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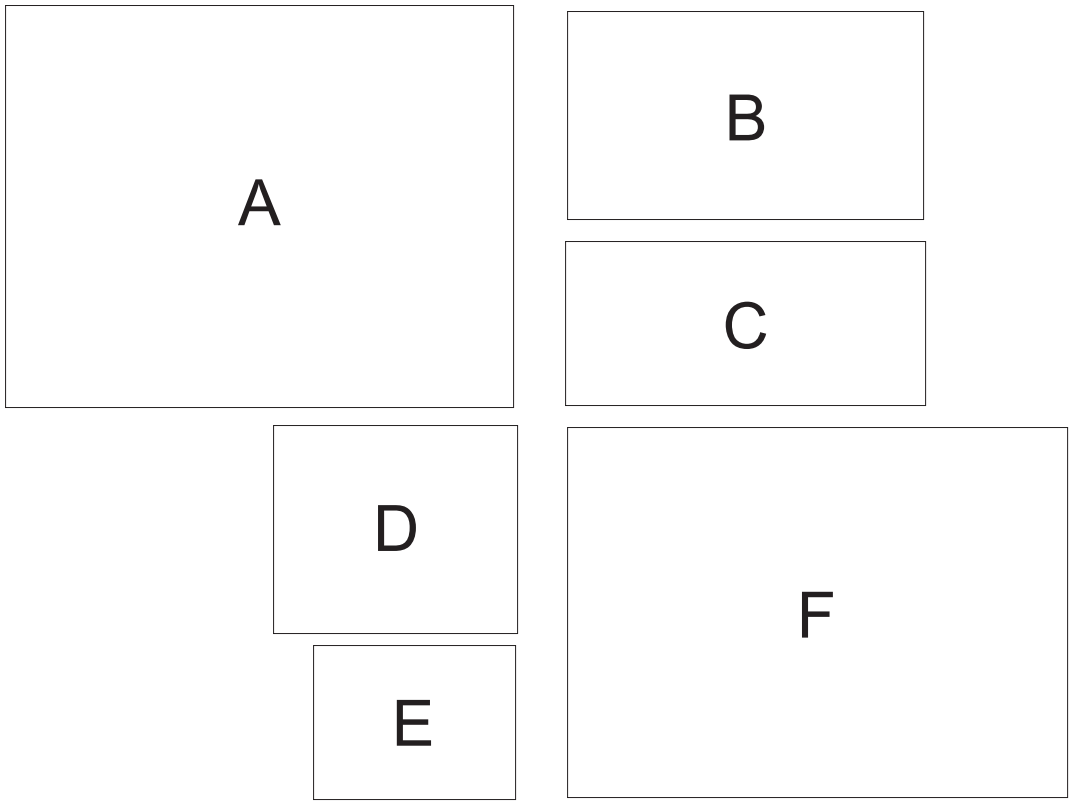
# Fish Communities of the Buffalo River Basin and Nearby Basins of Arkansas and their Relation to Selected Environmental Factors, 2001-2002

Prepared in cooperation with the
NATIONAL PARK SERVICE and the
U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE

Scientific Investigations Report 2004-5119

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




A - Richland Creek near Witts Springs

B - Longear sunfish—common throughout the Ozark Plateaus

C - Stippled darter—primarily restricted to small streams and is endemic to the Ozark Plateaus

D - Banded sculpin (top) and Ozark sculpin (bottom)—banded sculpins are widely distributed throughout the Ozark Plateaus. Ozark sculpins are less widely distributed and are endemic to the Ozark Plateaus

E - Smallmouth bass—an important game fish found throughout most of the Ozark Plateaus

F - Buffalo River just downstream from Rush Creek (photograph by Billy G. Justus, U.S. Geological Survey)

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**CONVERSION FACTORS AND ABBREVIATIONS**

| Multiply | By | To obtain |
|---|---|---|
| kilometer (km) | 0.6214 | mile (mi) |
| square kilometer ($km^2$) | 0.3861 | square mile ($mi^2$) |
| meter (m) | 3.281 | foot (ft) |
| square meter ($m^2$) | 10.76 | square foot ($ft^2$) |
| centimeter (cm) | 0.3937 | inch (in.) |
| millimeter (mm) | 0.03937 | inch (in.) |

# Fish Communities of the Buffalo River Basin and Nearby Basins of Arkansas and their Relation to Selected Environmental Factors, 2001-2002

By James C. Petersen

## Abstract

The Buffalo River lies in north-central Arkansas and is a tributary of the White River. Most of the length of the Buffalo River lies within the boundaries of Buffalo National River, a unit of the National Park Service; the upper 24 river kilometers lie within the boundary of the Ozark National Forest. Much of the upper and extreme lower parts of the basin on the south side of the Buffalo River is within the Ozark National Forest.

During the summers of 2001 and 2002, fish communities were sampled at 52 sites in the study area that included the Buffalo River Basin and selected smaller nearby basins within the White River Basin in north-central Arkansas. Water quality (including nutrient and bacteria concentrations) and several other environmental factors (such as stream size, land use, substrate size, and riparian shading) also were measured.

A total of 56 species of fish were collected from sites within the Buffalo River Basin in 2001 and 2002. All 56 species also were collected from within the boundaries of Buffalo National River. Twenty-two species were collected from headwater sites on tributaries of the Buffalo River; 27 species were collected from sites within or immediately adjacent to the Ozark National Forest. The list of species collected from Buffalo National River is similar to the list of species reported by previous investigators. Species richness at sites on the mainstem of the Buffalo River generally increased in a downstream direction. The number of species collected (both years combined) increased from 17 at the most upstream site to 38 near the mouth of the Buffalo River. In 2001 and 2002, a total of 53 species of fish were collected from sites outside the Buffalo River Basin.

Several fish community metrics varied among sites in different site categories (mainstem, large tributary, small tributary, headwater, and developed out-of-basin sites). Median relative abundances of stonerollers ranged from about 25 to 55 percent and were highest at headwater and developed out-of-basin sites and lowest at mainstem sites. The relative abundances at the headwater and developed out-of-basin sites were significantly different from the relative abundances at the mainstem sites. Percentages of individuals of algivorous/herbivorous, invertivorous, and piscivorous species at headwater sites were significantly lower than values at mainstem and developed out-of-basin sites. Percentages of individuals of invertivorous species at mainstem sites were significantly higher than values at small tributary, headwater, and developed out-of-basin sites. Percentages of top carnivores at mainstem sites were significantly higher than values at tributary and headwater sites. The numbers of darter, sculpin, plus madtom species at mainstem, large tributary, and developed out-of-basin sites were significantly higher than values at other sites, and the values at small tributary sites and headwater sites were each significantly different from values at the other four types of sites. The number of lithophilic spawning species at large tributary sites was not significantly different from values at mainstem and developed out-of-basin sites, but values for small tributary and headwater sites each were significantly different from values for all other categories. Index of biotic integrity scores varied among the site categories. Scores for mainstem sites were significantly larger than all but large tributary site scores. Scores for headwater sites were significantly smaller than mainstem and large tributary site scores.

Several analyses of the data described in this report suggest that drainage area is the most important single factor influencing fish communities of the Buffalo River Basin and nearby basins. Species richness increases with increasing drainage area and some species are restricted to smaller streams while other species are more common in larger streams. Some community metrics also are related to land use and related factors (proportion of cleared land and nutrient concentrations, for example), suggesting that substantial shifts in basin land use or point-source effluents will have effects on downstream fish communities.

## Introduction

The Buffalo River lies in north-central Arkansas and is a tributary of the White River (fig. 1). It has a length of approximately 240 km (National Park Service, 2003) and at its mouth has a drainage area of approximately 3,470 $km^2$ (Sullavan, 1974). Most of the length of the Buffalo River lies within the boundaries of Buffalo National River, a unit of the National Park Service; the upper 24 river kilometers lie within the boundary of the Ozark National Forest (National Park Service, 2003). Much (about 27 percent of the Buffalo River Basin) of the upper and extreme lower parts of the basin on the south side of the Buffalo River is within the Ozark National Forest.

The Buffalo River Basin lies within the Ozark Plateaus physiographic province (Fenneman, 1938), which is one of the

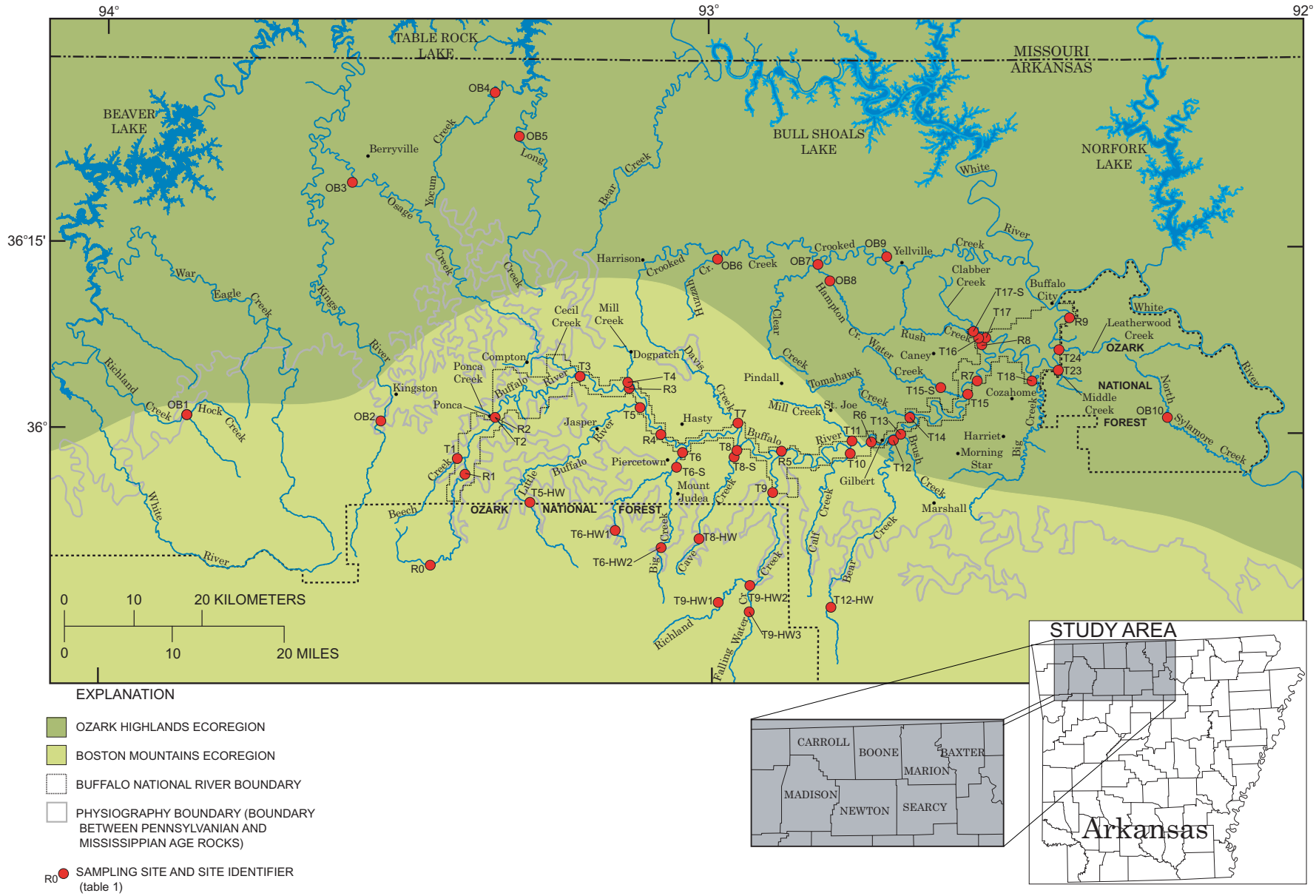



**Figure 1.** Location of sampling sites.

richest areas of the United States for fish species. More than 175 native and introduced species of fish occur in the Ozark Plateaus and immediately adjacent areas (Petersen, 1998). More than 60 species of fish previously have been documented from the Buffalo River (Guidroz, 1975; Cashner and Brown, 1977; Robison and Buchanan, 1988). Several fish species endemic to the Ozark Plateaus occur within the Buffalo River Basin and some of these species are probably more common in the Buffalo River Basin than in other streams in Arkansas (Robison and Buchanan, 1988; Robison, 1997).

No extensive surveys of fish communities of the Buffalo River have been done since 1973 and land-use changes in the Buffalo River Basin may result in changes in the structure of Buffalo River fish communities. To address a lack of information on existing fish communities and how potential changes in environmental factors would affect these communities, the U.S. Geological Survey (USGS) in cooperation with the National Park Service and the U.S. Department of Agriculture Forest Service conducted an investigation of fish communities in 2001-2002.

## Purpose and Scope

The purpose of this report is to describe the current (2001-2002) fish communities of the Buffalo River Basin and nearby basins of the White River Basin and to describe relations to selected environmental factors that may be affecting these fish communities. Fish communities are described using selected metrics (including species lists and proportions of selected taxa) and multivariate analyses of relative abundance data. Environmental factors described and examined for effects on the fish communities (Panfil and Jacobson, 2001; Jacobson and others, 2004; Petersen, 2004) include measures of basin characteristics, stream size, channel morphometry, substrate size, riparian shading, and water quality.

During the summers (June through September) of 2001 and 2002, fish communities were sampled at 52 sites in the study area (fig. 1, table 1). Almost all sites were sampled during both years. Water-quality samples were collected approximately quarterly from April 2001 to October 2002 and other environmental factors were measured at least once at each site.

During 2003, as part of another investigation funded by the National Park Service, several sites within the boundaries of Buffalo National River were sampled with the purpose of collecting fish species that were not collected during the 2001-2002 sampling periods because of sampling location, season, or methods. A list of additional species collected in 2003 is included in this report so that readers will have a complete list of species collected to date (2004) from Buffalo National River.

## Acknowledgments

This investigation was conducted in cooperation with the National Park Service and the U.S. Department of Agriculture Forest Service. Analysis of water-quality samples was provided by the Arkansas Department of Environmental Quality. Dan Magoulick (USGS and Arkansas Cooperative Fish and Wildlife Research Unit) and Shawn Hodges (Arkansas Cooperative Fish and Wildlife Research Unit) provided substantial input regarding sampling approach and site selection during 2001. Shawn Hodges, Mandy Scott (Arkansas Cooperative Fish and Wildlife Research Unit), and Dan Magoulick assisted substantially with fish sampling in 2001 and 2002. Mark Oliver, Ken Shirley, and other employees of the Arkansas Game and Fish Commission provided a boat and equipment and assisted with sampling of non-wadeable portions of several sites on the lower part of the Buffalo River. Several Forest Service employees assisted with sampling of several sites in 2001 and 2002. Several National Park Service employees assisted by providing logistical support and by assisting with sampling in one or both years; David Mott, Faron Usrey, Jessica Luraas, and John Petty were particularly helpful. The National Park Service also provided lodging for sampling crews. A number of landowners provided access to sampling sites. Daniel Dauwalter and Edmund Pert (formerly with the University of Arkansas-Pine Bluff), and William Keith (Arkansas Department of Environmental Quality) provided information and draft manuscripts related to an index of biotic integrity for fishes of the Ozark Highlands area of Arkansas that they have developed. Ty Blacklock assisted by volunteering as a crew member on several days in 2001. Billy Justus (USGS) provided invaluable assistance by leading fish sampling crews during several weeks of the sampling period. Much of the data used to describe environmental factors at some sites was collected in 1999 by USGS scientists (Panfil and Jacobson, 2001) and similar data were collected at the remaining sites in 2001 and 2002 (Jacobson and others, 2004). The cooperation of each of these agencies and individuals is gratefully acknowledged.

# Description of Study Area and its Fishes

The study area includes the Buffalo River Basin and selected smaller nearby basins within the White River Basin in north-central Arkansas (fig. 1). At its mouth, the Buffalo River has a drainage area of approximately 3,470 $km^2$ (Sullavan, 1974). All of the basins lie within the Ozark Plateaus physiographic province (Fenneman, 1938). Although most of the study sites (those upstream from about Bear Creek) in the Buffalo River Basin have basins that primarily are within the Boston Mountains ecoregion (fig. 1) (Omernik and Gallant, 1987), or physiographic section (Fenneman, 1938), many of these same basins are underlain by substantial amounts (as much as 64 percent) of limestone or dolomite. Sandstone and shale are more typical of the Boston Mountains physiographic section while limestone and dolomite are more typical of the Springfield and Salem Plateau physiographic sections

**Table 1.** Fish community sampling site information.

[Site identifier: R is Buffalo River site; T is Buffalo River tributary site; HW is a headwater site substantially upstream from the indicated tributary site; S is satellite site just upstream from the indicated tributary site. Site category: HW is headwater site; MS is mainstem sites of the Buffalo River; TS is small-basin tributary sites near confluence with the Buffalo River; TL is large-basin tributary sites near confluence with the Buffalo River; satellite sites are sites located within a few kilometers upstream from other sites at the mouths of tributaries; OD is out-of-basin sites in developed basins, generally with greater percentages of cleared land and higher road density; $km^2$, square kilometer]

| Site identifier (see fig. 1) | Site name | Site category | County | Township, range, section | Drainage area ($km^2$) | Cleared land in basin (percent) | Sample number[1] |
|---|---|---|---|---|---|---|---|
| R0 | Buffalo River at Dixon Ford near Fallsville | HW | Newton | T.13 N., R.23 W., sec. 5 | 51 | 3.1 | 1 |
| R1 | Buffalo River near Boxley | MS | Newton | T.15 N., R.23 W., sec. 22 | 150 | 4.2 | 2 |
| R2 | Buffalo River near Ponca | MS | Newton | T.16 N., R.22 W., sec. 30 | 297 | 7.4 | 3 |
| R3 | Buffalo River near Pruitt | MS | Newton | T.16 N., R.20 W., sec. 7 | 494 | 8.1 | 4 |
| R4 | Buffalo River near Hasty | MS | Newton | T.16 N., R.20 W., sec. 34 | 984 | 9.2 | 5 |
| R5 | Buffalo River near Woolum | MS | Searcy | T.15 N., R.18 W., sec. 4 | 1,553 | 10.3 | 6 |
| R6 | Buffalo River at Shine Eye near Gilbert | MS | Searcy | T.16 N., R.17 W., sec. 36 | 2,150 | 11.6 | 7 |
| R7 | Buffalo River at Highway 14 near Harriet | MS | Marion | T.17 N., R.15 W., sec. 34 | 2,778 | 15.0 | 8 |
| R8 | Buffalo River near Rush | MS | Marion | T.17 N., R.5 W., sec. 14 | 2,840 | 14.8 | 9 |
| R9 | Buffalo River near mouth near Buffalo City | MS | Marion | T.18 N., R.14 W., sec. 36 | 3,455 | 15.4 | 10 |
| T1 | Beech Creek near mouth near Boxley | TS | Newton | T.15 N., R.23 W., sec. 16 | 49 | 8.7 | 11 |
| T2 | Ponca Creek near mouth near Ponca | TS | Newton | T.16 N., R.22 W., sec. 30 | 12 | 9.1 | 12 |
| T3 | Cecil Creek near mouth near Erbie | TS | Newton | T.17 N., R.21 W., sec. 33 | 57 | 13.4 | 13 |
| T4 | Mill Creek near mouth near Pruitt | TS | Newton | T.16 N., R.20 W., sec. 6 | 54 | 14.3 | 14 |
| T5 | Little Buffalo River near mouth near Pruitt | TL | Newton | T.16 N., R.20 W., sec. 20 | 369 | 9.1 | 15 |
| T5-HW | East Fork Little Buffalo River near Murray | HW | Newton | T.15 N., R.22 W., sec. 34 | 58 | 5.6 | 16 |
| T6 | Big Creek near mouth near Carver | TL | Newton | T.15 N., R.19 W., sec. 6 | 230 | 10.9 | 17 |
| T6-S | Big Creek near Vendor | Satellite | Newton | T.15 N., R.20 W., sec. 13 | 219 | 12.9 | 18 |
| T6-HW1 | Left Fork Big Creek near Red Rock | HW | Newton | T.14 N., R.21 W., sec. 12 | 25 | 6.3 | 19 |
| T6-HW2 | Big Creek near Mt. Judea | HW | Newton | T.14 N., R.20 W., sec. 23 | 53 | 4.4 | 20 |
| T7 | Davis Creek near mouth near Mt. Hersey | TL | Newton | T.16 N., R.19 W., sec. 26 | 72 | 17.4 | 21 |
| T8 | Cave Creek near mouth near Mt. Hersey | TL | Newton | T.15 N., R.19 W., sec. 1 | 134 | 9.1 | 22 |
| T8-S | Cave Creek near Woolum | Satellite | Newton | T.16 N., R.19 W., sec. 11 | 130 | 10.7 | 23 |
| T8-HW | Cave Creek near Bass | HW | Newton | T.15 N., R.19 W., sec. 1 | 34 | 2.3 | 24 |
| T9 | Richland Creek near mouth near Eula | TL | Searcy | T.15 N., R.18 W., sec. 22 | 313 | 4.8 | 25 |
| T9-HW1 | Richland Creek near Ben Hur | HW | Newton | T.13 N., R.19 W., sec. 14 | 67 | 3.7 | 26 |
| T9-HW2 | Richland Creek near Witts Springs | HW | Searcy | T.13 N., R.18 W., sec. 6 | 113 | 2.6 | 27 |

**Table 1.** Fish community sampling site information.—Continued

[Site identifier: R is Buffalo River site; T is Buffalo River tributary site; HW is a headwater site substantially upstream from the indicated tributary site; S is satellite site just upstream from the indicated tributary site. Site category: HW is headwater site; MS is mainstem sites of the Buffalo River; TS is small-basin tributary sites near confluence with the Buffalo River; TL is large-basin tributary sites near confluence with the Buffalo River; satellite sites are sites located within a few kilometers upstream from other sites at the mouths of tributaries; OD is out-of-basin sites in developed basins, generally with greater percentages of cleared land and higher road density; $km^2$, square kilometer]

| Site identifier (see fig. 1) | Site name | Site category | County | Township, range, section | Drainage area ($km^2$) | Cleared land in basin (percent) | Sample number[1] |
|---|---|---|---|---|---|---|---|
| T9-HW3 | Falling Water Creek near Witts Springs | HW | Searcy | T.13 N., R.18 W., sec. 19 | 49 | 2.7 | 28 |
| T10 | Calf Creek near mouth near Silver Hill | TL | Searcy | T.15 N., R.17 W., sec. 3 | 124 | 25.8 | 29 |
| T11 | Mill Creek near mouth near Silver Hill | TS | Searcy | T.16 N., R.17 W., sec. 34 | 36 | 21.0 | 30 |
| T12 | Bear Creek near mouth near Gilbert | TL | Searcy | T.16 N., R.16 W., sec. 32 | 238 | 27.2 | 31 |
| T12-HW | Bear Creek near Welcome Home | HW | Searcy | T.13 N., R.17 W., sec. 16 | 37 | 21.1 | 32 |
| T13 | Brush Creek near mouth near Gilbert | TS | Searcy | T.16 N., R.16 W., sec. 28 | 50 | 27.0 | 33 |
| T14 | Tomahawk Creek near mouth near Tomahawk | TL | Searcy | T.16 N., R.16 W., sec. 20/21 | 95 | 31.5 | 34 |
| T15 | Water Creek near mouth near Evening Star | TL | Searcy | T.16 N., R.15 W., sec. 9 | 99 | 19.8 | 35 |
| T15-S | Water Creek near Maumee | Satellite | Searcy | T.16 N., R.16 W., sec. 1 | 89 | 23.4 | 36 |
| T16 | Rush Creek near mouth near Rush | TS | Marion | T.17 N., R.15 W., sec. 10 | 36 | 12.3 | 37 |
| T17 | Clabber Creek near mouth near Rush | TS | Marion | T.17 N., R.15 W., sec. 11 | 67 | 27.5 | 38 |
| T17-S | Clabber Creek near Rush | Satellite | Marion | T.17 N., R.15 W., sec. 3 | 54 | 26.6 | 39 |
| T18 | Big Creek near mouth near Cozahome | TL | Marion | T.17 N., R.14 W., sec. 33 | 346 | 25.0 | 40 |
| T23 | Middle Creek near mouth near Big Flat | TS | Marion | T.17 N., R.14 W., sec. 29 | 29 | 5.5 | 41 |
| T24 | Leatherwood Creek near mouth near Advance | TS | Marion | T.17 N., R.14 W., sec. 13 | 32 | 5.2 | 42 |
| OB1 | Hock Creek near Wesley | OD | Madison | T.16 N., R.27 W., sec. 28 | 41 | 31.7 | 43 |
| OB2 | Kings River near Kingston | OD [2] | Madison | T.16 N., R.24 W., sec. 29 | 162 | 13.6 | 44 |
| OB3 | Osage Creek near Berryville | OD | Carroll | T.19 N., R.25 W., sec. 12 | 380 | 29.4 | 45 |
| OB4 | Yocum Creek near Oak Grove | OD | Carroll | T.21 N., R.22 W., sec. 30 | 134 | 72.0 | 46 |
| OB5 | Long Creek near Denver | OD | Carroll | T.20 N., R.22 W., sec. 16 | 266 | 38.5 | 47 |
| OB6 | Huzzah Creek near Olvey | OD | Boone | T.18 N., R.19 W., sec. 10 | 63 | 82.9 | 48 |
| OB7 | Clear Creek near Pyatt | OD | Marion | T.18 N., R.17 W., sec. 7 | 282 | 63.6 | 49 |
| OB8 | Hampton Creek near Eros | OD | Marion | T.18 N., R.17 W., sec. 21 | 57 | 44.6 | 50 |
| OB9 | Crooked Creek near Summit | OD | Marion | T.18 N., R.16 W., sec. 6 | 1,037 | 51.0 | 51 |
| OB10 | North Sylamore Creek near Big Flat | HW | Stone | T.16 N., R.12 W., sec. 15 | 84 | 1.1 | 52 |

[1]Sample number and letter (a for 2001 and b for 2002) used in figures 8 and11.

[2]Site was not included in OD group for boxplots and multiple comparison tests because of relatively low percentage of cleared land in its basin.

(Fenneman, 1938), which generally corresponds with the Ozark Highlands ecoregion (Omernik and Gallant, 1987).

The differences in geology between the Springfield and Salem Plateaus (with their abundance of karst features—springs, sinkholes, and solution channels) and the Boston Mountains result in differences in hydrology, stream morphometry, and land use (Bennett and others, 1987; Adamski and others, 1995; Panfil and Jacobson, 2001). The topography of the Boston Mountains typically is steeper and more rugged than the Springfield and Salem Plateaus. Land use primarily is forest within the Boston Mountains, while a larger proportion of the Springfield and Salem Plateaus is used for pasture and production of cattle, hogs, and poultry. Streams in the Boston Mountains often have steeper gradients than streams in the Springfield and Salem Plateaus. Streams that cross from the Boston Mountains into the Springfield Plateau often go dry during periods of dry weather soon after they reach the karst limestone geology and then resurface farther downstream.

Streamflow characteristics of streams of the Ozark Plateaus are affected by geology and topography (Bennett and others, 1987; Adamski and others, 1995). Because of steeper topography and lack of karst features, streams of the Boston Mountains carry more runoff per unit of basin area than do streams of the Springfield and Salem Plateaus (Freiwald, 1985). They also often are more flashy and have greater peak streamflows (Giese and others, 1987; Hedman and others, 1987). Streams within the Springfield and Salem Plateaus often have segments which gain or lose substantial amounts of streamflow (Freiwald, 1987; Adamski and others, 1995) and can capture ground water from adjacent surface-water basins (Mott and others, 2000).

Land-use differences are related to geology and these differences in geology and land use contribute to differences in water quality. Streams in the Boston Mountains typically have lower alkalinity concentrations, lower specific conductance values, and lower pH values than streams in the Springfield and Salem Plateaus (Giese and others, 1987; Petersen, 1988; Adamski and others, 1995; Mott, 1997). The greater amounts of pasture land in the Springfield and Salem Plateaus often result in higher concentrations of nutrients (Giese and others, 1987; Petersen, 1988; Adamski and others, 1995; Mott, 1997, Davis and Bell, 1998).

More than 60 species of fish previously have been collected from the Buffalo River and its tributaries. Cashner and Brown (1977) reported 59 species from 16 sites sampled in 1965 and 1966 and from 3 other sites sampled by other investigators (Black, 1940; Buchanan, 1973; Guidroz, 1975). Robison and Buchanan (1988) reported 61 species collected from the Buffalo River and its tributaries prior to 1988. Combining these two lists yields a list of 63 species collected from the Buffalo River and its tributaries. Ten of these species are endemic to the Ozark Plateaus (Robison and Buchanan, 1988). The species previously collected in the Buffalo River Basin are primarily minnows (cyprinids, 20 species), darters (percids, 11 species), sunfish (centrarchids, 7 species), and catfish (ictalurids, 7 species).

# Methods of Study

Methods for data collection and statistical analysis are described in this section. Water-quality sampling, drainage-basin and reach-scale characteristics measurement, and fish sampling are included.

## Water-Quality Sampling

At most sites water samples were collected by the National Park Service (at a few sites samples were collected by the Arkansas Department of Environmental Quality or the USGS). Grab samples were collected from the centroid of streamflow approximately quarterly beginning in April 2001 and continuing through October 2002. Dissolved oxygen, pH, water temperature, and specific conductance were measured in the field. Samples were transported on ice to the Arkansas Department of Environmental Quality for analysis (except that samples collected by the USGS from Yocum Creek were transported to a USGS laboratory in Lakewood, Colorado). Water-quality data (field measurements, turbidity, fecal coliform bacteria, and nutrients) are summarized by site in Petersen (2004).

## Drainage-Basin and Reach-Scale Characteristic Measurement and Data Processing

Two sets of drainage-basin and reach-scale characteristics (table 2) were measured for each site. The first set of data includes basin-scale and reach-scale data collected by USGS Biological Resources Discipline scientists; the second set of data includes additional reach-scale data collected by USGS Water Resources Discipline scientists. These characteristics include measures of basin geology, basin physiography, basin land use (land cover and road network), channel geometry, velocity, stream substrate, channel stability, and riparian cover. A short description of methods used is given in the following paragraphs and in table 2. Methods are described in more detail and results are given in Panfil and Jacobson (2001), Jacobson and others (2004), and Petersen (2004).

Basin-scale characteristics (for example, drainage area, elevation range, drainage basin average slope, road density, road density within a stream buffer area, proportion cleared land, and proportion carbonate bedrock area) were measured using a geographic information system using Arc/Info and ArcView software (Environmental Research Systems Institute, 1998a, 1998b). Data layers were collected from a variety of sources, including the USGS, U.S. Environmental Protection Agency, U.S. Census Bureau, and the Center for Advanced Spatial Technologies at the University of Arkansas. The software then was used to manipulate information from the data layers and calculate values for the basin characteristics.

The first set of reach-scale characteristics was measured by Biological Resources Discipline scientists during field inventories conducted in 1999, 2001, and 2002 (Jacobson and

**Table 2.** Drainage-basin and reach-scale characteristic variables, definitions, and data sources.

[m, meters; $m^2$, square meters; $km^2$, square kilometers; <, less than; mm, millimeters; >, greater than; BRD and WRD indicate that data were collected by U.S. Geological Survey Biological Resources Discipline or Water Resources Discipline scientists, respectively; modified from Panfil and Jacobson, 2001]

| Variables | Definition | Data source or measurement technique |
|---|---|---|
| | **Geology** | |
| Carbonate bedrock area, as a proportion | Formations regrouped by dominant lithology; area with carbonate bedrock summed and divided by drainage area. | Modified 1:500,000-scale[1] state geologic map of Arkansas (Hofer and others, 1995) (BRD) |
| | **Physiography** | |
| Drainage area ($km^2$) | Total area upstream from upper end of study reach; drainage basin boundaries delineated using an ArcView Spatial Analyst Script (http://gis.esri.com/arcsripts/details.dfm?CFGRIDKEY=951497255) and refined by comparison with elevation contours on USGS 1:24,000 digital raster graphics. | |
| Elevation range (m) | Highest minus lowest elevation in study drainage basin. | 1:24,000-scale digital raster graphics (U.S. Geological Survey, 1999) (BRD) |
| Drainage-basin average slope (degrees) | Average slope for all grid cells within a study drainage basin where slope is calculated by comparison of each cell's elevation to that of the surrounding eight cells. | |
| | **Land Cover** | |
| Cleared land areas, as a proportion | Sum of area classified as developed, shrubland, transitional, herbaceous upland, or herbaceous cultivated (NLCD categories 33, 51, 71, 81, 82, 83, 84, 85), divided by drainage area. | 30-meter resolution National Land Cover Data (NLCD) (U.S. Geological Survey, 2000); Coverage for the state of Arkansas was based on Landsat Thematic Mapper (TM) scenes taken from April 1988 through December 1993. (BRD) |
| Steep, cleared land area, as a proportion | Cleared land area on slopes greater than seven degrees divided by drainage area (calculated by reclassifying and merging NLCD and slope grids). | |
| Cleared land area in stream buffer, as a proportion. | Cleared land area within stream buffers divided by total drainage area. | |
| | **Road Network** | |
| Road density ($m/m^2$) | Total road length within a basin divided by drainage area. | 1:100,000-scale TIGER/Line files (U.S. Census Bureau, 1992) (BRD) |
| Road density in stream buffer ($m/m^2$) | Total road length within a stream buffer divided by buffer area. | |
| | **Channel Geometry and Velocity** | |
| Reach gradient | Slope of a best-fit line through water surface points surveyed along the thalweg. | |
| Total residual pool length (m) | Total length of reach within residual pools. | |
| Residual pools, as a proportion | Total residual pool length divided by total reach length. | Calculated from the geometry of the longitudinal profile survey. (BRD) |
| Average residual pool length (m) | Total residual pool length divided by the number of residual pools. | |
| Average residual pool depth (m) | Residual pool area (measured along longitudinal profile) divided by total residual pool length. | |
| Pools, as a proportion of reach length | Total reach length classified as lateral, bluff, mid-channel, or obstruction pools divided by total reach length. | Calculated from visual identifications of habitat type made at each survey point along the longitudinal profile. (BRD) |
| Glides, as a proportion of reach length | Total reach length classified as glides divided by total reach length. | |
| Average bankfull channel width (m) | Total distance across channel at bankfull elevation; average from 3-6 cross sections. | Calculated from the geometry of surveyed cross sections. Bankfull elevation was projected into cross sections from indicators identified throughout the study reach. (BRD) |
| Average bankfull channel depth (m) | Bankfull channel area divided by bankfull channel width; average from 3-6 cross sections. | |
| Wetted width (m) | Length-weighted average of distance across wetted channel at each transect. | Calculated from tape or laser rangefinder measurements. (WRD) |
| Depth (m) | Length-weighted average of three depths at each transect. | Calculated from depth measurements using meter stick. (WRD) |
| Velocity index (mm) | Length-weighted average of three measures of velocity at each transect. | Calculated from differences between water elevations on upstream and downstream side of meter sticks. (WRD) |

**Table 2.** Drainage-basin and reach-scale characteristic variables, definitions, and data sources.—Continued

[m, meters; $m^2$, square meters; $km^2$, square kilometers; <, less than; mm, millimeters; >, greater than; BRD and WRD indicate that data were collected by U.S. Geological Survey Biological Resources Discipline or Water Resources Discipline scientists, respectively; modified from Panfil and Jacobson, 2001]

| Variables | Definition | Data source or measurement technique |
|---|---|---|
| | **Substrate** | |
| Mud/sand thalweg, as a proportion of reach length | Dominant particle size <2 mm; total reach length classified as mud/sand divided by total reach length. | Calculated from visual estimates of dominant particle size and embeddedness at each survey point along the longitudinal profile. Estimate made within a one-meter circle around the base of the surveyor's stadia rod. Embeddedness reported as the proportion of the circle covered with mud or sand, in intervals of 0.1. (BRD) |
| Gravel along thalweg, as a proportion of reach length | Dominant particles size 2-64 mm; total reach length classified as gravel divided by total reach length | |
| Cobbles and boulders along thalweg, as a proportion of reach length | Dominant particle size >64 mm; total reach length classified as cobbles/boulders divided by total reach length. | |
| Thalweg embeddedness index | Summation of embeddedness class times the proportion of reach length within each embeddedness class. | |
| Glide embeddedness, as a proportion | Average of embeddedness from two locations in each of three glides. | The proportion of a 60-cm quadrant covered with mud or sand, reported in intervals of 0.05. (BRD) |
| Glide D16 (mm) | $16^{th}$ percentile of particle size distribution; average from three glides. | Calculated from cumulative particles size distributions from pebble counts of 100 particles. (BRD) |
| Glide D50 (mm) | $50^{th}$ percentile of particle size distribution; average from three glides. | |
| Glide D84 (mm) | $84^{th}$ percentile of particle size distribution; average from three glides. | |
| Reach D16 (mm) | $16^{th}$ percentile of particle size distribution from two riffles, two pools, and two glides | |
| Reach D50 (mm) | $50^{th}$ percentile of particles size distribution from two riffles, two pools, and two glides | Calculated from cumulative particles size distributions from pebble counts of 300 particles. (WRD) |
| Reach D84 (mm) | $84^{th}$ percentile of particles size distribution from two riffles, two pools, and two glides | |
| Bedrock (percent) | Percent of 300 pebble count measurement point values that were bedrock | |
| Glide sorting (phi) | (D84-D16)/4 + (D95-D5)/6); where particle sizes were transformed to phi ($-\log_2$(diameter, mm)) and D84, D16, D95, and D5 are equal to $84^{th}$, $16^{th}$, $95^{th}$, and $5^{th}$ percentiles of particle size distribution in glides. | (BRD) |
| | **Channel Stability and Riparian Cover** | |
| Bank vegetation index | Summation of vegetation class times the proportion of reach length within each embeddedness class; average of left and right banks. | |
| Severely eroding banks, as a proportion of reach length | Total reach length classified as severely eroding divided by total reach length; average of left and right banks. | Calculated from visual estimates made at each survey point along the longitudinal profile. Observations made of vertical banks below bankfull elevation. (BRD) |
| Moderately and severely eroding banks, as a proportion of reach length | Total reach length classified as moderately or severely eroding divided by total reach length; average of left and right banks. | |
| Reach sinuosity | Total reach length divided by straight line distance between endpoints. | Calculated from planview of longitudinal profile survey. (BRD) |
| Open canopy angle (degrees) | Length-weighted average of angles measured from center of wetted channel at each transect | Individual open canopy angles are calculated by summing angles measured from center of wetted channel to visible horizon at either bank and subtracting the sum from 180 degrees. (WRD) |
| Canopy cover | Length-weighted average from densiometer readings at both ends of each transect | Calculated from concave spherical densiometer readings near water's edge at both ends of each transect. Methodology followed Fitzpatrick and others (1998). (WRD) |

[1]Map was tiled from 1:24,000-scale and coarser resolution data. Cells were reclassified to match geologic categories on the statewide 1:500,000-scale geologic map by Haley and others (1993).

others, 2004). Measurements were made in two locations through the reach: along a thalweg longitudinal profile and along cross sections in glide habitats. Glides are low gradient habitats with trapezoidal channels that often lack a distinct thalweg and have diffuse flow (fig. 6 of Panfil and Jacobson, 2001). The thalweg longitudinal profile was surveyed with a laser theodolite total station through a minimum of three riffle-pool sequences or a distance of at least 20 bankfull channel widths. At each point, water-surface and streambed elevations were surveyed and information was collected about thalweg habitat type, dominant substrate particle size, substrate embeddedness, percent of banks covered by vegetation or bedrock, and bank erosion. Measurements of habitat, substrate, and bank conditions were integrated over the reach using a distance-based averaging method.

