, North; S, South; E, East; W, West; IN, Indiana]

Short IDEM site number[1]	USGS station ID	USGS station name	USEPA Aggregate Nutrient Ecoregion[2]	Level III Ecoregion[3]	Latitude (degrees)	Longitude (degrees)
340	392755086444401	MILL CREEK 3800 FT US CR 1150N AT WALLACE JUNCTION	IX	71	39.46536	-86.74544
341	384333087082001	N FK PRARIE CK 3000 FT US CR 100E NR WASHINGTON, IN	IX	72	38.72586	-87.13886
342	395935086163801	EAGLE CREEK 2600 FT US WEST 146TH ST AT ZIONSVILLE	VI	55	39.99303	-86.27725
343	394214086065501	LICK CK 600 FT DS OF CARSON AV AT BEECH GROVE, IN	VI	55	39.70392	-86.11519
344	392116087052501	TURKEY CREEK 500 FT US CR 665 NR SALINE CITY, IN	IX	72	39.35447	-87.09036
346	393402086384301	MUD CREEK 5300 FT DS CR 1100W AT LITTLE POINT, IN	VI	55	39.56731	-86.64531
347	401219085344901	KILLBUCK CREEK 500 FT DS CR 800N NR GILMAN, IN	VI	55	40.20533	-85.58031
348	394307086474301	BLEDSOE BRANCH 500 FT US CR 400N NR FILLMORE, IN	VI	55	39.71867	-86.79542

[1]The full IDEM site number has a prefix of INRB, for example INRB01-301.

[2]U.S. Environmental Protection Agency, 2000a,b.

[3]U.S. Environmental Protection Agency, 1997b.

recorded. The subsamples were composited and marked as a single sample. At each site, periphyton samples were collected using the same substrate type—epilithic (rocks), epidendric (sticks), or epipsammic (sand)—during the sampling period. One modification to this study from the NAWQA protocols was that 10 periphyton subsamples were collected from the same substrate as close to the center of the reach as possible. Then five subsamples were selected that best represented the average algal cover at the sampled reach and these subsamples were composited into a single sample (Charles and others, 2000).

Seston samples were collected, following NAWQA surface-water sample protocols (Shelton, 1994), along the IDEM-specified transect with a 3-L bottle and a 0.476-cm nozzle; either a grab sample or a multiple vertical method was used. After the seston sample was collected, it was processed, following NAWQA algal protocols (Porter and others, 1993).

Algal-biomass samples were collected, homogenized, and filtered onto glass-fiber filters in the field by USGS personnel. All filters collected by the USGS were placed on dry ice and transported to the USGS Indiana Water Science Center laboratory for analysis. The CHLa and AFDM filters were analyzed at the USGS Indiana Water Science Center laboratory; all the POC filters were analyzed at the USGS National Water Quality Laboratory (NWQL) in Lakewood, Colorado.

Concentrations of CHLa were determined, following USEPA method 445, with a Turner Designs TD-700 fluorometer outfitted for CHLa analysis (Arar and Collins, 1997). There were two exceptions to method 445; filters were ground in Nalgene centrifuge tubes instead of glass to counter the problem of tube breakage, and samples were centrifuged at 1,500 revolutions per minute (approximately 320 g) for 15 minutes. At the modified centrifuge rate, the filter residue and acetone solution separated well. If samples did not separate well, they were placed in the centrifuge a second time or care was taken not to decant the solute. For consistency, all samples were allowed to steep for 2.5 hours. Concentrations of AFDM were determined, following USGS method B-3520-85 (Britton and Greeson, 1988) with two exceptions: the samples were filtered in the field, and the filters were not baked and weighed in the crucibles before use.

Quality-assurance methods for algal biomass samples included triplicate filters from the same sample to measure variability and a blank filter collected at each sampling reach to measure bias. Additionally, a fifth filter was collected at each site and 15 percent of these fifth CHLa filters were analyzed at the NWQL to measure laboratory variability.

Habitat assessments were collected one time, July through August 2001, at each site by IDEM personnel following standard IDEM methods (Indiana Department of Environmental Management, 1992). Habitat assessments were made at the same time fish communities were sampled. Habitat assessments include in-stream and riparian measurements that are incorporated into the Qualitative Habitat Evaluation Index (QHEI). A list of these habitat metrics are listed in appendix 1 (Dufour, 2002).

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

Biological-community (fish and invertebrates) samples were collected one time, July through September 2001, at each site by IDEM personnel following standard IDEM methods (Indiana Department of Environmental Management, 1992; Barbour and others, 1999). IDEM personnel calculated the biological-community attributes and metric scores for this study. Attributes are the raw data and metric scores are rankings of the data from poor (a score of one), fair to good (a score of three), and excellent (a score of 5). The metric scores are ranked using a large data set that includes unimpaired reference sites to impaired sites. Each attribute has a corresponding metric score (Dufour, 2002). A list of the fish and invertebrate attributes and metrics are listed in appendix 1.

Data sets for sampling dates, laboratory-analysis dates, and algal-biomass (periphyton and seston) are available at: *http://in.water.usgs.gov/NAWQAWHMI/neet.php*

Data Analysis

In large environmental datasets, natural variability often masks the relations among variables. An objective of this report was to develop a preliminary understanding of how algal biomass relates to biological community and environmental variables in the West Fork White River Basin in 2001. In this report, the environmental variables included nutrients, habitat, and basin characteristics. Two approaches were used for the preliminary analysis of the data sets. The first approach included ordination and regression analyses of the algal biomass, nutrient, and environmental data. The second approach compared the CHLa and nutrient values collected by IDEM and USGS personnel to USEPA published values. These approaches provided an exploratory analysis to identify which biological and environmental variables were significantly related to algal biomass. These approaches also were used as a data censoring tool and allowed researchers to determine the relations of interest to use as a starting point in future studies.

The ordination approach consisted of determining yearly site scores for the periphyton and seston data using PCA. The ordination approach consisted of determining site scores for the periphyton and seston data using PCA. In each PCA two measures of algal biomass for periphyton (CHLa and AFDM) and seston (CHLa and POC) were used. The site scores are considered yearly because all of the seasonal algal biomass data are included in the PCA site score determination. The regression approach related the periphyton and seston PCA site scores from the first axis to five basin characteristics, nine habitat, 12 nutrient variables, and 43 fish and 21 invertebrate attribute and metric scores. All data were normalized to a z-score prior to use in the data analyses, allowing for comparison of variables that were recorded in different units.

Basin-Characteristics Data

The basin characteristics used in this analysis were drainage area and land use (percentage of agriculture, forest, other, and urban) and these were determined by the USGS for this study. Drainage area was derived from the basin boundaries. Basin boundaries for each site were generated following the method outlined by Ries, III, and others (2004). This method combines the National Elevation Dataset, Digital Elevation Model data, and the National Hydrography Dataset, which is a comprehensive set of digital surface-water features. The basin boundaries were used to extract land-use information from the National Land Cover Dataset (NLCD) (U.S. Geological Survey, 2000). This conversion allowed the land-use data to be compared among and between basins. Each sampling site was assessed to determine in which Aggregate Nutrient Ecoregion (U.S. Environmental Protection Agency, 2000a,b) and Level III Ecoregion (U.S. Environmental Protection Agency, 1997b) it was located.

