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Chicago, Illinois 60604

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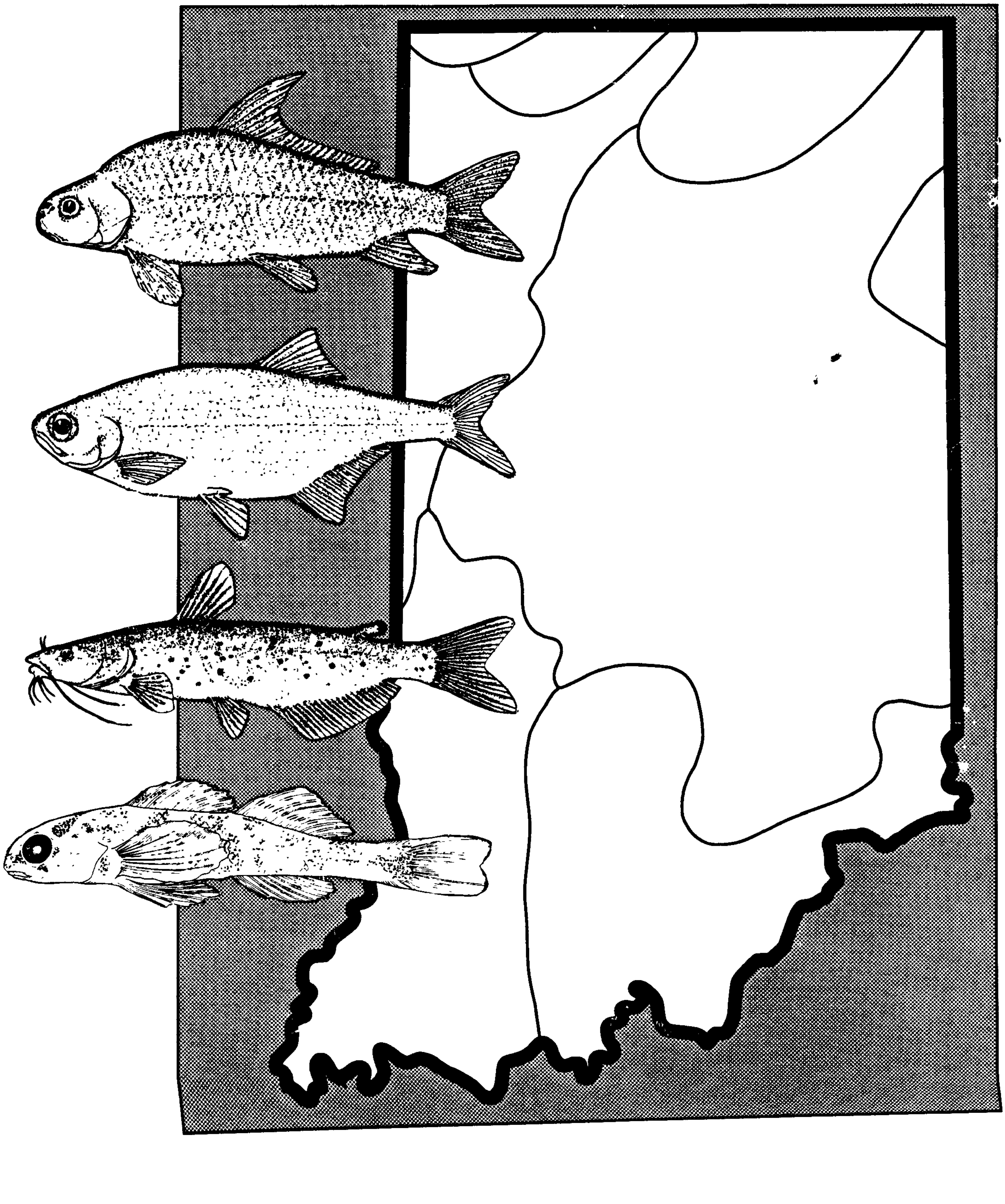
# Biological Criteria Development for Large Rivers with an Emphasis on An Assesment of the White River Drainage, Indiana



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# Biological Criteria Development for Large Rivers with an Emphasis on an Assessment of the White River Drainage, Indiana

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## NOTICE



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# EXECUTIVE SUMMARY

The Clean Water Act Amendments of 1987 mandate the development of biological criteria for evaluating the quality of the nation's surface waters. The White River drainage was investigated in Indiana to determine water resource expectations for large rivers. A total of 49 sites were sampled in the White River drainage in order to develop and calibrate an Index of Biotic Integrity for use in Indiana large rivers. Based on anticipated variance within the two ecoregions, sub-basins were established using natural areas as recognized by Homoya et al. (1985).

Three sub-basins were recognized and include the major drainage units of the White River; Lower White River, West Fork White River, and East Fork White River drainages. Graphical analysis of the data enabled the construction of maximum species richness lines for calibrating the Index of Biotic Integrity for 13 metrics as modified for application to Indiana. Metrics were primarily based on the previous works of Karr (1981), Karr et al. (1986), and Ohio EPA (1987). A few additional metrics are original to this study and were evaluated to quantify water quality degradation characteristics. This includes the proportion of large river taxa and a combination of sensitive benthic insectivores, e.g. darters, madtoms, and sculpins. The number of sunfish species was modified to include the black basses, Micropterus.

Separate metrics were developed for large ($1000 < x < 2000$ miles$^2$) and great river ($> 2000$ miles$^2$) drainage areas. Separate scoring criteria and metrics were developed for the two classifications. Stations with drainage areas less than 2000 miles$^2$ had a metric which included darters, madtoms, and sculpins (all benthic insectivores). These species are sensitive indicators of a quality aquatic resource. In reaches with drainage areas greater than 2000 miles$^2$ a metric evaluating the proportion of large river species was substituted. The proportion of large river species is based on the typical expectations of large river faunal composition after Pflieger (1975). Within these larger drainage reaches, a characteristic fauna is anticipated, thus deviation from these expectations suggests that the resource has been degraded.

The water resources of the three drainages were evaluated based on criteria calibrated for the White River drainage using the Indiana large river index. A normal curve distribution observed for the River drainages with respect to site biological resource classification. A trend towards decreasing biological quality with increasing drainage area was evident. The Lower White River drainage showed a highly skewed site distribution towards the lower extremes of biological quality. The trend was towards declining biological integrity with increasing drainage area in both the East and West Forks, although the East Fork White River possessed considerably better fish community at the headwaters. Site specific data included an evaluation of thermal impacts on the River based on keystone species and an evaluation of the Lower White River using the Index of Well-Being. Locality information, species specific scoring criteria for tolerance classification, trophic and reproductive guilds are included in the appendix.

## ACKNOWLEDGEMENTS

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# Biological Criteria Development for Large Rivers with an Emphasis on an Assessment of the White River Drainage, Indiana

## 1.0 INTRODUCTION

The reauthorization of the Clean Water Act and U.S. Environmental Protection Agency's policy requirement to adopt narrative and numerical biological criteria for assessing the nations' surface waters has prompted an instream assessment of the water quality of the State of Indiana. Section 304 (a) of the Clean Water Act (CWA) directs EPA to develop and publish water quality criteria and information on methods for measuring toxic pollutants on bases other than pollutant-by-pollutant, including biological monitoring and assessment methods. The Clean Water Act suggests using aquatic community components ("...plankton, fish, shellfish, wildlife, plant life..."; sec. 304(1)(a)) and community attributes ("... biological community diversity, productivity, and stability ..."; sec. 304(1)(c)) in any body of water and; factors necessary "...to restore and maintain the chemical, physical, and biological integrity of all navigable waters ..."(sec. 304(2)(a)) for "...the protection and propagation of shellfish, fish, and wildlife for classes and categories of receiving waters..." (sec. 304 (2)(b)) and "...on the measurement and classification of water quality" (sec. 304(2)(c)).

The term biological integrity originated in the Water Pollution Control Act Amendments of 1972 (PL 92-500) and has likewise appeared in subsequent versions (PL 95-217; PL 100-1). Karr and Dudley (1981) defined biological integrity as, "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the best natural habitats within a region". The use of a biological component to evaluate the ambient lotic aquatic community of our nations surface waters has been well discussed elsewhere (Karr et al. 1986; Ohio EPA 1987; Whittier et al. 1987; Simon et al. 1988; Davis 1990; Fausch et al. 1990; Karr 1991).

The assessment of the White River drainage enabled the objective evaluation of specific large river metric performance. The White River drainage has impacts associated with only a few point source dischargers. The primary discharge sources are municipal facilities and electric power generating stations distributed in the lower White River and the upper portions of the West Fork White River. The effects of thermal influence have been well documented in the literature (Raney and Menzel 1969; Brown 1976; Brungs and Jones 1977; Hokanson and Biesinger 1980; USEPA 1980; McCormick et al. 1981; EPRI 1981). The characteristic signature of thermal disturbance has been described by Gammon (1973) and has been studied for several decades in the middle Wabash River. Changes in sensitive species unable to tolerate increased thermal loads were documented for redhorses, percids, and other coolwater species. Gammon (1983) compared, predicted and observed, changes in the fish community near the Wabash and Cayuga Generating Stations on the middle Wabash River. Laboratory results compared favorably with adult responses from field observations. However, differences in results were due to differences between the juveniles and smaller individuals usually tested during laboratory treatments to the larger individuals usually encountered in the field. Gammon (1979, 1983) concluded that even with large amounts of temperature data that community response could not be predicted as well as if measured by field assessment.

The objective of this study was to evaluate the biological integrity in Indiana water resources based on "least impacted" reference sites for establishing baseline conditions (Hughes et al. 1986). Least impacted reference sites were representative of the subbasin under study and reflect the better sites without anthropogenic change. The following project goals were addressed during the White River biological criteria project:

o Develop biological criteria for large and great river reaches using the Index of Biotic Integrity and habitat classification;

- o Identify areas of least disturbance within the White River drainage for use as reference stations;
- o Develop maximum species richness (MSR) lines from reference stations for each Index of Biotic Integrity metric based on drainage area;
- o Evaluate and assess the impacts of four electric generating stations on the Lower and West Fork of the White River under differing temporal and spatial scales.

This technical report includes specific Index of Biotic Integrity criteria through the development of metrics and maximum species richness lines, to delineate areas of least disturbance in the White River drainage. The purpose of this study is not to verify ecoregion boundaries, additional study areas would need to be sampled to determine the heterogeneity of the "fuzzy border" areas.

## Definition of Reference Conditions

In order to make accurate evaluations of the region, various baseline geological, geographic, and climatic differences need to be assessed. The goal is not to provide a definition of pristine conditions, since these types of conditions are either few in number or nonexistent in heavily populated states (Hughes et al. 1982; Whittier et al. 1987). Our expectations are determined from the structural and functional attainable natural conditions of "least impacted" or reference sites. Assessment of these criteria need to be modified nationally, since different processes can be attributed to the regional expectations determining distribution of fishes. The ecoregion concept is useful for separating large expanses of habitat, since these areas are defined by the use of different structural components (Omernik 1987).

In order to select stations for sampling it is necessary to know the geographical boundary of the "ecoregions" within the State of Indiana. A valid ecoregion has boundaries where ecosystem variables or patterns change (Hughes et al. 1986). Omernik (1987) mapped the ecoregions of the conterminous United States from maps of land-surface form, soil types, potential natural vegetation, and land use. Each ecoregion was then delineated from areas of regional homogeneity. Ecoregions became a very useful mechanism for determining community complexity and establish boundaries associated with various land forms.

Ecoregions provide a geographical basis for determining the appropriate response from streams of similar proportion and complexity. By selecting reference sites for establishing the areas of "least impact", further calibration of the Index of Biotic Integrity and monitoring will reveal the current conditions of the surface waters of Indiana. Once ecoregional expectations are determined it is important to consider that conditions do not remain static. On the contrary, repeat sampling of stations, both reference and site specific will need to be conducted in order to document change over time.

Because of subregional differences further demarcation was made examining the role of basin or watershed within natural areas. Natural areas are similar to ecoregions with the exception of using a biotic component. Fish emigration is determined by the availability of water of appropriate quality to ensure existence, sustain growth, and increase fitness through reproduction. Likewise, species-specific differences exist in community structure which may not reveal differences in current water quality but may be determined by historical geomorphic (Leopold et al. 1964) or zoogeographic processes (Hocutt and Wiley 1986). Trends in Indiana water quality were evaluated using a basin approach, within the framework of ecoregions.

## Criteria for Selecting Reference Sites

Several procedures are available for determining reference stations. Larsen et al. (1986) and Whittier et al. (1987) chose sites after careful examination of aerial photographs, sub-basin specific information review, and on-site reconnaissance. This procedure is time consuming and requires that a limited number of high-quality sites be sampled in order to predict regional expectations. The current methods chosen were based on evaluation of Regional Water Quality Planning Maps (USGS undated) which identified known point and non-point sources which may influence site selection. An equal distribution of stations within all parts of the basins were selected based on historic collections sites (Jordan 1877; Gerking 1945; IDEM 1990) and were rigorously sampled in order to get representative, distance specific, quantifiable estimates of the species numbers and biomass. In order to avoid bias, these data points were determined for all metrics calibrated in the Index of Biotic Integrity. Maximum species richness lines were then compiled (see methods), followed by calculations of Index of Biotic Integrity values to reveal which stations were the "least impacted" stations for the White River drainage. Evaluation of habitat and other physical parameters refined the final list of reference sites. Sites which had habitat or water quality deficiencies, but still attained high index ratings would have been removed from the final list. This action was not required, since poor habitat and water quality affected various portions of the community resulting in a lowered index score. These sites are not pristine or undisturbed (few exist in Indiana), but they do represent the best conditions given the background activities (i.e. anthropogenic; cultural eutrophication).

Sampling was conducted in all mainstem river reaches in the Lower, East and West Forks of the White River from the headwater (<100 square miles) to the largest mainstem drainage area (ca. 11,400 square miles).

## 2.0 STUDY AREA

Indiana has an area of 36,291 square miles, and drains the Ohio, the upper Mississippi, and Great Lakes Regions (Seaber et al. 1984). These three regions were further subdivided into nine subregions (Fig. 1), five of which drain 86% of the State (USGS 1990). The State of Indiana lies within the limits of latitude 37° 46' 18" and 41° 45' 33" north, for an extreme length of 275.5 miles in a north-south direction; and between longitude 84° 47' 05" and 88° 05' 50" west with an extreme width in an east-west direction of 142.1 miles.

The State has a maximum topographic relief of about 900.9 ft, with elevations ranging from about 300.3 ft above mean sea level at the mouth of the Wabash River to slightly more than 1,201.2 ft in Randolph County in the east-central part of the state.

This report considers only the White River drainage and will be referred to as the River. The White River drains an area of 11,400 square miles (Hoggatt 1975). It crosses two ecoregions and is the second largest drainage in Indiana rivaled only by the Wabash River. The River drains the Eastern Corn Belt Plain and Interior River Lowland ecoregions (Omernik and Gallant, 1988). The River is located in central and southern Indiana and drains in a southwestern direction. Large tributaries which drain the Eastern Corn Belt Plain include the Driftwood, Big Blue, Flatrock, Eel, and Muscatatuck Rivers. The Interior River Lowland includes the mainstem Lower White River and the junction of the East and West Forks.

### Physiographic Provinces

Fenneman (1946) divided the State into two physiographic provinces based on the maximum extent of glaciation. The glaciated portion of the State contains the Central Lowland province, which includes the majority of the White River drainage, and the unglaciated portion is termed the Interior Low Plateaus province.

Schneider (1966) further divided Indiana into three broad physiographic areas that closely reflect the surface-water characteristics of the State. The White River drains a portion of the Tipton Till Plain, Scottsburg Lowland, Norman

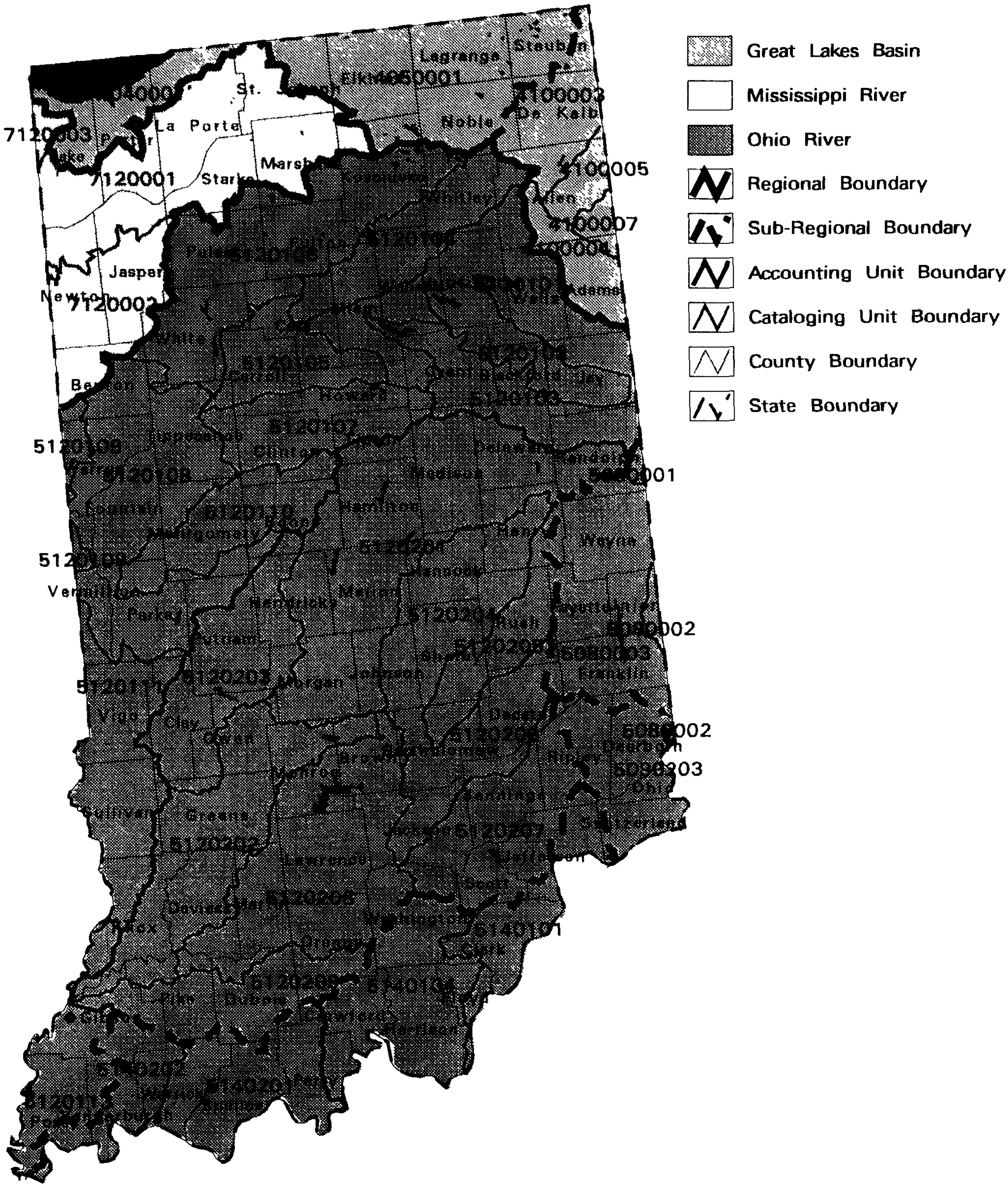


Figure 1. Map of Indiana showing Major and Minor drainage basins. (from USGS data).

Upland, Crawford Upland, Dearborn Upland, and Mitchell Plain. The Tipton TillPlain is characterized by a depositional plain of low relief that has been modified only slightly by postglacial stream erosion. The southern section of the State includes the Wisconsinan glacial boundary and represents a series of north- and south-trending uplands and lowlands. Landforms in this area are principally due to normal degradation processes.

The last major glaciation event dramatically altered central Indiana during the Wisconsinan period (14,000 to 22,000 years ago). As glaciers advanced and retreated, the land surface was dramatically altered as the landforms were eitherscoured by advancing glacial ice or the scoured materials were deposited by retreating glaciers. Two distinct glacial lobes are known to have advanced into Indiana, from the northeast out of the Lake Erie and Saginaw Bay basins and from the north from the Lake Michigan basin.

Ecoregions

Omernik and Gallant (1988) characterized the attributes of ecoregions of the midwest states. Indiana has six recognized ecoregions: Central Corn Belt Plain, Southern Michigan-Northern Indiana TillPlain, Huron-Erie Lake Plain, Eastern Corn Belt Plain, Interior Plateau, and Interior River Lowland (Fig. 2). The White River basin drains portions of the Eastern Corn Belt Plain and Interior River Lowland ecoregions.

The following is a description of the Eastern Corn Belt Plain and Interior River Lowland ecoregions, summarized from Omernik and Gallant (1988).

Eastern Corn Belt Plain

Much of the ecoregion consists of extensive cropland agriculture. It is distinguished from the western corn belt plains by the its natural forest cover and associated soils. The gently rolling glacial tillplain is broken by moraines, kames, and outwash plains. Elevations range between 399.3 ft to greater than 1320 ft. The ecoregion is characterized by low relief, typically less than 66 ft; however, some morainal hills occur in the northern portion near Lake Erie. Stream valleys are long and sinuous and generally narrow and shallow throughout the 31,800 miles$^2$ of the ecoregion. Small streams have narrow valley floors; larger streams have broad valley floors. Elevation varies from about 399.3 ft, in the southern portion of the ecoregion, to over 999.9 ft on a few of the hills in the north. Precipitation occurs mainly during the growing season and averages from 35 to 40 in annually. The ecoregion has few reservoirs or natural lakes.

Both perennial and intermittent streams are common in the ecoregion. Constructed drainage ditches and channelized streams further assist in soil drainage in flat, poorly drained areas. Stream density is approximately one half mile per square mile in the most typical portions of the ecoregion (Fig. 2).

The ecoregion is almost entirely farmland. The major crops produced are corn and soybeans. A total of 75% of the landuse is cropland, while the remaining 25% is permanent pasture, small woodlots, or urban. Emphasis on livestock includes the growing of feed grains and hay. Swine, beef and dairy cattle, chickens, and turkey are raised.

Most of the soils were developed under the influence of deciduous forest vegetation. The soils are loamy calcareous glacial till,overlain by loess deposits. The soils are lighter in color and more acid than the adjacent Central Corn Belt Plain. Hapludolls and Ochraqualf's are the dominant soil groups on dry and wet upland sites, respectively. Argiaquolls, Haplaquolls, and Medisaprists have developed in flats and depressions. Hapludalf's and Fragiudalf's are common on well drained slopes of valleys. Shallow Hapludolls occur on some valley sides where erosion has removed the glacial material and exposed the underlying shale limestone. Udifluvents and Fluvaquents have derived from silty alluvium in narrow floodplains.

The natural vegetation of the area consists of

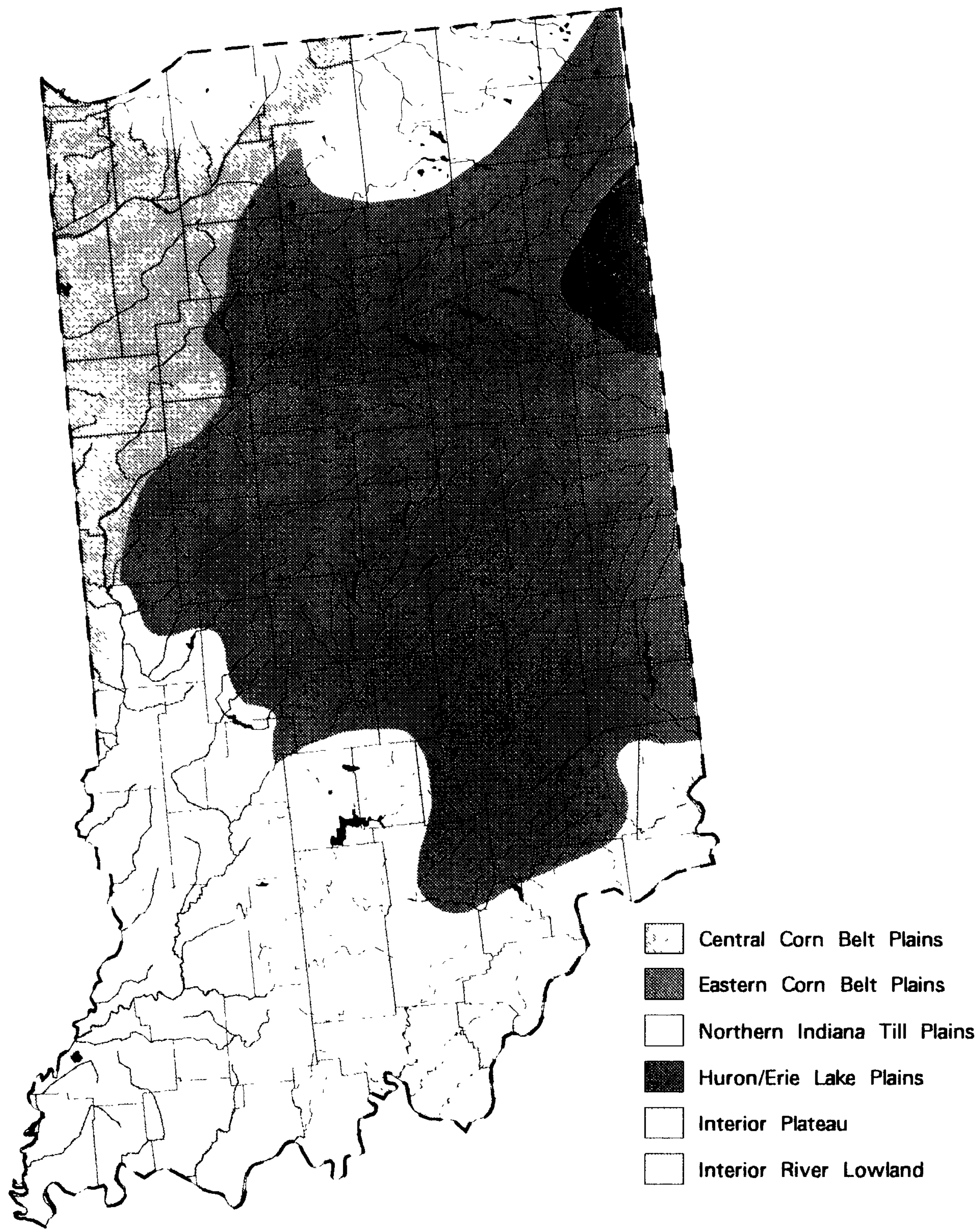


Figure 2. Map of Indiana showg the ecoregion designation from Omernik and Gallant (1988).

diverse hardwood forests, predominantly American beech and sugar maple. However, a significant amount of white oak, black oak, northern red oak, yellow popular, hickory, white ash, and black walnut exists. Many of the trees are common in adjacent ecoregions, but most are comprised of oak and hickory. Wetter sites include white oak, pin oak, northern red oak, yellow popular, ash, and sweetgum primarily, and shingle oak, black oak, and hickory also occur. Silver maple, cottonwood, sycamore, pin oak, elm, and sweetgum grow along rivers and stream corridors.

Interior River Lowland

The Interior River Lowland has varied land use including forestry, diverse cropland agriculture, orchards, livestock production, and oil and gas production. The ecoregion consists of dissected glacial tillplain which is covered by thick mantle loess, rolling narrow ridgetops, and a hilly to steep ridge and valley slopes. The ecoregion is characterized by areas ranging between 429-633.6 ft in elevation. Local relief varies between 3.3 ft on the tillplain to 108.9 ft on the rolling ridges, to nearly 660 ft on prominent ridges. Stream valleys in the hills are often intermittent becoming perennial when they reach the valley floors. Large watersheds in the ecoregion often drain as much as 350 miles$^2$ throughout the 19,000 miles$^2$ of the ecoregion in the midwest. Elevation varies from about 399.3 ft, in the southern portion of the ecoregion, to over 999.9 ft on a few of the hills in the north. Precipitation occurs mainly during the freeze period and averages from 39 to 46 in annually. The ecoregion has lakes, reservoirs, and numerous scattered ponds.

Both perennial and intermittent streams are common in the ecoregion. Constructed drainage ditches and channelized streams further drain soils in flat, poorly drained areas. Stream density is approximately two miles per square mile in the most typical portions of the ecoregion (Fig. 2).

The ecoregion has a diverse assemblage of land uses including farmland which is used for feed grains, and hay for livestock. Some corn, soybeans, and red clover seed are also grown. Undrained sites are used for forage crops, pasture or timber (almost 33% of the ecoregion is forested). Emphasis on mixed farming, livestock, and some orcharding and some grape vineyards occurs on the upland sites. Mostly beef cattle, swine and chickens are raised.

Most of the better drained soils of the Interior River Lowland ecoregion are generally light in color and moderately acidic. Hapludalphs, dominate in silty loess, glacial till, and sandy aeolian materials. Fragiudalphs have formed on some silt-covered ridgetops. Paleudalphs are common on old cherry limestones. Shallow hapludolls occur on steep slopes. Udifluvents, fluvaquents, and haplaquolls are found in poorly drained floodplains.

The natural vegetation of the area consists of oak-hickory forest. White oak, black oak, red oak, bitternut hickory, shagbark hickory, yellow popular, white ash, sugar maple, and black walnut occur on well drained soils. Pin oak, shingle oak, and sweetgum occur on wetter sites. Riparian areas support pin oak, silver maple, cottonwood, willow, sycamore, elm, sweetgum, ash, and river birch.

Natural Areas

A natural region is a major, generalized unit of the landscape where a distinctive assemblage of natural features is present (Homoya et al. 1985). It is similar to the ecoregion concept integrating several natural features, including climate, soils, glacial history, topography, exposed bedrock, presettlement vegetation, and physiography. It differs from the ecoregion concept in the utilization of biodiversity of the fauna and flora to delineate areas of relative homogeneity.

The White River drainage incorporates the Central Till Plain, Southwestern Lowlands, portions of the Highland Rim, Bluegrass, Southern Bottomlands, and Big River Natural Regions (Fig. 3).

The Central Till Plain is the largest natural

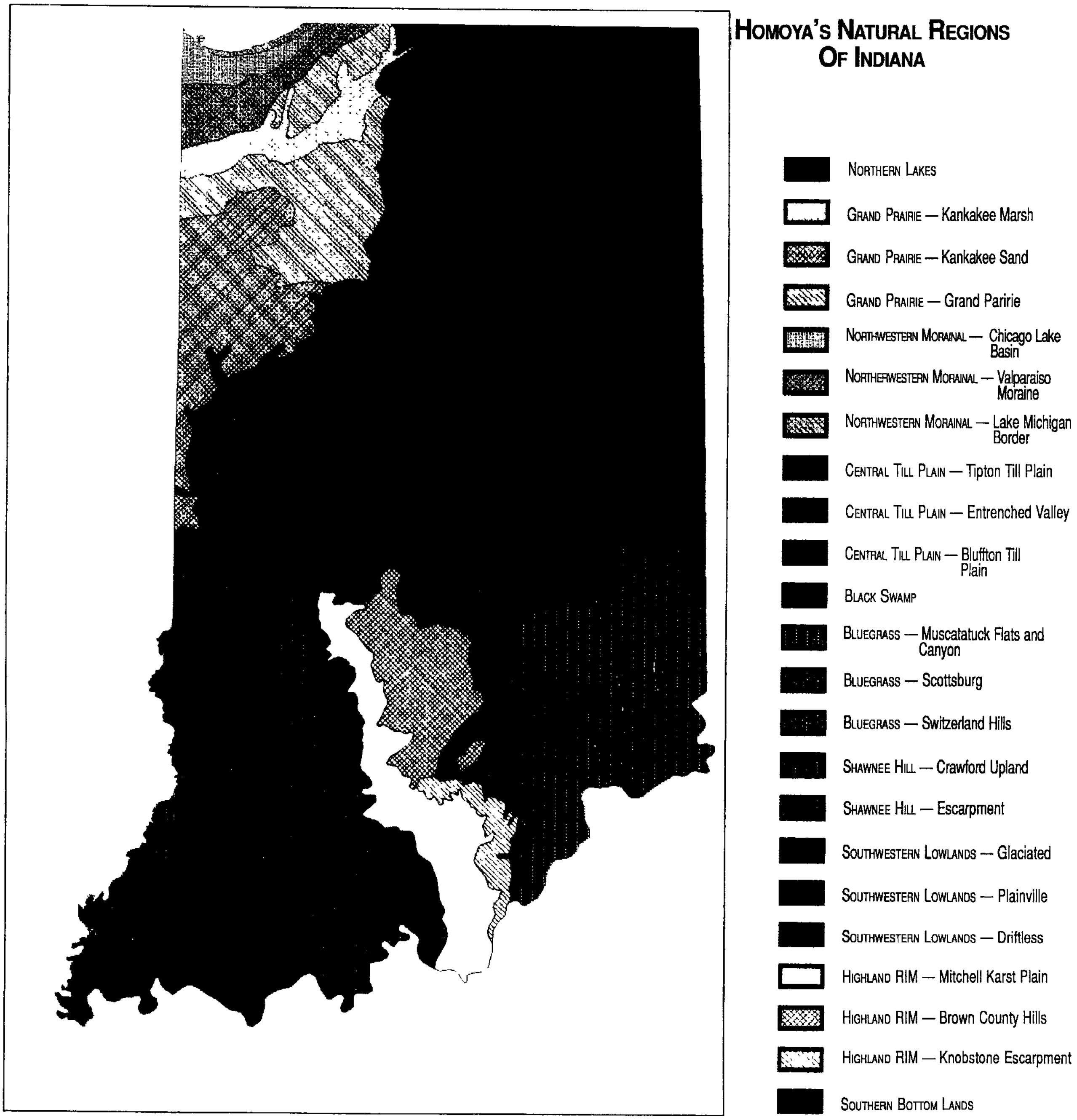


*Figure 3:* **Map of Indiana indicating the natural areas designation of Homoya et al. (1985)**

region in Indiana, formerly in the forested Wisconsinan till in the central portion of the state. The Region is topographically homogeneous although glacial moraines are common. The region is a major divide between the communities with a strong northern affinity and those with strong southern affinity, the Entrenched Valley is a concentrated continuum of northern, southern, eastern and western affinities. The Tipton Till Plain subsection is the predominant subsection of the West and upper East Fork drainages. The Tipton Till Plain is characterized by loamy Wisconsinan till. This section is mostly undissected plain formerly covered by an extensive beech-maple-oak forest.

The soils are predominantly neutral silt and silty clay loams. The northern flatwoods community associated with these poorly drained soils were ubiquitous but are now confined to the scattered woodlots. Species common to the woodlots include red maple, pin oak, bur oak, swamp white oak, Shumard's oak, American elm, and green ash. In slightly better drained soils beech, sugar maple, black maple, white oak, red oak, shagbark hickory, tulip popular, red elm, basswood, and white ash.

The Southwestern Lowlands Natural Region is characterized by low relief and extensive aggraded valleys. The lower White River and the lower portions of the East and West Forks occur in this Natural Region. Much of the area is nearly level, undissected, and poorly drained, although in several areas the topography is hilly and well drained. The region was glaciated by the Illinoian ice sheet. Three sections include the Plainville Sand section, Glaciated section, and Driftless Area section. The Glaciated is the only section which incorporates a portion of the West Fork White River.

The Glaciated Section corresponds with the Illinoian till plain. The soils are acid to neutral silt loams with a thick layer of loess. Natural communities include flatwoods forest in the Driftless Section which include shagbark hickory, shellbark hickory, pin oak, shingle oak, hackberry, green ash, red maple, and silver maple. This section had the greatest amount of prairie habitat south of the Wisconsian glacial boundary.

The Highland Rim physiographic region of the Interior Plateau ecoregion is subdivided into three subsections: Mitchell Karst Plain Section, Brown County Hills Section, and Knobstone Escarpment Section (Homoya et al. 1985). The Highland Rim is a discontinuous belt of underlying strata of Mississippian age, although some Pennsylvanian aged strata crop out in places. The region is unglaciated, with the exception of a relatively unmodified glaciated area at the northern and eastern boundary. The area possesses a large expanse of karst topography, rugged hills, and steep cliffs. Most of the area was forested during presettlement times, but large barrens occurred along with smaller areas of limestone and siltstone and gravel wash.

The major feature of the Mitchell Karst Plain include several natural community types most notably the karst plain which comprises caves, sinkhole ponds and swamps, flatwoods, barrens, limestone glade and several upland forest types. The plain is relatively level except for the limestone cliffs and rugged hills along the periphery of the range. Caves are common, the soil is generally well drained with silty loams derived from loess and weathered limestone. Acid cherry Baxter silty loam occurs mostly in the south. Along the gravel wash communities composed primarily of limestone and chert gravel border most streams. Characteristic species include Indian grass, Carolina willow, big bluestem, Carolina willow, ninebark, pale dogwood, and bulrush. Several forest communities occur, however, the western mesophytic forest type predominates and include white oak, sugar maple, shagbark hickory, pignut hickory, and white ash.

The Brown County Hills Section is characetrized by deeply dissected uplands underlain by siltstone, shale, and sandstone. The soils are well drained acid silt loams with minor amounts of loess. Bedrock is near the surface but rarely crops out. The natural communities are uniform dominated by oak-hickory, especially chestnut oak, and ravines with mesic species including beech, red oak, sugar maple, and white ash. Upper slopes usually have pure monotypic stands of chestnut oak, a thick growth of greenbrier, low growing shrubs, and a carpet of sedges.

The Knobstone Escarpment Section is similar in substrate and topography to the Brown County Hills Section. The major difference is the presence of Virginia pine in the upland forest communities. The pine is commonly co-dominant with chestnut oak on the many ridge crests and south facing slopes. American chestnut was historically dominant and has been taken over by Chestnut oak. Rock outcrops are rare and restricted to the ridge tops. Glades with shaly substrates are present, but rare, and occur on south facing slopes. They are usually sterile environments due to the unstable substrates and harsh conditions.
The Southern Bottomlands Natural Region is an alluvial bottomland along the rivers and larger streams in southwestern Indiana. It is distinguished from other bottomland regions in Indiana by the faunal affinity to the lower Mississippi River Valley and Gulf Coastal Plain. The Illinoian glacial border bisects the region placing the northern portion in the Central Lowlands physiographic province and the southern portion in the Interior Low Plateaus province. The glacial border has had little effect on the bottomland community. The soils of this Natural Region are mostly neutral to acid silt loams and are frequently flooded. The natural communities included bottomland forest, swamp, ponds, sloughs, and formerly marsh and prairie. The bottomland forest included pecan, sugarberry, swamp chestnut, pin oak, swamp white oak, red maple, silver maple, catalpa, shellbark hickory, sycamore, and green ash. The southern swamps and sloughs have bald cypress, swamp cottonwood, water locust, pumpkin ash, and overcup oak. The unique fauna of the region includes cottonmouth, hieroglyphic turtle, diamondbacked watersnake, eastern mud turtle, northern copperbelly, swamp rabbit, harlequin darter, and yellow crowned night heron.