Data also were collected in three glide habitats per reach. Channel cross sections were surveyed with the laser theodolite total station. Indicators of bankfull elevation (often the apex of point bars where bare gravel substrate transitioned into sandy substrate and perennial vegetation) along the longitudinal profile of the reach were identified and surveyed. Substrate characteristics and canopy cover also were measured at each cross section. Particle size distribution was estimated using Wolman pebble counts (Wolman, 1954). Embeddedness was estimated visually by comparing the percent of sand and mud particles surrounding or covering coarser substrates with illustrations of known embeddedness fractions.

Channel cross-section data and elevations of surveyed bankfull indicators were used to calculate several measures of bankfull geometry in glides. The cross-section data and elevations were used to interpolate a bankfull water-surface elevation.

A second set of reach-scale characteristics (Petersen, 2004) was collected by fish-sampling crews in 2001 and 2002 (generally on the day that the fish communities were sampled). Stream morphometry, water velocity, and measures of riparian cover were measured at several transects at each reach (table 2).

## Fish Sampling

Fish communities were sampled in 2001 and 2002 by teams composed of USGS, Arkansas Cooperative Fish and Wildlife Research Unit, National Park Service, Forest Service, and Arkansas Game and Fish Commission personnel. Sampling was conducted under the supervision of the USGS personnel.

Fish sampling was conducted using methods that generally conform with methods used by the USGS National Water Quality Assessment (NAWQA) program (Meador and others, 1993; Moulton and others, 2002); deviations are described below. Fish were sampled at each site using one or more types of electrofishing gear, as appropriate. Reaches corresponding to those measured for habitat characteristics were sampled in an upstream direction (single pass, rather than double pass as specified in NAWQA protocols) when using backpack or tote barge electrofishing gear. Sites with long sections of non-wadeable areas (sites R4, R5, R6, R7, R8, and R9) were sampled in a downstream direction using boat electrofishing gear. In many reaches more than one electrofishing gear was used because of differences in stream width and depth. In 2002, a combination of kick seining and electrofishing was used to sample benthic fishes and other riffle fishes; a common minnow seine (approximately 5 m by 1 m, 0.6-cm mesh) was placed across five to six different riffle locations and the substrate upstream from the seine was disturbed by kicking in a downstream direction while the electrofishing unit (usually a backpack) was operated. Kick seine samples also were collected at many sites in 2001, but usually not at reaches where well-defined riffles were absent (generally small, headwater streams in the Boston Mountains with mostly bedrock bottoms).

Most collected fish were identified in the field using identification keys for Arkansas (Robison and Buchanan, 1988) and Missouri (Pflieger, 1997) and were released. Fish that were not identified in the field were preserved for later identification in the laboratory. Because of the difficulty of rapidly distinguishing between central stonerollers (*Campostoma anomalum*) and largescale stonerollers (*Campostoma oligolepis*), individuals of these species were identified only as *Campostoma* spp.

## Statistical Analysis

Sites were placed in one or more categories (table 1) to (1) summarize fish community metrics for sites in selected categories, (2) evaluate the effects of environmental factors, and (3) evaluate the effects of proximity of tributary sites to the mainstem of the Buffalo River. Most sites were placed in one of five site categories based on drainage area, basin land use, and location relative to the Buffalo River. These site categories (sites on the mainstem of the Buffalo River (MS), sites near the mouth of large tributaries (TL), sites near the mouth of small tributaries (TS), headwater sites (HW), and out-of-basin sites (OD) in developed basins) were used to summarize measures of fish communities (except for species lists and species richness values these measures did not include data collected from the riffle seining) and environmental factors and to compare values of these measures among the site categories. Some other site groupings were selected to evaluate the effects of proximity to the Buffalo River mainstem (selected tributary sites and "satellite" sites a few kilometers upstream from the tributary sites) or to evaluate the effects of land use (developed out-of-basin sites paired with Buffalo River Basin sites).

Fish community metrics and measures of each environmental factor were calculated for individual sites. Boxplots were used to show the distribution of selected metric and environmental factor values by selected site category. Tukey's multiple comparison test of rank-transformed data (Helsel and Hirsch, 1992, p. 196) was used to test for differences ($p<0.05$) in these metrics or environmental factors among the five site categories.

A recently developed index of biotic integrity (IBI) for use with fish-community data in wadable streams in the Ozark Highlands ecoregion (which generally corresponds with the Springfield and Salem Plateaus) of Arkansas (Dauwalter and others, 2003) was used to calculate IBI values for each sample. The IBI can be calculated using seven metrics (table 3). Because black spot and other anomalies were not recorded for samples from the Buffalo River Basin and nearby basins, the "anomaly metric" was not included in the IBI calculations.

IBI scores were calculated using methods described by Dauwalter and others (2003). Values for two metrics (NDASCM and NLITSP) were adjusted for drainage area effects for calculation of the IBI. The qualitative site classifications for IBI scores are >0 - <20 (very poor), 20 - <40 (poor), 40 - <60 (fair), 60 - <80 (good), and 80 - 100 (reference).

Relations between fish community metrics and environmental factors were investigated using Spearman's rank correlation method to calculate Spearman's rho (Helsel and Hirsch, 1992, p. 217). Statistical significance was defined as $p<0.05$.

Four satellite sites were used to evaluate the effects of proximity to the Buffalo River on fish communities of tributaries of the Buffalo River that were at sites near (within about 1,000 meters) the Buffalo River. The satellite sites were located approximately 1 to 6 km upstream from their associated tributary sites. The similarity of fish communities at the tributary sites (T6, T8, T15, and T17) to fish communities at the associated satellite sites and with the closest Buffalo River mainstem site was measured using the percentage similarity index (Whittaker, 1952; Whittaker and Fairbanks, 1958). The index (PSC) is:

$$PSC = 100 - 0.5 \sum_{i=1}^{K} |a - b|$$

Where $a$ and $b$ are (for a given species) percentages of the total individuals in community A and B, respectively, and

$K$ is the total number of species in the two samples.

The similarity index also was used to measure the similarity of fish communities of sites comprising one other set of sites. The set was composed of developed out-of-basin sites and paired sites of similar drainage area but lower percentage of cleared land.

The relations between fish metric values (metrics used to calculate IBI scores, relative abundance of stonerollers, and IBI scores) and drainage area and selected land-use related factors (percent cleared land, nitrate concentration, and orthophosphorus concentration) at developed out-of-basin sites and paired Buffalo River Basin sites were evaluated using regression techniques and the Wilcoxon rank-sum test. Mean fish metric values were calculated for each site. Examination of x-y plots and a step-wise regression technique were used to select the "best" regression models with the mean fish metrics as dependent variables and one or more of the other factors as independent variables. The logarithmic (base 10) transformation of drainage area values was used when suggested by x-y plots.

When none of the land-use related factors were included in a regression model (because they were not statistically significant, $p>0.05$) the effects of the land-use related factors were evaluated by comparing regression model residuals for developed out-of-basin sites with residuals for Buffalo River Basin sites. The Wilcoxon rank-sum test was used for the comparison.

**Table 3.** Metrics used for calculation of index of biotic integrity for Ozark Highland streams of Arkansas.

[IBI, index of biotic integrity; --, not used to calculate IBI score for this study. IBI is described in Dauwalter and others (2003)]

| Raw metric | Acronym of raw metric | Relation to IBI score and stream site quality[1] | Metric score adjusted for drainage area[2] |
|---|---|---|---|
| Percent algivorous/herbivorous, invertivorous, piscivorous individuals[3] | PAHINP | Negative | No |
| Percent with black spot or an anomaly | -- | -- | -- |
| Percent green sunfish, bluegill, yellow bullhead, and channel catfish individuals | PGBYCC | Negative | No |
| Percent invertivorous individuals | PINVER | Positive | No |
| Percent top carnivores (individuals) | PTOPCA | Positive | No |
| Number of darter, sculpin, and madtom species | NDASCM | Positive | Yes |
| Number of lithophilic spawning species | NLITSP | Positive | Yes |

[1] Negative relation indicates that higher values of the metric reduce the IBI score, while positive relation indicates that higher values of the metric increase the IBI score.

[2] Metric scores were calculated from raw metric values. Drainage area size classification affected calculation of two metric scores.

[3] Species considered to use all of the indicated food types.

The taxonomic compositions (relative abundances of species) of the communities were analyzed using two types of multivariate analysis techniques: ordination and classification. A samples-by-species data matrix was input into the computer program PC-ORD version 4 (McCune and Mefford, 1999). Detrended correspondence analysis (DCA) (Hill, 1979a) was used to group reaches (samples) by their species composition (relative abundances). Two-way indicator species analysis (TWINSPAN) (Hill, 1979b), a classification technique, also was used to distinguish reaches. In the TWINSPAN analysis, pseudospecies (created by separating true species into entities defined by the relative abundance of that species) were created. Creating one or more pseudospecies from a true species allows relative abundance to influence TWINSPAN results. When relative abundance values exceeded 2.0, 5.0, 10.0, 20.0, and 40.0 percent (referred to as cut levels) a pseudospecies was created. TWINSPAN also produces lists of "preferential species" (pseudospecies and species that are at least twice as likely to occur in samples in a given classification group as in the alternate classification group).

Relations between multivariate analysis results and environmental factors were evaluated using two statistical methods. DCA results were compared to several environmental factors using Spearman correlations. The Wilcoxon rank-sum test (Helsel and Hirsch, 1992, p. 118) was used to test for differences in environmental factor values between selected TWINSPAN groups. Statistical significance was defined as $p<0.05$.

## Environmental Characteristics of Sampling Sites

Characteristics such as drainage area, geology, land use (for example, cleared land percentages and road density), and water quality are often related to fish communities and many of these characteristics differed among the site categories. Mainstem site basins were significantly ($p<0.05$) larger than other basins and the small tributary and headwater site basins were smaller than other types of basins (fig. 2). The percentages of cleared land in headwater site basins were significantly smaller than in other types of basins and the percentages of cleared land in developed out-of-basin site basins were significantly larger than in other types of basins. Road density was significantly higher in the developed out-of-basin site basins than in the mainstem and headwater basins. The percentages of carbonate rock in headwater site basins (generally 0 percent) were significantly less than in all but mainstem site basins. The median diameter of substrate particles of the basins appears to be inversely related to the median percentage of carbonate rock in the basin; basin types with the larger percentages of carbonate rock have the smaller median substrate particle sizes. The particle size at developed out-of-basin sites was significantly smaller than at other types of sites, and the particle size at most headwater sites was substantially larger than at most other sites. When site OB10 (the only headwater site in the Ozark Highlands ecoregion) was omitted from the group of headwater sites, the particle sizes at the remaining headwater sites were significantly larger than particle sizes at other site categories. Bank erosion often was greatest at sites in the headwater site basins (where the topography is very steep) and the developed out-of-basin site basins (where percentages of cleared land are highest), but these differences were not significant. Water quality among the site categories generally was similar, except that specific conductance was significantly higher at sites in the large tributary, small tributary, and developed out-of-basin categories than at sites in other categories, and nutrient concentrations generally were significantly higher at sites in the out-of-basin category than at sites in the other categories (fig. 2). The relatively high 75th and 90th percentile values of turbidity and fecal coliform bacteria at large tributary sites resulted from a runoff event sampled at a few sites.

Sites in the developed out-of-basin category (which were purposely selected to represent conditions at sites in more developed basins) generally were similar in size to sites in the large tributary category but had greater percentages of cleared land in their basins, greater percentages of carbonate rock in their basins, smaller substrate particle size, and higher nutrient concentrations than did sites in the large tributary category.

## Fishes of the Buffalo River Basin

About 79,000 fish were collected from sites in the Buffalo River Basin during the summers of 2001 and 2002. Collection methods included backpack, tote barge, and boat electrofishing gear and seines.

During the survey described in this report, in 2001 and 2002, a total of 56 fish species were collected from sites within the Buffalo River Basin (table 4, at end of report). All 56 species also were collected from within the National Park Service boundaries of Buffalo National River. Fifty species were collected from the Buffalo River mainstem within the boundaries of Buffalo National River and 48 species were collected from sites on tributaries of the Buffalo River within Buffalo National River boundaries. These species counts assume two species of stoneroller occur at these sites; central and largescale stonerollers occur in the basin and it is likely that both species occur at many of the sites. Guidroz (1975), Cashner and Brown (1977), and Robison and Buchanan (1988) reported both species from throughout the Buffalo River mainstem, although Robison and Buchanan (1988) noted that central stonerollers have a preference for small streams while largescale stonerollers have a preference for medium to large streams. Twenty-two species (assuming that largescale stonerollers were not present in these small streams) were collected from headwater sites on tributaries of the Buffalo River; 27 species (assuming one stoneroller species) were collected from sites on or immediately adjacent to the Ozark National Forest in the White River Basin.

The list of species collected from Buffalo National River is similar to the list of species reported by Cashner and Brown

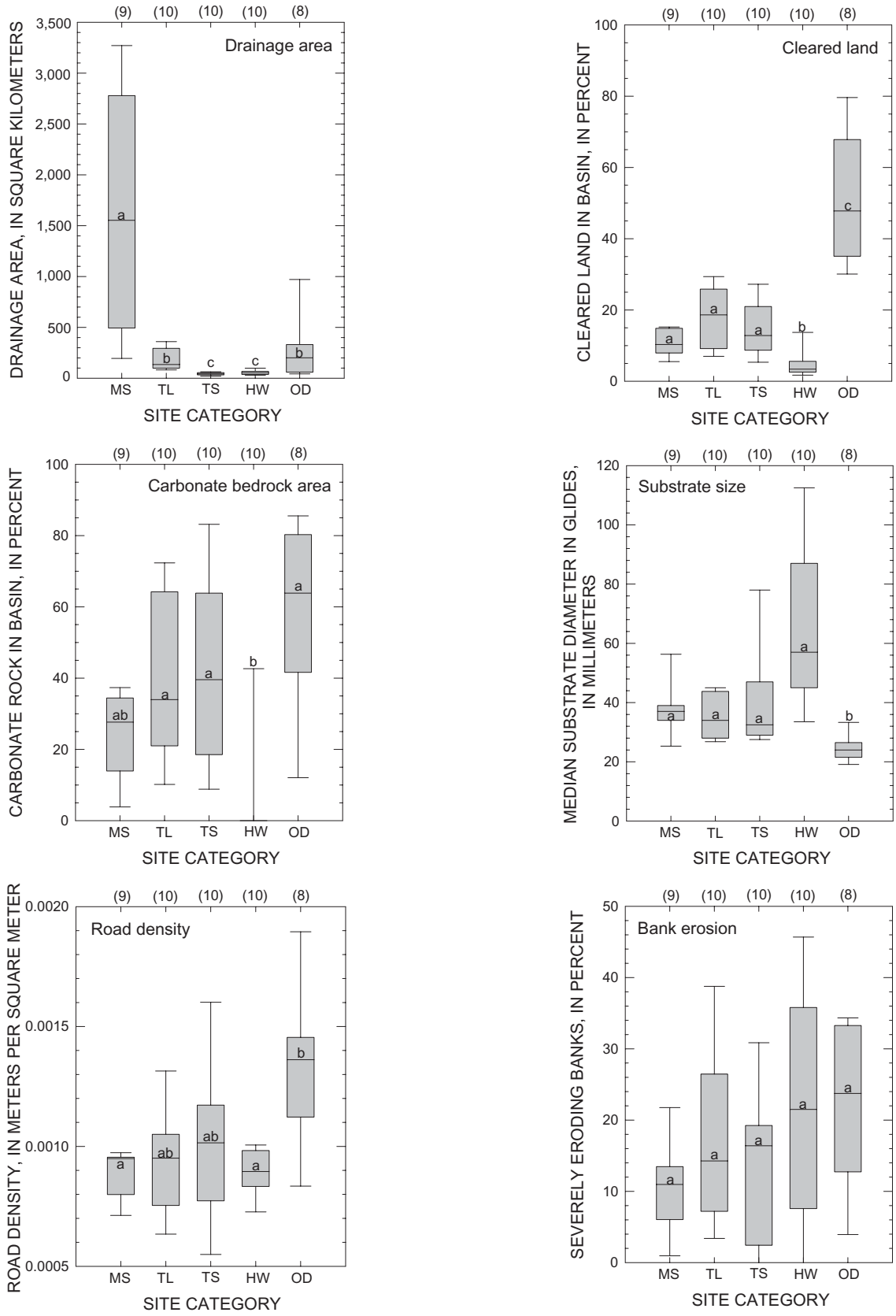



**Figure 2.** Distribution of values of selected environmental factors by site category.

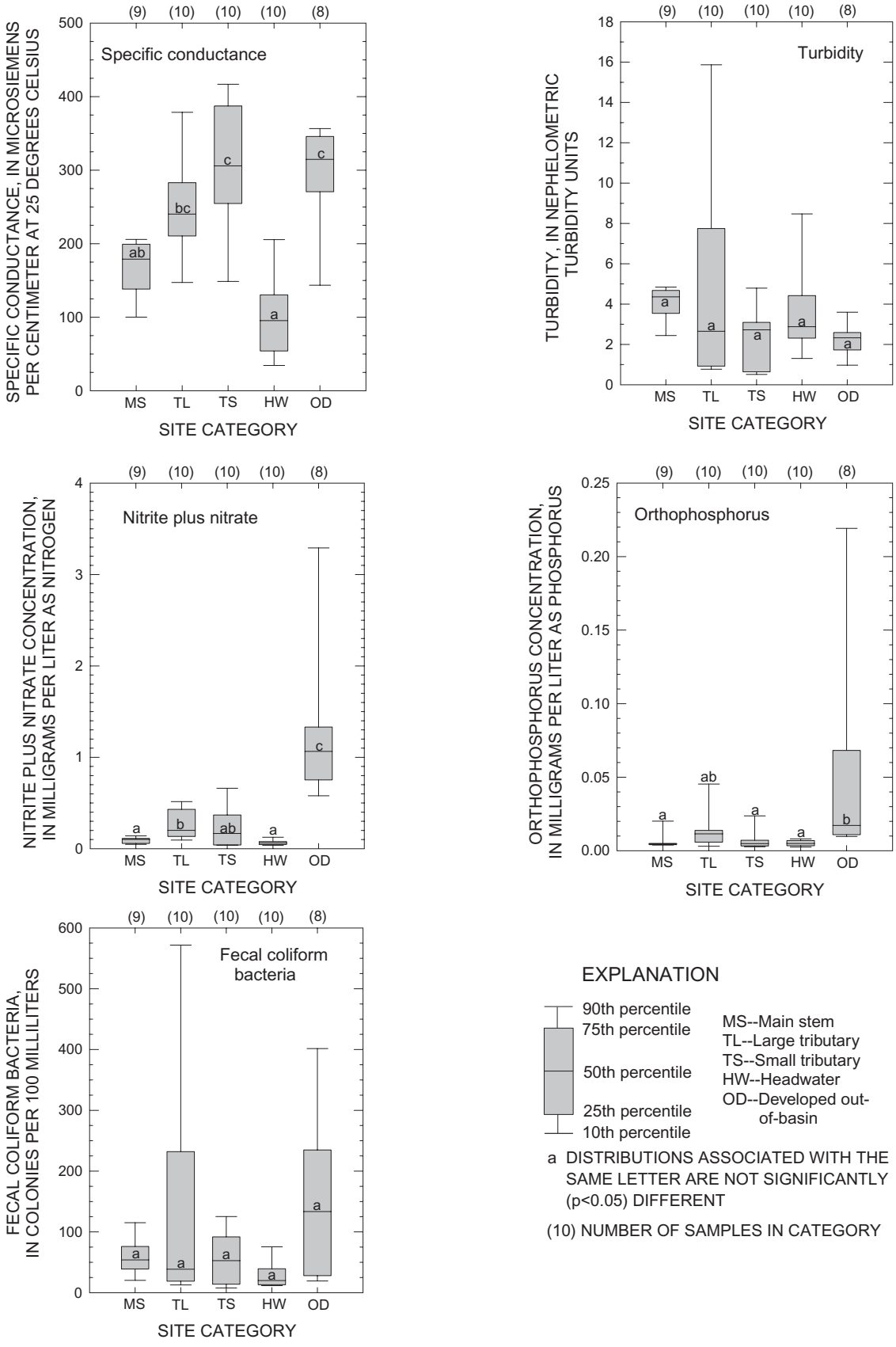



**Figure 2.** Distribution of values of selected environmental factors by site category.—Continued

(1977), Guidroz (1975), and Robison and Buchanan (1988). Species previously collected (Black, 1940; Cashner and Brown, 1977; Guidroz, 1975; Robison and Buchanan,1988) but not collected as part of this investigation in 2001 and 2002 are the American brook lamprey (*Lampetra appendix*), American eel (*Anguilla rostrata*), black bullhead (*Ameiurus melas*), blackside darter (*Percina maculata*), channel catfish (*Ictalurus punctatus*), gizzard shad (*Dorosoma cepedianum*), highfin carpsucker (*Carpiodes velifer*), speckled darter (*Etheostoma stigmaeum*), spotted bass (*Micropterus punctulatus*), spotted sucker (*Minytrema melanops*), and white bass (*Morone chrysops*). Species collected as part of this investigation in 2001 and 2002 but not previously collected (Black, 1940; Cashner and Brown, 1977; Guidroz, 1975; Robison and Buchanan,1988) from Buffalo National River are the redear sunfish (*Lepomis microlophus*), shorthead redhorse (*Moxostoma macrolepidotum*), redspotted sunfish (*Lepomis miniatus*), warmouth (*Lepomis gulosus*), and white sucker (*Catostomus commersoni*).

During 2003, several species not collected in 2001-2002 were collected during seasonally-targeted (for example winter or early spring) or habitat-targeted (for example, spring runs, backwater areas, and near the mouth of the Buffalo River) intensive sampling of Buffalo National River (James C. Petersen and Billy G. Justus, U.S. Geological Survey, written commun., 2003). American eel, gizzard shad, spotted sucker, freshwater drum (*Aplodinotus grunniens*), black crappie (*Pomoxis nigromaculatus*), channel catfish, least brook lamprey (*Lampetra aepyptera*), walleye (*Sander vitreus*), and quillback (*Carpiodes cyprinus*) were collected during this sampling. A brown trout (*Salmo trutta*) was observed in November 2003 in the Buffalo River between Middle Creek and Leatherwood Creek (Faron D. Usrey, National Park Service, oral commun., 2003). These collections and the observation increase the number of species collected from Buffalo National River to 73 (including both species of stonerollers).

Most species are minnows, darters, or sunfish (including black bass). Of the 56 species collected in the Buffalo River Basin in 2001 and 2002, 19 species were minnows, 9 species were darters, and 9 species were sunfish. Most other species are suckers (catostomids, six species), or catfish (ictalurids, five species).

The most ubiquitous species from sites within the boundaries of Buffalo National River were stonerollers, duskystripe shiners (*Luxilus pilsbryi*), rainbow darters (*Etheostoma caeruleum*), greenside darters (*Etheostoma blenniodes*), hornyhead chub (*Nocomis biguttatus*), and longear sunfish (*Lepomis megalotis*). These species were collected at almost all sites. These species are found throughout the upper White River system (Robison and Buchanan, 1988; and Pflieger, 1997).

The species collected (2001-2002) in the fewest samples from within the boundaries of Buffalo National River were the redspotted sunfish, rainbow trout (*Oncorhyncus mykiss*), redear sunfish, steelcolor shiner (*Cyprinella whipplei*), shorthead redhorse, white sucker, warmouth (*Lepomis gulosus*), brook silverside (*Labidesthes sicculus*), common carp (*Cyprinus carpio*), Ozark sculpin (*Cottus hypselurus*), and gilt darter (*Percina evides*). Most of these species were represented by only a few individuals.

Changes in the known distribution of Ozark sculpins and the apparent low abundance of gilt darters in the Buffalo River are of particular interest because of the small number of streams in Arkansas where these species are known to occur. The Ozark sculpin (two individuals) had previously been reported (Guidroz, 1975) in the Buffalo River Basin from only one site (a tributary to the Little Buffalo River) upstream from the mouth of the Buffalo River. However, several individuals of Ozark sculpin were collected from Rush Creek in 2002 and one individual was collected from Davis Creek in 2002. Several individuals were collected from a Buffalo River tributary spring run just downstream from Davis Creek in 2003 as part of another study by the author. Gilt darters (four individuals) were collected only from three sites in the middle portion of the Buffalo River (Buffalo River near Hasty, R4; Buffalo River at Highway 14 near Harriet, R7; and Buffalo River near Rush, R8) in 2001 and 2002. Gilt darters have been collected from several sites along the mainstem of the Buffalo River (Robison and Buchanan, 1988). Cashner and Brown (1977) reported gilt darters from most sites in the lower 80 km of the Buffalo River (from about site R6, Buffalo River at Shine Eye near Gilbert, downstream to the mouth), and Guidroz (1975) reported gilt darters (48 individuals) from locations between site R7 and R8 (Buffalo River at Highway 14 near Harriet and Buffalo River near Rush).

The most ubiquitous species from headwater sites in the Buffalo River Basin (all but site T12-HW on Bear Creek are on or immediately adjacent to the Ozark National Forest) were stonerollers, slender madtoms (*Noturus exilis*), duskystripe shiners, orangethroat darters (*Etheostoma spectabile*), and creek chub (*Semotilus atromaculatus*). Except for the creek chub, these species are found throughout the upper White River system (Robison and Buchanan, 1988; and Pflieger, 1997).

The species collected in the fewest samples from the headwater sites were the banded darter (*Etheostoma zonale*), black redhorse (*Moxostoma duquesnei*), and Ozark madtom (*Noturus albater*). These species were represented by only a few individuals.

Species richness at sites on the mainstem of the Buffalo River generally increased in a downstream direction (table 4), although the largest increase occurred in the upstream sections of the Buffalo River. The number of species collected (both years combined) increased from 17 at the most upstream site to 38 near the mouth of the Buffalo River. Species richness increased substantially between the site at Dixon Ford near Fallsville (R0, 17 species) and the site near Boxley (R1, 29 species) as drainage area increased from 51 to 150 $km^2$. Species richness remained at 29 at the next site near Ponca (R2) and then increased to 35 at the site near Pruitt (R3) as drainage area increased from 297 to 494 $km^2$. Species richness at sites between Pruitt and the mouth of the Buffalo River ranged from 35 to 38 species. Among the species that are usually present in the middle and lower sections of the Buffalo River (sites R3 through R9) and often not present in the upper sections of the

Buffalo River are blackspotted topminnow (*Fundulus olivaceus*), checkered madtom (*Noturus flavater*), flathead catfish (*Pylodictis olivaris*), golden redhorse (*Moxostoma erythrurum*), logperch (*Percina caprodes*), largemouth bass (*Micropterus salmoides*), longnose gar (*Lepisosteus osseus*), Ozark shiner (*Notropis ozarcanus*), rosyface shiner (*Notropis rubellus*), river redhorse (*Moxostoma carinatum*), and wedgespot shiner (*Notropis greenei*).

# Fishes of Nearby Basins of the White River System

Approximately 26,000 individuals were collected from sites outside the Buffalo River Basin in nearby basins of the White River system during the summers of 2001 and 2002. Collection methods included use of backpack, tote barge, and boat electrofishing equipment and seines.

In 2001 and 2002, a total of 53 species (including both species of stonerollers) were collected from 11 sites outside the Buffalo River Basin (table 4). Sixteen species (assuming only one species of stonerollers) were collected from the one site in the Ozark National Forest (OB10, North Sylamore Creek near Big Flat).

The most ubiquitous species from sites outside the Buffalo River Basin were stonerollers, duskystripe shiners, rainbow darters, smallmouth bass (*Micropterus dolomieu*), longear sunfish, green sunfish, and slender madtoms. These species were collected at almost all sites. These species are found throughout the upper White River Basin (Robison and Buchanan, 1988; and Pflieger, 1997).

The species collected in the fewest samples from outside the Buffalo River Basin were the black crappie (*Pomoxis nigromaculatus*), white crappie (*Pomoxis annularis*), redear sunfish, longnose gar, channel catfish, steelcolor shiner, gizzard shad, river redhorse, and Ozark sculpin. Most of these species were represented by only a few individuals.

# Comparison of Fish Community Metrics By Site Type

Several fish community metrics varied among sites in three site groupings: (1) category types based on drainage area, basin land use, and location relative to the Buffalo River (mainstem, large tributary, small tributary, headwater, and developed out-of-basin sites), (2) pairings of specific Buffalo River Basin sites with specific sites in other, more developed, basins, and (3) pairings of sites near the mouth of Buffalo River tributaries with upstream satellite sites) (table 1). The groupings were selected to evaluate fish community differences related to environmental factors such as stream size, percentages of cleared land, road density, and proximity of tributary sites to the mainstem of the Buffalo River.

## Comparison of Site Categories Based on Drainage Area, Basin Land Use, and Location

Relative abundances of the three most common families in these streams (minnows, darters, and sunfish) generally were similar among the five site categories (fig. 3, table 5). Minnows were the most abundant family for all site categories; median relative abundance values for the site categories ranged from about 60 to 70 percent. Relative abundance of minnows tended to be lowest at mainstem sites and highest at headwater and developed out-of-basin sites; however, no statistically significant ($p<0.05$) difference was detected among the five categories. Darters generally were the next most abundant family for each of the site categories; median relative abundances of darters ranged from about 10 to 15 percent. No statistically significant difference in relative abundance of darters was detected among the five categories. Sunfish generally were the third most abundant family for each of the site categories; median relative abundances of sunfish ranged from about 7 to 15 percent, except at mainstem sites where the median was about 18 percent. The relative abundance of sunfish at mainstem sites was significantly higher than at all but large tributary sites. The relative abundances of sunfish at small tributary, headwater, and developed out-of-basin sites were significantly lower than at mainstem sites.

Relative abundance of stonerollers varied among sites in the site categories (fig. 3, table 5). Median relative abundances of stonerollers ranged from about 25 to 55 percent and were highest at headwater and developed out-of-basin sites and lowest at mainstem sites. The relative abundances at the headwater and developed out-of-basin sites were significantly different from the relative abundances at the mainstem sites. Relative abundances at the tributary sites were not significantly different from sites in either of the three other categories.

A previous investigation (Petersen, 1998) describing fish communities of Ozark streams (drainage areas ranging from 61 to 4,318 $km^2$ and most greater than 100 $km^2$) and their relations to selected environmental factors indicated that the relative abundance of stonerollers was related to several land-use and nutrient-related factors. Typically the relative abundance of stonerollers was greater at sites associated with agricultural or urban activities (where nutrient concentrations were elevated and the streams were less shaded). This finding was substantiated only partially by the results of the study described in this report; fish communities of the headwater sites had the highest median percentage of stonerollers even though mean concentrations of nitrite plus nitrate and orthophosphorus generally were less than 0.10 and 0.005 mg/L, respectively. This may be the result of the small drainage area of the headwater sites and presumably low secondary production of insects and other animal food sources in these streams. However, PINVER values at headwater sites were substantially different only from PINVER

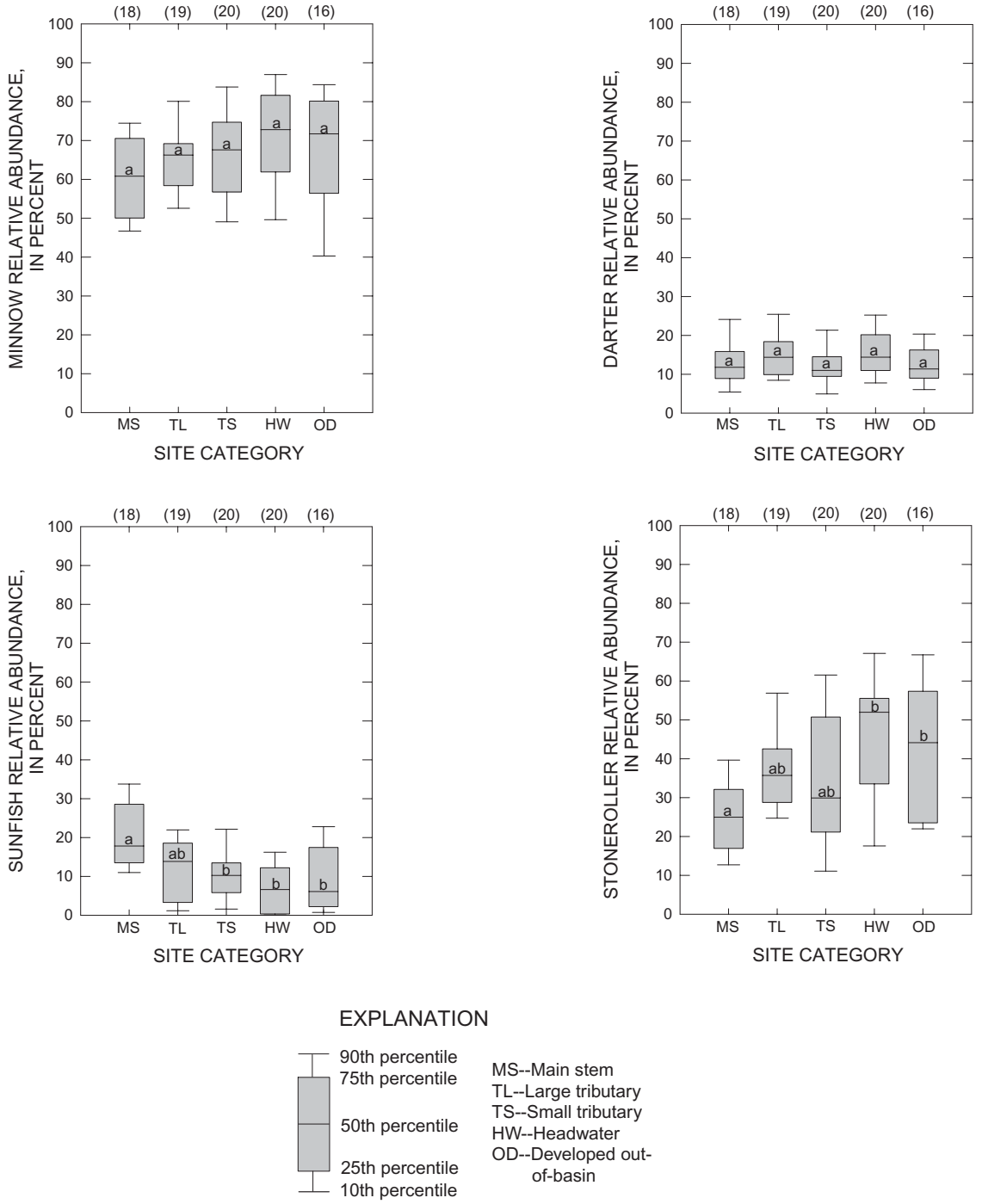



**Figure 3.** Distribution of relative abundance of minnows, darters, sunfish, and stonerollers by site category.

**Table 5.** Fish community metrics by site.

[PAHINP, percent algivorous/herbivorous, invertivorous, piscivorous individuals; PGBYCC, percent green sunfish, bluegills, yellow bullheads, and channel catfish; PINVER, percent invertivorous individuals; PTOPCA, percent top carnivores; NDASCM, number of darter, sculpin, and madtom species; NLITSP, number of lithophilic spawning species; IBI, index of biotic integrity; HW, headwaters; MS, mainstem; TS, small tributary, TL, large tributary; OD, developed out-of-basin]

| Site name | Site identifier | Sample date | Site category | Relative abundance | | | | PAHINP[1] | PGBYCC[1] | PINVER[1] | PTOPCA[1] | NDASCM[1] | NLITSP[1] | IBI score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Minnows (percent) | Sunfish (percent) | Darters (percent) | Stone-rollers (percent) | | | | | | | |
| Buffalo River at Dixon Ford near Fallsville | R0 | 06/25/01 | HW | 57.5 | 11.7 | 29.4 | 46.8 | 0.00 | 0.00 | 43.1 | 0.7 | 6 | 13 | 85 |
| Buffalo River at Dixon Ford near Fallsville | R0 | 06/20/02 | HW | 84.7 | 0.0 | 13.6 | 61.9 | 0.00 | 0.00 | 14.8 | 0.0 | 5 | 11 | 68 |
| Buffalo River near Boxley | R1 | 07/31/01 | MS | 72.4 | 10.8 | 9.4 | 51.1 | 0.16 | 1.25 | 21.7 | 1.3 | 7 | 18 | 83 |
| Buffalo River near Boxley | R1 | 08/07/02 | MS | 70.5 | 11.4 | 14.0 | 40.9 | 0.00 | 1.29 | 32.6 | 2.3 | 6 | 19 | 93 |
| Buffalo River near Ponca | R2 | 07/30/01 | MS | 50.0 | 13.5 | 25.4 | 17.9 | 0.09 | 0.94 | 47.5 | 4.2 | 9 | 24 | 100 |
| Buffalo River near Ponca | R2 | 07/23/02 | MS | 52.0 | 34.9 | 10.1 | 35.0 | 0.11 | 2.00 | 40.4 | 6.7 | 8 | 20 | 99 |
| Buffalo River near Pruitt | R3 | 08/03/01 | MS | 74.0 | 14.3 | 10.0 | 26.4 | 0.09 | 0.84 | 39.6 | 1.3 | 7 | 22 | 87 |
| Buffalo River near Pruitt | R3 | 06/27/02 | MS | 75.1 | 10.5 | 10.3 | 36.6 | 0.00 | 0.75 | 31.1 | 0.7 | 8 | 23 | 82 |
| Buffalo River near Hasty | R4 | 07/31/01 | MS | 65.6 | 18.1 | 13.3 | 16.9 | 0.24 | 1.85 | 54.8 | 4.1 | 8 | 23 | 91 |
| Buffalo River near Hasty | R4 | 07/15/02 | MS | 45.8 | 38.9 | 7.2 | 3.6 | 0.55 | 1.74 | 61.4 | 7.4 | 7 | 23 | 89 |
| Buffalo River near Woolum | R5 | 07/18/01 | MS | 59.4 | 20.2 | 15.9 | 32.1 | 0.00 | 0.99 | 40.3 | 3.7 | 7 | 23 | 90 |
| Buffalo River near Woolum | R5 | 07/16/02 | MS | 51.0 | 31.0 | 8.9 | 14.0 | 0.35 | 1.60 | 60.4 | 5.4 | 6 | 25 | 90 |
| Buffalo River at Shine Eye near Gilbert | R6 | 07/18/01 | MS | 62.3 | 12.6 | 21.1 | 23.5 | 0.11 | 0.22 | 39.0 | 4.8 | 9 | 24 | 94 |
| Buffalo River at Shine Eye near Gilbert | R6 | 07/17/02 | MS | 53.6 | 21.8 | 8.0 | 12.2 | 0.25 | 0.25 | 40.9 | 10.5 | 7 | 23 | 91 |
| Buffalo River at Highway 14 near Harriet | R7 | 07/20/01 | MS | 46.6 | 28.6 | 15.9 | 16.6 | 0.16 | 0.55 | 49.2 | 7.5 | 7 | 24 | 91 |
| Buffalo River at Highway 14 near Harriet | R7 | 09/13/02 | MS | 65.1 | 15.2 | 14.2 | 27.4 | 0.26 | 0.57 | 32.4 | 4.1 | 10 | 26 | 94 |
| Buffalo River near Rush | R8 | 07/26/01 | MS | 68.9 | 23.6 | 4.7 | 29.5 | 0.00 | 0.69 | 31.7 | 4.6 | 6 | 21 | 85 |
| Buffalo River near Rush | R8 | 07/18/02 | MS | 74.6 | 17.5 | 2.7 | 21.1 | 0.15 | 1.07 | 29.4 | 3.4 | 5 | 21 | 82 |
| Buffalo River near mouth near Buffalo City | R9 | 07/24/01 | MS | 48.5 | 16.8 | 26.1 | 26.7 | 0.80 | 0.93 | 51.6 | 6.0 | 7 | 23 | 89 |
| Buffalo River near mouth near Buffalo City | R9 | 07/12/02 | MS | 46.8 | 28.6 | 14.0 | 22.1 | 1.66 | 1.83 | 44.2 | 10.0 | 7 | 23 | 87 |
| Beech Creek near mouth near Boxley | T1 | 06/19/01 | TS | 77.0 | 7.5 | 11.5 | 55.6 | 0.00 | 0.39 | 19.9 | 1.0 | 6 | 15 | 81 |
| Beech Creek near mouth near Boxley | T1 | 06/20/02 | TS | 74.9 | 10.4 | 12.8 | 52.7 | 0.00 | 0.00 | 23.1 | 0.7 | 5 | 12 | 77 |