Nutrient Data

The nutrients used in this analysis were dissolved ammonia as N, dissolved nitrate plus nitrite as N, total Kjeldahl nitrogen as N, total nitrogen as N, and total phosphorus as P. Because concentrations of nitrate typically are two orders of magnitude greater than nitrite and because nitrite usually does not exceed 0.5 mg/L in surface water (National Research Council, 1978), concentrations of nitrite plus nitrate are referred to as nitrate in this report. Concentrations of total nitrogen were calculated as the sum of nitrate and TKN. Almost all of the ammonia data were censored below the reporting levels and were not included in the analysis. For nutrient analyses, the scope of this report is narrowed to nitrate, TKN, TN, and TP. Nutrient data was analyzed separately for the summer (July and August) and the fall (September) samples; the seasonal nutrient and the seasonal algal-biomass data were then compared to the PC1 sites scores using Spearman's rho to determine the most significant seasonal relations. Because algal-biomass samples were not collected in spring (May), comparisons between spring nutrient and spring algal-biomass concentrations could not be done.

Principal Components Analysis

Principal Components Analysis, an ordination technique, was used to calculate individual yearly algal-biomass site scores for the periphyton and seston samples. PCA site scores (Gauch, 1982; Jongman and others, 1995; McCune and Grace, 2002) are theoretical variables that minimize the total residual sum of squares after fitting straight lines to the algal-biomass data. Mean CHLa (periphyton and seston) and AFDM values were calculated from the three filters for each sample. Mean algal-biomass (periphyton and seston) and other data were normalized prior to running the ordination analysis. To calculate the yearly periphyton PCA site scores, the mean periphyton CHLa and mean AFDM data from the July and the September sampling were used; for the yearly seston PCA site scores the mean seston CHLa and POC data from the July and the September sampling were used.

In this report, a positive site score indicates an increase in algal-biomass along the axis and a negative site score indicates a decrease in algal-biomass along the axis. Only the principal components (PC) site scores from the first axis (PC1) are presented in this preliminary analysis, because the PC1 axis best explains the algal-biomass data (McCune and Grace, 2002). In theory, the PC1 site scores should be related to the variables that were used in the calculations, and the variable with the highest loading accounts for the majority of the variation, which should also have the highest correlation coefficient. As a validation step, the yearly periphyton and yearly seston PC1 site scores were related to the algal biomass-values, using Spearman's rho. The purpose of this preliminary analysis was to investigate all potential relations and identify those relations that were the strongest and warrant further investigation. In this report, for a relation to be considered statistically significant using PCA, the Spearman's rho statistic (r_S) was required to be greater than the absolute value of 0.45 and have at least a 95 percent significance level based on the sample size. Although an r_S of 0.45 is considered significant, it has a possibility of introducing a Type I error.

Several procedures—such as the Bonferroni correction—are available for adjusting the significance level when performing a large number (or "family") of tests simultaneously (Van Sickle, 2003). This adjustment reduces the chances of a Type I error (the relation is declared present when the relation is not present) at a specific alpha level. Although useful in reducing Type I error, this technique increases the chance of producing a Type II error (no relation declared when a relation is present). In this study, the goal was to investigate all potential relations and identify which relations were the strongest. Because this was a preliminary analysis and there were a limited number of significant relations, no corrections were applied.

The yearly PC1 site scores spatially represent the (periphyton and seston) algal-biomass and were related, using Primer V.6.1.5 (Primer-E Ltd, 2006), to the habitat, basin-characteristics (drainage area and land use), seasonal nutrient (summer (July) and fall (September) nitrate, TKN, TN, and TP), seasonal algal biomass (summer (July) and fall (September) CHLa, AFDM, and POC), and biological-community (fish and invertebrates) attributes and metric score data collected in 2001. Spearman's rank order (rho) correlations are the preferred method when determining relations among environmental data because (1) the initial sample size was greater than 30 for most variables and (2) environmental data typically are not normally distributed. Although the data from this study were normalized prior to analysis, all variables were not normally distributed, requiring a non-parametric statistic. PC site scores were related in a correlation matrix to determine the strongest relations. The variables with the strongest relations could help in the development of nutrient criteria.

Comparison With U.S. Environmental Protection Agency Data

The USEPA proposed criteria in 2000 for nitrate, TKN, TN, TP, CHLa (periphyton and seston), and turbidity at the 25th-percentile value of all data for each parameter for each Aggregate Nutrient and Level III Ecoregion. Consequently, the second analytical approach was to determine how the data collected by IDEM and USGS for CHLa and nutrients compared to USEPA published values (U.S. Environmental Protection Agency, 2000a,b). For the USEPA method, the median value for each parameter for each stream was calculated. Then, percentiles were determined for each of the four seasons in each ecoregion and the 25th-percentile of the combined four seasons was used as the proposed criteria. In this report, median nutrient (nitrate, TKN, TN, and TP) and CHLa values were calculated for all streams sampled within the same Aggregate Nutrient and Level III Ecoregions. However, seasonal statistics were not calculated because IDEM and USGS did not collect winter samples or spring samples—USEPA considers May as part of spring. In this report, the median values for all the streams within a specific ecoregion were used to calculate descriptive statistics (ranges—minimum and maximum—and percentiles—10th, 25th, 50th, 75th, and 90th). For CHLa (periphyton and seston), a mean of the three filters collected at each site was calculated and then a median of the means for all streams within each ecoregion was used to calculate the descriptive statistics. The descriptive statistics then were compared to published USEPA values for Ecoregions VI, IX, 55, and 72 (U.S. Environmental Protection Agency, 2000a,b).

Relations of the Principal Components Analysis Site Scores to Algal-Biomass, Habitat, Basin-Characteristics, Nutrient, and Biological-Community Data

PCA was used to calculate PC1 site scores from the algal-biomass (periphyton and seston) data for each site (all seasons). The periphyton PC1 site score was constrained by AFDM (July); the PC2 was constrained by CHLa (September). The combination of PC1 (60.6 percent) and PC2 (25.6 percent) site scores accounted for 86.2 percent of the total variation. The seston PC1 site score was constrained by the POC (September); the PC2 was constrained by the CHLa (September). The combination of PC1 (57.4 percent) and PC2 (23.6 percent) accounted for 81.0 percent of the variation. Because the PC1 site score accounted for a large amount of the total variation in both of the algal-biomass data sets, only PC1 (periphyton and seston) site scores were compared to the seasonal algal-biomass, habitat, basin-characteristics (drainage area and land use), seasonal nutrient, and biological-community (fish and invertebrates) attributes and metric score data.

The periphyton PC1 site score (table 2) was negatively related to two algal-biomass variables: mean periphyton CHLa (July) and mean AFDM (July and September). Although this result does not offer inferences about the relations of the periphyton PC1 site score to the environmental or biological-community (fish and invertebrate attributes and metric scores) data, these relations demonstrate that the periphyton PC1 site score represents an algal-biomass gradient that is largely defined by CHLa (July) and AFDM (July and September).

The periphyton PC1 site score, which is most influenced by July CHLa, was negatively related to one of nine habitat parameters (percent closed canopy) that were examined. This suggests that as the amount of closed canopy cover decreases the periphyton algal biomass increases. It is expected that as canopy cover opens, more light would reach the stream and increase algal-biomass growth (Vannote and others, 1980). The periphyton PC1 site score was positively related to one fish-community attribute (appendix 1) of 21 examined (percent tolerant), one invertebrate-community attribute of ten examined (EPT index), and one invertebrate-community metric score of ten examined (EPT index metric score). The shift to more tolerant fish species as algal biomass increases suggests a decrease from fair to poor water quality (Simon, 1991). One mechanism that could explain this shift to tolerant species is the increase in certain tolerant fish species (green sunfish, white sucker) capable of handling large diurnal swings in dissolved oxygen related to high algal-biomass levels. Often the higher the EPT index the better the water quality (Voelker, 2003). However, many EPT taxa are filter feeders (*Isonychia* and *Hydropsyche*) which might benefit from increased algal-biomass concentrations. The periphyton PC1 was not related to the basin characteristics or nutrients.