The Bluegrass natural region is named for its similarity to the physiography and natural communities of the Kentucky bluegrass region. The entire natural region has been covered by one or more pre-Wisconsin ice sheets but today only a thin veneer of till is present. The northern boundary of the region approximates the southern terminus of the Wisconsin glaciation. Most of the natural area was forested, although a few glade, cliff, and barren remnants remain, as well as non-forested aquatic communities. The natural area is comprised of three sections, Scottsburg Lowland, Muscatatuck Flat and Canyon, and Switzerland Hills Section. Only the Scottsburg Lowland Section is included in this discussion of the East Fork of the White River.

The Scottsburg Lowland Section is wide alluvial and lacustrine plains bordering major streams. Major soils are acid to neutral silt loams with a sizeable eolian sand occurring just east of the East Fork of the White River. No unique communities or species are known to be associated with it. Bedrock rarely crops out, with the major exception being the Falls of the Ohio. Predominant natural communities are floodplain forest and swamp. The swamp community is characterized by the occurrence of swamp cottonwood, red maple, pin oak, river birch, green ash, stiff dogwood, and buttonbush. The slightly better drained floodplain forest includes sweetgum, swamp chestnut oak, swamp white oak, American elm, black gum, beech, shellbark hickory, and occassionally pecan. The rare southern pale green orchid and northern copperbelly, eastern ribbon snake, are restricted to this area. Wetland features include swamps, acid seep springs, low-gradient, silt-bottomed, streams, rivers and ponds.

The Big River natural region is defined by aquatic habitat where the average flow is 7000 cfs or greater. This includes the lower White River to its confluence at the junction with the East and West Forks. The natural area is based on the presence of several fish species (lake sturgeon, shovelnose sturgeon, alligator gar, shortnose gar, skipjack herring, smallmouth buffalo, goldeye, mooneye, and blue sucker) and several mussel species. The alligator snapping turtle, hellbender, and riverweed are also rare species restricted to this area.

**Drainage Features**

Three major drainage units occur in the White River drainage of Indiana: the Lower White River, East Fork White River, and the West Fork White River drainages.

Lower White River

The Lower White River basin begins at the junction of the East and West Forks and consists otherwise of only minor tributaries. The lower White River drains 31.3% of the State. The White River flows southwest as a major tributary of the Wabash River. Minor tributaries include Lick Creek, Prides Creek, Harbin Conger Creek, Wilson Creek, Plass Ditch, and Robb Creek. The minor tributaries fluctuate with seasonal flows. The lower White River varies dramatically with baseflow from groundwater and contributions from the East and West Forks. Average discharge for the Lower White River, downstream of the SR 61 bridge, near Petersburg, is 11,850 cfs with ranges of 573 cfs during 7 day, 10 year low flow and 183,000 cfs during 100 year flood periods (Arvin, 1989).

West Fork White River

The West Fork White River drainage is the major northern segment of the Lower White River (comprising 5,372 miles$^2$) which joins with the East Fork White River near Petersburg. The West Fork White River has been impounded, and receives a substantial amount of its streamflow from surface water. The section immediately above Indianapolis has not been dredged and probably reflects the resident fish fauna. The major tributary segments of the West Fork White River includes: the Eel River, Big Walnut Creek, White Lick Creek, Eagle Creek, Fall Creek, Rattlesnake Creek, Cicero Creek, and Duck Creek. The West Fork White River occurs in several ecoregions and natural area sections. The average discharge of the West Fork White River near Newberry (Greene County upstream of the SR 57 bridge) is 4,746 cfs with ranges of 200 cfs during 7 day, 10 year low flow and 76,900 cfs during 100 year flood periods (Arvin, 1989).

East Fork White River

The East Fork White River drainage is the major south-eastern segment of the lower White River (draining 5,745 miles$^2$) which connects with the West Fork White River near Petersburg. The East Fork White River has fewer impoundments, and receives a substantial amount of its streamflow from surface water. The River emanates north-east of Indianapolis and is formed by the combination of Sugar Creek, Driftwood River, Flatrock River, and Big Blue River. The upper portions of the Driftwood River possess an excellent ichthyofauna comprised of over 70 species. Major tributary segments of the East Fork White River include: Lost River, Indian Creek, Salt River, Muscatatuck River, White Creek, and Sand Creek. The East Fork White River occurs in several ecoregions and natural area sections. The average discharge of the East Fork White River near Shoals (Martin County downstream of US HWY 50 bridge) is 5,467 cfs with ranges of 64 cfs during 7 day, 10 year low flow and 160,000 cfs during 100 year flood periods (Arvin, 1989).

**Historical White River Data**

The White River is considered one of Indiana's highest quality resources. The White River has been intensively examined including its limnology (Bybee and Malott 1914; Denham 1938); wastewater treatment (Calvert 1932, 1933; Crawford and Wangsness 1991); hydrology (Duwelius 1990); groundwater flow (Lapham 1981; Arihood and Lapham 1982; Lapham and Arihood 1984; Duwelius and Greeman 1989); and nonpoint sources (Martin and Craig 1990). The aquatic communities of the White River have been correlated with water quality (WAPORA 1976; Environmental Science and Engineering 1987). Anderson et al. (1973) examined periphyton and macrobenthos community structure in the vicinity of the thermal discharge at Petersburg, while Brinley (1942) examined plankton response to sewage treatment. The fish community has also been well studied including distribution (Jordan 1875; Gerking 1945; Whitaker et al. 1987); recovery after fish kills (Braun 1988); thermal influence (Proffitt and Benda 1971; Whitaker and Schlueter 1973; Whitaker et al. 1977; WAPORA 1976; EA Science and Technology 1992); and the fisheries potential (Christensen 1968). Additional fisheries studies have concentrated on the East Fork (Tolentino 1988) and the West Fork (Pearson 1977; Indiana Power and Light 1977; Kingsley 1983; Braun 1984).

The White River possesses a highly diverse fish community. Previous studies have documented a total of 75 species of fish in the White River basin. The earliest records of Jordan (1877) suggest the river was abundant with both food and non-game species. EA Science and Technology (1992) found 61 species in the Lower White River, while Whitaker and Schlueter (1973) collected 75 species. Tolentino and Ball (1988) collected 48 species in the lower East Fork White River. Pearson (1978) collected 32 species in the West Fork between Madison and Randolph Counties while Braun (1984) found 48 species. Gerking (1945) documented only 9 species from the West Fork in Marion County, Kingsley (1983) collected 54 species, and Whitaker et al. (1987) found 61 total species.

## 3.0 MATERIALS AND METHODS

### Sampling

#### Site Specific

In order to answer the basin-specific questions and to calibrate an IBI in order to evaluate ecosystem health, a sufficient number of samples were required for various drainages. A total of 53 locations (Fig. 4) were surveyed during September 1990 and August 1991 in order to compile the data needed to evaluate the maximum species richness lines for calibration of the Index of Biotic Integrity. Location information for each site is contained in Appendix E of this report. Since the primary purpose of this study was to evaluate the water quality of Indiana using biological methodology, no further evaluation of site specific data (e.g. site specific taxonomic species lists) will be included other than an overall taxa list for each sub-basin.

To ensure repeat sampling at the exact same site, all locations are based on latitude and longitude. Narrative descriptions for mileage are from the center point rather than the edge of the nearest town since the boundaries of many Indiana towns will change over the next century. All sites were evaluated based on drainage area, since this provides a reliable quantification (Hughes et al. 1986) of stream size. As drainage area increases, and with it stream order, fewer locations are available for comparative analysis.

#### Habitat

The diversity of habitats sampled has a major effect on data collection. A representative sample always requires that the entire range of riffle, run, pool, and extra-channel habitat be sampled, especially when large rivers are surveyed. Atypical samples result when unrepresentative habitats are sampled adjacent to the sampling site. Species richness near bridges or near the mouths of tributaries entering large rivers, lakes, or reservoirs are more likely to be characteristic of large-order habitats than the one under consideration (Fausch et al. 1984).

A general site description of each established sampling location was conducted using the field observation procedure of Ohio EPA (1989) and Rankin (1989). The Quality Habitat Evaluation Index takes into account important attributes of the habitat which increases heterogeneity. Scoring incorporates information on substrate composition, instream cover, channel morphology, riparian zone and bank erosion,

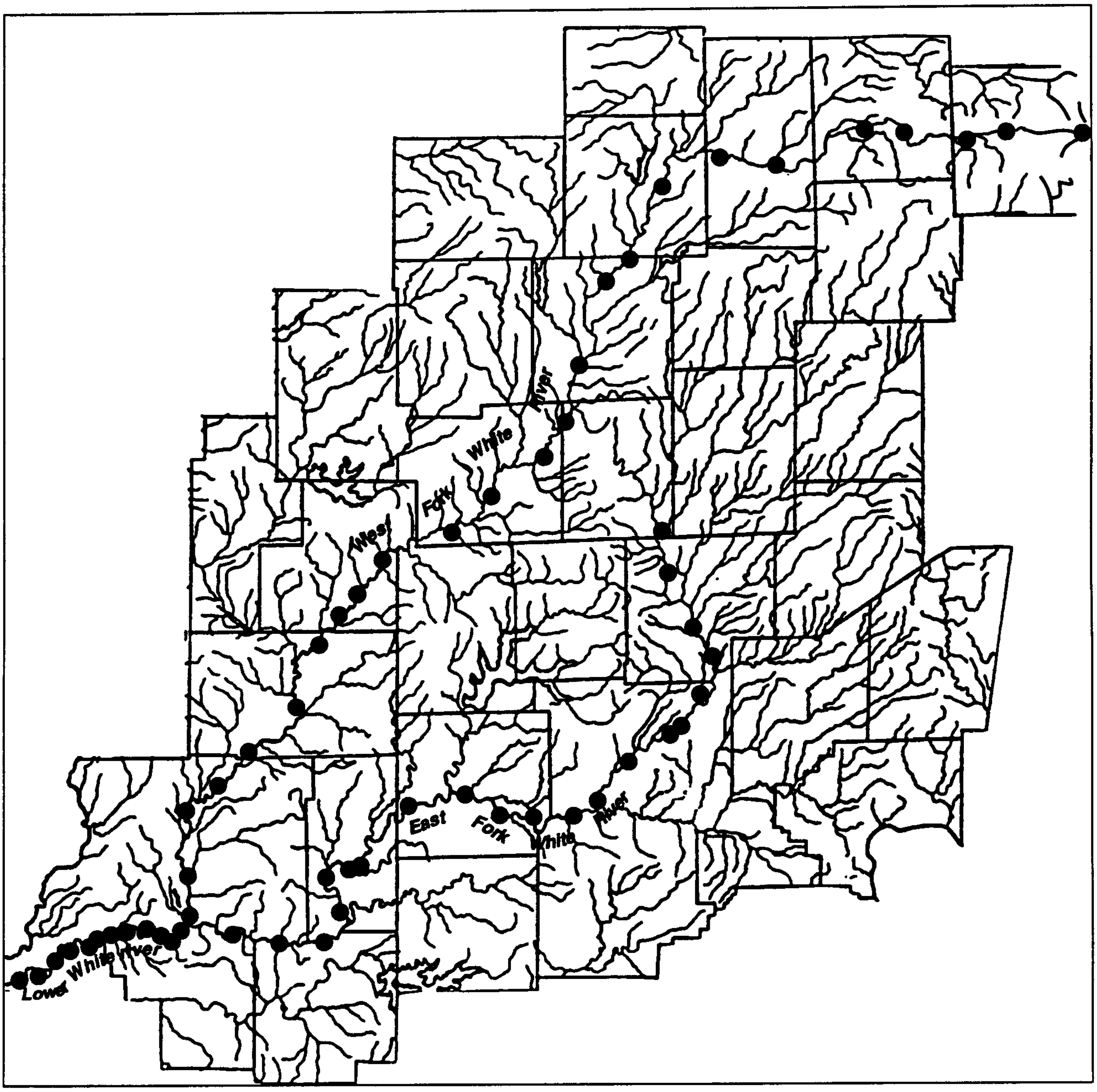


*Figure 4:* **White River drainage indicating the location of sampled locations during 1990 and 1991**

and pool and rifflequality. Physical/chemical parameters were recorded for each sample site to assist in assessing the biological data further: dissolved oxygen, pH, temperature, and specific conductivity. Equipment utilized for physical water quality analysis was a Hydrolab SVR2-SU meter following the specifications of the manufacturer.

## Community Analysis

### Sample Considerations

Only one electrofishing gear type need be used at each location (Jung and Libosvarsky 1965; Ohio EPA 1989). A T&J pulsed-DC generator capable of 300 volt output was mounted in a Coleman Sport-canoe. The boat was fished as the Sport Yak, wading in shallow riffles and runs, and floated through pools and unwadeable habitat.

An attempt was made to collect all fish at each site. Adult and juvenile specimens from each stream reach were identified to species utilizing the taxonomic keys of Gerking (1955), Trautman (1981), and Becker (1983). Cyprinid taxonomy follows Mayden (1989), canges in species nomenclature is listed in Appendix E for comaprability with previous investigations. The young-of-the-year fish less than 20 mm in length are not included in Index of Biotic Integrity or composite totals anal_..is. Early life stages exhibit high initial mortality (Simon 1989) and are difficult to collect with gear designed for larger fish (Angermeier and Karr 1986). Collection of fish from this category will be retained for possible future use in State water monitoring programs (e.g. ichthyoplankton index ($I^2$)).

The length of stream reach sampled is an important consideration. Karr et al. (1986) recommended in larger streams to select several contiguous riffle-pool sequences rather than relying on a standard length. When electrofishing equipment was employed in larger rivers (i.e. > 1,000 $mi^2$), samples were taken in units of 0.5 to 1.0 km (Gammon et al. 1981). The length of the sample reach was long enough to include all major habitat types. Distances of 11 to 15 stream widths were generally adequate to sample two cycles of habitat (Leopold et al. 1964). Photographs; township, range, and section numbers; latitude and longitude; and county locations were recorded on the data sheet.

Selecting the appropriate time of year for sampling is critical. Karr et al. (1986) found that periods of low-to moderate stream flow are preferred and the relatively variable flow conditions of early spring and late autumn/winter should be avoided. Species richness tends to be higher later in summer due to the presence of young-of-the-year of rare species, but this can be avoided if sampling does not incorporate young-of-the-year species. Samples of limited area may be less variable in early summer than comparable samples taken later in the year. A total of 5% of the total sites were resampled for precision and accuracy estimates.

### Sample Site Selection

Fish sample sites were selected based upon several factors:

1). Choosing stream reaches affected by point source dischargers;

2). Stream use issues (i.e. Lower White River adjacent Petersburg);

3). Location of physical habitat features (e.g. dams, changes in geology, changes in stream order, presence of stream confluence, etc.);

4). Location of non-point sources of pollution (e.g. urban areas or obvious farm runoff);

5). Variations in habitat suitability for fish;

6). Atypical habitat not representative of River reach or basin.

Whenever possible, sites were located upstream from pollution sources and adjacent tributaries (Gammon 1973). Stations were selected from natural areas, parks (Federal, State, County, and Local), exceptional designated streams, and from historical sampling locations whenever available.

When non-impacted areas were not present, "least impacted" areas were selected based on the above criteria. Sites were chosen which indicated recovery from channelization or potential non-point source areas, and which had a suitable riparian buffer on the shoreline. When a series of point source dischargers were located on a river, every effort was made to sample upstream of the discharger present on the highest upstream segment, or to search for areas of recovery between the dischargers (Krumholz 1946).

When impoundments or other physical habitat had been installed on the river, sampling was conducted in the tailwaters of a dam (area immediately downstream). Tailwaters possess the greatest resemblance of the lotic habitat. In areas where sampling could not be accomplished downstream of the dam due to lack of access, stream tributary segments were located upstream of the dam away from the immediate influence of the pooled portion. Likewise, bridges were usually sampled on the upstream side, away from the immediate vicinity of any structure and any construction effects. When deviated, habitat was more representative of the reach downstream.

Fish from each location were identified to species and enumerated. Smaller and more difficult to identify taxa were preserved for later examination and identification in the laboratory. All fish were examined for the presence of gross external anomalies. Incidence of these anomalies was defined as the presence of externally visible morphological anomalies (i.e. deformities, erosion, lesions/ulcers) and is expressed as percent of anomalous fish among all fish collected. Incidence of occurrence was computed for each species at each station.

Specific anomalies include: anchor worms; leeches; pugheadedness; fin rot; Aeromonas (causes ulcers, lesions, and skin growth, and formation of pus-producing surface lesions accompanied by scale erosion); dropsy (puffy body); swollen eyes; fungus; ich; curved spine; and swollen-bleeding mandible or opercle.

Hybrid species encountered in the field (e.g. centrarchids, cyprinids) were recorded on the data sheet, and if possible, potential parental combinations recorded.

## Index of Biotic Integrity

The ambient environmental condition was evaluated using the Index of Biotic Integrity (Karr 1981; Karr et al. 1986). This index relies on multiple parameters (termed "metrics") based on community concepts, to evaluate a complex system. It incorporates professional judgement in a systematic and sound manner, but sets quantitative criteria that enables determination of a continuum between poor and excellent based on species richness and composition, trophic and reproductive constituents, and fish abundance and condition. The twelve original Index of Biotic Integrity metrics reflect insights from several perspectives and cumulatively are responsive to changes of relatively small magnitude, as well as broad ranges of environmental degradation.

Since the metrics are differentially sensitive to various perturbations (e.g. siltation or toxic chemicals), as well as various degrees or levels of change within the range of integrity, conditions at a site can be determined with considerable accuracy. The interpretation of the index scoring is provided in six narrative categories that have been tested in Region V (Karr 1981; Table 1).

Several of the metrics are drainage size dependent and require calibration to determine numerical scores (Tables 2-3). The ecoregion approach developed by USEPA-Corvallis, OR,

**Table 1. Attributes of Index of Biotic Integrity (IBI) classification, total IBI scores, and integrity classes from Karr et al. (1986).**

| Total IBI score | Integrity Class | Attributes |
|---|---|---|
| 58-60 | Excellent | Comparable to the best situation without human disturbance; all regionally expected species for the habitat and stream size, including the most intolerant forms, are present with a full array of age (size) classes; balance trophic structure. |
| 48-52 | Good | Species richness somewhat below expectations, especially due to the loss of the most intolerant forms; some species are present with less than optimal abundances or size distributions; trophic structure shows some signs of stress. |
| 40-44 | Fair | Signs of additional deterioration include loss of intolerant forms, fewer species, highly skewed trophic structure (e.g. increasing frequency of omnivores and other tolerant species); older age classes of top predators may be rare. |
| 28-34 | Poor | Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present. |
| 12-22 | Very Poor | Few fish present, mostly introduced or tolerant forms; hybrids common; disease, parasites, fin damage, and other anomalies regular. |
| | No fish | Repeated sampling finds no fish. |

compared "least impacted" zones within the region (Omernik 1987). Ohio EPA (1987), modified several of the metrics in order to make them more sensitive to environmental effects from their experiences in Ohio and to account for stream and river size, faunal differences, and sampling gear selectivity. The current study utilizes the experiences of the Ohio EPA and Karr et al. (1986) in adapting an index for Indiana large and great rivers.

### Metrics

In general, the metrics utilized for the current study are those developed by the State of Ohio (Ohio EPA 1987) for analysis of surface water use-attainment. This includes modification of several of the original Index of Biotic Integrity metrics as proposed by Karr (1981).

Although the methodology and application of the ecoregional expectations are similar in approach to Ohio and much of the information below is taken directly from the Ohio document (Ohio EPA 1988), a significant difference exists between the Indiana and Ohio data bases. This

**Table 2. Index of Biotic Integrity metrics used to evaluate wadable/boatable large river (<2,000 miles² drainage area) sites in the White River drainage.**

| Metric Category | Metric | Scoring Classification 5 | 3 | 1 |
|---|---|---|---|---|
| Species Composition | Total Number of Species | >23 | 16-23 | >16 (Fig. 6) |
| | Number Darter/Sculpin/Madtom Species | > 4 | 2-4 | < 2 (Fig. 7) |
| | Number of Sunfish Species | > 4 | 2-4 | < 2 (Fig. 9) |
| | Number of Round-Bodied Suckers Species | > 4 | 2-4 | < 2 (Fig. 10) |
| | Number Sensitive Species | > 7 | 4-7 | < 4 (Fig. 11) |
| | % Tolerant Species | <15% | 15-30% | >30% (Fig. 12) |
| Trophic Composition | % Omnivores[1] ≤ 2,000 square miles | <15% | 15-30% | >30% (Fig. 13) |
| | % Insectivores[1] ≤ 2,000 square miles | <65% | 40-65% | >40% (Fig. 14) |
| | % Carnivores[1] | Varies with drainage area (Fig. 15) | | |
| Fish Condition | Catch per Unit Effort[1] | Varies with drainage area (Fig. 16) | | |
| | % Simple Lithophils[1] | Varies with drainage area (Fig. 17) | | |
| | % DELT anomalies[1] | <0.1% | 0.1-1.3% | >1.3% (Fig. 18) |

[1] Special scoring procedures are required when less than 100 individual fish are collected.

difference exists in how the metric expectations are developed. In Ohio, the ecoregional reference stations were combined into a single data set for the entire State, and later modifications were developed for the Huron-Erie Lake Plain. In Indiana, "least impacted" conditions will be developed on a regional basis, with recognition of basin differences within ecoregion, based on the natural areas classification of Homoya et al. (1985). Further evaluation at the completion of the study will determine if differential metric treatment is warranted for basin specific or larger scale criteria development.

**Table 3. Index of Biotic Integrity metrics used to evaluate wadable/boatable great river (>2,000 miles$^2$ drainage area) sites in the White River drainage.**

| Metric Category | Metric | Scoring Classification 5 | 3 | 1 |
|---|---|---|---|---|
| Species Composition | Total Number of Species | >23 | 16-23 | >16 (Fig. 6) |
| | % Large River Taxa | >27% | 13-27% | >13% (Fig. 8) |
| | Number of Sunfish Species | > 4 | 2-4 | < 2 (Fig. 9) |
| | Number of Round-Bodied Sucker Species | > 4 | 2-4 | < 2 (Fig. 10) |
| | Number of Sensitive Species | > 7 | 4-7 | < 4 (Fig. 11) |
| | % Tolerant Species | <15% | 15-30% | >30% (Fig. 12) |
| Trophic Composition | % Omnivores[1] > 2,000 square miles | <15% | 15-30% | >30% (Fig. 13) |
| | % Insectivores[1] > 2,000 square miles | >65% | 40-65% | >40% (Fig. 14) |
| | % Carnivores[1] | Varies with drainage area (Fig. 15) | | |
| Fish Condition | Catch per Unit Effort | Varies with drainage area (Fig. 16) | | |
| | % Simple Lithophils | Varies with drainage area (Fig. 17) | | |
| | % DELT anomalies[1] | <0.1% | 0.1-1.3% | >1.3% (Fig. 18) |

[1] Special scoring procedures are required when less than 100 individual fish are collected.

The Index of Biotic Integrity is sensitive to differences in collection effort and gear type. In order to account for these inherent biases, separate expectations are developed for each of the two stream classification types utilized in the current study. Large River sites (< 2000 miles$^2$) were primarily sampled for 500-1000 m using wading techniques when possible. These sites were sampled using a sport-yak configuration in the sport canoe, while larger unwadable great rivers (> 2000 miles$^2$) were sampled using the same boat-mounted equipment, but relied less on wading techniques.

Below is an explanation of each of the twelve metrics utilized for the calibration of the Indiana Index of Biotic Integrity for large rivers. Due to inherent differences at approximately 2000 miles$^2$ drainage area, different metrics were necessary to evaluate both large and great rivers (> 2000 mi$^2$ drainage area). No differences were observed between the ecoregions and drainage area for most metrics. This was anticipated due to the limitations of the gear type chosen and that large rivers tend to be integrators of the upstream drainage area.

Maximum species richness lines were drawn following the procedure of Fausch et al. (1984) and Ohio EPA (1987). Scatter plot data diagrams of individual metrics were first evaluated for basin specific patterns. The maximum species richness line method primarily used was the trisection method, with the exception of the total number of species metric. This requires the uppermost line to be drawn so that 95% of the data area lies beneath. When data from impacted sites was included and reflected fewer species than "least impacted sites" the MSR lines were drawn so trisection accounted for only the unimpacted sites. The other two lines were then drawn so the remainder of the area beneath the 95th percentile line was divided into three equivalent areas. In situations where no significant deviation in relationship was observed within the three basin segments, the segments were pooled to reflect an ecoregional consensus. Likewise, if no relationship with increasing drainage area was observed, the maximum species richness lines either leveled off at the point where no additional increases were exhibited or horizontal plots were delineated indicating no increase with drainage area.

The drainage area, where differentiation between large and great river sites was derived, was indicated on the graphs by a vertical dashed line on the MSR line for percent large river taxa. This relationship was determined by searching for bimodal patterns in the basin specific data set plots of species richness. A sixth order polynomial defined where a significant bimodal effect was evident for each of the drainage basins (Fig. 7). The tails of the data are not significant. However the point where the data differentiates into two distinct peaks suggest that the transition between large and great rivers occurs at approximately 2,000 miles$^2$ drainage area.

## Metric 1. Total Number of Fish Species (Large and Great Rivers)

### Impetus

This metric is utilized for all of the stream classification types used for calibrating the Indiana Index of Biotic Integrity for Large and Great Rivers. Unlike the Ohio metric, exotic species are included in the total number of taxa. The premise behind this metric is based on the observation that the number of fish species increases directly with environmental complexity and quality of the aquatic resource (Karr 1981; Karr et al. 1986). Although the number of exotic or introduced species may be indicative of a loss of integrity (Karr et al. 1986; Ohio EPA 1987), the differences between lower levels of biotic integrity resolution may be due to colonization of habitats by pioneer or tolerant taxa which tend to incorporate exotic species.

This single metric is considered to be one of the most powerful metrics in resolving water resource issues since a direct correlation exists between high quality resources and high numbers of species for warmwater assemblages (Ohio EPA 1987; Davis and Lubin 1989; Plafkin et al. 1989; Simon 1991). As total number of species increases, species become more specialized and have narrower niche breadths, numerous higher level interactions occur and presumably enable greater efficiency in resource utilization.

The clarification of drainage relationships, i.e. headwater and wadable Indiana streams in the Central Corn Belt Plain ecoregion, was made primarily on the data from this metric. Large River and wadable streams are differentiated at 1000 miles$^2$ drainage area.

### Large and Great Rivers Boat and Wading Sites

The number of species is not strongly correlated with drainage area at large or great river boat and wading sites up to ca. 11,400 miles$^2$. Determining the Index of Biotic Integrity scoring criteria for this metric did not require the recognition of sub-basins. Comparison of maximum species richness lines for the appropriate basin and drainage area did not reveal any significant differences between ecoregion or basin (Fig. 5; large and great river boat and wading sites).

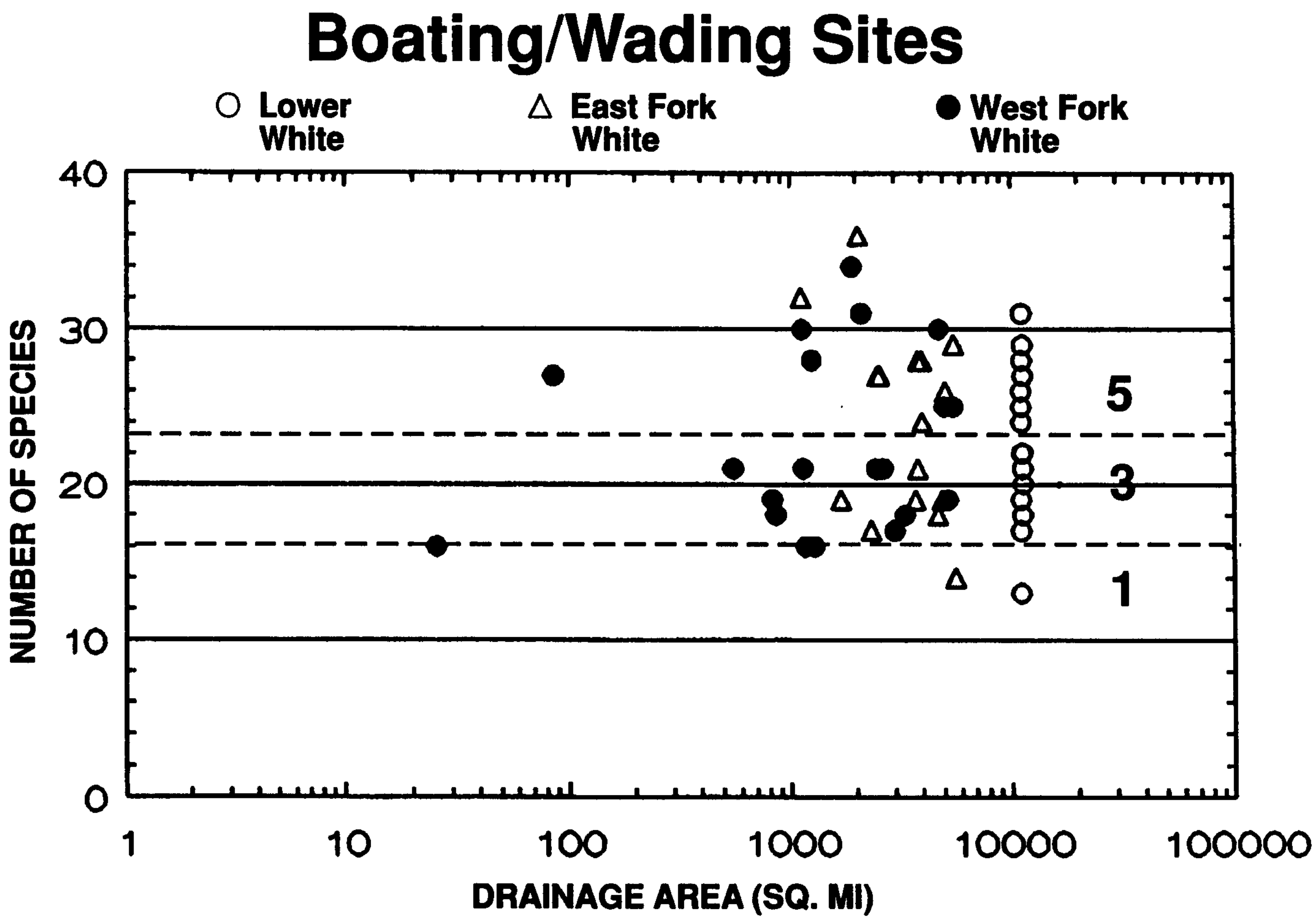


*Figure 5:* **Maximum species richness lines for determining trends in total number of species with increasing drainage area for the White River drainage.**

# Metric 2. Number of Benthic Insectivore Species (Large River < 2,000 miles²) Proportion Great River Species (Great River > 2,000 miles²)

## Impetus

Karr et al. (1986) indicated that the presence of members of the tribe Etheostomatini are indicative of a quality resource. Darters require high dissolved oxygen concentrations, are intolerant of toxicants and siltation, and thrive over clean substrates.

Life history information for all of the 27 Indiana species indicates darters are insectivorous, habitat specialists, and sensitive to physical and chemical environmental disturbances (Page 1983; Kuehne and Barbour 1983). Darters are excellent indicators of a quality resource, generally in riffle habitats.

## Large River Sites

The darters include the genera: Ammocrypta, Crystallaria, Etheostoma, and Percina. Of the 27 species recorded from Indiana, six are commonly found throughout the State and are not restricted to a particular stream size (Gerking 1945). Fifteen species are confined to the Ohio River basin; none of the species are restricted to the Mississippi River basin; and a single species occurs only in the Great Lakes drainage (Table 4).

For large river sites, those less than 2,000 miles² drainage area, this metric also includes members of the family Cottidae (sculpins) and Ictaluridae (madtoms; genus Noturus). The sculpins and madtoms are benthic insectivores and functionally occupy the same type of niche as darters. Their inclusion enables a greater degree of sensitivity in evaluating streams that naturally have fewer darter species. By adding madtoms and sculpins this metric asymptotes with increased drainage area (Fig. 7). The number of benthic insectivores remain static with increasing drainage area for each of the three basins. In the West Fork White River drainage, few darters occurred so this metric was estimated based on the total number of species which could be expected rather than observed during the current study. No differences in ecoregion expectations were observed between sites in the Interior River Lowland and Eastern Corn Belt Plain.

## Great River Sites

Due to a reduction of quality sites at higher drainage area categories for the Lower White River drainage the expected number of darter species should be reduced. The darter, madtom and sculpin species were not included in cumulative scoring for drainage areas greater than 2,000 miles² due to inconsistency in sampling and their patchy distribution in great rivers. In order to determine quality habitat in drainage areas greater than 2,000 miles² a subsitute metric was selected.

Pflieger (1971) noted that the large rivers of Missouri possessed a distinctive fish faunal assemblage that set them apart as a separate faunal region. Pflieger recognized that approximately 16% of the Missouri fauna belonged to this group. He correlated the distribution of the large river fauna with several factors controling their distribution. Although many environmental factors are involved, three (bottom type, current velocity, and turbidity) seem to be of fundamental importance. Significant differences between the turbid Missouri River and clearer Mississippi River

**Table 4. The distributional characteristics of Indiana darter (Etheostomatini), madtom (Noturus), and sculpin (Cottus) species.**

| | Distribution in Indiana Drainages | | | |
|---|---|---|---|---|
| Species | Statewide | Ohio River | Great Lakes | Mississippi River |
| Ammocrypta pellucida | X | | | |
| A. clara | | | X | X |
| Crystallaria asprella | X | | | |
| Etheostoma asprigene | X | | | |
| E. blennioides | | X | | |
| E. caeruleum | X | | | |
| E. camurum | | X | | |
| E. chlorosoma | X | | | |
| E. exile | | | X | |
| E. flabellare | X | | | |
| E. gracile | | X | | |
| E. histrio | | X | | |
| E. maculatum | | X | | |
| E. microperca[1] | X | | X | X |
| E. nigrum | X | | | |
| E. spectabile | | X | | |
| E. squamiceps | | X | | |
| E. tippecanoe | | X | | |
| E. variatum | | X | | |
| E. zonale | | | X | X |
| Percina caprodes | X | | | |
| P. copelandi | | X | | |
| P. evides | | X | | |
| P. maculata | X | | | |
| P. phoxocephala | | | X | X |
| P. sciera | | X | | |
| P. shumardi | | X | | X |
| Noturus eleutherus | | X | | |
| N. flavus | X | | | |
| N. gyrinus | X | | | |
| N. insignis | | X | | |
| N. miurus | | X | X | |
| N. nocturnus | | X | | |
| Cottus bairdi | X | | | |
| C. carolinae | | X | | |
| C. cognatus | | | X | |

[1] Restricted to northern portions of these drainages.