**Table 5.** Fish community metrics by site.—Continued

[PAHINP, percent algivorous/herbivorous, invertivorous, piscivorous individuals; PGBYCC, percent green sunfish, bluegills, yellow bullheads, and channel catfish; PINVER, percent invertivorous individuals; PTOPCA, percent top carnivores; NDASCM, number of darter, sculpin, and madtom species; NLITSP, number of lithophilic spawning species; IBI, index of biotic integrity; HW, headwaters; MS, mainstem; TS, small tributary, TL, large tributary; OD, developed out-of-basin]

| Site name | Site identifier | Sample date | Site category | Relative abundance | | | | PAHINP[1] | PGBYCC[1] | PINVER[1] | PTOPCA[1] | NDASCM[1] | NLITSP[1] | IBI score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Minnows (percent) | Sunfish (percent) | Darters (percent) | Stone-rollers (percent) | | | | | | | |
| Ponca Creek near mouth near Ponca | T2 | 07/31/01 | TS | 67.6 | 10.3 | 12.6 | 58.2 | 0.15 | 10.12 | 20.7 | 0.1 | 6 | 11 | 65 |
| Ponca Creek near mouth near Ponca | T2 | 06/25/02 | TS | 44.4 | 19.6 | 26.7 | 22.4 | 0.00 | 19.57 | 34.4 | 0.0 | 5 | 10 | 63 |
| Cecil Creek near mouth near Erbie | T3 | 06/20/01 | TS | 74.0 | 13.8 | 8.2 | 44.3 | 0.36 | 1.08 | 32.6 | 2.5 | 6 | 18 | 94 |
| Cecil Creek near mouth near Erbie | T3 | 06/24/02 | TS | 67.6 | 4.6 | 21.6 | 23.7 | 0.16 | 0.64 | 28.7 | 1.4 | 7 | 19 | 87 |
| Mill Creek near mouth near Pruitt | T4 | 08/01/01 | TS | 62.2 | 20.6 | 10.4 | 8.0 | 0.42 | 0.56 | 34.3 | 3.4 | 4 | 16 | 94 |
| Mill Creek near mouth near Pruitt | T4 | 06/21/02 | TS | 56.0 | 9.0 | 21.0 | 18.0 | 0.00 | 0.00 | 31.5 | 3.0 | 5 | 15 | 96 |
| Little Buffalo River near mouth near Pruitt | T5 | 08/02/01 | TL | 57.4 | 14.6 | 26.4 | 28.7 | 0.06 | 1.24 | 49.4 | 1.2 | 7 | 21 | 88 |
| Little Buffalo River near mouth near Pruitt | T5 | 08/19/02 | TL | 51.1 | 17.5 | 26.2 | 25.3 | 0.08 | 0.51 | 46.9 | 2.5 | 8 | 23 | 98 |
| East Fork Little Buffalo River near Murray | T5-HW | 06/23/01 | HW | 78.6 | 5.5 | 14.1 | 64.7 | 0.00 | 0.88 | 18.3 | 1.5 | 4 | 11 | 75 |
| East Fork Little Buffalo River near Murray | T5-HW | 06/19/02 | HW | 67.7 | 8.3 | 21.7 | 52.5 | 0.00 | 0.46 | 27.6 | 3.7 | 3 | 8 | 80 |
| Big Creek near mouth near Carver | T6 | 08/07/01 | TL | 69.3 | 22.2 | 5.3 | 32.5 | 0.00 | 1.98 | 31.3 | 0.9 | 8 | 24 | 84 |
| Big Creek near mouth near Carver | T6 | 07/24/02 | TL | 58.0 | 20.2 | 14.4 | 28.9 | 0.10 | 3.77 | 33.5 | 1.7 | 8 | 22 | 88 |
| Big Creek near Vendor | T6-S | 08/08/01 | Satellite | 50.2 | 41.0 | 6.1 | 23.5 | 0.00 | 0.20 | 49.9 | 5.8 | 5 | 19 | 95 |
| Big Creek near Vendor | T6-S | 07/23/02 | Satellite | 58.7 | 24.5 | 12.6 | 14.8 | 0.00 | 0.60 | 40.8 | 5.1 | 7 | 21 | 100 |
| Left Fork Big Creek near Red Rock | T6-HW1 | 06/25/01 | HW | 86.0 | 5.6 | 7.7 | 30.1 | 0.00 | 3.50 | 10.5 | 0.0 | 3 | 8 | 55 |
| Left Fork Big Creek near Red Rock | T6-HW1 | 06/19/02 | HW | 87.4 | 0.4 | 11.6 | 51.4 | 0.00 | 0.38 | 12.3 | 0.0 | 3 | 6 | 55 |
| Big Creek near Mt. Judea | T6-HW2 | 07/26/01 | HW | 70.8 | 12.2 | 7.8 | 69.5 | 0.15 | 1.31 | 20.2 | 2.0 | 4 | 10 | 78 |
| Big Creek near Mt. Judea | T6-HW2 | 06/25/02 | HW | 66.0 | 12.2 | 16.9 | 55.0 | 0.00 | 1.79 | 35.6 | 1.1 | 6 | 17 | 87 |
| Davis Creek near mouth near Mt. Hersey | T7 | 08/03/01 | TL | 68.9 | 2.7 | 15.0 | 21.2 | 0.00 | 0.00 | 21.0 | 0.3 | 7 | 16 | 77 |

**Table 5.** Fish community metrics by site.—Continued

[PAHINP, percent algivorous/herbivorous, invertivorous, piscivorous individuals; PGBYCC, percent green sunfish, bluegills, yellow bullheads, and channel catfish; PINVER, percent invertivorous individuals; PTOPCA, percent top carnivores; NDASCM, number of darter, sculpin, and madtom species; NLITSP, number of lithophilic spawning species; IBI, index of biotic integrity; HW, headwaters; MS, mainstem; TS, small tributary, TL, large tributary; OD, developed out-of-basin]

| Site name | Site identifier | Sample date | Site category | Relative abundance | | | | PAHINP[1] | PGBYCC[1] | PINVER[1] | PTOPCA[1] | NDASCM[1] | NLITSP[1] | IBI score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Minnows (percent) | Sunfish (percent) | Darters (percent) | Stone-rollers (percent) | | | | | | | |
| Davis Creek near mouth near Mt. Hersey | T7 | 07/22/02 | TL | 60.2 | 2.4 | 22.8 | 28.6 | 0.00 | 0.23 | 25.5 | 0.0 | 8 | 14 | 76 |
| Cave Creek near mouth near Mt. Hersey | T8 | 08/08/01 | TL | 66.5 | 13.9 | 17.0 | 35.4 | 0.00 | 0.00 | 41.0 | 1.5 | 6 | 19 | 92 |
| Cave Creek near mouth near Mt. Hersey | T8 | 07/26/02 | TL | 46.5 | 22.2 | 24.2 | 24.3 | 0.43 | 0.72 | 50.9 | 2.7 | 8 | 22 | 99 |
| Cave Creek near Woolum | T8-S | 08/01/01 | Satellite | 67.0 | 20.2 | 9.3 | 38.7 | 0.10 | 0.38 | 34.9 | 2.1 | 6 | 18 | 94 |
| Cave Creek near Woolum | T8-S | 07/24/02 | Satellite | 70.1 | 11.6 | 12.7 | 50.2 | 0.00 | 0.09 | 29.1 | 0.6 | 7 | 20 | 82 |
| Cave Creek near Bass | T8-HW | 07/25/01 | HW | 86.5 | 0.3 | 12.5 | 75.1 | 0.00 | 0.28 | 13.2 | 0.0 | 5 | 8 | 64 |
| Cave Creek near Bass | T8-HW | 08/01/02 | HW | 91.7 | 0.2 | 6.8 | 49.2 | 0.00 | 0.10 | 7.6 | 0.0 | 4 | 11 | 62 |
| Richland Creek near mouth near Eula | T9 | 07/13/01 | TL | 63.6 | 2.2 | 13.3 | 39.6 | 0.47 | 1.10 | 20.4 | 0.8 | 4 | 18 | 70 |
| Richland Creek near Ben Hur | T9-HW1 | 08/06/01 | HW | 76.8 | 5.8 | 11.8 | 53.2 | 0.14 | 2.89 | 20.1 | 0.1 | 3 | 9 | 59 |
| Richland Creek near Ben Hur | T9-HW1 | 07/25/02 | HW | 58.4 | 7.4 | 20.1 | 36.6 | 0.00 | 3.36 | 37.2 | 1.0 | 3 | 8 | 70 |
| Richland Creek near Witts Springs | T9-HW2 | 06/28/01 | HW | 67.1 | 13.9 | 14.9 | 45.1 | 0.00 | 1.22 | 28.5 | 2.2 | 3 | 11 | 78 |
| Richland Creek near Witts Springs | T9-HW2 | 08/21/02 | HW | 78.4 | 3.3 | 14.6 | 55.7 | 0.00 | 0.21 | 20.8 | 1.2 | 4 | 14 | 75 |
| Falling Water Creek near Witts Springs | T9-HW3 | 06/29/01 | HW | 42.7 | 39.2 | 9.0 | 11.1 | 2.51 | 13.07 | 49.2 | 2.5 | 4 | 13 | 80 |
| Falling Water Creek near Witts Springs | T9-HW3 | 07/25/02 | HW | 65.4 | 18.5 | 10.3 | 30.5 | 0.00 | 1.65 | 29.2 | 4.9 | 5 | 13 | 92 |
| Calf Creek near mouth near Silver Hill | T10 | 06/21/01 | TL | 83.8 | 0.4 | 9.8 | 73.3 | 0.00 | 0.00 | 11.5 | 0.2 | 6 | 19 | 73 |
| Calf Creek near mouth near Silver Hill | T10 | 07/22/02 | TL | 70.8 | 0.5 | 15.8 | 53.4 | 0.00 | 0.00 | 17.9 | 0.3 | 7 | 20 | 76 |
| Mill Creek near mouth near Silver Hill | T11 | 06/22/01 | TS | 78.5 | 1.8 | 3.9 | 28.0 | 0.00 | 0.00 | 17.1 | 0.4 | 3 | 16 | 70 |
| Mill Creek near mouth near Silver Hill | T11 | 06/29/02 | TS | 72.4 | 2.0 | 12.9 | 46.3 | 0.00 | 0.00 | 16.9 | 0.0 | 6 | 16 | 74 |
| Bear Creek near mouth near Gilbert | T12 | 07/12/01 | TL | 54.7 | 21.7 | 18.6 | 35.7 | 0.00 | 0.00 | 43.3 | 4.9 | 7 | 22 | 100 |

**Table 5.** Fish community metrics by site.—Continued

[PAHINP, percent algivorous/herbivorous, invertivorous, piscivorous individuals; PGBYCC, percent green sunfish, bluegills, yellow bullheads, and channel catfish; PINVER, percent invertivorous individuals; PTOPCA, percent top carnivores; NDASCM, number of darter, sculpin, and madtom species; NLITSP, number of lithophilic spawning species; IBI, index of biotic integrity; HW, headwaters; MS, mainstem; TS, small tributary, TL, large tributary; OD, developed out-of-basin]

| Site name | Site identifier | Sample date | Site category | Relative abundance | | | | PAHINP[1] | PGBYCC[1] | PINVER[1] | PTOPCA[1] | NDASCM[1] | NLITSP[1] | IBI score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Minnows (percent) | Sunfish (percent) | Darters (percent) | Stone-rollers (percent) | | | | | | | |
| Bear Creek near mouth near Gilbert | T12 | 08/08/02 | TL | 67.8 | 15.8 | 10.1 | 42.8 | 0.37 | 0.91 | 31.9 | 1.7 | 11 | 27 | 90 |
| Bear Creek near Welcome Home | T12-HW | 06/27/01 | HW | 74.8 | 0.1 | 23.0 | 55.4 | 0.00 | 0.00 | 28.7 | 0.0 | 5 | 11 | 74 |
| Bear Creek near Welcome Home | T12-HW | 07/30/02 | HW | 77.4 | 0.0 | 18.8 | 54.4 | 0.00 | 0.00 | 26.4 | 0.0 | 5 | 10 | 72 |
| Brush Creek near mouth near Gilbert | T13 | 07/16/01 | TS | 89.4 | 1.4 | 5.0 | 64.9 | 0.00 | 0.12 | 9.1 | 0.0 | 4 | 12 | 64 |
| Brush Creek near mouth near Gilbert | T13 | 06/28/02 | TS | 89.0 | 1.1 | 4.9 | 72.4 | 0.00 | 0.00 | 6.6 | 0.0 | 7 | 12 | 66 |
| Tomahawk Creek near mouth near Tomahawk | T14 | 08/10/01 | TL | 67.8 | 8.2 | 13.3 | 33.5 | 0.00 | 0.10 | 27.0 | 1.7 | 9 | 23 | 88 |
| Tomahawk Creek near mouth near Tomahawk | T14 | 07/19/02 | TL | 74.5 | 9.0 | 9.0 | 51.5 | 0.31 | 0.39 | 18.7 | 2.1 | 9 | 25 | 87 |
| Water Creek near mouth near Evening Star | T15 | 08/21/01 | TL | 84.9 | 5.0 | 8.6 | 59.2 | 0.00 | 0.00 | 18.1 | 0.9 | 10 | 25 | 80 |
| Water Creek near mouth near Evening Star | T15 | 07/08/02 | TL | 59.6 | 14.1 | 8.3 | 40.4 | 0.64 | 0.64 | 29.8 | 1.9 | 7 | 21 | 90 |
| Water Creek near Maumee | T15-S | 08/09/01 | Satellite | 80.6 | 5.1 | 8.2 | 30.1 | 0.00 | 0.00 | 20.9 | 3.3 | 5 | 17 | 89 |
| Water Creek near Maumee | T15-S | 08/22/02 | Satellite | 73.4 | 2.9 | 15.2 | 45.8 | 0.00 | 0.00 | 16.2 | 2.2 | 7 | 15 | 85 |
| Rush Creek near mouth near Rush | T16 | 07/25/01 | TS | 64.1 | 8.5 | 11.3 | 23.0 | 0.00 | 0.00 | 21.3 | 0.5 | 5 | 13 | 76 |
| Rush Creek near mouth near Rush | T16 | 08/23/02 | TS | 39.8 | 7.0 | 17.7 | 13.4 | 0.00 | 0.00 | 24.7 | 0.0 | 5 | 9 | 70 |
| Clabber Creek near mouth near Rush | T17 | 07/27/01 | TS | 72.8 | 13.2 | 10.7 | 48.7 | 0.00 | 0.29 | 25.1 | 2.0 | 9 | 21 | 89 |
| Clabber Creek near mouth near Rush | T17 | 08/23/02 | TS | 74.5 | 12.1 | 9.2 | 39.1 | 0.14 | 0.14 | 23.6 | 2.2 | 7 | 18 | 89 |
| Clabber Creek near Rush | T17-S | 08/09/01 | Satellite | 65.7 | 15.2 | 13.5 | 37.4 | 0.00 | 0.44 | 30.2 | 4.6 | 6 | 15 | 96 |
| Clabber Creek near Rush | T17-S | 08/28/02 | Satellite | 74.5 | 8.5 | 12.8 | 44.8 | 0.15 | 0.31 | 24.7 | 1.9 | 7 | 18 | 88 |
| Big Creek near mouth near Cozahome | T18 | 07/10/01 | TL | 66.2 | 18.9 | 12.7 | 41.7 | 0.35 | 0.58 | 30.2 | 3.6 | 7 | 18 | 92 |
| Big Creek near mouth near Cozahome | T18 | 07/10/02 | TL | 59.8 | 13.6 | 17.6 | 37.1 | 0.67 | 1.34 | 35.9 | 1.8 | 9 | 20 | 91 |

**Table 5.** Fish community metrics by site.—Continued

[PAHINP, percent algivorous/herbivorous, invertivorous, piscivorous individuals; PGBYCC, percent green sunfish, bluegills, yellow bullheads, and channel catfish; PINVER, percent invertivorous individuals; PTOPCA, percent top carnivores; NDASCM, number of darter, sculpin, and madtom species; NLITSP, number of lithophilic spawning species; IBI, index of biotic integrity; HW, headwaters; MS, mainstem; TS, small tributary, TL, large tributary; OD, developed out-of-basin]

| Site name | Site identifier | Sample date | Site category | Relative abundance | | | | PAHINP[1] | PGBYCC[1] | PINVER[1] | PTOPCA[1] | NDASCM[1] | NLITSP[1] | IBI score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Minnows (percent) | Sunfish (percent) | Darters (percent) | Stone-rollers (percent) | | | | | | | |
| Middle Creek near mouth near Big Flat | T23 | 07/11/01 | TS | 56.1 | 25.1 | 9.9 | 8.8 | 0.00 | 1.17 | 40.9 | 5.8 | 6 | 11 | 95 |
| Middle Creek near mouth near Big Flat | T23 | 07/11/02 | TS | 57.4 | 10.2 | 9.7 | 31.8 | 0.57 | 2.27 | 27.8 | 1.1 | 6 | 17 | 83 |
| Leatherwood Creek near mouth near Advance | T24 | 07/11/01 | TS | 53.8 | 23.6 | 16.0 | 19.8 | 0.94 | 4.72 | 44.3 | 0.0 | 4 | 12 | 72 |
| Leatherwood Creek near mouth near Advance | T24 | 07/11/02 | TS | 61.6 | 13.2 | 10.0 | 24.7 | 0.00 | 4.74 | 28.9 | 2.1 | 5 | 13 | 86 |
| Hock Creek near Wesley | OB1 | 08/15/01 | OD | 83.8 | 0.3 | 9.2 | 63.4 | 0.00 | 0.05 | 14.9 | 0.1 | 7 | 15 | 74 |
| Hock Creek near Wesley | OB1 | 06/26/02 | OD | 84.4 | 1.4 | 8.8 | 67.1 | 0.13 | 0.65 | 12.1 | 0.3 | 5 | 14 | 72 |
| Kings River near Kingston | OB2 | 08/14/01 | OD[2] | 73.6 | 8.3 | 12.3 | 32.5 | 0.36 | 0.93 | 27.2 | 0.3 | 7 | 21 | 79 |
| Kings River near Kingston | OB2 | 06/26/02 | OD[1] | 68.5 | 11.6 | 12.4 | 53.4 | 0.80 | 2.39 | 23.9 | 3.2 | 6 | 16 | 90 |
| Osage Creek near Berryville | OB3 | 08/13/01 | OD | 70.9 | 4.7 | 17.2 | 47.4 | 0.16 | 0.60 | 34.3 | 0.7 | 9 | 24 | 85 |
| Osage Creek near Berryville | OB3 | 08/20/02 | OD | 82.6 | 3.0 | 10.9 | 69.7 | 0.30 | 0.39 | 16.5 | 0.6 | 9 | 22 | 77 |
| Yocum Creek near Oak Grove | OB4 | 08/15/01 | OD | 61.5 | 18.7 | 11.9 | 21.9 | 1.90 | 7.77 | 21.2 | 6.0 | 8 | 20 | 84 |
| Yocum Creek near Oak Grove | OB4 | 08/05/02 | OD | 29.8 | 16.2 | 35.7 | 10.3 | 1.84 | 4.78 | 42.6 | 6.3 | 7 | 13 | 91 |
| Long Creek near Denver | OB5 | 08/17/01 | OD | 72.5 | 5.8 | 9.6 | 22.8 | 1.68 | 2.99 | 14.6 | 3.1 | 6 | 22 | 83 |
| Long Creek near Denver | OB5 | 09/10/02 | OD | 55.6 | 13.6 | 15.3 | 23.6 | 2.63 | 2.83 | 27.3 | 4.3 | 9 | 23 | 89 |
| Huzzah Creek near Olvey | OB6 | 08/16/01 | OD | 84.8 | 6.4 | 5.3 | 57.1 | 0.10 | 0.17 | 16.1 | 0.7 | 4 | 14 | 73 |
| Huzzah Creek near Olvey | OB6 | 08/26/02 | OD | 76.5 | 5.3 | 11.8 | 49.5 | 0.34 | 0.67 | 17.5 | 0.8 | 5 | 17 | 78 |
| Clear Creek near Pyatt | OB7 | 08/16/01 | OD | 57.3 | 23.0 | 7.4 | 28.3 | 0.00 | 3.50 | 37.4 | 4.3 | 7 | 22 | 97 |
| Clear Creek near Pyatt | OB7 | 09/17/02 | OD | 54.1 | 21.1 | 10.1 | 26.5 | 1.05 | 6.14 | 30.9 | 3.5 | 6 | 21 | 88 |
| Hampton Creek near Eros | OB8 | 08/22/01 | OD | 73.3 | 0.7 | 12.1 | 55.8 | 0.00 | 0.25 | 13.6 | 0.4 | 5 | 14 | 73 |
| Hampton Creek near Eros | OB8 | 08/22/02 | OD | 60.5 | 1.0 | 18.4 | 40.9 | 0.41 | 0.55 | 19.5 | 0.4 | 5 | 15 | 77 |
| Crooked Creek near Summit | OB9 | 07/23/01 | OD | 38.7 | 26.4 | 20.5 | 23.4 | 2.33 | 2.58 | 48.8 | 8.6 | 9 | 21 | 87 |
| Crooked Creek near Summit | OB9 | 09/18/02 | OD | 77.7 | 7.8 | 5.9 | 57.6 | 0.00 | 0.12 | 17.8 | 2.0 | 10 | 22 | 81 |
| North Sylamore Creek near Big Flat | OB10 | 08/20/01 | HW | 56.5 | 13.9 | 20.2 | 23.9 | 0.00 | 0.00 | 34.3 | 5.3 | 5 | 13 | 92 |
| North Sylamore Creek near Big Flat | OB10 | 07/17/02 | HW | 40.6 | 11.2 | 27.4 | 11.2 | 0.00 | 0.00 | 40.9 | 6.3 | 5 | 13 | 94 |

[1]Metrics used in an IBI developed for the Ozarks by Dauwalter and others, 2003.

[2]Site was not included in OD group for boxplots and multiple comparison tests because of relatively low percent of cleared land in its basin.

values at mainstem sites. Other explanations for the high relative abundance of stonerollers at headwater sites may be the relatively high percentage of bedrock substrate that may provide a good substrate for periphyton attachment at the headwater sites and the presence of fewer top carnivores at the headwater sites. Fish communities of the developed out-of-basin sites had the second highest median percentage of stonerollers. However, relative abundances of stonerollers at individual developed out-of-basin sites often were lower than relative abundances of stonerollers at sites in other categories.

Several other fish community metrics used to calculate an IBI (Dauwalter and others, 2003) varied among the site categories (fig. 4, table 5). Median PAHINP values (a measure of omnivorous feeders) were less than about 0.3 percent and generally were similar among site types. The lowest median was for headwater sites and the highest median was for developed out-of-basin sites. Several of the PAHINP values at developed out-of-basin sites exceeded 1.0 percent. PAHINP values for headwater sites were significantly lower than values for mainstem and developed out-of-basin sites. Median PINVER values (percent invertivorous individuals) ranged from about 20 to 40 percent and were highest at mainstem sites and lowest at developed out-of-basin sites. PINVER values for mainstem sites were significantly higher than values at small tributary, headwater, and developed out-of-basin sites. Median PTOPCA values (percent top carnivores) ranged from about 1 to 4 percent and were highest at mainstem sites and lowest at the headwater and small tributary sites. PTOPCA values at mainstem sites were significantly higher than values at tributary and headwater sites. Median PGBYCC values (percent green sunfish, bluegills, yellow bullheads, and channel catfish) were less than 1 percent and were not significantly different among site categories. Values sometimes were substantially higher than 1 percent at some small tributary and developed out-of-basin sites. Median NDASCM values (number of darter, sculpin, and madtom species) ranged from 4 to 8 species and were lowest at the headwater and small tributary sites and highest at the large tributary sites. The NDASCM values at mainstem, large tributary, and developed out-of-basin sites were significantly higher than values at other sites, and the values at small tributary sites and headwater sites were each significantly different from values at the other four types of sites. Median NLITSP values (number of lithophilic spawning species) ranged from 11 to 23 species and were lowest at the headwater and small tributary sites and highest at the mainstem sites. Values for large tributary sites were not significantly different from values for mainstem and developed out-of-basin sites, but values for each of the site categories were significantly different from values for small tributary and mainstem sites.

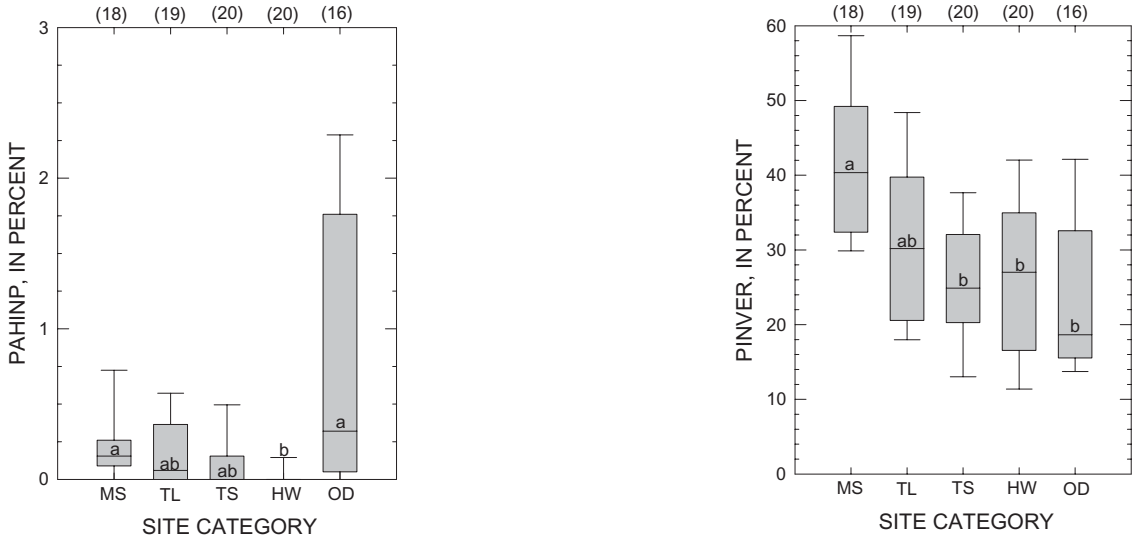
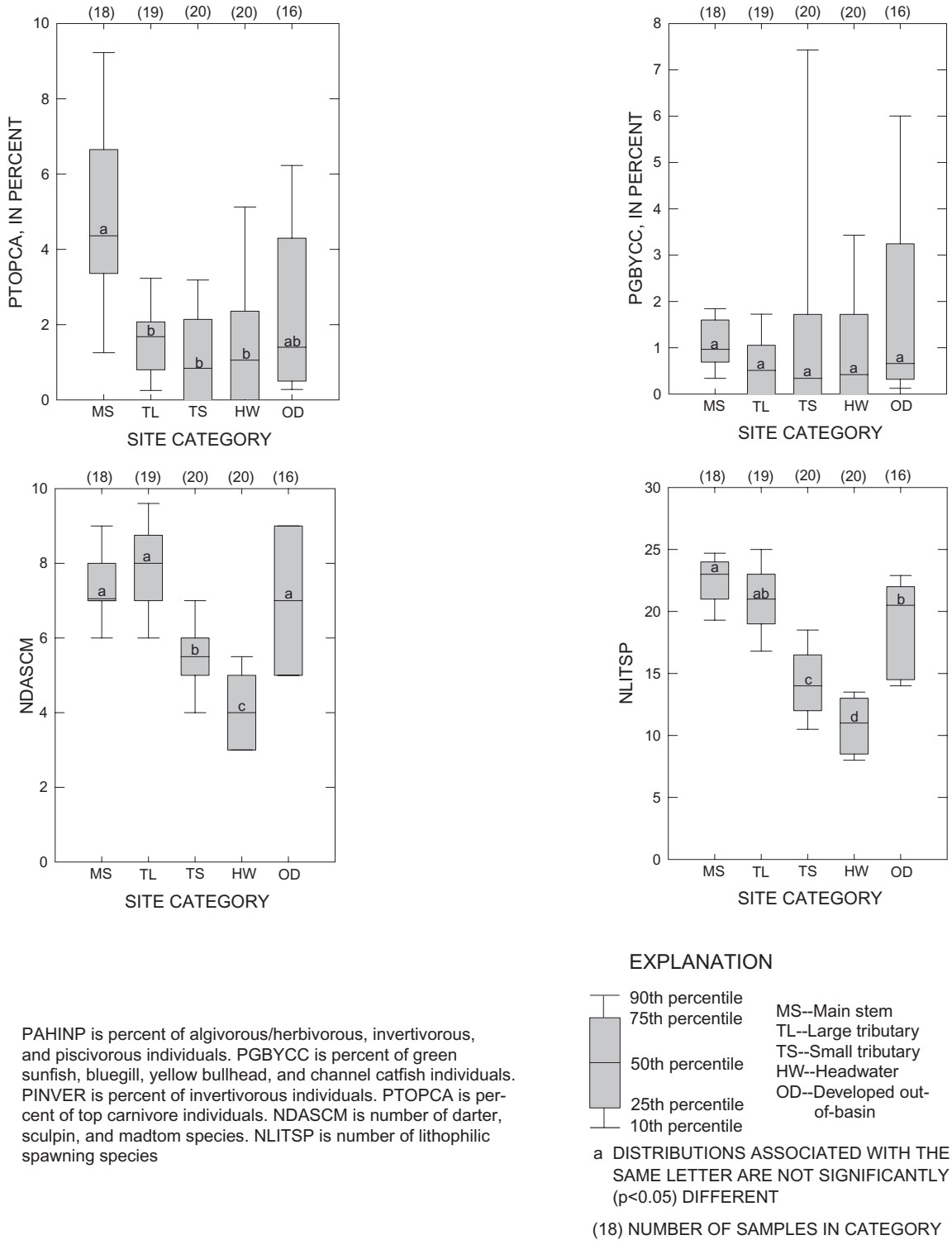



**Figure 4.** Distribution of metrics related to index of biotic integrity by site category.




PAHINP is percent of algivorous/herbivorous, invertivorous, and piscivorous individuals. PGBYCC is percent of green sunfish, bluegill, yellow bullhead, and channel catfish individuals. PINVER is percent of invertivorous individuals. PTOPCA is percent of top carnivore individuals. NDASCM is number of darter, sculpin, and madtom species. NLITSP is number of lithophilic spawning species

**Figure 4.** Distribution of metrics related to index of biotic integrity by site category.—Continued

Median IBI scores varied among the five site categories (fig. 5, table 5). Median scores ranged from about 75 at headwater sites to 90 at mainstem sites. At least half of the mainstem, large tributary, small tributary, and developed out-of-basin sites had scores of 80 or more (reference classification) for samples in at least one year. Scores for mainstem sites were significantly larger than all but large tributary site scores. Scores for headwater sites were significantly smaller than mainstem and large tributary site scores. Scores for two headwater sites were less than 60 (fair classification). Scores at the developed out-of-basin sites (where percentages of cleared land typically exceeded 35 percent and road density typically exceeded 0.0011 $m/m^2$) were not significantly different from scores from sites in the large tributary category (with similar sized drainage areas) or from scores from sites from most other categories.

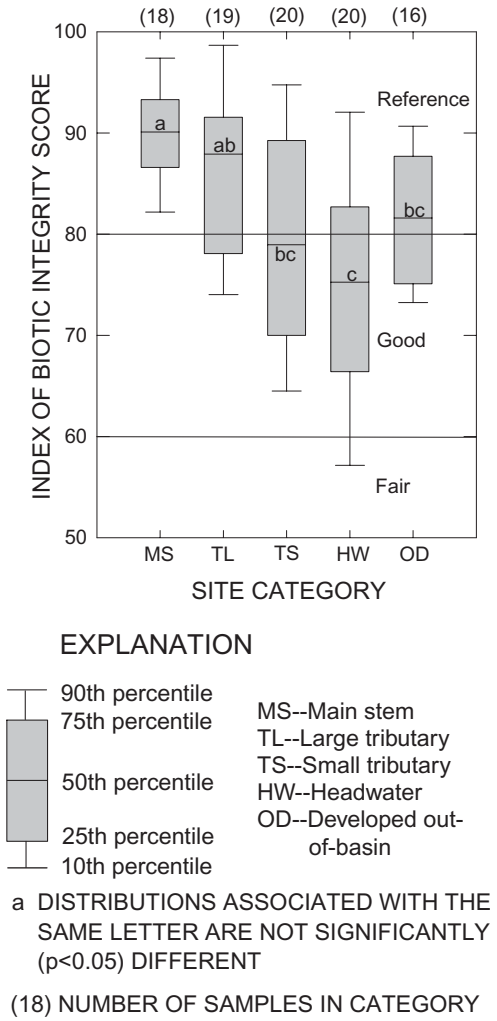



**Figure 5.** Distribution of index of biotic integrity values by site category.

The lower scores at headwater sites may be influenced by the use of an IBI developed for the Ozark Highlands for evaluation of sites that are in the Boston Mountains. Only one of the headwater sites (OB10, North Sylamore Creek near Big Flat) is in the Ozark Highlands; it had the highest mean IBI score of the headwater sites. The metrics that had the largest effect on the low IBI scores of headwater sites were PTOPCA and PINVER.

## Comparison of Buffalo River Basin Sites and Paired Out-of-Basin Sites

Nine developed out-of-basin sites were compared to selected sites in the Buffalo River Basin; the sites were paired based on similarity of drainage area (table 6). The proportion of cleared land was substantially greater at developed out-of-basin sites than at the associated Buffalo River Basin sites. Comparisons were based on selected fish community metrics.

Comparison of two measures of trophic function between communities of the paired sites suggests differences between the two types of sites (table 6). Although PAHINP values at the developed out-of-basin site generally were slightly higher than the values at the associated paired Buffalo River Basin sites, the values were usually less than 1 percent and usually did not differ from the Buffalo River Basin sites by more than 0.1 to 0.2 percent. Somewhat higher PAHINP values occurred at Long Creek and Yocum Creek, both of which are upstream from Table Rock Lake (fig. 1). PINVER generally was lower at the developed out-of-basin sites than at the associated Buffalo River sites. The greatest difference was between Long Creek and Buffalo River near Ponca. However, little difference occurred at some sites (for example, Kings River and Buffalo River near Boxley—the Kings River site has a relatively low percentage of cleared land in its basin compared to other developed out-of-basin sites).

