National Park Service
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Natural Resource Program Center

Fish Community Monitoring at Buffalo National River: 2006 – 2007 Status Report

Natural Resource Technical Report NPS/HTLN/NRTR—2009/185

ON THE COVER
Fish collection with a towed barge electrofishing unit at Buffalo National River.
Photograph by: The Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program.

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Heartland Network
Natural Resource Monitoring

March 2009

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

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Please cite this publication as:

Dodd, H.R. 2009. Fish community monitoring at Buffalo National River: 2006-2007 status report. Natural Resource Technical Report NPS/HTLN/NRTR—2009/185. National Park Service, Fort Collins, Colorado.

NPS D-139, March 2009

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Executive Summary

The Buffalo River lies in the Ozark Plateaus and is one of the few remaining free-flowing rivers in the U.S. The Buffalo National River (BUFF) was established to protect the river corridor with only a small percentage of the watershed located within the park boundary. Therefore, most of the watershed is unprotected from human disturbances that degrade water quality and stream habitat. The Ozark Plateaus is known for the direct interaction between ground water and streamflow, creating an additional factor that may place the water quality and biotic community of the Buffalo River at risk.

The fish communities of the Buffalo River and its tributaries are good indicators of water quality. Fish perform many ecological functions in lotic ecosystems and have varying tolerances to anthropogenic disturbances. Fish are also longer-lived than many other aquatic organisms and therefore fish community composition can give a history of past environmental conditions. Several fish found in the Buffalo River are endemic to the Ozark Plateau region and many species are extremely sensitive to poor water quality conditions. In May 2006, annual monitoring was initiated at BUFF to assess the status and obtain baseline information on fish communities, physical habitat, water quality, and overall stream integrity of the Buffalo River. Six sites on the mainstem of the Buffalo River were sampled annually in 2006-2007. Tributaries to the Buffalo River were also sampled during this time period. The first set of six tributaries was sampled in 2006 and a second set was sampled in 2007.

The high species richness, number of sensitive taxa, and relative abundance of fish, along with low occurrences of disease and deformities, indicate a highly diverse and healthy fish community in the Buffalo River. In general, fish communities at mainstem sites were very similar from one year to the next. Fish communities among the tributaries were variable; some tributaries had very diverse communities and high stream integrity, whereas a few had low to moderate diversity. Physical habitat and water quality changed very little during the 2006-2007 collection period, and water quality conditions were within the range of previous Buffalo River studies. Data collected through this long-term monitoring program can be used by park managers to gain insight on potential problem areas within the park and to locate high quality areas in need of additional protection. This baseline data can also be useful in tracking the effectiveness of management strategies by observing trends in fish communities and stream integrity over time.

Acknowledgements

We would like to thank the staff at the Buffalo National River, particularly Faron Usrey and Shawn Hodges, for their valuable advice and assistance in the field. We would also like to thank Ken Shirley, Stan Todd, and Mark Oliver of the Arkansas Game and Fish Commission for their help with field work and use of sampling equipment.

Introduction

The Buffalo National River (BUFF), located in north-central Arkansas, is one of the two largest units of the National Park Service in the Ozark Plateaus. BUFF is located in three physiographic regions: the Boston Mountains and the Springfield and Salem Plateaus. The Boston Mountains region is characterized by sandstone and shale, while the Springfield and Salem Plateaus consist of limestone and dolomite geologic formations. Karst features, such as sinkholes, caves, springs, and losing reaches of stream, are common in the Springfield and Salem Plateaus and create direct interactions between ground water and streamflow. The Buffalo River is one of the few remaining free-flowing rivers in the U.S. BUFF was established to protect the river corridor. The park boundary encompasses only 11% of the watershed (Mott and Luraas 2004), leaving much of the watershed unprotected from human activities, such as agriculture, urbanization, and logging, that result in alteration of water quantity and quality in Ozark streams. The direct interaction between ground water and streamflow in this region, coupled with the small area of the watershed protected by the park, places the water quality and biotic community of the Buffalo River at risk.

The fish communities of the Buffalo River and its tributaries are an important component of the park because of the various roles fish play in river ecosystems (e.g., mussel hosts, predators, competitors) and because fish have various tolerances to human and natural disturbances, making them worthy of monitoring. The Ozark Plateaus is one of the richest areas of the United States for fish species. Petersen and Justus (2005) and Petersen (2005) reported 74 species of fish from BUFF, with several of these species endemic to the Ozarks. The Buffalo River Basin is considered a hot spot for “at risk” fish and mussel species (species with a vulnerable or imperiled ranking by The Nature Conservancy and the Natural Heritage Network) because of the presence of 10 or more “at risk” species (Master *et al*. 1998). Many species, such as darters, sculpins, and madtoms, are intolerant to water quality and habitat degradation (Robison and Buchanan 1988; Pflieger 1997; Dauwalter *et al*. 2003). Therefore, tracking the composition of the fish community is a useful monitoring tool for assessing changes in stream integrity. In addition to their value as environmental indicators, direct economic value also can be associated with several fish species of the park because of money spent by anglers fishing for species such as bass and other sunfishes, suckers, and catfish.

The primary goal for fish community monitoring at BUFF is to detect changes in stream integrity and water quality using biotic indicators as well as physical/chemical parameters. Information obtained from this long-term monitoring program can be used by park managers to evaluate the effects of past activities and management decisions on fish communities and aid in making decisions on future management practices.

Objectives

The specific objectives for fish community monitoring at BUFF are:

(1) to determine the status and trends in fish communities by quantifying metrics such as species richness, diversity, abundance, and composition and use those metrics to calculate multi-metric indices (Karr, 1981; Dauwalter *et al*. 2003) for the mainstem and tributaries, and

(2) to estimate the spatial and temporal natural variability of fish community metric values and indices among collection sites, and examine correlations between metric values and associated habitat values such as stream size characteristics, habitat availability, riparian characteristics, substrate characteristics, and water quality.

Methods

Study Area and Reach Selection

BUFF is located in the Ozark Plateaus of north-central Arkansas and is approximately 380 km^2, encompassing 135 km of the Buffalo River. Sample reaches at BUFF were randomly selected using the Generalized Random Tessellation Stratified (GRTS) method allowing for spatially balanced locations of sample reaches along the river (Stevens and Olsen 2004). A total of twelve reaches were sampled each year: six mainstem reaches sampled annually and six tributary reaches sampled on a five year rotation for a total of 30 tributaries sampled (Figures 1 and 2). The first two panels of tributaries were sampled during 2006-2007. Permanent reaches for mainstem sites were established in 2006. Tributary reaches were established during the year in which they were sampled (panel 1 in 2006, panel 2 in 2007; see Table 1 for stream names). Reach lengths were based on 20 times mean wetted stream width. For detailed information on GRTS methods used for site selection, methods on establishing permanent reaches, and the re-visit design for tributaries, see the Ozarks Rivers Fish Community Protocol (Petersen *et al*. 2008).

Fish Collection

Fish communities were sampled from late May to mid-June in 2006 and 2007. Fish were collected at six mainstem reaches during both years in addition to six tributaries in 2006 (panel 1; Figure 1) and six tributaries in 2007 (panel 2; Figure 2). Fish were collected using pulsed DC electrofishing gear. Selection of sampling gear was based on the efficiency of each gear type to capture fish in various habitat conditions. Mainstem reaches were sampled using two pass boat electrofishing (one pass along each bank) in the deep pools, supplemented by towed barge or backpack electrofishing in shallower riffle and run areas. Most tributaries were narrow and shallow; therefore, they were sampled by one pass with either the backpack or towed barge electrofishing gear. Prior to the first year of sampling, staff visited boat access points along the river and talked with park personnel to assess gear needed for fish community monitoring. Because sample sites were randomly selected, placing some locations several kilometers from river access points, HTLN staff were unable to visit specific sample locations until fish collection commenced in 2006. Therefore, gear thought to be effective at capturing fish based on conditions at nearby access points may not have been effective at the particular sample reach. Thus, the gear used at two mainstem reaches (B1 and B4) was changed in 2007 to more efficiently sample the habitat within these reaches. All future monitoring at mainstem sites will use the sampling gear and proportion of sampling effort established at reaches during the 2007 (second) field season. For greater detail on electrofishing gear used at each reach and percentage of sampling effort by gear, see the Ozarks Rivers Fish Community Protocol (Petersen *et al*. 2008).

During sampling, fish were collected with nets and placed in aerated buckets or in-stream holding pens. All fish were identified to species, if possible, and counted. A subsample of 30 individuals per species were measured and weighed, and any diseases or anomalies were recorded. Fish that were too small to identify in the field were preserved for laboratory identification. All other fish were released back into the sample reach.