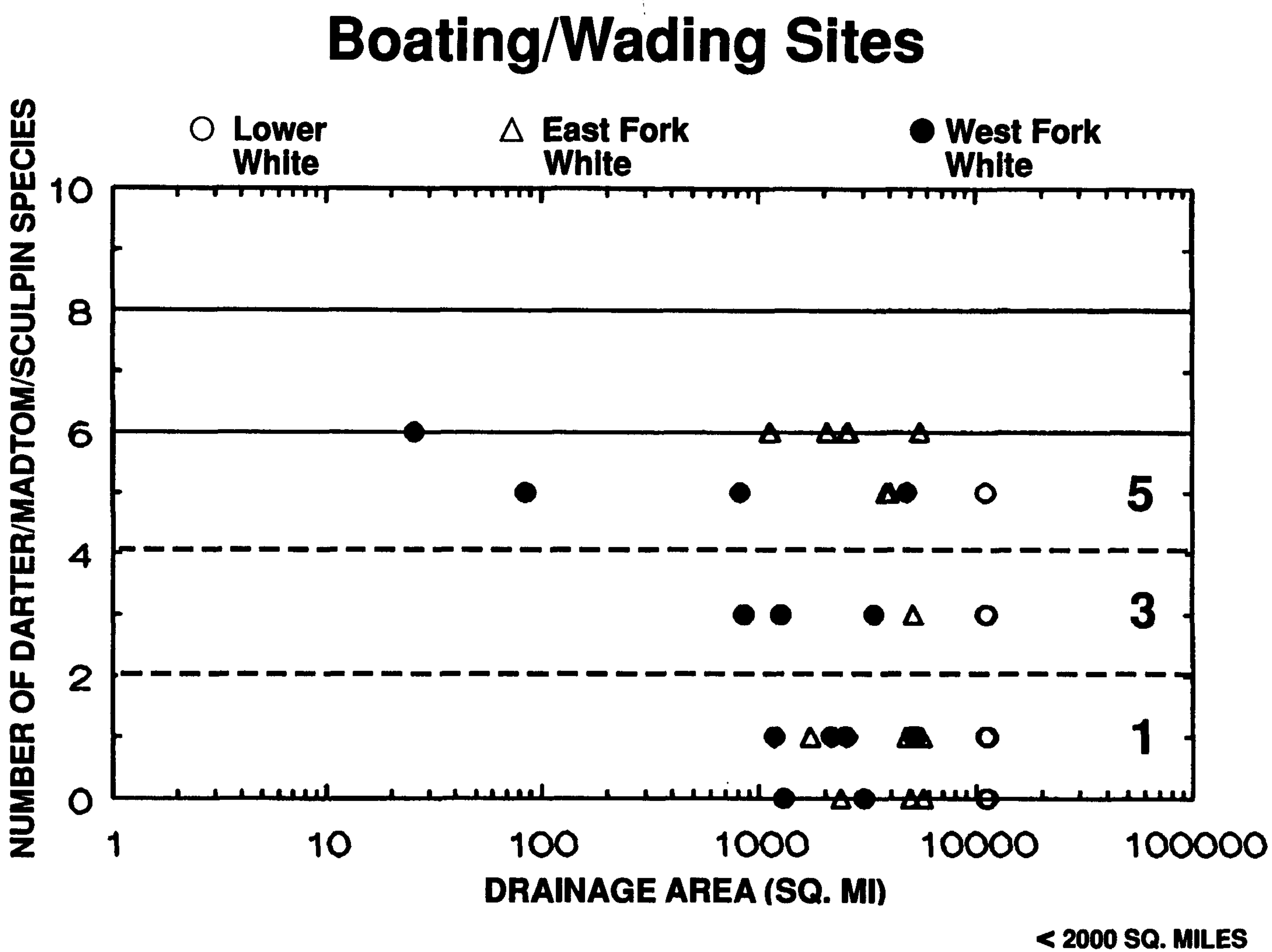


*Figure 6:* **Maximum species richness lines for determining trends in number of darter/madtom/sculpin species with increasing drainage area for the White River drainage.**

**Table 5. List of Indiana fish species considered to be indicative of a Large River Fauna (Pflieger, 1971; Gerking, 1945).**

| Common Name | Scientific Name |
|---|---|
| Silver lamprey | Ichthyomyzon unicuspis |
| Chestnut lamprey | I. castaneus |
| Lake sturgeon | Acipenser fulvescens |
| Shovelnose sturgeon | Scaphryhncus platoryhncus |
| Paddlefish | Polyodon spathula |
| Alligator gar | Atractosteus spatula |
| Shortnose gar | Lepisosteus platostomus |
| Skipjack herring | Alosa chrysochloris |
| Threadfin shad | Dorosoma cepedianum |
| American eel | Anguilla rostrata |
| Mooneye | Hiodon alosoides |
| Goldeye | Hiodon tergisus |
| Silver chub | Macrhybopsis storeriana |
| Gravel chub | Erimystax x-punctata |
| Speckled chub | Extrarius aestivalis |
| Mississippi Silvery minnow | Hybognathus nuchalis |
| River chub | Nocomis micropogon |
| Emerald shiner | Notropis atherinoides |
| Silverband shiner | N. shumardi |
| Spottail shiner | N. hudsonius |
| Mimic shiner | N. volucellus |
| Channel shiner | N. wickliffi |
| Bullhead minnow | Pimephales vigilax |
| Blue sucker | Cycleptus elongatus |
| Smallmouth buffalo | Ictiobus bubalus |
| Bigmouth buffalo | I. cyprinellus |
| Black buffalo | I. niger |
| Channel catfish | Ictalurus punctatus |
| Blue catfish | I. furcatus |
| Flathead catfish | Pylodictis olivaris |
| Burbot | Lota lota |
| White bass | Morone chrysops |
| Yellow bass | M. mississippiensis |
| Sauger | Stizostedion canadense |
| Walleye | S. vitreum |
| Crystal darter | Crystallaria asprella |
| Eastern sand darter | Ammocrypta pellucida |
| Western sand darter | A. clara |
| Channel darter | Percina copelandi |
| River darter | P. shumardi |
| Freshwater drum | Aplodinotus grunniens |

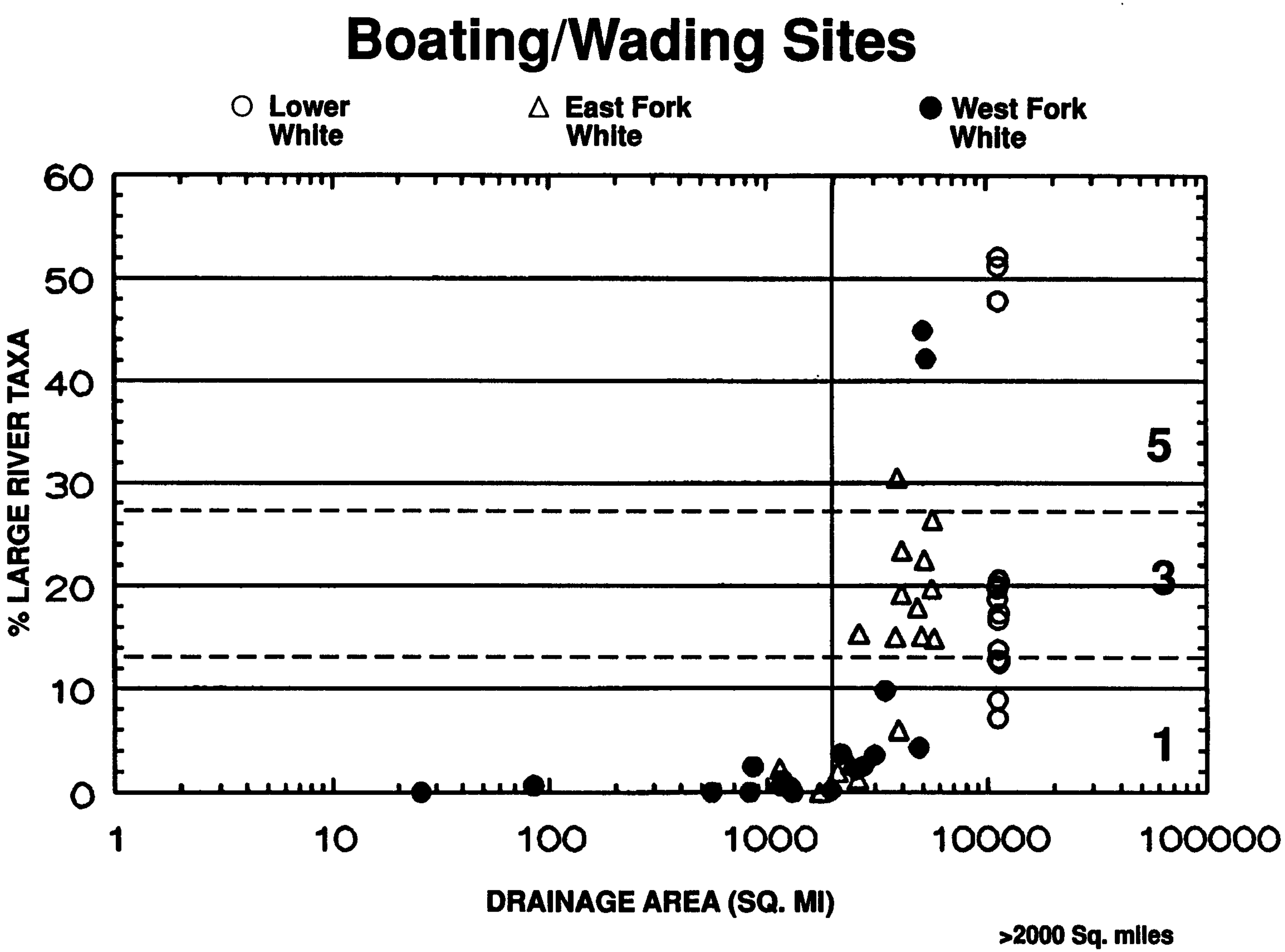


*Figure 7:* **Maximum species richness lines for determining trends in the proportion of large river species with increasing drainage area for the White River drainage.**

were noted based on the silt load, absence of rubble bottoms, and flow characteristics. The reduction in backwater habitat also limits the presence of reproductive habitat for such species as gar (Wallus et al., 1990). The number of large river species increased considerably as large river stations exceeded 2,000 $miles^2$ drainage area (Fig. 7). The selection of taxa representative of large river habitat (Table 5) was based on Pflieger (1971) and Burr and Warren (1986). The list of species was then compared with known distributions of Indiana species (Gerking, 1945).

## Metric 3. Number of Sunfish Species (Large and Great Rivers)

### Impetus

This metric followed Karr (1981) and Karr et al. (1986) by including the number of sunfish species (family Centrarchidae), however the black basses (Micropterus spp) were included. Unlike the Ohio metric, the redear sunfish Lepomis microlophus is included because it is native to Indiana (Table 6). Hybrid sunfish are not included in this metric following Ohio EPA (1987).

This metric is an important measure of pool habitat quality. It includes all members of the sunfish genera Ambloplites (rock bass), Centrarchus (round sunfish), Lepomis (sunfish), and Pomoxis (crappies), as well as, the ecological equivalent Elassomatidae (Elassoma zonatum). Sunfish normally occupy slower moving water which may act as sinks for the accumulation of toxins and siltation. This metric measures degradation of rock substrates (i.e. gravel and boulder) and instream cover (Pflieger 1975; Trautman 1981), and the associated aquatic macroinvertebrate community which are an important food resource for sunfish (Forbes and Richardson 1920; Becker 1983). Sunfish are important components of the aquatic community since they are wide ranging, and distributed in most streams and rivers of Indiana. They are also very susceptible to electrofishing gear. Karr et al. (1986) found sunfish to occupy the intermediate to upper ends of sensitivity of the index of biotic integrity.

### Large and Great River Sites

The amount of pool habitat is a limiting factor in many river reaches which prohibits colonization by sunfish. This metric did not show any difference in scoring based on ecoregion or sub-basin. The number of sunfish species is not affected by increasing drainage area using boat-wading methods (Fig. 8).

Table 6. List of Indiana sunfish species for evaluating quality pool habitat.

| Common Name | Scientific Name |
|---|---|
| Rock bass | Ambloplites rupestris |
| Flier | Centrarchus macropterus |
| Green sunfish | Lepomis cyanellus |
| Pumpkinseed | L. gibbosus |
| Warmouth | L. gulosus |
| Orangespotted sunfish | L. humilis |
| Bluegill | L. macrochirus |
| Longear sunfish | L. megalotis |
| Redear sunfish | L. microlophus |
| Spotted sunfish | L. punctatus |
| White crappie | Pomoxis annularis |
| Black crappie | P. nigromaculatus |
| Smallmouth bass | Micropterus dolomieui |
| Spotted bass | M. punctulatus |
| Largemouth bass | M. salmoides |

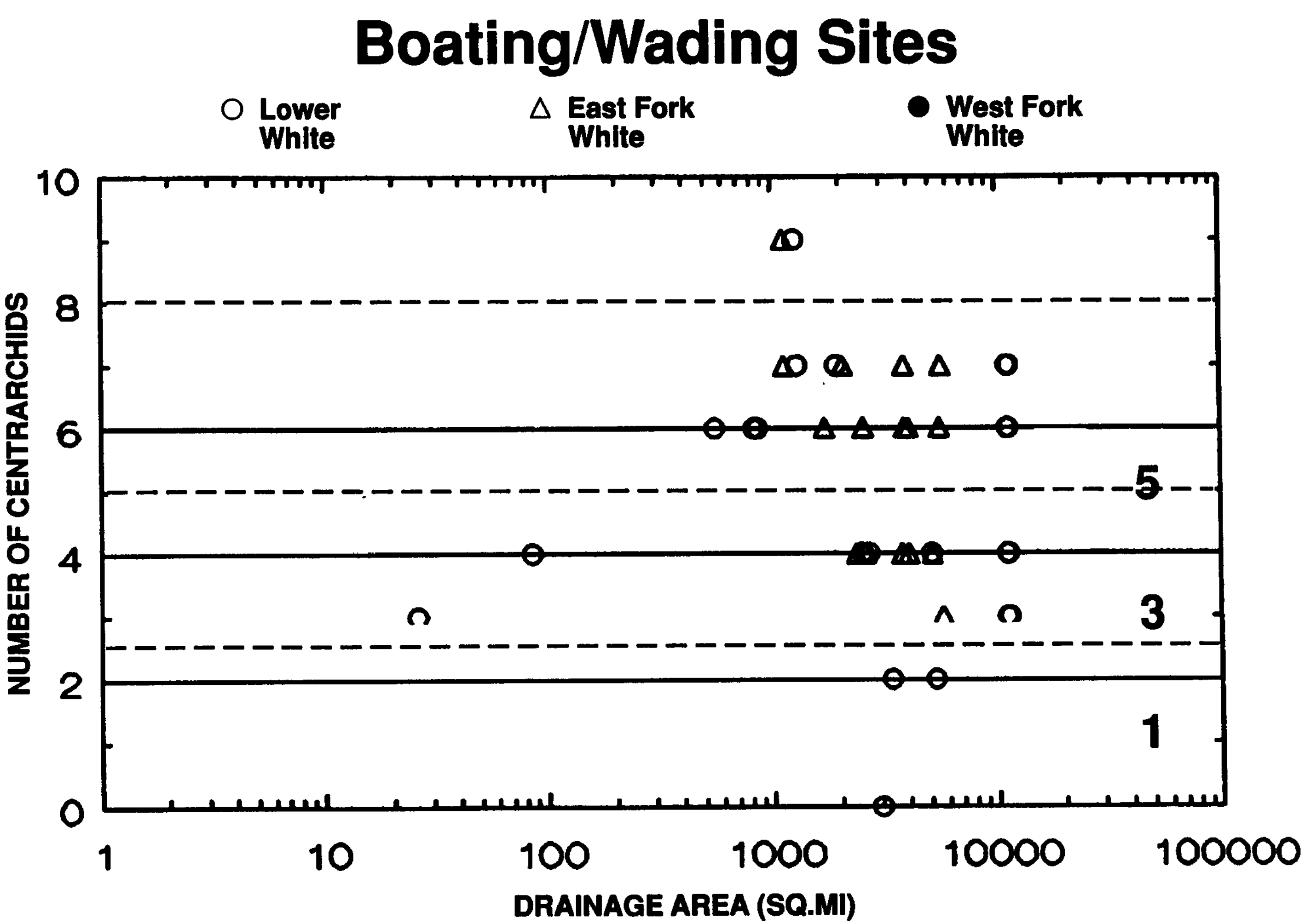


*Figure 8:* **Maximum species richness lines for determining trends in number of Centrarchids species with increasing drainage area for the White River drainage.**

# Metric 4. Number of Round-Bodied Sucker Species (Large and Great Rivers)

### Impetus

The original Index of Biotic Integrity metrics included the number of sucker species (Karr 1981; Karr et al. 1986). Suckers represent a major component of the Indiana fish fauna since their total biomass usually ranks them among the highest contributors to the community. Most sucker species are intolerant to habitat and water quality degradation (Phillips and Underhill 1971; Karr et al. 1986; Trautman 1981; Becker 1983) and this results in sensitivity at the higher end of environmental quality. Suckers, due to their long life cycles (10-20 years), provide a long-term assessment of past environmental conditions. Of the 19 species extant in Indiana, Lagochila lacera is considered extinct, seven species are widely distributed throughout the State (Table 7). Extant sucker genera include: Cycleptus, Carpiodes, Catostomus, Erimyzon, Hypentelium, Ictiobus, Minytrema, and Moxostoma.

### Large and Great River Sites

The number of sucker species, with the exception of the Catostomus commersoni, Ictiobus and Carpiodes, represent sensitive species intolerant to thermal, siltation, and toxins stresses. The redhorses are particularly important indicator organisms in large rivers. Round-bodied suckers include members of the genera Cycleptus, Hypentelium, Moxostoma, Minytrema, and Erimyzon. These species are effectively sampled with boat electrofishing gear and comprise a significant component of large river fish faunas. Their feeding and reproductive requirements are indicative of sensitivity to turbidity and marginal to poor water quality. The number of species were not significantly different between large and great rivers, among the two ecoregions or between sub-basins (Fig. 9).

Table 7. Distributional characteristics of Indiana sucker species (family Catostomidae).

| Species | Statewide | Large Rivers | Rare Taxa |
|---|---|---|---|
| Cycleptus elongatus | | X | X |
| Carpiodes carpio | X | X | |
| C. cyprinus | X | | |
| C. velifer | | X | X |
| Catostomus catostomus | | | X |
| C. commersoni | X | | |
| Erimyzon oblongus | X | | |
| E. sucetta | | | X |
| Hypentelium nigricans | X | X | |
| Ictiobus bubalus | X | X | |
| I. cyprinellus | X | X | |
| I. niger | | X | |
| Lagochila lacera | | | EXTINCT |
| Minytrema melanops | | X | |
| Moxostoma anisurum | X | X | |
| M. carinatum | | X | X |
| M. duquesnei | X | X | X |
| M. erythrurum | X | X | X |
| M. macrolepidotum | X | X | |
| M. valenciennesi | | X | X |

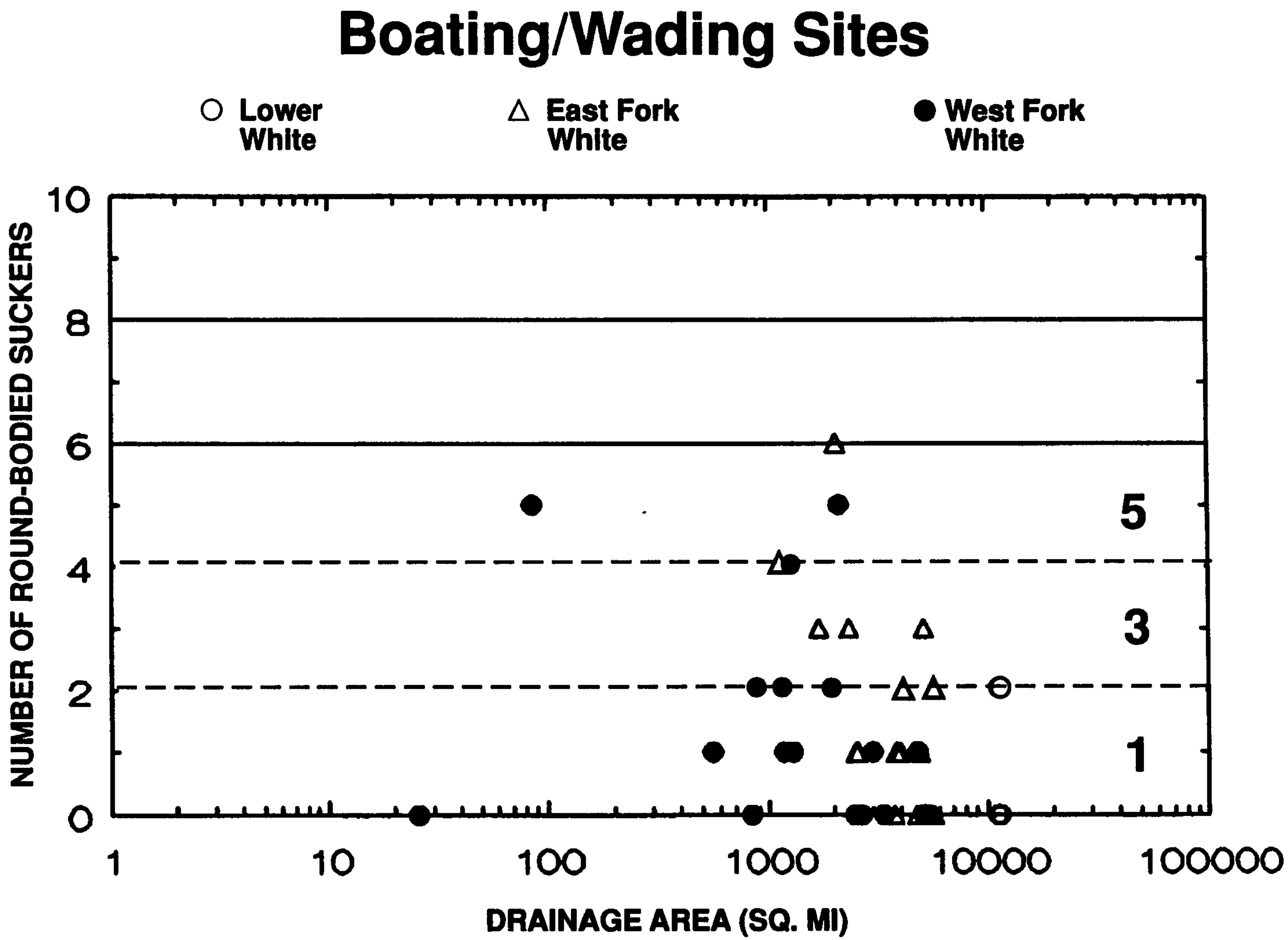


*Figure 9:* **Maximum species richness lines for determining trends in number of round-bodied sucker species with increasing drainage area for the White River drainage.**

# Metric 5. Number of Sensitive Species (Large and Great Rivers)

## Impetus

The number of sensitive species metric distinguishes between streams of highest quality. Designation of too many species as intolerant will prevent this metric from discriminating among the highest quality resources. Only species that are highly intolerant to a variety of disturbances were included in this metric so it will respond to diverse types of perturbations (Table 8; see Appendix A for species-specific information).

The number of intolerant taxa is a modification of the original index developed by Ohio EPA (1987). The metric included moderately intolerant species when sampling at headwater sites. This combination is called sensitive species since few intolerant taxa are expected. The moderately intolerant species meet most of the established criteria of Ohio EPA (1987). An absence of these species would indicate a severe anthropogenic stress or loss of habitat.

The criteria for determining intolerance is based on the numerical and graphical analysis of Ohio's regional data base, Gerking's (1945) documentation of historical changes in the distribution of Indiana species, and supplemental information from regional ichthyofaunal texts (Pflieger 1975; Smith 1979; Trautman 1981; Becker 1983; Burr and Warren 1986). Intolerant taxa are those which decline with decreasing environmental quality and disappear, as viable populations, when the aquatic environment degrades to the "fair"category (Karr et al. 1986). The intolerant species list was divided into three categories, all are included in this metric for scoring:

1). common intolerant species (I): species which are intolerant, but are widely distributed in the best streams in Indiana;

2). uncommon or geographically restricted species (S): species that are infrequently captured or that have restricted ranges;

3). rare or possibly extirpated species (R): intolerant species that are rarely captured or which lack recent status data.

Commonly occurring intolerant species made up 5-10% of the common species in Indiana. This was a recommended guideline of Karr (1981) and Karr et al. (1986). Although the addition of species designated as uncommon or rare sensitive species (categories 2 and 3), inflates the number of intolerant species above the 10% guideline, nowhere in the State do all of the species coexist at the same time. In order to evaluate streams in the Large and Great river categories, only the sensitive species metric will be used until further resolution is possible with the addition of adjacent ecoregion sampling. Until more sampling is completed or improvements in water quality warrant it, the sensitive species metric (Ohio EPA 1987) will be used for all Large and Great river classifications in Indiana.

## Large and Great River Wading and Boat Sites

The expected number of intolerant species was anticipated to increase with drainage area among the wading sites, however, such a positive trend is not evident in White River drainage data (Fig. 10). Intolerant taxa are scarce and may even decrease at larger wading and boat sites. In order to provide meaningful stream reach comparisons in Indiana, the sensitive species metric is currently retained until further evaluation can be completed.

**Table 8. List of Indiana fish species considered to be sensitive to a wide variety of environmental disturbances including water quality and habitat degradation.**

| Sensitive Species Common Name | Scientific Name | Common Name | Scientific Name |
|---|---|---|---|
| Ohio lamprey | Ichthyomyzon bdellium | Mountain madtom | Noturus eleutherus |
| Northern brk lamprey | I. fossor | Slender madtom | N. exilis |
| Least brook lamprey | Lampetra aepyptera | Stonecat | N. flavus |
| American brk lamprey | L. appendix | Brindled madtom | N. miurus |
| | | Freckled madtom | N. nocturnus |
| Paddlefish | Polyodon spatula | | |
| | | Northern cavefish | Amblyopsis spelaea |
| Goldeye | Hiodon alosoides | Southern cavefish | T. subterraneus |
| Mooneye | H. tergisus | | |
| | | Northern studfish | Fundulus catenatus |
| Redside dace | Clinostomus elongatus | Starhead topminnow | F. dispar |
| Streamline chub | Erimystax dissimilis | | |
| Gravel chub | E. x-punctata | Brook silverside | Labidesthes sicculus |
| Speckled chub | Extrarius aestivalis | | |
| Bigeye chub | Hybopsis amblops | Rock bass | Ambloplites rupestris |
| Pallid shiner | H. amnis | Longear sunfish | Lepomis megalotis |
| Rosefin shiner | Lythrurus ardens | Smallmouth bass | Micropterus dolomieui |
| Hornyhead chub | Nocomis biguttatus | | |
| River chub | N. micropogon | Western sand darter | Ammocrypta clara |
| Pugnose shiner | Notropis anogenus | Eastern sand darter | A. pellucida |
| Popeye shiner | N. ariommus | Greenside darter | Etheostoma blennioides |
| Bigeye shiner | N. boops | Rainbow darter | E. caeruleum |
| Ironcolor shiner | N. chalybaeus | Bluebreast darter | E. camurum |
| Blacknose shiner | N. heterodon | Harlequin darter | E. histrio |
| Blackchin shiner | N. heterolepis | Spotted darter | E. squamiceps |
| Sand shiner | N. ludibundis | Tippecanoe darter | E. tippecanoe |
| Silver shiner | N. photogenis | Variegate darter | E. variatum |
| Rosyface shiner | N. rubellus | Banded darter | E. zonale |
| Weed shiner | N. texanus | Logperch | Percina caprodes |
| Mimic shiner | N. volucellus | Channel darter | P. copelandi |
| Pugnose minnow | Opsopoeodus emiliae | Gilt darter | P. evides |
| Longnose dace | Rhinichthys cataractae | Slenderhead darter | P. phoxocephala |
| | | Dusky darter | P. sciera |
| Blue sucker | Cycleptus elongatus | | |
| Highfin carpsucker | Carpiodes velifer | | |
| Northern hogsucker | Hypentelium nigricans | | |
| Silver redhorse | Moxostoma anisurum | | |
| River redhorse | M. carinatum | | |
| Black redhorse | M. duquesnei | | |
| Golden redhorse | M. erythurum | | |
| Shorthead redhorse | M. macrolepidotum | | |
| Greater redhorse | M. valenciennesi | | |

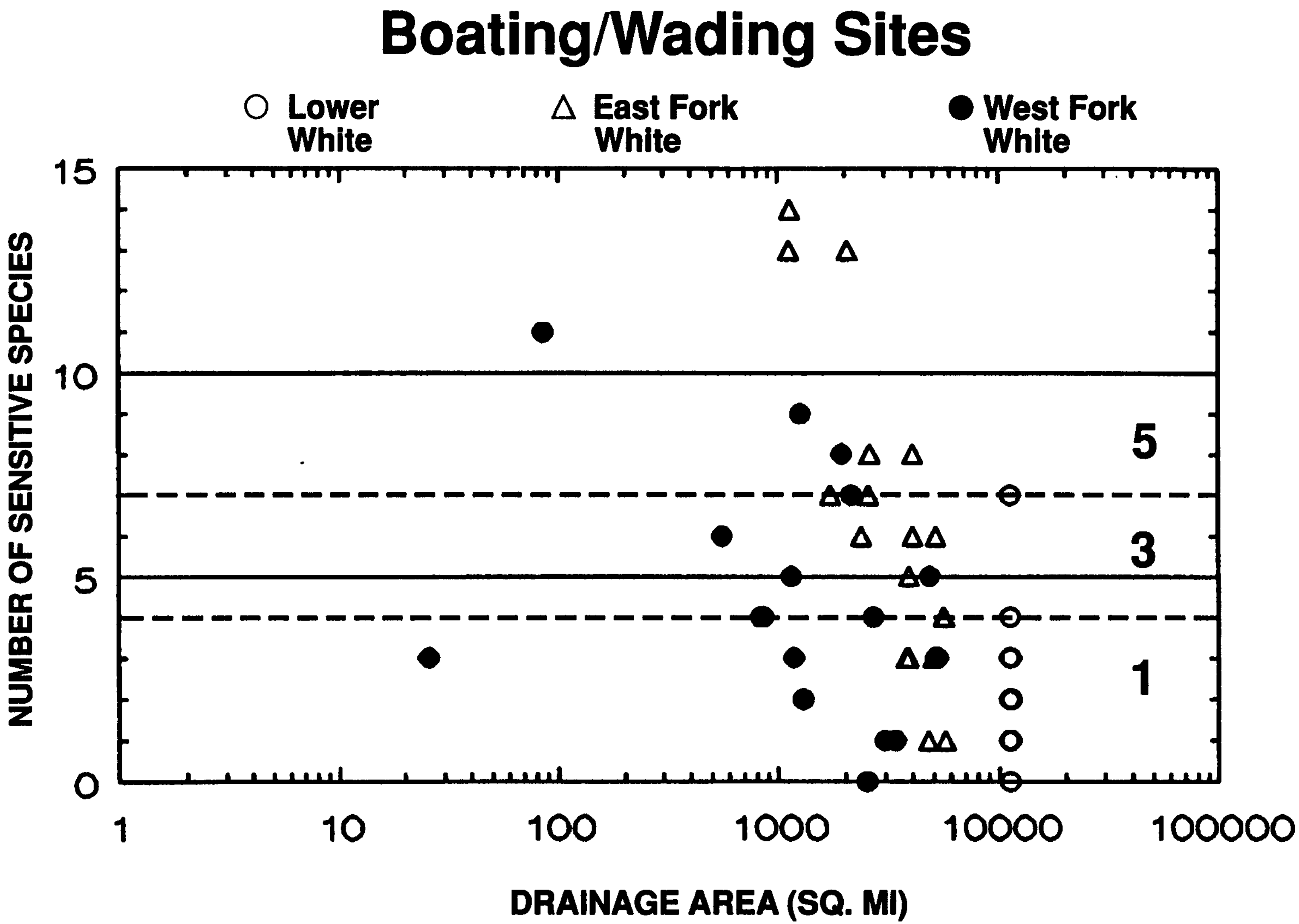


*Figure10:* **Maximum species richness lines for determining trends in number of sensitive species with increasing drainage area for the White River drainage.**

## Metric 6. Percent Abundance of Tolerant Species (Large and Great Rivers)

### Impetus

This metric is a modification of the original index metric, the percentage of green sunfish (Karr et al. 1986), by Ohio EPA (1987). This metric detects a decline in stream quality from fair to poor categories. The green sunfish, Lepomis cyanellus, is a species that is often present in moderate numbers in many Midwest streams and can become a dominant member of the community in cases of degradation or poor water quality. A tolerance to disturbed environments enables the green sunfish to survive and reproduce even under perturbed conditions. Although the green sunfish is widely distributed in the Midwest, it is most commonly collected in low order streams. This introduces an inherent bias for moderate to large rivers. Karr et al. (1986) suggested additional species could be substituted for the green sunfish if they responded in a similar manner. Several species in Indiana meet this criteria of increasing in proportion with increasing degradation of stream quality. This increase in the number of tolerant species increases the sensitivity of this metric for various sized streams and rivers. Since different species have habitat requirements that are correlated with stream size, composition of the tolerant species metric does not change with drainage area.

Indiana's tolerant species are listed in Table 9. This list is based on a numerical and graphical analysis of Indiana catch data and historical changes in the distribution of fishes throughout Indiana (Gerking 1945). Tolerant species were selected based on the following criteria:

1) present at poor or fair sites: Based on our data base of Indiana collections these species are commonly collected at sites ranked either fair or poor.

2) historically increases in abundance: Based on historical collection information (Gerking 1945) these species increase in abundance and have not indicated any reduction in distribution.

3) increased tolerance to degraded conditions: these species increased in community dominance when environmental conditions shifted from good to fair or poor environmental quality.

Species listed as tolerant taxa exhibit diverse tolerance to thermal loadings, siltation, habitat degradation, and certain toxins (Gammon, 1983; OEPA, 1987).

### Large and Great River Wading and Boat Sites

No relationship was evident for drainage areas greater than 1000 miles$^2$ (Fig. 11), nor was there any relationship with ecoregion or sub-basin apparent for the White River drainage.

**Table 9. List of Indiana fish species considered to be highly tolerant to a wide variety of environmental disturbances including water quality and habitat degradation for Large River sites in Indiana.**

| Tolerant Species Common Name | Scientific Name |
|---|---|
| Longnose gar | *Lepisosteus osseus* |
| Shortnose gar | *L. platostomus* |
| Gizzard shad | *Dorosoma cepedianum* |
| Central mudminnow | *Umbra limi* |
| Carp | *Cyprinus carpio* |
| Goldfish | *Carrasius auratus* |
| Red shiner | *Cyprinella lutrensis* |
| Golden shiner | *Notemigonus crysoleucas* |
| Bluntnose minnow | *Pimephales notatus* |
| Fathead minnow | *P. promelas* |
| Blacknose dace | *Rhinichthys atratulus* |
| Creek chub | *Semotilus atromaculatus* |
| River carpsucker | *Carpiodes cyprinus* |
| Quillback | *C. carpio* |
| Smallmouth buffalo | *Ictiobus bubalus* |
| Bigmouth buffalo | *I. cyprinellus* |
| White sucker | *Catostomus commersoni* |
| Channel catfish | *Ictalurus punctatus* |
| Flathead catfish | *Pylodictis olivaris* |
| Yellow bullhead | *Amieurus natalis* |
| Brown bullhead | *A. melas* |
| Eastern banded killifish | *Fundulus diaphanus diaphanus* |
| Freshwater drum | *Aplodinotus grunniens* |
| White bass | *Morone chrysops* |
| Green sunfish | *Lepomis cyanellus* |

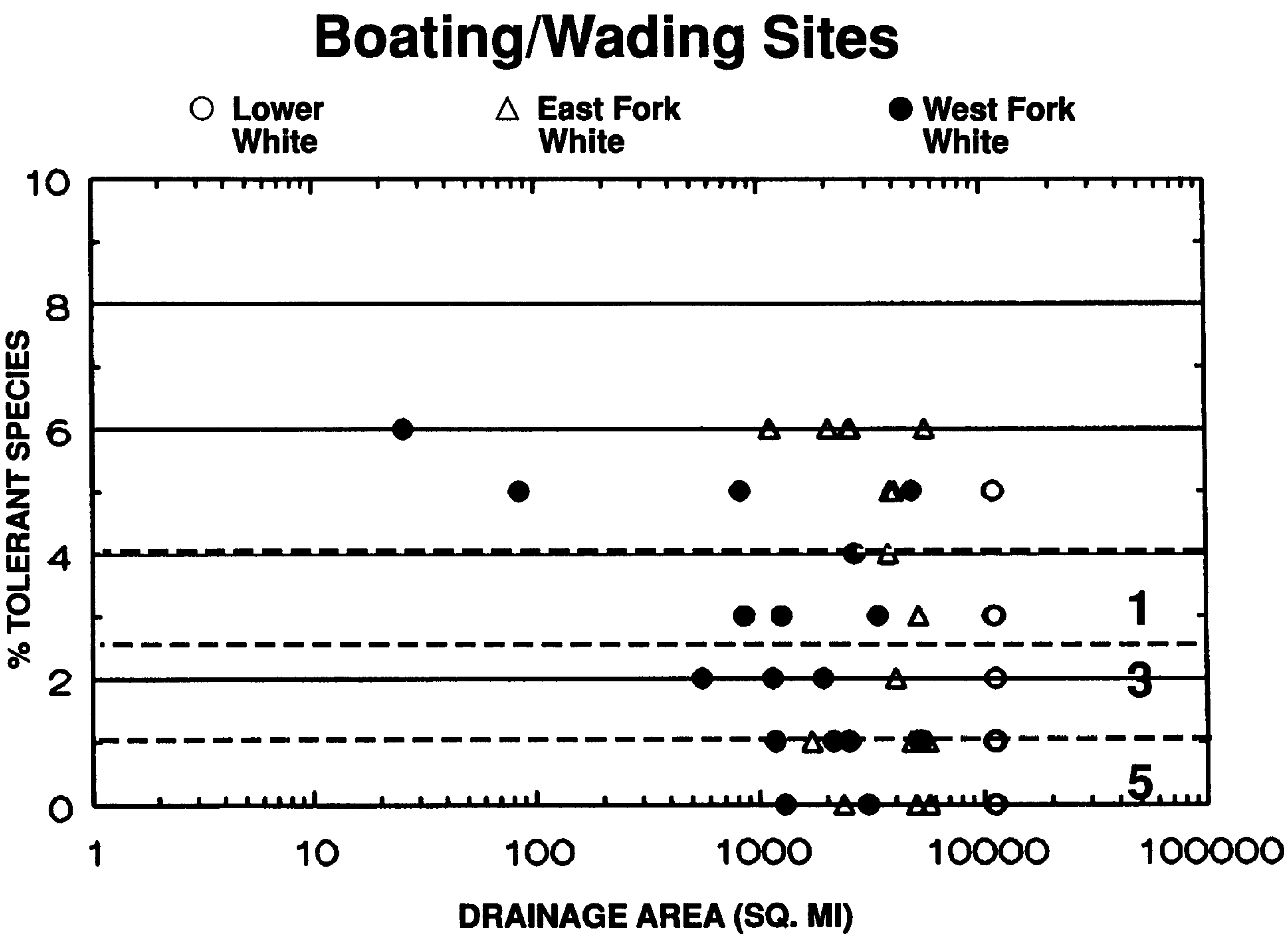


*Figure 11:* **Maximum species richness lines for determining trends in the proportion of tolerant species with increasing drainage area for the White River drainage.**

# Metric 7. Proportion of Omnivores (Large and Great Rivers)

## Impetus

The definition of an omnivore follows that of Karr (1981) and Karr et al. (1986), which requires species to take significant quantities of both plant and animal materials (including detritus) and have the ability, usually indicated by the presence of a long gut and dark peritoneum, to utilize both. Omnivores are species whose diets include at least 25% plant and 25% animal foods. Fishes which do not feed on plants but on a variety of animal material are not considered omnivores. Dominance of omnivores suggests specific components of the food base are less reliable, increasing the success of more opportunistic species. Specialized filter-feeders are not included in this metric after Ohio EPA (1987) since these species are sensitive to environmental degradation, e.g. paddlefish, Polyodon spathula and lamprey ammocoetes, Lampetra and Ichthyomyzon. Species which tended to shift diet due to degraded environmental conditions were also not included as omnivores, e.g. Semotilus atromaculatus and Rhinichthys atratulus. This metric evaluates the intermediate to low categories of environmental quality (Table 10; see Appendix B for species-specific feeding guild classification).

## Large and Great River Wading and Boat Sites

Due to minor changes in omnivore classification, only those species which consistently feed as omnivores were included in our analysis. These values differ from the omnivore percentages of Karr et al. (1986) but resemble Ohio EPA's (1987) classification. No relationship with drainage area was found for large or great river sites (Fig. 12).