The seston PC1 site score (table 3), which is most influenced by September POC, was negatively related to four algal-biomass variables: mean seston CHLa (July and September) and POC (July and September). Although these relations do not offer inferences to the relations of the seston PC1 site score to the environmental or biological-community (fish and invertebrate attributes and metric scores) data, these relations demonstrate that the seston PC1 site score represents an algal-biomass gradient that is largely defined by CHLa (July and September) and POC (July and September).

The seston PC1 site score was also negatively related to two nutrient variables: TKN (July) and TP (July). The only significant relations with nutrients were in July and suggest that as algal-biomass increases in July, it reduces the nutrient concentrations through algal uptake. It also suggests that the best time to sample seston would be during the summer and fall to find significant relations between nutrients and algal

Table 2. Significant Spearman’s rho relations of the yearly periphyton Principal Components Analysis axis 1 site scores (PC1) to algal biomass, habitat, basin characteristics, and nutrients and fish- and invertebrate-community attributes and metric scores, 2001.

[r_s, Spearman’s rho statistic (probability <0.05); n, number of samples; ns, no statistically significant relations EPT, Ephemeroptera, Plecoptera, Trichoptera]

Category	Parameter and attribute/metric	r_s
	Parameter	
Periphytonalgal biomass (n=30)	Mean ash-free dry mass, July	-0.8051
	Mean ash-free dry mass, September	- .5172
	Mean periphyton chlorophyll *a*, July	- .8857
Habitat (n=30)	Percent open canopy	- .4969
Basin characteristics (n=30)	ns	ns
Nutrients (n=30)	ns	ns
	Attribute/metric	
Fish (n=30)	Percent tolerant	.4830
Invertebrates (n=16)	EPT index	.6439
	EPT index metric score	.6356

biomass. One possible reason for significant relations in summer and fall may be that nutrient concentrations are uniformly high during the spring (compared to the summer and fall) because of application of fertilizer and increased runoff from more-frequent and larger precipitation events. Also, higher algal growth tends to occur during periods of stable flow and warmer weather typically associated with fall. Because algal-biomass samples were not collected in the spring, it was not possible to determine from this study if spring is the time to see relations between the algal-biomass and nutrients. However, in similar IDEM/USGS studies conducted in 2002 in the East Fork White River and Whitewater River Basins (Caskey and others, 2007) and in 2003 in the Upper Wabash River Basin (Leer and others, 2007), the most numerous and most significant relations between algal-biomass and nutrients were in the fall and summer.

The seston PC1 site score was not significantly related to the habitat and basin-characteristics variables. The seston PC1 site score was negatively related to one fish-community attribute of 21 examined, large-river percent, and one invertebrate-community attribute of ten examined, EPT-to-total ratio. The significant relation suggests that as algal-biomass increases, the percent of large river fish decreases is probably more a function of the lack of large river sites sampled in the 2001 study than an ecological reason; no boat sites were sampled in 2001. The decrease in the EPT to total ratio as algal biomass increases suggests a decrease in water quality.

The only significant relation in Ohio streams that Miltner and Rankin (1998) found between nutrients and biological communities was with the fish community. No relations between nutrients and the invertebrate community were found. In this 2001 study, both fish and invertebrate community variables showed statistically significant relations to algal-biomass and suggest that both biological communities may be a useful measure of nutrient enrichment in streams. Significant relations between algal-biomass and fish- and invertebrate-community data were found in the data analysis for similar studies in the East Fork White River and Whitewater River Basins in 2002 (Caskey and others, 2007) and the Upper Wabash River Basin in 2003 (Leer and others, 2007). Additionally, a change in fish-community composition was suggested in the 2002 and 2003 studies. In the 2002 study, as periphyton algal biomass increased, fish-community composition shifted from one dominated by carnivores and other niche-specific specialists to a community dominated by generalist-feeding and pioneer species. In the 2003 study, as periphyton algal biomass increased, fish-community composition shifted from one dominated by insectivores to a community dominated by tolerant species.

The low number and weak relations of the periphyton and seston PC1 site scores to the invertebrate community (attributes and metric scores) may be the result of three possible factors: (1) sample size, (2) sample method, and (3) taxonomic resolution of invertebrate data. In multivariate studies, sample size has been shown to affect the inferences that can be drawn from a data set; this may be why no relations were noted between the PC1 (periphyton and seston) and the invertebrate-community attributes and metric scores. In this study, invertebrates were collected only at sites with riffles; only 16 or 19 sites had algal-biomass and invertebrate community data; compared to 30 and 33 sites for the algal-biomass and fish-community data. Another possible reason for the lack of invertebrate-community attributes and metric score relations could

Table 3. Significant Spearman's rho relations of the yearly seston Principal Components Analysis axis 1 site scores (PC1) to algal biomass, habitat, basin characteristics, and nutrients and fish- and invertebrate-community attributes and metric scores, 2001.

[r_s, Spearman's rho statistic (probability <0.05); n, number of samples; ns, no statistically significant relations; N, nitrogen; P, phosphorus; EPT, Ephemeroptera, Plecoptera, Trichoptera

Category	Parameter and attribute/metric	r_s
	Parameter	
Seston algal biomass (n=33)	Particulate organic carbon, July	-0.8332
	Particulate organic carbon, September	- .8325
	Mean seston chlorophyll *a*, July	- .7390
	Mean seston chlorophyll *a*, September	- .5842
Habitat (n=33)	ns	ns
Basin characteristics (n=33)	ns	ns
Nutrients (n=33)	Total Kjeldahl nitrogen-N, July	- .6518
	Total phosphorus-P, July	- .5049
	Attribute/metric	
Fish (n=33)	Large-river percent	- .5833
Invertebrates (n=19)	EPT to total ratio	- .4915

be related to the collection methods. The invertebrate-community samples were collected from a specific habitat type (riffle) within the sampling reach; this targeted-habitat approach represents only the habitat sampled. If a multihabitat approach had been used for the collection of the invertebrate communities it may have revealed a community more representative of the entire sampling reach; this multihabitat approach may have increased the number of significant relations between the PC1 sites scores and the invertebrate-community attributes and metrics. Finally, the lack of invertebrate-community attribute/metric score relations also could be the result of invertebrate-identification resolution. IDEM identifies invertebrates to family level; therefore, it is possible that if identification were to a lower taxonomic level, a statistically significant relation between PC1 (periphyton and seston) and invertebrate-community attributes and metric scores could be documented.

Drainage-Area and Land-Use Analysis

Basin characteristics such as drainage area and land use can affect the relations between nutrients, algal biomass, and biological-community data. To understand how the choice of sampling sites might have affected the results, an analysis of the drainage area and land use was done. The drainage area and land-use values in this section were determined by the USGS for this study.

The random site selection in 2001 in the West Fork White River Basin was skewed to small streams. Of the 34 sites sampled in the West Fork White Basin, 61.8 percent were headwater streams (less than 50 km^2); all of the sites were wadeable, small streams less than 854 km^2 (fig. 2A). In the West Fork White River Basin, drainage-basin size ranged from 1.5 km^2 to 853.8 km^2 (table 4). Because of the small basin size for many of the sites, the lack of relations among the periphyton PC1 and the habitat, basin-characteristics, nutrient, and biological-community data was not expected. The River Continuum Concept (Vannote and others, 1980) suggests that periphyton would dominate primary production in smaller streams, with more suitable substrate (rock, sticks, sand), shallower water, and less turbidity than in larger streams. As streams get larger, deeper, and have less shading, seston would dominate primary production. It follows that the significant relations would be with the periphyton instead of the seston algal biomass. Because larger (boat) sites were not sampled for algal biomass in 2001, it is possible that there was not enough of a gradient to observe significant relations with basin size.