Habitat and Water Quality

Physical habitat and water quality data were collected in conjunction with fish sampling. An 11 transect method was used to collect data on general channel morphology, fish cover, and bank conditions within the entire reach. In-stream habitat (depth, velocity, substrate, *etc*.) and fish cover (presence of boulders, hydrophytes, *etc*.) were assessed at three points per transect (see Petersen *et al*. 2008 for a list of all habitat parameters collected). Fish cover along the banks (undercut banks, overhanging terrestrial vegetation, *etc*.) and bank/riparian stability were assessed on the left and right banks at each transect. Water quality was collected using discrete and unattended (continuous) sampling methods. Discrete measurements of temperature, dissolved oxygen, pH, and conductivity were collected before and after fish sampling at each reach using hand-held meters. To obtain continuous (hourly) CORE 5 data (temperature, dissolved oxygen, pH, specific conductance, and turbidity), loggers were also deployed in the upper, middle, and lower Buffalo River for a period of approximately 2 weeks. Detailed methods on habitat and water quality collection are located in the Ozarks Rivers Fish Community Protocol (Petersen *et al*. 2008).

Data Analysis

Biological metrics were calculated for each reach sampled in 2006 and 2007. These metrics reflect fish community diversity (species richness and Simpson's Diversity Index), abundance (catch per unit effort), composition (number and percent composition by biomass of sensitive taxa), and overall stream integrity (Index of Biotic Integrity). Community diversity was assessed using Simpson's Diversity Index which gives the probability that two individuals picked at random from the site are the same species. Therefore, the index decreases with increasing diversity and ranges from 0 (completely diverse) to 1 (no diversity). For community composition, number and percent composition of sucker (Catastomidae), sunfish (Centrarchidae), minnow (Cyprinidae), and darter/sculpin/madtom (*Etheostoma* and *Percina*/*Cottus*/*Noturus*) species were calculated because these metrics are typically used in several Index of Biotic Integrity (IBI) calculations (Karr 1981, Dauwalter *et al*. 2003, Smogor 2005) and demonstrate sensitivity to human disturbance. The IBI developed by Dauwalter *et al*. (2003) was used to assess overall stream health and includes seven metrics: 1) percent of individuals as algivorous/herbivorous, invertivorous, and piscivorous; 2) percent with an anomaly (disease, eroded fins, lesions, or tumors) or blackspot parasite; 3) percent as green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*), yellow bullhead (*Ameiurus natalis*), or channel catfish (*Ictalurus punctatus*); 4) percent invertivores; 5) percent top carnivores; 6) number of darter/sculpin/madtom species; 7) number of lithophilic (sand/gravel) spawning species. Each of the seven raw metric values was scored from 0 to 10 based on upper and lower thresholds developed for the Ozarks region. The metric scores were added to calculate an IBI score that ranges from 0 to 100. Based on this IBI score, the overall integrity of the stream is classified from very poor to excellent: very poor = 0-20; poor = 20-40; fair = 40-60; good = 60-80; excellent (reference condition) = 80-100. More detailed methods on calculating

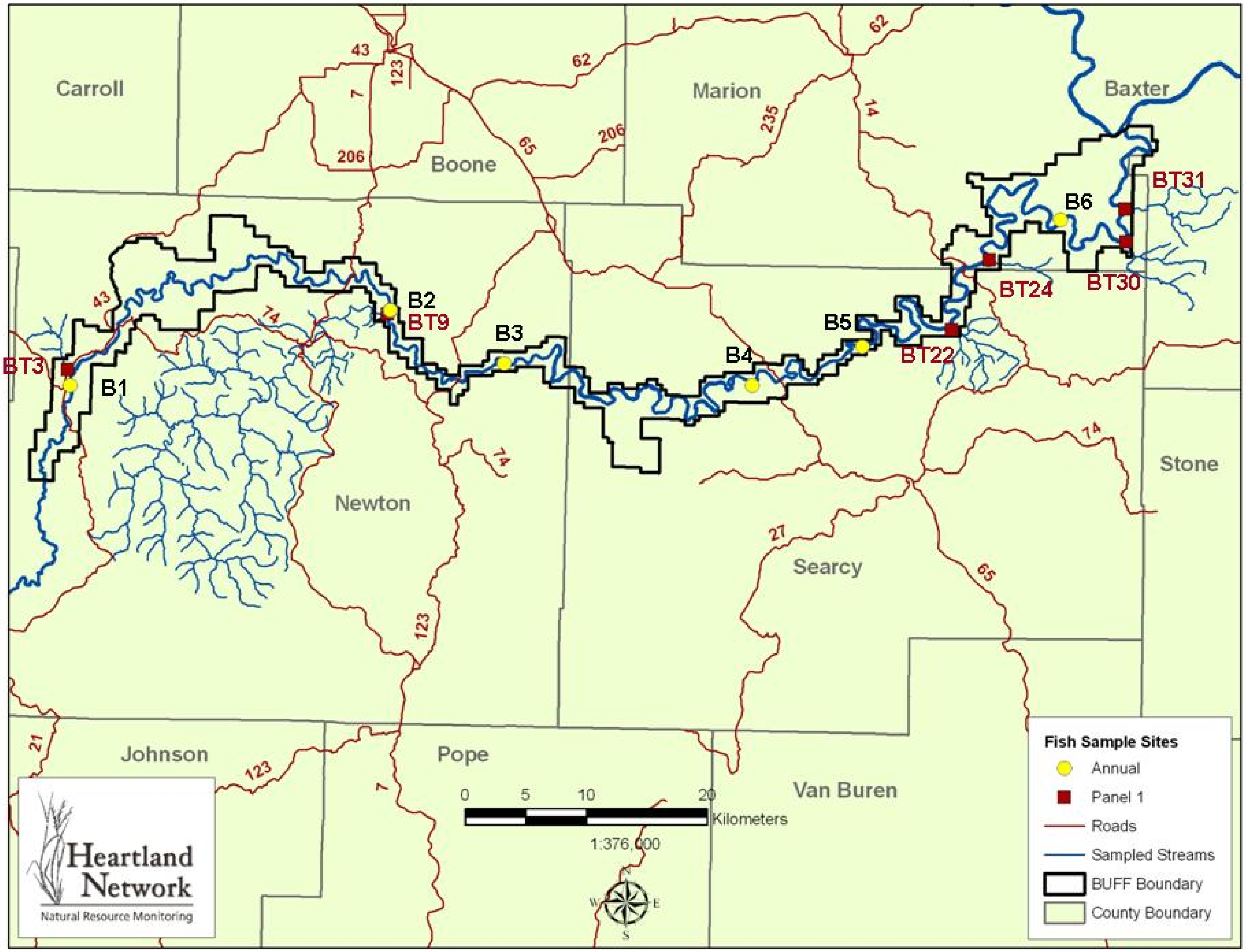


Figure 1. Location of mainstem reaches sampled annually (yellow circles) and panel 1 tributaries sampled in 2006 (dark red squares).