Table 10. List of Indiana fish species considered to be omnivores.

| Omnivores Common Name | Scientific Name |
|---|---|
| Gizzard shad | Dorosoma cepedianum |
| Threadfin shad | D. petenense |
| Central mudminnow | Umbra limi |
| Goldfish | Carassius auratus |
| Grass carp | Ctenopharyngodon idella |
| Carp | Cyprinus carpio |
| Cypress minnow | Hybognathus hayi |
| Central silvery minnow | H. nuchalis |
| Silver carp | Hypopthalmichthys molitrix |
| Bluntnose minnow | Pimephales notatus |
| Fathead minnow | P. promelas |
| Bullhead minnow | P. vigilax |
| River carpsucker | Carpiodes carpio |
| Quillback | C. cyprinus |
| Highfin carpsucker | C. velifer |
| White sucker | Catostomus commersoni |

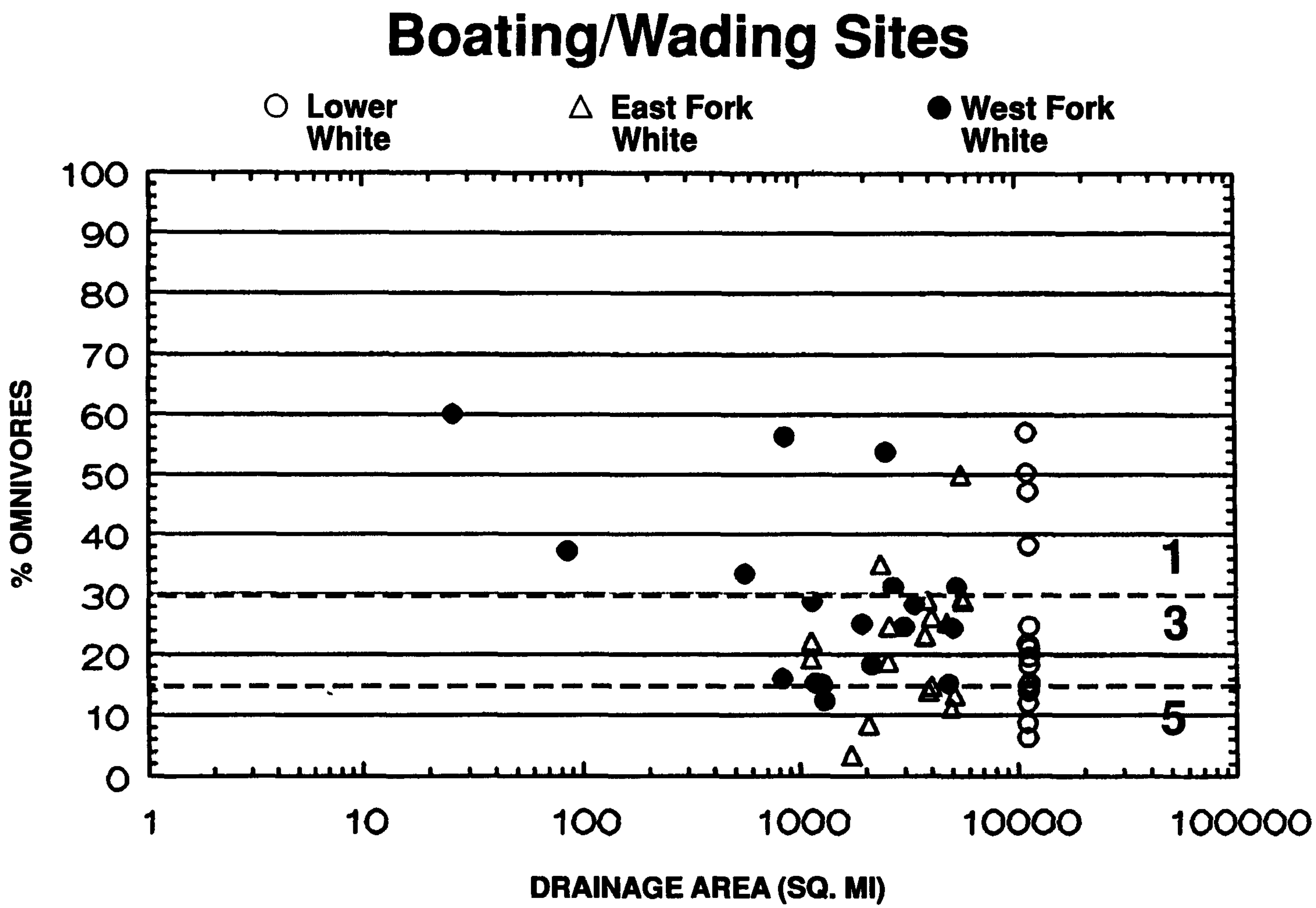


*Figure 12:* **Maximum species richness lines for determining trends in the proportion of omnivores with increasing drainage area for the White River drainage.**

# Metric 8. Proportion of Insectivores (Large and Great Rivers)

## Impetus

The proportion of insectivores is a modification of Karr et al.'s (1986) original metric, proportion of insectivorous cyprinidae. This metric is intended to respond to a lowering of the benthic macroinvertebrate community which comprises the primary food base for most fishes. As disturbance increases, the diversity of insect larvae decreases, triggering an increase in the omnivorous trophic level. Thus, this metric varies inversely with metric 7 with increased environmental degradation. The inclusion of all insectivorous species was based on the observation that all regions of Indiana do not possess high proportions of insectivorous cyprinids in high quality streams. This metric was recalibrated following the recommendation of Karr et al. (1986; see Appendix B for species-specific classification).

## Large and Great River Wading and Boat Sites

Insectivorous species designation generally conforms to that provided in Karr et al. (1986), however, I concur with Ohio EPA in the elimination of the opportunistic feeding creek chub, Semotilus atromaculatus, and blacknose dace, Rhinichthys atratulus, from the insectivore designation. Leonard and Orth (1986) felt that the current trophic definitions of Karr et al. (1986) were rather arbitrary since they observed a negative correlation between insectivores and biotic integrity in a West Virginia stream. Scoring criteria indicated no relationship existed between drainage area and proportion of insectivorous fishes in either ecoregion or sub-basin in the White River drainage (Fig. 13).

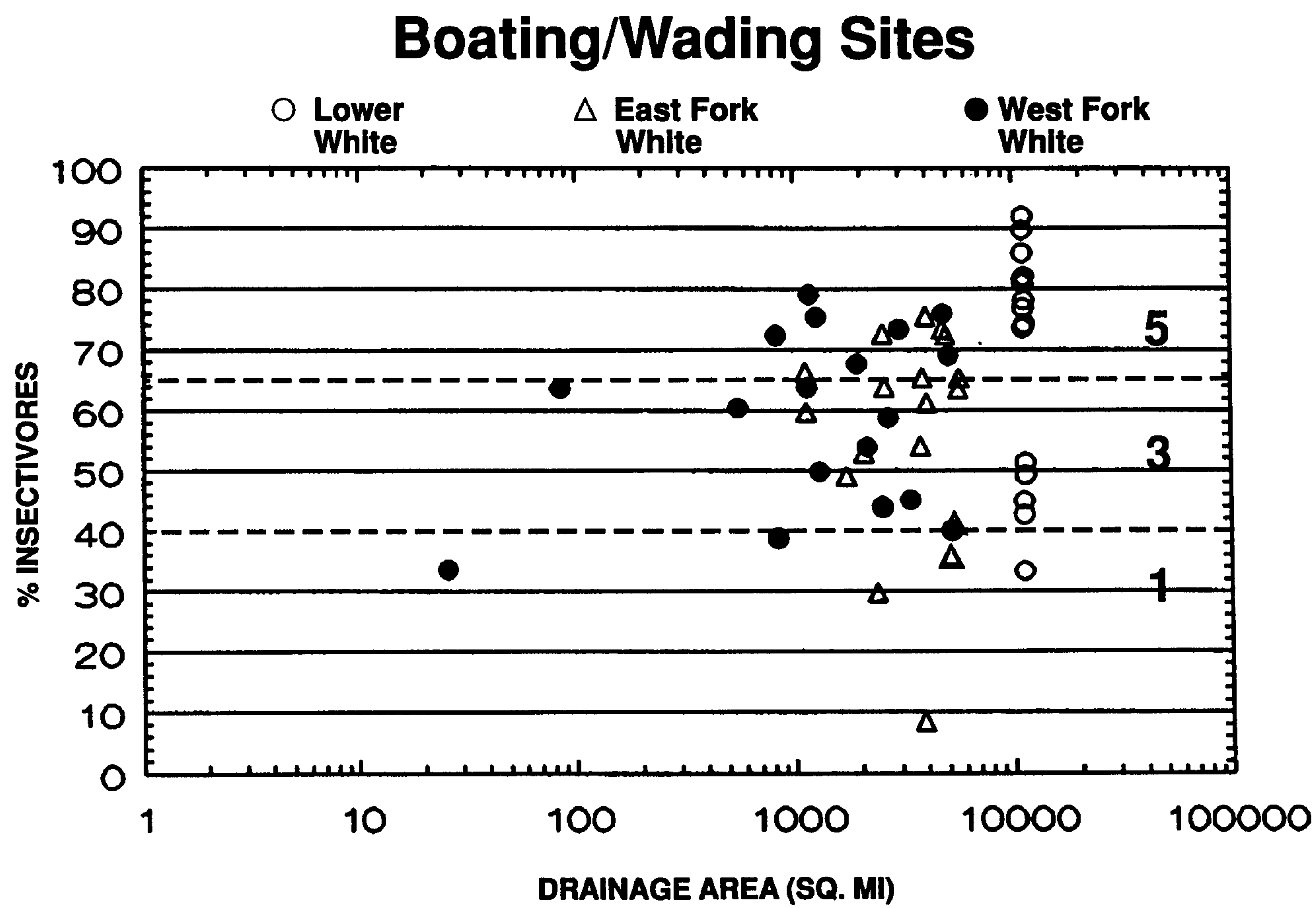


*Figure 13:* **Maximum species richness lines for determining trends in the proportion of insectivores with increasing drainage area for the White River drainage.**

# Metric 9. Proportion of Carnivores (Large and Great Rivers)

## Impetus

Karr (1981) developed the carnivore metric to measure community integrity in the upper trophic levels of the fish community. It is only in high quality environments that upper trophic levels are able to flourish. This metric includes individuals of species in which the adults are predominantly piscivores, although some may feed on invertebrates and fish as larvae or juveniles. Species which are opportunistic do not fit into this metric, e.g. creek chub or channel catfish, Ictalurus punctatus (Karr et al. 1986; Ohio EPA 1987). Karr et al. (1986) suggest that some members of this group may feed extensively on crayfish and various vertebrates, e.g. frogs. Species-specific classifications are included in Appendix B and include piscivores (P) and carnivores (C).

## Large and Great River Wading and Boat Sites

Karr (1981) suggested that the proportion of carnivores should be a reflection of drainage area. Such a correlation in streams greater than 20 miles$^2$ was not found by Ohio EPA or previous ecoregion studies (Simon, 1991). A drainage area relationship was observed between the sub-basins and increasing drainage area in the White River drainage. The proportion of carnivores from the current data base was considerably higher than that approximated in Karr et al.'s (1986) original numbers (Fig. 14).

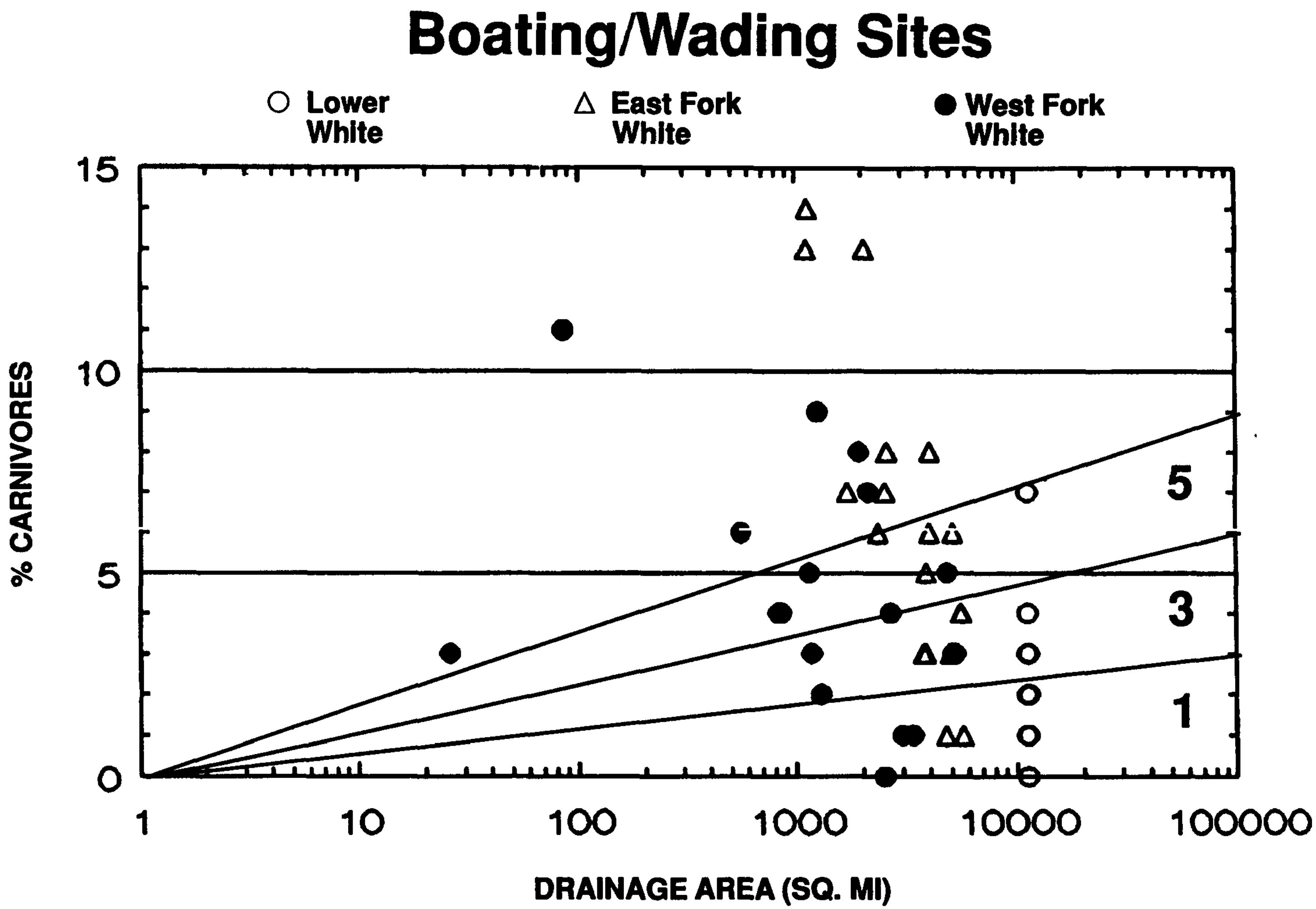


*Figure 14:* **Maximum species richness lines for determining trends in the proportion of carnivores with increasing drainage area for the White River drainage.**

## Metric 10. Number of Individuals in a Sample (Large and Great Rivers)

### Impetus

This metric evaluates populations and is expressed as catch per unit of effort. Effort is expressed by relative number of individuals per length of reach sampled, per unit of area sampled, or per unit time spent depending on the gear used. Karr et al. (1986) suggest that this metric is most sensitive at intermediate to low ends of the sensitivity continuum. When low numbers of individuals are observed the normal trophic relationships are generally disturbed enough to have severe effects on fish abundance. Because of this effect, scoring adjustments are encouraged for large river sites in which less than 100 individuals are collected (see next section for details). As integrity increases, total abundance increases and becomes more variable depending on the level of energy and other natural chemical factors limiting production. Under certain circumstances, e.g. channelization, increases in the abundance of tolerant fishes can be observed (Ohio EPA 1987). Lyons (1992) and Steedman (1986) found that abundance, excluding tolerant species, was highest at fair quality sites and lower at sites classified as excellent. Our catch per unit effort was determined based on the total number of individuals collected per 15 times the channel width without modification for tolerant taxa. The reach sampled was 500 m if the stream was < 33 m wide or 1000 m maximum distance if the stream was > 33 m wide. Each shocking run was conducted with a standardized effort of 30 minutes of sampling per shoreline in 1000 m zones and 15 minutes per shoreline at 500 m sites.

### Large and Great River Wading and Boat Sites

A drainage area-dependent relationship was observed for the White River drainage (Fig. 15). Even at the river reach with the smallest drainage area a minimum of 100 fish was collected. If fewer than 100 fish are collected during a sampling event, alternate scoring procedures are required (see next section for details).

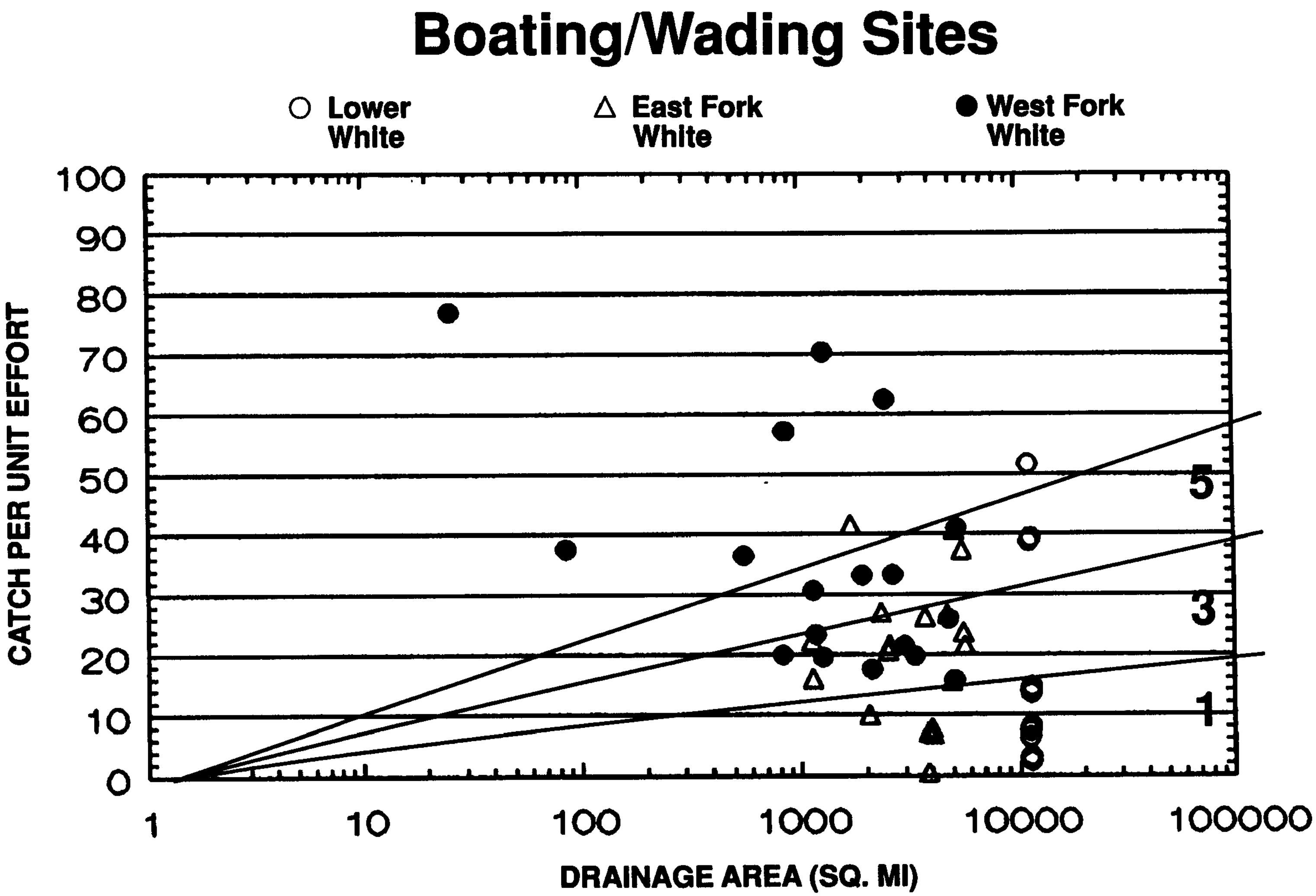


*Figure 15*: **Maximum species richness lines for determining trends in the catch per unit effort with increasing drainage area for the White River drainage.**

# Metric 11. Proportion of Individuals as Simple Lithophilic Spawners (Large and Great Rivers)

## Impetus

This metric is a replacement for the original index metric, proportion of hybrids (Karr et al. 1986), by Ohio EPA (1987). The hybrid metric was abandoned since the original intent of the metric was to assess the extent to which degradation has altered reproductive isolation among species. Difficulties of identification, lack of occurrence in headwater and impacted streams, and presence in high quality streams among certain taxa, e.g., cyprinids and centrarchids, caused a lack of sensitivity for the hybrid metric.

Spawning guilds have been shown to be affected by habitat quality (Balon 1975; Berkman and Rabeni 1987) and have been suggested as an alternative metric (Angermeier and Karr 1986). Reproductive attributes of simple spawning behavior requires clean gravel or cobble for success (i.e. lithophilous) and are the most environmentally sensitive (Ohio EPA 1987). Simple lithophils broadcast eggs which then come into contact with the substrate. Eggs develop in the interstitial spaces between sand, gravel, and cobble substrates without parental care.
Berkman and Rabeni (1987) observed an inverse correlation between simple lithophilic spawners and the proportion of silt in streams. Historically, some simple lithophilic spawners have experienced significant range reductions due to increased silt loads in streams. Some simple lithophils do not require clean substrates for reproduction. Larvae of these species are buoyant, adhesive, or possess fast developing eggs with phototactic larvae which have minimal contact with the substrate (Balon 1975) and are not included in the above designation. Simple lithophils are sensitive to environmental disturbance, particularly siltation. Designated lithophilic species are included in Table 11 (see Appendix C for species-specific ratings).

## Large and Great River Wading and Boat Sites

A relationship with drainage area was observed at large or great river sites for the proportion of lithophilic species in the White River drainage (Fig. 16). Scoring was completed using the trisection method of Fausch et al. (1984). The lack of an increased relationship in the largest White River drainage reaches was thought to be a reflection of degraded condtions. Best professional judgement was used in evaluating this metric. Simple lithophils are major components of fish communities indicating the importance of clean gravel and cobble substrates.

**Table 11. List of Indiana species considered to be simple lithophilic spawners.**

| Simple Lithophils Common Name | Scientific name | Common Name | Scientific Name |
|---|---|---|---|
| Paddlefish | Polyodon spatula | Spotted sucker | Minytrema melanops |
| Lake sturgeon | Acipenser fulvescens | Silver redhorse | Moxostoma anisurum |
| Shovelnose sturgeon | Scaphirhynchus platorynchus | River redhorse | M. carinatum |
| | | Black redhorse | M. duquesnei |
| Redside dace | Clinostomus elongatus | Golden redhorse | M. erythrurum |
| Lake chub | Couesius plumbeus | Shorthead redhorse | M. macrolepidotum |
| Streamline chub | Erimystax dissimilis | Greater redhorse | M. valenciennesi |
| Gravel chub | E. x-punctata | | |
| Cent silvery minnow | Hybognathus hayi | Burbot | Lota lota |
| Mississippi silvery minnow | H. nuchalis | | |
| Bigeye chub | Hybopsis amblops | Western sand darter | Ammocrypta clara |
| Pallid shiner | H. amnis | Eastern sand darter | A. pellucida |
| Striped shiner | Luxilus chrysocephalus | Rainbow darter | Etheostoma caeruleum |
| Rosefin shiner | Lythrurus ardens | Orangethroat darter | E. spectabile |
| Popeye shiner | N. ariommus | Tippecanoe darter | E. tippecanoe |
| River shiner | N. blennius | Variegate darter | E. variatum |
| Bigeye shiner | N. boops | Crystal darter | Crystallaria asprella |
| Silver shiner | N. photogenis | Logperch | Percina caprodes |
| Rosyface shiner | N. rubellus | Channel darter | P. copelandi |
| Southn redbelly dace | Phoxinus erythrogaster | Gilt darter | P. evides |
| Blacknose dace | Rhinichthys atratulus | Blackside darter | P. maculata |
| Longnose dace | R. cataractae | Slenderhead darter | P. phoxocephala |
| | | Dusky darter | P. sciera |
| Blue sucker | Cycleptus elongatus | River darter | P. shumardi |
| Longnose sucker | Catostomus catostomus | Sauger | Stizostedion canadense |
| White sucker | C. commersoni | Walleye | S. vitreum |
| Northern hogsucker | Hypentilium nigricans | | |

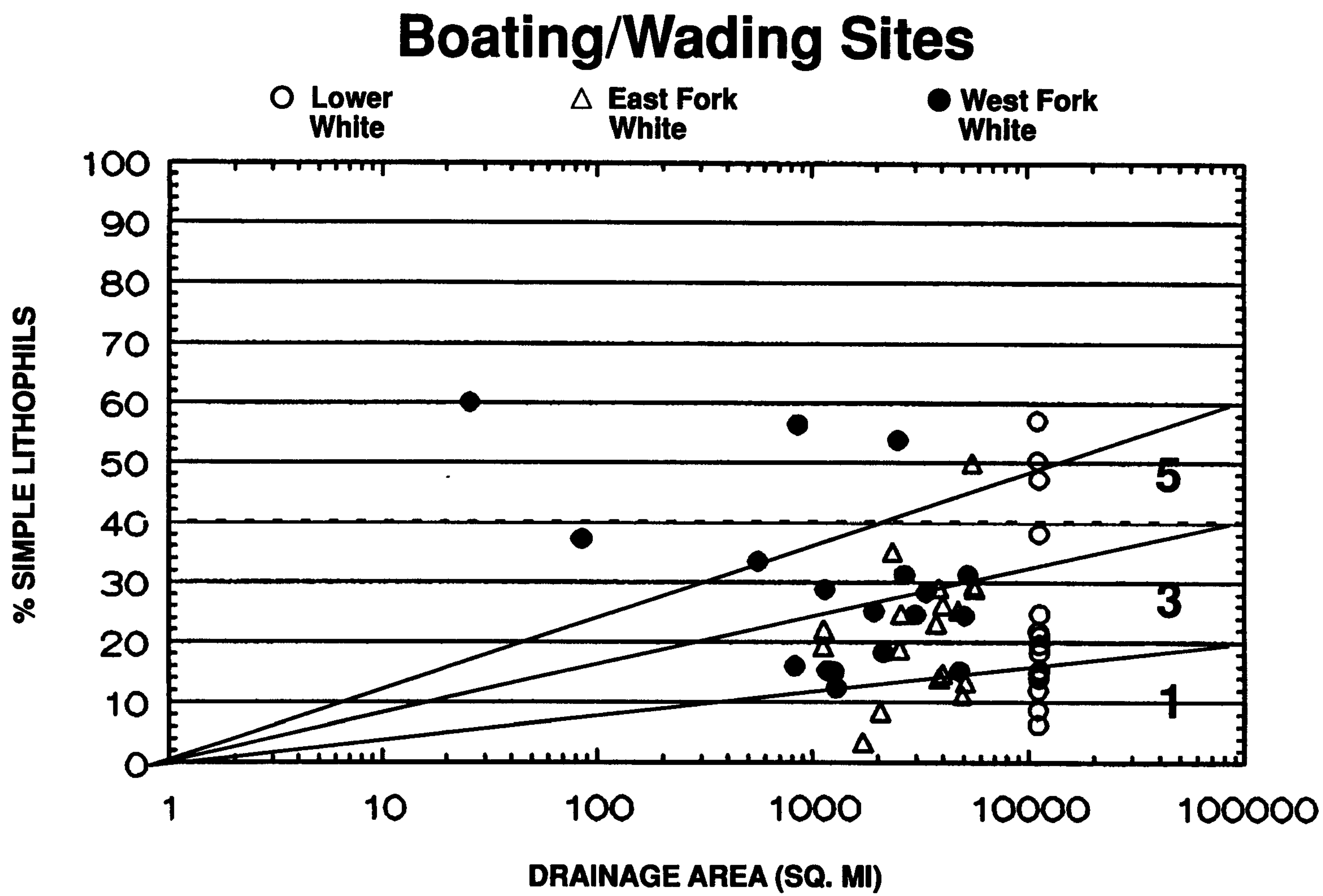


*Figure 16*: **Maximum species richness lines for determining trends in the proportion of simple lithophil species with increasing drainage area for the White River drainage.**

# Metric 12. Proportion of Individuals with Deformities, Eroded Fins, Lesions, and Tumors (Large and Great Rivers)

## Impetus

This metric evaluates the status of individual fish in the community using the percent occurrence of external anomalies and corresponds to the percent of diseased fish in Karr's (1981) original index. Studies of fish populations indicate that anomalies are either absent or occur at very low rates naturally, but reach higher percentages at impacted sites (Mills et al. 1966; Berra and Au 1981; Baumann et al. 1987). Common causes for deformities, eroded fins, lesions, and tumors are a result of bacterial, fungal, viral, and parasitic infections, neoplastic diseases, and chemicals (Allison et al. 1977; Post 1983; Ohio EPA 1987). An increase in the frequency of occurrence of these anomalies is an indication of stress and environmental degradation caused by chemical pollutants, overcrowding, improper diet, excessive siltation, and other perturbations. The presence of black spot is not included in the above analyses since infestation varies in degree and is a function of the presence of snails, thus it is not solely related to environmental stress (Allison et al. 1977; Berra and Au 1981). Whittier et al. (1987) showed no relationship between Ohio stream quality and black spot. Other parasites are also excluded due to the lack of consistent relationship with environmental degradation.

In Ohio and in the current study, the highest incidence of deformities, eroded fins, lesions, and tumors occurred in fish communities downstream from dischargers of industrial and municipal wastewater, and areas subjected to the intermittent stresses from combined sewers and urban runoff. Leonard and Orth (1986) found this metric to correspond to increased degradation in streams in West Virginia. Karr et al. (1986) observed this metric to be most sensitive at the lowest extremes of the Index of Biotic Integrity.

## Large and Great River Wading and Boat Sites

The scoring criteria used for this metric follows Ohio EPA (1987) and was developed by analyzing wading and boat data. For wading sites, the median score was rounded to the nearest 0.1% for the highest expected score and 90th percentile value. According to Ohio protocols, if a single fish in a sample of less than 200 fish was captured with anomalies this would have been enough to exceed the established criterion. Ohio EPA scoring modifications enable a single diseased fish to be present at a site to score a "5" and two fish at a site to score a "3" when less than 200 individuals are collected (Fig. 17).

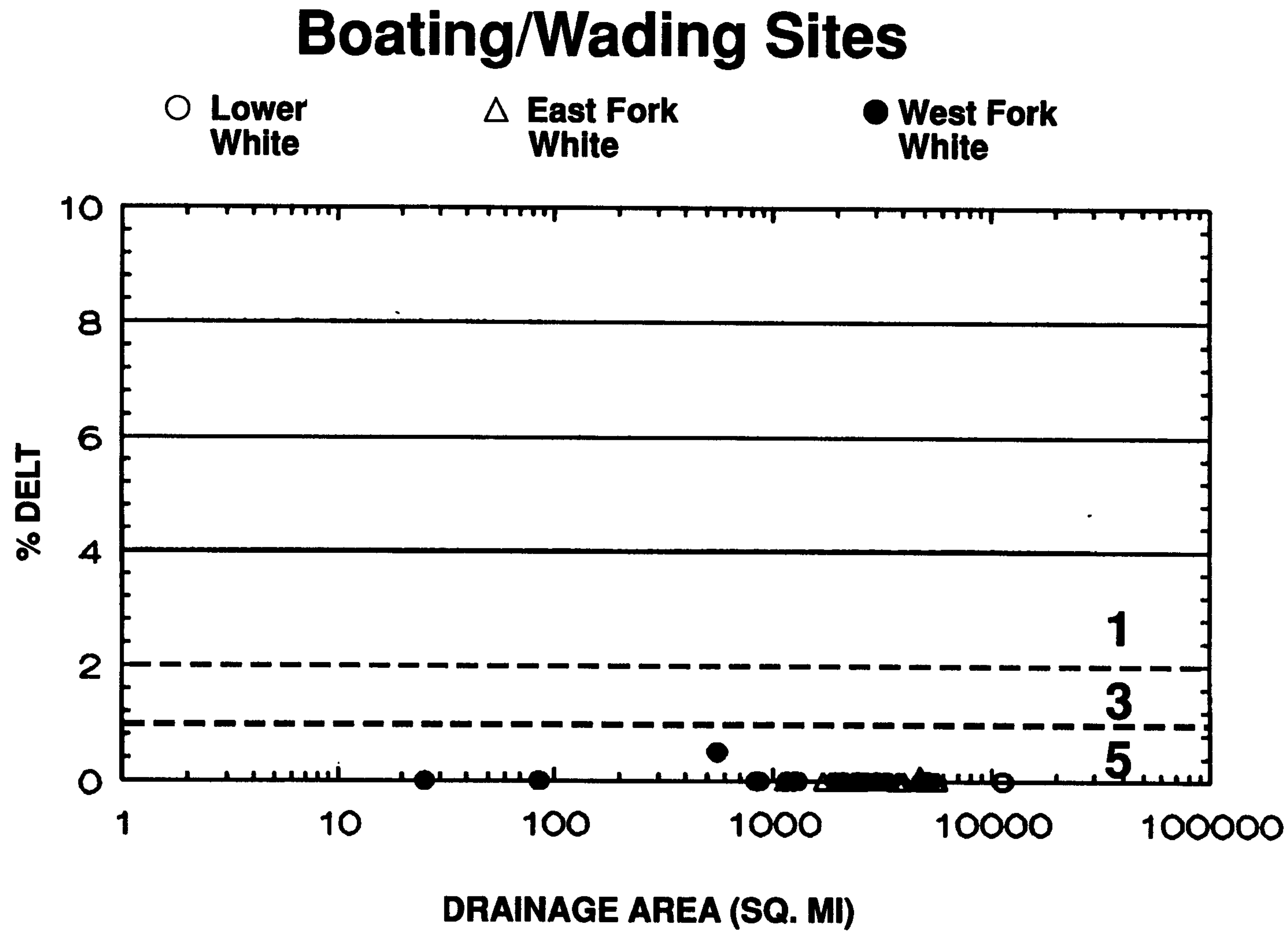


*Figure 17*: **Maximum species richness lines for determining trends in the proportion of diseased, eroded fins, lesions, and tumors (DELT) with increasing drainage area for the White River drainage.**

## Scoring Modifications

Samples with extremely low numbers in the catch can present a scoring problem in some of the proportional metrics unless adjustments are made to reduce the possibility of rewarding degraded sites. Aquatic habitats impacted by anthropogenic disturbances may exhibit a disruption in the food base and comprise very few individuals. At such low population sizes the normal structure of the community is unpredictable (Ohio EPA 1987). Based on Ohio EPA experiences, the proportion of omnivores, insectivorous fishes, and percent individuals affected by anomalies do not always match expected trends. Although scores are expected to deviate strongly from those of high quality areas, this is not always observed. Rather, at times the opposite metric score is achieved due to low numbers of individuals or absence of certain taxa.

Scoring very degraded sites without modifying scoring criteria for the proportional metrics can overrate the total index score for these sites. The following scoring modifications proposed by Ohio EPA (1987) were adopted for evaluating Indiana sites with low numbers of individuals.

Proportion of omnivores for large river and great river sites is assigned a score of "1" if less than 100 total individuals are collected. When less than 150 individuals are collected, but are dominated (>50%) by such species as creek chub and blacknose dace a "1" can be assigned when dominated by generalist feeders. This is left up to the biologist's best professional judgement when at the site.

Proportion of insectivores is scored a "1" when a high proportion of insectivores is observed and less than 100 individuals are collected. At sites with less than 150 individuals, this metric can be scored "1" if the community was dominated (>50%) by either striped shiner, common shiner, or spotfin shiner. These species that can act as omnivores under certain conditions (Angermeier 1985).

Proportion of top carnivores metric should be scored a "1" when dominated by high numbers (> 50%) of grass pickerel in impacted wading areas.

Proportion of simple lithophils always scores a "1" at sites with less than 100 total individuals. Based on Ohio EPA data (1987) this is rarely different from its score without the adjustment.

Proportion of individuals with deformities, erosion, lesions and tumor anomalies is scored a "1" when less than 100 individuals are collected. A high proportion of young fishes may also be sufficient reason to score a "1" since they will not have had sufficient time to develop anomalies from exposure to chemical contaminants.

No scoring adjustments are necessary for proportion of tolerant species. Some professional discretion is possible when scoring metrics. For example, if the metric score is within 5% of the species richness trisection lines, award of an intermediate value can be made, i.e. a score of 2 or 4.

## RESULTS AND DISCUSSION

### Lower White River Drainage

*Species Composition*: A total of 13 sites were sampled in the Lower White River basin during 1990 and 1991. A total of 61 species were collected (Table 12) and were numerically dominated by cyprinid, centrarchid, and ictalurid species.

The fish assemblages of the Lower White River ranges from a low of poor (score of 27; Petersburg site) to fair (score of 44; Giro site) based on the Index of Biotic Integrity scoring criteria (Fig. 18a). An increasing trend in biological condition was observed from the junction of the East and West Forks to the mouth of the Lower White Rivers. The Index of Biotic Integrity scores of the sites approximated a normal curve. The frequency distribution for each of the IBI community categories for the Lower White stations (16) follows: fair 31.3% (5 stations); fair-poor 37.5% (6 stations); and poor 31.3% (5 stations). The sites which had low index values were closest to the Petersburg and Ratts Generating Stations and to a limited extent the city of Hazelton. The Lower White River 0.5 mi downstream of Giro had high biotic integrity. This River segment deserves protection to ensure that the quality of the resource continues. The lowermost reaches of the Lower White River were degraded probably as a result of the Wabash River near Mt. Carmel, Illinois.

The Lower White River possesses several species unique to the White River drainage; harlequin darter Etheostoma histrio, skipjack herring Alosa chrysochloris, and redfin shiner Cyprinella lutrensis. Etheostoma histrio is considered state endangered based on the single specimen from the CR 1300S access near Iona. This species was thought to be extirpated from Indiana since it was last collected 100 years ago by David Starr Jordan (1890). Species of concern also include the eastern sand darter, Ammocrypta pellucida. This species is State listed and was collected approximately 10 miles downstream of the junction of the East and West Forks. Alosa chrysochloris is a large river species and was distributed in the lower White immediately upstream of Hazelton. The species C. lutrensis is considered tolerant and are known to form hybrid swarms with C. spiloptera.

*Species Trends*: Longitudinal trends of IBI and number of species show increasing scores from the junction of the East and West Forks of the White River to the Wabash River (Fig. 18a). The confluence below the two Forks and at the mouth of the Wabash River had the lowest biotic integrity, with the highest biotic integrity 18 River Miles (RM) downstream of the confluence. Biotic integrity and number of species in the stretch of the River below Hazelton were reduced, however, this was thought to be a function of the bedrock substrate. The lower most reaches of the Lower White River were degraded, probably as a result of the influence of the Wabash River near Mt. Carmel, Illinois.