Four taxonomic metrics that were used to compare paired sites indicate that structural differences between communities of the developed out-of-basin sites and Buffalo River Basin sites are not consistent (table 6). Within most pairs, the percentages of darters were similar. For three site pairs (Hock Creek and Buffalo River at Dixon Ford near Fallsville, Huzzah Creek and Buffalo River at Dixon Ford near Fallsville and Buffalo River near Boxley, Clear Creek and Buffalo River near Ponca), the percentage of darters at developed out-of-basin sites was less than at the paired sites. The percentage of darters was higher at Osage Creek than at Buffalo River near Pruitt. The NDASCM values at the Buffalo River Basin sites within a pair were consistently higher (by one to three species) only at Buffalo River near Ponca (relative to Clear Creek) and Buffalo River at Dixon Ford near Fallsville and Buffalo River near Boxley (relative to Huzzah Creek). At other pairs of sites, the NDASCM value was similar among the pair, or the value was slightly higher at the developed out-of-basin site. The PGBYCC value at about half (four of nine) of the developed out-of-basin sites was higher than at the associated sites in the Buffalo River Basin; at most of these out-of-basin sites the value exceeded

**Table 6.** Comparison of fish community metrics for paired Buffalo River Basin sites and developed out-of-basin sites.

[$km^2$, square kilometers; PAHINP, percent algivorous/herbivorous, invertivorous, piscivorous individuals; PINVER, percent invertivorous individuals; PGBYCC, percent green sunfish, bluegills, yellow bullheads, and channel catfish; NDASCM, number of darter, sculpin, and madtom species; IBI, index of biotic integrity]

| Site ID | Site name | Drainage area ($km^2$) | Cleared land (percent) | PAHINP[1] | PINVER[1] | PGBYCC[1] | NDASCM[1] | Relative abundance | | IBI scores |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Darters (percent)[1] | Stonerollers (percent)[1] | |
| OB1 | Hock Creek near Wesley | 41 | 32 | 0.0-0.1 | 12-15 | 0.1-0.6 | 5-7 | 8.8-9.2 | 63-67 | 72-74 |
| R0 | Buffalo River at Dixon Ford near Fallsville | 51 | 3 | 0.0-0.0 | 15-43 | 0.0-0.0 | 5-6 | 13.6-29.4 | 47-62 | 68-85 |
| OB8 | Hampton Creek near Eros | 57 | 45 | 0.0-0.4 | 14-19 | 0.2-0.6 | 5-5 | 12.1-18.4 | 41-56 | 73-77 |
| T5-HW | East Fork Little Buffalo River near Murray | 58 | 6 | 0.0-0.0 | 18-28 | 0.5-0.9 | 3-4 | 14.1-21.7 | 52-65 | 75-80 |
| OB6 | Huzzah Creek near Olvey | 63 | 83 | 01.-0.3 | 16-17 | 0.2-0.7 | 4-5 | 5.3-11.8 | 49-54 | 73-78 |
| R0 | Buffalo River at Dixon Ford near Fallsville | 51 | 3 | 0.0-0.0 | 15-43 | 0.0-0.0 | 5-6 | 13.6-29.4 | 47-62 | 68-85 |
| R1 | Buffalo River near Boxley | 150 | 4 | 0.0-0.2 | 22-33 | 1.2-1.3 | 6-7 | 9.4-14.0 | 41-51 | 83-93 |
| OB4 | Yocum Creek near Oak Grove | 134 | 72 | 1.8-1.9 | 21-43 | 4.8-7.8 | 7-8 | 11.9-35.7 | 10-22 | 84-91 |
| T8-S | Cave Creek near Woolum | 130 | 11 | 0.0-0.1 | 29-35 | 0.1-0.4 | 6-7 | 9.3-12.7 | 39-50 | 82-94 |
| R1 | Buffalo River near Boxley | 150 | 4 | 0.0-0.2 | 22-33 | 1.2-1.3 | 6-7 | 9.4-14.0 | 41-51 | 83-93 |
| OB2 | Kings River near Kingston | 162 | 14 | 0.4-0.8 | 24-27 | 0.9-2.4 | 6-7 | 12.3-12.4 | 32-53 | 79-90 |
| R1 | Buffalo River near Boxley | 150 | 4 | 0.0-0.2 | 22-33 | 1.2-1.3 | 6-7 | 9.4-14.0 | 41-51 | 83-93 |
| OB5 | Long Creek near Denver | 266 | 38 | 1.7-2.6 | 15-27 | 2.8-3.0 | 6-9 | 9.6-15.3 | 23-23 | 83-89 |
| R2 | Buffalo River near Ponca | 297 | 7 | 0.1-0.1 | 40-48 | 0.9-2.0 | 8-9 | 10.1-25.4 | 17-35 | 99-100 |
| OB7 | Clear Creek near Pyatt | 282 | 64 | 0.0-1.0 | 31-37 | 3.5-6.1 | 6-7 | 7.4-10.1 | 26-28 | 88-97 |
| R2 | Buffalo River near Ponca | 297 | 7 | 0.1-0.1 | 40-48 | 0.9-2.0 | 8-9 | 10.1-25.4 | 17-35 | 99-100 |
| OB3 | Osage Creek near Berryville | 380 | 29 | 0.2-0.3 | 17-34 | 0.4-0.6 | 8-9 | 10.9-17.2 | 47-70 | 77-85 |
| R3 | Buffalo River near Pruitt | 494 | 8 | 0.0-0.1 | 31-40 | 0.8-0.8 | 7-8 | 10.0-10.3 | 26-37 | 82-87 |
| OB9 | Crooked Creek near Summit | 1,037 | 51 | 0.0-2.3 | 18-49 | 0.1-2.6 | 9-10 | 5.9-20.5 | 23-41 | 81-87 |
| R4 | Buffalo River near Hasty | 984 | 9 | 0.2-0.6 | 55-61 | 1.7-1.8 | 7-8 | 7.2-13.0 | 4-17 | 89-91 |

[1]Values are ranges for 2001 and 2002 data.

about 2.5 percent. The percentage of stonerollers at three of the nine out-of-basin sites exceeded the percentage of stonerollers at the associated Buffalo River Basin sites. The greatest difference was at the two sets of sites with the largest basins, where percentages of stonerollers ranged from approximately 23 to 41 percent at Crooked Creek (compared to 4 to 17 percent at Buffalo River near Hasty) and approximately 47 to 70 percent at Osage Creek (compared to 26 to 37 percent at Buffalo River near Pruitt).

IBI scores generally were somewhat lower at the developed out-of-basin sites than at the associated Buffalo River Basin sites. For all but one group of sites, the mean IBI score was lower at the developed out-of-basin sites than at the Buffalo River Basin site. The mean IBI score for Yocum Creek was slightly higher than one paired site and slightly lower than the other paired site. For the other groups of sites, the difference in the mean IBI values ranged from 1.0 (Huzzah Creek and Buffalo River at Dixon Ford) to 13.5 (Long Creek and Buffalo River near Ponca) and typically was less than 4.0.

Regression models with the mean fish metrics as dependent variables and one or more of the other factors as independent variables indicate that drainage area and land-use related factors are important factors in determining fish community structure (table 7). For most fish metrics the logarithm of drainage area was a significant ($p<0.05$) independent variable in the regression model. Nutrient concentrations were significant variables in the regression model for PAHINP and PGBYCC. However, two of the three highest values of PGBYCC were at sites closest to reservoirs, suggesting that proximity to a downstream reservoir increases values of PGBYCC. For PINVER, Wilcoxon rank-sum tests of regression residuals indicated that residuals associated with developed out-of-basin sites were significantly different from residuals associated with the Buffalo River Basin sites, suggesting that the PINVER values are lower at sites with higher proportions of cleared land in their basin.

**Table 7.** Regression models of relation between fish community metrics and drainage area and land-use related factors.

[DA, drainage area; PAHINP, percent algivorous/herbivorous, invertivorous, piscivorous individuals; PGBYCC, percent green sunfish, bluegills, yellow bullheads, and channel catfish; PINVER, percent invertivorous individuals; PTOPCA, percent top carnivores; NDASCM, number of darter, sculpin, and madtom species; NLITSP, number of lithophilic spawning species; SR, percent of stonerollers; IBI, index of biotic integrity; $r^2$, correlation coefficient; NA, not applicable; NS, not significant]

| | Regression coefficients | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Metric | Log DA | DA | Cleared land in basin (percent) | Nitrite + nitrate | Ortho-phosphorus | Intercept | $r^2$ | Wilcoxon rank-sum test[1] (p-value) |
| PAHINP | 0.42 | - | - | 0.36 | 4.7 | -0.87 | 0.81 | NA |
| PGBYCC | - | - | - | 1.23 | - | 0.65 | 0.52 | NA |
| PINVER | 17.9 | - | - | - | - | -10.9 | 0.52 | 0.003 |
| PTOPCA | 3.38 | - | - | - | - | -5.12 | 0.39 | NS |
| NDASCM | 2.94 | - | - | - | - | 0.11 | 0.67 | NS |
| NLITSP | 8.34 | - | - | - | - | -0.31 | 0.77 | NS |
| SR | -23.1 | - | - | - | - | 92.3 | 0.40 | NS |
| IBI | 10.0 | - | - | - | - | 61.4 | 0.39 | NS |

[1]Tests for differences between regression model residuals associated with developed out-of-basin sites and paired Buffalo River Basin sites.

## Comparison of Tributary Sites and Satellite Sites

Many of the sites on tributaries of the Buffalo River were located within 700 meters of the confluence with the Buffalo River. Because of the proximity of these sites to the Buffalo River, it was suspected that the fish communities of these tributary sites were substantially influenced by the fish communities of the Buffalo River (Osborne and Wiley, 1992). Fish communities of four tributary sites (T6, T8, T15, and T17) were compared to associated satellite sites that were 1 to 6 km upstream from the tributary site using the percentage similarity index (PSC) and species richness to assess the effect of proximity to the Buffalo River on the fish communities. The fish communities of the tributary sites also were compared to the nearest sites on the mainstem of the Buffalo River.

Although the fish communities of the tributary sites often appear to be affected by the proximity of the Buffalo River, fish communities near the mouths of tributaries of the Buffalo River were not consistently more similar to fish communities of the Buffalo River than to fish communities of upstream satellite sites. Species richness of the tributary sites generally was greater than species richness of the upstream satellite sites but less than the species richness of nearby sites on the mainstem of the Buffalo River (table 8). Fish communities of sites near the mouths of Big Creek (T6) and Clabber Creek (T17) were substantially more similar to their associated satellite sites than to nearby sites on the mainstem of the Buffalo River (table 8). However, some samples from sites near the mouths of Cave Creek (T8) and Water Creek (T15) were more similar to the samples from the mainstem of the Buffalo River than to the satellite sites. PSC values for comparisons between the tributary sites and their associated satellite sites ranged from 61 to 84 percent, while PSC values for comparisons between the tributary sites and nearby mainstem sites ranged from 51 to 81 percent. Neither distance between the tributary site and the confluence with the Buffalo River (table 8) nor the ratio of drainage area of the tributary to the drainage area of the mainstem site appears to explain these inconsistent PSC results.

**Table 8.** Comparison of percent similarity index values and species richness between satellite sites and associated Buffalo River tributary and mainstem sites.

[PSC, percentage similarity index]

| Sites | PSC (percent) | Distance from tributary site to mouth of tributary (meters) | Ratio of the drainage area of the tributary to the drainage area of the mainstem site | Species richness | | |
|---|---|---|---|---|---|---|
| | | | | Satellite[1] | Tributary[1] | Mainstem[1] |
| Big Creek | | 1,400 | 0.23 | 26-29 | 29 | 32-34 |
| T6 and T6-S 2001 | 69 | | | | | |
| T6 and T6-S 2002 | 67 | | | | | |
| T6 and R4 2001 | 58 | | | | | |
| T6 and R4 2002 | 51 | | | | | |
| Cave Creek | | 300 | 0.09 | 25 | 24-29 | 29-34 |
| T8 and T8-S 2001 | 79 | | | | | |
| T8 and T8-S 2002 | 66 | | | | | |
| T8 and R5 2001 | 81 | | | | | |
| T8 and R5 2002 | 61 | | | | | |
| Water Creek | | 750 | 0.04 | 18-22 | 30 | 33-34 |
| T15 and T15-S 2001 | 61 | | | | | |
| T15 and T15-S 2002 | 61 | | | | | |
| T15 and R7 2001 | 48 | | | | | |
| T15 and R7 2002 | 70 | | | | | |
| Clabber Creek | | 600 | 0.02 | 20-24 | 24-26 | 30-33 |
| T17 and T17-S 2001 | 84 | | | | | |
| T17 and T17-S 2002 | 83 | | | | | |
| T17 and R8 2001 | 68 | | | | | |
| T17 and R8 2002 | 71 | | | | | |

[1]Values shown are ranges for 2001 and 2002.

# Relations between Fish Community Metrics and Selected Environmental Factors

Several fish community metrics were correlated with selected environmental factors. These factors included basin characteristics such as drainage area, land use (for example, cleared land proportion and road density), and geology, and reach characteristics such as width and depth, slope, substrate size, and water-quality constituent values.

Most of the metrics were strongly correlated with factors related to drainage area (table 9). Some metrics also were correlated with factors related to land use or geology, but these correlations usually were weaker (lower absolute value of rho) and often were not statistically significant.

As examples of the interaction of the influences of drainage area and land use on fish communities, the relations between drainage area and land use were examined in more detail for PINVER (percent invertivorous fish) and stoneroller relative abundance at a subset of sites composed of mainstem, large tributary, and developed out-of-basin category sites. Large tributary and developed out-of-basin sites were included in this comparison because of the similar drainage areas of sites in these categories (fig. 2).

Percentages of cleared land and PINVER were moderately and significantly correlated (rho= -0.50, p=0.0003). At mainstem sites (which generally had basins containing less than 15 percent cleared land) PINVER generally ranged from 30 to 60 percent, but at large tributary sites (which generally had basins containing 10 to 30 percent cleared land) PINVER generally ranged from about 10 to 50 percent. At developed out-of-basin sites (which generally had basins containing more than 30 percent cleared land) PINVER generally ranged from about 10 to 40 percent (sites with the largest PINVER percentages were the largest developed out-of-basin sites) (fig. 6). PINVER appeared to decrease among the similarly-sized large tributary and developed out-of-basin sites as cleared land percentages exceeded about 20 percent and then ceased to decrease as cleared land percentages increased beyond about 30 percent.

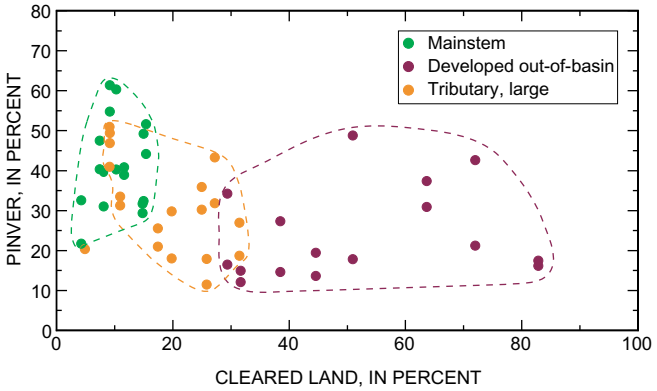



**Figure 6.** Relation between percent invertivores and percentage of cleared land in basin for mainstem, large tributary, and developed out-of-basin sites.

**Table 9.** Correlation between drainage area and other environmental factors

[NS, not significant (p>0.05); <, less than; GD16-GD84, 16th, 50th, and 84th percentile of particle size in glides; RD16-RD84, 16th, 50th, and 84th percentile of particle size in reach]

| Environmental factors | rho | p-value |
|---|---|---|
| Elevation range | 0.71 | <0.0001 |
| Drainage basin average slope | NS | NS |
| Carbonate rock | NS | NS |
| Cleared land | 0.22 | 0.03 |
| Cleared land in stream buffer | 0.46 | <0.0001 |
| Steep cleared land | 0.22 | 0.02 |
| Road density | NS | NS |
| Road density in stream buffer | 0.33 | <0.01 |
| Reach gradient | -0.83 | <0.0001 |
| Total residual pool length | NS | NS |
| Residual pool, proportion | 0.63 | <0.0001 |
| Average residual pool length | NS | NS |
| Average residual pool depth | 0.60 | <0.0001 |
| Pools, proportion | 0.47 | <0.0001 |
| Glides, proportion | NS | NS |
| Average bankfull width | 0.89 | <0.0001 |
| Average bankfull depth | 0.59 | <0.0001 |
| Wetted width | 0.86 | <0.0001 |
| Depth | 0.67 | <0.0001 |
| Velocity index | 0.33 | <0.01 |
| Reach sinuosity | -0.27 | <0.01 |
| Mud and sand along thalweg | NS | NS |
| Gravel along thalweg | NS | NS |
| Cobbles and boulders along thalweg | NS | NS |
| Thalweg embeddedness index | 0.48 | <0.0001 |
| Glide embeddedness | NS | NS |
| GD16 | NS | NS |
| GD50 | NS | NS |
| GD84 | -0.22 | 0.03 |
| RD16 | NS | NS |
| RD50 | NS | NS |
| RD84 | NS | NS |
| Bedrock | NS | NS |
| Glide sorting | NS | NS |
| Bank vegetation index | NS | NS |
| Eroding banks, severe | NS | NS |
| Eroding banks, moderate and severe | NS | NS |
| Open canopy angle | 0.70 | <0.0001 |
| Canopy cover | -0.51 | <0.0001 |
| Water temperature | 0.45 | <0.0001 |
| Specific conductance | NS | NS |
| pH | 0.29 | <0.01 |
| Dissolved oxygen | NS | NS |
| Turbidity | NS | NS |
| Fecal coliform bacteria | NS | NS |
| Ammonia | NS | NS |
| Nitrite plus nitrate | NS | NS |
| Orthophosphorus | NS | NS |

Drainage area and stoneroller relative abundance were moderately and significantly correlated (rho=-0.51, p=0.0003). At mainstem sites (which generally exceeded 500 km$^2$) stoneroller relative abundance generally ranged from 10 to 40 percent, but at large tributary sites (which generally were smaller than 500 km$^2$) stoneroller relative abundance generally ranged from about 20 to 60 percent (fig. 7).

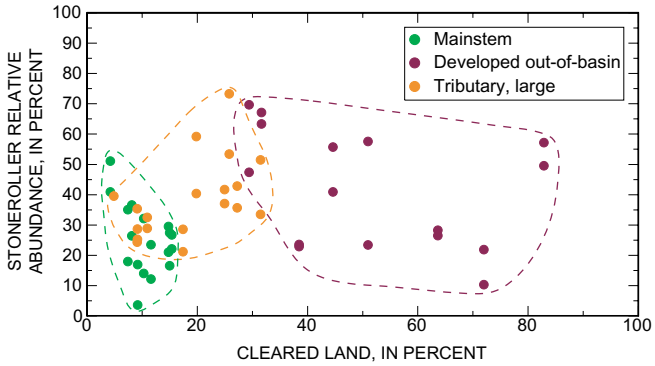



**Figure 7.** Relation between stoneroller relative abundance and percentage of cleared land in basin for mainstem, large tributary, and developed out-of-basin sites.

Percentage of cleared land and stoneroller relative abundance were less correlated (rho= 0.25, p=0.07) than percentage of cleared land and PINVER; however, stoneroller relative abundance appears to be affected by land use. At mainstem sites (which generally had basins containing less than 15 percent cleared land) stoneroller relative abundance ranged from 10 to 40 percent, but at large tributary sites (which generally had basins containing 10 to 30 percent cleared land) stoneroller relative abundance generally ranged from about 20 to 60 percent. At developed out-of-basin sites (which generally had basins containing more than 30 percent cleared land) stoneroller relative abundance ranged from about 10 to 70 percent (fig. 7) and most sites with the lowest stoneroller relative abundance were among the largest developed out-of-basin sites. Stoneroller relative abundance appeared to increase among the similarly-sized large tributary and developed out-of-basin sites as cleared land percentages exceeded about 20 percent and then ceased to increase as cleared land percentages increased beyond about 30 percent.

Relative abundances of the three most common families in these streams (minnows, darters, and sunfish) were correlated with several environmental factors. Minnow relative abundance was significantly correlated with drainage area, several channel morphometry measures, road density, reach slope, extreme bank erosion, and moderate to extreme bank erosion (table 10). All of these environmental factors except road density and the two indices of bank erosion correlate strongly with drainage area. In general, higher minnow relative abundance occurred at sites in smaller basins with narrower widths, shallower depths, steeper reach slope, less road density, and greater bank erosion. Darter relative abundance was significantly correlated only with substrate (glide) sorting and water temperature (table 10). In general, higher darter relative abundance occurred at sites where water temperature was lower and substrate particle size was diverse. Sunfish generally were the third most abundant family for each of the site categories; median relative abundances of sunfish generally were higher at mainstem sites that at other sites. Sunfish relative abundance was correlated with drainage area, several channel morphometry measures including basin slope, canopy angle, road density, reach slope, the two measures of bank erosion, embeddedness along the thalweg, reach substrate particle size, temperature, and pH (table 10). All of these environmental factors except basin slope, road density, the particle size variables, extreme bank erosion, and moderate to extreme bank erosion correlate strongly with drainage area. In general, higher sunfish relative abundance occurred at sites in larger basins with wider and deeper channels, less steep basin and reach slope, greater road density, larger substrate particle size, less bank erosion, higher water temperature, and higher pH.

Relative abundance of stonerollers appears to be affected by factors related to drainage area. The effects of factors other than drainage area and associated factors are difficult to distinguish. Stoneroller relative abundance was significantly correlated with drainage area, basin elevation range, proportion of carbonate rock in the basin, several channel morphometry measures, reach slope, two indices of bank erosion, proportion of mud and sand along the thalweg, and specific conductance (most of which were similarly correlated with relative abundance of minnows, the family that includes stonerollers) (table 10). All of these environmental factors except elevation range, proportion of carbonate rock in the basin, proportion of mud and sand, bank erosion, glide length proportion, and specific conductance correlate strongly with drainage area. In general, stoneroller relative abundances were highest at headwater and developed out-of-basin sites and lowest at mainstem sites.

Several other fish community metrics used to calculate an IBI also appear to be affected by several environmental factors related to drainage area and land use (table 11). PAHINP values were significantly correlated with drainage area, several factors significantly correlated with drainage area (several channel morphometry measures, several measures related to amounts of cleared land in the basin, canopy angle, embeddedness along the thalweg, reach slope, particle size in glides, and water temperature), road density in stream buffers, and basin slope. In general, higher PAHINP values occurred at sites with wider widths and greater depths in larger basins, greater proportions of cleared land in the basin, greater substrate embeddedness, higher water temperatures, and smaller basin and reach slopes. PINVER values were significantly correlated with drainage area, several factors significantly correlated with drainage area (several channel morphometry measures, several measures related to amounts of cleared land in the basin, embeddedness along the thalweg, reach slope, and water temperature), canopy angle, several measures related to particle size, bank erosion, and nitrite plus nitrate concentration. Many of these factors also are correlated with drainage area. However, although proportions of cleared land and steep cleared land were positively

**Table 10.** Correlation between relative abundance of minnows, darters, sunfish, and stonerollers and environmental factors.

[NS, not significant (p>0.05);<, less than; GD16-GD84, 16th, 50th, and 84th percentile of particle size in glides; RD16-RD84, 16th, 50th, and 84th percentile of particle size in reach]

| Environmental factor | Minnows | | Darters | | Sunfish | | Stonerollers | |
|---|---|---|---|---|---|---|---|---|
| | rho | p-value | rho | p-value | rho | p-value | rho | p-value |
| Drainage area | -0.32 | <0.01 | NS | NS | 0.48 | <0.0001 | -0.30 | <0.01 |
| Elevation range | -0.35 | <0.01 | NS | NS | 0.52 | <0.0001 | -0.35 | <0.01 |
| Drainage basin average slope | NS | NS | NS | NS | 0.20 | 0.05 | NS | NS |
| Carbonate rock | NS | NS | NS | NS | NS | NS | -0.27 | <0.01 |
| Cleared land | NS | NS | NS | NS | NS | NS | NS | NS |
| Cleared land in stream buffer | NS | NS | NS | NS | NS | NS | NS | NS |
| Steep cleared land | NS | NS | NS | NS | NS | NS | NS | NS |
| Road density | NS | NS | NS | NS | NS | NS | NS | NS |
| Road density in stream buffer | -0.26 | <0.01 | NS | NS | 0.28 | <0.01 | NS | NS |
| Reach gradient | 0.31 | <0.01 | NS | NS | -0.42 | <0.0001 | 0.33 | <0.01 |
| Total residual pool length | -0.31 | <0.01 | NS | NS | 0.49 | <0.0001 | -0.23 | 0.02 |
| Residual pool, proportion | 0.31 | <0.01 | NS | NS | 0.45 | <0.0001 | NS | NS |
| Average residual pool length | -0.37 | <0.01 | NS | NS | 0.52 | <0.0001 | -0.34 | <0.01 |
| Average residual pool depth | -0.20 | 0.04 | NS | NS | 0.41 | <0.0001 | -0.23 | 0.02 |
| Pools, proportion | -0.40 | <0.01 | NS | NS | 0.49 | <0.0001 | -0.34 | <0.01 |
| Glides, proportion | NS | NS | NS | NS | NS | NS | -0.20 | 0.04 |
| Average bankfull width | -0.24 | 0.01 | NS | NS | 0.44 | <0.0001 | NS | NS |
| Average bankfull depth | -0.31 | <0.01 | NS | NS | 0.49 | <0.0001 | -0.29 | <0.01 |
| Wetted width | -0.39 | <0.01 | NS | NS | 0.56 | <0.0001 | -0.37 | <0.01 |
| Depth | -0.30 | <0.01 | NS | NS | 0.53 | <0.0001 | -0.35 | <0.01 |
| Velocity index | NS | NS | NS | NS | NS | NS | NS | NS |
| Reach sinuosity | NS | NS | NS | NS | NS | NS | NS | NS |
| Mud and sand along thalweg | NS | NS | NS | NS | NS | NS | -0.22 | 0.02 |
| Gravel along thalweg | NS | NS | NS | NS | NS | NS | NS | NS |
| Cobbles and boulders along thalweg | NS | NS | NS | NS | NS | NS | NS | NS |
| Thalweg embeddedness index | NS | NS | NS | NS | 0.25 | 0.01 | NS | NS |
| Glide embeddedness | NS | NS | NS | NS | 0.20 | 0.04 | NS | NS |
| GD16 | NS | NS | NS | NS | NS | NS | NS | NS |
| GD50 | NS | NS | NS | NS | NS | NS | NS | NS |
| GD84 | NS | NS | NS | NS | NS | NS | NS | NS |
| RD16 | NS | NS | NS | NS | 0.23 | 0.02 | NS | NS |
| RD50 | NS | NS | NS | NS | 0.21 | 0.04 | NS | NS |
| RD84 | NS | NS | NS | NS | NS | NS | NS | NS |
| Bedrock | NS | NS | NS | NS | NS | NS | NS | NS |
| Glide sorting | NS | NS | 0.20 | 0.05 | NS | NS | NS | NS |
| Bank vegetation index | NS | NS | NS | NS | NS | NS | NS | NS |

**Table 10.** Correlation between relative abundance of minnows, darters, sunfish, and stonerollers and environmental factors.—**Continued**

[NS, not significant (p>0.05);<, less than; GD16-GD84, 16th, 50th, and 84th percentile of particle size in glides; RD16-RD84, 16th, 50th, and 84th percentile of particle size in reach]

| Environmental factor | Minnows | | Darters | | Sunfish | | Stonerollers | |
|---|---|---|---|---|---|---|---|---|
| | rho | p-value | rho | p-value | rho | p-value | rho | p-value |
| Eroding banks, severe | 0.30 | <0.01 | NS | NS | -0.48 | <0.0001 | 0.32 | <0.01 |
| Eroding banks, moderate and severe | 0.20 | 0.04 | NS | NS | -0.29 | <0.01 | 0.20 | 0.04 |
| Open canopy angle | NS | NS | NS | NS | 0.29 | <0.01 | NS | NS |
| Canopy cover | NS | NS | NS | NS | NS | NS | NS | NS |
| Water temperature | NS | NS | -0.20 | 0.05 | 0.35 | <0.01 | NS | NS |
| Specific conductance | NS | NS | NS | NS | NS | NS | -0.24 | 0.02 |
| pH | NS | NS | NS | NS | 0.27 | <0.01 | NS | NS |
| Dissolved oxygen | NS | NS | NS | NS | NS | NS | NS | NS |
| Turbidity | NS | NS | NS | NS | NS | NS | NS | NS |
| Fecal coliform bacteria | NS | NS | NS | NS | NS | NS | NS | NS |
| Ammonia | NS | NS | NS | NS | NS | NS | NS | NS |
| Nitrite plus nitrate | NS | NS | NS | NS | NS | NS | NS | NS |
| Orthophosphorus | NS | NS | NS | NS | NS | NS | NS | NS |

correlated with drainage area, they were negatively correlated with PINVER values. Although larger PINVER values tended to occur at sites with larger basins (and larger drainage area was correlated with larger proportions of cleared land and steep cleared land), larger PINVER values also tended to occur at sites with smaller proportions of cleared land and steep cleared land in their basins. In general, PINVER values were higher at sites with wider widths and greater depths in larger basins, but with smaller proportions of cleared land and steep cleared land in their basins, less nutrient enrichment, less bank erosion, and larger substrates. PTOPCA values were significantly correlated with drainage area, several factors significantly correlated with drainage area (basin elevation range, several channel morphometry measures, canopy angle and cover, embeddedness along the thalweg, reach slope, reach sinuosity, some measures related to substrate particle size, pH, and water temperature), some measures related to substrate particle size, and bank erosion. In general, larger PTOPCA values occurred at sites with wider widths and greater depths in larger basins, higher pH, and higher water temperatures, but with less bank erosion, and larger substrates. PGBYCC values were significantly correlated with drainage area, several factors significantly correlated with drainage area (several channel morphometry measures, sinuosity, and water temperature), proportion of cobbles and boulders along the thalweg, and dissolved-oxygen concentration. In general, higher PGBYCC values occurred at sites with wider widths and greater depths in larger basins, lower dissolved-oxygen concentrations, and higher water temperatures. NDASCM values were significantly correlated with drainage area, several factors significantly correlated with drainage area (elevation range, several channel morphometry measures, several measures related to amounts of cleared land in the basin, canopy angle and cover, embeddedness along the thalweg, reach slope, measures related to particle size, and pH), nitrite plus nitrate concentration, basin slope, proportion of carbonate rock, other channel morphometry measures, other measures related to particle size, bank vegetation index, velocity, specific conductance, fecal coliform bacteria, and nitrite plus nitrate concentration. NDASCM previously has been reported to be correlated with drainage area (Dauwalter and others, 2003). Several factors positively correlated with NDASCM (cleared land proportion, smaller substrate particle size, nitrite plus nitrate concentration, fecal coliform bacteria concentration) would not be expected to favor darters, sculpins, and madtoms because these species generally prefer clean, well-oxygenated streams with gravel- or larger-sized substrate (Robison and Buchanan, 1988; Pflieger, 1997). Many of these correlations may be the result of the correlation with drainage area. NLITSP values were significantly correlated with drainage area, several factors significantly correlated with drainage area (elevation range, several channel morphometry measures, several measures related to amounts of cleared land in the basin, road density in stream buffer, canopy angle and cover, embeddedness along the thalweg, reach slope, several measures related to particle size, velocity index, water temperature, and pH), basin slope, carbonate rock, measures of residual pool length, measures of particle size, nitrite plus nitrate concentration, and fecal coliform bacteria concentration. NLITSP has previously been reported to be correlated with drainage area (Dauwalter and others, 2003).

**Table 11.** Correlation between index of biotic integrity metrics and index of biotic integrity scores and environmental factors.

[PAHINP, percent of algivorous/herbivorous, invertivorous, and piscivorous individuals; PINVER, percent of invertivorous individuals; PGBYCC, percent of green sunfish, bluegill, yellow bullhead, and channel catfish; PTOPCA, percent of top carnivores, NDASCM, number of darter, sculpin, and madtom species; NLITSP, number of lithophilic spawning species; IBI, index of biotic integrity; <, less than; NS, not significant (p>0.05); GD16-GD84, 16$^{th}$, 50$^{th}$, and 84$^{th}$ percentile of particle size in glides; RD16-RD84, 16$^{th}$, 50$^{th}$, and 84$^{th}$ percentile of particle size in reach]

| Environmental factor | PAHINP | | PINVER | | PTOPCA | | PGBYCC | | NDASCM | | NLITSP | | IBI score | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | rho | p-value | rho | p-value | rho | p-value | rho | p-value | rho | p-value | rho | p-value | rho | p-value |
| Drainage area | 0.38 | <0.01 | 0.49 | <0.0001 | 0.60 | <0.0001 | 0.20 | 0.04 | 0.60 | <0.0001 | 0.81 | <0.0001 | 0.51 | <0.0001 |
| Elevation range | NS | NS | 0.55 | <0.0001 | 0.38 | <0.01 | 0.27 | <0.01 | 0.38 | <0.01 | 0.56 | <0.0001 | 0.36 | <0.01 |
| Drainage basin average slope | -0.23 | 0.02 | NS | NS | NS | NS | NS | NS | -0.26 | <0.01 | -0.23 | 0.02 | NS | NS |
| Carbonate rock | NS | NS | NS | NS | NS | NS | -0.20 | 0.04 | 0.29 | <0.01 | 0.25 | 0.01 | NS | NS |
| Cleared land | 0.25 | 0.01 | -0.22 | 0.02 | NS | NS | NS | NS | 0.42 | <0.0001 | 0.37 | <0.01 | NS | NS |
| Cleared land in stream buffer | 0.30 | <0.01 | NS | NS | NS | NS | NS | NS | 0.52 | <0.0001 | 0.52 | <0.0001 | NS | NS |
| Steep cleared land | 0.21 | 0.03 | -0.25 | 0.01 | NS | NS | NS | NS | 0.37 | <0.0001 | 0.31 | <0.01 | NS | NS |
| Road density | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Road density in stream buffer | 0.20 | 0.04 | NS | NS | NS | NS | NS | NS | NS | NS | 0.26 | <0.01 | NS | NS |
| Reach gradient | -0.38 | <0.0001 | -0.38 | <0.0001 | -0.50 | <0.0001 | NS | NS | -0.56 | <0.0001 | -0.75 | <0.0001 | NS | NS |
| Total residual pool length | 0.32 | <0.01 | 0.51 | <0.0001 | 0.54 | <0.0001 | 0.24 | 0.02 | 0.43 | <0.0001 | 0.63 | <0.0001 | 0.47 | <0.0001 |
| Residual pool, proportion | NS | NS | 0.46 | <0.0001 | 0.48 | <0.0001 | 0.25 | 0.01 | 0.26 | <0.01 | 0.42 | <0.0001 | 0.44 | <0.0001 |
| Average residual pool length | 0.36 | <0.01 | NS | NS | 0.41 | <0.0001 | NS | NS | 0.45 | <0.0001 | 0.66 | <0.0001 | 0.40 | <0.01 |
| Average residual pool depth | NS | NS | 0.39 | <0.0001 | 0.43 | <0.0001 | 0.25 | 0.01 | NS | NS | 0.42 | <0.0001 | 0.36 | <0.01 |
| Pools, proportion | 0.28 | <0.01 | 0.47 | <0.0001 | 0.42 | <0.0001 | 0.50 | <0.0001 | NS | NS | 0.35 | <0.01 | 0.36 | <0.01 |
| Glides, proportion | NS | NS | NS | NS | NS | NS | -0.21 | 0.04 | 0.22 | 0.03 | NS | NS | NS | NS |
| Average bankfull width | 0.26 | <0.01 | 0.47 | <0.0001 | 0.49 | <0.0001 | NS | NS | 0.45 | <0.0001 | 0.69 | <0.0001 | 0.43 | <0.0001 |
| Average bankfull depth | 0.25 | 0.01 | 0.47 | <0.0001 | 0.40 | <0.0001 | NS | NS | 0.39 | <0.01 | 0.59 | <0.0001 | 0.47 | <0.0001 |
| Wetted width | 0.35 | <0.01 | 0.56 | <0.0001 | 0.58 | <0.0001 | 0.26 | <0.01 | 0.46 | <0.0001 | 0.73 | <0.0001 | 0.55 | <0.0001 |
| Depth | 0.28 | <0.01 | 0.50 | <0.0001 | 0.53 | <0.0001 | 0.33 | <0.01 | 0.22 | 0.03 | 0.51 | <0.0001 | 0.45 | <0.0001 |
| Velocity index | NS | NS | NS | NS | NS | NS | NS | NS | 0.27 | <0.01 | 0.23 | 0.02 | NS | NS |
| Reach sinuosity | NS | NS | NS | NS | -0.31 | <0.01 | -0.25 | 0.01 | NS | NS | NS | NS | NS | NS |
| Mud and sand along thalweg | NS | NS | NS | NS | 0.24 | 0.02 | NS | NS | NS | NS | NS | NS | NS | NS |

**Table 11.** Correlation between index of biotic integrity metrics and index of biotic integrity scores and environmental factors.—Continued

[PAHINP, percent of algivorous/herbivorous, invertivorous, and piscivorous individuals; PINVER, percent of invertivorous individuals; PGBYCC, percent of green sunfish, bluegill, yellow bullhead, and channel catfish; PTOPCA, percent of top carnivores, NDASCM, number of darter, sculpin, and madtom species; NLITSP, number of lithophilic spawning species; IBI, index of biotic integrity; <, less than; NS, not significant (p>0.05); GD16-GD84, 16th, 50th, and 84th percentile of particle size in glides; RD16-RD84, 16th, 50th, and 84th percentile of particle size in reach]

| Environmental factor | PAHINP | | PINVER | | PTOPCA | | PGBYCC | | NDASCM | | NLITSP | | IBI score | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | rho | p-value | rho | p-value | rho | p-value | rho | p-value | rho | p-value | rho | p-value | rho | p-value |
| Gravel along thalweg | NS | NS | -0.23 | 0.02 | NS | NS | NS | NS | 0.23 | 0.02 | NS | NS | NS | NS |
| Cobbles and boulders along thalweg | NS | NS | 0.25 | 0.01 | NS | NS | 0.25 | 0.01 | NS | NS | NS | NS | NS | NS |
| Thalweg embeddedness index | 0.22 | 0.03 | 0.21 | 0.04 | 0.33 | <0.01 | NS | NS | 0.27 | <0.01 | 0.48 | <0.0001 | 0.37 | <0.01 |
| Glide embeddedness | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | 0.21 | 0.03 |
| GD16 | -0.23 | 0.02 | NS | NS | -0.20 | 0.04 | NS | NS | NS | NS | NS | NS | NS | NS |
| GD50 | NS | NS | NS | NS | -0.22 | 0.03 | NS | NS | -0.26 | <0.01 | -0.26 | <0.01 | NS | NS |
| GD84 | NS | NS | NS | NS | NS | NS | NS | NS | -0.27 | <0.01 | -0.32 | <0.01 | NS | NS |
| RD16 | NS | NS | 0.32 | <0.01 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| RD50 | NS | NS | 0.27 | <0.01 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| RD84 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | -0.21 | 0.04 | NS | NS |
| Bedrock | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Glide sorting | NS | NS | 0.20 | 0.05 | NS | NS | 0.36 | <0.01 | -0.20 | 0.04 | NS | NS | NS | NS |
| Bank vegetation index | NS | NS | NS | NS | NS | NS | NS | NS | 0.25 | 0.01 | NS | NS | NS | NS |
| Eroding banks, severe | NS | NS | -0.40 | <0.0001 | -0.36 | <0.01 | NS | NS | NS | NS | NS | NS | -0.38 | <0.01 |
| Eroding banks, moderate and severe | NS | NS | -0.30 | <0.01 | -0.28 | <0.01 | NS | NS | NS | NS | NS | NS | -0.31 | <0.01 |
| Open canopy angle | 0.28 | <0.01 | 0.29 | <0.01 | 0.36 | <0.01 | NS | NS | 0.35 | <0.01 | -0.57 | <0.0001 | 0.31 | <0.01 |
| Canopy cover | NS | NS | NS | NS | -0.25 | 0.01 | NS | NS | -0.26 | 0.01 | -0.42 | <0.0001 | -0.23 | 0.03 |
| Water temperature | 0.28 | <0.01 | 0.22 | 0.03 | 0.33 | <0.01 | 0.27 | <0.01 | NS | NS | 0.38 | <0.01 | NS | NS |
| Specific conductance | NS | NS | NS | NS | NS | NS | NS | NS | 0.26 | 0.01 | NS | NS | NS | NS |
| pH | NS | NS | NS | NS | 0.32 | <0.01 | NS | NS | 0.24 | 0.02 | 0.40 | <0.01 | 0.23 | 0.03 |
| Dissolved oxygen | NS | NS | NS | NS | NS | NS | -0.36 | <0.01 | NS | NS | NS | NS | NS | NS |
| Turbidity | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Fecal coliform bacteria | NS | NS | NS | NS | NS | NS | NS | NS | 0.22 | 0.03 | 0.24 | 0.02 | NS | NS |
| Ammonia | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Nitrite plus nitrate | NS | NS | -0.27 | <0.01 | NS | NS | NS | NS | 0.32 | <0.01 | 0.26 | 0.01 | NS | NS |
| Orthophosphorus | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

IBI scores appear to be affected by several factors related to drainage area and some factors that may be related to land use (table 11). IBI scores were significantly correlated with drainage area, several factors significantly correlated with drainage area (basin elevation range, several channel morphometry measures, canopy angle and cover, embeddedness, and pH), and bank erosion. In general, higher IBI scores occurred at sites in larger basins with less bank erosion.