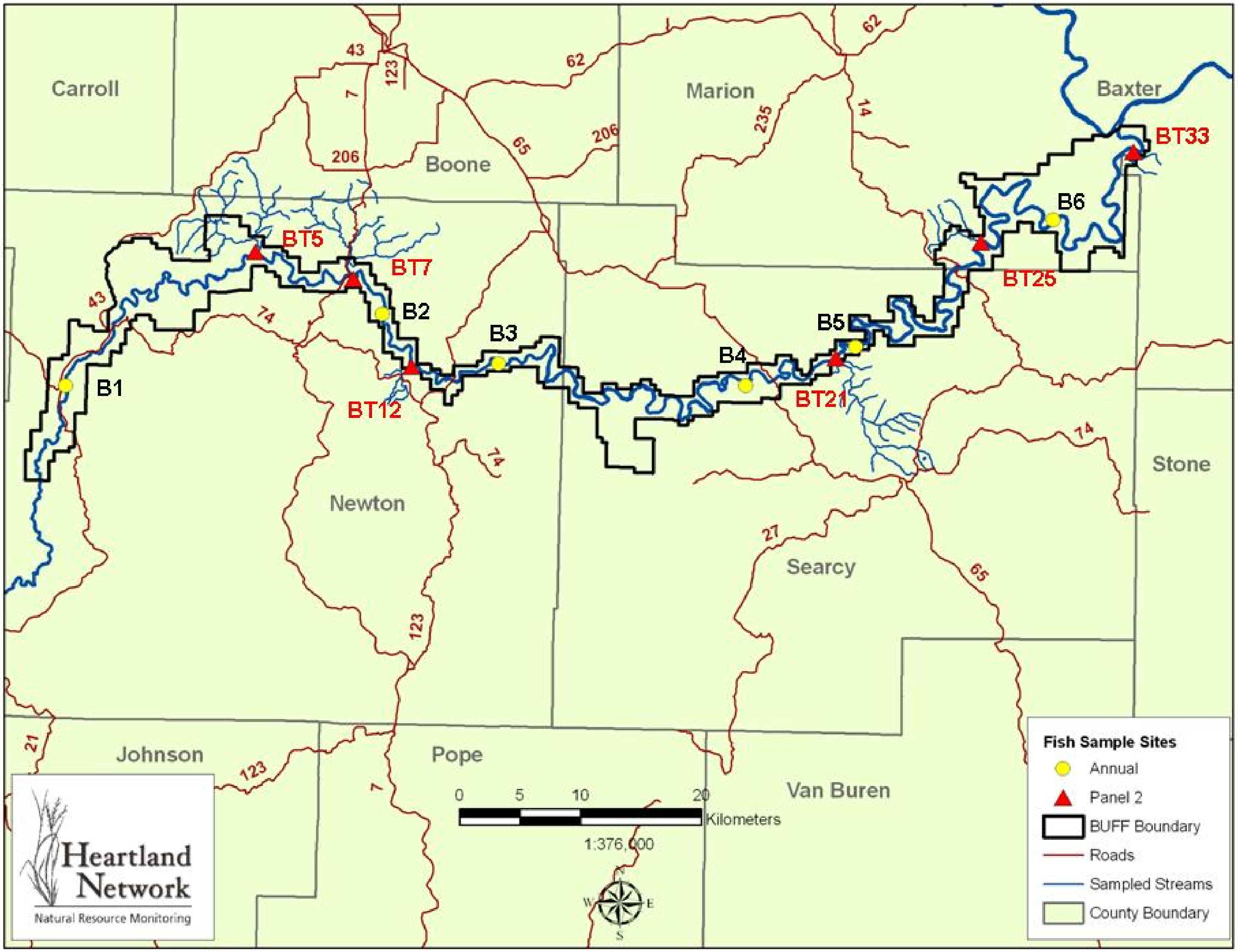


Figure 2. Location of mainstem reaches sampled annually (yellow circles) and panel 2 tributaries sampled in 2007 (red triangles).

biological metrics used in this report can be found in the Ozarks Rivers Fish Community Protocol (Petersen *et al*. 2008) and Dauwalter *et al*. 2003.

Physical habitat and water quality data were summarized using averages with standard errors (SE) or 95% confidence intervals (CI), or using percentages, where appropriate. Physical habitat data were analyzed as in-stream habitat, fish cover, and bank stability. To compare in-stream habitat between years, averages and 95% CIs were calculated and plotted for each mainstem reach sampled. Because samples were obtained from the same sites each year, the data are paired and any inferences regarding statistical differences must be made relative to the mean of the differences between the two years. The CIs for the two separate means for each year are irrelevant for such inferences (e.g., Cumming and Finch 2005). Thus, average differences between years for in-stream habitat parameters, along with 95% CIs of these differences, were calculated for mainstem reaches to determine if a habitat variable was similar (i.e., a 95% CI of the difference encompasses zero) between years. Analysis of in-stream substrate data used the Wentworth code for particle sizes (see Appendix 1 for the code categories and size ranges). For assessment of stream banks, stability was calculated by summing the scores of four bank metrics (angle, percent vegetation, height, and substrate) at each transect, and averaging across transects to obtain a bank stability score for the reach. Scores of 4 to 7 indicate stable banks, 8 to 10 are at risk, 11 to 15 are unstable, and 16 to 22 are very unstable. As with in-stream habitat data, differences in bank stability between years and 95% CIs were used to assess similarity in banks at mainstem reaches. For water quality data, both continuous and discrete measurements were analyzed using averages and standard errors.

Results

Fish Community

Diversity and Abundance

Species richness (i.e., number of species) at mainstem reaches ranged from 23 to 40 in 2006 and 23 to 44 in 2007. Richness appeared to be similar between years at each mainstem reach with the exception of B2 and B4 (Figure 3, top panel). At reach B2, richness declined in 2007 primarily due to fewer madtom species captured; richness increased by 10 species at B4 possibly due to a sample gear change in 2007. Diversity was high (i.e., low Simpson's Index) at all mainstem reaches, and similar between 2006 and 2007 (Figure 3, middle panel). Abundance ranged from 10.2 to 18.2 fish/min in 2006 and 4.2 to 9.2 fish/min in 2007 (Figure 3, bottom panel), and was similar between years for most mainstem sites. However, large differences in abundance were found at B2 and B6 with a decrease by more than 10 fish/min in 2007. Complete lists of fish species and numbers collected at mainstem reaches are shown in Appendix 2.

For tributaries sampled in 2006, species richness ranged from 8 to 32 and abundance ranged from 7.9 to 17.0 fish/min (Table 1). The Little Buffalo had the highest number of species and greatest abundance of all tributaries sampled in 2006. Diversity was high (low Simpson's Index) at most tributaries with the exception of Hickory Creek, which had a Simpson's Index of 0.57. The low diversity at Hickory Creek was due to the predominance of sculpins (a sensitive taxon).

Tributaries sampled in 2007 ranged from 7 to 27 species and 6.0 to 24.0 fish/min. Mill Creek had the highest richness and greatest abundance of those tributaries sampled in 2007. Fish diversity was high (low Simpson's Index) at four of the six tributaries sampled in 2007, with Brush and Panther Creeks having moderate to low fish diversity. Complete lists of fish species and numbers collected in tributaries are shown in Appendices 3 and 4.

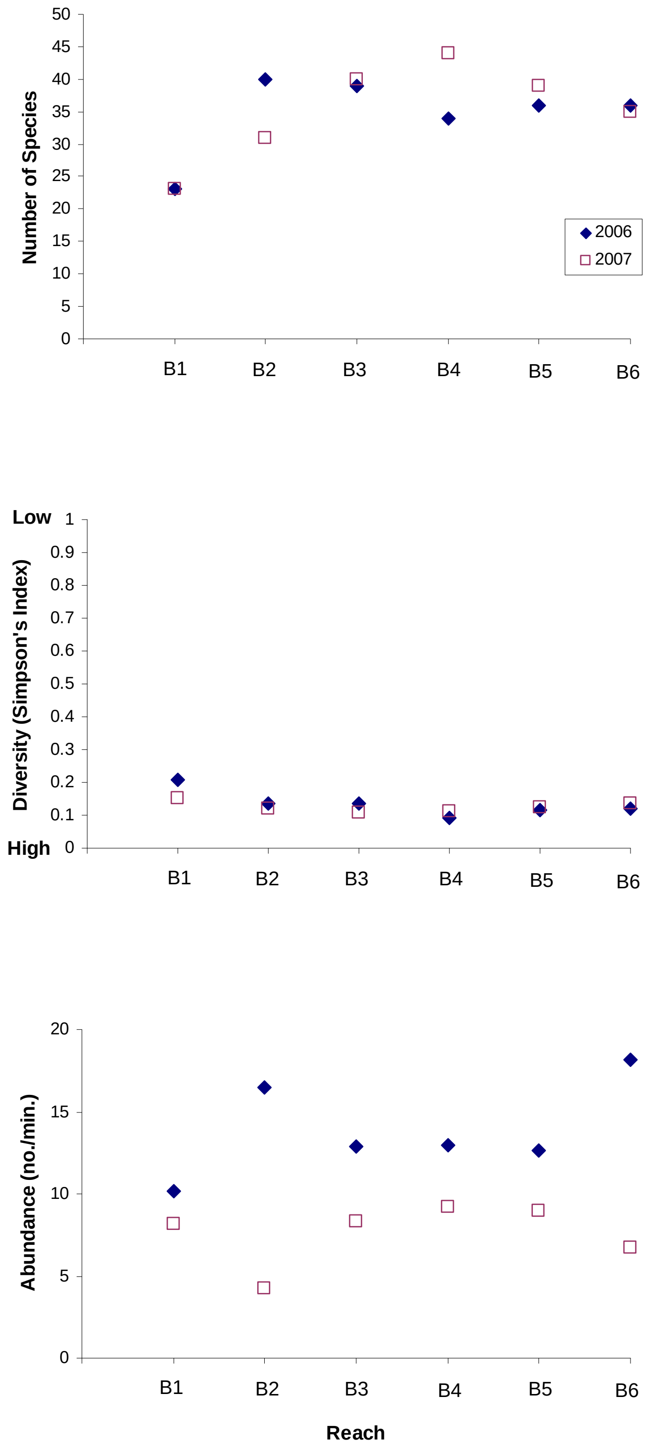


Figure 3. Species richness, community diversity (Simpson's Index), and abundance for mainstem reaches in 2006-2007. B1 is the upstream most mainstem site. B6 is the downstream most site.

Table 1. Species richness, diversity (Simpson's Index), and abundance for tributaries sampled in 2006 and 2007.