Although there were no large streams sampled in the West Fork White River Basin, there was still a gradient from headwater to medium-sized (wadeable) streams (fig. 2A). The large range of basin drainage area that was sampled could account for, or influence, the significant relations documented by the PC1 (periphyton and seston) and the environmental and biological-community data. Previous studies suggest that drainage-basin size (stream order) could mask relations of

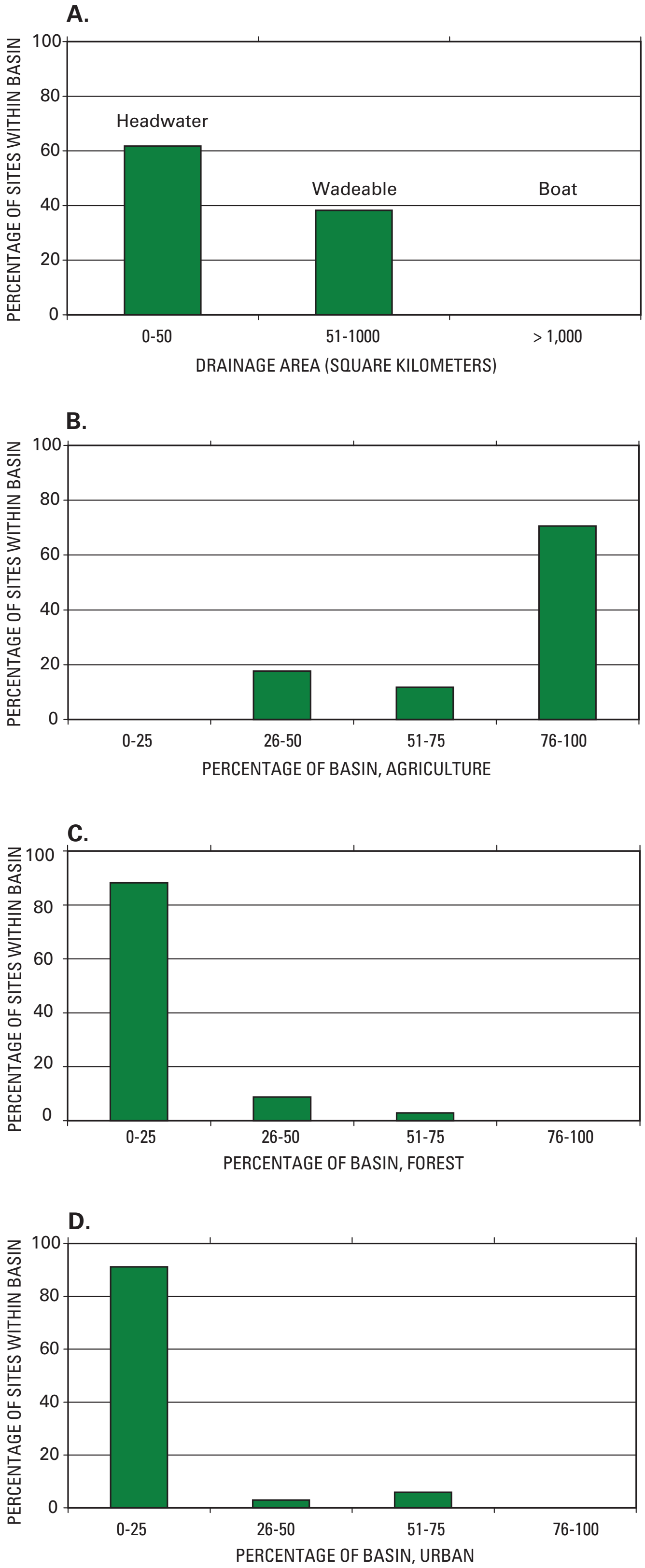

Figure 2. Graphs showing the percentage of drainage area and agricultural, forest, and urban land use in the West Fork White River Basin, Indiana, 2001.

environmental variables to biological communities. Stream size was significant in explaining relations between algal-community assemblages (Carpenter and Waite, 2000) and fish-community assemblages (Caskey, 2003) and environmental variables. Different fish and algal communities were found in small streams compared to large streams. Additionally, stronger relations were found between nutrients and fish- and invertebrate-community attributes and metric scores when data was analyzed by basin size (Frey and Caskey, 2007). Miltner and Rankin (1998) found the only significant relations between nutrients (TP and total inorganic nitrogen) and biological communities (fish) were in headwater streams. For this report, to keep the sample size large, analysis was done on all sites combined.

The dominant mean land use of the sites sampled in the West Fork White River Basin was agriculture (81.0 percent), followed by forest (10.5 percent) and urban (7.5 percent) (table 4). Of the streams that were sampled, 71 percent of the sites had at least 76 percent agricultural land use in the basin (fig. 2B). Agricultural land use of the West Fork White River Basin sites ranged from 39.7 to 98.7 percent (table 4). In a study of Midwest agriculturally dominated landscapes, Wang and others (1997) noted when land use within a drainage basin is less than 50 percent agriculture, biological-community relations are complex and difficult to identify. As the percentage of agricultural land use increases to more than 50 percent, however, a significant negative relation can be observed with fish Index of Biological Integrity (IBI) scores. Because most basins in this study had more than 76 percent agricultural land use, an agricultural land-use gradient was not found. This lack of an agricultural land-use gradient potentially could mask relations among the PC1 site scores (periphyton and seston) and the environmental variables and biological-community (fish and invertebrates) attributes and metric scores.

About 88 percent of the sites in the West Fork White River Basin had basins that consisted of less than 25 percent forest land use (fig. 2C). The forested land use of the West Fork White River Basin sites ranged from 0.2 to 54.7 percent (table 4). Studies have shown that forested landscapes are less likely to have elevated nutrients. This is in part because an established riparian zone acts as a buffer and filters surface-water runoff (Jordan and others, 1993).

Almost all of the sites in the West Fork White River Basin had basins that consisted of less than 25 percent urban land use (fig. 2D). The urban land use of the West Fork White River Basin sites ranged from 0 to 55.0 percent; about 92 percent of the sites had less than 10 percent urban land use (table 4). Studies from across the United States have shown that agricultural and urban landscapes can have elevated levels of nutrients (Mueller and Helsel, 1996). If nutrient concentrations were elevated at all the sites, the lack of a nutrient gradient could potentially mask relations among the PC1 (periphyton and seston) and the environmental variables and biological-community (fish and invertebrates) attributes and metric scores.

Table 4. Basin characteristics of the 34 algal-biomass sampling sites in the West Fork White River Basin, Indiana, July through September 2001.