As a group, these metrics indicate that stream size (drainage area and channel morphometry measures) and land use affect fish communities of streams in the Buffalo River Basin and adjacent basins. Stream size had the largest effect on fish communities. Factors that may be affected by land use (for example, proportion cleared land, proportion steep cleared land, nitrite plus nitrate concentration, and bank erosion) also appear to affect some metrics.

## Results of Ordination Analysis

Detrended correspondence analysis (DCA) was used to compare the community structure at 52 sites using 103 samples collected in 2001 and 2002. Only the first two axes were used in the analyses. Eigenvalues of axis 1 and axis 2 were 0.345 and 0.190, respectively.

The results of this DCA ordination also indicate that drainage area is an important determinant of fish community structure. The DCA ordination results indicated that fish communities of most of the mainstem sites of the Buffalo River were substantially different from communities of most of the headwater sites (fig. 8). Headwater sites generally had axis 1 scores from about 100 to 250 and axis 2 scores from about 0 to 100, while mainstem sites generally had axis 1 scores from about 0 to 125 and axis 2 scores from about 100 to 125. The headwater sites with the smallest drainage area (Left Fork Big Creek near Red Rock, samples 19a and 19b; Cave Creek near Bass, samples 24a and 24b; and Bear Creek near Welcome Home, samples 32a and 32b) had the highest axis 1 scores; the mainstem sites with the largest drainage area (Buffalo River near mouth near Buffalo City, 10a and 10b; Buffalo River near Rush, 9a and 9b) had axis 1 scores of about 60 (intermediate scores among the mainstem sites).

The DCA ordination results also indicated that fish communities of most of the tributary sites had characteristics that were intermediate to characteristics of communities of the larger headwater sites and the mainstem sites. Tributary site communities generally had axis 1 scores from about 75 to 175; these scores were similar to those for the larger headwater sites and most of the mainstem sites. Large tributary sites generally had axis 1 and axis 2 scores that were similar to scores for the mainstem sites; only scores for Davis Creek (21a and 21b) and Calf Creek (29a and 29b) were dissimilar to the mainstem site scores. However, several of the small tributary sites had axis 2 scores that were higher than most of scores of the mainstem and headwater sites.

The developed out-of-basin sites generally had axis 1 and axis 2 scores that were similar to scores of many of the mainstem, headwater, or tributary site scores. Only a few sites (Yocum Creek, 46b; Hampton Creek, 50a and 50b) had scores that differed substantially from scores of most other sites. Hampton Creek was one of the few sites that had a substantial population of Ozark sculpin.

The potential for differences in fish community in different ecoregions is indicated by the substantial difference in the scores for North Sylamore Creek (52a and 52b) and the scores for all of the other headwater sites. North Sylamore Creek is in the Ozark Highlands and other headwater sites are in the Boston Mountains.

A DCA of a subset of sites indicated that land use and drainage area affected the structure of fish communities. DCA was used to compare the community structure at a subset of the 52 sites (the paired developed out-of-basin sites and the sites from the Buffalo River Basin). Eigenvalues of axis 1 and axis 2 were 0.266 and 0.137, respectively. The sites from the Buffalo River Basin were paired with the developed out-of-basin sites such that the drainage areas of the sites in a pair (or sometimes a group of three sites) were similar but the proportion of cleared land was substantially higher at the developed out-of-basin site in the pair. The results of this DCA ordination (fig. 9) indicate (as did the results of the DCA ordination of the 52-site data set) that sites with larger drainage areas generally are associated with lower axis 1 site scores, However, the results of this DCA ordination (fig. 9) also indicate that although sites within a pair (or sometimes a group of three sites) had similar drainage areas, the fish communities associated with the Buffalo River Basin sites usually were substantially different from the developed out-of-basin sites. For example, in a comparison of samples from Osage Creek and the Buffalo River near Pruitt, the Osage Creek samples (with an associated higher proportion of cleared land in the basin) had higher axis 1 scores. Similarly, axis 1 scores for samples from Crooked Creek, Long Creek, Yocum Creek, Hampton Creek, and Hock Creek almost always were higher than axis 1 scores for samples from the sites with lower proportions of cleared land that were paired with these sites. For three groups of sites (Clear Creek and Buffalo River near Ponca; Huzzah Creek, Buffalo River at Dixon Ford near Fallsville, and Buffalo River near Boxley; Kings River and Buffalo River near Boxley) a consistent difference in site scores was not evident. The similarity in sites scores for the Kings River site (samples 44a and 44b) and Buffalo River near Boxley (samples 2a and 2b) may be explained by the low proportion of cleared land for the Kings River site. The proportion is the lowest of the developed out-of-basin sites. The developed out-of-basin sites that are members of the other two groups of sites are located within a few hundred meters of substantially larger streams, suggesting that the axis 1 scores of the out-of-basin sites are lower than they would have been if the distance to the larger stream had been greater.

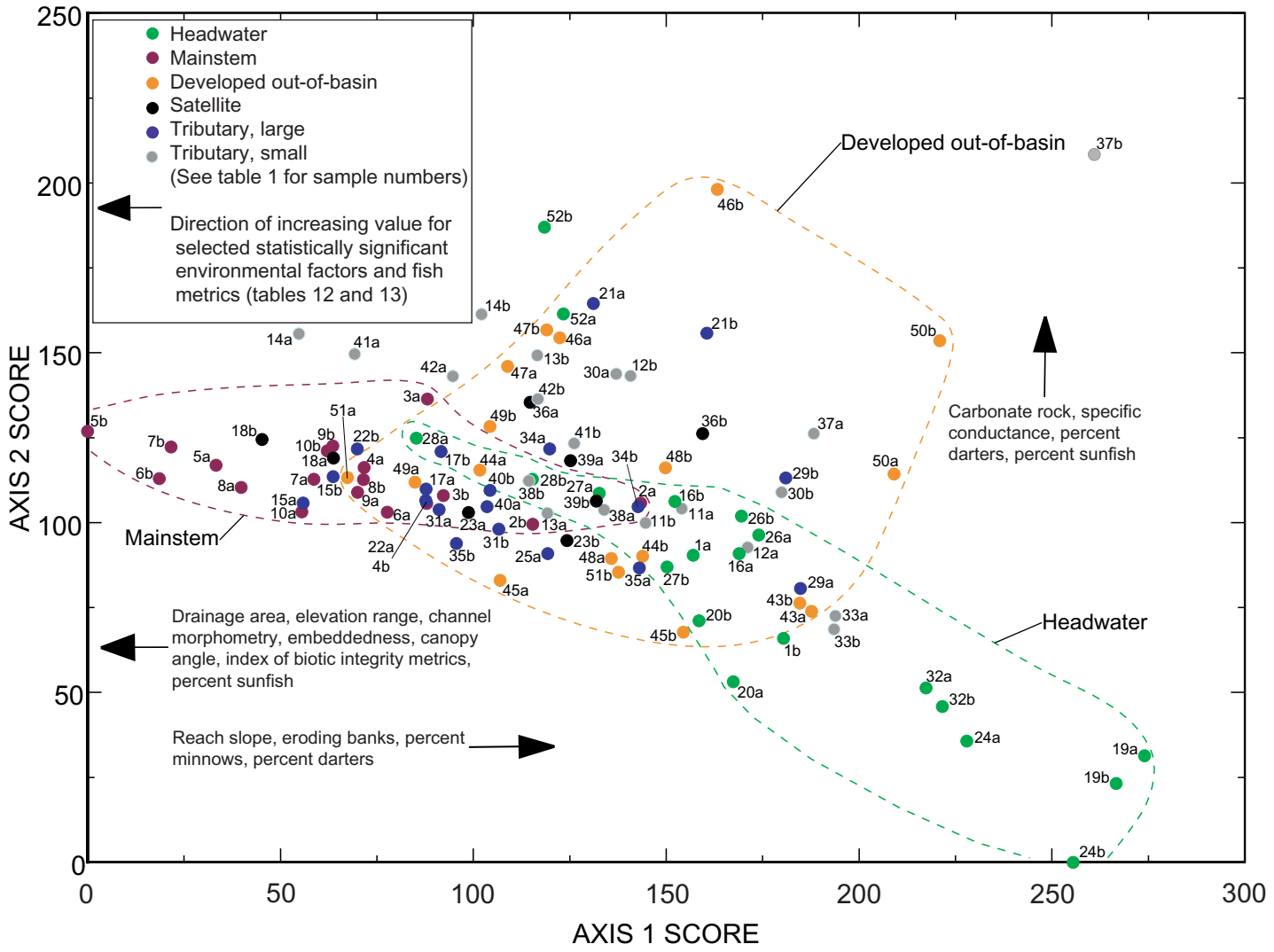



**Figure 8.** Detrended correspondence analysis (DCA) site scores for 52 sites.

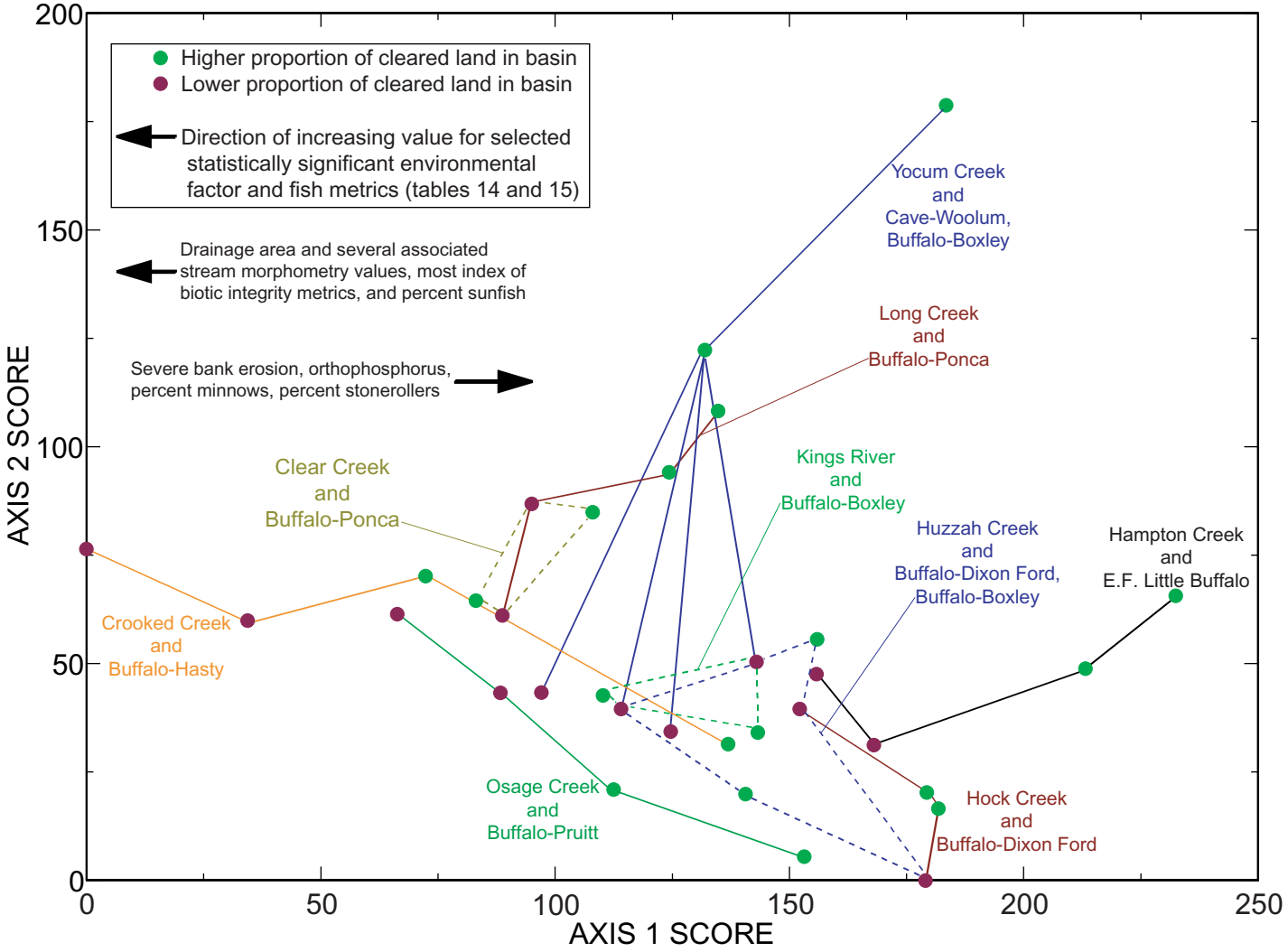



**Figure 9.** Detrended correspondence analysis (DCA) site score for subset of sites.

# Relations Between Ordination Analysis Results, Environmental Factors, and Community Metrics

Axis 1 scores (for the 52 sites) were significantly ($p<0.05$) correlated with drainage area, several factors that are related to drainage area, and other factors (table 12, fig. 8). These factors include several measures of channel morphometry, basin elevation range, two measures of bank erosion, two measures of riparian cover, road density in stream buffer, and several measures related to substrate size or embeddedness. In general, sites with higher axis 1 scores are associated with smaller basins, shallower and narrower channels, steeper channels, less mud and sand along the thalweg, less embeddedness along the thalweg and in glides, greater bank erosion, more canopy cover, and less road density near the streams.

Axis 1 scores were significantly correlated with few water-quality factors (table 12, fig. 8). Axis 1 scores were correlated with mean pH and water temperature. In general, sites with higher axis 1 scores had lower pH values and water temperatures; sites with the highest axis 1 scores were headwater sites in the Boston Mountains.

**Table 12.** Correlation between detrended correspondence analysis axis scores and environmental factors.

[NS, not significant ($p>0.05$); <, less than; GD16-GD84, 16$^{th}$, 50$^{th}$, and 84$^{th}$ percentile of particle size in glides; RD16-RD84, 16$^{th}$, 50$^{th}$, and 84$^{th}$ percentile of particle size in reach]

| Environmental factor | Axis 1 | | Axis 2 | |
|---|---|---|---|---|
| | rho | p-value | rho | p-value |
| Drainage area | -0.69 | <0.0001 | NS | NS |
| Elevation range | -0.64 | <0.0001 | NS | NS |
| Drainage basin average slope | NS | NS | NS | NS |
| Carbonate rock | NS | NS | 0.46 | <0.0001 |
| Cleared land | NS | NS | NS | NS |
| Cleared land in stream buffer | NS | NS | NS | NS |
| Steep cleared land | NS | NS | NS | NS |
| Road density | NS | NS | 0.24 | 0.02 |
| Road density in stream buffer | -0.30 | <0.01 | 0.20 | 0.04 |
| Reach gradient | 0.60 | <0.0001 | -0.22 | 0.03 |
| Total residual pool length | -0.61 | <0.0001 | NS | NS |
| Residual pool, proportion | -0.51 | <0.0001 | NS | NS |
| Average residual pool length | -0.62 | <0.0001 | NS | NS |
| Average residual pool depth | -0.57 | <0.0001 | NS | NS |
| Pools, proportion | -0.53 | <0.0001 | 0.24 | 0.01 |
| Glides, proportion | NS | NS | 0.28 | <0.01 |
| Average bankfull width | -0.62 | <0.0001 | NS | NS |
| Average bankfull depth | -0.62 | <0.0001 | NS | NS |
| Wetted width | -0.72 | <0.0001 | NS | NS |
| Depth | -0.68 | <0.0001 | NS | NS |
| Velocity index | NS | NS | NS | NS |
| Reach sinuosity | NS | NS | -0.22 | 0.03 |
| Mud and sand along thalweg | -0.21 | 0.04 | 0.27 | <0.01 |

**Table 12.** Correlation between detrended correspondence analysis axis scores and environmental factors.—Continued

[NS, not significant (p>0.05); <, less than; GD16-GD84, 16th, 50th, and 84th percentile of particle size in glides; RD16-RD84, 16th, 50th, and 84th percentile of particle size in reach]

| Environmental factor | Axis 1 | | Axis 2 | |
|---|---|---|---|---|
| | rho | p-value | rho | p-value |
| Gravel along thalweg | NS | NS | 0.33 | <0.01 |
| Cobbles and boulders along thalweg | NS | NS | NS | NS |
| Thalweg embeddedness index | -0.42 | <0.0001 | NS | NS |
| Glide embeddedness | -0.21 | 0.04 | NS | NS |
| GD16 | NS | NS | -0.23 | 0.02 |
| GD50 | NS | NS | -0.36 | <0.01 |
| GD84 | NS | NS | -0.36 | <0.01 |
| RD16 | -0.22 | 0.04 | NS | NS |
| RD50 | NS | NS | NS | NS |
| RD84 | NS | NS | NS | NS |
| Bedrock | NS | NS | -0.23 | 0.03 |
| Glide sorting | NS | NS | NS | NS |
| Bank vegetation index | NS | NS | NS | NS |
| Eroding banks, severe | 0.49 | <0.0001 | NS | NS |
| Eroding banks, moderate and severe | 0.37 | <0.01 | NS | NS |
| Open canopy angle | -0.48 | <0.0001 | NS | NS |
| Canopy cover | 0.34 | <0.01 | NS | NS |
| Water temperature | -0.37 | <0.01 | NS | NS |
| Specific conductance | NS | NS | 0.50 | <0.0001 |
| pH | -0.35 | <0.01 | 0.25 | 0.01 |
| Dissolved oxygen | NS | NS | NS | NS |
| Turbidity | NS | NS | NS | NS |
| Fecal coliform bacteria | NS | NS | NS | NS |
| Ammonia | NS | NS | NS | NS |
| Nitrite plus nitrate | NS | NS | NS | NS |
| Orthophosphorus | NS | NS | NS | NS |

Index of biotic integrity (IBI) scores and all of the metrics used to calculate IBI scores were significantly correlated with axis 1 scores (table 13, fig. 8). Sites with higher axis 1 scores (generally narrower and shallower streams with smaller basins) had lower values of PAHINP, PGBYCC, PINVER, PTOPCA, NDASCM, and NLITSP.

**Table 13.** Correlation between detrended correspondence analysis axis score and fish metric values.

[[NS, not significant (p>0.05); <, less than; PAHINP, percent of algivorous/herbivorous, invertivorous, and piscivorous individuals; PINVER, percent of invertivorous individuals; PGBYCC, percent of green sunfish, bluegill, yellow bullhead, and channel catfish; PTOPCA, percent of top carnivores, NDASCM, number of darter, sculpin, and madtom species; NLITSP, number of lithophilic spawning species; IBI, index of biotic integrity]

| | Axis 1 | | Axis 2 | |
|---|---|---|---|---|
| | rho | p-value | rho | p-value |
| PAHINP | -0.39 | <0.0001 | 0.23 | 0.02 |
| PGBYCC | -0.32 | <0.01 | NS | NS |
| PINVER | -0.79 | <0.0001 | 0.38 | <0.0001 |
| PTOPCA | -0.73 | <0.0001 | 0.43 | <0.0001 |
| NDASCM | -0.41 | <0.0001 | NS | NS |
| NLITSP | -0.69 | <0.0001 | NS | NS |
| IBI score | -0.74 | <0.0001 | 0.39 | <0.0001 |
| Percent darters | NS | NS | 0.22 | 0.03 |
| Percent minnows | 0.58 | <0.0001 | -0.62 | <0.0001 |
| Percent sunfish | -0.82 | <0.0001 | 0.39 | <0.01 |
| Percent stonerollers | 0.68 | <0.0001 | -0.81 | <0.0001 |

Axis 1 scores were significantly correlated with several taxonomic measures (table 13, fig. 8). Percent minnows and percent stonerollers generally increased with increasing axis 1 scores. Percent sunfish generally decreased with increasing axis 1 scores.

Axis 2 scores were significantly correlated with proportion of carbonate rock in basin, road density, several measures of channel morphometry, and several measures of substrate size (table 12, fig. 8). In general, sites with higher axis 2 scores had higher proportions of carbonate rock in their basins, higher road density, straighter channels, higher proportions of pools and glides, less bedrock, and smaller substrate. The strengths of these correlations (rho values) generally were less than the strength of the correlations with the axis 1 values. The strongest correlation was with the proportion of carbonate rock. This correlation (and the correlation with percentage of bedrock in the streambed) and the absence of a significant correlation with drainage area or other measures of stream size suggests that axis 2 scores are affected by the geology and other factors that differ between the Boston Mountains and the Springfield and Salem Plateaus.

Axis 2 scores were correlated with specific conductance and pH (table 12, fig. 8). In general, sites with higher axis 2 scores had higher specific conductance and pH values; sites with the lowest axis 2 scores were headwater sites in the Boston Mountains.

IBI scores and several IBI metrics were significantly correlated with axis 2 scores (table 13, fig. 8). Sites with higher axis 2 scores generally had higher values of PAHINP, PINVER, PTOPCA, NDASCM, and NLITSP.

Axis 2 scores were significantly correlated with several taxonomic metrics (table 13, fig. 8). Percent darters and percent sunfish generally increased with increasing axis 2 scores. Percent minnows and percent stonerollers generally decreased with increasing axis 2 scores.

The results of the DCA ordination used to compare the community structure at a subset of the 52 sites (the developed out-of-basin sites and the paired sites from the Buffalo River Basin) indicate that factors related to drainage area, geology, and land use are important determinants of fish community structure. Several factors related to drainage area (depth, width, bankfull depth, bankfull width, and others) were significantly and strongly correlated (negative values of rho as much as 0.78) with axis 1 scores from the DCA (table 14, fig. 9).

In general, within a pair of sites the developed out-of-basin site (with its higher proportion of cleared land in the basin) had higher axis 1 values (fig. 9). This may be the result of the slightly (about 5 to 10 percent) larger drainage area of many of the developed out-of-basin sites among the paired sites. However, it appears that, for a given drainage area, axis 1 values are higher for developed out-of-basin sites than for the sites from the Buffalo River Basin (fig. 10). This suggests that the higher proportion of cleared land within the basins of the developed out-of- basin sites may influence the fish communities of these sites, but few significant correlations with land-use related factors were found.

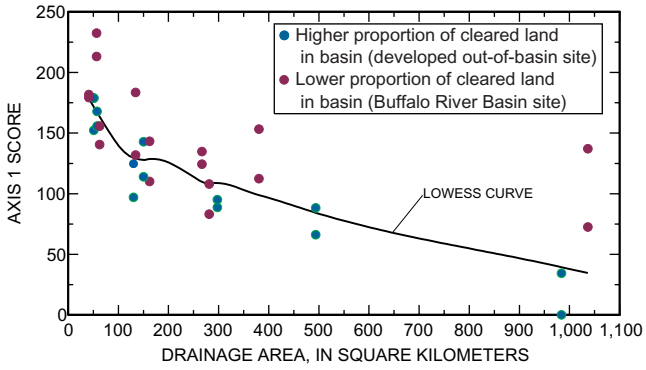



**Figure 10.** Relation between detrended corresponded analysis (DCA) axis 1 score and drainage area for subset of sites.

**Table 14.** Correlation between detrended correspondence analysis axis scores (from subset of sites) and environmental factors.

[NS, not significant (p>0.05); <, less than; GD16-GD84, 16th, 50th, and 84th percentile of particle size in glides; RD16-RD84, 16th, 50th, and 84th percentile of particle size in reach]

| Environmental factor | Axis 1 | | Axis 2 | |
|---|---|---|---|---|
| | rho | p-value | rho | p-value |
| Drainage area | -0.79 | <0.0001 | NS | NS |
| Elevation range | -0.84 | <0.0001 | NS | NS |
| Drainage basin average slope | NS | NS | NS | NS |
| Carbonate rock | NS | NS | 0.46 | 0.01 |
| Cleared land | NS | NS | NS | NS |
| Cleared land in stream buffer | NS | NS | NS | NS |
| Steep cleared land | NS | NS | NS | NS |
| Road density | NS | NS | NS | NS |
| Road density in stream buffer | NS | NS | NS | NS |
| Reach gradient | 0.56 | <0.01 | -0.47 | <0.01 |
| Total residual pool length | -0.55 | <0.01 | NS | NS |
| Residual pool, proportion | NS | NS | NS | NS |
| Average residual pool length | -0.62 | <0.01 | 0.43 | 0.02 |
| Average residual pool depth | -0.45 | 0.01 | NS | NS |
| Pools, proportion | NS | NS | 0.38 | 0.03 |
| Glides, proportion | NS | NS | 0.42 | 0.02 |
| Average bankfull width | -0.65 | <0.01 | NS | NS |
| Average bankfull depth | -0.59 | <0.01 | NS | NS |
| Wetted width | -0.78 | <0.0001 | NS | NS |
| Depth | -0.60 | <0.01 | NS | NS |
| Velocity index | NS | NS | NS | NS |
| Reach sinuosity | NS | NS | NS | NS |
| Mud and sand along thalweg | NS | NS | NS | NS |
| Gravel along thalweg | NS | NS | 0.45 | 0.01 |
| Cobbles and boulders along thalweg | NS | NS | NS | NS |
| Thalweg embeddedness index | -0.49 | <0.01 | 0.38 | 0.04 |
| Glide embeddedness | NS | NS | -0.36 | 0.05 |
| GD16 | NS | NS | NS | NS |
| GD50 | NS | NS | NS | NS |
| GD84 | NS | NS | NS | NS |
| RD16 | NS | NS | NS | NS |
| RD50 | NS | NS | NS | NS |
| RD84 | NS | NS | NS | NS |
| Bedrock | NS | NS | -0.55 | <0.01 |
| Glide sorting | NS | NS | NS | NS |
| Bank vegetation index | NS | NS | NS | NS |
| Eroding banks, severe | 0.53 | <0.01 | NS | NS |
| Eroding banks, moderate and severe | NS | NS | NS | NS |
| Open canopy angle | NS | NS | NS | NS |
| Canopy cover | NS | NS | NS | NS |
| Water temperature | NS | NS | NS | NS |
| Specific conductance | NS | NS | 0.45 | 0.02 |
| pH | NS | NS | NS | NS |
| Dissolved oxygen | NS | NS | NS | NS |
| Turbidity | -0.38 | 0.05 | NS | NS |
| Fecal coliform bacteria | NS | NS | NS | NS |
| Ammonia | NS | NS | NS | NS |
| Nitrite plus nitrate | NS | NS | NS | NS |
| Orthophosphorus | 0.43 | 0.02 | NS | NS |

Axis 1 scores were significantly correlated with two water-quality factors (table 14). Axis 1 scores generally decreased as turbidity increased and increased as orthophosphorus concentrations increased.

IBI scores and most of the metrics used to calculate IBI scores were significantly ($p<0.05$) correlated with axis 1 scores (table 15). Sites with higher axis 1 scores (generally narrower and shallower streams with smaller basins and higher proportions of cleared land in their basin) had lower values of PGBYCC, PINVER, PTOPCA, NDASCM, and NLITSP.

**Table 15.** Correlation between detrended correspondence analysis axis scores (from subset of sites) and fish metric values.

[NS, not significant ($p>0.05$); <, less than; PAHINP, percent of algivorous/herbivorous, invertivorous, and piscivorous individuals; PINVER, percent of invertivorous individuals; PGBYCC, percent of green sunfish, bluegill, yellow bullhead, and channel catfish; PTOPCA, percent of top carnivores, NDASCM, number of darter, sculpin, and madtom species; NLITSP, number of lithophilic spawning species; IBI, index of biotic integrity]

| | Axis 1 | | Axis 2 | |
|---|---|---|---|---|
| | rho | p-value | rho | p-value |
| PAHINP | NS | NS | 0.57 | <0.01 |
| PGBYCC | -0.42 | 0.02 | 0.75 | <0.0001 |
| PINVER | -0.70 | <0.01 | 0.46 | 0.01 |
| PTOPCA | -0.55 | <0.01 | 0.72 | <0.01 |
| NDASCM | -0.52 | <0.01 | NS | NS |
| NLITSP | -0.75 | <0.0001 | NS | NS |
| IBI score | -0.66 | <0.01 | 0.58 | <0.01 |
| Percent darters | NS | NS | NS | NS |
| Percent minnows | 0.41 | 0.02 | -0.77 | <0.0001 |
| Percent sunfish | -0.73 | <0.0001 | 0.63 | <0.01 |
| Percent stonerollers | 0.64 | <0.01 | -0.87 | <0.0001 |

Axis 1 scores were significantly correlated with several taxonomic measures (table 15). Percent minnows and percent stonerollers generally increased with increasing axis 1 scores. Percent sunfish generally decreased with increasing axis 1 scores.

Axis 2 scores were significantly ($p<0.05$) correlated primarily with factors related to geology (table 14). In general, sites with higher axis 2 scores had higher proportions of carbonate rock in their basins, higher specific conductance values, and less bedrock on the streambed. The strengths of these correlations (rho values) generally were less than the strength of the correlations between other environmental factors and axis 1 values. One of the strongest correlations (rho value) was with the proportion of carbonate rock. This correlation (and the correlation with proportion of bedrock in the streambed) and the absence of a significant correlation with basin area or other measures of stream size suggests that axis 2 scores are affected by the geology and other factors that differ between the Boston Mountains and the Springfield and Salem Plateaus. No water-quality factors (other than specific conductance) were significantly correlated with axis 2 scores.

IBI scores and several IBI metrics were significantly correlated with axis 2 scores (table 15). Sites with higher axis 2 scores generally had higher values of PAHINP, PGBYCC, PINVER, and PTOPCA.

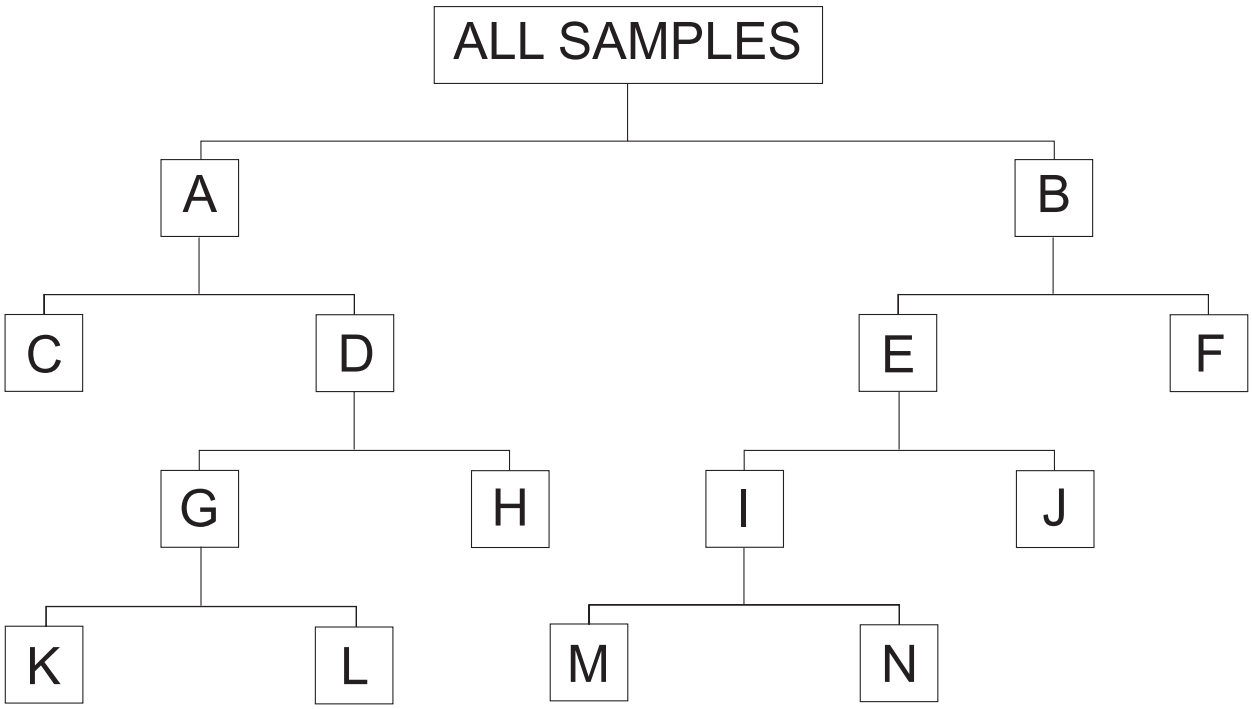
Axis 2 scores were significantly correlated with several taxonomic measures (table 15). Percent sunfish generally increased with increasing axis 2 scores. Percent minnows and percent stonerollers generally decreased with increasing axis 2 scores.

# Results of Classification Analysis

Two-way indicator species analysis (TWINSPAN), a classification technique, was used to classify fish communities using relative abundance data collected in 2001 and 2002. The resulting hierarchies of samples are shown in a dendrogram. Similar samples are joined at a lower level in the dendrogram, while more dissimilar samples join at a higher level (Gauch, 1982).

The classification yielded relatively consistent separation of sites (samples) by drainage area, site type (mainstem, tributary, headwater, out-of-basin), and land-use categories (fig. 11). For example, samples from sites in large basins generally were more similar to samples from other sites in large basins than to samples from small basins; headwater sites generally were most similar to other headwater sites; and sites with higher proportions of cleared land in the basin were more similar to other sites with higher proportions of cleared land in the basin.

Results of TWINSPAN analyses indicate that fish communities of the Buffalo River Basin and nearby areas primarily are influenced by drainage area. The first division was into a group (group A, fig. 11) that included samples from the 22 sites with the largest basins (greater than 134 $km^2$) and another group (group B) that included samples from all but 1 of the 15 sites with the smallest basins (less than 53 $km^2$). Most of the smaller sites in group A are tributary sites located within about 900 meters of the Buffalo River. All of the headwater sites were classified in group B. Bigeye chub (*Notropis amblops*), Arkansas saddled darter (*Etheostoma euzonum*), longear sunfish, Ozark bass (*Ambloplites constellatus*), and bluntnose minnow (*Pimephales notatus*) were indicator species for group A (the group containing the sites with the largest basins). Although they were not identified by TWINSPAN as indicator species, southern redbelly dace (*Phoxinus erythrogaster*) and an orangethroat darter pseudospecies were more commonly found at the sites in group B (sites with the smaller basins). Stonerollers had high relative abundance values (greater than 40 percent) at most of these sites.