Tributary	Tributary No.	Number of Species	Diversity (Simpson's Index)	Abundance (no. / min)
		2006 - Panel 1		
Whiteley	BT3	11	0.28	12.7
Little Buffalo	BT9	32	0.18	17.0
Spring	BT22	19	0.19	11.0
Hickory	BT24	8	0.57	10.0
Middle	BT30	24	0.12	7.9
Leatherwood	BT31	22	0.11	9.3
		2007 - Panel 2		
Cecil	BT5	18	0.14	6.0
Mill	BT7	27	0.16	24.0
Sheldon Branch	BT12	17	0.32	14.1
Brush	BT21	11	0.51	8.4
Panther	BT25	7	0.68	21.1
Stewart	BT33	13	0.35	7.4

Community Composition

At mainstem reaches, number of sucker species ranged from 2 to 4 in 2006 and 2 to 5 in 2007, and was similar between years at each mainstem reach (Table 2). Percent composition (by biomass) of sucker species ranged from 0.3 to 45.0% in 2006 and 18.9 to 57.4%. Reach B1, B3, and B6 showed an increase in sucker composition in 2007, possibly due to gear change at B1 and an increase in boat electrofishing effort at B3 and B6. Number of species and percent composition of sunfish were similar between years at most mainstem sites, with B1 having the lowest percent composition and B6 having the highest composition of sunfish in both years (Table 2). One exception was site B3 which showed a decline in percent sunfish composition of 29.5% in 2007. Number of minnow species was also similar across years at mainstem reaches and ranged from 9 to 16 in both years (Table 2). Percent composition of minnows ranged from 6.2 to 75.2% in 2006 and 2.2 to 24.2% in 2007. Site B1 had the highest percent composition of minnows in both years but showed a decline of 51% in 2007, likely due to change in sampling gear. For darter/sculpin/madtom species, numbers and percent composition were found to be similar at each mainstem site across years with the exception of species richness of these taxa at site B2 (Table 2).

Most tributaries sampled in 2006 had low numbers of sucker (range = 0-2) and sunfish (range = 1-6) species, which is typical of small streams (Table 2). The Little Buffalo, a larger tributary, had the highest number and percent composition of both sucker and sunfish species. Number of minnow species collected in tributaries in 2006 ranged from 0 (Hickory Creek) to 12 (Little Buffalo) with percent composition ranging from 0 to 57.7%. Number of darter/sculpin/madtom species ranged from 5 to 8 and percent composition ranged from 3.4 to 88.3%. The Little Buffalo River had the lowest composition of darters/sculpins/madtoms, while Hickory Creek had the highest composition due to the large number of sculpins collected at this tributary.

In 2007, sampled tributaries also showed low numbers of sucker and sunfish species, ranging from 0 to 2 and 2 to 4, respectively (Table 2). Of the six tributaries sampled, Mill Creek had the highest richness and percent composition of suckers (7.5%) and sunfish (65.9%); while Brush and Panther Creeks contained no sucker species and had the lowest number of sunfish species (2 species). Number of minnow species and number of darter/sculpin/madtom species ranged from 2 to 10 and 2 to 7, respectively. Panther Creek had the lowest number of minnow and darter/sculpin/madtom taxa while Mill Creek had the highest richness of these taxa. Panther Creek also had the lowest percent composition of minnows (6.7 %) but the highest percent composition of darters/sculpins/madtoms (58.3%).

Stream Integrity

IBI scores for mainstem reaches ranged from 72 to 93 in 2006 and 69 to 90 in 2007, with all reaches falling into the good or excellent categories for stream integrity (Table 3). In general, IBI scores were similar (<5 point difference in IBI scores; Karr 1981) between years with the exception of B6, which declined by a score of 14. In 2007, percent of individuals with anomalies increased from 0.2 to 1.1 % at site B6, which decreased the score of that metric by 8 points.

Tributaries sampled in 2006 had IBI scores ranging from 64 to 82, indicating good to excellent stream health (Table 3). The Little Buffalo, which had the highest richness, abundance, and number of darter/sculpin/madtom species, had the highest IBI score and rated as having excellent stream integrity. Whiteley Creek had the lowest IBI score of those streams sampled in 2006, although this stream still rated as having good stream integrity due to the presence of fish species intolerant to human disturbance.

IBI scores for tributaries sampled during 2007 ranged from 55 to 82 (fair to excellent; Table 3). Three tributaries ranked as fair: Brush, Panther, and Stewart creeks. Panther Creek had the lowest IBI score of the six tributaries sampled in 2007 and also had the lowest richness, diversity, and number of darter/sculpin/madtom species. Mill Creek, which had the highest richness, abundance, and number of darter/sculpin/madtom species, had the highest IBI score and ranked as having excellent stream health.

Table 2. Number of species and percent composition (by biomass) of sucker, sunfish, and minnow families, and sculpin/madtom/darter species for reaches sampled in 2006 and 2007.

Sample Reach	No. Species Suckers	% Comp Suckers	No. Species Sunfish	% Comp Sunfish	No. Species Minnows	% Comp Minnows	No. Species Darters, Sculpins, Madtoms	% Comp Darters, Sculpins, Madtoms
				2006 - Panel 1				
Mainstem								
B1	2	0.3	3	1.0	9	75.2	6	21.9
B2	4	24.2	5	52.5	14	6.2	10	1.5
B3	3	16.8	5	55.4	16	8.0	9	1.6
B4	3	11.8	5	60.0	14	14.9	8	6.8
B5	3	45.0	5	41.1	15	10.0	8	2.4
B6	3	2.7	5	73.0	12	12.5	10	5.2
Tributaries								
Whiteley	0	0.0	1	8.0	4	57.7	5	34.3
Little Buffalo	2	10.4	6	73.0	12	10.9	8	3.4
Spring	0	0.0	3	16.9	4	18.5	5	49.8
Hickory	0	0.0	1	10.0	0	0.0	5	88.3
Middle	1	0.7	3	52.4	7	16.1	8	21.1
Leatherwood	1	0.5	2	43.2	8	22.9	6	20.7
				2007 - Panel 2				
Mainstem								
B1	2	25.5	3	11.3	9	24.2	6	34.4
B2	3	37.3	5	43.8	11	4.1	6	0.4
B3	4	47.8	4	25.9	14	4.2	11	1.1
B4	4	18.9	6	56.3	16	11.6	11	3.3
B5	5	57.4	5	35.7	13	5.1	10	0.5
B6	5	26.5	6	64.8	11	2.2	9	0.9
Tributaries								
Cecil	1	1.5	3	57.7	6	18.6	7	21.7
Mill	2	7.5	4	65.9	10	16.9	7	7.9
Sheldon Branch	0	0.0	3	21.5	10	61.6	3	10.2
Brush	0	0.0	2	27.5	5	71.1	4	1.4
Panther	0	0.0	2	33.6	2	6.7	2	58.3
Stewart	0	0.0	3	48.4	3	39.8	4	5.8

Table 3. Index of Biotic Integrity (IBI) scores and metric values for each reach sampled in 2006 and 2007. AHIP = individuals that are Algivorous, Herbivorous, Invertivorous, and Piscivorous, Anom = individuals with an Anomaly (disease, eroded fins, lesions, tumors, or blackspot), GBYC = individuals as Green sunfish, Bluegill, Yellow bullhead, or Channel catfish, Invert = individuals that are invertivorous, Carn = individuals that are top carnivores, DSM = Darter/ Sculpin/Madtom species, Lithophilic = species that are sand/gravel spawners.

Sample Reach	% AHIP	% Anom	% GBYC	% Invert	% Carn	No. DSM Species	No. Lithophilic Species	IBI
				2006 - Panel 1				
Mainstem								
B1	0.1	2.0	1.1	41.7	0.6	6	19	72
B2	0.5	0.9	2.7	70.1	2.7	10	29	83
B3	0.7	2.9	2.6	65.0	4.5	9	27	80
B4	0.5	1.7	0.6	67.0	3.4	8	25	80
B5	0.4	0.1	0.6	62.3	2.2	8	25	91
B6	0.2	0.2	0.7	67.6	4.0	10	25	93
Tributaries								
Whiteley	0.0	3.8	1.5	47.1	0.0	5	8	64
Little Buffalo	0.8	1.5	3.2	58.5	2.6	8	23	82
Spring	0.8	0.4	1.3	20.6	0.4	5	14	70
Hickory	0.0	0.0	0.0	9.9	0.0	5	6	67
Middle	1.2	1.4	5.6	48.2	0.5	8	17	69
Leatherwood	2.2	0.0	6.7	47.4	0.0	6	15	79
				2007 - Panel 2				
Mainstem								
B1	0.2	2.4	2.2	45.7	0.2	6	18	69
B2	0.2	0.4	7.2	50.2	8.4	6	21	82
B3	0.1	0.9	1.4	59.5	4.3	11	28	84
B4	0.2	1.5	0.4	55.4	7.0	11	31	84
B5	0.5	0.4	0.9	49.6	2.9	10	27	90
B6	0.4	1.1	2.8	53.5	11.7	9	24	79
Tributaries								
Cecil	0.0	7.1	6.7	46.1	3.7	7	13	80
Mill	0.5	2.3	2.1	58.0	2.5	7	20	82
Sheldon Branch	0.0	1.5	1.1	27.7	0.0	3	13	60
Brush	0.0	0.3	1.4	3.7	0.0	4	9	57
Panther	0.3	0.1	1.3	11.7	0.0	2	5	55
Stewart	1.0	0.6	3.8	36.5	0.0	4	8	58