The number of species showed a similar pattern as IBI trends (Fig. 18b). Reduced number of species was apparent downstream of the Generating Stations (lowest in the entire Lower White; 16 species). Maximum number of species was exhibited approximately 18 RM downstream, when a second perturbation below Hazelton caused a further decline in species number. The lowermost reaches of the Lower White River also has a significant substrate change from sand to bedrock downstream of Hazelton. Reduced biological condition in this area of the River may be a reflection of reducted habitat complexity.

Another observation was the pattern exhibited by the CPUE of darters and redhorse (Fig. 19e, f). Redhorse were completely absent from the Lower White River with no species occurring until R.M. 1.5. Redhorse are known to be sensitive to thermal changes (Gammon, 1983), as well as other perturbations such as siltation and reduced dissolved oxygen. Darter species were not commonly found in the Lower White River even though suitable habitat and other physical characteristics were present. The number of darter species oscillated (Fig. 18c) throughout the Lower White River.

**Table 12. Species list of taxa collected in the White River drainage: East Fork, West Fork, and Lower White River drainages, Indiana, during sampling in 1990 and 1991.**

| | Drainage | | |
|---|---|---|---|
| | East Fork White | West Fork White | Lower White |
| **Petromyzontiformes-lampreys** | | | |
| Petromyzontidae - lamprey | | | |
| Ichthyomyzon casteneus Girard, chestnut lamprey | X | | |
| I. unicuspis Hubbs and Trautman, Silver lamprey | X | | |
| **Lepisosteiformes - gars** | | | |
| Lepisosteidae - gars | | | |
| Lepisosteus oculatus Winchell, spotted gar | X | X | X |
| L. osseus Linnaeus, longnose gar | X | X | X |
| L. platostomus, shortnose gar | X | X | X |
| **Amiiformes - bowfin** | | | |
| Amiidae - bowfin | | | |
| Amia calva Linnaeus, bowfin | X | X | X |
| **Anguilliformes** | | | |
| Anguillidae - eel | | | |
| Anguilla rostrata (Lesueur), American eel | X | | |
| **Clupeiformes - herring, shad** | | | |
| Cluepidae - herring | | | |
| Alosa chrysochloris (Rafinesque), skipjack herring | | | X |
| Dorosoma cepedianum (Lesueur), gizzard shad | X | X | X |
| D. petensese (Gunther), threadfin shad | X | X | X |
| **Osteoglossiformes - mooneyes** | | | |
| Hiodon tergisus Lesueur, mooneye | X | | |
| **Salmoniformes - pike and mudminnows** | | | |
| Esocidae - pikes | | | |
| Esox americanus Gmelin, grass pickerel | X | | |
| **Cypriniformes - carps and minnows** | | | |
| Cyprinidae - carps and minnows | | | |
| Campostoma anomulum (Rafinesque), stoneroller | X | X | |
| Carassius auratus (Linneaus), goldfish | | X | X |
| Cyprinella lutrensis (Baird and Girard), red shiner | | | X |
| C. spiloptera Cope, spotfin shiner | X | X | X |
| C. whipplei (Girard), steelcolor shiner | X | X | X |
| Cyprinus carpio Linneaus, carp | X | X | X |
| Ericymba buccata Cope, silverjaw minnow | X | X | X |
| Erimystax dissimilis Kirtland, streamline chub | X | | |
| Extrarius aestivalis Girard, speckled chub | | X | |

## Table 12. (Continued).

| | Drainage | | |
|---|---|---|---|
| **Cyprinidae - minnows (Continued)** | East Fork White | West Fork White | Lower White |
| Hybopsis amblops Rafinesque, bigeye chub | X | X | |
| Hybognathus nuchalis Agassiz, Mississippi silvery minnow | X | X | X |
| Luxilus chrysocephalus (Rafinesque), striped shiner | | X | X |
| Lythrurus umbratilis (Girard), redfin shiner | X | X | X |
| Macrhybopsis storeriana (Kirtland), silver chub | X | | X |
| Nocomis micropogon (Cope), river chub | X | | |
| Notemigonus crysoleucus (Mitchell), golden shiner | X | X | |
| Notropis atherinoides Rafinesque, emerald shiner | X | X | X |
| N. blennius (Girard), river shiner | | | X |
| N. boops Gilbert, bigeye shiner | | X | |
| N. buchanani Meek, ghost shiner | | X | |
| N. ludibundus Cope, sand shiner | X | X | X |
| N. photogenis (Cope), silver shiner | X | X | |
| N. rubellus (Agassiz), rosyface shiner | X | X | |
| N. shumardi (Girard), silverband shiner | X | | X |
| N. volucellus (Cope), mimic shiner | X | X | X |
| N. wickliffi,channel shiner | | X | |
| Opsopoedus emilie Hay, pugnose minnow | X | X | |
| Phenacobius mirabilis (Girard), suckermouth minnow | X | X | X |
| Pimephales notatus (Rafinesque), bluntnose minnow | X | X | X |
| P. promelas Rafinesque, fathead minnow | X | X | |
| P. vigilax (Baird and Girard), bullhead minnow | X | X | X |
| Semotilus atromaculatus (Mitchill),creek chub | | X | |
| **Catostomidae - suckers and buffalo** | | | |
| Carpiodes carpio (Rafinesque), river carpsucker | X | X | X |
| C. cyprinus (Lesueur), quillback | X | X | X |
| C. velifer (Rafinesque), highfin carpsucker | X | X | X |
| Catostomus commersoni Lacepede, white sucker | | X | |
| Hypentelium nigricans (Lesueur), northern hogsucker | X | X | |
| Ictiobus bubalus (Rafinesque), smallmouth buffalo | X | X | X |
| I. cyprinellus (Valenciennes), bigmouth buffalo | X | X | |
| Minytrema melanops (Rafinesque), spotted sucker | X | X | |
| Moxostoma anisurum (Rafinesque), silver redhorse | X | X | |
| M. carinatum (Cope), river redhorse | X | X | |
| M. duquesnei (Lesueur), black redhorse | X | X | X |
| M. erythurum (Rafinesque), golden redhorse | X | X | |
| M. macrolepidotum (Lesueur), shorthead redhorse | X | X | X |
| | | | |
| **Siluriformes - bullhead and catfish** | | | |
| Ictaluridae - bullhead and catfish | | | |
| Ameiurus natalis (Lesueur), yellow bullhead | X | X | |
| Ictalurus furcatus (Lesueur), blue catfish | X | | |
| I. punctatus (Rafinesque), channel catfish | X | X | X |
| Noturus flavus Rafinesque, stonecat | X | | |

**Table 12. (Continued)**

| | Drainage | | |
|---|---|---|---|
| **Ictaluridae - bullhead and catfish (Continued)** | East Fork White | West Fork White | Lower White |
| N. eleutherus Jordan, mountain madtom | X | X | X |
| N. miurus Jordan, brindled madtom | X | | X |
| N. nocturnus Jordan and Gilbert, freckled madtom | | | X |
| Pylodoctis olivaris (Rafinesque), flathead catfish | X | X | X |
| | | | |
| **Percopsiformes - cavefish, pirate perch, trout-perch** | | | |
| Apherododeridae - pirate perch | | | |
| Aphredoderus sayanus (Gilliams), pirate perch | X | | |
| | | | |
| **Atheriniformes - topminnows, silversides** | | | |
| Fundulidae - topminnows | | | |
| Fundulus notatus (Rafinesque), blackstripe topminnow | X | X | X |
| F. olivaceus (Storer), blackspotted topminnow | | | X |
| Poeciliidae - live-bearing fishes | | | |
| Gambusia affinis (Baird and Girard), mosquitofish | | | X |
| Atherinidae - silversides | | | |
| Labidesthes sicculus (Cope), brook silverside | X | X | X |
| | | | |
| **Perciformes - basses, sunfish, perch, darters** | | | |
| Moronidae - temperate basses | | | |
| Morone chrysops (Rafinesque), white bass | X | X | X |
| M. mississippiensis Jordan and Eigenmann, yellow bass | | | X |
| Centrarchidae - black bass and sunfish | | | |
| Ambloplites rupestris (Rafinesque), rock bass | X | X | |
| Lepomis cyanellus Rafinesque, green sunfish | X | X | X |
| L. gibbosus (Linnaeus), pumpkinseed | X | | X |
| L. gulosus (Cuvier), warmouth | X | | X |
| L. humilis (Girard), orangespotted sunfish | | X | X |
| L. macrochirus Rafinesque, bluegill | X | X | X |
| L. microlophus (Gunther), redear sunfish | X | X | X |
| L. megalotis (Rafinesque), longear sunfish | X | X | X |
| L. punctatus (Valenciennes), spotted sunfish | X | X | |
| Micropterus dolomieui Lacepede, smallmouth bass | X | X | X |
| M. punculatus Rafinesque, spotted bass | X | X | |
| M. salmoides (Lacepede), largemouth bass | X | X | X |
| Pomoxis annularis Rafinesque, white crappie | X | X | X |
| P. nigromaculatus (Lesueur), black crappie | X | X | |
| Percidae - perch and darters | | | |
| Ammocrypta clara Jordan and Meek, western sand darter | X | | X |
| A. pellucida Agassiz, eastern sand darter | X | | X |
| Etheostoma asprigene (Forbes), mud darter | X | X | X |
| E. blennioides Rafinesque, greenside darter | X | X | |
| E. caeruleum Storer, rainbow darter | | X | |
| E. flabellare Rafinesque, fantail darter | X | | |

**Table 12. (Continued).**

| | Drainage | | | |
|---|---|---|---|---|
| **Percidae - perch and darters (Continued)** | East Fork White | West Fork White | Lower White | |
| E. gracile (Girard), slough darter | | X | | |
| E. histrio (Jordan and Gilbert), harlequin darter | | | X | |
| E. nigrum Rafinesque, johnny darter | X | X | | |
| E. spectabile (Agassiz), orangethroat darter | X | X | | |
| Percina caprodes (Rafinesque), logperch | | X | | |
| P. maculata (Girard), blackside darter | X | | X | |
| P. phoxocephala (Nelson), slenderhead darter | X | X | X | |
| P. sciera (Swain), dusky darter | X | X | X | |
| Stizostedion canadense (Smith), sauger | X | | | |
| Sciaenidae - drum | | | | |
| Aplodinotus grunniens Rafinesque, freshwater drum | X | X | X | |
| Cottidae - sculpins | | | | |
| Cottus bairdi Girard, mottled sculpin | X | X | | |
| C. carolinae (Gill), banded sculpin | | X | | |
| Total Number of Species | 81 | 74 | 61 | 101 |

*Population Attributes*: Although the Index of Biotic Integrity has the capacity to evaluate a specific location, additional site specific measures need to be examined. Therefore, longitudinal trends were evaluated based on catch per unit effort (CPUE). These values were standardized based on time (60 minutes) within distance (1000 m). Measures were based on sensitive and tolerant species trends. The sensitive species measures included CPUE of darters and redhorse, while tolerant measures included CPUE of buffalo (Ictiobus spp.), carpsuckers (Carpiodes spp.), channel catfish (Ictalurus punctatus), and gizzard shad (Dorosoma cepedianum). These species are expected to increase with perturbations.

An important consideration when evaluating trends in the Lower White River is to recognize that virtually no reference sites exist. Even the site immediately below the confluence of the two Forks was perturbed and not truly representative of reference condition. Due to this observation, no "least impacted" conditions exist for the Lower White River. None of the stations were considered excellent or good resource waters.

In the immediate vicinity of the two Generating Stations, the CPUE of buffalo, carpsuckers, and gizzard shad all declined with increases in thermal load. Temperatures in the reach below the junction of the East and West Forks and SR 61 bridge were greater than 5°C above ambient conditions (Table 13). The CPUE of carpsuckers and channel catfish increased rapidly within 5 RM downstream (Fig. 19b, c). The inability of buffalo and redhorse to colonize this reach may have been an indirect effect of the thermal loadings (Fig. 19a, e). Redhorse would not have been able to tolerate the thermal conditions, while buffalo may not have been able to compete with the thermophilic carpsuckers.

Gizzard shad have a preference for warm thermal discharges were found in high concentrations above the discharge and in low concentrations throughout the rest of the Lower White River (Fig. 19d). This suggests that gizzard shad populations may be forced upstream of the thermal input and unable to exploit the area beneath the outfalls.

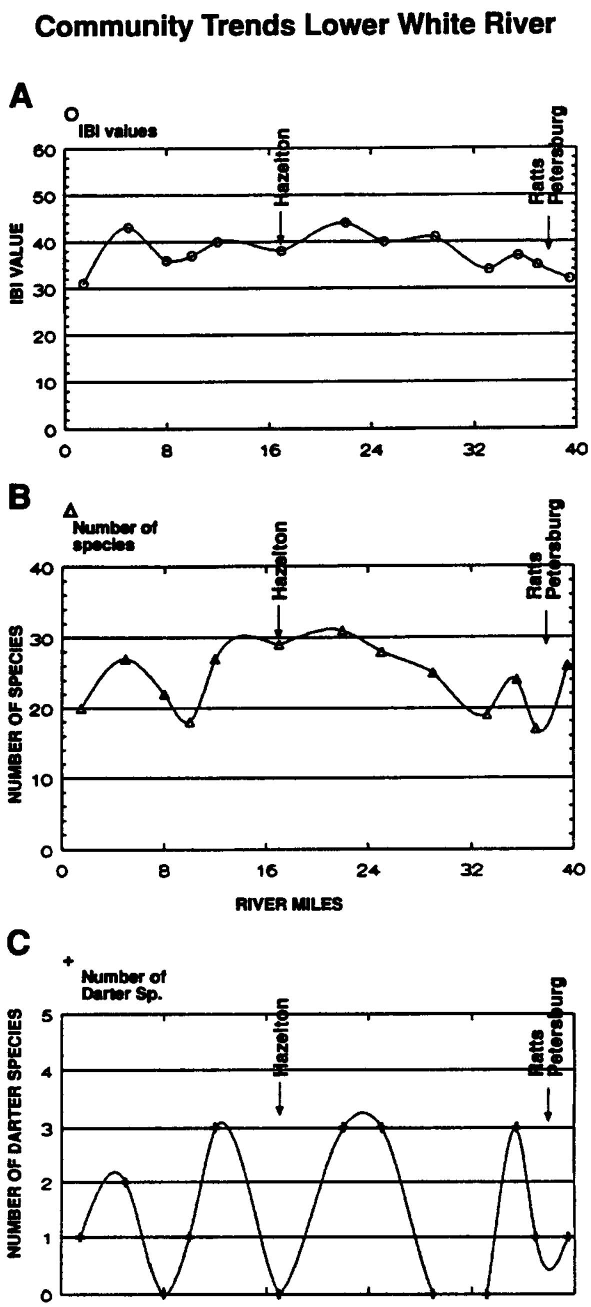


*FIGURE 18:* **Longitudinal community trends in lower White River subdrainage for IBI and species diversity. a. IBI values, b. number of species, c. number of darter species.**

**Table 13. Thermal and dissolved oxygen grab profiles from the junction of the East and West Forks White River to SR 61 bridge, 1991.**

| River Mile[1] | Dissolved Oxygen (ppm) | Temperature (°C) |
|---|---|---|
| 40.0 (Junction) | 6.2 | 26.5 |
| 39.5 (P-I) | 6.9 | 26.6 |
| 39.0 (P-O) | 4.7 | 40.8 |
| 38.5 (R-I) | 5.0 | 30.8 |
| 38.0 (R-O) | 5.5 | 38.8 |
| 37.5 (SR 61) | 6.9 | 31.7 |

[1] P = Petersburg GS; R = Ratts GS; I = Influent; O = Outfall (outside mixing zone).

<u>East Fork White River Drainage</u>

*<u>Species Composition</u>*: A total of 18 wading and boat sites were sampled in the East Fork White River basin during 1990 and 1991. A highly diverse community of 81 species were collected (Table 12), and were numerically dominated by cyprinids, centrarchid, and catostomid species. The headwaters of the East Fork White River, including the Driftwood River, were extremely diverse and composed of cyprinids, darters, and catostomids. The headwaters of the East Fork rated the highest biological integrity.

The fish community assemblage of the East Fork White River drainage ranged from a low of poor-very poor (score of 25; one station) to good (score of 51; three stations) based on IBI scoring criteria (Fig. 20). The biotic integrity of the East Fork White River varied with increasing drainage area. Stations above RM212 scored considerably higher (10 IBI points) than downstream sites. Like

# Community Trends Lower White River

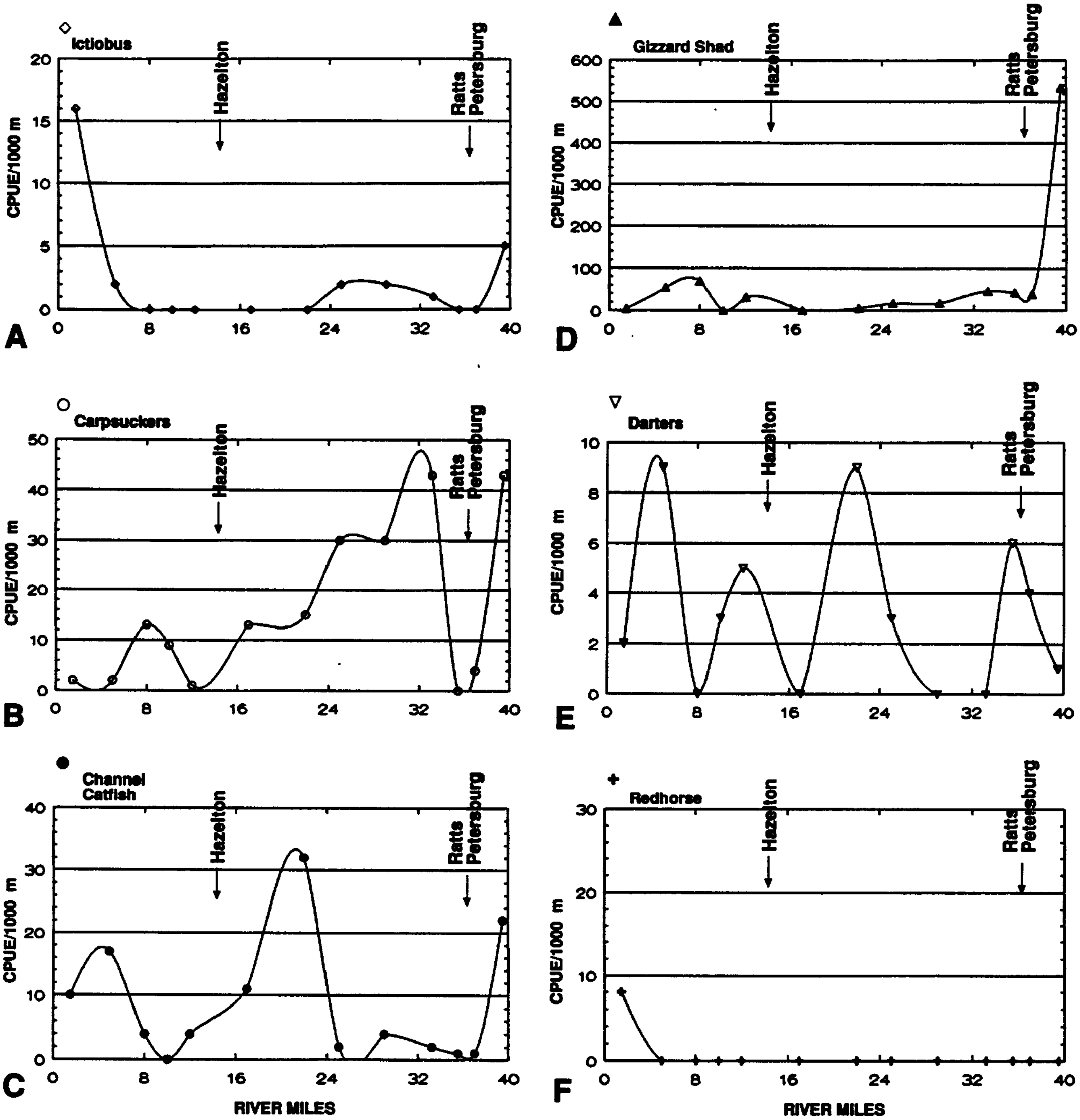


*FIGURE 19:* **Longitudinal community trends in lower White River subdrainage catch per unit effort. a. CPUE buffalo, b. CPUE carpsucker, c. CPUE channel catfish, d. CPUE gizzard shad, e. CPUE darters, f. CPUE redhorse.**

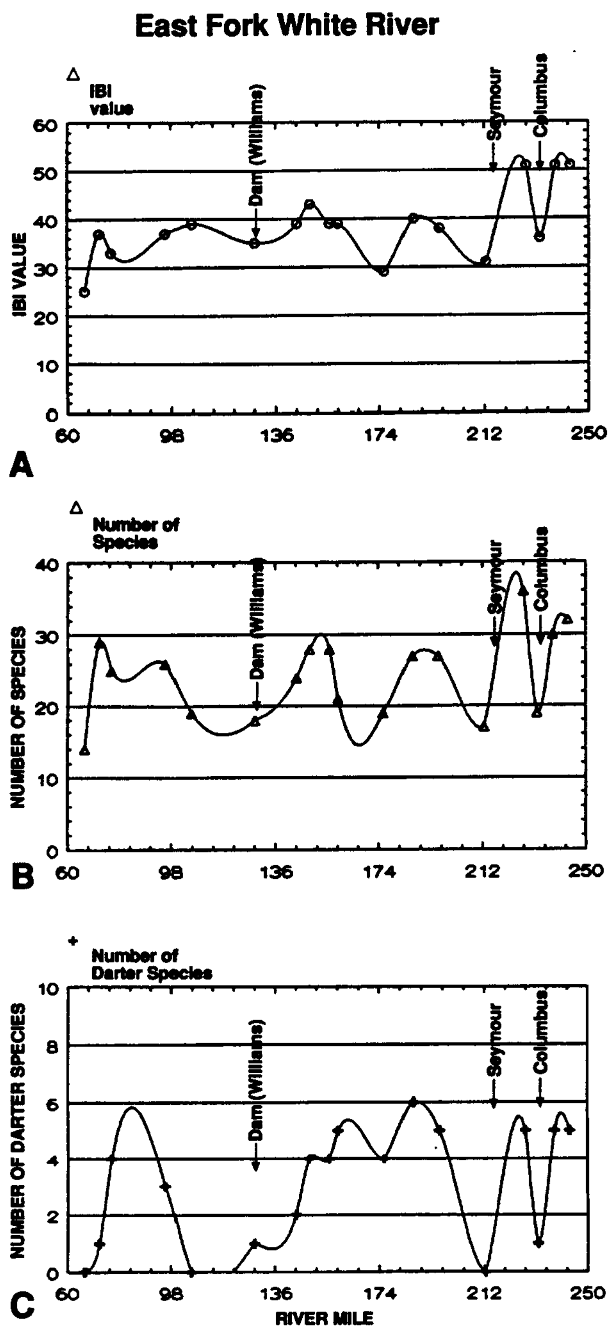


*Figure 20:* **Longitudinal community trends in East Fork White River subdrainage for IBI and species diversity. a. IBI values, b. number of species, c. number of darter species.**

the Lower White River, the IBI scores of the East Fork White River drainage approximated a normal distribution with respect to water quality classification. The frequency distribution for East Fork White River stations (18) within each IBI classification follows: good 16.7% (3 stations); fair 11.1% (2 stations); fair-poor 50.0% (9 stations); poor 16.7% (3 stations); poor-very poor 5.6% (1 station). Fish were collected at all sites in the East Fork White River drainage. Sites which had low index values were primarily attributed to non-point sources (e.g., cities). An exceptional stream in the East Fork White River drainage was the Driftwood River, a main tributary component of the upper East Fork White River. Stations sampled in the Driftwood and upper East Fork White River had good index of biotic intergity scores for all sites sampled.

Species unique to the East Fork White River include silver lamprey Ichthyomyzon unicuspis, chestnut lamprey I. casteneus, mooneye Hiodon tergisus, grass pickerel Esox americanus, streamline chub Erimystax dissimilis, river chub Nocomis micropogon, blue catfish Ictalurus furcatus, stonecat Noturus flavus, pirate perch Aphredoderus sayanus, fantail darter Etheostoma flabellare, and sauger Stizostedion canadense. The occurrence of these species in the East Fork White River suggests these species may have been reduced or extirpated from the West Fork and Lower White River drainages.

*Species Trends*: Longitudinal trends suggest that the non-point sources including the cities of Columbus and Seymour have reduced the biological integrity of the East Fork of the White River (Fig. 20a). The dam at Williams has also slightly reduced biological integrity in the area immediately upstream probably as a result of reduced flows and declining dissolved oxygen levels. The decline in biological integrity in the lowermost reaches of the East Fork White River cannot be explained. It should be noted that the system recovers immediately upstream of the Generating Stations.

The number of species also paralleled the IBI longitudinal trend with reductions in species richness below cities and above dams. A

# East Fork White River

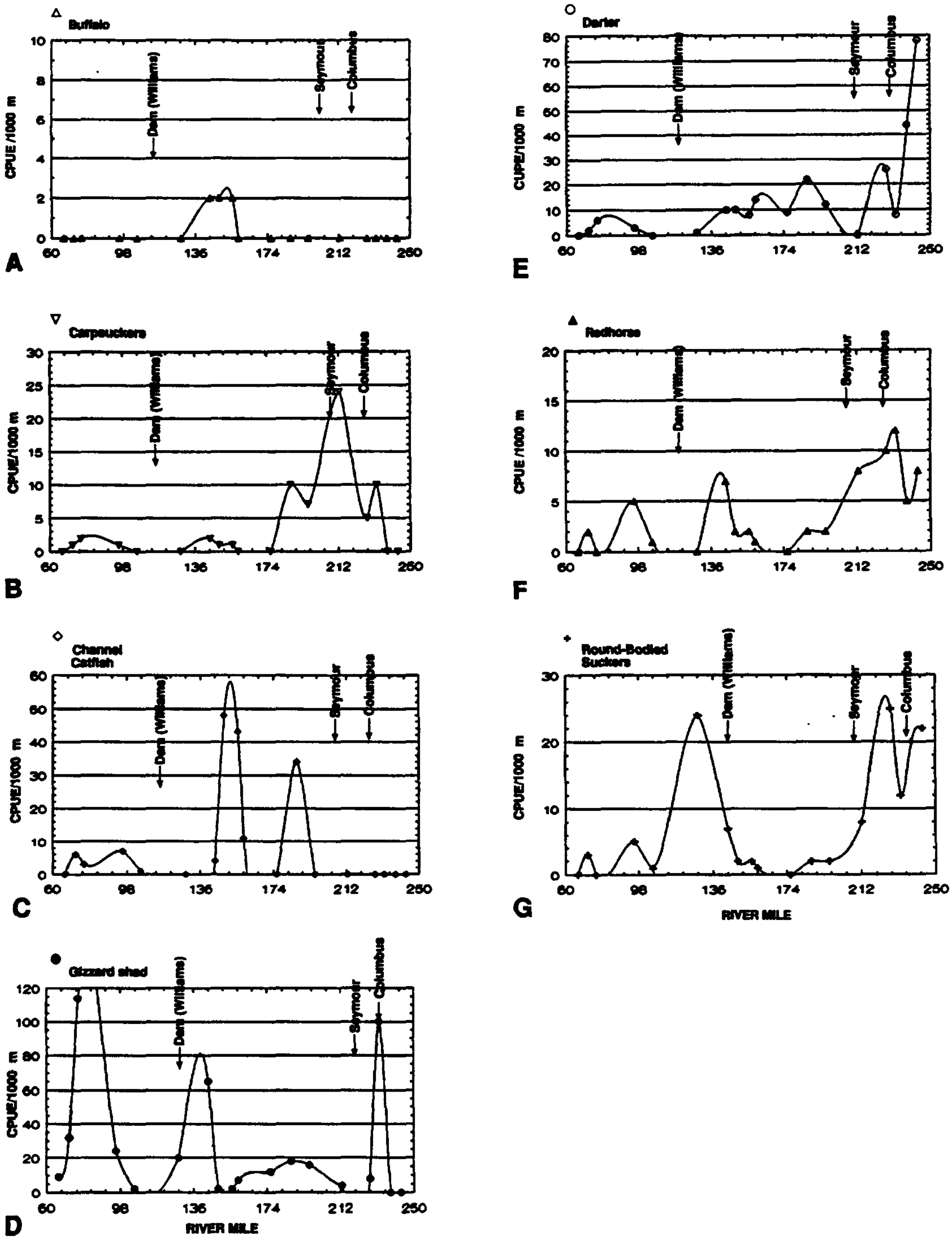


*Figure 21:* **Longitudinal community trends in East Fork White River subdrainage catch per unit effort. a CPUE buffalo, b. CPUE carpsucker, c. CPUE channel catfish, d. CPUE gizzard shad, e. CPUE darters, f. CPUE redhorse, g. CPUE round-bodied suckers.**

depression occurred for a short distance below Columbus, while Seymour reduced species richness for a distance of 12.5 RM. The change in principal substrate from gravel and sand to primarily sand below Seymour not considered a primary reason for species reduction.

The number of darter species also was reduced below the cities and above the dams (Fig. 20c). A total of 10 species were collected from the East Fork White River, with 5 commonly being sympatric. Recovery from perturbations were observed at the next downstream station in each case. The reduction in number of darter species at the junction with the Lower White River was not anticipated since habitat and other physical attributes of the location suggested that darters should have been present.

*Population Attributes*: Population specific longitudinal trends were examined for CPUE of sensitive and tolerant species (Fig. 21a-g). The same species as previously listed were analyzed, as well as the total number of round-bodied suckers. As anticipated, the CPUE of tolerant species were very low (i.e. buffalo, carpsuckers, channel catfish, and gizzard shad) except for perturbed areas in the East Fork White River (Fig. 21a-d). Sensitive species such as darters, redhorse, and round-bodied suckers all exhibited high CPUE in the East Fork White River except in perturbed areas (Fig. 21e-g).

## West Fork White River Drainage

*Species Composition*: A total of 18 sites were sampled in the West Fork White River. A total of 74 species were collected (Table 12) and were numerically dominated by centrarchid, cyprinid, and catostomid species.

The fish community assemblage of the West Fork White River ranged from a low of poor-very poor (score of 24; one station) to a high of good (score of 46; one stations) based on IBI classification criteria (Fig. 22a). The biotic integrity of the West Fork White River varied with increasing drainage area. Stations below electrical generating stations scored considerably worse than upstream sites, with the exception of Perry K

**West Fork White River**

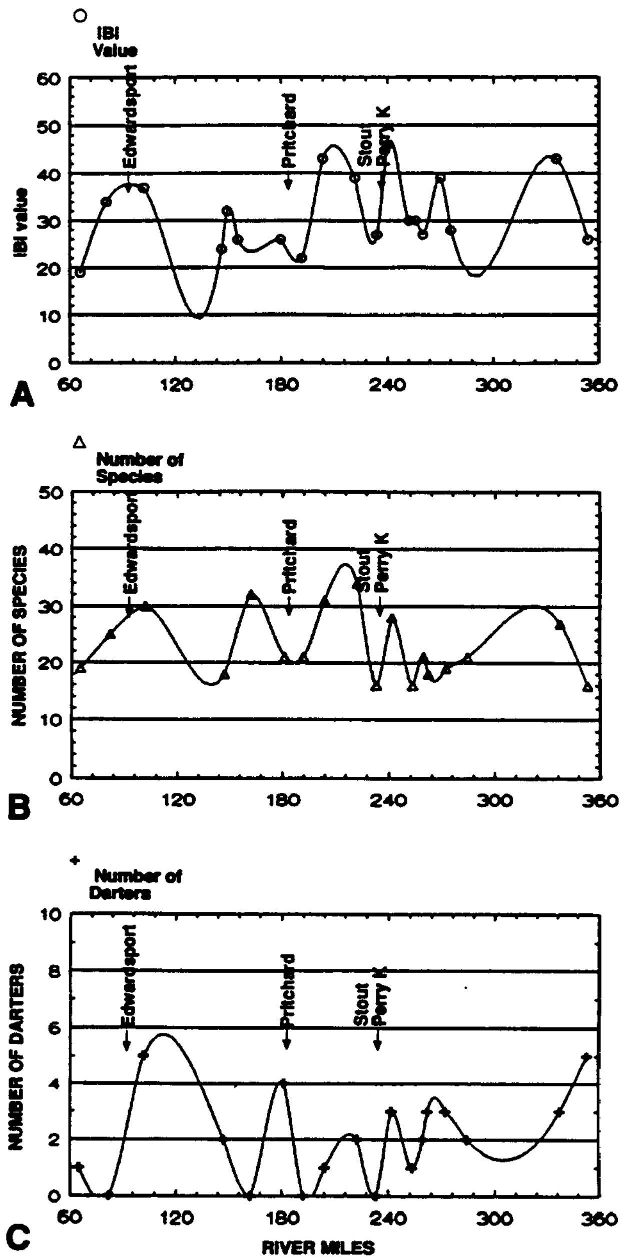


*Figure 22:* **Longitudinal community trends in West Fort White River subdrainage for IBI and species diversity. a. IBI values, b. number of species, c. number of darter species**

# West Fork White River

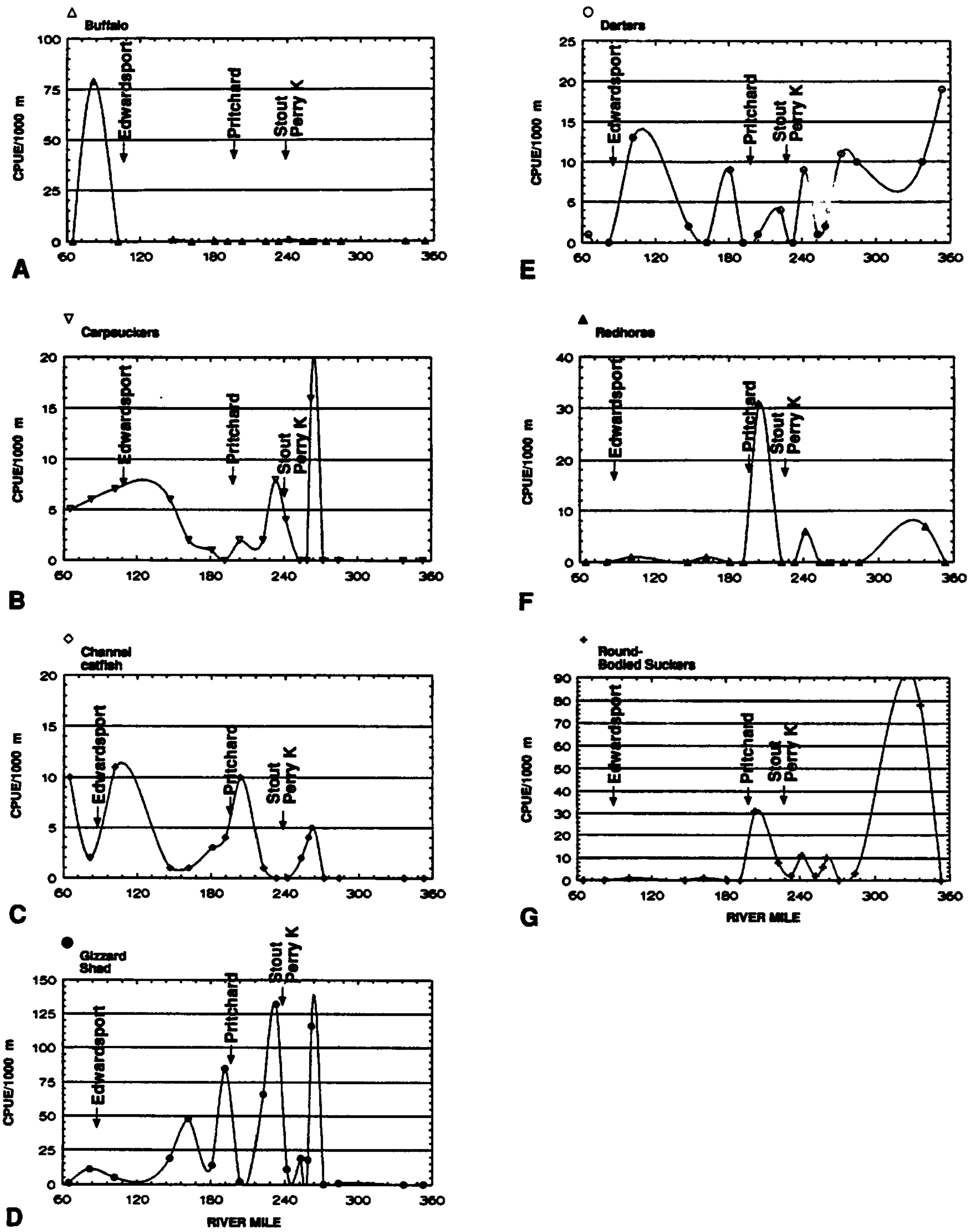


*Figure 23*: **Longitudinal community trends in West Fork White River subdrainage catch per unit effort. a. CPUE buffalo, b. CPUE carpsucker, c. CPUE channel catfish, d. CPUE gizzard shad, e. CPUE darters, f. CPUE redhorse, g. CPUE round-bodied suckers.**

and Stout. The West Fork White River drainage IBI scores approximated a skewed curve towards lower water resource quality. Among the 18 West Fork White River stations 5.6% (1) were classified as good; 11.1% (2 stations) as fair; 16.7% (3 stations) as fair-poor; 22.2% (4 stations) as poor; and 33.3% (6 station) as poor-very poor. Fish were collected at all sites in the West Fork White River drainage. Sites which had low index values were downstream of thermal input sources, nonpoint source impacts, and urban areas. An exceptional stream segment in the West Fork White River drainage included the Broad Ripple (Marion County) reach.

Species unique to the West Fork White River include speckled chub Extrarius aestivalis, bigeye chub Notropis boops, ghost shiner N. buchanani, creek chub Semotilus atromaculatus, white sucker Catostomus commersoni, rainbow darter Etheostoma caeruleum, slough darter E. gracile, logperch Percina caprodes, and banded sculpin Cottus carolinae. Two of these species, S. atromaculatus and C. commersoni are considered tolerant, which coupled with the reduction in sensitive East Fork White River taxa, indicates chronic thermal stress.