EXPLANATION

1-5 are pseudospecies numbers associated with indicator species for relative abundances of <2, <5, <10, <20, and <40 percent, respectively; pseudospecies thet were not determined to be indicator species but were most commonly associated with a TWINSPAN category are enclosed in parentheses. MS, mainstream; TL, large tributary; TS, small tributary; HW, headwater; OD, developed out-of-basin. ASD, Arkansas saddled darter; BDS, banded sculpin; BEC, bigeye shiner; BLG, bluegill; BNM, bluntnose minnow; BRH, black redhorse; BTM, blackspotted topminnow; CRC, creek chub; DSS, duskystripe shiner; GSD, greenside darter; LES, longear sunfish; NSF, northern studfish; OKS, Ozark sculpin; OTD, orangethroat darter; OZB, Ozark bass; OZC, Ozark chub; RBN, rainbow darter; SLM, slender madtom; SMB, smallmouth bass; SRD, southern redbelly dace; STS, striped shiner; USR, unidentified stoneroller; YKD, yoke darter. Sample numbers refer to both samples a and b (2001 and 2002), unless specifically noted as a and b

**Figure 11.** Classification of fish communities by two-way indicator species analysis (TWINSPAN).

| TWINSPAN group and indicator species | Category | Samples (table 1) | TWINSPAN group and indicator species | Category | Samples (table 1) |
|---|---|---|---|---|---|
| A | | | H | MS | |
| BEC1, ASD1, LES3, OZB1, BNM1 | MS | 2,3,4,5,6,7,8,9,10 | DSS5 | TL | 36a |
| | TL | 15,17,18,22,23,25a, 31,34,35,36a,40 | | TS | 14a,39a,41a |
| | TS | 13,14,38,39,41,42a | | HW | |
| | HW | | | OD | |
| | OD | 44,45,47,48a,49,51 | | | |
| | | | I | MS | |
| B | MS | | BDS1, BTM1 | TL | 21,29,36b |
| (OTD2, SRD1) | TL | 21,29,36b | | TS | 11,12,30,33b,37,42b |
| | TS | 11,12,30,33,37,42b | | HW | 1b,16a,52 |
| | HW | 1,16,19,20,24,26, 27,28,32,52 | | OD | 43,46,48b,50 |
| | OD | 46,48b,50 | | | |
| | | | J | MS | |
| C | MS | 3b,4,5,6,7,8,9,10 | GSD2, SLM2 | TL | |
| OZC1,BES2,YKD2 | TL | 15,22a,31a,40 | | TS | |
| | TS | | | HW | 1a,16b,20b,26,27,28 |
| | HW | | | OD | |
| | OD | 45a,51a | | | |
| | | | K | MS | 2,3a |
| D | MS | 2,3a | ASD1 | TL | 17,18,22b,23,31b, 34,35 |
| BDS1 | TL | 17,18,22b,23,25a, 31b,34,35,36a | | TS | 13a,38,39b,41b,42a |
| | TS | 13,14,38,39,41,42a | | HW | |
| | HW | | | OD | 44b,45a,49a,51a |
| | OD | 44,45b,47,48a,49,51b | | | |
| E | MS | | L | MS | |
| DSS3, SMB1, NSF1, RBD2 | TL | 21,29,36b | BLG1, BDS3 | TL | 25a |
| | TS | 11,12,30,33b,37,42b | | TS | 13b,14b |
| | HW | 1,16,20b,26,27,28,52 | | HW | |
| | OD | 43,46,48b,50 | | OD | 44a,47a,48a,49b |
| F | MS | | M | MS | |
| (SRD1,CRC1) | TL | | SRD2, OKS2 | TL | |
| | TS | 33a | | TS | 33b,37b |
| | HW | 19,20a,24,32 | | HW | |
| | OD | | | OD | 50 |
| G | MS | 2,3a | N | MS | |
| BES1,BRH1 (USR4,ASD1,STS1) | TL | 17,18,22b,23,25a, 31b,34,35 | DSS4 | TL | 21,29,36b |
| | TS | 13,14b,38,39b,41b,42a | | TS | 11,12,16a,30,37a,42b |
| | HW | | | HW | 16,52 |
| | OD | 44,45b,47,48a,49,51b | | OD | 43,46,48b |

**Figure 11.** Classification of fish communities by two-way indicator species analysis (TWINSPAN).—Continued

The next division of group A divided samples of fish communities from sites in the largest basins (group C, primarily sites on the mainstem of the Buffalo River) from samples from a group of sites in somewhat smaller basins (group D, sites from the upstream part of the Buffalo River mainstem, tributaries of the Buffalo River, and several developed out-of-basin sites with relatively large proportions of cleared land). Indicator species for group C (sites with the largest basins) were Ozark chub (*Erimystax harryi*), a bigeye shiner (*Notropis boops*) pseudospecies, and a yoke darter (*Etheostoma juliae*) pseudospecies. Banded sculpin (*Cottus carolinae*) was the only indicator species for group D (the sites with smaller, and sometimes more agricultural, basins). Orangethroat darters also were collected at many of the sites in group D.

Major differences (drainage area, site type, land use) in the sites in further divisions of group C were not evident. No further divisions of group C are shown in figure 11.

The next division of group D divided samples of fish communities into a group of sites with larger basins (group G) (often with more cleared land in the basin) and a group of sites with smaller basins (group H). However, drainage area appears to be the more consistent difference between sites in the two groups. Indicator species for group G are bigeye shiner and black redhorse; the indicator species for group H is a duskystripe shiner pseudospecies with relative abundance greater than 20 percent. Stoneroller (pseudospecies with relative abundance greater than 10 percent), Arkansas saddled darter, and striped shiner (*Luxilus chrysocephalus*) also were collected at most of the sites in group G.

Group G was divided into groups L and K. The division of group G resulted in one group (group L) with a larger percentage of sites with higher proportions of cleared land within their basins. Indicator species for group L were bluegill and a banded sculpin pseudospecies. The indicator species for group K was the Arkansas saddled darter.

The division of the group of samples from sites with smaller basins (group B) yielded a group of samples from sites that were primarily headwater sites (and were the three headwater sites with the smallest basins) (group F) and a group of samples from sites that generally had larger basins or were tributaries of the Buffalo River (group E). Many of the sites in group E had relatively high proportions of cleared land in their basins. Indicator species for group E were a duskystripe shiner pseudospecies, smallmouth bass (*Micropterus dolomieu*), northern studfish (*Fundulus catenatus*), and a rainbow darter pseudospecies. Although they were not identified as indicator species, southern redbelly dace and creek chubs were collected from most of the samples in group F and less than half of the samples in group E.

The division of group E yielded a group of samples from sites that tended to have larger drainage areas and higher proportions of cleared land (group I) and another group of samples from sites that tended to have smaller drainage areas and lower proportions of cleared land (group J). Seven of the 26 samples in group I were for sites that had basins containing greater than 30 percent cleared land, while none of the 9 samples in group J were associated with basins containing greater than 30 percent cleared land. Ten of the 26 samples in group I were from sites that had basins larger than 60 $km^2$, while none of the 9 samples in group J were associated with basins larger than 60 $km^2$. Indicator species for group I were banded sculpin and blackspotted top minnows. Indicator species for group J were a greenside darter pseudospecies and a slender madtom pseudospecies.

The division of group I yielded a group of three sites (four samples) where Ozark sculpin were collected (group M). Indicator species for group M were an Ozark sculpin pseudospecies and a southern redbelly dace pseudospecies. The indicator species for group N was a duskystripe shiner pseudospecies.

## Relations Between Classification Analysis Results and Environmental Factors

The results of the TWINSPAN analyses suggest that drainage area and related factors are important determinants of fish community structure. For selected groups, the Wilcoxon rank sum test was used to test for differences between environmental factors associated with the selected groups.

For groups A and B, statistically significant ($p<0.05$) differences were detected in drainage area and several significantly correlated factors (table 9), including several stream morphometry measures, proportions of cleared land and cleared land in stream buffer, canopy angle and cover, thalweg embeddedness, water temperature, and pH (table 16). Significant factors not significantly correlated with drainage area include glide embeddedness, bank vegetation index, and two measures of bank erosion. In general, sites in group A are in larger basins, have greater proportions of cleared land in their basins, have less vegetated banks, and have less bank erosion.

For groups E and F, statistically significant differences were detected in drainage area and stream morphometry measures, several measures of substrate particle size, and pH (table 16). Although not statistically significant, proportions of cleared land, concentrations of nitrite plus nitrate, and concentrations of orthophosphorus for sites in group E were higher than for sites in group F. Among the sites in group E and F, the nine sites with the highest mean concentrations of nitrite plus nitrate and the eight sites with the highest mean concentrations of orthophosphorus were in group E. In general, sites in group E are in larger basins, have deeper and wider wetted channels, higher pH values, many of the highest proportions of cleared land in their basins, and many of the highest nutrient concentrations.

For groups I and J, statistically significant differences were detected in basin proportions of carbonate rock, cleared land, and steep cleared land; several measures of substrate particle size; several water-quality factors; and some stream morphometry values (table 16). Drainage area was not significantly different between the two groups. In general, sites in group I were associated with higher proportions of carbonate rock and cleared land in their basin; smaller substrate particle size; and higher water temperatures, specific conductance, pH, bacteria concentrations, and nutrient concentrations.

**Table 16.** Probabilities that environmental factors do not differ between two-way indicator species analysis (TWINSPAN) groups.

[See figure 11 for TWINSPAN groups. NS, not significant (p>0.05); <, less than; GD16-GD84, 16th, 50th, and 84th percentile of particle size in glides; RD16-RD84, 16th, 50th, and 84th percentile of particle size in reach; PAHINP, percent of algivorous/herbivorous, invertivorous, and piscivorous individuals; PINVER, percent of invertivorous individuals; PGBYCC, percent of green sunfish, bluegill, yellow bullhead, and channel catfish; PTOPCA, percent of top carnivores, NDASCM, number of darter, sculpin, and madtom species; NLITSP, number of lithophilic spawning species; IBI, index of biotic integrity; NS, not significant (p>0.05); GD16-GD84, 16th, 50th, and 84th percentile of particle size in glides; RD16-RD84, 16th, 50th, and 84th percentile of particle size in reach]

| Environmental factor | TWINSPAN groups | | |
|---|---|---|---|
| | A and B | E and F | K and L |
| Drainage area | <0.0001 | <0.01 | NS |
| Elevation range | <0.0001 | NS | NS |
| Drainage basin average slope | NS | 0.02 | NS |
| Carbonate rock | NS | NS | <0.01 |
| Cleared land | 0.03 | NS | <0.01 |
| Cleared land in stream buffer | <0.01 | NS | NS |
| Steep cleared land | NS | NS | <0.01 |
| Road density | NS | NS | <0.01 |
| Road density in stream buffer | 0.04 | 0.01 | NS |
| Reach gradient | <0.0001 | 0.04 | 0.03 |
| Total residual pool length | <0.0001 | 0.01 | NS |
| Residual pool, proportion | <0.01 | 0.04 | 0.02 |
| Average residual pool length | <0.0001 | <0.01 | NS |
| Average residual pool depth | <0.0001 | NS | <0.01 |
| Pools, proportion | <0.01 | NS | NS |
| Glides, proportion | NS | NS | <0.01 |
| Average bankfull width | <0.0001 | NS | 0.02 |
| Average bankfull depth | <0.0001 | NS | NS |
| Wetted width | <0.0001 | <0.01 | NS |
| Depth | <0.0001 | 0.01 | <0.01 |
| Velocity index | NS | NS | NS |
| Reach sinuosity | NS | <0.01 | NS |
| Mud and sand along thalweg | NS | NS | NS |
| Gravel along thalweg | NS | NS | <0.01 |
| Cobbles and boulders along thalweg | NS | NS | 0.03 |
| Thalweg embeddedness index | <0.0001 | NS | NS |
| Glide embeddedness | 0.04 | NS | NS |
| GD16 | NS | 0.02 | <0.01 |
| GD50 | NS | <0.01 | <0.01 |
| GD84 | NS | <0.01 | <0.01 |
| RD16 | NS | NS | NS |
| RD50 | NS | NS | NS |
| RD84 | NS | NS | <0.01 |
| Bedrock | NS | NS | NS |
| Glide sorting | NS | NS | <0.01 |
| Bank vegetation index | 0.02 | NS | NS |
| Eroding banks, severe | <0.01 | NS | NS |
| Eroding banks, moderate and severe | <0.01 | NS | NS |
| Open canopy angle | <0.0001 | NS | NS |
| Canopy cover | <0.01 | NS | NS |
| Water temperature | <0.01 | NS | <0.01 |
| Specific conductance | NS | NS | <0.01 |
| pH | <0.01 | 0.02 | <0.01 |
| Dissolved oxygen | NS | NS | NS |
| Turbidity | NS | NS | NS |
| Fecal coliform bacteria | NS | NS | 0.02 |
| Ammonia | NS | NS | NS |
| Nitrite plus nitrate | NS | NS | <0.01 |
| Orthophosphorus | NS | NS | <0.01 |

## Implications of Fish Community Information for Buffalo National River and the Ozark National Forest

Streams of Buffalo National River and the Ozark National Forest are noted by many for their high quality. The Buffalo River, Richland Creek, and North Sylamore Creek are part of the National Wild and Scenic Rivers System (Schwilling and others, 1999). Parts of the Buffalo River and several tributaries flow through federal wilderness areas administered by the National Park Service and the Forest Service (Schwilling and others, 1999). The Buffalo River, Richland Creek, Falling Water Creek, North Sylamore Creek, and the Kings River are designated extraordinary resource waters by the State of Arkansas (Arkansas Pollution Control and Ecology Commission, 1998).

Several fish species endemic to the Ozark Plateaus (table 4) occur within streams of Buffalo National River and the Ozark National Forest. Some of these streams are considered strongholds for some of these species. The Ozark shiner, Ozark bass, and the yoke darter are probably more common in the Buffalo River than in any other stream in Arkansas (Robison and Buchanan, 1988; Robison, 1997). The checkered madtom has been collected from only a few areas of Arkansas, including the Buffalo River and its tributaries (Robison and Buchanan, 1988).

Analysis of fish community data from streams in Buffalo National River, the Ozark National Forest, and adjacent areas of the Ozark Plateaus indicates that fish communities are affected by a number of environmental factors. Several of these are factors that are determined or influenced by the location of the stream in the landscape—factors such as drainage area and geology (and associated factors such as stream width, stream depth, streamflow, and streambed substrate), proximity to larger streams, and proximity to reservoirs. Biological factors such as habitat preferences, predation, and the geographical distribution of fish species (not addressed in this study) also can be important. Some of these same factors and other factors can be affected by human activities—factors such as bank erosion, channel morphometry, streamflow, water temperature, turbidity, and nutrient concentrations. The interaction of all these factors can make it difficult to monitor and assess stream conditions and aquatic communities and evaluate the relation to existing environmental factors.

Several analyses of the data described in this report suggest that drainage area is the most important single factor influencing these fish communities. Species richness increases with increasing drainage area and some species are restricted to smaller streams while other species are more common in larger streams. Some analyses indicated that fish communities also are affected by land use and related factors (proportion of cleared land, nutrient concentrations, for example). Percent invertivorous individuals (PINVER) generally was lower at developed out-of-basin sites (fig. 4) than at other sites, and results of regression models (table 7) indicated that PINVER values at developed out-of-basin sites and paired sites in the Buffalo River Basin were affected by land-use related factors. Nutrient concentrations were statistically significant variables in regression models of the relation between drainage area, land-use related factors, and two other fish metrics (PAHINP and PGBYCC). These results, among others, indicate that substantial shifts in basin land use or point-source effluents could have effects on downstream fish communities.

Fish community data may not identify sites in the Buffalo River Basin adversely affected by water quality or other environmental factors as accurately as macroinvertebrate community data. Mott (1997) reported that highest mean nitrite plus nitrate concentrations have occurred in the middle section (from R4 to R8) of the Buffalo River and that many of the highest mean nitrite plus nitrate concentrations for tributaries have occurred in tributaries to this section of the Buffalo River. Several studies of macroinvertebrate communities of Buffalo National River have described macroinvertebrate communities in the middle sections of the Buffalo River that were indicative of degraded conditions (Bryant, 1997; Bradley, 2001; Usrey, 2001). Macroinvertebrate indices of community integrity (ICI) proposed by Mathis (2001) for the Buffalo River and applied by Mathis (2001) to data collected by Bryant (1997) and Bradley (2001) suggested that sites in the middle section of the Buffalo River (from near R2 to near R7) were slightly to moderately degraded and some tributaries of this section of the Buffalo River (Calf, Bear, and Tomahawk Creeks) were slightly to severely degraded. None of the evaluated fish community metrics in this report indicated that this section of the Buffalo River was degraded relative to other sections of the Buffalo River. Fish IBI, PINVER, PTOPCA, NDASCM, NLITSP, and percent stoneroller values for Calf Creek (T10) were substantially different from values for Water Creek (T15), which was the fourth tributary site (reference site) sampled by Bradley (2001). Fish community metric values for Bear Creek and Tomahawk Creek were not substantially different from values for Water Creek.

## Summary

The Buffalo River lies in north-central Arkansas and is a tributary of the White River. Most of the length of the Buffalo River lies within the National Park Service boundaries of Buffalo National River; the upper 24 river kilometers lie within the boundary of the Ozark National Forest. Much of the upper and extreme lower parts of the basin on the south side of the Buffalo River is within the Ozark National Forest.

The Buffalo River Basin lies within the Ozark Plateaus, which is one of the richest areas of the United States for fish species. More than 60 species of fish previously have been documented from the Buffalo River.

During the summers of 2001 and 2002 fish communities were sampled at 52 sites, by the U.S. Geological Survey in cooperation with the National Park Service and the U.S. Department of Agriculture Forest Service in the study area that

included the Buffalo River Basin and selected smaller nearby basins within the White River Basin in north-central Arkansas. Water quality and several other habitat factors also were measured.

In 2001 and 2002, a total of 56 species were collected from sites within the Buffalo River Basin. All 56 species also were collected from within the National Park Service boundaries of Buffalo National River. Twenty-two species were collected from headwater sites on tributaries of the Buffalo River; 27 species were collected from sites on or immediately adjacent to the Ozark National Forest in the White River Basin. The list of species collected from Buffalo River National River is similar to the list of species reported by previous investigators. In 2001 and 2002, a total of 53 species were collected from sites outside the Buffalo River Basin.

Most species are minnows (cyprinids), darters (percids), or sunfish (centrarchids). Of the 56 species collected in the Buffalo River Basin in 2001 and 2002, 19 species were minnows, 9 species were darters, and 9 species were sunfish. Most other species are suckers (catostomids, six species) or catfish (ictalurids, five species).

Species richness at sites on the mainstem of the Buffalo River generally increased in a downstream direction. The number of species collected (both years combined) increased from 17 at the most upstream site to 38 near the mouth of the Buffalo River. Species richness increased substantially between the site at Dixon Ford near Fallsville (R0, 17 species) and the site near Boxley (R1, 29 species) as drainage area increased from 51 to 150 $km^2$.

Several fish community metrics varied among sites in five different site categories (mainstem, large tributary, small tributary, headwater, and developed out-of-basin sites). Minnows were the most abundant family for all site categories; median relative abundance values for the site categories ranged from about 60 to 70 percent. Darters generally were the next most abundant family for each site category; median relative abundances of darters ranged from about 10 to 15 percent. No statistically significant difference in relative abundance of minnows or darters was detected among the category types. Sunfish generally were the third most abundant family for each of the site categories; median relative abundances of sunfish ranged from about 7 to 15 percent, except at mainstem sites where the median was about 18 percent and significantly higher than all but large tributary sites. Relative abundance of stonerollers varied among sites in the five site categories. Median relative abundances of stonerollers ranged from about 25 to 55 percent and were highest at headwater and developed out-of-basin sites and lowest at mainstem sites. The relative abundances at the headwater and developed out-of-basin sites were significantly different from the relative abundances at the mainstem sites.

Several other fish community metrics used to calculate an index of biotic integrity score (IBI) varied among site categories. PAHINP (percent algivorous/herbivorous, invertivorous, and piscivorous individuals) values for headwater sites were significantly lower than values for mainstem and developed out-of-basin sites. PINVER (percent invertivorous individuals) values for mainstem sites were significantly higher than values at small tributary, headwater, and developed out-of-basin sites. PTOPCA (percent top carnivores) values at mainstem sites were significantly higher than values at tributary and headwater sites. The NDASCM (number of darter, sculpin, and madtom species) values at mainstem, large tributary, and developed out-of-basin sites were significantly higher than values at other sites and the values at small tributary sites and headwater sites were each significantly different from values at the other four types of sites. Median NLITSP (number of lithophilic spawning species) values for large tributary sites were not significantly different from values for mainstem and developed out-of-basin sites, but values for other site categories were significantly different from values for all other categories.

Median IBI scores varied among the site categories. Scores for mainstem sites were significantly larger than all but large tributary site scores. Scores for headwater sites were significantly smaller than mainstem and large tributary site scores. The lower scores at headwater sites may be influenced by the use of an IBI developed for the Ozark Highlands ecoregion for evaluation of sites that are in the Boston Mountains ecoregion.

A comparison of nine developed out-of-basin sites with similarly sized sites in the Buffalo River Basin showed differences in two measures of trophic function (PAHINP and PINVER) between communities of the paired sites. Four taxonomic metrics (percent darter; NDASCM; PGBYCC—percent green sunfish, bluegill, yellow bullhead, and channel catfish; and percent stonerollers) that were used to compare paired sites indicate that structural differences between developed out-of-basin sites and Buffalo River Basin sites are not consistent. IBI scores generally were somewhat lower at the developed out-of-basin sites than at the associated Buffalo River Basin sites.

Regression analysis of data from these paired sites indicated that although all of the selected fish metrics were affected by drainage area some metrics also were affected by land-use related factors. Nutrient concentrations were significant variables in regression models for PAHINP and PGBYCC (proximity to downstream reservoirs may also have affected PGBYCC values). Analysis of regression residuals indicated that PINVER values are lower at sites with higher proportions of cleared land in their basin.

For the 52-site dataset, several fish community metrics were correlated with environmental factors. These factors included basin characteristics such as drainage area, land use (cleared land and road density), and geology and reach characteristics such as width and depth, slope, substrate size, and water quality. Most of the metrics were strongly correlated with factors related to drainage area. Some metrics also were correlated with factors related to land use or geology, but these correlations usually were weaker (lower absolute value of rho) and often were not statistically significant.

Proximity of sites on tributaries of the Buffalo River to the mainstem of the Buffalo River appears to be another factor that affects fish communities of these tributary sites. For example, species richness at sites near the mouth of Buffalo River tributaries generally was intermediate to species richness at nearby Buf-

falo River mainstem sites and at satellite sites slightly upstream from the site near the tributary mouth.

Detrended correspondence analysis (DCA) was used to compare fish communities of two different sets of sites (all sites, developed out-of-basin sites paired with Buffalo River Basin sites). The results of these analyses and correlation analyses of the DCA scores indicate that drainage area is an important determinant of fish community structure. However, DCA results also indicated that land use (and related factors such as nutrient concentrations), geology, and proximity to the Buffalo River can influence the fish communities.

Two-way indicator species analysis (TWINSPAN), a classification technique, was used to classify fish communities using relative abundance data collected in 2001 and 2002. The results of the TWINSPAN analyses indicate that drainage area and related factors are important determinants of fish community structure. Bigeye chub, Arkansas saddled darter, longear sunfish, Ozark bass, and bluntnose minnow were indicator species for the group of sites including the sites with the largest drainage areas. Southern redbelly dace and orangethroat darter were commonly found at sites with smaller drainage area. Stoneroller relative abundance generally exceeded 40 percent at these smaller basin sites. Land use (and related factors) and geology were significantly different between some groups classified by TWINSPAN.

Several analyses of the data described in this report suggest that drainage area is the most important single factor influencing of the fish communities of the Buffalo River Basin (and nearby basins). Species richness increases with increasing drainage area and some species are restricted to smaller streams while other species are more common in larger streams. Some analyses indicated that fish communities also are affected by land use and related factors. These results, among others, indicate that substantial shifts in basin land use or point-source effluents could have effects on downstream fish communities. For example, regression model results indicated that percent invertivorous individuals (PINVER), percent algivorous/herbivorous, invertivorous, and piscivorous individuals (PAHINP), and percent green sunfish, bluegill, yellow bullhead, and channel catfish (PGBYCC) were significantly ($p<0.05$) affected by land-use related factors.

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# Glossary

**Algivorous/herbivorous** - typically consuming algae or other plant material.

**Developed out-of-basin site** - a site located outside of the Buffalo River Basin and in a basin with a relatively high percentage of cleared land and a relatively high road density.

**Endemic** - restricted to a specific geographic region.

**Headwater site** - a site located in the upstream part of a basin, typically with a drainage area of less than 100 $km^2$.

**Index of biotic integrity (IBI)** - a multi-metric index used to assess stream quality. Values are expected to decrease with disturbance.

**Invertivorous** - typically consuming insects, crayfish, and other invertebrates.

**Large-tributary site** - a site located near the mouth of a large tributary of the Buffalo River, typically with a drainage area of 200 to 400 $km^2$.

**Mainstem site** - a site with a drainage area of greater than 100 $km^2$ located on the Buffalo River.

**NDASCM** - number of darter, sculpin, and madtom species. For a given drainage area, values are expected to decrease with disturbance.

**NLITSP** - number of lithophilic (associated with cobble, gravel, and other rock) spawning species as defined in Dauwalter and others (2003). For a given drainage area, values are expected to decrease with disturbance.

**PAHINP** - percent of individuals in a sample that are algivorous/herbivorous, invertivorous, and piscivorous species as defined in Dauwalter and others (2003). These are species with generalized feeding preferences. Values are expected to increase with disturbance.

**PGBYCC** - percent of individuals that are green sunfish, bluegills, yellow bullheads, or channel catfish. Values are expected to increase with disturbance.

**PINVER** - percent of individuals in a sample that are invertivorous species as defined in Dauwalter and others (2003). Values are expected to decrease with disturbance.

**Piscivorous** - typically consuming fish.

**Pseudospecies** - a grouping defined in two-way indicator species analysis (TWINSPAN) that is defined by the actual species and its relative abundance in the sample.

**PTOPCA** - percent of individuals that are top carnivores as defined in Dauwalter and others (2003). Values are expected to decrease with disturbance.

**Relative abundance** - the proportion of individuals of a given species in a sample (in percent).

**Satellite site** - a site located a few kilometers upstream from a site near the mouth of a tributary. Differences between the satellite site and the downstream site were used to evaluate the effects of proximity to the Buffalo River mainstem on fish communities.

**Small-tributary site** - a site located near the mouth of a small tributary of the Buffalo River, typically with a drainage area of less than 100 $km^2$.