Habitat and Water Quality

In-stream Habitat

On average, most mainstem reaches were similar among years in terms of in-stream habitat, although some reaches in 2007 were slightly deeper with higher flows (Figures 4 and 5). Average width was found to be similar between years at most mainstem reaches with the 95% CI of average difference in width (Figure 4; top panel) encompassing zero (no difference). The exception is reach B5 which was wider by 14 m in 2007. Average depth, velocity (Figure 4; middle and bottom panel), and substrate size (Figure 5; top panel) were also found to be similar between years at a majority of mainstem reaches. However, reach B1 had greater depths (by 17.4 cm), higher velocity (by 0.07 m/s) and larger substrate in 2007 (from small pebble in 2006 to small cobble in 2007), and reach B2 had higher velocity (by 0.13 m/s) in 2007. In general, average width, velocity, and discharge tended to increase in a downstream direction, whereas average depth and substrate of the reach showed no clear longitudinal trend.

For tributaries sampled in 2006, the Little Buffalo River was substantially larger than the other streams sampled with a discharge of 0.34 m^3/s and an average width and depth of 19.5 m and 49 cm, respectively (Table 4). Hickory Creek was the smallest stream sampled in 2006 with an average width of 4.8 m and depth of 10.6 cm. Spring Creek had the highest average velocity (0.22 m/s) and Whiteley, located in the Boston Mountains region, had the largest average substrate with a Wentworth substrate code of approximately 16 (small cobble; 64-90 mm).

Cecil Creek was the widest (12.7 m) and deepest (46.2 cm) stream sampled in 2007 followed by Mill Creek, which had the highest velocity (0.14 m/s) and discharge (0.23 m^3/s; Table 4). Stewart Creek had the largest substrate on average with a Wentworth substrate code of about 20 (boulder; 256-362 mm) due to the large amount of bedrock in this stream. Sheldon Branch and Panther creeks were the smallest tributaries sampled in 2007 with discharge measurements of 0.001 m^3/s and 0.004 m^3/s, respectively.

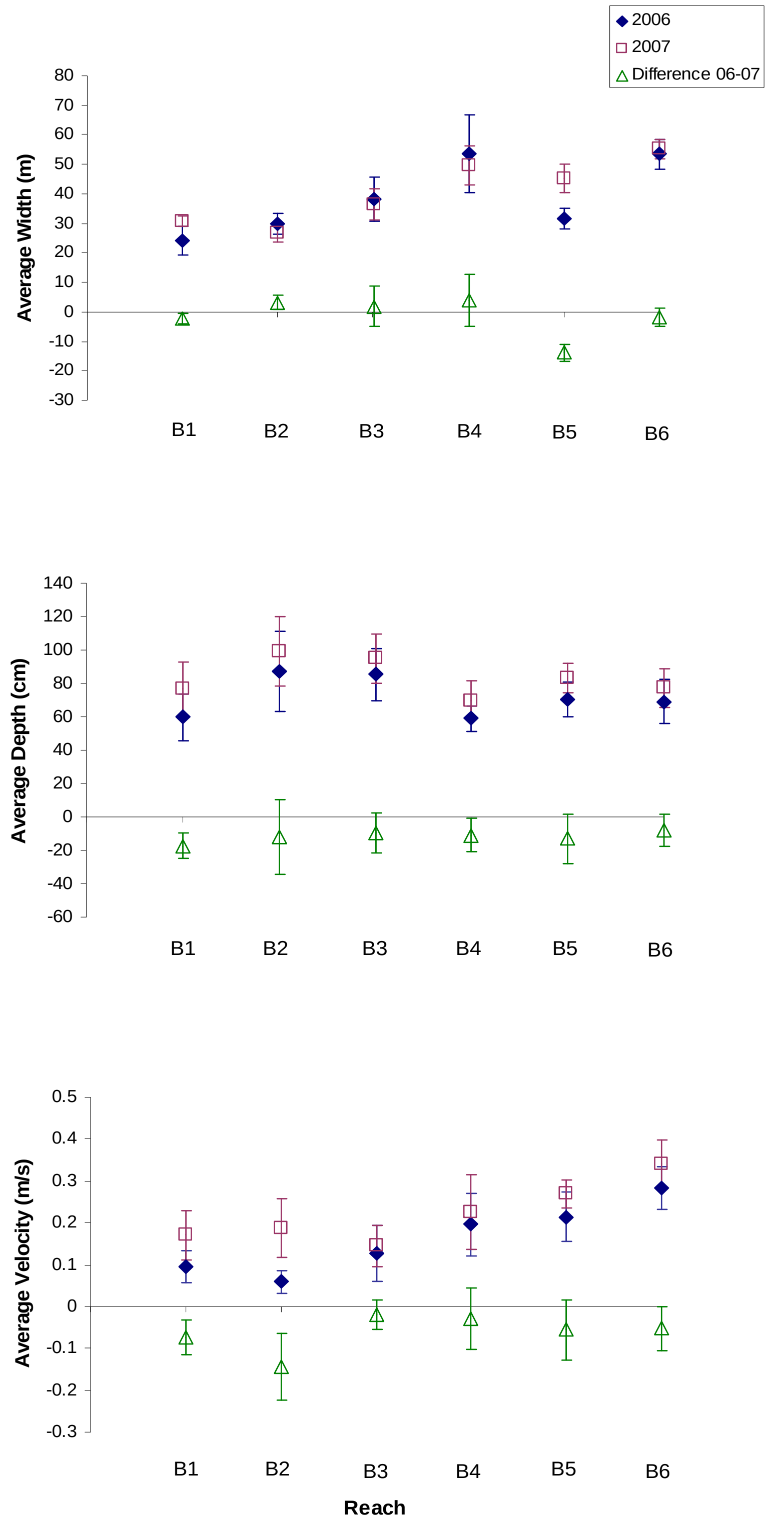
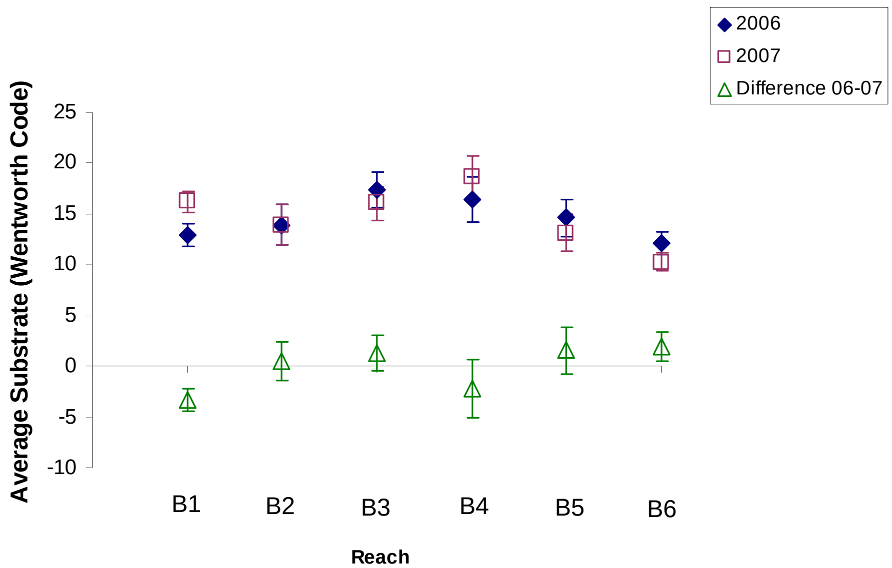


Figure 4. Average width, depth, and velocity (95% CI) at mainstem reaches and average differences among in-stream habitat parameters (95% CI) between years.