*Population Attributes*: Longitudinal trends suggest that the thermal and non-point sources have reduced the biological intergity of the West Fork of the White River (Fig. 22a). The cities of Muncie, Noblesville, and Fishers reduced the biotic integrity of the upper West Fork White River. Due to sample locations, any individual impacts which may have been present could not be discerned between the Stout and Perry K Generating Stations. The Pritchard and Edwardsport Generating Stations significantly reduced the biological integrity in the area immediately downstream. The Pritchard Generating Station decline was the most significant of the entire study. It should be noted that the West Fork White River drainage exhibited declining biotic integrity immediately upstream of the junction as a result of the Edwardsport Generating Station.

The number of species also paralleled the IBI longitudinal trend with reductions in species richness below urban areas and the Generating Stations (Fig. 22b). Recovery down river from the Generating Stations often required distances of 12 to 24 miles. Species richness was depressed for 50 miles below Muncie.

The number of darter species also was reduced below cities and electric generating stations (Fig. 22c). A total of 9 darter species were collected from the West Fork with 5 species commonly being sympatric. Some initial recovery from perturbations were usually observed at the next downstream station, with the exception of the Pritchard and Edwardsport Generating Stations.

*Population Attributes*: Population specific longitudinal trends (CPUE) were examined for sensitive and tolerant species (Fig. 23a-g). The CPUE of tolerant species was very low (i.e. buffalo, carpsuckers, channel catfish, and gizzard shad) except for perturbed areas in the West Fork White River (Fig. 23a-d). Sensitive species such as darters, redhorse, and round-bodied suckers all exhibited high CPUE in the West Fork White River except in perturbed areas (Fig. 23e-g). Flathead catfish were virtually absent from the upper West Fork White River. Increases in this tolerant species were only observed in the lower 120 RM of the West Fork.

Reference Sites

Reference sites are localities which best represent the regional framework under study. Reference sites define the "reference condition" or "least impacted" condition which define the Maximum Species Richness line based on the 95th percentile. Subsequent recalibration of the individual IBI metrics can concentrate on these sites during future monitoring efforts. Few natural areas remain in the White River drainage. The list of candidate sites are based on superior Index of Biotic Integrity scores, typical habitat for the ecoregion, and professional judgement (Table 14). The reference sites listed are those which achieved the highest biotic integrity based on species composition, trophic and reproductive guilds, catch per unit effort, and disease factors.

**Table 14. Reference sites determined using fish community biotic integrity for the White River drainage, Indiana.**

| | |
|---|---|
| **Lower White River Drainage** | **Lower White River**: Knox County: no bridge access, 4.5 mi upstream Iona, Harrison Twp., T 1N R 9W S 11 (site: 91-214). |
| | **Lower White River**: Knox County, at CR 1300S Road acess, 1.25 mi SE Iona, Johnson Twp., T 1N R 9W S 7 (site 91-215). |
| **East Fork White River Drainage** | **Driftwood River**: Bartholomew County: at CR 650N bridge, 6.5 mi NW Columbus, Ninevah Twp., T 10N R 5E S 21. long. 86° 58' 22" lat. 39° 17' 24" (site: 90-259). |
| | **Driftwood River**: Bartholomew County: at CR 350N bridge, 3 mi NW Columbus, Columbus Twp., T 9N R 5E S 10 (site: 90-279). |
| | **East Fork White River**: Bartholomew County: at CR 800S bridge, Azalia, Sand Creek Twp., T 8N R 6E S 33. long. 85° 51' 37" lat. 39° 05' 06" (site: 90-257). |
| | **East Fork White River**: Lawrence County: at Palestine Road at B.R. Edwards property, 1.25 mi SE Bedford, Shawswick Twp., T 4N R 1E S 6. long. 86° 27' 33" lat. 38° 48' 26" (site: 90-249). |
| **West Fork White River Drainage** | **West Fork White River**: Marion County: between Westfield Blvd. and College Ave. bridges, Broad Ripple, Washington Twp., T 16N R 3E S 1/2. long. 86° 09' 42" lat. 39° 51' 44" (site: 90-280). |
| | **West Fork White River**: Randolph County: at SR 32/1 bridge, 1.25 mi S Farmland, Stony Creek Twp., T 20N R 12E S 19. long. 85° 07' 27" lat. 40° 10' 19" (site: 90-271). |
| | **West Fork White River**: Morgan County: at CR 375E bridge, Henderson Ford Boat Launch, 2.0 mi SE Centerton, Green Twp., T 12N R 2E S 6/7. long. 86° 21' 20" lat. 39° 29' 58" (site: 90-242). |

## Predicted vs. Observed Faunas

Based on species thermal tolerances (Brungs and Jones, 1977; EPRI, 1981; Gammon, 1983) it is possible to correlate anticipated (predicted) community composition based on thermal loadings with actual community composition. Gammon (1983) examined the ambient thermal preferences of common Wabash River species with thermal preferences determined in the laboratory. Close agreements between the predicted and observed species thermal preferences were observed. Minor differences were attributed to differences in life stage, since the majority of species specific testing is conducted with juveniles. The thermal tolerances of many Indiana species are unknown, however, a representative portion of the White River fauna has been studied (Table 15).

Field and laboratory thermal preference studies

**Table 15. Temperature tolerance of White River fish species determined by laboratory experiments and field observation (EPRI, 1981; Gammon, 1983).**

| Scientific Name | Field Preferred Temperature° C | | | | Laboratory Temperature, °C | |
|---|---|---|---|---|---|---|
| | Low | Preferred | Avoidance | High | Upper Preferred | Upper Ultimate Incipient Lethal |
| **Lepisosteidae** | | | | | | |
| Lepisosteus oculatus | -- | -- | -- | 33-35 | -- | 38.0 |
| L. osseus | -- | 30-36 | 34.5 | 33-38 | 25.3-33.1 | -- |
| L. platostomus | -- | 27-35 | 34.5 | 34-41 | -- | -- |
| **Anguillidae** | | | | | | |
| Anguilla rostrata | 11.9 | -- | -- | 35 | -- | -- |
| **Clupeidae** | | | | | | |
| Alosa chrysochloris | 27.0 | -- | >30 | 30.5 | -- | -- |
| Dorosoma cepedianum | 4.2 | 26-34 | 30-34 | 34-38 | 19-20.5 | 28.5-36.5 |
| D. petenense | -- | -- | -- | 33-35 | -- | 32-38 |
| **Hiodontidae** | | | | | | |
| Hiodon alosoides | -- | 22-29 | -- | -- | -- | -- |
| H. tergisus | -- | 22-29 | -- | -- | -- | -- |
| **Esocidae** | | | | | | |
| Esox americanus | -- | -- | -- | -- | -- | -- |
| E. lucius | 12.9 | -- | -- | 22.0 | -- | 33.0 |
| **Cyprinidae** | | | | | | |
| Campostoma anomalum | 8.9 | 22.7-23.8 | 27.2 | 33.8 | 26.2-28.8 | 21-33 |
| Cyprinella lutrensis | -- | -- | -- | 34.4 | 21.8-25.1 | 39.0 |
| C. spiloptera | 2.2 | -- | -- | 35-42 | 29.4-31.9 | 24-36 |
| Cyprinus carpio | <12.6 | 27.5-35 | >34.5 | 33-38 | 32 | 35.7-40.6 |
| Hybognathus nuchalis | -- | -- | -- | 35.5-42 | -- | 38.0 |
| Notemigonus crysoleucas | 6.7 | 30-32 | -- | 30-35 | 16.8-23.7 | 33-39.5 |
| Notropis atherinoides | -- | -- | -- | 31-42 | 6.0-23.0 | 30.7-37.7 |
| N. photogenis | 15.5 | 26.7-27 | -- | 35 | -- | -- |
| N. rubellus | 2.8 | 28.3-30 | -- | 35 | 26.0-28.4 | 21-33 |
| N. volucellus | 4.4 | -- | -- | 35 | -- | -- |
| Pimephales notatus | 2.8 | <26.7 | -- | 31.1-35 | 26.7-29.3 | 21-33.3 |
| P. promelas | 15.5 | -- | -- | 25.6 | 26.0-28.5 | 32.4-34 |
| P. vigilax | 6.0 | -- | -- | 37-42 | -- | -- |
| Rhinichthys atratulus | 10.0 | <27 | -- | 34 | -- | 29.3-31.9 |
| Semotilus atromaculatus | 15.6 | -- | -- | 34 | -- | 30.3-33 |

**Table 15. Continued.**

| Scientific Name | Field Preferred Temperature° C | | | | Laboratory Temperature, °C | |
|---|---|---|---|---|---|---|
| | Low | Preferred | Avoidance | High | Upper Preferred | Upper Ultimate Incipient Lethal |
| **Catostomidae** | | | | | | |
| Carpiodes carpio | -- | 24-34.5 | >33 | 33.8-39 | -- | 35.2-36.5 |
| C. cyprinus | -- | 26-32 | -- | 32.2-34.5 | 22.1 | 37.2 |
| C. velifer | -- | -- | >33 | 33.9-41 | -- | -- |
| Catostomus commersoni | <10 | 16-27 | 25-27 | 27.7-30.6 | 27.0 | 29.3-30.0 |
| Hypentelium nigricans | 2.2 | 26.6-27.7 | >27.7 | 35 | 26.6-29.8 | 27-33 |
| Ictiobus bubalus | -- | 22-32 | -- | 34-36 | -- | -- |
| Minytrema melanops | -- | 25-27 | -- | -- | -- | >31.0 |
| Moxostoma anisurum | -- | -- | -- | 35 | -- | -- |
| M. erythurum | 11 | 22-27.5 | -- | 28-33 | -- | -- |
| M. macrolepidotum | 7 | 22-27.5 | -- | 33-35 | -- | -- |
| **Ictaluridae** | | | | | | |
| Ameiurus melas | -- | -- | -- | 32.8 | -- | 35.0-35.7 |
| A. natalis | -- | -- | -- | 32.8 | 27.6-28.8 | 36.4 |
| Ictalurus punctatus | <11.7 | 26-35 | >36 | 28.5-41 | 29.0 | 35.0-37.8 |
| Pylodictis olivaris | 21.7 | 24-36 | -- | 33-36 | -- | -- |
| **Fundulidae** | | | | | | |
| Fundulus diaphanus | -- | -- | 35 | 37.8 | 21.0 | 34.5 |
| **Moronidae** | | | | | | |
| Morone chrysops | -- | 22-29.5 | 29 | 34 | 30.0-32.0 | 35.3-36.1 |
| M. mississippiensis | -- | 31-31.5 | -- | -- | -- | -- |
| **Centrarchidae** | | | | | | |
| Ambloplites rupestris | 2.2 | 27.5 | 34 | 30-35 | 29.0-30.2 | 30-33 |
| Lepomis cyanellus | 20.0 | -- | -- | 30-41 | 28.2 | 30.3-35.0 |
| L. gibbosus | 11.9 | 24.4-31 | -- | 32.8-35.6 | 23.8-27.7 | 35.6-38.1 |
| L. macrochirus | 20.6 | 22-34 | -- | 33-38 | 30.3-32.3 | 33.8-39.0 |
| L. megalotis | -- | -- | -- | 33-37.8 | -- | -- |
| Micropterus dolomieui | 16.7 | -- | -- | 35 | 28.0-29.0 | 27-36.3 |
| M. punctulatus | 20.6 | 27-28.5 | -- | 27-35 | 30.0-32.0 | 33-39 |
| M. salmoides | 14.8 | 27-29 | -- | 28-35 | 27.0-32.0 | 35.5-40.0 |
| Pomoxis annularis | 5.0 | 26-31 | -- | 31.1 | 10.4-19.8 | >32.8 |
| P. nigromaculatus | 16.5 | 23.8-28.3 | -- | 26.6-35 | 20.5-24.6 | 30.0-34.9 |
| **Percidae** | | | | | | |
| Etheostoma blennioides | 2.8 | -- | -- | 35 | -- | 32.2 |
| E. flabellare | 2.8 | 19.4-20 | -- | 30.6 | -- | 32.1 |
| E. nigrum | 20.1 | -- | -- | 28.8 | -- | 31.4 |

**Table 15. Continued.**

| Scientific Name | Field Preferred Temperature° C Low | Preferred | Avoidance | High | Laboratory Temperature, °C Upper Preferred | Upper Ultimate Incipient Lethal |
|---|---|---|---|---|---|---|
| **Percidae (Continued)** | | | | | | |
| Stizostedion canadense | -- | 26-28 | 30 | 29-33.6 | -- | 30.4 |
| S. vitreum | -- | -- | 30 | 27.4-30.6 | -- | 31.6->34.4 |
| **Cottidae** | | | | | | |
| Cottus bairdi | 15.6 | -- | -- | 23.3 | -- | 30.9 |
| C. carolinae | 15.6 | 20 | 28.3 | 29.4 | -- | -- |
| **Sciaenidae** | | | | | | |
| Aplodinotus grunniens | -- | 22-30 | -- | 28-38 | 31.3 | 34.0-36.0 |

were completed during the late 1970's as a part of the Section 316 demonstrations required by the Clean Water Act. It was anticipated that species having a thermal preference for temperatures below 29°C would disappear from the vicinity of the mixing zone. Based on the community composition determined by EA Science and Technology (1992) and the current study for the Lower White River, no deviations were observed between predicted and observed community response. This substantiates the premise that the impact observed in the Lower White River was a result of thermal loading and was not habitat related. Based on the thermal model, species present below each of the generating stations should be comprised of thermophilic species such as carp, channel catfish, flathead catfish, carpsucker, and buffalo.

The absence of cooler water (e.g. redhorse, sauger, walleye, northern pike) species would be anticipated based on the thermal preferences of these taxa. The reduction of gizzard shad between the junction of the East and West Forks of the White River and the SR 62 bridge (downstream of Petersburg Generating Station) may be due to the species upper critical thermal maximum being exceeded. This may have resulted in the observed population declines in the portion of the River downstream of the Petersburg and Ratts Generating Stations. The presence of only carp, Mississippi silvery minnow, and red shiner among the cyprinids, would be anticipated since these three species are reported as "tolerant" to high thermal loadings. The lack of smallmouth bass would be expected but occurrence of largemouth and spotted bass was anticipated. The absence of darters, with the exception of johnny darter, was expected. However, it is important to note that no information is available for the thermal preferences of any species of Percina and Ammocrypta, and for many species of Etheostoma. Further experimentation with these sensitive species would need to be completed before thermal sensitivity can be determined.

Gammon (1983) found a similar response with Wabash River fish (Fig. 24). Based on an intake control sample, several scenarios were evaluated based on a model of the rivers thermal changes along a spatial scale. All cases assumed instantaneous mixing. Based on temperature, the changes in community composition observed after start-up were attributed to temperature. The initial scenario (case 1) predicts the thermal regime using mean river discharge and overall mean monthly ambient temperatures under maximum thermal loadings by the generating stations. Case 2 assumes completely mixed temperatures using mean river discharge and extreme high mean monthly temperature. A final case assumes that the entire flow of the Wabash River passes through the Generating Station when operating at maximum capacity. Superimposed on these cases are the thermal preferences of common species. Case 1 predicts the temperatures would exceed the thermal preferences of redhorses, sauger, walleye, would have their thermal preferences exceeded for much of the summer, while the temperatures would exceed the preferences of smallmouth bass, goldeye, mooneye, and *Pimephales* spp. for a single month. Other species would not experience thermal stress. Assuming case 2, all of the above species would be eliminated, as well as white crappie, skipjack herring, and shiners, for perhaps a single month each summer.

Theoretically, the Petersburg and Ratts Generating Stations can take the entire flow of the White River during low flow ($Q_{7,10}$) conditions. This does not occur due to permit constraints on these facilities. However, when the model developed by Gammon (1983) in which the entire river flow could be used by facilities on the Wabash River was applied to this situation, the predicted species composition were very similar to what was found.

Finally, changes of the thermal regime of the White River also influences reproduction, competition, and trophic dynamics of the community. These diffuse or direct competitive interactions cannot be adequately modeled. However, the lack of recovery of redhorse in the Lower White River can possibly be attributed to the competitive edge of carpsuckers once temperatures have returned to acceptable ranges.

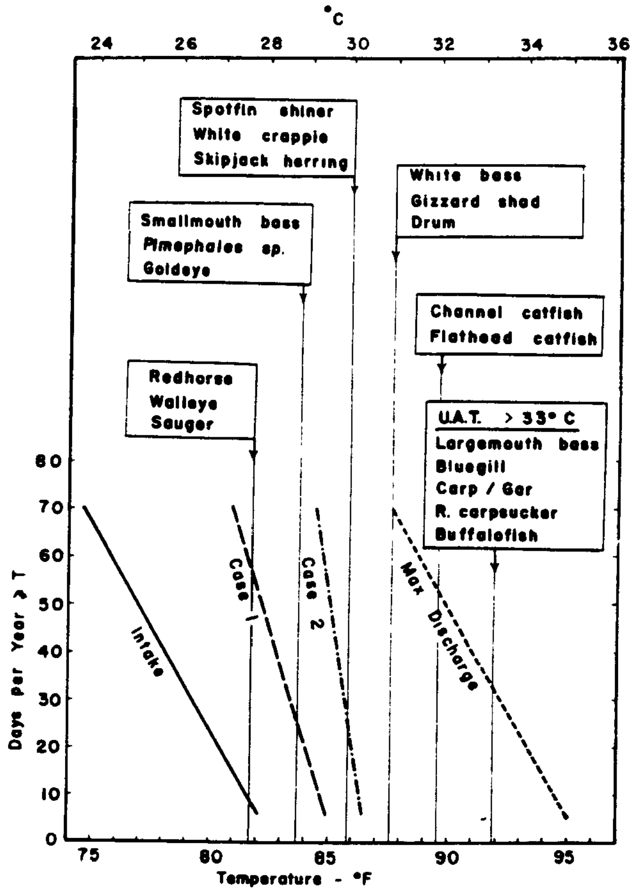


*Figure 24.* **Ambient temperature of the middle Wabash River and thermal changes from heated effluents in relation to the thermal preferenda of some resident fishes (after Gammon 1983).**

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## APPENDICES

A. Adjacent State comparisons of tolerance classifications for computing the Index of Biotic Integrity for Indiana taxa.

B. Adjacent State comparisons of feeding guilds for computing the Index of Biotic Integrity for Indiana taxa.

C. Adjacent State comparisons of Reproductive guilds for computing the Index of Biotic Integrity for Indiana taxa.

D. Site Specific Index of Biotic Integrity scores for each of the stations sampled in the White River drainage.

E. Fish nomenclature changes for the species of fish occurring within the political boundaries of Indiana.

Appendix A. Adjacent State comparisons of tolerance classifications[1] for computing the Index of Biotic Integrity for Indiana taxa.

| Taxon | IN | OH | IL |
|---|---|---|---|
| **Petromyzontiformes-lampreys** | | | |
| Petromyzontidae - lamprey | | | |
| Ichthyomyzon bdellium (Jordan), Ohio lamprey | S | S | |
| I. casteneus Girard, chestnut lamprey | - | | |
| I. fossor Reighard and Cummins, northern brook lamprey | S | R | |
| I. unicuspis Hubbs and Trautman, silver lamprey | - | - | |
| Lampetra aepyptera (Abbott), least brook lamprey | R | - | |
| L. appendix (DeKay), American brook lamprey | R | S | |
| Petromyzon marinus Linnaeus, sea lamprey | - | - | |
| **Acipenseriformes - paddlefish, sturgeons** | | | |
| Polyodontidae - paddlefish | | | |
| Polyodon spatula (Walbaum), paddlefish | S | S | |
| Acipenseridae - sturgeon | | | |
| Acipenser fulvescens Rafinesque, lake sturgeon | - | - | |
| Scaphirhynchus platorynchus (Rafinesque), shovelnose sturgeon | - | - | |
| **Lepisosteiformes - gars** | | | |
| Lepisosteidae - gars | | | |
| Atractosteus spatula (Lacepede), alligator gar | - | - | |
| Lepisosteus oculatus Winchell, spotted gar | - | - | |
| L. osseus Linnaeus, longnose gar | - | - | |
| L. platostomus Rafinesque, shortnose gar | - | - | |
| **Amiiformes - bowfin** | | | |
| Amiidae - bowfin | | | |
| Amia calva Linnaeus, bowfin | - | - | |
| **Anguilliformes - eels** | | | |
| Anguillidae - eel | | | |
| Anguilla rostrata (Lesueur), American eel | T | - | |
| **Clupeiformes - herring, shad** | | | |
| Clupeidae - herring | | | |
| Alosa chrysochloris (Rafinesque), skipjack herring | - | - | |
| A. pseudoharengus (Wilson), alewife | - | - | |
| Dorosoma cepedianum (Lesueur), gizzard shad | - | - | |
| D. petenense (Gunther), threadfin shad | - | - | |
| **Osteoglossiformes - mooneye** | | | |
| Hiodontidae - mooneye | | | |
| Hiodon alosoides (Rafinesque), goldeye | R | R | |
| H. tergisus Lesueur, mooneye | R | R | I |
| **Salmoniformes - trout, salmon, whitefish** | | | |
| Salmonidae - salmon and whitefish | | | |
| Coregonus artedii Lesueur, cisco or lake herring | - | - | I |
| C. clupeaformis (Mitchill), lake whitefish | - | - | I |
| C. hoyi (Gill), bloater | - | | I |
| C. zenithicus (Jordan and Evermann), shortjaw cisco | - | | |
| Oncorhynchus mykiss Walbaum, rainbow trout | M | - | I |
| O. kisutch (Walbaum), coho salmon | M | - | I |
| O. tshawytscha (Walbaum), chinook salmon | M | - | I |
| Salvelinus fontinalis (Mitchell), brook trout | M | - | I |
| S. namaycush (Walbaum), lake trout | M | - | I |
| Salmo salar (Walbaum), Atlantic salmon | M | | |
| S. trutta Linneaus, brown trout | M | - | I |
| Osmeridae - smelt | | | |
| Osmerus mordax (Mitchill), rainbow smelt | - | - | |

| | IN | OH | IL |
|---|---|---|---|
| Umbridae - mudminnows | | | |
| Umbra limi (Kirtland), central mudminnow | T | T | |
| Esocidae - pikes | | | |
| Esox americanus Gmelin, grass pickerel | P | P | |
| E. lucius Linnaeus, northern pike | - | - | I |
| E. masquinongy Mitchill, muskellunge | - | - | |
| **Cypriniformes - carps and minnows** | | | |
| Cyprinidae - carps and minnows | | | |
| Campostoma anomulum (Rafinesque), stoneroller | - | - | |
| C. oligolepis Hubbs and Greene, largescale stoneroller | - | | I |
| Carassius auratus (Linneaus), goldfish | T | T | |
| Clinostomus elongatus (Kirtland), redside dace | R | I | |
| Couesius plumbeus (Agassiz), lake chub | - | - | |
| Ctenopharyngodon idella Valenciennes, grass carp | T | | |
| Cyprinella lutrensis (Baird and Girard), red shiner | T | - | |
| C. spiloptera Cope, spotfin shiner | - | - | I |
| C. whipplei (Girard), steelcolor shiner | - | P | I |
| Cyprinus carpio Linneaus, carp | T | T | |
| Ericymba buccata Cope, silverjaw minnow | - | - | |
| Erimystax dissimilis Kirtland, streamline chub | R | R | |
| E. x-punctata Hubbs and Crowe, gravel chub | M | M | |
| Extrarius aestivalis Girard, speckled chub | R | S | |
| Hybognathus hayi Jordan, cypress minnow | - | - | |
| H. nuchalis Agassiz, Mississippi silvery minnow | - | - | I |
| Hybopsis amblops (Rafinesque), bigeye chub | I | I | I |
| H. amnis Hubbs and Greene, pallid shiner | R | | I |
| Hypophthalmichthys molitrix Valenciennes, silver carp | T | | |
| Luxilus chrysocephalus (Rafinesque), striped shiner | - | - | |
| L. cornutus (Mitchell), common shiner | - | - | |
| Lythrurus ardens (Cope), rosefin shiner | M | M | |
| L. fumeus Evermann, ribbon shiner | - | | |
| L. umbratilis (Girard), redfin shiner | - | - | |
| Macrhybopsis storeriana (Kirtland), silver chub | - | - | |
| Nocomis biguttatus (Kirtland), hornyhead chub | I | I | |
| N. micropogon (Cope), river chub | I | I | I |
| Notemigonus crysoleucus (Mitchell), golden shiner | T | T | |
| Notropis anogenus Forbes, pugnose shiner | S | S | I |
| N. atherinoides Rafinesque, emerald shiner | - | - | |
| N. ariommus (Cope), popeye shiner | S | S | |
| N. blennius (Girard), river shiner | - | I | |
| N. boops Gilbert, bigeye shiner | I | I | |
| N. buchanani Meek, ghost shiner | - | - | |
| N. chalybaeus (Cope), ironcolor shiner | I | | I |
| N. dorsalis (Agassiz), bigmouth shiner | - | - | |
| N. heterodon (Cope), blacknose shiner | R | R | I |
| N. heterolepis Eigenmann and Eigenmann, blackchin shiner | S | S | I |
| N. hudsonius (Clinton), spottail shiner | P | P | |
| N. ludibundus Cope, sand shiner | M | M | |
| N. photogenis (Cope), silver shiner | R | I | |
| N. rubellus (Agassiz), rosyface shiner | I | I | I |
| N. shumardi (Girard), silverband shiner | I | | |
| N. texanus (Girard), weed shiner | R | | I |
| N. volucellus (Cope), mimic shiner | I | I | I |
| N. wickliffi, channel shiner | I | | |
| Opsopoeodus emiliae Hay, pugnose minnow | R | R | I |
| Phenacobius mirabilis (Girard), suckermouth minnow | - | - | |
| Phoxinus erythrogaster (Rafinesque), southern redbelly dace | - | - | I |
| Pimephales notatus (Rafinesque), bluntnose minnow | T | T | |
| P. promelas Rafinesque, fathead minnow | T | T | |
| P. vigilax (Baird and Girard), bullhead minnow | - | - | I |
| Rhinichthys atratulus Agassiz, blacknose dace | T | T | I |
| R. cataractae (Valenciennes), longnose dace | R | R | |

| | IN | OH | IL |
|---|---|---|---|
| Semotilus atromaculatus (Mitchill), creek chub | T | T | |
| Catostomidae - suckers and buffalo | | | |
| Cycleptus elongatus (Lesueur), blue sucker | R | R | I |
| Carpiodes carpio (Rafinesque), river carpsucker | - | - | |
| C. cyprinus (Lesueur), quillback | - | - | |
| C. velifer (Rafinesque), highfin carpsucker | S | - | I |
| Catostomus catostomus (Forster), longnose sucker | - | - | |
| C. commersoni Lacepede, white sucker | T | T | |
| Erimyzon oblongus (Mitchill), creek chubsucker | - | - | |
| E. sucetta (Lacepede), lake chubsucker | - | - | I |
| Hypentelium nigricans (Lesueur), northern hogsucker | M | M | I |
| Ictiobus bubalus (Rafinesque), smallmouth buffalo | - | - | |
| I. cyprinellus (Valenciennes), bigmouth buffalo | - | - | |
| I. niger (Rafinesque), black buffalo | - | - | |
| Minytrema melanops (Rafinesque), spotted sucker | - | - | |
| Moxostoma anisurum (Rafinesque), silver redhorse | M | M | I |
| M. carinatum (Cope), river redhorse | R | I | I |
| M. duquesnei (Lesueur), black redhorse | R | I | I |
| M. erythurum (Rafinesque), golden redhorse | M | M | |
| M. macrolepidotum (Lesueur), shorthead redhorse | M | M | I |
| M. valenciennesi Jordan, greater redhorse | R | R | |
| **Siluriformes - bullhead and catfish** | | | |
| Ictaluridae - bullhead and catfish | | | |
| Ameiurus catus (Linnaeus), white catfish | - | - | |
| A. melas (Rafinesque), black bullhead | T | P | |
| A. natalis (Lesueur), yellow bullhead | P | T | |
| A. nebulosus (Lesueur), brown bullhead | P | T | |
| Ictalurus furcatus (Lesueur), blue catfish | - | - | |
| I. punctatus (Rafinesque), channel catfish | - | - | |
| Noturus eleutherus Jordan, mountain madtom | R | R | I |
| N. exilis Nelson, slender madtom | R | | I |
| N. flavus Rafinesque, stonecat | I | I | I |
| N. gyrinus (Mitchill), tadpole madtom | - | - | |
| N. miurus Jordan, brindled madtom | R | I | I |
| N. nocturnus Jordan and Gilbert, freckled madtom | R | | |
| N. stigmosus Taylor, northern madtom | R | R | I |
| Pylodictis olivaris (Rafinesque), flathead catfish | - | - | |
| **Percopsiformes - cavefish, pirate perch, trout-perch** | | | |
| Amblyopsidae - cavefish | | | |
| Amblyopsis spelaea DeKay, northern cavefish | S | | |
| Typhalichthys subterraneus Girard, southern cavefish | S | | |
| Aphredoderidae - pirate perch | | | |
| Aphredoderus sayanus (Gilliams), pirate perch | - | - | |
| Percopsidae - trout-perch | | | |
| Percopsis omiscomaycus (Walbaum), trout-perch | - | - | |
| **Gadiformes - cod** | | | |
| Gadidae - cod | | | |
| Lota lota (Linnaeus), burbot | - | - | |
| **Atheriniformes - topminnows, silversides** | | | |
| Fundulidae - topminnows | | | |
| Fundulus catenatus (Storer), northern studfish | R | | |
| F. diaphanus (Lesueur), banded killifish | - | S | |
| F. dispar (Agassiz), northern starhead topminnow | R | | |
| F. notatus (Rafinesque), blackstripe topminnow | - | - | |
| Poeciliidae - live-bearing fishes | | | |
| Gambusia affinis (Baird and Girard), mosquitofish | - | - | |
| Atherinidae - silversides | | | |
| Labidesthes sicculus (Cope), brook silverside | M | M | |

| | IN | OH | IL |
|---|---|---|---|
| **Gasterosteiformes - sticklebacks** | | | |
| Gasterosteidae - sticklebacks | | | |
| Culaea inconstans (Kirtland), brook stickleback | - | - | |
| Pungitius pungitius (Linnaeus), ninespine stickleback | - | | |
| | | | |
| **Perciformes - basses, sunfish, perch, darters** | | | |
| Moronidae - temperate basses | | | |
| Morone chrysops (Rafinesque), white bass | - | - | |
| M. mississippiensis Jordan and Eigenmann, yellow bass | - | | |
| M. saxatilis (Walbaum), striped bass | - | | |
| Centrarchidae - black bass and sunfish | | | |
| Ambloplites rupestris (Rafinesque), rock bass | M | - | I |
| Centrarchus macropterus (Lacepede), flier | - | | |
| Lepomis cyanellus Rafinesque, green sunfish | T | T | |
| L. gibbosus (Linnaeus), pumpkinseed | P | P | |
| L. gulosus (Cuvier), warmouth | - | - | |
| L. humilis (Girard), orangespotted sunfish | - | - | |
| L. macrochirus Rafinesque, bluegill | P | P | |
| L. megalotis (Rafinesque), longear sunfish | M | M | I |
| L. microlophus (Gunther), redear sunfish | - | - | |
| L. punctatus (Valenciennes), spotted sunfish | - | | |
| L. symmetricus Forbes, bantam sunfish | - | | |
| Micropterus dolomieui Lacepede, smallmouth bass | M | M | I |
| M. punctulatus Rafinesque, spotted bass | - | - | |
| M. salmoides (Lacepede), largemouth bass | - | - | |
| Pomoxis annularis Rafinesque, white crappie | - | - | |
| P. nigromaculatus (Lesueur), black crappie | - | - | |
| Elassomatidae - pygmy sunfish | | | |
| Elassoma zonatum Jordan, banded pygmy sunfish | - | | |
| Percidae - perch and darters | | | |
| Ammocrypta clara Jordan and Meek, western sand darter | R | | I |
| A. pellucida (Agassiz), eastern sand darter | R | R | I |
| Etheostoma asprigene (Forbes), mud darter | - | | |
| E. blennioides (Rafinesque), greenside darter | M | M | I |
| E. caeruleum Storer, rainbow darter | M | M | I |
| E. camurum (Cope), bluebreast darter | R | R | I |
| E. chlorosoma (Hay), bluntnose darter | - | | |
| E. exile (Girard), Iowa darter | - | - | I |
| E. flabellare Rafinesque, fantail darter | - | - | I |
| E. gracile (Girard), slough darter | - | | |
| E. histrio (Jordan and Gilbert), harlequin darter | S | R | |
| E. maculatum Kirtland, spotted darter | R | R | |
| E. microperca Jordan and Gilbert, least darter | - | - | I |
| E. nigrum Rafinesque, johnny darter | - | - | |
| E. spectabile (Agassiz), orangethroat darter | - | - | I |
| E. squamiceps Jordan, spottail darter | - | | I |
| E. tippecanoe Jordan and Evermann, tippecanoe darter | R | R | |
| E. variatum Kirtland, variegate darter | R | I | |
| E. zonale (Cope), banded darter | I | I | I |
| Perca flavescens (Mitchill), yellow perch | - | - | |
| Percina caprodes (Rafinesque), logperch | M | M | |
| P. copelandi (Jordan), channel darter | S | S | |
| P. evides (Jordan and Copeland), gilt darter | R | S | |
| P. maculata (Girard), blackside darter | - | - | |
| P. phoxocephala (Nelson), slenderhead darter | I | R | I |
| P. sciera (Swain), dusky darter | M | M | I |
| P. shumardi (Girard), river darter | - | - | |
| Stizostedion canadense (Smith), sauger | - | - | |
| S. vitreum (Mitchill), walleye | - | - | |
| Sciaenidae - drum | | | |
| Aplodinotus grunniens Rafinesque, freshwater drum | P | P | |
| Cottidae - sculpins | | | |
| Cottus bairdi Girard, mottled sculpin | - | - | I |

| | IN | OH | IL |
|---|---|---|---|
| C. carolinae (Gill), banded sculpin | - | | I |
| C. cognatus Richardson, slimy sculpin | - | - | |
| Myoxocephalus thompsoni (Girard), deepwater sculpin | - | - | |
| **Hypothetical:** | | | |
| Fundulus olivaceus (Storer), blackspotted topminnow | - | | |
| Hybognathus hankinsoni Hubbs, brassy minnow | - | | |
| Percina vigil Hay, yellow saddleback darter | M | | |
| Scardinius erythropthalmus (Linneaus), rudd | T | | |
| **Extirpated:** | | | |
| Alosa alabamae Jordan and Evermann, Alabama shad | - | | |
| Coregonus nigripinnis (Gill), blackfin cisco | S | | |
| C. reighardi (Koelz), shortnose cisco | S | | |
| Crystallaria asprella Jordan, crystal darter | S | S | |
| Esox masquinongy Mitchill, Great Lakes Muskellunge | - | - | |
| Lagochila lacera Jordan and Brayton, harelip sucker | S | | |
| Percina uranidea (Jordan and Gilbert), stargazing darter | S | | |

[1]Tolerance Categories: (See text for explanation)

R - Rare Intolerant
S - Special Intolerant
I - Common Intolerant
M - Moderately Intolerant
T - Highly Tolerant
P - Moderately Tolerant
- - Tolerance classification moderate

Appendix B. Adjacent State comparisons of feeding guilds[1] for computing the Index of Biotic Integrity for Indiana taxa.