**Thalweg** - the line connecting the deepest points longitudinally along a stream channel.

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Buffalo River at Dixon Ford near Fallsville | Buffalo River at Dixon Ford near Fallsville | Buffalo River near Boxley | Buffalo River near Boxley | Buffalo River near Ponca |
|---|---|---|---|---|---|
| **Site identifier** | **R0** | **R0** | **R1** | **R1** | **R2** |
| **Date** | **6/25/01** | **6/20/02** | **7/31/01** | **8/7/02** | **7/30/01** |
| Species richness (number of species) | 16 | 12 | 25 | 23 | 29 |
| Bigeye chub | -- | -- | 0.31 | 1.57 | 0.47 |
| Bigeye shiner | 0.67 | -- | 1.56 | 0.72 | 0.66 |
| Bluntnose minnow | -- | -- | 0.39 | 1.00 | 0.38 |
| Common carp | -- | -- | -- | -- | -- |
| Creek chub | 1.34 | 5.68 | -- | 0.29 | -- |
| Duskystripe shiner | 6.02 | 5.68 | 12.42 | 8.58 | 23.80 |
| Hornyhead chub | -- | 1.14 | 1.25 | 0.43 | 1.32 |
| Ozark minnow | 1.34 | 8.52 | 3.75 | 9.44 | 1.79 |
| Ozark chub | -- | -- | -- | -- | 0.38 |
| Ozark shiner | -- | -- | -- | -- | 0.47 |
| Rosyface shiner | -- | -- | -- | -- | -- |
| Southern redbelly dace | 0.33 | 1.70 | -- | -- | -- |
| Steelcolor shiner | -- | -- | -- | -- | -- |
| Stoneroller | 46.82 | 61.93 | 51.09 | 40.92 | 17.93 |
| Striped shiner | -- | -- | -- | -- | -- |
| Telescope shiner | -- | -- | 1.33 | 7.44 | 2.08 |
| Wedgespot shiner | -- | -- | -- | -- | 0.28 |
| Whitetail shiner | 1.00 | -- | 0.31 | 0.14 | 0.47 |
| Arkansas saddled darter | -- | -- | 0.08 | -- | 0.76 |
| Banded darter | 0.67 | -- | -- | -- | 1.61 |
| Fantail darter | -- | -- | -- | -- | -- |
| Gilt darter | -- | -- | -- | -- | -- |
| Greenside darter | 2.01 | 0.57 | 1.88 | 4.15 | 2.83 |
| Logperch | -- | -- | -- | -- | -- |
| Orangethroat darter | 2.34 | 0.57 | -- | 0.86 | -- |
| Rainbow darter | 18.06 | 11.93 | 7.19 | 7.30 | 15.96 |
| Stippled darter | 6.35 | 0.57 | 0.23 | 1.72 | 0.38 |
| Yoke darter | -- | -- | -- | -- | 3.87 |
| Black crappie | -- | -- | -- | -- | -- |
| Bluegill | -- | -- | -- | -- | -- |
| Green sunfish | -- | -- | 1.09 | 1.29 | 0.85 |
| Largemouth bass | -- | -- | -- | -- | -- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Buffalo River at Dixon Ford near Fallsville | Buffalo River at Dixon Ford near Fallsville | Buffalo River near Boxley | Buffalo River near Boxley | Buffalo River near Ponca |
|---|---|---|---|---|---|
| **Site identifier** | **R0** | **R0** | **R1** | **R1** | **R2** |
| **Date** | **6/25/01** | **6/20/02** | **7/31/01** | **8/7/02** | **7/30/01** |
| Longear sunfish | 11.04 | -- | 8.44 | 7.87 | 8.50 |
| Ozark bass | -- | -- | 0.47 | 1.72 | 1.42 |
| Redear sunfish | -- | -- | -- | -- | -- |
| Redspotted sunfish | -- | -- | -- | -- | -- |
| Smallmouth bass | 0.67 | -- | 0.78 | 0.57 | 2.74 |
| Spotted bass | -- | -- | -- | -- | -- |
| Warmouth | -- | -- | -- | -- | -- |
| White crappie | -- | -- | -- | -- | -- |
| Black redhorse | -- | -- | 0.16 | -- | 0.19 |
| Golden redhorse | -- | -- | -- | 0.14 | -- |
| Northern hog sucker | 0.33 | 0.57 | 0.23 | 1.72 | 0.94 |
| Redhorse, unidentified | -- | -- | -- | -- | -- |
| River redhorse | -- | -- | -- | -- | -- |
| Shorthead redhorse | -- | -- | -- | -- | -- |
| White sucker | -- | -- | -- | -- | -- |
| Channel catfish | -- | -- | -- | -- | -- |
| Checkered madtom | -- | -- | -- | -- | -- |
| Flathead catfish | -- | -- | -- | -- | -- |
| Ozark madtom | -- | -- | 0.08 | -- | 3.12 |
| Slender madtom | 1.00 | 1.14 | 0.16 | 0.29 | 5.48 |
| Yellow bullhead | -- | -- | 0.16 | -- | 0.09 |
| Ammocoetes (immature lamprey) | -- | -- | 0.08 | -- | -- |
| Chestnut lamprey | -- | -- | -- | -- | -- |
| Longnose gar | -- | -- | -- | -- | -- |
| Gizzard shad | -- | -- | -- | -- | -- |
| Rainbow trout | -- | -- | -- | -- | -- |
| Blackspotted topminnow | -- | -- | -- | -- | -- |
| Northern studfish | -- | -- | -- | 0.57 | 0.38 |
| Brook silverside | -- | -- | RK | -- | -- |
| Banded sculpin | -- | -- | 6.56 | 1.29 | 0.85 |
| Ozark sculpin | -- | -- | -- | -- | -- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Buffalo River near Ponca | Buffalo River near Pruitt | Buffalo River near Pruitt | Buffalo River near Hasty | Buffalo River near Hasty |
|---|---|---|---|---|---|
| Site identifier | R2 | R3 | R3 | R4 | R4 |
| Date | 7/23/02 | 8/3/01 | 6/27/02 | 7/31/01 | 7/15/02 |
| Species richness (number of species) | 27 | 32 | 31 | 34 | 32 |
| Bigeye chub | 0.11 | 1.07 | 3.32 | 13.16 | 1.47 |
| Bigeye shiner | 0.22 | 2.42 | 3.74 | 10.22 | 9.36 |
| Bluntnose minnow | 0.11 | 0.51 | 4.15 | 1.70 | 3.03 |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | --- | --- | --- | --- | --- |
| Duskystripe shiner | 12.08 | 21.45 | 15.86 | 16.33 | 7.16 |
| Hornyhead chub | 0.89 | 1.35 | 0.50 | 0.57 | --- |
| Ozark minnow | 1.33 | 5.96 | 6.56 | 2.93 | 11.65 |
| Ozark chub | 0.89 | 0.14 | 0.42 | 0.24 | 0.28 |
| Ozark shiner | --- | 2.09 | 1.00 | --- | 4.95 |
| Rosyface shiner | --- | 2.19 | 1.08 | 0.24 | 1.01 |
| Southern redbelly dace | --- | --- | --- | --- | --- |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 35.03 | 26.43 | 36.63 | 16.94 | 3.58 |
| Striped shiner | --- | --- | --- | 0.09 | --- |
| Telescope shiner | 1.11 | 8.75 | 1.25 | 2.70 | 1.65 |
| Wedgespot shiner | --- | 0.37 | --- | 0.24 | 0.28 |
| Whitetail shiner | 0.22 | 1.30 | 0.58 | 0.28 | 1.38 |
| Arkansas saddled darter | 0.78 | 1.26 | 2.82 | 2.37 | 1.56 |
| Banded darter | 0.44 | 0.93 | 0.42 | 0.99 | 0.46 |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | 0.05 | --- |
| Greenside darter | 4.10 | 1.07 | 1.91 | 1.51 | 1.56 |
| Logperch | --- | --- | --- | 0.05 | 0.73 |
| Orangethroat darter | --- | --- | --- | --- | --- |
| Rainbow darter | 3.55 | 3.12 | 3.32 | 4.50 | 1.65 |
| Stippled darter | 0.55 | --- | --- | --- | --- |
| Yoke darter | 0.67 | 3.63 | 1.83 | 3.79 | 1.19 |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | 0.05 | --- | 0.24 | 0.46 |
| Green sunfish | 1.88 | 0.74 | 0.75 | 1.61 | 1.19 |
| Largemouth bass | --- | --- | 0.08 | 0.09 | 0.28 |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Buffalo River near Ponca | Buffalo River near Pruitt | Buffalo River near Pruitt | Buffalo River near Hasty | Buffalo River near Hasty |
|---|---|---|---|---|---|
| Site identifier | R2 | R3 | R3 | R4 | R4 |
| Date | 7/23/02 | 8/3/01 | 6/27/02 | 7/31/01 | 7/15/02 |
| Longear sunfish | 26.39 | 12.33 | 9.14 | 12.21 | 30.09 |
| Ozark bass | 3.66 | 0.74 | 0.33 | 2.22 | 4.95 |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 2.99 | 0.47 | 0.25 | 1.70 | 1.93 |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | 0.22 | 0.09 | 0.33 | 0.47 | 3.39 |
| Golden redhorse | --- | --- | --- | --- | 1.19 |
| Northern hog sucker | 0.67 | 0.28 | 0.50 | 0.33 | 1.19 |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | --- | --- | --- | --- | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | 0.89 | 0.05 | 0.25 | 0.05 | --- |
| Slender madtom | 1.00 | 0.05 | 0.08 | --- | --- |
| Yellow bullhead | 0.11 | 0.05 | --- | --- | 0.09 |
| Ammocoetes (immature lamprey) | --- | --- | 0.08 | 0.05 | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | 0.05 | 0.08 | 0.05 | 0.28 |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | --- | 0.19 | 0.08 | 0.62 | 0.73 |
| Northern studfish | 0.11 | 0.84 | 1.00 | 1.42 | 0.92 |
| Brook silverside | --- | 0.05 | --- | 0.05 | --- |
| Banded sculpin | RK | --- | 1.66 | --- | 0.37 |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Buffalo River near Woolum | Buffalo River near Woolum | Buffalo River at Shine Eye near Gilbert | Buffalo River at Shine Eye near Gilbert | Buffalo River at Highway 14 near Harriet |
|---|---|---|---|---|---|
| Site identifier | R5 | R5 | R6 | R6 | R7 |
| Date | 7/18/01 | 7/16/02 | 7/18/01 | 7/17/02 | 7/20/01 |
| Species richness (number of species) | 29 | 34 | 33 | 30 | 33 |
| Bigeye chub | 2.14 | 3.41 | 3.64 | 5.76 | 1.50 |
| Bigeye shiner | 3.82 | 13.07 | 2.17 | 3.26 | 1.66 |
| Bluntnose minnow | 1.53 | 7.02 | 2.12 | 2.38 | 2.37 |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | --- | 0.07 | --- | --- | --- |
| Duskystripe shiner | 11.92 | 4.94 | 22.83 | 20.80 | 13.88 |
| Hornyhead chub | 0.31 | 0.35 | 0.22 | --- | 0.63 |
| Ozark minnow | 4.89 | 2.43 | 3.37 | 2.13 | 0.39 |
| Ozark chub | 0.15 | 0.56 | 1.20 | 0.25 | 2.76 |
| Ozark shiner | --- | 1.11 | 0.38 | 0.25 | 1.34 |
| Rosyface shiner | 0.15 | 1.18 | 0.92 | 2.51 | 0.87 |
| Southern redbelly dace | --- | --- | --- | --- | --- |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 32.09 | 13.97 | 23.48 | 12.16 | 16.56 |
| Striped shiner | --- | --- | --- | --- | --- |
| Telescope shiner | 1.30 | 1.95 | 0.71 | 3.13 | 0.24 |
| Wedgespot shiner | 0.08 | --- | 0.49 | 0.50 | 1.18 |
| Whitetail shiner | 0.99 | 0.97 | 0.76 | 0.50 | 3.23 |
| Arkansas saddled darter | 1.22 | 0.14 | 1.85 | 0.25 | 1.74 |
| Banded darter | 2.22 | 0.97 | 4.18 | 1.38 | 4.02 |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 3.90 | 3.76 | 5.33 | 1.13 | 5.99 |
| Logperch | 0.31 | 0.63 | --- | --- | --- |
| Orangethroat darter | --- | --- | --- | --- | --- |
| Rainbow darter | 5.04 | 2.43 | 3.70 | 1.38 | 2.13 |
| Stippled darter | --- | --- | --- | --- | --- |
| Yoke darter | 3.21 | 0.97 | 6.03 | 3.88 | 1.97 |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | 0.07 | --- | --- | --- |
| Green sunfish | 0.99 | 1.25 | 0.11 | --- | 0.39 |
| Largemouth bass | --- | 0.35 | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Buffalo River near Woolum | Buffalo River near Woolum | Buffalo River at Shine Eye near Gilbert | Buffalo River at Shine Eye near Gilbert | Buffalo River at Highway 14 near Harriet |
|---|---|---|---|---|---|
| Site identifier | R5 | R5 | R6 | R6 | R7 |
| Date | 7/18/01 | 7/16/02 | 7/18/01 | 7/17/02 | 7/20/01 |
| Longear sunfish | 15.43 | 24.55 | 7.77 | 11.90 | 20.82 |
| Ozark bass | 1.83 | 1.67 | 2.39 | 7.02 | 3.31 |
| Redear sunfish | --- | --- | --- | --- | 0.16 |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 1.91 | 3.13 | 2.28 | 2.88 | 3.94 |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | 0.46 | 4.80 | 1.20 | 5.76 | 0.71 |
| Golden redhorse | 0.15 | 1.18 | --- | 5.39 | 0.08 |
| Northern hog sucker | 3.59 | 0.90 | 1.63 | 2.51 | 5.21 |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | 0.08 | 0.21 | --- | --- | 1.03 |
| Shorthead redhorse | --- | --- | --- | 0.13 | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | 0.08 | --- | 0.11 | 0.25 | --- |
| Flathead catfish | --- | 0.21 | 0.16 | 0.63 | 0.24 |
| Ozark madtom | --- | RK | 0.22 | 0.63 | 1.03 |
| Slender madtom | --- | --- | 0.05 | RK | 0.08 |
| Yellow bullhead | --- | 0.28 | 0.11 | 0.25 | 0.16 |
| Ammocoetes (immature lamprey) | 0.08 | --- | 0.05 | --- | --- |
| Chestnut lamprey | --- | 0.07 | --- | --- | --- |
| Longnose gar | --- | --- | --- | --- | --- |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | --- | --- | 0.16 | --- | 0.08 |
| Northern studfish | 0.15 | 1.39 | 0.33 | 1.00 | 0.32 |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | --- | --- | 0.05 | --- | --- |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study are.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Buffalo River at Highway 14 near Harriet | Buffalo River near Rush | Buffalo River near Rush | Buffalo River near mouth near Buffalo City | Buffalo River near mouth near Buffalo City |
|---|---|---|---|---|---|
| Site identifier | R7 | R8 | R8 | R9 | R9 |
| Date | 9/13/02 | 7/26/01 | 7/18/02 | 7/24/01 | 7/12/02 |
| Species richness (number of species) | 34 | 30 | 33 | 33 | 36 |
| Bigeye chub | 0.78 | 1.79 | 2.67 | 0.40 | 1.16 |
| Bigeye shiner | 1.19 | 2.49 | 4.27 | 2.53 | 2.82 |
| Bluntnose minnow | 1.35 | 1.97 | 1.60 | 0.67 | 0.33 |
| Common carp | --- | --- | --- | 0.13 | 0.17 |
| Creek chub | --- | --- | --- | --- | --- |
| Duskystripe shiner | 23.41 | 19.19 | 29.98 | 9.47 | 17.11 |
| Hornyhead chub | 1.09 | 0.12 | 0.15 | 1.07 | 0.83 |
| Ozark minnow | 3.42 | 5.72 | 7.17 | --- | 0.17 |
| Ozark chub | 3.78 | 3.76 | 2.36 | 2.40 | 0.33 |
| Ozark shiner | 0.16 | 0.17 | --- | --- | --- |
| Rosyface shiner | 0.62 | 0.92 | 2.29 | 0.13 | 0.66 |
| Southern redbelly dace | --- | --- | --- | --- | --- |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 27.40 | 29.48 | 21.05 | 26.66 | 22.09 |
| Striped shiner | --- | --- | --- | 1.33 | 0.33 |
| Telescope shiner | 0.31 | 0.64 | 0.61 | 2.80 | 0.17 |
| Wedgespot shiner | 1.45 | 1.45 | 1.30 | 0.53 | 0.50 |
| Whitetail shiner | 0.16 | 1.21 | 1.14 | 0.40 | 0.17 |
| Arkansas saddled darter | 4.14 | 0.98 | 0.76 | 1.20 | 1.50 |
| Banded darter | 1.55 | 1.27 | RK | 6.53 | 2.82 |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | 0.05 | --- | RK | --- | --- |
| Greenside darter | 4.45 | 0.81 | 1.07 | 6.80 | 4.32 |
| Logperch | 0.05 | --- | 0.46 | 0.13 | 0.17 |
| Orangethroat darter | --- | --- | --- | --- | 1.83 |
| Rainbow darter | 2.43 | 0.75 | 0.46 | 2.40 | 3.32 |
| Stippled darter | --- | --- | --- | --- | --- |
| Yoke darter | 1.55 | 0.87 | RK | 9.07 | RK |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | --- | --- | 0.80 | 0.50 |
| Green sunfish | 0.31 | 0.69 | 0.92 | 0.13 | 0.17 |
| Largemouth bass | --- | 0.12 | --- | 0.27 | 0.33 |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study are.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Buffalo River at Highway 14 near Harriet | Buffalo River near Rush | Buffalo River near Rush | Buffalo River near mouth near Buffalo City | Buffalo River near mouth near Buffalo City |
|---|---|---|---|---|---|
| Site identifier | R7 | R8 | R8 | R9 | R9 |
| Date | 9/13/02 | 7/26/01 | 7/18/02 | 7/24/01 | 7/12/02 |
| Longear sunfish | 11.03 | 18.73 | 13.27 | 10.27 | 18.27 |
| Ozark bass | 2.54 | 2.43 | 1.07 | 2.40 | 7.14 |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | 0.08 | 0.13 | 0.17 |
| Smallmouth bass | 1.29 | 1.62 | 2.21 | 2.80 | 1.99 |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | 1.61 | 0.17 | 2.44 | 0.53 | 6.64 |
| Golden redhorse | --- | 0.06 | 0.15 | 0.40 | 0.17 |
| Northern hog sucker | 1.40 | 1.79 | 1.22 | 0.40 | 1.66 |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | 0.47 | --- | 0.15 | --- | 0.33 |
| Flathead catfish | 0.26 | 0.23 | 0.08 | 0.53 | 0.50 |
| Ozark madtom | 1.04 | 0.06 | RK | --- | RK |
| Slender madtom | 0.10 | --- | --- | 0.53 | --- |
| Yellow bullhead | 0.26 | --- | 0.15 | --- | 1.16 |
| Ammocoetes (immature lamprey) | 0.05 | --- | --- | --- | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | 0.17 | --- | --- | --- |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | 0.16 | 0.35 | 0.15 | 0.67 | --- |
| Northern studfish | 0.16 | --- | 0.76 | 5.47 | 0.17 |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | --- | --- | --- | --- | --- |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Beech Creek near mouth near Boxley | Beech Creek near mouth near Boxley | Ponca Creek near mouth near Ponca | Ponca Creek near mouth near Ponca | Cecil Creek near mouth near Erbie |
|---|---|---|---|---|---|
| **Site identifier** | **T1** | **T1** | **T2** | **T2** | **T3** |
| **Date** | **6/19/01** | **6/20/02** | **7/31/01** | **6/25/02** | **6/20/01** |
| Species richness (number of species) | 17 | 13 | 17 | 14 | 23 |
| Bigeye chub | --- | --- | --- | --- | 0.36 |
| Bigeye shiner | 0.98 | --- | --- | 0.24 | 2.33 |
| Bluntnose minnow | --- | --- | --- | 0.24 | --- |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | --- | --- | 0.60 | --- | --- |
| Duskystripe shiner | 19.39 | 14.73 | 8.04 | 14.80 | 10.04 |
| Hornyhead chub | 0.49 | 1.40 | 0.45 | 1.91 | 1.97 |
| Ozark minnow | 0.39 | 6.03 | --- | 4.77 | 1.97 |
| Ozark chub | --- | --- | --- | --- | --- |
| Ozark shiner | --- | --- | --- | --- | --- |
| Rosyface shiner | 0.10 | --- | --- | --- | 2.51 |
| Southern redbelly dace | --- | --- | --- | --- | --- |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 55.61 | 52.73 | 58.18 | 22.43 | 44.27 |
| Striped shiner | --- | --- | --- | --- | --- |
| Telescope shiner | --- | --- | 0.15 | --- | 8.78 |
| Wedgespot shiner | --- | --- | --- | --- | 0.18 |
| Whitetail shiner | --- | --- | 0.15 | --- | 1.61 |
| Arkansas saddled darter | --- | --- | --- | --- | --- |
| Banded darter | --- | --- | 0.15 | --- | --- |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 0.69 | 2.24 | --- | 0.24 | 0.54 |
| Logperch | --- | --- | --- | --- | --- |
| Orangethroat darter | 0.30 | --- | 0.15 | --- | 1.25 |
| Rainbow darter | 10.24 | 9.40 | 11.76 | 25.30 | 6.27 |
| Stippled darter | 0.30 | 1.12 | 0.60 | 1.19 | 0.18 |
| Yoke darter | --- | --- | --- | --- | --- |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | --- | 0.15 | --- | --- |
| Green sunfish | 0.39 | --- | 9.97 | 19.57 | 0.72 |
| Largemouth bass | --- | --- | 0.15 | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Beech Creek near mouth near Boxley | Beech Creek near mouth near Boxley | Ponca Creek near mouth near Ponca | Ponca Creek near mouth near Ponca | Cecil Creek near mouth near Erbie |
|---|---|---|---|---|---|
| **Site identifier** | **T1** | **T1** | **T2** | **T2** | **T3** |
| **Date** | **6/19/01** | **6/20/02** | **7/31/01** | **6/25/02** | **6/20/01** |
| Longear sunfish | 6.10 | 9.68 | --- | --- | 10.57 |
| Ozark bass | 0.59 | 0.56 | --- | --- | 1.79 |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 0.39 | 0.14 | --- | --- | 0.72 |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | --- | --- | --- | --- | --- |
| Golden redhorse | --- | --- | --- | --- | --- |
| Northern hog sucker | --- | --- | --- | --- | 1.43 |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | --- | --- | --- | --- | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | --- | --- | --- | --- | --- |
| Slender madtom | 1.08 | 0.56 | 4.61 | 6.68 | 0.18 |
| Yellow bullhead | --- | --- | --- | --- | 0.36 |
| Ammocoetes (immature lamprey) | --- | --- | --- | --- | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | --- | --- | --- | --- |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | --- | --- | 0.60 | 0.24 | 0.36 |
| Northern studfish | 0.20 | 0.14 | 2.53 | 0.48 | --- |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | 2.76 | 1.26 | 1.79 | 1.91 | 1.61 |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Cecil Creek near mouth near Erbie | Mill Creek near mouth near Pruitt | Mill Creek near mouth near Pruitt | Little Buffalo River near mouth near Pruitt | Little Buffalo River near mouth near Pruitt |
|---|---|---|---|---|---|
| **Site identifier** | **T3** | **T4** | **T4** | **T5** | **T5** |
| **Date** | **6/24/02** | **8/1/01** | **6/21/02** | **8/2/01** | **8/19/02** |
| Species richness (number of species) | 26 | 21 | 18 | 30 | 31 |
| Bigeye chub | 1.44 | 3.23 | 1.50 | 3.65 | 0.59 |
| Bigeye shiner | 0.64 | --- | 0.50 | 0.65 | 0.85 |
| Bluntnose minnow | 0.64 | 12.78 | 9.00 | 2.94 | 6.35 |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | --- | --- | --- | --- | --- |
| Duskystripe shiner | 28.37 | 21.49 | 16.00 | 10.88 | 8.97 |
| Hornyhead chub | 1.92 | 2.67 | 0.50 | 0.59 | 1.18 |
| Ozark minnow | 8.33 | 10.11 | 10.00 | 4.18 | 5.25 |
| Ozark chub | --- | --- | --- | --- | --- |
| Ozark shiner | --- | --- | --- | 0.88 | 0.51 |
| Rosyface shiner | 0.96 | 1.69 | --- | 0.71 | 0.68 |
| Southern redbelly dace | --- | --- | --- | --- | --- |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 23.72 | 8.01 | 18.00 | 28.71 | 25.30 |
| Striped shiner | --- | --- | --- | --- | --- |
| Telescope shiner | 1.28 | 2.25 | 0.50 | 3.82 | 0.51 |
| Wedgespot shiner | 0.16 | --- | --- | 0.24 | 0.68 |
| Whitetail shiner | 0.16 | --- | --- | 0.18 | 0.25 |
| Arkansas saddled darter | --- | --- | --- | 0.88 | 0.76 |
| Banded darter | 0.16 | RK | --- | 1.65 | 1.18 |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 2.56 | 2.67 | 1.50 | 1.65 | 5.41 |
| Logperch | --- | --- | --- | --- | --- |
| Orangethroat darter | 0.32 | --- | 1.50 | --- | 0.25 |
| Rainbow darter | 18.27 | 7.72 | 18.00 | 5.59 | 8.71 |
| Stippled darter | 0.32 | --- | --- | --- | --- |
| Yoke darter | --- | --- | --- | 16.65 | 9.90 |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | 0.16 | 0.42 | --- | --- | --- |
| Green sunfish | 0.48 | 0.14 | --- | 1.18 | 0.42 |
| Largemouth bass | --- | --- | --- | 0.06 | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Cecil Creek near mouth near Erbie | Mill Creek near mouth near Pruitt | Mill Creek near mouth near Pruitt | Little Buffalo River near mouth near Pruitt | Little Buffalo River near mouth near Pruitt |
|---|---|---|---|---|---|
| **Site identifier** | **T3** | **T4** | **T4** | **T5** | **T5** |
| **Date** | **6/24/02** | **8/1/01** | **6/21/02** | **8/2/01** | **8/19/02** |
| Longear sunfish | 2.56 | 16.71 | 6.00 | 12.24 | 14.72 |
| Ozark bass | 1.12 | 1.97 | 3.00 | 0.76 | 1.18 |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 0.32 | 1.40 | --- | 0.35 | 1.18 |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | --- | --- | --- | 0.12 | 0.85 |
| Golden redhorse | --- | --- | --- | --- | 0.08 |
| Northern hog sucker | 0.16 | 1.26 | 0.50 | 0.12 | 2.28 |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | --- | --- | --- | --- | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | --- | --- | --- | 0.35 | 0.34 |
| Slender madtom | 0.64 | 0.14 | 0.50 | 0.12 | 0.93 |
| Yellow bullhead | --- | --- | --- | 0.06 | 0.08 |
| Ammocoetes (immature lamprey) | --- | --- | --- | 0.06 | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | --- | --- | --- | 0.17 |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | RK | 1.26 | 0.50 | 0.41 | 0.17 |
| Northern studfish | 0.16 | 0.28 | 1.00 | 0.35 | 0.25 |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | 5.13 | 3.79 | 11.50 | --- | --- |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | East Fork Little Buffalo River near Murray | East Fork Little Buffalo River near Murray | Big Creek near mouth near Carver | Big Creek near mouth near Carver | Left Fork Big Creek near Red Rock |
|---|---|---|---|---|---|
| Site identifier | T5-HW | T5-HW | T6 | T6 | T6-HW1 |
| Date | 6/23/01 | 6/19/02 | 8/7/01 | 7/24/02 | 6/25/01 |
| Species richness (number of species) | 13 | 10 | 29 | 29 | 9 |
| Bigeye chub | --- | --- | 0.96 | --- | --- |
| Bigeye shiner | --- | --- | 0.96 | 0.94 | --- |
| Bluntnose minnow | --- | --- | 2.03 | 5.24 | --- |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | 0.22 | --- | --- | 0.21 | 1.40 |
| Duskystripe shiner | 10.60 | 12.44 | 10.64 | 10.69 | --- |
| Hornyhead chub | 2.21 | 2.76 | 1.47 | 0.73 | 9.79 |
| Ozark minnow | 0.88 | --- | 18.44 | 10.27 | --- |
| Ozark chub | --- | --- | 0.05 | --- | --- |
| Ozark shiner | --- | --- | 0.71 | 0.10 | --- |
| Rosyface shiner | --- | --- | 0.46 | 0.10 | --- |
| Southern redbelly dace | --- | --- | --- | --- | 44.76 |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 64.68 | 52.53 | 32.52 | 28.93 | 30.07 |
| Striped shiner | --- | --- | 0.46 | 0.21 | --- |
| Telescope shiner | --- | --- | 0.61 | 0.52 | --- |
| Wedgespot shiner | --- | --- | --- | --- | --- |
| Whitetail shiner | --- | --- | --- | --- | --- |
| Arkansas saddled darter | --- | --- | 0.15 | 0.63 | --- |
| Banded darter | --- | --- | 0.15 | 0.63 | --- |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 0.44 | 4.15 | 0.71 | 1.05 | --- |
| Logperch | --- | --- | --- | --- | --- |
| Orangethroat darter | 0.44 | --- | --- | --- | 5.59 |
| Rainbow darter | 13.25 | 17.51 | 2.84 | 7.97 | --- |
| Stippled darter | --- | --- | 0.05 | --- | 2.10 |
| Yoke darter | --- | --- | 1.42 | 4.09 | --- |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | --- | --- | --- | --- |
| Green sunfish | 0.88 | 0.46 | 1.98 | 3.67 | 3.50 |
| Largemouth bass | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | East Fork Little Buffalo River near Murray | East Fork Little Buffalo River near Murray | Big Creek near mouth near Carver | Big Creek near mouth near Carver | Left Fork Big Creek near Red Rock |
|---|---|---|---|---|---|
| **Site identifier** | **T5-HW** | **T5-HW** | **T6** | **T6** | **T6-HW1** |
| **Date** | **6/23/01** | **6/19/02** | **8/7/01** | **7/24/02** | **6/25/01** |
| Longear sunfish | 3.09 | 4.15 | 19.35 | 15.09 | 2.10 |
| Ozark bass | --- | --- | 0.46 | 1.05 | --- |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 1.55 | 3.69 | 0.41 | 0.42 | --- |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | --- | --- | 0.10 | --- | --- |
| Golden redhorse | --- | --- | 0.05 | 0.10 | --- |
| Northern hog sucker | 0.66 | 0.46 | 0.15 | 1.05 | --- |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | --- | --- | --- | --- | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | --- | --- | --- | 0.10 | --- |
| Slender madtom | 1.10 | 1.84 | 0.86 | 1.57 | 0.70 |
| Yellow bullhead | --- | --- | --- | 0.10 | --- |
| Ammocoetes (immature lamprey) | --- | --- | --- | --- | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | --- | --- | 0.21 | --- |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | --- | --- | 0.86 | 0.52 | --- |
| Northern studfish | --- | --- | 1.11 | 0.10 | --- |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | --- | --- | 0.05 | 3.67 | --- |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Left Fork Big Creek near Red Rock | Big Creek near Mt. Judea | Big Creek near Mt. Judea | Big Creek near Vendor | Big Creek near Vendor |
|---|---|---|---|---|---|
| Site identifier | T6-HW1 | T6-HW2 | T6-HW2 | T6-S | T6-S |
| Date | 6/19/02 | 7/26/01 | 6/25/02 | 8/8/01 | 7/23/02 |
| Species richness (number of species) | 7 | 12 | 19 | 26 | 29 |
| Bigeye chub | --- | --- | --- | 0.51 | 1.00 |
| Bigeye shiner | --- | 1.31 | 6.46 | 0.61 | 3.48 |
| Bluntnose minnow | --- | --- | --- | 0.20 | 3.98 |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | 0.88 | --- | 0.55 | --- | 0.10 |
| Duskystripe shiner | --- | --- | 1.10 | 7.16 | 5.87 |
| Hornyhead chub | --- | --- | --- | 1.23 | 0.50 |
| Ozark minnow | --- | --- | 2.34 | 8.39 | 25.57 |
| Ozark chub | --- | --- | --- | --- | --- |
| Ozark shiner | --- | --- | --- | 0.20 | 2.19 |
| Rosyface shiner | --- | --- | --- | 2.15 | --- |
| Southern redbelly dace | 35.13 | --- | 0.14 | --- | --- |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 51.38 | 69.52 | 55.02 | 23.54 | 14.83 |
| Striped shiner | --- | --- | --- | 0.10 | 0.50 |
| Telescope shiner | --- | --- | 0.41 | 5.42 | 0.60 |
| Wedgespot shiner | --- | --- | --- | --- | --- |
| Whitetail shiner | --- | --- | --- | 0.61 | 0.10 |
| Arkansas saddled darter | --- | --- | --- | 0.10 | 0.20 |
| Banded darter | --- | --- | --- | 1.02 | 1.89 |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | --- | --- | 0.55 | 0.72 | 2.99 |
| Logperch | --- | --- | --- | --- | --- |
| Orangethroat darter | 9.88 | 1.02 | 6.46 | --- | --- |
| Rainbow darter | --- | 1.60 | 4.26 | 4.30 | 5.97 |
| Stippled darter | 1.75 | 5.22 | 5.64 | --- | --- |
| Yoke darter | --- | --- | --- | RK | 1.59 |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | --- | --- | --- | --- |
| Green sunfish | 0.38 | 1.16 | 1.79 | 0.20 | 0.60 |
| Largemouth bass | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Left Fork Big Creek near Red Rock | Big Creek near Mt. Judea | Big Creek near Mt. Judea | Big Creek near Vendor | Big Creek near Vendor |
|---|---|---|---|---|---|
| **Site identifier** | **T6-HW1** | **T6-HW2** | **T6-HW2** | **T6-S** | **T6-S** |
| **Date** | **6/19/02** | **7/26/01** | **6/25/02** | **8/8/01** | **7/23/02** |
| Longear sunfish | --- | 9.00 | 9.35 | 35.01 | 18.61 |
| Ozark bass | --- | 1.02 | 0.69 | 3.48 | 4.48 |
| Redear sunfish | --- | --- | --- | --- | 0.20 |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | --- | 1.02 | 0.41 | 2.35 | 0.60 |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | --- | --- | --- | 0.31 | 0.70 |
| Golden redhorse | --- | --- | --- | --- | --- |
| Northern hog sucker | --- | 6.97 | 2.20 | 1.33 | 0.40 |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | --- | --- | --- | --- | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | --- | --- | --- | --- | 0.10 |
| Slender madtom | 0.63 | 2.03 | 2.06 | 0.10 | RK |
| Yellow bullhead | --- | 0.15 | --- | --- | --- |
| Ammocoetes (immature lamprey) | --- | --- | --- | --- | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | --- | --- | --- | --- |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | --- | --- | --- | 0.51 | 0.40 |
| Northern studfish | --- | --- | 0.41 | 0.41 | 0.30 |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | --- | --- | 0.14 | --- | 2.29 |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Davis Creek near mouth near Mt. Hersey | Davis Creek near mouth near Mt. Hersey | Cave Creek near mouth near Mt. Hersey | Cave Creek near mouth near Mt. Hersey | Cave Creek near Woolum |
|---|---|---|---|---|---|
| Site identifier | T7 | T7 | T8 | T8 | T8-S |
| Date | 8/3/01 | 7/22/02 | 8/8/01 | 7/26/02 | 8/1/01 |
| Species richness (number of species) | 17 | 19 | 24 | 29 | 25 |
| Bigeye chub | --- | --- | 2.47 | 1.14 | 1.72 |
| Bigeye shiner | --- | --- | 0.69 | 1.43 | 1.15 |
| Bluntnose minnow | --- | 0.69 | 1.10 | 5.01 | 1.72 |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | --- | --- | --- | --- | --- |
| Duskystripe shiner | 39.32 | 26.01 | 16.19 | 12.30 | 11.02 |
| Hornyhead chub | 1.20 | 1.73 | 0.96 | 1.29 | 2.30 |
| Ozark minnow | 3.93 | 0.23 | 2.33 | 0.29 | 6.70 |
| Ozark chub | --- | --- | --- | --- | --- |
| Ozark shiner | --- | --- | 1.10 | --- | --- |
| Rosyface shiner | 1.03 | --- | 0.69 | 0.29 | 0.86 |
| Southern redbelly dace | 0.34 | 2.89 | --- | --- | --- |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 21.20 | 28.55 | 35.39 | 24.32 | 38.70 |
| Striped shiner | --- | --- | 0.41 | 0.14 | --- |
| Telescope shiner | 1.88 | 0.12 | 4.66 | 0.14 | 2.68 |
| Wedgespot shiner | --- | --- | --- | 0.14 | --- |
| Whitetail shiner | --- | --- | 0.55 | --- | 0.10 |
| Arkansas saddled darter | --- | --- | 3.29 | 3.00 | 0.77 |
| Banded darter | --- | 0.23 | 1.78 | 1.72 | 1.15 |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 0.17 | 0.92 | 1.92 | 3.86 | 4.02 |
| Logperch | --- | --- | --- | --- | --- |
| Orangethroat darter | 1.20 | 3.70 | --- | --- | --- |
| Rainbow darter | 13.50 | 17.80 | 5.76 | 9.87 | 3.35 |
| Stippled darter | 0.17 | 0.12 | --- | --- | --- |
| Yoke darter | --- | --- | 4.25 | 5.72 | --- |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | --- | --- | 0.43 | 0.10 |
| Green sunfish | --- | 0.23 | --- | 0.29 | 0.29 |
| Largemouth bass | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Davis Creek near mouth near Mt. Hersey | Davis Creek near mouth near Mt. Hersey | Cave Creek near mouth near Mt. Hersey | Cave Creek near mouth near Mt. Hersey | Cave Creek near Woolum |
|---|---|---|---|---|---|
| **Site identifier** | **T7** | **T7** | **T8** | **T8** | **T8-S** |
| **Date** | **8/3/01** | **7/22/02** | **8/8/01** | **7/26/02** | **8/1/01** |
| Longear sunfish | 2.39 | 2.20 | 12.35 | 18.60 | 17.72 |
| Ozark bass | --- | --- | 0.41 | 1.86 | 1.44 |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 0.34 | --- | 1.10 | 0.86 | 0.67 |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | 0.14 | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | --- | --- | --- | 2.29 | 0.57 |
| Golden redhorse | --- | --- | --- | --- | --- |
| Northern hog sucker | --- | 0.23 | 0.82 | 1.00 | 1.34 |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | --- | --- | --- | --- | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | 0.17 | --- | --- | 0.29 | 0.10 |
| Slender madtom | 1.03 | 0.35 | 0.82 | 1.72 | 0.86 |
| Yellow bullhead | --- | --- | --- | --- | --- |
| Ammocoetes (immature lamprey) | --- | --- | --- | --- | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | --- | --- | --- | --- |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | --- | 0.12 | 0.14 | 0.43 | 0.38 |
| Northern studfish | 0.51 | --- | 0.82 | 0.43 | 0.29 |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | 11.62 | 13.76 | --- | 1.00 | --- |
| Ozark sculpin | --- | 0.12 | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Cave Creek near Woolum | Cave Creek near Bass | Cave Creek near Bass | Richland Creek near mouth near Eula | Richland Creek near Ben Hur |
|---|---|---|---|---|---|
| **Site identifier** | **T8-S** | **T8-HW** | **T8-HW** | **T9** | **T9-HW1** |
| **Date** | **7/24/02** | **7/25/01** | **8/1/02** | **7/13/01** | **8/6/01** |
| Species richness (number of species) | 25 | 10 | 12 | 25 | 12 |
| Bigeye chub | 1.23 | --- | --- | --- | --- |
| Bigeye shiner | 2.27 | --- | --- | 1.41 | --- |
| Bluntnose minnow | 1.70 | --- | --- | 0.16 | --- |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | --- | 3.95 | 13.23 | 0.31 | 0.85 |
| Duskystripe shiner | 8.04 | 0.19 | 3.54 | 7.69 | 18.73 |
| Hornyhead chub | 1.42 | --- | 0.52 | 0.31 | --- |
| Ozark minnow | 4.35 | --- | --- | 5.34 | 4.08 |
| Ozark chub | --- | --- | --- | --- | --- |
| Ozark shiner | 0.09 | --- | --- | --- | --- |
| Rosyface shiner | 0.66 | --- | --- | 4.71 | --- |
| Southern redbelly dace | --- | 7.34 | 25.21 | --- | --- |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 50.24 | 75.07 | 49.17 | 39.56 | 53.17 |
| Striped shiner | --- | --- | --- | 0.78 | --- |
| Telescope shiner | 0.09 | --- | --- | 2.35 | --- |
| Wedgespot shiner | --- | --- | --- | 0.78 | --- |
| Whitetail shiner | --- | --- | --- | 0.16 | --- |
| Arkansas saddled darter | 0.47 | --- | --- | --- | --- |
| Banded darter | 0.85 | --- | --- | 8.79 | --- |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 4.16 | 0.09 | --- | 1.26 | 0.56 |
| Logperch | --- | --- | --- | --- | --- |
| Orangethroat darter | --- | 8.56 | 3.54 | --- | 11.27 |
| Rainbow darter | 7.10 | 0.09 | --- | --- | --- |
| Stippled darter | --- | 3.76 | 3.23 | 3.30 | --- |
| Yoke darter | 0.09 | --- | --- | --- | --- |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | --- | --- | 0.16 | --- |
| Green sunfish | 0.09 | 0.28 | 0.10 | 0.63 | 2.75 |
| Largemouth bass | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Cave Creek near Woolum | Cave Creek near Bass | Cave Creek near Bass | Richland Creek near mouth near Eula | Richland Creek near Ben Hur |
|---|---|---|---|---|---|
| **Site identifier** | **T8-S** | **T8-HW** | **T8-HW** | **T9** | **T9-HW1** |
| **Date** | **7/24/02** | **7/25/01** | **8/1/02** | **7/13/01** | **8/6/01** |
| Longear sunfish | 10.97 | --- | 0.10 | 0.63 | 2.96 |
| Ozark bass | 0.38 | --- | --- | 0.16 | --- |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 0.19 | --- | --- | 0.63 | 0.14 |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | 1.32 | --- | --- | --- | --- |
| Golden redhorse | 0.28 | --- | --- | 1.88 | --- |
| Northern hog sucker | 1.42 | --- | 0.31 | 6.28 | --- |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | 0.94 | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | --- | --- | --- | --- | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | --- | --- | --- | --- | --- |
| Slender madtom | 0.19 | 0.66 | 0.73 | --- | 5.07 |
| Yellow bullhead | --- | --- | --- | 0.31 | 0.14 |
| Ammocoetes (immature lamprey) | --- | --- | --- | --- | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | --- | --- | --- | --- |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | 0.28 | --- | --- | --- | --- |
| Northern studfish | --- | --- | --- | --- | 0.28 |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | 2.08 | --- | 0.31 | 11.46 | --- |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Richland Creek near Ben Hur | Richland Creek near Witts Spring | Richland Creek near Witts Spring | Falling Water Creek near Witts Spring | Falling Water Creek near Witts Spring |
|---|---|---|---|---|---|
| **Site identifier** | **T9-HW1** | **T9-HW2** | **T9-HW2** | **T9-HW3** | **T9-HW3** |
| **Date** | **7/25/02** | **6/28/01** | **8/21/02** | **6/29/01** | **7/25/02** |
| Species richness (number of species) | 10 | 14 | 17 | 17 | 16 |
| Bigeye chub | --- | --- | --- | --- | --- |
| Bigeye shiner | --- | --- | --- | --- | --- |
| Bluntnose minnow | --- | --- | --- | --- | --- |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | 1.34 | --- | 0.21 | 0.50 | 0.82 |
| Duskystripe shiner | 11.41 | 17.32 | 18.35 | 8.04 | 21.81 |
| Hornyhead chub | --- | 2.44 | 2.27 | 4.02 | 1.65 |
| Ozark minnow | 9.06 | 0.98 | 0.21 | 11.06 | 8.23 |
| Ozark chub | --- | --- | --- | --- | --- |
| Ozark shiner | --- | --- | --- | --- | --- |
| Rosyface shiner | --- | --- | --- | --- | --- |
| Southern redbelly dace | --- | --- | --- | --- | --- |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 36.58 | 45.12 | 55.67 | 11.06 | 30.45 |
| Striped shiner | --- | --- | --- | --- | --- |
| Telescope shiner | --- | --- | 0.41 | 2.01 | --- |
| Wedgespot shiner | --- | --- | --- | --- | --- |
| Whitetail shiner | --- | 1.22 | 1.24 | 6.03 | 2.47 |
| Arkansas saddled darter | --- | --- | --- | --- | --- |
| Banded darter | --- | --- | --- | --- | --- |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 3.69 | 4.39 | 10.93 | 3.02 | 3.70 |
| Logperch | --- | --- | --- | --- | --- |
| Orangethroat darter | 16.44 | --- | 1.24 | 3.02 | 2.06 |
| Rainbow darter | --- | 10.49 | 2.47 | 3.02 | 4.12 |
| Stippled darter | --- | --- | --- | --- | 0.41 |
| Yoke darter | --- | --- | --- | --- | --- |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | --- | --- | --- | --- |
| Green sunfish | 3.36 | 1.22 | 0.21 | 10.55 | 1.65 |
| Largemouth bass | --- | --- | --- | --- | --- |
| Longear sunfish | 3.02 | 10.49 | 1.86 | 26.13 | 11.93 |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Richland Creek near Ben Hur | Richland Creek near Witts Spring | Richland Creek near Witts Spring | Falling Water Creek near Witts Spring | Falling Water Creek near Witts Spring |
|---|---|---|---|---|---|
| **Site identifier** | **T9-HW1** | **T9-HW2** | **T9-HW2** | **T9-HW3** | **T9-HW3** |
| **Date** | **7/25/02** | **6/28/01** | **8/21/02** | **6/29/01** | **7/25/02** |
| Ozark bass | --- | 0.49 | 0.41 | 0.50 | 1.23 |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 1.01 | 1.71 | 0.82 | 2.01 | 3.70 |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | --- | --- | --- | --- | --- |
| Golden redhorse | --- | --- | --- | --- | --- |
| Northern hog sucker | --- | 2.20 | 1.03 | 0.50 | 1.23 |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | --- | --- | --- | --- | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | --- | --- | --- | --- | --- |
| Slender madtom | 14.09 | 0.73 | 2.27 | 6.03 | 4.53 |
| Yellow bullhead | --- | --- | --- | 2.51 | --- |
| Ammocoetes (immature lamprey) | --- | --- | --- | --- | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | --- | --- | --- | --- |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | --- | --- | --- | --- | --- |
| Northern studfish | --- | 1.22 | 0.41 | --- | --- |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | --- | --- | --- | --- | --- |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Calf Creek near mouth near Silver Hill | Calf Creek near mouth near Silver Hill | Mill Creek near mouth near Silver Hill | Mill Creek near mouth near Silver Hill | Bear Creek near mouth near Gilbert |
|---|---|---|---|---|---|
| **Site identifier** | **T10** | **T10** | **T11** | **T11** | **T12** |
| **Date** | **6/21/01** | **7/22/02** | **6/22/01** | **6/29/02** | **7/12/01** |
| Species richness (number of species) | 21 | 23 | 19 | 19 | 26 |
| Bigeye chub | --- | --- | --- | --- | 0.79 |
| Bigeye shiner | 0.21 | 0.23 | 0.22 | 1.00 | 2.89 |
| Bluntnose minnow | --- | 0.15 | --- | --- | --- |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | --- | --- | 0.33 | --- | --- |
| Duskystripe shiner | 8.27 | 14.21 | 32.35 | 13.18 | 9.97 |
| Hornyhead chub | 0.14 | 0.62 | 2.63 | 1.99 | 1.44 |
| Ozark minnow | 0.42 | 0.31 | 0.11 | 0.25 | 1.84 |
| Ozark chub | --- | --- | --- | --- | 0.52 |
| Ozark shiner | --- | --- | --- | --- | --- |
| Rosyface shiner | --- | 0.08 | 1.43 | 1.24 | 0.13 |
| Southern redbelly dace | 0.71 | 1.62 | 2.63 | 8.21 | --- |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 73.34 | 53.36 | 27.96 | 46.27 | 35.70 |
| Striped shiner | 0.07 | --- | --- | --- | 0.52 |
| Telescope shiner | 0.57 | 0.23 | 10.75 | 0.25 | 0.39 |
| Wedgespot shiner | --- | --- | --- | --- | 0.39 |
| Whitetail shiner | 0.07 | --- | 0.11 | --- | 0.13 |
| Arkansas saddled darter | 0.07 | --- | --- | --- | 3.54 |
| Banded darter | --- | --- | --- | 0.25 | 1.84 |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 0.21 | 0.15 | 0.44 | 0.75 | 3.67 |
| Logperch | --- | --- | --- | --- | --- |
| Orangethroat darter | 1.84 | 6.41 | --- | 0.25 | --- |
| Rainbow darter | 7.71 | 8.88 | 3.51 | 11.69 | 6.96 |
| Stippled darter | --- | 0.23 | --- | --- | --- |
| Yoke darter | --- | 0.15 | --- | --- | 2.62 |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | --- | --- | --- | --- |
| Green sunfish | --- | --- | --- | --- | --- |
| Largemouth bass | --- | --- | 0.22 | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Calf Creek near mouth near Silver Hill | Calf Creek near mouth near Silver Hill | Mill Creek near mouth near Silver Hill | Mill Creek near mouth near Silver Hill | Bear Creek near mouth near Gilbert |
|---|---|---|---|---|---|
| **Site identifier** | **T10** | **T10** | **T11** | **T11** | **T12** |
| **Date** | **6/21/01** | **7/22/02** | **6/22/01** | **6/29/02** | **7/12/01** |
| Longear sunfish | 0.21 | 0.15 | 1.32 | 1.99 | 16.80 |
| Ozark bass | --- | --- | --- | --- | 2.89 |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 0.21 | 0.31 | 0.22 | --- | 1.97 |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | --- | 0.69 | --- | --- | 0.39 |
| Golden redhorse | 0.21 | 0.15 | --- | --- | --- |
| Northern hog sucker | 0.71 | 1.39 | 0.66 | 0.50 | 1.71 |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | --- | --- | --- | --- | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | --- | --- | --- | --- | --- |
| Slender madtom | 0.21 | 0.39 | --- | 0.25 | 1.84 |
| Yellow bullhead | --- | --- | --- | --- | --- |
| Ammocoetes (immature lamprey) | --- | --- | --- | --- | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | --- | --- | --- | --- |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | 0.25 | --- |
| Blackspotted topminnow | 0.07 | 0.08 | 0.11 | 0.25 | 0.26 |
| Northern studfish | 0.21 | 0.31 | 0.66 | 0.25 | 0.26 |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | 4.53 | 9.88 | 14.36 | 11.19 | 0.52 |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Bear Creek near mouth near Gilbert | Bear Creek near Welcome Home | Bear Creek near Welcome Home | Brush Creek near mouth near Gilbert | Brush Creek near mouth near Gilbert |
|---|---|---|---|---|---|
| Site identifier | T12 | T12-HW | T12-HW | T13 | T13 |
| Date | 8/8/02 | 6/27/01 | 7/30/02 | 7/16/01 | 6/28/02 |
| Species richness (number of species) | 36 | 13 | 12 | 14 | 15 |
| Bigeye chub | 1.08 | --- | --- | --- | --- |
| Bigeye shiner | 2.36 | 0.51 | --- | --- | --- |
| Bluntnose minnow | 1.16 | --- | --- | --- | 0.43 |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | --- | 12.70 | 10.00 | 1.54 | --- |
| Duskystripe shiner | 13.49 | 1.53 | 1.52 | 13.88 | 8.00 |
| Hornyhead chub | 0.74 | --- | --- | 2.37 | 1.71 |
| Ozark minnow | 4.92 | 1.28 | 0.91 | 0.95 | 0.71 |
| Ozark chub | --- | --- | --- | --- | --- |
| Ozark shiner | 0.12 | --- | --- | --- | --- |
| Rosyface shiner | 0.21 | --- | --- | --- | --- |
| Southern redbelly dace | --- | 0.34 | 6.82 | 5.34 | 5.71 |
| Steelcolor shiner | 0.50 | --- | --- | --- | --- |
| Stoneroller | 42.82 | 55.41 | 54.39 | 64.89 | 72.43 |
| Striped shiner | 0.17 | --- | --- | 0.24 | --- |
| Telescope shiner | 0.04 | --- | --- | --- | --- |
| Wedgespot shiner | --- | --- | --- | --- | --- |
| Whitetail shiner | 0.21 | 2.98 | 3.79 | 0.24 | --- |
| Arkansas saddled darter | 1.12 | --- | --- | --- | --- |
| Banded darter | 0.66 | --- | --- | --- | 0.14 |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 2.94 | 0.68 | 1.67 | --- | 0.86 |
| Logperch | --- | --- | --- | --- | --- |
| Orangethroat darter | 0.54 | 15.94 | 13.94 | 3.44 | 0.14 |
| Rainbow darter | 3.93 | 5.03 | 3.03 | 1.54 | 3.57 |
| Stippled darter | 0.04 | 1.36 | 0.15 | --- | --- |
| Yoke darter | 0.87 | --- | --- | --- | 0.14 |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | --- | --- | --- | --- |
| Green sunfish | 0.54 | --- | --- | 0.12 | --- |
| Largemouth bass | 0.04 | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Bear Creek near mouth near Gilbert | Bear Creek near Welcome Home | Bear Creek near Welcome Home | Brush Creek near mouth near Gilbert | Brush Creek near mouth near Gilbert |
|---|---|---|---|---|---|
| **Site identifier** | **T12** | **T12-HW** | **T12-HW** | **T13** | **T13** |
| **Date** | **8/8/02** | **6/27/01** | **7/30/02** | **7/16/01** | **6/28/02** |
| Longear sunfish | 13.61 | 0.09 | --- | 1.30 | 1.14 |
| Ozark bass | 0.54 | --- | --- | --- | --- |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 1.12 | --- | --- | --- | --- |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | 0.04 | --- | 0.15 | --- | --- |
| Golden redhorse | --- | --- | --- | --- | --- |
| Northern hog sucker | 1.99 | --- | --- | --- | 0.14 |
| Redhorse, unidentified | 1.94 | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | 0.12 | --- | --- | --- | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | 0.17 | --- | --- | --- | --- |
| Slender madtom | 0.41 | 2.13 | 3.64 | 2.37 | 0.57 |
| Yellow bullhead | 0.37 | --- | --- | --- | --- |
| Ammocoetes (immature lamprey) | --- | --- | --- | --- | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | 0.04 | --- | --- | --- | --- |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | 0.29 | --- | --- | --- | --- |
| Northern studfish | 0.79 | --- | --- | --- | --- |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | 0.04 | --- | --- | 1.78 | 4.29 |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Tomahawk Creek near mouth near Tomahawk | Tomahawk Creek near mouth near Tomahawk | Water Creek near mouth near Evening Star | Water Creek near mouth near Evening Star | Water Creek near Maumee |
|---|---|---|---|---|---|
| **Site identifier** | **T14** | **T14** | **T15** | **T15** | **T15-S** |
| **Date** | **8/10/01** | **7/19/02** | **8/21/01** | **7/8/02** | **8/9/01** |
| Species richness (number of species) | 29 | 30 | 30 | 30 | 22 |
| Bigeye chub | 0.20 | 0.08 | 0.19 | 0.96 | 1.31 |
| Bigeye shiner | 0.10 | 0.47 | 0.81 | 1.60 | --- |
| Bluntnose minnow | 0.30 | 0.08 | 0.06 | 1.60 | 0.49 |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | --- | --- | --- | --- | --- |
| Duskystripe shiner | 11.26 | 17.94 | 17.75 | 9.94 | 29.08 |
| Hornyhead chub | 4.84 | 1.65 | 1.19 | 1.60 | 2.29 |
| Ozark minnow | 13.83 | 1.65 | 2.00 | 1.60 | 6.86 |
| Ozark chub | --- | 0.08 | --- | 0.32 | --- |
| Ozark shiner | --- | --- | 0.19 | --- | --- |
| Rosyface shiner | 0.69 | 0.55 | 0.44 | 0.96 | 1.47 |
| Southern redbelly dace | --- | --- | --- | --- | --- |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 33.50 | 51.46 | 59.19 | 40.38 | 30.07 |
| Striped shiner | 0.20 | 0.16 | 0.06 | --- | --- |
| Telescope shiner | 2.57 | 0.24 | 0.56 | RK | 7.68 |
| Wedgespot shiner | 0.10 | 0.16 | 1.31 | 0.32 | 0.16 |
| Whitetail shiner | 0.20 | --- | 1.13 | 0.32 | 1.14 |
| Arkansas saddled darter | 1.09 | 1.02 | 1.63 | 3.21 | RK |
| Banded darter | 1.28 | --- | 0.88 | 1.28 | --- |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 1.68 | 0.31 | 1.81 | 2.56 | 0.16 |
| Logperch | --- | --- | --- | --- | --- |
| Orangethroat darter | 1.78 | 0.63 | 0.13 | RK | 0.33 |
| Rainbow darter | 7.21 | 6.61 | 3.81 | 1.28 | 7.68 |
| Stippled darter | --- | --- | --- | --- | --- |
| Yoke darter | 0.30 | 0.39 | 0.38 | --- | --- |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | --- | --- | --- | --- |
| Green sunfish | 0.10 | 0.08 | --- | --- | --- |
| Largemouth bass | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Tomahawk Creek near mouth near Tomahawk | Tomahawk Creek near mouth near Tomahawk | Water Creek near mouth near Evening Star | Water Creek near mouth near Evening Star | Water Creek near Maumee |
|---|---|---|---|---|---|
| **Site identifier** | **T14** | **T14** | **T15** | **T15** | **T15-S** |
| **Date** | **8/10/01** | **7/19/02** | **8/21/01** | **7/8/02** | **8/9/01** |
| Longear sunfish | 6.42 | 6.77 | 4.06 | 12.18 | 1.80 |
| Ozark bass | 0.40 | 0.47 | 0.38 | 1.28 | 1.63 |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 1.28 | 1.65 | 0.56 | 0.64 | 1.63 |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | 0.89 | 0.16 | 0.13 | 3.53 | --- |
| Golden redhorse | --- | --- | --- | 1.92 | --- |
| Northern hog sucker | 1.68 | 1.65 | 0.19 | 6.73 | 0.33 |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | 0.10 | 0.47 | 0.06 | 0.96 | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | --- | 0.08 | 0.13 | RK | --- |
| Slender madtom | 0.99 | 0.79 | 0.38 | 0.32 | 0.16 |
| Yellow bullhead | --- | 0.31 | --- | 0.64 | --- |
| Ammocoetes (immature lamprey) | --- | --- | --- | --- | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | --- | --- | --- | --- |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | 1.58 | 0.47 | 0.19 | 0.96 | 0.33 |
| Northern studfish | 0.40 | 0.39 | 0.31 | 1.28 | 0.16 |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | 5.04 | 3.23 | 0.13 | 1.60 | 5.23 |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Water Creek near Maumee | Rush Creek near mouth near Rush | Rush Creek near mouth near Rush | Clabber Creek near mouth near Rush | Clabber Creek near mouth near Rush |
|---|---|---|---|---|---|
| Site identifier | T15-S | T16 | T16 | T17 | T17 |
| Date | 8/22/02 | 7/25/01 | 8/23/02 | 7/27/01 | 8/23/02 |
| Species richness (number of species) | 18 | 16 | 11 | 26 | 24 |
| Bigeye chub | --- | --- | --- | 0.10 | 0.81 |
| Bigeye shiner | --- | --- | --- | --- | --- |
| Bluntnose minnow | 0.17 | --- | 0.29 | 0.10 | 0.54 |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | --- | --- | --- | 0.10 | --- |
| Duskystripe shiner | 24.92 | 21.08 | 7.56 | 20.46 | 26.19 |
| Hornyhead chub | 1.18 | 2.79 | 4.65 | 1.63 | 2.17 |
| Ozark minnow | 0.84 | 0.52 | --- | --- | 4.07 |
| Ozark chub | --- | --- | --- | --- | --- |
| Ozark shiner | --- | --- | --- | --- | --- |
| Rosyface shiner | 0.51 | --- | --- | 0.29 | 0.27 |
| Southern redbelly dace | --- | 16.03 | 13.95 | --- | --- |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 45.79 | 23.00 | 13.37 | 48.70 | 39.08 |
| Striped shiner | --- | --- | --- | --- | --- |
| Telescope shiner | --- | --- | --- | 0.38 | 1.09 |
| Wedgespot shiner | --- | --- | --- | --- | --- |
| Whitetail shiner | --- | 0.70 | --- | 1.06 | 0.27 |
| Arkansas saddled darter | 0.34 | --- | --- | 0.67 | 2.17 |
| Banded darter | 0.17 | --- | --- | 0.29 | 0.68 |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 1.35 | 0.17 | 0.29 | 2.59 | 2.85 |
| Logperch | --- | --- | --- | --- | --- |
| Orangethroat darter | 4.71 | 7.32 | 9.88 | 0.29 | 0.54 |
| Rainbow darter | 8.59 | 3.31 | 7.56 | 6.63 | 2.85 |
| Stippled darter | --- | 0.52 | --- | 0.10 | 0.14 |
| Yoke darter | --- | --- | --- | 0.10 | --- |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | --- | --- | --- | --- |
| Green sunfish | --- | --- | --- | 0.29 | --- |
| Largemouth bass | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Water Creek near Maumee | Rush Creek near mouth near Rush | Rush Creek near mouth near Rush | Clabber Creek near mouth near Rush | Clabber Creek near mouth near Rush |
|---|---|---|---|---|---|
| **Site identifier** | **T15-S** | **T16** | **T16** | **T17** | **T17** |
| **Date** | **8/22/02** | **7/25/01** | **8/23/02** | **7/27/01** | **8/23/02** |
| Longear sunfish | 0.67 | 8.01 | 6.98 | 10.85 | 9.91 |
| Ozark bass | 0.84 | 0.17 | --- | 0.29 | 0.41 |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 1.35 | 0.35 | --- | 1.73 | 1.76 |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | --- | 0.52 | --- | 0.10 | 0.27 |
| Golden redhorse | --- | --- | --- | --- | --- |
| Northern hog sucker | 0.67 | --- | --- | 1.25 | 1.76 |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | --- | --- | --- | --- | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | --- | --- | --- | --- | --- |
| Slender madtom | 0.17 | --- | --- | 0.48 | 0.27 |
| Yellow bullhead | --- | --- | --- | --- | 0.14 |
| Ammocoetes (immature lamprey) | --- | --- | --- | --- | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | --- | --- | --- | --- |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | --- | 0.70 | --- | 0.96 | 0.54 |
| Northern studfish | 0.17 | --- | --- | 0.48 | 1.22 |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | 7.58 | 14.81 | 4.36 | 0.10 | --- |
| Ozark sculpin | --- | --- | 31.10 | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Clabber Creek near Rush | Clabber Creek near Rush | Big Creek near mouth near Cozahome | Big Creek near mouth near Cozahome | Middle Creek near mouth near Big Flat |
|---|---|---|---|---|---|
| Site identifier | T17-S | T17-S | T18 | T18 | T23 |
| Date | 8/9/01 | 8/28/02 | 7/10/01 | 7/10/02 | 7/11/01 |
| Species richness (number of species) | 20 | 24 | 25 | 26 | 18 |
| Bigeye chub | 0.59 | 0.31 | --- | --- | --- |
| Bigeye shiner | --- | 0.15 | --- | --- | --- |
| Bluntnose minnow | --- | --- | 0.35 | 2.68 | 7.02 |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | --- | --- | --- | --- | --- |
| Duskystripe shiner | 24.01 | 18.86 | 21.43 | 13.17 | 30.41 |
| Hornyhead chub | 0.88 | 1.70 | 0.58 | 0.89 | 4.09 |
| Ozark minnow | --- | 5.56 | 0.35 | 2.46 | --- |
| Ozark chub | --- | --- | 0.46 | 0.67 | --- |
| Ozark shiner | --- | --- | --- | --- | --- |
| Rosyface shiner | --- | 0.31 | 0.35 | 0.67 | --- |
| Southern redbelly dace | --- | --- | --- | --- | --- |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 37.41 | 44.82 | 41.71 | 37.05 | 8.77 |
| Striped shiner | --- | --- | --- | --- | --- |
| Telescope shiner | 0.15 | 0.77 | 0.46 | --- | --- |
| Wedgespot shiner | 0.15 | --- | 0.35 | 1.79 | 0.58 |
| Whitetail shiner | 2.50 | 2.01 | 0.23 | 0.45 | 5.26 |
| Arkansas saddled darter | 0.15 | 0.31 | 0.46 | 0.45 | --- |
| Banded darter | 0.44 | 0.93 | 1.15 | 2.01 | 0.58 |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 1.18 | 1.55 | 1.27 | 3.35 | 5.85 |
| Logperch | --- | --- | --- | --- | --- |
| Orangethroat darter | 2.80 | 0.93 | --- | --- | 1.17 |
| Rainbow darter | 8.98 | 8.96 | 3.00 | 9.82 | 2.34 |
| Stippled darter | --- | 0.15 | --- | --- | --- |
| Yoke darter | --- | --- | 6.80 | 2.01 | --- |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | 0.15 | --- | --- | --- |
| Green sunfish | 0.44 | 0.15 | 0.23 | 0.67 | 1.17 |
| Largemouth bass | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Clabber Creek near Rush | Clabber Creek near Rush | Big Creek near mouth near Cozahome | Big Creek near mouth near Cozahome | Middle Creek near mouth near Big Flat |
|---|---|---|---|---|---|
| Site identifier | T17-S | T17-S | T18 | T18 | T23 |
| Date | 8/9/01 | 8/28/02 | 7/10/01 | 7/10/02 | 7/11/01 |
| Longear sunfish | 10.16 | 6.34 | 15.09 | 11.16 | 17.54 |
| Ozark bass | 0.74 | --- | 2.19 | 1.12 | --- |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | 0.58 |
| Smallmouth bass | 3.83 | 1.85 | 1.38 | 0.67 | 5.85 |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | --- | --- | --- | 0.89 | --- |
| Golden redhorse | --- | 0.31 | 0.12 | 0.45 | --- |
| Northern hog sucker | 2.50 | 1.55 | 0.23 | 1.34 | --- |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | --- | --- | --- | 0.22 | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | --- | --- | --- | 1.56 | --- |
| Slender madtom | 1.62 | 1.08 | 1.27 | 2.46 | 0.58 |
| Yellow bullhead | --- | --- | 0.35 | 0.67 | --- |
| Ammocoetes (immature lamprey) | --- | --- | --- | --- | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | --- | --- | --- | --- |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | 0.59 | 0.46 | 0.12 | --- | 3.51 |
| Northern studfish | 0.88 | 0.77 | --- | --- | 3.51 |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | --- | --- | 0.12 | 1.34 | 1.17 |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Middle Creek near mouth near Big Flat | Leatherwood Creek near mouth near Advance | Leatherwood Creek near mouth near Advance | Hock Creek near Wesley | Hock Creek near Wesley |
|---|---|---|---|---|---|
| Site identifier | T23 | T24 | T24 | OB1 | OB1 |
| Date | 7/11/02 | 7/11/01 | 7/11/02 | 8/15/01 | 6/26/02 |
| Species richness (number of species) | 21 | 18 | 19 | 18 | 18 |
| Bigeye chub | --- | --- | --- | --- | --- |
| Bigeye shiner | 0.57 | --- | --- | --- | --- |
| Bluntnose minnow | --- | 3.77 | 2.11 | --- | --- |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | 0.57 | --- | --- | 4.74 | 2.47 |
| Duskystripe shiner | 16.48 | 19.81 | 26.32 | 14.53 | 12.61 |
| Hornyhead chub | 7.95 | 3.77 | 6.84 | 0.16 | 0.65 |
| Ozark minnow | --- | 2.83 | 0.53 | 1.05 | 1.56 |
| Ozark chub | --- | --- | --- | --- | --- |
| Ozark shiner | --- | --- | --- | --- | --- |
| Rosyface shiner | --- | --- | --- | --- | --- |
| Southern redbelly dace | --- | --- | --- | --- | --- |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 31.82 | 19.81 | 24.74 | 63.37 | 67.10 |
| Striped shiner | --- | 0.94 | --- | --- | --- |
| Telescope shiner | --- | 0.94 | --- | --- | --- |
| Wedgespot shiner | --- | --- | --- | --- | --- |
| Whitetail shiner | --- | 1.89 | 1.05 | --- | --- |
| Arkansas saddled darter | 0.57 | 0.94 | --- | --- | --- |
| Banded darter | --- | --- | 0.53 | --- | --- |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 1.70 | 0.94 | 0.53 | 0.05 | --- |
| Logperch | --- | --- | --- | 0.05 | --- |
| Orangethroat darter | 0.57 | --- | 2.11 | 6.37 | 3.38 |
| Rainbow darter | 6.82 | 14.15 | 6.84 | 2.42 | 4.55 |
| Stippled darter | --- | --- | --- | 0.26 | 0.91 |
| Yoke darter | --- | --- | --- | --- | --- |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | --- | --- | --- | 0.13 |
| Green sunfish | 1.70 | 3.77 | 4.74 | 0.05 | 0.52 |
| Largemouth bass | --- | --- | --- | --- | 0.26 |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Middle Creek near mouth near Big Flat | Leatherwood Creek near mouth near Advance | Leatherwood Creek near mouth near Advance | Hock Creek near Wesley | Hock Creek near Wesley |
|---|---|---|---|---|---|
| Site identifier | T23 | T24 | T24 | OB1 | OB1 |
| Date | 7/11/02 | 7/11/01 | 7/11/02 | 8/15/01 | 6/26/02 |
| Longear sunfish | 7.39 | 19.81 | 6.32 | 0.11 | 0.52 |
| Ozark bass | 0.57 | --- | --- | --- | --- |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 0.57 | --- | 2.11 | 0.11 | --- |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | 5.68 | --- | 3.68 | --- | --- |
| Golden redhorse | 1.14 | --- | 0.53 | --- | 0.13 |
| Northern hog sucker | 6.25 | 0.94 | 3.16 | 0.21 | 0.52 |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | 0.94 | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | --- | --- | --- | --- | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | --- | --- | --- | --- | --- |
| Slender madtom | 2.84 | 1.89 | 3.16 | 3.11 | 2.21 |
| Yellow bullhead | 0.57 | 0.94 | --- | --- | --- |
| Ammocoetes (immature lamprey) | --- | --- | --- | --- | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | --- | --- | --- | --- |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | 0.57 | 1.89 | 1.58 | 0.42 | 0.26 |
| Northern studfish | 1.14 | --- | 3.16 | 2.16 | 0.26 |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | 4.55 | --- | --- | 0.84 | 1.95 |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Kings River near Kingston | Kings River near Kingston | Osage Creek near Berryville | Osage Creek near Berryville | Yocum Creek near Oak Grove |
|---|---|---|---|---|---|
| Site identifier | OB2 | OB2 | OB3 | OB3 | OB4 |
| Date | 8/14/01 | 6/26/02 | 8/13/01 | 8/20/02 | 8/15/01 |
| Species richness (number of species) | 28 | 20 | 37 | 32 | 25 |
| Bigeye chub | 3.84 | 0.40 | 4.16 | 0.91 | --- |
| Bigeye shiner | 0.36 | --- | 3.16 | 0.56 | --- |
| Bluntnose minnow | 0.47 | --- | 1.08 | 1.17 | --- |
| Common carp | --- | --- | --- | --- | --- |
| Creek chub | --- | --- | --- | --- | 0.16 |
| Duskystripe shiner | 11.46 | 6.77 | 6.44 | 5.54 | 26.31 |
| Hornyhead chub | 0.31 | 0.80 | --- | --- | 8.08 |
| Ozark minnow | 22.97 | 7.17 | 5.44 | 3.76 | 2.38 |
| Ozark chub | --- | --- | 0.64 | 0.04 | --- |
| Ozark shiner | --- | --- | --- | --- | --- |
| Rosyface shiner | 0.05 | --- | 0.04 | --- | 0.32 |
| Southern redbelly dace | --- | --- | --- | --- | --- |
| Steelcolor shiner | --- | --- | 1.28 | 0.61 | --- |
| Stoneroller | 32.45 | 53.39 | 47.38 | 69.68 | 21.87 |
| Striped shiner | 0.16 | --- | 1.08 | 0.30 | 2.22 |
| Telescope shiner | 1.56 | --- | 0.16 | --- | 0.16 |
| Wedgespot shiner | --- | --- | --- | --- | --- |
| Whitetail shiner | --- | --- | 0.04 | --- | --- |
| Arkansas saddled darter | --- | --- | --- | 0.04 | --- |
| Banded darter | 0.05 | --- | 2.52 | 1.38 | --- |
| Fantail darter | --- | --- | --- | --- | 0.16 |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 0.52 | 1.99 | 7.12 | 4.37 | 0.79 |
| Logperch | --- | --- | 0.24 | --- | 1.58 |
| Orangethroat darter | --- | 0.80 | 0.04 | --- | 2.38 |
| Rainbow darter | 11.40 | 8.37 | 6.64 | 4.71 | 6.81 |
| Stippled darter | 0.36 | 1.20 | 0.04 | 0.22 | 0.16 |
| Yoke darter | --- | --- | 0.60 | 0.13 | --- |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | 0.36 | 0.80 | 0.04 | 0.26 | 1.58 |
| Green sunfish | 0.57 | 1.59 | 0.44 | 0.09 | 5.86 |
| Largemouth bass | 0.05 | --- | 0.04 | 0.13 | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Kings River near Kingston | Kings River near Kingston | Osage Creek near Berryville | Osage Creek near Berryville | Yocum Creek near Oak Grove |
|---|---|---|---|---|---|
| **Site identifier** | **OB2** | **OB2** | **OB3** | **OB3** | **OB4** |
| **Date** | **8/14/01** | **6/26/02** | **8/13/01** | **8/20/02** | **8/15/01** |
| Longear sunfish | 7.10 | 5.98 | 3.40 | 2.08 | 5.23 |
| Ozark bass | --- | 0.80 | 0.08 | 0.22 | 3.96 |
| Redear sunfish | --- | --- | 0.08 | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 0.26 | 2.39 | 0.60 | 0.22 | 1.58 |
| Spotted bass | --- | --- | --- | --- | 0.48 |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | 0.31 | 1.99 | 2.44 | 0.04 | 1.58 |
| Golden redhorse | 0.05 | --- | 0.64 | 0.17 | --- |
| Northern hog sucker | 1.92 | 1.59 | 2.68 | 2.08 | 1.74 |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | 0.12 | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | 0.04 | --- | --- |
| Checkered madtom | --- | --- | --- | --- | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | 0.10 | RK | 0.20 | 0.48 | --- |
| Slender madtom | 0.67 | 2.79 | 0.16 | 0.17 | 0.16 |
| Yellow bullhead | --- | --- | 0.08 | 0.04 | 0.32 |
| Ammocoetes (immature lamprey) | 0.26 | --- | --- | 0.04 | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | --- | --- | --- | --- |
| Gizzard shad | --- | --- | 0.08 | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | 0.52 | --- | 0.40 | 0.17 | --- |
| Northern studfish | 0.26 | 0.40 | 0.36 | 0.26 | --- |
| Brook silverside | --- | --- | --- | 0.09 | --- |
| Banded sculpin | 1.61 | 0.80 | --- | 0.04 | 4.12 |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Yocum Creek near Oak Grove | Long Creek near Denver | Long Creek near Denver | Huzzah Creek near Olvey | Huzzah Creek near Olvey |
|---|---|---|---|---|---|
| Site identifier | OB4 | OB5 | OB5 | OB6 | OB6 |
| Date | 8/5/02 | 8/17/01 | 9/10/02 | 8/16/01 | 8/26/02 |
| Species richness (number of species) | 21 | 32 | 35 | 24 | 23 |
| Bigeye chub | --- | 0.06 | 0.20 | --- | --- |
| Bigeye shiner | --- | 0.06 | 1.52 | 0.71 | --- |
| Bluntnose minnow | --- | 1.19 | 1.11 | 8.24 | 3.69 |
| Common carp | --- | 0.62 | --- | --- | --- |
| Creek chub | --- | --- | 0.10 | --- | 0.08 |
| Duskystripe shiner | 11.40 | 31.07 | 21.86 | 6.88 | 19.48 |
| Hornyhead chub | 7.72 | 2.43 | 2.23 | 0.61 | 0.42 |
| Ozark minnow | --- | 11.54 | 3.95 | 9.49 | 2.77 |
| Ozark chub | --- | 0.06 | --- | --- | --- |
| Ozark shiner | --- | --- | --- | --- | --- |
| Rosyface shiner | --- | 0.31 | 0.10 | --- | --- |
| Southern redbelly dace | --- | 0.19 | --- | --- | 0.08 |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 10.29 | 22.83 | 23.58 | 57.14 | 49.54 |
| Striped shiner | 0.37 | 1.68 | 0.91 | 1.70 | 0.17 |
| Telescope shiner | --- | --- | --- | --- | 0.25 |
| Wedgespot shiner | --- | --- | --- | --- | --- |
| Whitetail shiner | --- | 0.44 | --- | 0.07 | --- |
| Arkansas saddled darter | --- | --- | 0.10 | --- | --- |
| Banded darter | --- | --- | 0.30 | --- | --- |
| Fantail darter | RK | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 1.47 | 1.19 | 1.01 | 0.24 | 0.25 |
| Logperch | 2.21 | 0.56 | 0.10 | --- | --- |
| Orangethroat darter | 15.81 | 0.44 | 1.42 | 2.75 | 2.77 |
| Rainbow darter | 15.81 | 7.05 | 12.04 | 2.31 | 8.82 |
| Stippled darter | 0.37 | --- | 0.20 | --- | --- |
| Yoke darter | --- | 0.37 | 0.10 | --- | --- |
| Black crappie | --- | --- | --- | 0.03 | --- |
| Bluegill | 1.84 | 1.43 | 2.53 | 0.07 | 0.34 |
| Green sunfish | 2.94 | 1.31 | 0.20 | 0.07 | 0.34 |
| Largemouth bass | 1.84 | --- | 0.51 | 0.07 | 0.08 |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Yocum Creek near Oak Grove | Long Creek near Denver | Long Creek near Denver | Huzzah Creek near Olvey | Huzzah Creek near Olvey |
|---|---|---|---|---|---|
| Site identifier | OB4 | OB5 | OB5 | OB6 | OB6 |
| Date | 8/5/02 | 8/17/01 | 9/10/02 | 8/16/01 | 8/26/02 |
| Longear sunfish | 5.51 | --- | 6.78 | 5.53 | 3.86 |
| Ozark bass | 2.94 | 2.43 | 2.13 | 0.44 | 0.25 |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 0.74 | 0.56 | 1.42 | 0.20 | 0.42 |
| Spotted bass | 0.37 | 0.06 | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | 0.37 | --- | --- | --- | --- |
| Black redhorse | --- | 1.87 | --- | --- | --- |
| Golden redhorse | --- | 0.37 | 0.40 | 0.03 | --- |
| Northern hog sucker | --- | 2.74 | 0.61 | 0.54 | 0.34 |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | 0.06 | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | 0.19 | --- | --- | --- |
| Checkered madtom | --- | --- | --- | --- | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | --- | --- | --- | --- | --- |
| Slender madtom | 0.37 | --- | RK | 0.61 | 0.25 |
| Yellow bullhead | --- | 0.06 | 0.10 | 0.03 | --- |
| Ammocoetes (immature lamprey) | --- | --- | 0.10 | --- | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | --- | 0.20 | --- | --- |
| Gizzard shad | --- | --- | 0.71 | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | 0.74 | 0.25 | 0.71 | 2.10 | 1.01 |
| Northern studfish | --- | 0.56 | 1.82 | --- | 0.08 |
| Brook silverside | --- | --- | 0.10 | 0.14 | --- |
| Banded sculpin | 16.91 | 5.99 | 10.83 | --- | 4.70 |
| Ozark sculpin | --- | --- | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Clear Creek near Pyatt | Clear Creek near Pyatt | Hampton Creek near Eros | Hampton Creek near Eros | Crooked Creek near Summit |
|---|---|---|---|---|---|
| **Site identifier** | **OB7** | **OB7** | **OB8** | **OB8** | **OB9** |
| **Date** | **8/16/01** | **9/17/02** | **8/22/01** | **8/22/02** | **7/23/01** |
| Species richness (number of species) | 30 | 32 | 19 | 18 | 30 |
| Bigeye chub | 0.14 | 0.19 | --- | --- | --- |
| Bigeye shiner | 0.70 | 0.29 | --- | --- | 1.00 |
| Bluntnose minnow | 2.10 | 0.29 | 0.13 | --- | 0.91 |
| Common carp | --- | 0.29 | --- | --- | 0.17 |
| Creek chub | --- | --- | --- | --- | --- |
| Duskystripe shiner | 15.55 | 15.05 | 9.17 | 10.15 | 8.48 |
| Hornyhead chub | 0.42 | 1.63 | 1.82 | 2.19 | --- |
| Ozark minnow | 2.38 | 5.56 | 1.76 | 1.65 | 0.33 |
| Ozark chub | 0.14 | --- | --- | --- | 1.58 |
| Ozark shiner | --- | --- | --- | --- | --- |
| Rosyface shiner | 0.84 | RK | --- | --- | --- |
| Southern redbelly dace | --- | --- | 4.65 | 5.62 | --- |
| Steelcolor shiner | --- | --- | --- | --- | --- |
| Stoneroller | 28.29 | 26.46 | 55.78 | 40.88 | 23.44 |
| Striped shiner | 0.14 | 0.48 | --- | --- | --- |
| Telescope shiner | 4.20 | 2.49 | --- | --- | 0.67 |
| Wedgespot shiner | RK | 0.86 | --- | --- | 1.33 |
| Whitetail shiner | 2.38 | 0.48 | --- | --- | 0.83 |
| Arkansas saddled darter | --- | --- | --- | --- | 2.33 |
| Banded darter | 0.42 | RK | --- | --- | 3.33 |
| Fantail darter | --- | --- | --- | --- | --- |
| Gilt darter | --- | --- | --- | --- | --- |
| Greenside darter | 1.26 | 0.38 | --- | --- | 5.24 |
| Logperch | --- | --- | --- | --- | --- |
| Orangethroat darter | 0.14 | --- | 7.66 | 7.68 | 0.50 |
| Rainbow darter | 4.76 | 9.40 | 4.40 | 10.70 | 8.15 |
| Stippled darter | --- | --- | --- | --- | 0.17 |
| Yoke darter | 0.84 | 0.29 | --- | --- | 0.83 |
| Black crappie | --- | --- | --- | --- | --- |
| Bluegill | --- | 0.96 | --- | 0.14 | 0.25 |
| Green sunfish | 3.50 | 5.08 | 0.25 | 0.14 | 0.25 |
| Largemouth bass | --- | 0.77 | 0.13 | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Clear Creek near Pyatt | Clear Creek near Pyatt | Hampton Creek near Eros | Hampton Creek near Eros | Crooked Creek near Summit |
|---|---|---|---|---|---|
| Site identifier | OB7 | OB7 | OB8 | OB8 | OB9 |
| Date | 8/16/01 | 9/17/02 | 8/22/01 | 8/22/02 | 7/23/01 |
| Longear sunfish | 15.13 | 11.60 | --- | 0.27 | 17.37 |
| Ozark bass | 0.84 | 0.96 | 0.13 | 0.14 | 5.07 |
| Redear sunfish | --- | --- | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- | --- | --- |
| Smallmouth bass | 3.50 | 1.73 | 0.19 | 0.27 | 3.49 |
| Spotted bass | --- | --- | --- | --- | --- |
| Warmouth | --- | --- | --- | --- | --- |
| White crappie | --- | --- | --- | --- | --- |
| Black redhorse | 5.46 | 1.63 | --- | --- | 1.16 |
| Golden redhorse | 0.14 | 0.19 | --- | --- | 0.50 |
| Northern hog sucker | 4.62 | 6.04 | 0.57 | 0.41 | 4.66 |
| Redhorse, unidentified | --- | --- | --- | --- | --- |
| River redhorse | --- | --- | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- | --- | --- |
| White sucker | --- | --- | --- | --- | --- |
| Channel catfish | --- | --- | --- | --- | --- |
| Checkered madtom | --- | --- | --- | --- | --- |
| Flathead catfish | --- | --- | --- | --- | --- |
| Ozark madtom | RK | 0.58 | --- | --- | 0.83 |
| Slender madtom | 1.12 | 1.73 | 0.25 | 0.27 | 2.33 |
| Yellow bullhead | --- | 0.10 | --- | 0.27 | 2.08 |
| Ammocoetes (immature lamprey) | --- | 0.10 | 0.06 | --- | --- |
| Chestnut lamprey | --- | --- | --- | --- | --- |
| Longnose gar | --- | --- | --- | --- | --- |
| Gizzard shad | --- | --- | --- | --- | --- |
| Rainbow trout | --- | --- | --- | --- | --- |
| Blackspotted topminnow | 0.14 | 0.48 | 0.31 | --- | 1.58 |
| Northern studfish | 0.56 | --- | 1.01 | 0.55 | 1.16 |
| Brook silverside | --- | --- | --- | --- | --- |
| Banded sculpin | 0.28 | 3.93 | 4.71 | 3.16 | --- |
| Ozark sculpin | --- | --- | 7.04 | 15.50 | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Crooked Creek near Summit | North Sylamore Creek near Big Flat | North Sylamore Creek near Big Flat |
|---|---|---|---|
| **Site identifier** | **OB9** | **OB10** | **OB10** |
| **Date** | **9/18/02** | **8/20/01** | **7/17/02** |
| Species richness (number of species) | 28 | 14 | 14 |
| Bigeye chub | --- | --- | --- |
| Bigeye shiner | 0.17 | --- | 0.33 |
| Bluntnose minnow | 0.17 | --- | --- |
| Common carp | --- | --- | --- |
| Creek chub | --- | --- | --- |
| Duskystripe shiner | 17.53 | 25.10 | 27.72 |
| Hornyhead chub | --- | 6.12 | 1.32 |
| Ozark minnow | 0.47 | --- | --- |
| Ozark chub | 0.76 | --- | --- |
| Ozark shiner | --- | --- | --- |
| Rosyface shiner | --- | --- | --- |
| Southern redbelly dace | --- | --- | --- |
| Steelcolor shiner | --- | --- | --- |
| Stoneroller | 57.60 | 23.88 | 11.22 |
| Striped shiner | 0.29 | --- | --- |
| Telescope shiner | 0.06 | 1.43 | --- |
| Wedgespot shiner | 0.06 | --- | --- |
| Whitetail shiner | 0.58 | --- | --- |
| Arkansas saddled darter | 0.12 | --- | --- |
| Banded darter | 0.29 | --- | --- |
| Fantail darter | --- | 2.65 | 7.59 |
| Gilt darter | --- | --- | --- |
| Greenside darter | 1.75 | --- | --- |
| Logperch | 0.06 | --- | --- |
| Orangethroat darter | 0.17 | --- | 0.66 |
| Rainbow darter | 3.38 | 17.55 | 19.14 |
| Stippled darter | 0.06 | --- | --- |
| Yoke darter | 0.06 | --- | --- |
| Black crappie | --- | --- | --- |
| Bluegill | --- | --- | --- |
| Green sunfish | 0.12 | --- | --- |
| Largemouth bass | --- | --- | --- |