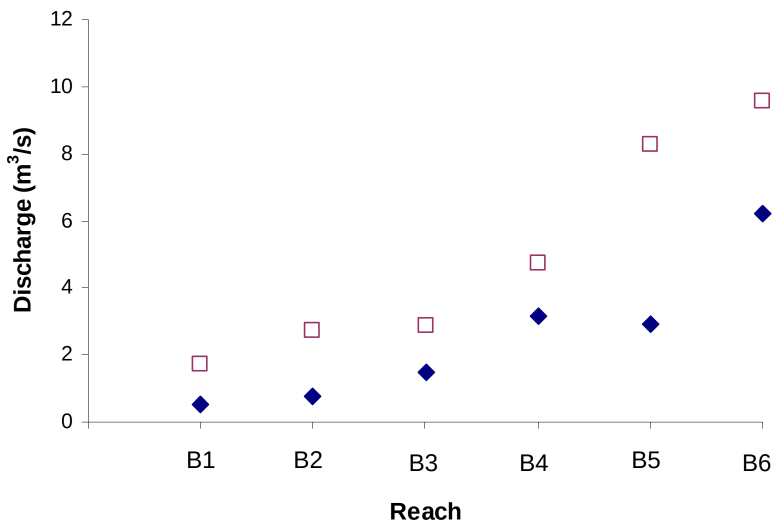


Figure 5. Average substrate size with 95% CI (using Wentworth code) and total discharge at mainstem reaches sampled in 2006 and 2007. Average differences in substrate size (95% CI) between years are designated by triangles.

Table 4. Average width, depth, velocity, and substrate (± 1 SE) and total discharge for tributaries sampled in 2006 and 2007.

Tributary	Average Width (m)	Average Depth (cm)	Average Velocity (m/s)	Average Substrate (Wentworth Code)	Discharge (m^3/s)
			2006 - Panel		
Whiteley	5.9 ± 0.6	29.5 ± 5.3	0.05 ± 0.01	15.7 ± 0.99	0.001
Little Buffalo	19.5 ± 1.7	49.0 ± 6.2	0.14 ± 0.04	13.3 ± 0.43	0.34
Spring	6.4 ± 0.9	17.2 ± 2.4	0.22 ± 0.04	12.9 ± 0.52	0.11
Hickory	4.8 ± 0.5	10.6 ± 2.1	0.07 ± 0.01	13.4 ± 0.40	0.03
Middle	7.0 ± 0.9	25.6 ± 4.6	0.07 ± 0.01	13.6 ± 0.76	0.08
Leatherwood	6.3 ± 0.6	11.1 ± 1.9	0.07 ± 0.01	11.8 ± 0.47	0.03
			2007 - Panel 2		
Cecil	12.7 ± 0.8	46.2 ± 6.1	0.11 ± 0.03	16.0 ± 0.83	0.20
Mill	9.5 ± 1.0	33.1 ± 3.1	0.14 ± 0.03	10.9 ± 0.23	0.23
Sheldon Branch	3.2 ± 0.4	14.2 ± 2.2	0.03 ± 0.01	11.7 ± 0.64	0.001
Brush	4.7 ± 0.9	15.9 ± 2.4	0.08 ± 0.02	13.8 ± 0.51	0.01
Panther	4.2 ± 0.5	11.6 ± 3.2	0.03 ± 0.01	11.7 ± 0.58	0.004
Stewart	4.7 ± 0.5	11.3 ± 1.3	0.09 ± 0.02	19.6 ± 1.16	0.01

Fish Cover

Fish cover was assessed at each transect within the sample reach. Because several cover types may be present at a transect, the percentages given are percent of the reach that contain each cover type; therefore, percentages do not add to 100% for the reach. All mainstem reaches had a high percentage of small woody debris in 2006 (68-95%) and 2007 (59-91%), and no artificial cover present (Figure 6). Site B1 showed an increase in small woody debris of 22% in 2007 and a decrease in percent boulder cover of about 30%. Reach B4, B5, and B6 had a high percent of overhanging vegetation in 2006 (91%, 45%, and 64%, respectively), but low percentages in 2007 (14%, 0%, and 23%, respectively). Percent of tree/root cover at reach B2 and B4 increased by over 30% in 2007. The increase in tree/root cover along the banks at these sites could be a function of higher flows in 2007. However, higher flows would also suggest wetted width should have increased in 2007, potentially increasing the percent of overhanging vegetation available to fish. Yet width was found to be similar among years (except at B5) and overhanging vegetation decreased at three sites. All other fish cover types made up a relatively small percentage of the mainstem reaches with the exception of filamentous algae and bluff (within 5 m of water) cover at B6.

As with the mainstem reaches, tributaries sampled in both 2006 and 2007 had a high percentage of small woody debris cover and no artificial cover present (Table 5). Whiteley, Middle, and Stewart creeks showed a fairly even distribution among the remaining cover types present within the stream. The Little Buffalo River and Spring Creek had greater than 35% of the reach containing bluff cover, and Leatherwood Creek had approximately 30% of the reach with hydrophytes. In 2007, Cecil, Mill, and Panther creeks had greater than 40% of the reach as tree/root cover.

Bank/Riparian

Banks at mainstem reaches were categorized as unstable (score between 11 and 15) based on stability scores. Averages ranged from 11.2 to 14.7 in 2006 and 12.0 to 14.3 in 2007 (Figure 7). Based on average differences in stability scores and 95% CIs (triangles in Figure 7), bank stability was similar between years at each mainstem reach with the exception of reach B6 where the 95% CI of the average difference did not encompass zero. Banks at site B6 were more stable in 2006, increasing from a score of 11.2 to a score of 14.3 in 2007 due primarily to an increase in bank height and an increase in the proportion of banks with sand or gravel/sand substrate.

Banks were rated as being at risk (score between 8 and 10) or unstable (score between 11 and 15) for most tributaries sampled (Table 6). Streams sampled in 2006 ranged from 10.0 to 14.1 in stability scores (at risk to unstable banks). Of these six streams, Whiteley Creek had the lowest stability score (i.e., most stable banks); while Little Buffalo River had the highest score (i.e., least stable). In 2007, bank stability scores ranged from 10.1 to 16.5 (at risk to very unstable) with Stewart Creek having the most stable banks of all panel 2 tributaries; while banks at Panther Creek were very unstable.

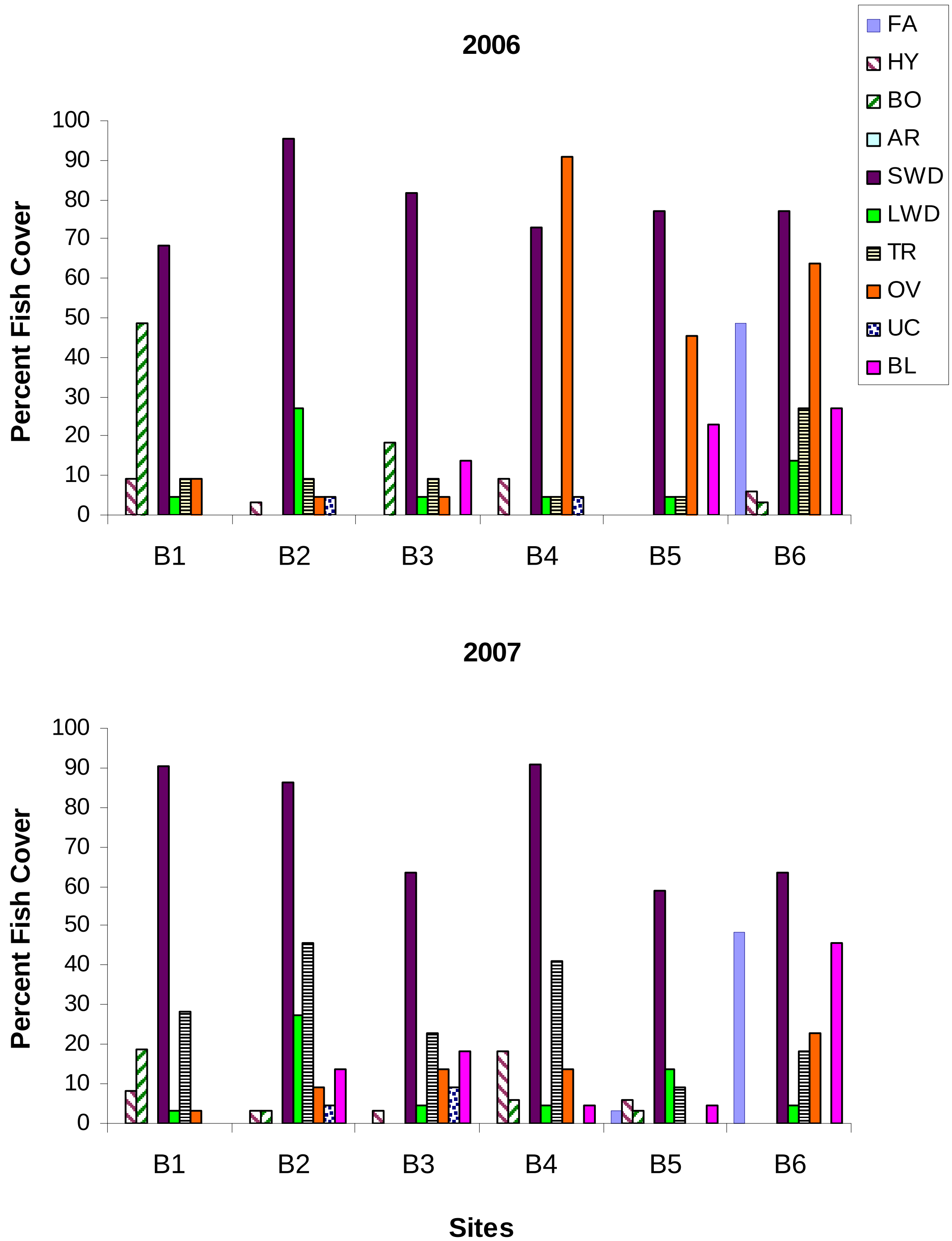


Figure 6. Percentage of the reach covered by each fish cover type at mainstem reaches sampled in 2006 and 2007. Cover types are: filamentous algae (FA), hydrophytes (HY), boulder (BO), artificial (AR), small woody debris (SWD), large woody debris (LWD), trees/roots (TR), overhanging vegetation (OV), undercut bank (UC), and bluff within 5m of water's edge (BL). Percentages for a reach do not add to 100% because multiple cover types were present at each reach.