| | IN | OH | IL |
|---|---|---|---|
| **Petromyzontiformes-lampreys** | | | |
| Petromyzontidae - lamprey | | | |
| Ichthyomyzon bdellium (Jordan), Ohio lamprey | P | P | |
| I. casteneus Girard, chestnut lamprey | P | | |
| I. fossor Reighard and Cummins, northern brook lamprey | F | F | |
| I. unicuspis Hubbs and Trautman, silver lamprey | P | P | |
| Lampetra aepyptera (Abbott), least brook lamprey | F | F | |
| L. appendix (DeKay), American brook lamprey | F | F | |
| Petromyzon marinus Linnaeus, sea lamprey | P | P | |
| **Acipenseriformes - paddlefish, sturgeons** | | | |
| Polyodontidae - paddlefish | | | |
| Polyodon spatula (Walbaum), paddlefish | F | F | |
| Acipenseridae - sturgeon | | | |
| Acipenser fulvescens Rafinesque, lake sturgeon | V | V | |
| Scaphirhynchus platorynchus (Rafinesque), shovelnose sturgeon | I | I | |
| **Lepisosteiformes - gars** | | | |
| Lepisosteidae - gars | | | |
| Atractosteus spatula (Lacepede), alligator gar | P | P | |
| Lepisosteus oculatus Winchell, spotted gar | P | P | C |
| L. osseus Linnaeus, longnose gar | P | P | C |
| L. platostomus Rafinesque, shortnose gar | P | P | C |
| **Amiiformes - bowfin** | | | |
| Amiidae - bowfin | | | |
| Amia calva Linnaeus, bowfin | P | P | C |
| **Anguilliformes - eels** | | | |
| Anguillidae - eel | | | |
| Anguilla rostrata (Lesueur), American eel | C | C | C |
| **Clupeiformes - herring, shad** | | | |
| Clupeidae - herring | | | |
| Alosa chrysochloris (Rafinesque), skipjack herring | P | P | C |
| A. pseudoharengus (Wilson), alewife | F | - | |
| Dorosoma cepedianum (Lesueur), gizzard shad | O | O | O |
| D. petenense (Gunther), threadfin shad | O | O | |
| **Osteoglossiformes - mooneye** | | | |
| Hiodontidae - mooneye | | | |
| Hiodon alosoides (Rafinesque), goldeye | I | I | C |
| H. tergisus Lesueur, mooneye | I | I | |
| **Salmoniformes - trout, salmon, whitefish** | | | |
| Salmonidae - salmon and whitefish | | | |
| Coregonus artedii Lesueur, cisco or lake herring | F | - | |
| C. clupeaformis (Mitchill), lake whitefish | V | V | |
| C. hoyi (Gill), bloater | - | | |
| C. zenithicus (Jordan and Evermann), shortjaw cisco | - | | |
| Oncorhynchus mykiss Walbaum, rainbow trout | P | - | |
| O. kisutch (Walbaum), coho salmon | P | - | |
| O. tshawytscha (Walbaum), chinook salmon | P | - | |
| Salvelinus fontinalis (Mitchell), brook trout | P | - | |
| S. namaycush (Walbaum), lake trout | P | P | |
| Salmo salar (Walbaum), Atlantic salmon | P | | |
| S. trutta Linneaus, brown trout | P | - | |
| Osmeridae - smelt | | | |
| Osmerus mordax (Mitchill), rainbow smelt | V | - | |

| | IN | OH | IL |
|---|---|---|---|
| Umbridae - mudminnows | | | |
| Umbra limi (Kirtland), central mudminnnow | O | I | O |
| Esocidae - pikes | | | |
| Esox americanus Gmelin, grass pickerel | P | P | C |
| E. lucius Linnaeus, northern pike | P | P | C |
| E. masquinongy Mitchill, muskellunge | P | P | |
| | | | |
| **Cypriniformes - carps and minnows** | | | |
| Cyprinidae - carps and minnows | | | |
| Campostoma anomulum (Rafinesque), stoneroller | H | H | |
| C. oligolepis Hubbs and Greene, largescale stoneroller | H | | |
| Carassius auratus (Linneaus), goldfish | O | O | O |
| Clinostomus elongatus (Kirtland), redside dace | I | I | |
| Couesius plumbeus (Agassiz), lake chub | I | | |
| Ctenopharyngodon idella Valenciennes, grass carp | O | | |
| Cyprinella lutrensis (Baird and Girard), red shiner | I | I | I |
| C. spiloptera Cope, spotfin shiner | I | I | I |
| C. whipplei (Girard), steelcolor shiner | I | I | I |
| Cyprinus carpio Linneaus, carp | O | O | O |
| Ericymba buccata Cope, silverjaw minnow | I | I | I |
| Erimystax dissimilis Kirtland, streamline chub | I | I | |
| E. x-punctata Hubbs and Crowe, gravel chub | I | I | |
| Extrarius aestivalis Girard, speckled chub | I | I | |
| Hybognathus hayi Jordan, cypress minnow | O | | |
| H. nuchalis Agassiz, Mississippi silvery minnow | O | | |
| Hybopsis amblops (Rafinesque), bigeye chub | I | I | |
| H. amnis Hubbs and Greene, pallid shiner | I | | |
| Hypophthalmichthys molitrix Valenciennes, silver carp | O | | |
| Luxilus chrysocephalus (Rafinesque), striped shiner | I | I | I |
| L. cornutus (Mitchell), common shiner | I | I | I |
| Lythrurus ardens (Cope), rosefin shiner | I | I | |
| L. fumeus Evermann, ribbon shiner | I | | |
| L. umbratilis (Girard), redfin shiner | I | I | I |
| Macrhybopsis storeriana (Kirtland), silver chub | I | I | |
| Nocomis biguttatus (Kirtland), hornyhead chub | I | I | I |
| N. micropogon (Cope), river chub | I | I | |
| Notemigonus crysoleucus (Mitchell), golden shiner | I | I | O |
| Notropis anogenus Forbes, pugnose shiner | I | I | |
| N. atherinoides Rafinesque, emerald shiner | I | I | I |
| N. ariommus (Cope), popeye shiner | I | I | |
| N. blennius (Girard), river shiner | I | I | I |
| N. boops Gilbert, bigeye shiner | I | I | |
| N. buchanani Meek, ghost shiner | I | I | |
| N. chalybaeus (Cope), ironcolor shiner | I | | I |
| N. dorsalis (Agassiz), bigmouth shiner | I | I | O |
| N. heterodon (Cope), blacknose shiner | I | I | I |
| N. heterolepis Eigenmann and Eigenmann, blackchin shiner | I | I | O |
| N. hudsonius (Clinton), spottail shiner | I | I | I |
| N. ludibundus Cope, sand shiner | I | I | I |
| N. photogenis (Cope), silver shiner | I | I | |
| N. rubellus (Agassiz), rosyface shiner | I | I | I |
| N. texanus (Girard), weed shiner | I | | |
| N. volucellus (Cope), mimic shiner | I | I | O |
| N. wickliffi, channel shiner | I | | |
| Opsopoeodus emiliae Hay, pugnose minnow | I | I | I |
| Phenacobius mirabilis (Girard), suckermouth minnow | I | I | I |
| Phoxinus erythrogaster (Rafinesque), southern redbelly dace | H | H | |
| Pimephales notatus (Rafinesque), bluntnose minnow | O | O | O |
| P. promelas Rafinesque, fathead minnow | O | O | O |
| P. vigilax (Baird and Girard), bullhead minnow | O | O | O |
| Rhinichthys atratulus Agassiz, blacknose dace | G | G | O |
| R. cataractae (Valenciennes), longnose dace | I | I | |
| Semotilus atromaculatus (Mitchill), creek chub | G | G | I |

| | IN | OH | IL |
|---|---|---|---|
| Catostomidae - suckers and buffalo | | | |
| Cycleptus elongatus (Lesueur), blue sucker | I | I | O |
| Carpiodes carpio (Rafinesque), river carpsucker | O | O | O |
| C. cyprinus (Lesueur), quillback | O | O | O |
| C. velifer (Rafinesque), highfin carpsucker | O | O | O |
| Catostomus catostomus (Forster), longnose sucker | I | I | |
| C. commersoni Lacepede, white sucker | O | O | |
| Erimyzon oblongus (Mitchill), creek chubsucker | I | I | |
| E. sucetta (Lacepede), lake chubsucker | I | I | |
| Hypentelium nigricans (Lesueur), northern hogsucker | I | I | |
| Ictiobus bubalus (Rafinesque), smallmouth buffalo | I | I | |
| I. cyprinellus (Valenciennes), bigmouth buffalo | I | I | |
| I. niger (Rafinesque), black buffalo | I | I | |
| Minytrema melanops (Rafinesque), spotted sucker | I | I | |
| Moxostoma anisurum (Rafinesque), silver redhorse | I | I | |
| M. carinatum (Cope), river redhorse | I | I | |
| M. duquesnei (Lesueur), black redhorse | I | I | |
| M. erythurum (Rafinesque), golden redhorse | I | I | |
| M. macrolepidotum (Lesueur), shorthead redhorse | I | I | |
| M. valenciennesi Jordan, greater redhorse | I | I | |
| **Siluriformes - bullhead and catfish** | | | |
| Ictaluridae - bullhead and catfish | | | |
| Ameirus catus (Linnaeus), white catfish | - | I | |
| A. melas (Rafinesque), black bullhead | I | I | |
| A. natalis (Lesueur), yellow bullhead | I | I | |
| A. nebulosus (Lesueur), brown bullhead | I | I | |
| Ictalurus furcatus (Lesueur), blue catfish | C | C | |
| I. punctatus (Rafinesque), channel catfish | C | - | C |
| Noturus eleutherus Jordan, mountain madtom | I | I | |
| N. exilis Nelson, slender madtom | I | | |
| N. flavus Rafinesque, stonecat | I | I | |
| N. gyrinus (Mitchill), tadpole madtom | I | I | |
| N. miurus Jordan, brindled madtom | I | I | |
| N. nocturnus Jordan and Gilbert, freckled madtom | I | | |
| N. stigmosus Taylor, northern madtom | I | I | |
| Pylodictis olivaris (Rafinesque), flathead catfish | P | P | C |
| **Percopsiformes - cavefish, pirate perch, trout-perch** | | | |
| Amblyopsidae - cavefish | | | |
| Amblyopsis spelaea DeKay, northern cavefish | G | | |
| Typhalichthys subterraneus Girard, southern cavefish | G | | |
| Apherododeridae - pirate perch | | | |
| Aphredoderus sayanus (Gilliams), pirate perch | I | I | |
| Percopsidae - trout-perch | | | |
| Percopsis omiscomaycus (Walbaum), trout-perch | I | I | |
| **Gadiformes - cod** | | | |
| Gadidae - cod | | | |
| Lota lota (Linnaeus), burbot | - | - | |
| **Atheriniformes - topminnows, silversides** | | | |
| Fundulidae - topminnows | | | |
| Fundulus catenatus (Storer), northern studfish | I | | |
| F. diaphanus (Lesueur), banded killifish | I | I | |
| F. dispar (Agassiz), northern starhead topminnow | I | | |
| F. notatus (Rafinesque), blackstripe topminnow | I | I | |
| Poeciliidae - live-bearing fishes | | | |
| Gambusia affinis (Baird and Girard), mosquitofish | I | I | |
| Atherinidae - silversides | | | |
| Labidesthes sicculus (Cope), brook silverside | I | I | |

| | IN | OH | IL |
|---|---|---|---|
| **Gasterosteiformes - sticklebacks** | | | |
| Gasterosteidae - sticklebacks | | | |
| Culaea inconstans (Kirtland), brook stickleback | I | I | |
| Pungitius pungitius (Linnaeus), ninespine stickleback | I | | |
| **Perciformes - basses, sunfish, perch, darters** | | | |
| Moronidae - temperate basses | | | |
| Morone chrysops (Rafinesque), white bass | P | P | C |
| M. mississippiensis Jordan and Eigenmann, yellow bass | P | | C |
| M. saxatilis (Walbaum), striped bass | P | P | |
| Centrarchidae - black bass and sunfish | | | |
| Ambloplites rupestris (Rafinesque), rock bass | C | C | C |
| Centrarchus macropterus (Lacepede), flier | I | | |
| Lepomis cyanellus Rafinesque, green sunfish | I | I | |
| L. gibbosus (Linnaeus), pumpkinseed | I | I | |
| L. gulosus (Cuvier), warmouth | C | C | |
| L. humilis (Girard), orangespotted sunfish | I | I | |
| L. macrochirus Rafinesque, bluegill | I | I | |
| L. megalotis (Rafinesque), longear sunfish | I | I | |
| L. microlophus (Gunther), redear sunfish | I | I | |
| L. punctatus (Valenciennes), spotted sunfish | I | | |
| Micropterus dolomieui Lacepede, smallmouth bass | C | C | C |
| M. punctulatus Rafinesque, spotted bass | C | C | |
| M. salmoides (Lacepede), largemouth bass | C | C | C |
| Pomoxis annularis Rafinesque, white crappie | - | - | C |
| P. nigromaculatus (Lesueur), black crappie | - | - | C |
| Elassomatidae - pygmy sunfish | | | |
| Elassoma zonatum Jordan, banded pygmy sunfish | I | | |
| Percidae - perch and darters | | | |
| Ammocrypta clara Jordan and Meek, western sand darter | I | | |
| A. pellucida (Agassiz), eastern sand darter | I | I | |
| Etheostoma asprigene (Forbes), mud darter | I | | |
| E. blennioides (Rafinesque), greenside darter | I | I | |
| E. caeruleum Storer, rainbow darter | I | I | |
| E. camurum (Cope), bluebreast darter | I | I | |
| E. chlorosoma (Hay), bluntnose darter | I | | |
| E. exile (Girard), Iowa darter | I | I | |
| E. flabellare Rafinesque, fantail darter | I | I | |
| E. gracile (Girard), slough darter | I | | |
| E. histrio (Jordan and Gilbert), harlequin darter | I | | |
| E. kennicotti (Putnam), stripetail darter | I | | |
| E. maculatum Kirtland, spotted darter | I | I | |
| E. microperca Jordan and Gilbert, least darter | I | I | |
| E. nigrum Rafinesque, johnny darter | I | I | |
| E. spectabile (Agassiz), orangethroat darter | I | I | |
| E. squamiceps Jordan, spottail darter | I | | |
| E. tippecanoe Jordan and Evermann, tippecanoe darter | I | I | |
| E. variatum Kirtland, variegate darter | I | I | |
| E. zonale (Cope), banded darter | I | I | |
| Perca flavescens (Mitchill), yellow perch | - | - | C |
| Percina caprodes (Rafinesque), logperch | I | I | |
| P. copelandi (Jordan), channel darter | I | I | |
| P. evides (Jordan and Copeland), gilt darter | I | I | |
| P. maculata (Girard), blackside darter | I | I | |
| P. phoxocephala (Nelson), slenderhead darter | I | I | |
| P. sciera (Swain), dusky darter | I | I | |
| P. shumardi (Girard), river darter | I | I | |
| Stizostedion canadense (Smith), sauger | P | P | C |
| S. vitreum (Mitchill), walleye | P | P | C |
| Sciaenidae - drum | | | |
| Aplodinotus grunniens Rafinesque, freshwater drum | - | - | |
| Cottidae - sculpins | | | |
| Cottus bairdi Girard, mottled sculpin | I | I | |

| | IN | OH | IL |
|---|---|---|---|
| *C. carolinae* (Gill), banded sculpin | I | | |
| *C. cognatus* Richardson, slimy sculpin | - | - | |
| *Myoxocephalus thompsoni* (Girard), deepwater sculpin | - | - | |
| Hypothetical: | | | |
| *Fundulus olivaceus* (Storer), blackspotted topminnow | I | | |
| *Hybognathus hankinsoni* Hubbs, brassy minnow | O | | |
| *Percina vigil* Hay, yellow saddleback darter | I | | |
| *Scardinius erythropthalmus* (Linneaus), rudd | O | | |
| Extirpated: | | | |
| *Alosa alabamae* Jordan and Evermann, Alabama shad | - | | |
| *Coregonus nigripinnis* (Gill), blackfin cisco | - | | |
| *C. reighardi* (Koelz), shortnose cisco | - | | |
| *Crystallaria asprella* Jordan, crystal darter | I | S | |
| *Esox masquinongy* Mitchill, Great Lakes Muskellunge | P | P | |
| *Lagochila lacera* Jordan and Brayton, harelip sucker | - | | |
| *Lepomis symmetricus* Forbes, bantam sunfish | I | | |
| *Percina uranidea* (Jordan and Gilbert), stargazing darter | I | | |

[1]Feeding Guild Categories: (See text for explanation)

P - Piscivore
F - Filter Feeder
V - Invertivore
I - Specialist Insectivore
O - Omnivore
G - Generalist
H - Herbivore
C - Carnivore
- - Functional Feeding Guild behaviorally plastic

Appendix C. Adjacent State comparisons of reproductive guilds[1] for computing the Index of Biotic Integrity for Indiana taxa.

| | IN | OH | IL[2] |
|---|---|---|---|
| **Petromyzontiformes-lampreys** | | | |
| Petromyzontidae - lamprey | | | |
| Ichthyomyzon bdellium (Jordan), Ohio lamprey | N | N | |
| I. casteneus Girard, chestnut lamprey | N | | |
| I. fossor Reighard and Cummins, northern brook lamprey | N | N | |
| I. unicuspis Hubbs and Trautman, silver lamprey | N | N | |
| Lampetra aepyptera (Abbott), least brook lamprey | N | N | |
| L. appendix (DeKay), American brook lamprey | N | N | |
| Petromyzon marinus Linnaeus, sea lamprey | N | N | |
| **Acipenseriformes - paddlefish, sturgeons** | | | |
| Polyodontidae - paddlefish | | | |
| Polyodon spatula (Walbaum), paddlefish | S | S | |
| Acipenseridae - sturgeon | | | |
| Acipenser fulvescens Rafinesque, lake sturgeon | S | S | |
| Scaphirhynchus platorynchus (Rafinesque), shovelnose sturgeon | S | S | |
| **Lepisosteiformes - gars** | | | |
| Lepisosteidae - gars | | | |
| Atractosteus spatula (Lacepede), alligator gar | M | M | |
| Lepisosteus oculatus Winchell, spotted gar | M | M | |
| L. osseus Linnaeus, longnose gar | M | M | |
| L. platostomus Rafinesque, shortnose gar | M | M | |
| **Amiiformes - bowfin** | | | |
| Amiidae - bowfin | | | |
| Amia calva Linnaeus, bowfin | C | C | |
| **Anguilliformes - eels** | | | |
| Anguillidae - eel | | | |
| Anguilla rostrata (Lesueur), American eel | - | - | |
| **Clupeiformes - herring, shad** | | | |
| Clupeidae - herring | | | |
| Alosa chrysochloris (Rafinesque), skipjack herring | M | M | |
| A. pseudoharengus (Wilson), alewife | M | M | |
| Dorosoma cepedianum (Lesueur), gizzard shad | M | M | |
| D. petenense (Gunther), threadfin shad | M | M | |
| **Osteoglossiformes - mooneye** | | | |
| Hiodontidae - mooneye | | | |
| Hiodon alosoides (Rafinesque), goldeye | M | M | |
| H. tergisus Lesueur, mooneye | M | M | |
| **Salmoniformes - trout, salmon, whitefish** | | | |
| Salmonidae - salmon and whitefish | | | |
| Coregonus artedii Lesueur, cisco or lake herring | M | M | |
| C. clupeaformis (Mitchill), lake whitefish | M | M | |
| C. hoyi (Gill), bloater | M | | |
| C. zenithicus (Jordan and Evermann), shortjaw cisco | M | | |
| Oncorhynchus mykiss Walbaum, rainbow trout | N | N | |
| O. kisutch (Walbaum), coho salmon | N | N | |
| O. tshawytscha (Walbaum), chinook salmon | N | N | |
| Salvelinus fontinalis (Mitchell), brook trout | N | N | |
| S. namaycush (Walbaum), lake trout | N | N | |
| Salmo salar (Walbaum), Atlantic salmon | N | | |
| S. trutta Linneaus, brown trout | N | N | |
| Osmeridae - smelt | | | |
| Osmerus mordax (Mitchill), rainbow smelt | M | M | |

| | IN | OH | IL |
|---|---|---|---|
| Umbridae - mudminnows | | | |
| Umbra limi (Kirtland), central mudminnnow | C | C | |
| Esocidae - pikes | | | |
| Esox americanus Gmelin, grass pickerel | M | M | |
| E. lucius Linnaeus, northern pike | M | M | |
| E. masquinongy Mitchill, muskellunge | M | M | |
| **Cypriniformes - carps and minnows** | | | |
| Cyprinidae - carps and minnows | | | |
| Campostoma anomulum (Rafinesque), stoneroller | N | N | |
| C. oligolepis Hubbs and Greene, largescale stoneroller | N | | |
| Carassius auratus (Linneaus), goldfish | M | M | |
| Clinostomus elongatus (Kirtland), redside dace | S | S | |
| Couesius plumbeus (Agassiz), lake chub | S | | |
| Ctenopharyngodon idella Valenciennes, grass carp | M | | |
| Cyprinella lutrensis (Baird and Girard), red shiner | N | N | |
| C. spiloptera Cope, spotfin shiner | M | M | |
| C. whipplei (Girard), steelcolor shiner | M | M | |
| Cyprinus carpio Linneaus, carp | M | M | |
| Ericymba buccata Cope, silverjaw minnow | M | M | |
| Erimystax dissimilis Kirtland, streamline chub | S | S | |
| E. x-punctata Hubbs and Crowe, gravel chub | S | S | |
| Extrarius aestivalis Girard, speckled chub | M | M | |
| Hybognathus hayi Jordan, cypress minnow | M | | |
| H. nuchalis Agassiz, Mississippi silvery minnow | S | | |
| Hybopsis amblops (Rafinesque), bigeye chub | S | S | |
| H. amnis Hubbs and Greene, pallid shiner | S | | |
| Hypophthalmichthys molitrix Valenciennes, silver carp | M | | |
| Luxilus chrysocephalus (Rafinesque), striped shiner | S | S | |
| L. cornutus (Mitchell), common shiner | S | S | |
| Lythrurus ardens (Cope), rosefin shiner | S | S | |
| L. fumeus Evermann, ribbon shiner | M | | |
| L. umbratilis (Girard), redfin shiner | N | N | |
| Macrhybopsis storeriana (Kirtland), silver chub | M | M | |
| Nocomis biguttatus (Kirtland), hornyhead chub | N | N | |
| N. micropogon (Cope), river chub | N | N | |
| Notemigonus crysoleucus (Mitchell), golden shiner | M | M | |
| Notropis anogenus Forbes, pugnose shiner | M | M | |
| N. atherinoides Rafinesque, emerald shiner | M | M | |
| N. ariommus (Cope), popeye shiner | S | S | |
| N. blennius (Girard), river shiner | S | S | |
| N. boops Gilbert, bigeye shiner | S | S | |
| N. buchanani Meek, ghost shiner | M | M | |
| N. chalybaeus (Cope), ironcolor shiner | M | | |
| N. dorsalis (Agassiz), bigmouth shiner | M | M | |
| N. heterodon (Cope), blacknose shiner | M | M | |
| N. heterolepis Eigenmann and Eigenmann, blackchin shiner | M | M | |
| N. hudsonius (Clinton), spottail shiner | M | M | |
| N. ludibundus Cope, sand shiner | M | M | |
| N. photogenis (Cope), silver shiner | S | S | |
| N. rubellus (Agassiz), rosyface shiner | S | S | |
| N. shumardi (Girard), silverband shiner | S | | |
| N. texanus (Girard), weed shiner | M | | |
| N. volucellus (Cope), mimic shiner | M | M | |
| N. wickliffi, channel shiner | M | | |
| Opsopoeodus emiliae Hay, pugnose minnow | M | M | |
| Phenacobius mirabilis (Girard), suckermouth minnow | S | S | |
| Phoxinus erythrogaster (Rafinesque), southern redbelly dace | S | S | |
| Pimephales notatus (Rafinesque), bluntnose minnow | C | C | |
| P. promelas Rafinesque, fathead minnow | C | C | |
| P. vigilax (Baird and Girard), bullhead minnow | C | C | |
| Rhinichthys atratulus Agassiz, blacknose dace | S | S | |
| R. cataractae (Valenciennes), longnose dace | S | S | |

| | IN | OH | IL |
|---|---|---|---|
| Semotilus atromaculatus (Mitchill), creek chub | N | N | |
| | | | |
| Catostomidae - suckers and buffalo | | | |
| Cycleptus elongatus (Lesueur), blue sucker | S | S | |
| Carpiodes carpio (Rafinesque), river carpsucker | M | M | |
| C. cyprinus (Lesueur), quillback | M | M | |
| C. velifer (Rafinesque), highfin carpsucker | M | M | |
| Catostomus catostomus (Forster), longnose sucker | S | S | |
| C. commersoni Lacepede, white sucker | S | S | |
| Erimyzon oblongus (Mitchill), creek chubsucker | M | M | |
| E. sucetta (Lacepede), lake chubsucker | M | M | |
| Hypentelium nigricans (Lesueur), northern hogsucker | S | S | |
| Ictiobus bubalus (Rafinesque), smallmouth buffalo | M | M | |
| I. cyprinellus (Valenciennes), bigmouth buffalo | M | M | |
| I. niger (Rafinesque), black buffalo | M | M | |
| Minytrema melanops (Rafinesque), spotted sucker | S | S | |
| Moxostoma anisurum (Rafinesque), silver redhorse | S | S | |
| M. carinatum (Cope), river redhorse | S | S | |
| M. duquesnei (Lesueur), black redhorse | S | S | |
| M. erythurum (Rafinesque), golden redhorse | S | S | |
| M. macrolepidotum (Lesueur), shorthead redhorse | S | S | |
| M. valenciennesi Jordan, greater redhorse | S | S | |
| | | | |
| **Siluriformes - bullhead and catfish** | | | |
| Ictaluridae - bullhead and catfish | | | |
| Ameiurus catus (Linnaeus), white catfish | C | C | |
| A. melas (Rafinesque), black bullhead | C | C | |
| A. natalis (Lesueur), yellow bullhead | C | C | |
| A. nebulosus (Lesueur), brown bullhead | C | C | |
| Ictalurus furcatus (Lesueur), blue catfish | C | C | |
| I. punctatus (Rafinesque), channel catfish | C | C | |
| Noturus eleutherus Jordan, mountain madtom | C | C | |
| N. exilis Nelson, slender madtom | C | | |
| N. flavus Rafinesque, stonecat | C | C | |
| N. gyrinus (Mitchill), tadpole madtom | C | C | |
| N. miurus Jordan, brindled madtom | C | C | |
| N. nocturnus Jordan and Gilbert, freckled madtom | C | | |
| N. stigmosus Taylor, northern madtom | C | C | |
| Pylodictis olivaris (Rafinesque), flathead catfish | C | C | |
| | | | |
| **Percopsiformes - cavefish, pirate perch, trout-perch** | | | |
| Amblyopsidae - cavefish | | | |
| Amblyopsis spelaea DeKay, northern cavefish | C | | |
| Typhalichthys subterraneus Girard, southern cavefish | C | | |
| Aphredoderidae - pirate perch | | | |
| Aphredoderus sayanus (Gilliams), pirate perch | M | M | |
| Percopsidae - trout-perch | | | |
| Percopsis omiscomaycus (Walbaum), trout-perch | M | M | |
| | | | |
| **Gadiformes - cod** | | | |
| Gadidae - cod | | | |
| Lota lota (Linnaeus), burbot | S | S | |
| | | | |
| **Atheriniformes - topminnows, silversides** | | | |
| Fundulidae - topminnows | | | |
| Fundulus catenatus (Storer), northern studfish | M | | |
| F. diaphanus (Lesueur), banded killifish | M | M | |
| F. dispar (Agassiz), northern starhead topminnow | M | | |
| F. notatus (Rafinesque), blackstripe topminnow | M | M | |
| Poeciliidae - live-bearing fishes | | | |
| Gambusia affinis (Baird and Girard), mosquitofish | N | N | |
| Atherinidae - silversides | | | |
| Labidesthes sicculus (Cope), brook silverside | M | M | |

| | IN | OH | IL |
|---|---|---|---|
| **Gasterosteiformes - sticklebacks** | | | |
| Gasterosteidae - sticklebacks | | | |
| Culaea inconstans (Kirtland), brook stickleback | C | C | |
| Pungitius pungitius (Linnaeus), ninespine stickleback | C | | |
| **Perciformes - basses, sunfish, perch, darters** | | | |
| Moronidae - temperate basses | | | |
| Morone chrysops (Rafinesque), white bass | M | M | |
| M. mississippiensis Jordan and Eigenmann, yellow bass | M | | |
| M. saxatilis (Walbaum), striped bass | M | M | |
| Centrarchidae - black bass and sunfish | | | |
| Ambloplites rupestris (Rafinesque), rock bass | C | C | |
| Centrarchus macropterus (Lacepede), flier | C | | |
| Lepomis cyanellus Rafinesque, green sunfish | C | C | |
| L. gibbosus (Linnaeus), pumpkinseed | C | C | |
| L. gulosus (Cuvier), warmouth | C | C | |
| L. humilis (Girard), orangespotted sunfish | C | C | |
| L. macrochirus Rafinesque, bluegill | C | C | |
| L. megalotis (Rafinesque), longear sunfish | C | C | |
| L. microlophus (Gunther), redear sunfish | C | C | |
| L. punctatus (Valenciennes), spotted sunfish | C | | |
| Micropterus dolomieui Lacepede, smallmouth bass | C | C | |
| M. punctulatus Rafinesque, spotted bass | C | C | |
| M. salmoides (Lacepede), largemouth bass | C | C | |
| Pomoxis annularis Rafinesque, white crappie | C | C | |
| P. nigromaculatus (Lesueur), black crappie | C | C | |
| Elassomatidae - pygmy sunfish | | | |
| Elassoma zonatum Jordan, banded pygmy sunfish | C | | |
| Percidae - perch and darters | | | |
| Ammocrypta clara Jordan and Meek, western sand darter | S | | |
| A. pellucida (Agassiz), eastern sand darter | S | S | |
| Etheostoma asprigene (Forbes), mud darter | M | | |
| E. blennioides (Rafinesque), greenside darter | M | S | |
| E. caeruleum Storer, rainbow darter | S | S | |
| E. camurum (Cope), bluebreast darter | S | S | |
| E. chlorosoma (Hay), bluntnose darter | M | | |
| E. exile (Girard), Iowa darter | M | M | |
| E. flabellare Rafinesque, fantail darter | C | C | |
| E. gracile (Girard), slough darter | N | | |
| E. histrio (Jordan and Gilbert), harlequin darter | M | | |
| E. kennicotti (Putnam), stripetail darter | C | | |
| E. maculatum Kirtland, spotted darter | S | S | |
| E. microperca Jordan and Gilbert, least darter | N | N | |
| E. nigrum Rafinesque, johnny darter | C | C | |
| E. spectabile (Agassiz), orangethroat darter | S | S | |
| E. squamiceps Jordan, spottail darter | C | | |
| E. tippecanoe Jordan and Evermann, tippecanoe darter | S | S | |
| E. variatum Kirtland, variegate darter | S | S | |
| E. zonale (Cope), banded darter | M | S | |
| Perca flavescens (Mitchill), yellow perch | M | M | |
| Percina caprodes (Rafinesque), logperch | S | S | |
| P. copelandi (Jordan), channel darter | S | S | |
| P. evides (Jordan and Copeland), gilt darter | S | S | |
| P. maculata (Girard), blackside darter | S | S | |
| P. phoxocephala (Nelson), slenderhead darter | S | S | |
| P. sciera (Swain), dusky darter | S | S | |
| P. shumardi (Girard), river darter | S | S | |
| Stizostedion canadense (Smith), sauger | S | S | |
| S. vitreum (Mitchill), walleye | S | S | |
| Sciaenidae - drum | | | |
| Aplodinotus grunniens Rafinesque, freshwater drum | M | M | |
| Cottidae - sculpins | | | |
| Cottus bairdi Girard, mottled sculpin | C | C | |

| | IN | OH | IL |
|---|---|---|---|
| C. carolinae (Gill), banded sculpin | C | | |
| C. cognatus Richardson, slimy sculpin | C | - | |
| Myoxocephalus thompsoni (Girard), deepwater sculpin | C | - | |
| Hypothetical: | | | |
| Fundulus olivaceus (Storer), blackspotted topminnow | M | | |
| Hybognathus hankinsoni Hubbs, brassy minnow | - | | |
| Percina vigil Hay, yellow saddleback darter | S | | |
| Scardinius erythropthalmus (Linneaus), rudd | M | | |
| Extirpated: | | | |
| Alosa alabamae Jordan and Evermann, Alabama shad | N | | |
| Coregonus nigripinnis (Gill), blackfin cisco | N | | |
| C. reighardi (Koelz), shortnose cisco | N | | |
| Crystallaria asprella Jordan, crystal darter | S | S | |
| Esox masquinongy Mitchill, Great Lakes Muskellunge | M | M | |
| Lagochila lacera Jordan and Brayton, harelip sucker | - | | |
| Lepomis symmetricus Forbes, bantam sunfish | C | | |
| Percina uranidea (Jordan and Gilbert), stargazing darter | S | | |

[1] Reproductive Guild Categories: (See text for explanation)

N - Complex, no parental care
C - Complex with parental care
M - Simple, miscellaneous
S - Simple Lithophil

[2] The State of Illinois does not use a reproductive guild classification metric.

Appendix D. Site Specific Index of Biotic Integrity scores for each of the stations sampled in the White River drainage.

**WHITE RIVER BIOCRITERIA STUDY**

Station Number: 90-230 Drainage Area: 11,295 $mi^2$ Date: IX:5:90

Site: IN: Knox/Gibson Co: White River, at SR 56, Hazelton, Decker Twp. T 1N R 10W S 29.
Long: 87° 32' 45" Lat: 35° 30' 06".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 21 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 51.2% | 5 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 3 | 3 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 1 | 1 |
| 6. PERCENT TOLERANT SPECIES | 2.4% | 5 |
| 7. PERCENT OMNIVORES | 47.2% | 1 |
| 8. PERCENT INSECTIVORES | 49.2% | 3 |
| 9. PERCENT CARNIVORES | 4.2% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 740 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 2.4% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 32 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-231 Drainage Area: 11,192 $mi^2$ Date: IX:5:90

Site: IN: Knox/Pike Co: White River, at CR 1350S, 1 mi SE Iona, Johnson Twp. T 1N R 9W S 7.
Long: 87° 27'47" Lat: 38° 31'53".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 22 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 13.8% | 2 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 3 | 3 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 0 | 1 |
| 6. PERCENT TOLERANT SPECIES | 13.9% | 5 |
| 7. PERCENT OMNIVORES | 14.1% | 5 |
| 8. PERCENT INSECTIVORES | 76.8% | 5 |
| 9. PERCENT CARNIVORES | 7.4% | 2 |
| 10. CATCH PER UNIT OF EFFORT | 538 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 3.5% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 36 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-232 Drainage Area: 11,125 mi$^2$ Date: IX:5:90

Site: IN: Knox/Pike Co: White River, at SR 61 bridge, Petersburg, Harrison Twp. T 1N R 8W S 15.
Long: 87° 17' 19" Lat: 38° 30' 42".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 13 | 1 |
| 2. PERCENT LARGE RIVER TAXA | 19.7% | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 3 | 3 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 1 | 1 |
| 6. PERCENT TOLERANT SPECIES | 51.7% | 1 |
| 7. PERCENT OMNIVORES | 57.1% | 1 |
| 8. PERCENT INSECTIVORES | 33.3% | 1 |
| 9. PERCENT CARNIVORES | 29.9% | 5 |
| 10. CATCH PER UNIT OF EFFORT | 147 | 1 |
| 11. PERCENT SIMPLE LITHOPHILS | 18.4% | 5 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 28 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-233  Drainage Area: 5,243 $mi^2$  Date: IX:5:90

Site: IN: Knox/Daviess Co: West Fork White River, at SR 50/150 bridge, 3.5 mi E Wheatland, Steen Twp. T 3N R 8W S 36. Long: 87° 14' 21" Lat: 38° 38' 18".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 19 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 42.2% | 5 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | - | - |
| 3. NUMBER OF SUNFISH SPECIES | 2 | 2 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 3 | 1 |
| 6. PERCENT TOLERANT SPECIES | 41.0% | 1 |
| 7. PERCENT OMNIVORES | 31.3% | 1 |
| 8. PERCENT INSECTIVORES | 39.8% | 1 |
| 9. PERCENT CARNIVORES | 28.9% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 83 | 1 |
| 11. PERCENT SIMPLE LITHOPHILS | 0 | 1 |
| 12. PERCENT DELT | 0 | 1 |
| TOTAL IBI SCORE | | 19 |

**WHITE RIVER BIOCRITERIA STUDY**

Station Number: 90-234 Drainage Area: 5,600 $mi^2$ Date: IX:6:90

Site: IN: Daviess/Dubois Co: East Fork White River, at CR 1125E bridge, Portersville, Reeve Twp. T 1N R 5W S 21. Long: 86° 58' 34" Lat: 38° 30' 08".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 29 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 26.4% | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 5 | 5 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 2 | 2 |
| 5. NUMBER OF SENSITIVE SPECIES | 4 | 2 |
| 6. PERCENT TOLERANT SPECIES | 23.6% | 3 |
| 7. PERCENT OMNIVORES | 29.4% | 3 |
| 8. PERCENT INSECTIVORES | 63.5% | 3 |
| 9. PERCENT CARNIVORES | 7.4% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 326 | 2 |
| 11. PERCENT SIMPLE LITHOPHILS | 10.4% | 3 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 37 |

**WHITE RIVER BIOCRITERIA STUDY**

Station Number: 90-235 Drainage Area: 2,486 $mi^2$ Date: IX:13:90

Site: IN: Morgan Co: West Fork White River, at SR 39 bridge, Martinsville, Jefferson Twp. T 12N R 1E S 32. Long: 86° 27' 03" Lat: 39° 26' 02".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 21 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 2.2% | 1 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 3 | 3 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 0 | 1 |
| 6. PERCENT TOLERANT SPECIES | 62.4% | 1 |
| 7. PERCENT OMNIVORES | 53.8% | 1 |
| 8. PERCENT INSECTIVORES | 44.0% | 3 |
| 9. PERCENT CARNIVORES | 2.2% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 450 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 4.9% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 24 |

**WHITE RIVER BIOCRITERIA STUDY**

Station Number: 90-236    Drainage Area: 4,793 mi$^2$    Date: IX:6:90

Site: IN: Knox/Daviess Co: West Fork White River, at SR 58 bridge, 2 mi W Elnora, Vigo Twp. T 5N R 6W S 7/18. Long: 87° 07' 23" Lat: 38° 52' 34".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 30 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 4.3% | 1 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 3 | 3 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 1 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 5 | 3 |
| 6. PERCENT TOLERANT SPECIES | 25.9% | 3 |
| 7. PERCENT OMNIVORES | 15.2% | 4 |
| 8. PERCENT INSECTIVORES | 75.8% | 5 |
| 9. PERCENT CARNIVORES | 9.0% | 3 |
| 10. CATCH PER UNIT OF EFFORT | 467 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 2.1% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 37 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-237 Drainage Area: 3,343 $mi^2$ Date: IX:13:90

Site: IN: Owen Co: West Fork White River, at Main Street bridge, Freedom, Franklin Twp. T 9N R 3W S 21. Long: 86° 51' 58" Lat: 39° 12' 16".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 18 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 9.8% | 1 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 1 | 1 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 1 | 1 |
| 6. PERCENT TOLERANT SPECIES | 19.7% | 3 |
| 7. PERCENT OMNIVORES | 28.3% | 3 |
| 8. PERCENT INSECTIVORES | 45.1% | 3 |
| 9. PERCENT CARNIVORES | 4.0% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 173 | 1 |
| 11. PERCENT SIMPLE LITHOPHILS | 4.0% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 24 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-238 Drainage Area: 2,988 $mi^2$ Date: IX:13:90

Site: IN: Owen Co: West Fork White River, at SR 46 bridge, Spencer, Washington Twp. T 10N R 3W S 29. Long: 86° 45' 43" Lat: 39° 16' 48".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 17 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 3.6% | 1 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 0 | 1 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 1 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 1 | 1 |
| 6. PERCENT TOLERANT SPECIES | 21.4% | 3 |
| 7. PERCENT OMNIVORES | 24.6% | 3 |
| 8. PERCENT INSECTIVORES | 73.3% | 5 |
| 9. PERCENT CARNIVORES | 1.8% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 439 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 16.9% | 5 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 32 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-240 Drainage Area: 5,071 $mi^2$ Date: IX:16:90

Site: IN: Knox/Daviess Co: West Fork White River, at SR 358 bridge, 1 mi SE Edwardsport, Vigo Twp. T 4N R 7/8W S 12/7. Long: 87° 14' 29" Lat: 38° 47' 42".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 25 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 44.9% | 5 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 2 | 2 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 3 | 1 |
| 6. PERCENT TOLERANT SPECIES | 15.7% | 4 |
| 7. PERCENT OMNIVORES | 24.4% | 3 |
| 8. PERCENT INSECTIVORES | 69.0% | 5 |
| 9. PERCENT CARNIVORES | 6.6% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 287 | 1 |
| 11. PERCENT SIMPLE LITHOPHILS | 4.9% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 34 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-241 Drainage Area: 2,658 $mi^2$ Date: IX:13:90