**Table 4.** Species richness and relative abundance of fish taxa at sites in study area.--Continued

[Relative abundance values are in percent of total individuals in the sample; common names of endemic species are shaded; --, species not collected; RK, species collected only in riffle kick sample]

| Site | Crooked Creek near Summit | North Sylamore Creek near Big Flat | North Sylamore Creek near Big Flat |
|---|---|---|---|
| **Site identifier** | **OB9** | **OB10** | **OB10** |
| **Date** | **9/18/02** | **8/20/01** | **7/17/02** |
| Longear sunfish | 5.65 | 8.57 | 4.95 |
| Ozark bass | 0.41 | 2.86 | 4.95 |
| Redear sunfish | --- | --- | --- |
| Redspotted sunfish | --- | --- | --- |
| Smallmouth bass | 1.63 | 2.45 | 1.32 |
| Spotted bass | --- | --- | --- |
| Warmouth | --- | --- | --- |
| White crappie | --- | --- | --- |
| Black redhorse | 4.14 | --- | --- |
| Golden redhorse | 0.35 | --- | --- |
| Northern hog sucker | 3.15 | --- | --- |
| Redhorse, unidentified | --- | --- | --- |
| River redhorse | --- | --- | --- |
| Shorthead redhorse | --- | --- | --- |
| White sucker | --- | --- | --- |
| Channel catfish | --- | --- | --- |
| Checkered madtom | --- | --- | --- |
| Flathead catfish | --- | --- | --- |
| Ozark madtom | 0.29 | 0.20 | --- |
| Slender madtom | 0.64 | 1.43 | 5.94 |
| Yellow bullhead | --- | --- | --- |
| Ammocoetes (immature lamprey) | --- | --- | --- |
| Chestnut lamprey | --- | --- | --- |
| Longnose gar | --- | --- | --- |
| Gizzard shad | --- | --- | --- |
| Rainbow trout | --- | --- | --- |
| Blackspotted topminnow | 0.06 | 0.20 | 0.99 |
| Northern studfish | --- | 2.24 | 1.32 |
| Brook silverside | --- | --- | --- |
| Banded sculpin | --- | 5.31 | 12.54 |
| Ozark sculpin | --- | --- | --- |

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