[IDEM, Indiana Department of Environmental Management; USGS, U.S. Geological Survey; ID, identification number; USEPA, U.S. Environmental Protection Agency; FT, feet; US, upstream; INDPLS, Indianapolis; CR, County Road; SR, State Route; DS, downstream; CK, Creek.; FK, Fork; DCH, Ditch; NR, near; AV, Avenue; ST, Street; N, North; S, South; E, East; W, West; IN, Indiana]

Short IDEM site number[1]	USGS station name	Drainage area (km^2)	Land use (percentage)[2]			
			Ag	Forest	Urban	Other
301	EAGAN DITCH 1000 FT US CR 350N NR WASHINGTON, IN	21.7	95.9	2.9	1.1	0.0
302	HINKLE CK 1500 FT US EAST 216TH ST AT DEMING, IN	46.9	96.7	2.0	.3	1.0
303	RICHLAND CREEK 2200 FT US SR 43 AT WHITEHALL,IN	17.9	49.8	45.8	.6	3.8
304	HONEY CR 2300 FT US SR 135 AT STONES CROSSING,IN	7.8	90.3	1.1	8.6	.0
305	BREWER DCH 2000 FT DS CR 1450W NR PLEASANTVILLE,IN	32.1	49.8	37.7	.4	12.1
306	SOUTH PRONG 1200 FT US SR 44 AT COPE,IN	83.7	77.9	21.0	.7	.4
311	POLYWOG CK 3000 FT US CR 300S AT NEW LANCASTER, IN	38.0	98.0	.9	.5	.6
313	KANE DITCH 1200 FT DS CR 700E NR EPSOM,IN	23.4	90.0	4.8	5.1	.1
314	LICK CREEK 1200 FT DS SOUTH HARDING ST AT INDPLS	58.5	39.7	5.0	55.0	.4
316	BEAMAN DITCH 3800 FT US CR 800N NR BROWNSBURG, IN	6.9	98.7	.2	1.2	.0
318	LITTLE EAGLE CREEK 2100 FT US WEST 16TH ST INDPLS	49.6	44.8	5.3	49.4	.5
319	KIGIN DITCH 300 FT US CR 900W NR EKIN, IN	4.1	98.0	1.2	0	.9
320	BIG WALNUT CK 3700 FT US 1-70 NR PLEASANT GARDENS	853.8	81.7	16.4	1.2	.8
321	UNNAMED CREEK 3500 FT DS CR 1100E NR FARLEN, IN	1.5	60.6	38.8	0	.6
322	W FK WHITE LICK CK 1500 FT US I-70 NR PLAINFIELD	160.5	89.0	7.9	2.6	.6
323	JAKES CREEK 600 FT DS CR 700W AT BETHEL, IN	46.1	73.9	5.3	19.8	1.0
324	BIG WALNUT CREEK 1600 FT US CR 900E NR BARNARD, IN	308.8	96.7	2.2	.8	.3
327	FALL CREEK 1300 FT DS CR 300E NR EMPORIA, IN	118.3	92.3	5.9	1.1	.7
330	LAMBS CREEK 1600 FT DS BEREAN RD NR WILBUR,IN	30.2	43.9	54.7	.4	1.1
331	CICERO CREEK 5000 FT US SR 38 AT NOBLESVILLE, IN	558.0	94.2	1.4	1.9	2.5
332	PLUM CREEK 1800 FT US CR 800N AT NEW MAYSVILLE, IN	4.9	97.1	2.9	0	0
335	WHITE RIVER 2800 FT DS CR 200S NR WINCHESTER, IN	26.7	97.4	2.3	0	.3
336	BILLY CREEK 400 FT DS CR 125S NR HARMONY,IN	19.3	74.9	13.3	10.1	1.7
337	SLOAN DITCH 4800 FT DS SR 67 NR DIXON,IN	9.4	86.9	1.8	11.3	.1

Table 4. Basin characteristics of the 34 algal-biomass sampling sites in the West Fork White River Basin, Indiana, July through September 2001.—Continued

[IDEM, Indiana Department of Environmental Management; USGS, U.S. Geological Survey; ID, identification number; USEPA, U.S. Environmental Protection Agency; FT, feet; US, upstream; INDPLS, Indianapolis; CR, County Road; SR, State Route; DS, downstream; CK, Creek.; FK, Fork; DCH, Ditch; NR, near; AV, Avenue; ST, Street; N, North; S, South; E, East; W, West; IN, Indiana]

Short IDEM site number[1]	USGS station name	Drainage area (km^2)	Land use (percentage)[2]			
			Ag	Forest	Urban	Other
338	E FK WHITE LICK CK 1400FT US OLD 67 MOORESVILLE	125.7	79.7	5.3	14.5	.5
339	LAMBERSON DITCH 1300 FT US CR 700N NR AROMA, IN	14.5	96.6	.9	1.6	.9
340	MILL CREEK 3800 FT US CR 1150N AT WALLACE JUNCTION	563.1	91.5	7.5	0.7	0.3
341	N FK PRARIE CK 3000 FT US CR 100E NR WASHINGTON,IN	159.7	91.2	7.5	.1	1.2
342	EAGLE CREEK 2600 FT US WEST 146TH ST AT ZIONSVILLE	154.8	95.8	2.6	.7	.8
343	LICK CK 600 FT DS OF CARSON AV AT BEECH GROVE,IN	46.6	43.3	5.4	50.9	.4
344	TURKEY CREEK 500 FT US CR 665 NR SALINE CITY, IN	13.7	84.2	13.4	.1	2.3
346	MUD CREEK 5300 FT DS CR 1100W AT LITTLE POINT,IN	93.4	95.4	3.3	1.3	.1
347	KILLBUCK CREEK 500 FT DS CR 800N NR GILMAN, IN	158.8	85.8	5.1	8.1	1.0
348	BLEDSOE BRANCH 500 FT US CR 400N NR FILLMORE, IN	12.6	71.5	24.5	4.0	0
	Minimum	1.5	39.7	.2	0	0
	Mean	113.8	81.0	10.5	7.5	1.1
	Median	42.0	89.5	5.2	1.1	.6
	Maximum	853.8	98.7	54.7	55.0	12.1
	Standard deviation	188.9	19.1	13.9	14.8	2.1

[1]The full IDEM site number has a prefix of INRB, for example INRB01-301.

[2]Land-use percentages were determined by the U.S. Geological Survey using the National Land Cover Dataset (U.S. Geological Survey, 2000).

Comparison of the Data to Ecoregion Nutrient Criteria

The values for nutrients (nitrate, TKN, TN, and TP) and CHLa (periphyton and seston) were compared to published USEPA values for the respective ecoregions. A comparison of the values from the IDEM/USGS and USEPA data sets was done to (1) determine whether USEPA data, which were used to set the nutrient water-quality criteria, and the IDEM/USGS data had similar ranges of values; and (2) determine if the IDEM/USGS streams would exceed the proposed USEPA 25th-percentile nutrient water-quality criteria for the ecoregions. Of the 34 sites sampled, 22 sites on 21 streams were in Ecoregion VI; 12 sites on 12 streams were in Ecoregion IX (fig. 1, table 1). All of the 22 streams sampled in Ecoregion VI were also in Ecoregion 55. Nine of the 12 streams sampled in Ecoregion IX were in Ecoregion 72; the 3 remaining sites sampled in Ecoregion IX were in Ecoregion 71. Because only three streams were in Ecoregion 71, no comparison was made with published USEPA values. In general, the range of data for most variables was similar between the USEPA and IDEM/USGS data sets, although some variables had new maximum concentrations. Concentrations of CHLa for periphyton provide a new range because of the small amount of periphyton data in the USEPA data set.

The IDEM/USGS values for TKN fell within the range of the published values for Ecoregions VI, IX, 55, and 72 (table 5). The IDEM/USGS 25th-percentile TKN values were greater than the published values for Ecoregions VI, IX, and 55. If the proposed USEPA TKN water-quality criteria for Ecoregions VI and IX were enacted, of the individual samples collected, 65.1 percent in Ecoregion VI and 79.2 percent in Ecoregion IX would have exceeded those criteria.