Table 5. Percentage of the reach covered by each fish cover type at tributaries sampled in 2006 and 2007. Cover types are: filamentous algae (FA), hydrophytes (HY), boulder (BO), artificial (AR), small woody debris (SWD), large woody debris (LWD), trees/roots (TR), overhanging vegetation (OV), undercut bank (UC), and bluff within 5m of water's edge (BL).

Tributary	%FA	%HY	%BO	%AR	%SWD	%LWD	%TR	% OV	%UC	%BL
2006 - Panel 1										
Whiteley	3.0	6.1	18.2	0.0	72.7	4.5	18.2	4.5	13.6	18.2
Little Buffalo	27.3	0.0	6.1	0.0	77.3	18.2	4.5	13.6	13.6	36.4
Spring	9.1	0.0	0.0	0.0	90.9	4.5	27.3	9.1	22.7	40.9
Hickory	0.0	24.2	27.3	0.0	86.4	18.2	9.1	4.5	22.7	0.0
Middle	0.0	21.2	9.1	0.0	95.5	0.0	18.2	9.1	13.6	18.2
Leatherwood	0.0	30.3	3.0	0.0	95.5	9.1	22.7	4.5	9.1	4.5
2007 - Panel 2										
Cecil	0.0	27.3	3.0	0.0	81.8	18.2	45.5	4.5	9.1	0.0
Mill	3.0	0.0	0.0	0.0	86.4	0.0	40.9	13.6	31.8	9.1
Sheldon Branch	27.3	0.0	0.0	0.0	100.0	4.5	13.6	0.0	9.1	22.7
Brush	0.0	0.0	12.1	0.0	50.0	0.0	13.6	4.5	13.6	27.3
Panther	3.0	6.1	0.0	0.0	90.9	9.1	40.9	0.0	18.2	13.6
Stewart	0.0	21.2	9.1	0.0	100.0	0.0	22.7	22.7	4.5	13.6

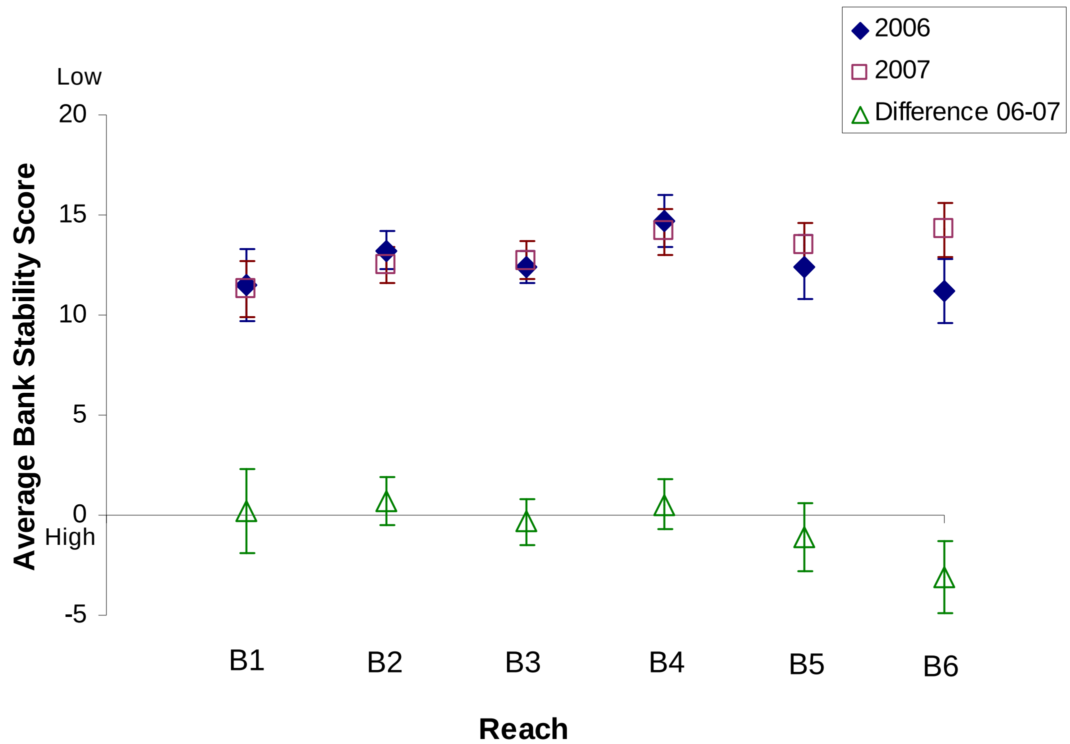


Figure 7. Average bank stability score (95% CI) and average differences in bank stability (95% CI) for mainstem reaches.

Table 6. Average bank stability score (+ 1 SE) for tributaries sampled in 2006 and 2007.

Tributary	Average Bank Stability		
	2006 - Panel 1		
Whiteley	10.0	+	0.82
Little Buffalo	14.1	+	0.69
Spring	12.7	+	0.48
Hickory	13.6	+	0.34
Middle	12.9	+	0.37
Leatherwood	13.5	+	0.55
	2007 - Panel		
Cecil	11.2	+	0.80
Mill	12.6	+	0.52
Sheldon Branch	10.8	+	0.46
Brush	12.7	+	0.42
Panther	16.5	+	0.63
Stewart	10.1	+	0.48

Water Quality

Continuous (hourly) water quality data were collected in the upper, middle, and lower sections of the Buffalo River to assess general conditions of the river at the time of sampling. Average water temperature, pH, and specific conductance were found to be lower in 2007, while turbidity was higher in 2007 (Table 7), possibly due to higher discharge in 2007 (Figure 5). All CORE 5 measurements were within typical ranges found in the Buffalo River (Petersen 1998, Moix and Galloway 2004) with the exception of specific conductance at Carver in 2006, which was much higher than recorded values in previous studies. Water quality loggers were deployed in different locations in 2007 than in 2006 due to logistical constraints. However, future deployment of loggers will be carried out at three locations: Pruitt (upper river), Tyler Bend (middle river), and Rush (lower river).

Static water quality and air temperature data were collected before and after fish sampling at each reach sampled in 2006 and 2007. Although air temperatures were higher in 2007 (range = 23.5-30.0 ^{o}C) compared to 2006 (range = 17.0-22.0 ^{o}C), average water temperatures at mainstem reaches tended to be slightly lower in 2007. In general, average pH, specific conductance, and dissolved oxygen were similar between years at mainstem reaches with the exception of pH at site B1, specific conductance and dissolved oxygen at site B2, and dissolved oxygen at B5.

Water quality data for tributaries fell within typical ranges found in previous studies of Buffalo River tributaries (Mott 1997, Moix and Galloway 2004). Water temperatures for tributaries ranged from 14.9 to 27.6 ^{o}C in 2006 and from 15.5 to 22.6 ^{o}C in 2007. Hickory and Panther creeks had the lowest water temperatures due primarily to the influence of springs in the watershed. pH values varied little among the streams sampled in 2006 and 2007. However, dissolved oxygen tended to be much higher in tributaries sampled in 2007 with four streams having concentrations above 10 mg/L. Specific conductance was also relatively high (> 400 us/cm) at Middle Creek in 2006 and Stewart Creek in 2007.

Table 7. Average CORE 5 water quality measurements (± 1SE) collected continuously by loggers at upper, middle, and lower sections of the Buffalo River in 2006 and 2007.