Site: IN: Morgan Co: West Fork White River, at Border Street bridge, 2 mi S Paragon, Baker Twp. T 11N R 1W S 19. Long: 86° 33' 32" Lat: 39° 22' 23".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 21 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 2.5% | 1 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 2 | 2 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 4 | 2 |
| 6. PERCENT TOLERANT SPECIES | 33.3% | 1 |
| 7. PERCENT OMNIVORES | 31.3% | 1 |
| 8. PERCENT INSECTIVORES | 58.8% | 3 |
| 9. PERCENT CARNIVORES | 4.2% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 240 | 1 |
| 11. PERCENT SIMPLE LITHOPHILS | 21.3% | 5 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 26 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-242 Drainage Area: 2,123 $mi^2$ Date: IX:13:90

Site: IN: Morgan Co: West Fork White River, at CR 375E bridge, Henderson Ford boat launch, 2 mi SE Centerton, Green Twp. T 12N R 2E S 6/7. Long: 86° 21' 20" Lat: 39° 29' 58".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 31 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 3.7% | 1 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 5 | 5 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 5 | 5 |
| 5. NUMBER OF SENSITIVE SPECIES | 7 | 4 |
| 6. PERCENT TOLERANT SPECIES | 17.5% | 3 |
| 7. PERCENT OMNIVORES | 18.3% | 3 |
| 8. PERCENT INSECTIVORES | 53.9% | 3 |
| 9. PERCENT CARNIVORES | 8.8% | 3 |
| 10. CATCH PER UNIT OF EFFORT | 464 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 8.6% | 3 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 43 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-245 Drainage Area: 5,672 $mi^2$ Date: IX:6:90

Site: IN: Daviess/Pike Co: East Fork White River, at SR 257 bridge, 8-1/8 mi S Washington, Harrison Twp. T 1N R 6W S 8. Long: 87° 06' 34" Lat: 38° 32'17".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 14 | 1 |
| 2. PERCENT LARGE RIVER TAXA | 14.9% | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 1 | 1 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 1 | 1 |
| 6. PERCENT TOLERANT SPECIES | 21.5% | 3 |
| 7. PERCENT OMNIVORES | 28.9% | 3 |
| 8. PERCENT INSECTIVORES | 65.3% | 4 |
| 9. PERCENT CARNIVORES | 6.6% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 121 | 1 |
| 11. PERCENT SIMPLE LITHOPHILS | 2.5% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 25 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-246 Drainage Area: 4,927 $mi^2$ Date: IX:12:90

Site: IN: Martin Co: East Fork White River, at SR 50/150S, Shoals, Halbert Twp. T 3N R 3W S 19/30. Long: 86° 47' 33" Lat: 38° 40' 02".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 19 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 15.1% | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 3 | 3 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 1 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 3 | 1 |
| 6. PERCENT TOLERANT SPECIES | 15.5% | 4 |
| 7. PERCENT OMNIVORES | 11.2% | 5 |
| 8. PERCENT INSECTIVORES | 72.4% | 5 |
| 9. PERCENT CARNIVORES | 15.5% | 5 |
| 10. CATCH PER UNIT OF EFFORT | 232 | 1 |
| 11. PERCENT SIMPLE LITHOPHILS | 7.8% | 3 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 39 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-247 Drainage Area: 4,720 mi$^2$ Date: IX:18:90

Site: IN: Lawrence Co: East Fork White River, at SR 450 bridge, Spicer Launch, Williams, Spice Valley Twp. T 4N R 2W S 8/9. Long: 86° 38' 47" Lat: 38° 47' 56".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 18 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 17.9% | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 4 | 4 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 1 | 1 |
| 6. PERCENT TOLERANT SPECIES | 26.7% | 3 |
| 7. PERCENT OMNIVORES | 25.3% | 3 |
| 8. PERCENT INSECTIVORES | 73.3% | 5 |
| 9. PERCENT CARNIVORES | 1.4% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 809 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 4.2% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 35 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-248 Drainage Area: 4,004 $mi^2$ Date: IX:18:90

Site: IN: Lawrence Co: East Fork White River, at SR 37 bridge, 3 mi S Bedford, Shawswick Twp. T 5N R 1W S 34. Long: 86° 30' 48" Lat: 38° 49' 33".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 24 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 23.4% | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 2 | 2 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 2 | 2 |
| 5. NUMBER OF SENSITIVE SPECIES | 4 | 2 |
| 6. PERCENT TOLERANT SPECIES | 6.9% | 5 |
| 7. PERCENT OMNIVORES | 26.2% | 3 |
| 8. PERCENT INSECTIVORES | 61.3% | 3 |
| 9. PERCENT CARNIVORES | 4.1% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 764 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 6.9% | 3 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 39 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-249 Drainage Area: 3,988 $mi^2$ Date: IX:20:90

Site: IN: Lawrence Co: East Fork White River, at Palestine Road, at B.R.Edwards Property, 1-1/4 mi SE Bedford, T 4N R 1E S 6. Long: 86° 27' 33" Lat: 38° 48' 26".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 28 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 19.2% | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 2 | 2 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 1 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 6 | 3 |
| 6. PERCENT TOLERANT SPECIES | 7.8% | 5 |
| 7. PERCENT OMNIVORES | 14.7% | 5 |
| 8. PERCENT INSECTIVORES | 75.4% | 5 |
| 9. PERCENT CARNIVORES | 9.4% | 3 |
| 10. CATCH PER UNIT OF EFFORT | 798 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 1.1% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 43 |

## WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-250 Drainage Area: 3,848 $mi^2$ Date: IX:18:90

Site: IN: Lawrence Co: East Fork White River, at Lawrenceport boat launch, Lawrenceport, Bono Twp. T 4N R 1E S 26/23. Long: 86° 22' 50" Lat: 38° 45' 16".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 28 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 6.0% | 1 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 3 | 3 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 1 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 5 | 3 |
| 6. PERCENT TOLERANT SPECIES | 7.2% | 5 |
| 7. PERCENT OMNIVORES | 14.0% | 5 |
| 8. PERCENT INSECTIVORES | 8.4% | 1 |
| 9. PERCENT CARNIVORES | 8.9% | 3 |
| 10. CATCH PER UNIT OF EFFORT | 850 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 5.1% | 2 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 39 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-251 Drainage Area: 3,829 $mi^2$ Date: IX:18:90

Site: IN: Lawrence Co: East Fork White River, at Tunnelton Road bridge, Tunnelton, Guthrie Twp. T 4N R 2E S 19. Long: 86° 20' 10" Lat: 38° 45' 48".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 21 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 30.5% | 5 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 5 | 5 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 1 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 3 | 1 |
| 6. PERCENT TOLERANT SPECIES | 0.5% | 5 |
| 7. PERCENT OMNIVORES | 29.1% | 3 |
| 8. PERCENT INSECTIVORES | 65.4% | 4 |
| 9. PERCENT CARNIVORES | 3.4% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 817 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 0.6% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 39 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-252 Drainage Area: 2,564 $mi^2$ Date: IX:19:90

Site: IN: Jackson Co: East Fork White River, at SR 235 bridge, 1 mi E Medora, Carr Twp. T 5N R 3E S 36/35. Long: 86° 08' 51" Lat: 38° 49' 13".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 22 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 13.8% | 2 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 3 | 3 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 0 | 1 |
| 6. PERCENT TOLERANT SPECIES | 13.9% | 5 |
| 7. PERCENT OMNIVORES | 14.1% | 5 |
| 8. PERCENT INSECTIVORES | 76.8% | 5 |
| 9. PERCENT CARNIVORES | 7.4% | 2 |
| 10. CATCH PER UNIT OF EFFORT | 538 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 3.5% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 36 |

**WHITE RIVER BIOCRITERIA STUDY**

Station Number: 90-253 Drainage Area: 2,516 $mi^2$ Date: IX:19:90

Site: IN: Jackson Co: East Fork White River, at SR 50 bridge, 2 mi NW Brownstown, Brownstown Twp. T 5N R 4E S 9/10. Long: 86° 04' 51" Lat: 38° 52' 46".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 27 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 1.3% | 1 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 5 | 5 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 1 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 7 | 4 |
| 6. PERCENT TOLERANT SPECIES | 20.5% | 3 |
| 7. PERCENT OMNIVORES | 18.7% | 3 |
| 8. PERCENT INSECTIVORES | 72.6% | 5 |
| 9. PERCENT CARNIVORES | 6.0% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 635 | 4 |
| 11. PERCENT SIMPLE LITHOPHILS | 2.7% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 38 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-254 Drainage Area: 3,731 $mi^2$ Date: IX:19:90

Site: IN: Jackson Co: East Fork White River, at CR 360S bridge, 3/4 mi E Sparksville, Carr Twp. T 4N R 3E S 18/17. Long: 86° 13' 38" Lat: 38° 46' 39".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 19 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 15.0% | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 2 | 2 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 3 | 1 |
| 6. PERCENT TOLERANT SPECIES | 26.2% | 3 |
| 7. PERCENT OMNIVORES | 23.1% | 3 |
| 8. PERCENT INSECTIVORES | 54.0% | 3 |
| 9. PERCENT CARNIVORES | 5.6% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 359 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 1.4% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 29 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-255 Drainage Area: 2,342 mi$^2$ Date: IX:20:90

Site: IN: Jackson Co: East Fork White River, at SR 258 bridge, 2 mi W Seymour, Jackson Twp. T 6N R 5E S 11/12. Long: 85° 55' 46" Lat: 38° 58' 25".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 17 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 2.7% | 1 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 2 | 2 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 3 | 3 |
| 5. NUMBER OF SENSITIVE SPECIES | 6 | 3 |
| 6. PERCENT TOLERANT SPECIES | 27.0% | 1 |
| 7. PERCENT OMNIVORES | 35.1% | 1 |
| 8. PERCENT INSECTIVORES | 29.7% | 1 |
| 9. PERCENT CARNIVORES | 27.0% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 37 | 1 |
| 11. PERCENT SIMPLE LITHOPHILS | 10.8% | 1 |
| 12. PERCENT DELT | 0 | 1 |
| TOTAL IBI SCORE | | 19 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-257 Drainage Area: 2,053 mi$^2$ Date: IX:17:90

Site: IN: Bartholomew Co: East Fork White River, at CR 800S bridge, Azalia, Sand Creek Twp. T 8N R 6E S 33. Long: 85° 51' 37" Lat: 39° 05' 06".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 36 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 2.0% | 1 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 4 | 4 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 6 | 5 |
| 5. NUMBER OF SENSITIVE SPECIES | 13 | 5 |
| 6. PERCENT TOLERANT SPECIES | 10.0% | 5 |
| 7. PERCENT OMNIVORES | 8.4% | 5 |
| 8. PERCENT INSECTIVORES | 52.9% | 3 |
| 9. PERCENT CARNIVORES | 5.9% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 558 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 16.3% | 5 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 51 |

**WHITE RIVER BIOCRITERIA STUDY**

**Station Number: 90-258 Drainage Area: 1,707 mi²** **Date: IX:17:90**

**Site: IN: Bartholomew Co: East Fork White River, at SR 46/11 bridge, Columbus, Columbus Twp. T 9N R 5E S 23. Lat: unknown Long: unknown.**

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 19 | 3 |
| 2. PERCENT LARGE RIVER TAXA | -- | - |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | 1 | 1 |
| 3. NUMBER OF SUNFISH SPECIES | 4 | 4 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 3 | 3 |
| 5. NUMBER OF SENSITIVE SPECIES | 7 | 4 |
| 6. PERCENT TOLERANT SPECIES | 41.5% | 1 |
| 7. PERCENT OMNIVORES | 3.4% | 5 |
| 8. PERCENT INSECTIVORES | 49.0% | 3 |
| 9. PERCENT CARNIVORES | 13.6% | 3 |
| 10. CATCH PER UNIT OF EFFORT | 147 | 1 |
| 11. PERCENT SIMPLE LITHOPHILS | 8.2% | 3 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 36 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-259 Drainage Area: 1,126 $mi^2$ Date: IX:17:90

Site: IN: Bartholomew Co: Driftwood River, at CR 650N bridge, 6-1/2 mi NW Columbus, Nineveh Twp. T 10N R 5E S 21. Long: 86° 58' 22" Lat: 39° 17' 24".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 32 | 5 |
| 2. PERCENT LARGE RIVER TAXA | -- | -- |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | 6 | 5 |
| 3. NUMBER OF SUNFISH SPECIES | 6 | 5 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 4 | 4 |
| 5. NUMBER OF SENSITIVE SPECIES | 13 | 5 |
| 6. PERCENT TOLERANT SPECIES | 22.2% | 3 |
| 7. PERCENT OMNIVORES | 19.3% | 3 |
| 8. PERCENT INSECTIVORES | 66.3% | 5 |
| 9. PERCENT CARNIVORES | 13.6% | 3 |
| 10. CATCH PER UNIT OF EFFORT | 243 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 14.4% | 5 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 51 |

**WHITE RIVER BIOCRITERIA STUDY**

Station Number: 90-260 Drainage Area: 5,104 mi$^2$ Date: IX:12:90

Site: IN: Martin Co: East Fork White River, at SR 550 bridge, 2 mi SE Loogootee, Center Twp. T 3N R 4W S 32. Long: 86° 53' 11" Lat: 38° 38' 50".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 26 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 22.5% | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 2 | 2 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 3 | 3 |
| 5. NUMBER OF SENSITIVE SPECIES | 6 | 3 |
| 6. PERCENT TOLERANT SPECIES | 40.8% | 1 |
| 7. PERCENT OMNIVORES | 13.3% | 5 |
| 8. PERCENT INSECTIVORES | 35.8% | 1 |
| 9. PERCENT CARNIVORES | 30.8% | 5 |
| 10. CATCH PER UNIT OF EFFORT | 120 | 1 |
| 11. PERCENT SIMPLE LITHOPHILS | 11.7% | 3 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 37 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-265 Drainage Area: 1,294 $mi^2$ Date: IX:24:90

Site: IN: Marion Co: West Fork White River, at Martin Luther King Drive bridge, Indianapolis, Center Twp. T 16N R 3E S 28/33/27/34. Long: 86° 11' 54" Lat: 39° 47' 18".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 16 | 2 |
| 2. PERCENT LARGE RIVER TAXA | -- | -- |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | 0 | 1 |
| 3. NUMBER OF SUNFISH SPECIES | 5 | 5 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 1 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 2 | 1 |
| 6. PERCENT TOLERANT SPECIES | 70.3% | 1 |
| 7. PERCENT OMNIVORES | 12.4% | 5 |
| 8. PERCENT INSECTIVORES | 49.8% | 3 |
| 9. PERCENT CARNIVORES | 4.9% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 283 | 1 |
| 11. PERCENT SIMPLE LITHOPHILS | 0.7% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 27 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-266 Drainage Area: 1,925 $mi^2$ Date: IX:24:90

Site: IN: Marion Co: West Fork White River, at Southport Road bridge, 7 mi S Indianapolis, Decatur Twp. T 14N R 3E S 7/8. Long: 86° 14' 11" Lat: 39° 39' 47".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 34 | 5 |
| 2. PERCENT LARGE RIVER TAXA | – | – |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | 2 | 2 |
| 3. NUMBER OF SUNFISH SPECIES | 4 | 4 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 2 | 2 |
| 5. NUMBER OF SENSITIVE SPECIES | 8 | 5 |
| 6. PERCENT TOLERANT SPECIES | 33.2% | 1 |
| 7. PERCENT OMNIVORES | 25.1% | 3 |
| 8. PERCENT INSECTIVORES | 67.7% | 5 |
| 9. PERCENT CARNIVORES | 1.5% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 1125 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 1.4% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 39 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-267 Drainage Area: 1,147 mi$^2$ Date: IX:25:90

Site: IN: Hamilton Co: West Fork White River, at SR 234 bridge, 3 mi N Fishers, Noblesville Twp. T 18N R 4E S 13. Long: 86° 01' 22" Lat: 40° 00' 01".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 21 | 3 |
| 2. PERCENT LARGE RIVER TAXA | -- | -- |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | 2 | 2 |
| 3. NUMBER OF SUNFISH SPECIES | 6 | 5 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 2 | 2 |
| 5. NUMBER OF SENSITIVE SPECIES | 5 | 3 |
| 6. PERCENT TOLERANT SPECIES | 30.7% | 1 |
| 7. PERCENT OMNIVORES | 28.8% | 3 |
| 8. PERCENT INSECTIVORES | 63.8% | 3 |
| 9. PERCENT CARNIVORES | 6.7% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 163 | 1 |
| 11. PERCENT SIMPLE LITHOPHILS | 0.6% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 30 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-268 Drainage Area: 858 mi$^2$ Date: IX:26:90

Site: IN: Hamilton Co: West Fork White River, at SR 19/32 bridge, Noblesville, at Schmidt's Bait and Tackle, Noblesville Twp. T 19N R 4/5E S 36/31. Long: 86° 00' 55" Lat: 40° 02' 53".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 18 | 3 |
| 2. PERCENT LARGE RIVER TAXA | -- | -- |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | 3 | 3 |
| 3. NUMBER OF SUNFISH SPECIES | 4 | 4 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 2 | 2 |
| 5. NUMBER OF SENSITIVE SPECIES | 4 | 2 |
| 6. PERCENT TOLERANT SPECIES | 57.2% | 1 |
| 7. PERCENT OMNIVORES | 56.4% | 1 |
| 8. PERCENT INSECTIVORES | 38.7% | 1 |
| 9. PERCENT CARNIVORES | 5.8% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 243 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 4.9% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 27 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-269 Drainage Area: 828 $mi^2$ Date: IX:26:90

Site: IN: Hamilton Co: West Fork White River, at Strawtown bridge or 234th Street, 1 mi W Strawtown, White River Twp. T 20/19N R 5E S 4/33/34. Long: 86° 57' 51" Lat: 40° 07' 42".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 19 | 3 |
| 2. PERCENT LARGE RIVER TAXA | -- | -- |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | 5 | 5 |
| 3. NUMBER OF SUNFISH SPECIES | 4 | 4 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 4 | 2 |
| 6. PERCENT TOLERANT SPECIES | 19.9% | 3 |
| 7. PERCENT OMNIVORES | 16.0% | 4 |
| 8. PERCENT INSECTIVORES | 72.3% | 5 |
| 9. PERCENT CARNIVORES | 10.6% | 3 |
| 10. CATCH PER UNIT OF EFFORT | 282 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 1.1% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 39 |

**WHITE RIVER BIOCRITERIA STUDY**

Station Number: 90-271 Drainage Area: 85.5 $mi^2$ Date: IX:27:90

Site: IN: Randolph Co: West Fork White River, at SR 1/32 bridge, 1-1/4 mi S Farmland, Stony Creek Twp. T 20N R 12E S 19. Long: 85° 07' 27" Lat: 40° 10' 19".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 27 | 5 |
| 2. PERCENT LARGE RIVER TAXA | -- | -- |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | 5 | 5 |
| 3. NUMBER OF SUNFISH SPECIES | 3 | 3 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 4 | 4 |
| 5. NUMBER OF SENSITIVE SPECIES | 11 | 5 |
| 6. PERCENT TOLERANT SPECIES | 37.6% | 1 |
| 7. PERCENT OMNIVORES | 37.3% | 1 |
| 8. PERCENT INSECTIVORES | 63.7% | 3 |
| 9. PERCENT CARNIVORES | 4.2% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 311 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 32.2% | 5 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 43 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-272 Drainage Area: 25.6 $mi^2$ Date: IX:27:90

Site: IN: Randolph Co: West Fork White River, at CR 300E bridge, 3 mi E Winchester, White River Twp. T 17N R 14E S 13. Long: 84° 55' 06" Lat: 40° 11' 19".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 16 | 2 |
| 2. PERCENT LARGE RIVER TAXA | -- | -- |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | 6 | 5 |
| 3. NUMBER OF SUNFISH SPECIES | 2 | 2 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 3 | 1 |
| 6. PERCENT TOLERANT SPECIES | 76.9% | 1 |
| 7. PERCENT OMNIVORES | 60.1% | 1 |
| 8. PERCENT INSECTIVORES | 33.6% | 1 |
| 9. PERCENT CARNIVORES | 0.7% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 143 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 3.5% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 26 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-274 Drainage Area: 555 $mi^2$ Date: IX:27:90

Site: IN: Madison Co: West Fork White River, at SR 13 bridge, Perkinsville, Jackson Twp.
T 20N R 6E S 33. Long: 85° 51' 47" Lat: 40° 08' 31".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 21 | 3 |
| 2. PERCENT LARGE RIVER TAXA | – | – |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | 2 | 2 |
| 3. NUMBER OF SUNFISH SPECIES | 4 | 4 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 1 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 6 | 3 |
| 6. PERCENT TOLERANT SPECIES | 36.5% | 1 |
| 7. PERCENT OMNIVORES | 33.5% | 1 |
| 8. PERCENT INSECTIVORES | 60.4% | 3 |
| 9. PERCENT CARNIVORES | 5.6% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 197 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 1.5% | 1 |
| 12. PERCENT DELT | 0.5 | 5 |
| TOTAL IBI SCORE | | 28 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-276 Drainage Area: 1174 mi$^2$ Date: IX:25:90

Site: IN: Hamilton Co: West Fork White River, at River Road bridge, Carmel/Fisher, Delaware Twp. T 18N R 4E S 34. Long: 86° 03' 48" Lat: 39° 57' 28".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 16 | 2 |
| 2. PERCENT LARGE RIVER TAXA | -- | -- |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | 1 | 1 |
| 3. NUMBER OF SUNFISH SPECIES | 6 | 5 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 1 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 3 | 1 |
| 6. PERCENT TOLERANT SPECIES | 23.3% | 3 |
| 7. PERCENT OMNIVORES | 15.3% | 4 |
| 8. PERCENT INSECTIVORES | 79.0% | 5 |
| 9. PERCENT CARNIVORES | 6.3% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 176 | 1 |
| 11. PERCENT SIMPLE LITHOPHILS | 1.7% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 30 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-277 Drainage Area: 5532 $mi^2$ Date: IX:12:90

Site: IN: Martin Co: East Fork White River, at SR 231 bridge, 11-3/4 mi S Loogootee, Rutherford Twp. T 1N R 4/5W S 24/19. Long: 86° 54' 48" Lat: 38° 29' 46".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 25 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 19.7 | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 3 | 3 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 4 | 2 |
| 6. PERCENT TOLERANT SPECIES | 37.4% | 1 |
| 7. PERCENT OMNIVORES | 49.9% | 1 |
| 8. PERCENT INSECTIVORES | 40.9% | 3 |
| 9. PERCENT CARNIVORES | 9.7% | 3 |
| 10. CATCH PER UNIT OF EFFORT | 401 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 3.5% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 33 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-279 Drainage Area: 1136 $mi^2$ Date: IX:17:90

Site: IN: Bartholomew Co: Driftwood River, at CR 350N bridge, 3 mi NW Columbus, Columbus Twp. T 9N R 5E S 10. Lat: unavailable Long: unavailable.

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 30 | 5 |
| 2. PERCENT LARGE RIVER TAXA | -- | -- |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | 6 | 5 |
| 3. NUMBER OF SUNFISH SPECIES | 4 | 4 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 4 | 4 |
| 5. NUMBER OF SENSITIVE SPECIES | 14 | 5 |
| 6. PERCENT TOLERANT SPECIES | 15.9% | 4 |
| 7. PERCENT OMNIVORES | 22.1% | 3 |
| 8. PERCENT INSECTIVORES | 59.7% | 3 |
| 9. PERCENT CARNIVORES | 17.1% | 5 |
| 10. CATCH PER UNIT OF EFFORT | 258 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 27.9% | 5 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 51 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 90-280 Drainage Area: 1261 $mi^2$ Date: IX:25:90

Site: IN: Marion Co: West Fork White River, between Westfield Blvd. and College Ave. bridges, Broad Ripple, Washington Twp. T 16N R 3E S 1/2. Long: 86° 09' 42" Lat: 39° 51' 44".

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 28 | 5 |
| 2. PERCENT LARGE RIVER TAXA | -- | -- |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | 3 | 3 |
| 3. NUMBER OF SUNFISH SPECIES | 6 | 5 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 4 | 4 |
| 5. NUMBER OF SENSITIVE SPECIES | 9 | 5 |
| 6. PERCENT TOLERANT SPECIES | 19.5% | 3 |
| 7. PERCENT OMNIVORES | 15.1% | 4 |
| 8. PERCENT INSECTIVORES | 75.3% | 5 |
| 9. PERCENT CARNIVORES | 9.6% | 3 |
| 10. CATCH PER UNIT OF EFFORT | 405 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 4.4% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 46 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 91-210 Drainage Area: 11,118 mi$^2$ Date: VIII:27:91

Site: IN: Knox Co: Lower White River, 0.5 mi d/s junction of East and West Forks at Power lines, 3.5 mi N of SR 61 bridge, Harrison Twp. T 1N R 8W S 1/12.

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 26 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 18.7% | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 5 | 5 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 3 | 1 |
| 6. PERCENT TOLERANT SPECIES | 38.8% | 1 |
| 7. PERCENT OMNIVORES | 50.3% | 1 |
| 8. PERCENT INSECTIVORES | 44.9% | 3 |
| 9. PERCENT CARNIVORES | 4.8% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 1682 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 1.8% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 32 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 91-211  Drainage Area: 11125 $mi^2$  Date: VIII:27:91

Site: IN: Knox Co: Lower White River, at SR 61 bridge, 1-1/4 mi N Petersburg, Harrison Twp.
T 1N R 8W S 15.

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 17 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 7.1% | 1 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 2 | 2 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 2 | 1 |
| 6. PERCENT TOLERANT SPECIES | 2.9% | 5 |
| 7. PERCENT OMNIVORES | 8.7% | 5 |
| 8. PERCENT INSECTIVORES | 89.7% | 5 |
| 9. PERCENT CARNIVORES | 1.7% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 1501 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 0.3% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 35 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 91-212 Drainage Area: 11,126.5 $mi^2$ Date: VIII:27:91

Site: IN: Knox Co: Lower White River, 1.5 mi d/s SR 61 bridge, 2-1/4 mi NW Petersburg, Harrison Twp. T 1N R 8W S 16/17.

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 24 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 20.0% | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 4 | 4 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 2 | 1 |
| 6. PERCENT TOLERANT SPECIES | 7.7% | 5 |
| 7. PERCENT OMNIVORES | 21.8% | 3 |
| 8. PERCENT INSECTIVORES | 73.5% | 5 |
| 9. PERCENT CARNIVORES | 5.2% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 878 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 1.6% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 37 |

**WHITE RIVER BIOCRITERIA STUDY**

Station Number: 91-213 Drainage Area: 11,129 mi$^2$ Date: VIII:28:91

Site: IN: Knox Co: Lower White River, 1-1/4 mi S Willis, Harrison Twp.
T 1N R 8/9W S 1/6.

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 19 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 8.9% | 1 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 1 | 1 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 2 | 1 |
| 6. PERCENT TOLERANT SPECIES | 6.1% | 5 |
| 7. PERCENT OMNIVORES | 12.0% | 5 |
| 8. PERCENT INSECTIVORES | 85.9% | 5 |
| 9. PERCENT CARNIVORES | 2.1% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 1647 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 0.1% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 34 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 91-214 Drainage Area: 11,134 $mi^2$ Date: VIII:28:91

Site: IN: Knox Co: Lower White River, 4-1/2 mi u/s Iona, Harrison Twp.
T 1N R 9W S 11.

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 25 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 12.8% | 1 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 4 | 4 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 2 | 1 |
| 6. PERCENT TOLERANT SPECIES | 7.3% | 5 |
| 7. PERCENT OMNIVORES | 6.3% | 5 |
| 8. PERCENT INSECTIVORES | 81.5% | 5 |
| 9. PERCENT CARNIVORES | 3.4% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 1160 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 6.9% | 3 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 41 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 91-215 Drainage Area: 11,193 $mi^2$ Date: VIII:29:91

Site: IN: Knox Co: Lower White River, at CR 1300S bridge, 1-1/4 mi SE Iona, Johnson Twp. T 1N R 9W S 7.

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 28 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 12.8% | 1 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 4 | 4 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 4 | 2 |
| 6. PERCENT TOLERANT SPECIES | 7.3% | 5 |
| 7. PERCENT OMNIVORES | 14.9% | 5 |
| 8. PERCENT INSECTIVORES | 92.0% | 5 |
| 9. PERCENT CARNIVORES | 3.3% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 1157 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 0.3% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 40 |

**WHITE RIVER BIOCRITERIA STUDY**

Station Number: 91-216 Drainage Area: 11,195 $mi^2$ Date: VIII:29:91

Site: IN: Knox Co: Lower White River, 0.5 mi d/s Giro, Johnson Twp.
T 1N R 10W S 23.

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 31 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 16.7% | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 4 | 4 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 7 | 4 |
| 6. PERCENT TOLERANT SPECIES | 6.4% | 5 |
| 7. PERCENT OMNIVORES | 14.0% | 5 |
| 8. PERCENT INSECTIVORES | 80.8% | 5 |
| 9. PERCENT CARNIVORES | 5.1% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 1638 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 0.7% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 44 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 91-217  Drainage Area: 11,295 $mi^2$  Date: IX:4:91

Site: IN: Knox Co: Lower White River, at old 41 bridge, Hazelton, Johnson Twp.
T 1N R 10W S 27.

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 29 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 47.8% | 5 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 3 | 3 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 3 | 1 |
| 6. PERCENT TOLERANT SPECIES | 13.5% | 5 |
| 7. PERCENT OMNIVORES | 38.2% | 1 |
| 8. PERCENT INSECTIVORES | 51.3% | 3 |
| 9. PERCENT CARNIVORES | 10.5% | 3 |
| 10. CATCH PER UNIT OF EFFORT | 1051 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 0.6% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 38 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 91-218 Drainage Area: 11,309 $mi^2$ Date: IX:4:91

Site: IN: Knox Co: Lower White River, 1-1/2 mi W SR 41 bridge, 2 mi SW Hazelton, Decker Twp. T 1N R 11W S 36.

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 27 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 20.6% | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 5 | 5 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 2 | 1 |
| 6. PERCENT TOLERANT SPECIES | 8.3% | 5 |
| 7. PERCENT OMNIVORES | 19.6% | 3 |
| 8. PERCENT INSECTIVORES | 73.9% | 5 |
| 9. PERCENT CARNIVORES | 6.2% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 1044 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 0.5% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 40 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 91-219 Drainage Area: 11,312 $mi^2$ Date: IX:4:91

Site: IN: Knox Co: Lower White River, 2 mi S Decker Chapel, Decker Twp.
T 1S R 11W S 2.

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 18 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 20.5% | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 4 | 4 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 1 | 1 |
| 6. PERCENT TOLERANT SPECIES | 3.2% | 5 |
| 7. PERCENT OMNIVORES | 18.3% | 3 |
| 8. PERCENT INSECTIVORES | 78.1% | 5 |
| 9. PERCENT CARNIVORES | 3.5% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 2407 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 0.1% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 37 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 91-220 Drainage Area: 11,340 $mi^2$ Date: IX:5:91

Site: IN: Knox Co: Lower White River, 6 mi SW Hazelton, Dick Ryder's Camp, Decker Twp.
T 1S R 11W S 3/4.

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 22 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 12.5% | 1 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 4 | 4 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 2 | 1 |
| 6. PERCENT TOLERANT SPECIES | 7.7% | 5 |
| 7. PERCENT OMNIVORES | 15.3% | 4 |
| 8. PERCENT INSECTIVORES | 82.0% | 5 |
| 9. PERCENT CARNIVORES | 2.6% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 1454 | 5 |
| 11. PERCENT SIMPLE LITHOPHILS | 0.6% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| | TOTAL IBI SCORE | 36 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 91-221 Drainage Area: 11,345 $mi^2$ Date: IX:5:91

Site: IN: Knox Co: Lower White River, 6-1/2 mi SW Hazelton, Decker Twp.
T 1N R 11W S 16/17.

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 27 | 5 |
| 2. PERCENT LARGE RIVER TAXA | 17.3% | 3 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 6 | 5 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 0 | 1 |
| 5. NUMBER OF SENSITIVE SPECIES | 2 | 1 |
| 6. PERCENT TOLERANT SPECIES | 14.6% | 5 |
| 7. PERCENT OMNIVORES | 21.0% | 3 |
| 8. PERCENT INSECTIVORES | 74.1% | 5 |
| 9. PERCENT CARNIVORES | 4.7% | 1 |
| 10. CATCH PER UNIT OF EFFORT | 804 | 4 |
| 11. PERCENT SIMPLE LITHOPHILS | 1.1% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 43 |

WHITE RIVER BIOCRITERIA STUDY

Station Number: 91-222 Drainage Area: 11,348 $mi^2$ Date: IX:5:91

Site: IN: Knox Co: Lower White River, 1-1/2 mi u/s Wabash River, 2 mi NE Mt. Carmel, Illinois.
T 1S R 12W S 24.

| METRIC | ACTUAL OBSERVATION | IBI SCORE |
|---|---|---|
| 1. TOTAL NUMBER OF SPECIES | 20 | 3 |
| 2. PERCENT LARGE RIVER TAXA | 52.1% | 5 |
| NUMBER OF DARTER/MADTOM/SCULPIN SPECIES | -- | -- |
| 3. NUMBER OF SUNFISH SPECIES | 1 | 1 |
| 4. NUMBER OF ROUND-BODIED SUCKER SPECIES | 2 | 2 |
| 5. NUMBER OF SENSITIVE SPECIES | 2 | 1 |
| 6. PERCENT TOLERANT SPECIES | 39.4% | 1 |
| 7. PERCENT OMNIVORES | 24.7% | 3 |
| 8. PERCENT INSECTIVORES | 42.5% | 1 |
| 9. PERCENT CARNIVORES | 34.4% | 5 |
| 10. CATCH PER UNIT OF EFFORT | 518 | 3 |
| 11. PERCENT SIMPLE LITHOPHILS | 1.5% | 1 |
| 12. PERCENT DELT | 0 | 5 |
| TOTAL IBI SCORE | | 31 |

Appendix E. Fish nomenclature changes for the species of fish occurring within the political boundaries of Indiana.

| | Previous Nomenclature |
|---|---|
| **Petromyzontiformes-lampreys** | |
| **Petromyzontidae** - lamprey | |
| *Lampetra appendix* (DeKay), American brook lamprey | *Lampetra lamottei* |
| **Lepisteiformes - gars** | |
| **Lepisosteidae** - gars | |
| *Atractosteus spatula* (Lacepede), alligator gar | *Lepisosteus spatula* |
| **Salmoniformes - trout, salmon, whitefish** | |
| **Salmonidae** - salmon and whitefish | |
| *Oncorhynchus mykiss* Walbaum, rainbow trout | *Salmo gairdneri* |
| **Cypriniformes - carps and minnows** | |
| **Cyprinidae** - carps and minnows | |
| *Campostoma oligolepis* Hubbs and Greene, largescale stoneroller | previously considered *Campostoma anomalum pullum* |
| *Cyprinella lutrensis* (Baird and Girard), red shiner | *Notropis lutrensis* |
| *C. spiloptera* Cope, spotfin shiner | *Notropis spilopterus* |
| *C. whipplei* (Girard), steelcolor shiner | *Notropis whipplei* |
| *Erimystax dissimilis* Kirtland, streamline chub | *Hybopsis dissimilis* |
| *E. x-punctata* Hubbs and Crowe, gravel chub | *Hybopsis x-punctata* |
| *Extrarius aestavalis* Girard, speckled chub | *Hybopsis aestavalis* |
| *Hybopsis amnis* Hubbs and Greene, pallid shiner | *Notropis amnis* |
| *Luxilus chrysocephalus* (Rafinesque), striped shiner | *Notropis chrysocephalus* |
| *L. cornutus* (Mitchell), common shiner | *Notropis cornutus* |
| *Lythrurus ardens* (Cope), rosefin shiner | *Notropis ardens* |
| *L. fumeus* Evermann, ribbon shiner | *Notropis fumeus* |
| *L. umbratilis* (Girard), redfin shiner | *Notropis umbratilis* |
| *Macrhybopsis storeriana* (Kirtland), silver chub | *Hybopsis storeriana* |
| *Notropis ludibundus* Cope, sand shiner | *Notropis stramineus* |
| *Opsopoeodus emiliae* Hay, pugnose minnow | *Notropis emiliae* |
| **Siluriformes - bullhead and catfish** | |
| **Ictaluridae** - bullhead and catfish | |
| *Ameiurus catus* (Linnaeus), white catfish | *Ictalurus catus* |
| *A. melas* (Rafinesque), black bullhead | *Ictalurus melas* |
| *A. natalis* (Lesueur), yellow bullhead | *Ictalurus natalis* |
| *A. nebulosus* (Lesueur), brown bullhead | *Ictalurus nebulosus* |
| **Atheriniformes - topminnows, silversides** | |
| **Fundulidae** - topminnows | previously Cyprinodontidae |
| **Perciformes - basses, sunfish, perch, darters** | |
| **Moronidae** - temperate basses | previously Percichthyidae |
| *Morone chrysops* (Rafinesque), white bass | |
| *M. mississippiensis* Jordan and Eigenmann, yellow bass | |
| *M. saxatilis* (Walbaum), striped bass | |
| **Elassomatidae** - pygmy sunfish | previously Centrarchidae |
| *Elassoma zonatum* Jordan, banded pygmy sunfish | |
| **Percidae** - perches and darters | |
| *Crystallaria asprella* Jordan, crystal darter | *Ammocrypta asprella* |

# REPORT DOCUMENTATION PAGE

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**13. ABSTRACT** *(Maximum 200 words)*

The White River drainage was investigated during 1990-1991 to determine water resource expectations for large rivers. A total of 49 sites were sampled within three watersheds to develop and calibrate an Index of Biotic Integrity for use in Indiana large rivers. Maximum species richness lines were developed for large rivers (less than 2000 $mi^2$) and great rivers (greater than 2000 $mi^2$ drainage areas). A few metrics are original to this study including the number of centrarchid species, an all benthic insectivore metric incorporating darters, madtoms, and sculpins in large rivers, and the proportion of large river species. The proportion of large river species is based on the typical expectations of large river faunal composition based on Pflieger (1975). The lower White River showed a highly skewed IBI indicating lower extremes in water resource integrity. The trend in the East and West Forks was toward declining biological integrity with increasing drainage area. Site specific data including an evaluation of fishery community trends, tolerance classifications, trophic and reproductive guilds are included.

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