The IDEM/USGS values for nitrate fell within or were close to the range of the published values for Ecoregions VI, IX, 55, and 72 (table 6). The IDEM/USGS 25th-percentile nitrate value was greater than the published value for Ecoregion IX. A higher new maximum concentration was found for Ecoregion 55. If the proposed USEPA nitrate water-quality criteria for Ecoregions VI and IX were enacted, of the individual samples collected, 60.5 percent in Ecoregion VI and 70.8 percent in Ecoregion IX would have exceeded those criteria.

Table 5. Total Kjeldahl nitrogen as N values collected in 2001 from the Indiana Department of Environmental Management/U.S. Geological Survey study and the published U.S. Environmental Protection Agency values for Aggregate Nutrient Ecoregions VI and IX and Level III Ecoregions 55 and 72.

[All data except number of streams are total Kjeldahl nitrogen as nitrogen values in milligrams per liter; N, nitrogen; IDEM, Indiana Department of Environmental Management; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; shading indicates value exceeds published U.S. Environmental Protection Agency value for Aggregate Nutrient Ecoregions VI and IX, all seasons; **bold** text indicates value exceeds published U.S. Environmental Protection Agency value for Level III Ecoregions 55 and 72 reference conditions, all seasons; nc, not calculated in U.S. Environmental Protection Agency Nutrient Criteria documents]

Statistic	IDEM/USGS values	USEPA values, all seasons[1]		IDEM/USGS values	USEPA values, all seasons	IDEM/USGS values	USEPA values, all seasons
		Aggregate Nutrient Ecoregion VI[2]	Level III Ecoregion 55[2]		Aggregate Nutrient Ecoregion IX[3]		Level III Ecoregion 72[3]
Number of streams	21	628	198	12	1,609	9	154
Minimum value	.335	.025	.050	.280	.000	.280	.025
10th percentile	.470	nc	nc	.280	nc	.280	nc
25th percentile	**.600**	.591	.400	.423	.300	.310	.539
50th percentile	.800	nc	nc	.595	nc	.635	nc
75th percentile	1.05	nc	nc	1.04	nc	1.12	nc
90th percentile	1.55	nc	nc	1.30	nc	1.55	nc
Maximum value	2.55	4.50	3.50	1.55	4.83	1.55	4.32

[1]Values are the median of all seasons for all samples collected from a single stream.

[2]U.S. Environmental Protection Agency, 2000a.

[3]U.S. Environmental Protection Agency, 2000b.

Table 6. Nitrite plus nitrate as N values collected in 2001 from the Indiana Department of Environmental Management/ U.S. Geological Survey study and the published U.S. Environmental Protection Agency values for Aggregate Nutrient Ecoregions VI and IX and Level III Ecoregions 55 and 72.

[All data except number of streams are nitrite plus nitrate as nitrogen values in milligrams per liter; N, nitrogen; IDEM, Indiana Department of Environmental Management; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; shading indicates value exceeds published U.S. Environmental Protection Agency value for Aggregate Nutrient Ecoregions VI and IX, all seasons; **bold** text indicates value exceeds published U.S. Environmental Protection Agency value for Level III Ecoregions 55 and 72 reference conditions, all seasons; nc, not calculated in U.S. Environmental Protection Agency Nutrient Criteria documents]

Statistic	IDEM/ USGS values	USEPA values, all seasons[1]		IDEM/ USGS values	USEPA values, all seasons	IDEM/ USGS values	USEPA values, all seasons
		Aggregate Nutrient Ecoregion VI[2]	Level III Ecoregion 55[2]		Aggregate Nutrient Ecoregion IX[3]		Level III Ecoregion 72[3]
Number of streams	21	717	219	12	1,671	9	173
Minimum value	.265	.010	.025	.009	.000	.009	.003
10th percentile	.412	nc	nc	.013	nc	.009	nc
25th percentile	.510	.633	1.60	.214	.125	.018	.215
50th percentile	1.75	nc	nc	.880	nc	.735	nc
75th percentile	2.55	nc	nc	1.80	nc	1.30	nc
90th percentile	3.55	nc	nc	2.40	nc	4.35	nc
Maximum value	**8.40**	10.7	8.13	4.35	9.78	4.35	8.63

[1]Values are the median of all seasons for all samples collected from a single stream.

[2]U.S. Environmental Protection Agency, 2000a.

[3]U.S. Environmental Protection Agency, 2000b.

The IDEM/USGS values for TN fell within or were close to the range of the published values for Ecoregions VI, IX, 55, and 72 (table 7). The IDEM/USGS 25th-percentile TN value was greater than the published value for Ecoregion IX. New minimum concentrations were found for Ecoregion VI and Ecoregion 55 and maximum concentration for Ecoregion 55. If the proposed USEPA TN water-quality criteria for Ecoregions VI and IX were enacted, of the individual samples collected, 51.2 percent in Ecoregion VI and 75.0 percent in Ecoregion IX would have exceeded those criteria.

The IDEM/USGS values for TP fell within the range of the published values for Ecoregions VI, IX, 55, and 72 (table 8). The IDEM/USGS 25th-percentile TP values were greater than the published values for Ecoregion VI, IX, and 55. The IDEM/USGS maximum concentrations were all lower than the published values for Ecoregions VI, IX, and 55; they were about eight times lower for Ecoregion VI. However, the IDEM/USGS minimum TP concentrations were higher than the published values for Ecoregions IV, IX, 55, and 72. A new maximum concentration was recorded for Ecoregion 72. If the proposed USEPA TP water-quality criteria for Ecoregions VI and IX were enacted, of the individual samples collected, 69.8 percent in Ecoregion VI and 87.5 percent in Ecoregion IX would have exceeded those criteria.

The IDEM/USGS values for mean periphyton CHLa provide a new range or expand the range of the published values for Ecoregions VI, IX, 55, and 72 (table 9). The IDEM/USGS 25th-percentile mean periphyton CHLa value was about half of the published value for Ecoregion IX. A new maximum concentration was found for Ecoregion IX. If the proposed USEPA mean periphyton CHLa water-quality criterion for Ecoregion IX were enacted, of the individual samples collected, 31.8 percent in Ecoregion IX would have exceeded that criterion. No comparison was made for Ecoregion VI because of the lack of published values in the USEPA nutrient-criteria document (Environmental Protection Agency, 2000a).

Table 7. Total nitrogen as N values collected in 2001 from the Indiana Department of Environmental Management/U.S. Geological Survey study and the published U.S. Environmental Protection Agency values for Aggregate Nutrient Ecoregions VI and IX and Level III Ecoregions 55 and 72.

[All data except number of streams are total nitrogen as nitrogen values in milligrams per liter; N, nitrogen; IDEM, Indiana Department of Environmental Management; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; shading indicates a new minimum value or exceeds the published U.S. Environmental Protection Agency value for Aggregate Nutrient Ecoregions VI and IX, all seasons; **bold** text indicates a new minimum value or exceeds the published U.S. Environmental Protection Agency value for Level III Ecoregions 55 and 72 reference conditions, all seasons; nc, not calculated in U.S. Environmental Protection Agency Nutrient Criteria documents]

Statistic	IDEM/USGS values	USEPA values, all seasons[1]		IDEM/USGS values	USEPA values, all seasons	IDEM/USGS values	USEPA values, all seasons
		Aggregate Nutrient Ecoregion VI[2]	Level III Ecoregion 55[2]		Aggregate Nutrient Ecoregion IX[3]		Level III Ecoregion 72[3]
Number of streams	21	77	2	12	274	9	21
Minimum value	**.745**	.885	3.63	.298	.240	.298	.470
10th percentile	1.14	nc	nc	.323	nc	.298	nc
25th percentile	1.54	2.18	3.63	.943	.692	.690	1.67
50th percentile	2.55	nc	nc	1.63	nc	1.57	nc
75th percentile	3.50	nc	nc	2.46	nc	2.34	nc
90th percentile	5.10	nc	nc	2.99	nc	5.90	nc
Maximum value	**9.26**	10.1	3.78	5.90	12.4	5.90	7.09

[1]Values are the median of all seasons for all samples collected from a single stream.

[2]U.S. Environmental Protection Agency, 2000a.

[3]U.S. Environmental Protection Agency, 2000b.

The IDEM/USGS values for mean seston CHLa provide a new range or expand the range of the published values for Ecoregions VI, IX, 55, and 72 (table 10). The IDEM/USGS minimum concentrations were higher than the published values for Ecoregions VI and IX. The IDEM/USGS 25th-percentile mean seston CHLa value was higher than published value for Ecoregion 72. If the proposed USEPA mean seston CHLa water-quality criteria for Ecoregions VI and IX were enacted, of the individual samples collected, 51.2 percent in Ecoregion VI and 62.5 percent in Ecoregion IX would have exceeded those criteria.

Table 8. Total phosphorus as P values collected in 2001 from the Indiana Department of Environmental Management/ U.S. Geological Survey study and the published U.S. Environmental Protection Agency values for Aggregate Nutrient Ecoregions VI and IX and Level III Ecoregions 55 and 72.

[All data except number of streams are total phosphorus as phosphorus values in milligrams per liter; P, phosphorus; IDEM, Indiana Department of Environmental Management; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; shading indicates value exceeds published U.S. Environmental Protection Agency value for Aggregate Nutrient Ecoregions VI and IX, all seasons; **bold** text indicates value exceeds published U.S. Environmental Protection Agency value for Level III Ecoregions 55 and 72 reference conditions, all seasons; nc, not calculated in U.S. Environmental Protection Agency Nutrient Criteria documents]

Statistic	IDEM/ USGS values	USEPA values, all seasons[1]		IDEM/ USGS values	USEPA values, all seasons	IDEM/ USGS values	USEPA values, all seasons
		Aggregate Nutrient Ecoregion VI[2]	Level III Ecoregion 55[2]		Aggregate Nutrient Ecoregion IX[3]		Level III Ecoregion 72[3]
Number of streams	21	815	225	12	2,104	9	183
Minimum value	.054	.005	.010	.015	.000	.015	.001
10th percentile	.060	nc	nc	.029	nc	.015	nc
25th percentile	**.086**	.076	.063	.050	.037	.048	.083
50th percentile	.120	nc	nc	.106	nc	.110	nc
75th percentile	.170	nc	nc	.270	nc	.350	nc
90th percentile	.215	nc	nc	.370	nc	1.77	nc
Maximum value	.285	2.23	1.82	1.77	2.40	**1.77**	1.60

[1]Values are the median of all seasons for all samples collected from a single stream.

[2]U.S. Environmental Protection Agency, 2000a.

[3]U.S. Environmental Protection Agency, 2000b.

Table 9. Mean periphyton chlorophyll *a* values collected in 2001 from the Indiana Department of Environmental Management/ U.S. Geological Survey study and the published U.S. Environmental Protection Agency values for Aggregate Nutrient Ecoregions VI and IX and Level III Ecoregions 55 and 72.

[All data except number of streams are mean periphyton chlorophyll *a* values in milligrams per square meter; IDEM, Indiana Department of Environmental Management; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; shading indicates value exceeds published U.S. Environmental Protection Agency value for Aggregate Nutrient Ecoregion IX, all seasons; nd, no data collected or published in U.S. Environmental Protection Agency Nutrient Criteria documents; nc, not calculated in U.S. Environmental Protection Agency Nutrient Criteria documents]

Statistic	IDEM/ USGS values	USEPA values, all seasons[1]		IDEM/ USGS values	USEPA values, all seasons	IDEM/ USGS values	USEPA values, all seasons
		Aggregate Nutrient Ecoregion VI[2]	Level III Ecoregion 55[2]		Aggregate Nutrient Ecoregion IX[3]		Level III Ecoregion 72[3]
Number of streams	21	nd	nd	12	6	9	nd
Minimum value	8.29	nd	nd	2.00	11.0	2.00	nd
10th percentile	9.18	nd	nd	7.33	nc	2.00	nd
25th percentile	18.5	nd	nd	9.60	20.4	9.33	nd
50th percentile	35.4	nd	nd	19.3	nc	10.6	nd
75th percentile	52.2	nd	nd	46.5	nc	51.2	nd
90th percentile	89.6	nd	nd	103	nc	197	nd
Maximum value	207	nd	nd	197	62.0	197	nd

[1]Values are the median of all seasons for all samples collected from a single stream.

[2]U.S. Environmental Protection Agency, 2000a.

[3]U.S. Environmental Protection Agency, 2000b.

Table 10. Mean seston chlorophyll *a* values collected in 2001 from the Indiana Department of Environmental Management/U.S. Geological Survey study and the published U.S. Environmental Protection Agency values for Aggregate Nutrient Ecoregions VI and IX and Level III Ecoregions 55 and 72.

[All data except number of streams are mean seston chlorophyll *a* values in micrograms per liter; IDEM, Indiana Department of Environmental Management; USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; **bold** text indicates a new minimum value or exceeds the published U.S. Environmental Protection Agency value for Level III Ecoregions 55 and 72 reference conditions, all seasons; nd, no data collected or published in U.S. Environmental Protection Agency Nutrient Criteria documents; nc, not calculated in U.S. Environmental Protection Agency Nutrient Criteria documents]

Statistic	IDEM/USGS values	USEPA values, all seasons[1]		IDEM/USGS values	USEPA values, all seasons	IDEM/USGS values	USEPA values, all seasons
		Aggregate Nutrient Ecoregion VI[2]	Level III Ecoregion 55[2]		Aggregate Nutrient Ecoregion IX[3]		Level III Ecoregion 72[3]
Number of streams	21	63	nd	12	71	9	2
Minimum value	.699	.250	nd	1.07	.225	**1.07**	1.50
10th percentile	1.03	nc	nd	1.36	nc	1.07	nc
25th percentile	1.58	2.70	nd	1.84	2.25	**2.29**	1.50
50th percentile	4.54	nc	nd	2.89	nc	3.04	nc
75th percentile	4.96	nc	nd	5.93	nc	7.25	nc
90th percentile	6.83	nc	nd	15.0	nc	15.8	nc
Maximum value	28.7	47.6	nd	15.8	36.7	**15.8**	6.55

[1]Values are the median of all seasons for all samples collected from a single stream.

[2]U.S. Environmental Protection Agency, 2000a.

[3]U.S. Environmental Protection Agency, 2000b.

Conclusions

Excessive inputs of nutrients into streams have human-health, economic, and ecological consequences. In 2000, the U.S. Environmental Protection Agency (USEPA) proposed nutrient water-quality criteria to protect streams from excess nutrients. This report is one of several reports done as a cooperative effort between Indiana Department of Environmental Management (IDEM) and the U.S. Geological Survey (USGS) to collect new data to assist IDEM in determination of nutrient criteria. Data were gathered from July through September 2001 at 34 randomly selected sites in the West Fork White River Basin, Indiana, for algal biomass, habitat, nutrients, and biological communities (fish and invertebrates). Basin characteristics (land use and drainage area) and biological-community attributes and metric scores were determined for the basin of each sampling site. Yearly Principal Components Analysis site scores were calculated for algal-biomass (periphyton and seston). The yearly Principal Components Analysis site scores for the first axis (PC1) were related using Spearman's rho to the algal-biomass, habitat, basin-characteristics, nutrient, biological-community attribute and metric score data. Summer (July) appears to be the best time to sample to find significant relations between seston PC1 and nutrient variables and fish-community attributes and metric scores. From the initial analysis, fish- and invertebrate-community attributes and metric scores may reflect the impacts of increased algal-biomass associated with high concentrations of nutrients.

The periphyton PC1 site score, which was most influenced by ash-free dry mass (AFDM), was negatively related to one habitat variable (percent closed canopy). The periphyton PC1 site scores were positively related to one fish-community attribute (percent tolerant); one invertebrate-community attribute, Ephemeroptera, Plecoptera, and Trichoptera (EPT index); and one invertebrate-community metric score (EPT index metric score). The periphyton PC1 was not related to the basin characteristics or nutrients.

The seston PC1 site score, which was most influenced by particulate organic carbon, was negatively related to two nutrient variables: total Kjeldahl nitrogen (July) and total phosphorus (July). The seston PC1 site scores were negatively related to one fish-community attribute (large-river percent) and one invertebrate-community attribute (EPT-to-total ratio). The seston PC1 was not related to the habitat or basin-characteristic data.

To understand how the choice of sampling sites might have affected the results, an analysis of the drainage area and land use was done. Of the 34 sites sampled in the West Fork White Basin, 61.8 percent were headwater streams (less than 50 km^2); all of the sites were wadeable, small streams less than 854 km^2. No boat sites were sampled and the lack of large streams may explain the lack of relations with basin size. The dominant mean land use of the sites sampled was agriculture (81.0 percent), followed by forest (10.5 percent) and urban (7.5 percent). Of the streams that were sampled, 71 percent of the sites had at least 76 percent agricultural land use in the basin. This lack of an agricultural land-use gradient potentially could mask relations among the PC1 site scores (periphyton and seston) and the environmental variables and biological-community (fish and invertebrates) attributes and metric scores.

The values for nutrients (nitrate, TKN, TN, and TP) and chlorophyll *a* (CHLa) (periphyton and seston) were compared to published USEPA values for the respective ecoregions. CHLa (periphyton and seston) values were either greater than the 25th-percentile published USEPA values or extended data ranges in Aggregate Nutrient and Level III Ecoregions. If the values for the 25th percentile proposed by the USEPA were adopted as nutrient water-quality criteria, the percentage of samples in the West Fork White River Basin that would have exceeded these criteria ranged from 31.8 percent in Ecoregion IX for periphyton CHLa to 87.5 percent in Ecoregion IX for TP.

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Appendix 1. Metrics used by Indiana Department of Environmental Management for habitat, fish, and invertebrates (Dufour, 2002).

Metrics[1]	Definition
	Habitat
SubstrateScore	A metric to evaluate substrate type, origin, silt cover, and embeddedness.
InstreamCoverScore	Instream cover types and the amount (availability) of instream cover.
ChannelMorphologyScore	Quality of the stream channel related to the creation and stability of instream habitat (channel sinuosity, channel development, channelization, stability, and modifications).
RiparianZoneandBankErosionScore	Quality of the riparian buffer zone and flood-plain vegetation, looking at riparian width, predominant surrounding land uses, and bank-erosion status.
PoolGlideQualityScore	Quality of pool/glide taking into account maximum pool depth, morphology, and velocity.
RiffleRunQualityScore	Quality of riffle/run, taking into account riffle/run depth, substrate, and embeddedness.
GradientScore	A measure of the influence of gradient and stream size on the biological community and available habitat.
	Fish[2]
SpeciesCount	Number of species, excluding hybrid species (exclude gizzard shad if in the Wabash River mainstem and drainage area is greater than 5,180 square kilometers).
DMS_SpeciesCount	Number of darter, madtom, and sculpin species, excluding hybrid species.
Darter_SpeciesCount	Number of darter species, excluding hybrid species.
Headwater_Percent	Percent of headwater individuals.
LargeRiver_Percent	Percent of large river individuals (exclude gizzard shad if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).
Sunfish_SpeciesCount	Number of sunfish species, excluding hybrid species.
Centrarchid_SpeciesCount	Number of centrarchidae species, excluding hybrid species.
Minnow_SpeciesCount	Number of minnow species, excluding hybrid species.
Sucker_SpeciesCount	Number of sucker species, excluding hybrid species.
RoundBodySucker_SpeciesCount	Number of round-body sucker species, excluding hybrid species.
Salmonid_SpeciesCount	Number of salmonid species, excluding hybrid species.
Sensitive_SpeciesCount	Number of sensitive species, excluding hybrid species.
Tolerant_Percent	Percent of tolerant individuals (exclude gizzard shad if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).
Omnivore_Percent	Percent of omnivore individuals (exclude gizzard shad if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).
Insectivore_Percent	Percent of insectivore or invertivore individuals (exclude gizzard shad if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).
Pioneer_Percent	Percent of pioneer individuals.
Carnivore_Percent	Percent of carnivore or piscivore individuals (exclude gizzard shad if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).
CatchPerUnitEffort	Catch per unit effort (CPUE) or total number of individuals.
CPUElessShads	Catch per Unit Effort (CPUE), excluding the number of gizzard shad individuals if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).
SimpleLithophil_Percent	Percent of simple lithophilic species (exclude gizzard shad if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).
DELT_Percent	Percent of individuals with deformities, eroded fins, lesions, and tumors (DELT), including multiple DELTs (exclude gizzard shad if in the Wabash River mainstem and drainage area greater than 5,180 square kilometers).

Appendix 1. Metrics used by Indiana Department of Environmental Management for habitat, fish, and invertebrates (Dufour, 2002).—Continued

Metrics[1]	Definition
Invertebrates	
Family Level HBI	Summation of the tolerance value times the number of individuals for a specific family divided by the total count of individuals for families with a tolerance value.
Number of Taxa	Number of families identified in the subsample.
Number of Individuals	Total number of individuals for all families identified in the subsample.
Percent Dominant Taxa	Highest number of individuals for a given family divided by the total number of individuals in the subsample.
EPT Index	Total number of families represented in the orders Ephemeroptera, Plecoptera, and Trichoptera.
EPT Count	Total number of individuals for orders Ephemeroptera, Plecoptera, and Trichoptera.
EPT Count to Total Number of Individuals	Total number of individuals for orders Ephemeroptera, Plecoptera, and Trichoptera divided by the total number of individuals in the subsample.
EPT Count to Chironomid Count	Total number of individuals for orders Ephemeroptera, Plecoptera, and Trichoptera divided by the total number of chironomidae.
Chironomid Count	Total number of chironomids in the subsample.
Total Number of Individuals to Number of Squares Sorted	Total number of individuals in the subsample divided by the number of squares needed to reach the total number of individuals.

[1]Each of the fish- and invertebrate community metrics also has a corresponding attribute with the same name but consists of the raw data.

[2] Specific fish species associated with each metric can be found in Dufour, 2002.

Frey, Caskey, and Lowe—**Relations of Principal Components Analysis Site Scores to Algal-Biomass, Habitat, Basin-Characteristics, Nutrient, and Biological-Community Data in the West Fork White River Basin, Indiana, 2001**—Scientific Investigations Report 2007–5222