River Section (Location Name; number of samples)	Average Water Temperature (°C)	Average pH	Average Specific Conductance (µS/cm)	Average Dissolved Oxygen (mg/L)	Average Turbidity (NTU)
			2006		
Middle (Carver; n = 494)	25.7 ± 0.1	7.80 ± 0.00	412.8 ± 1.6	7.90 ± 0.05	0.36 ± 0.01
Lower (Rush; n = 332)	27.2 ± 0.1	8.08 ± 0.01	224.3 ± 0.2	8.12 ± 0.06	1.17 ± 0.06
			2007		
Upper (Pruitt; n = 257)	23.8 ± 0.1	7.69 ± 0.04	188.1 ± 0.9	6.29 ± 0.11	7.27 ± 1.30
Middle (Tyler Bend; n = 142)	22.5 ± 0.1	7.44 ± 0.01	213.5 ± 0.4	9.05 ± 0.05	1.70 ± 0.26

Table 8. Average discrete water quality measurements and air temperature (± 1 SE) collected by hand-held meters at each sample reach in 2006 and 2007. n = 2. No data for SE indicates only one sample taken. NC = not collected.

Sample Reach	Average Water Temperature (°C)			Average Air Temperature (°C)			Average pH			Average Specific Conductance (µS/cm)			Average Dissolved Oxygen (mg/L)		
							2006 - Panel 1								
Mainstem															
B1	18.1	±	1.6	18.0	±	2.0	7.06	±	0.11	96.9	±	3.4	9.09	±	0.77
B2	26.6	±	0.7	22.0	±	2.0	7.17	±	0.09	245.1	±	2.8	7.38	±	0.34
B3	25.8	±	0.7	18.0	±	2.0	7.55	±	0.00	221.2	±	14.5	8.35	±	0.78
B4	25.6	±	1.7	17.5	±	2.5	7.57	±	0.09	223.8	±	2.5	8.95	±	0.97
B5	27.7	±	0.4	NC	±		7.68	±	0.00	218.0	±	33.2	7.10	±	0.64
B6	27.2	±	1.1	17.0	±		7.82	±	0.10	186.1	±	61.3	8.21	±	0.67
Tributaries															
Whiteley	16.2	±	0.4	17.0	±	2.0	7.29	±	0.25	125.9	±	25.3	8.16	±	0.43
Little Buffalo	27.6	±	0.1	20.5	±	1.5	7.58	±	0.05	228.5	±	0.6	8.04	±	0.14
Spring	17.7	±	0.7	22.5	±	1.5	7.35	±	0.03	207.4	±	38.1	8.97	±	0.25
Hickory	14.9	±	0.4	15.0	±		7.36	±	0.14	242.0	±	0.3	9.92	±	0.14
Middle	18.6	±		9.0	±		7.86	±	0.09	401.8	±	0.3	7.78	±	0.13
Leatherwood	21.9	±	0.4	NC	±		7.86	±	0.02	361.0	±	18.3	7.44	±	0.01
							2007 - Panel 2								
Mainstem															
B1	17.8	±	1.3	23.5	±	2.5	7.96	±	0.18	77.9	±	0.8	9.66	±	0.01
B2	21.5	±	0.7	28.5	±	0.5	7.18	±	0.03	175.2	±	2.1	10.20	±	0.28
B3	22.3	±	0.4	25.0	±	1.0	7.13	±	0.17	216.0	±	1.9	9.09	±	0.37
B4	23.2	±	1.6	29.3	±	5.8	7.19	±	0.27	220.3	±	5.1	9.48	±	0.98
B5	28.3	±	0.6	30.0	±	0.5	7.66	±	0.41	239.7	±	6.9	9.81	±	0.23
B6	26.9	±	0.4	29.5	±	0.5	7.67	±	0.28	262.1	±	6.9	9.51	±	0.07
Tributaries															
Cecil	16.7	±	0.6	26.5	±	0.5	7.44	±	0.12	205.1	±	2.9	11.71	±	0.19
Mill	19.6	±	0.9	26.0	±	0.0	7.46	±	0.22	334.7	±	3.8	11.00	±	0.18
Sheldon Branch	18.8	±	0.0	24.0	±	1.0	7.57	±	0.15	268.1	±	37.7	7.83	±	0.23
Brush	18.9	±	0.2	23.3	±	0.8	7.49	±	0.26	358.5	±	1.3	10.23	±	0.11
Panther	15.5	±	0.6	27.0	±	1.0	6.91	±	0.09	244.7	±	5.9	11.33	±	0.20
Stewart	22.6	±	0.9	29.3	±	1.3	7.71	±	0.13	412.4	±	45.4	9.81	±	0.35

Discussion

The high number of fish species, number of sensitive taxa (darters, sculpins, madtoms), and their abundance at BUFF, along with low occurrences of disease and deformities, indicate a highly diverse and healthy fish community. Overall, fish community metrics at mainstem reaches were similar between years, suggesting little change in community structure from one year to the next and giving a good baseline to detect changes in stream integrity. For the most part, physical habitat and water quality changed very little during the collection period. Thus, the changes in fish community composition observed at a few reaches are likely due to adjustments in gear used or sampling effort. For instance, increases in species richness at B4 and sucker composition at B1 were probably due to the change in gear being more effective at capturing fish in 2007. Changes in richness and abundance at reach B2 and composition of suckers at B3 and B6 are most likely due to an increase in boat sampling effort at these sites in 2007. These data demonstrate the importance of maintaining consistency among gear and sampling effort. Therefore, future data collection at mainstem sites will follow those methods used in 2007, which are detailed in the Ozarks Rivers Fish Community Protocol (Petersen *et al*. 2008).

Fish communities among the tributaries were more variable than mainstem sites. Several tributaries sampled had a diverse community and high stream integrity, while a few had low or moderate diversity and stream integrity. The wider and deeper habitats available in the Little Buffalo River and Mill and Cecil creeks could be a contributing factor to the high diversity of the fish community. Because of the relatively large size of the Little Buffalo River, the fish community has a higher composition of suckers and sunfish making it more similar to a mainstem site than a tributary. Hickory and Panther creeks had the lowest species richness and diversity. The cooler water temperatures created by springs in Hickory and Panther creeks may explain the low species richness and the dominance of a few species in these streams. However, Hickory Creek was found to have good overall stream integrity, while Panther Creek had poorer stream health due in part to low numbers of sensitive taxa. Additional water quality issues caused by land use practices in the watershed of Panther Creek could also be affecting the fish communities of this stream. Brush Creek had low species richness and diversity as well as a lower IBI score compared to other tributaries. Water removal for a municipal water supply is likely the factor impacting the fish community in this tributary.

In-stream and bank habitat at mainstem sites were similar among years. Width, discharge, and velocity increased in a downstream direction, as expected in river systems. However, depth and substrate did not show a clear longitudinal pattern, where an increase in depth and decrease in substrate size would be expected downstream. Water levels were slightly higher in 2007, somewhat increasing depth and velocity at mainstem sites, but did not seem to have a substantial effect on availability of fish cover. A high percent of small woody debris was present at all sites in both years with other fish cover types making up a small percentage of the mainstem reaches. Although bank stability scores were consistent among years, banks at mainstem reaches were rated as unstable, and banks along tributaries were rated as having low bank stability. While some areas of the Buffalo River have higher rates of bank erosion, we would not expect every sample site along the Buffalo River to have unstable banks. The scoring criteria used for bank stability, which is based on US Geological Survey protocols, may not accurately assess the bank condition of Ozark rivers, specifically the Buffalo River and its tributaries. Additional analysis and assessment is warranted to determine the effectiveness of this scoring system for bank stability.

Water quality data fell within typical ranges found in previous studies of the Buffalo River and were consistent among years at mainstem sites. Although air temperatures were higher in 2007, average water temperatures tended to be slightly lower at mainstem reaches in 2007. Collection of continuous water quality data showed not only water temperature to be lower during early summer 2007, but pH and specific conductance were also lower and turbidity was higher in 2007, possibly due to higher discharge in 2007.

Results of this fish community and habitat monitoring can be valuable to park managers in order to gain insight on potential problem areas within the park and to locate high quality areas in need of protection. This baseline data can also be useful in tracking the effectiveness of management strategies by observing trends in fish communities and stream integrity over time. Furthermore, collection of physical habitat data in conjunction with fish data can be important in eliminating habitat as a factor influencing annual variation in fish communities or can be useful in explaining true temporal changes in the biota.

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Appendix 1. Wentworth code classifications for substrate.

Size Code	Min Particle Diameter (mm)	Max Particle Diameter (mm)	Category	Midpoint
1	0.0	0.1	Silt/clay	0.0
2	0.1	0.1	Very fine sand	0.1
3	0.1	0.3	Fine sand	0.2
4	0.3	0.5	Medium sand	0.4
5	0.5	1.0	Course sand	0.8
6	1.0	2.0	Coarse sand	1.5
7	2.0	4.0	Fine gravel	3.0
8	4.0	5.7	Medium gravel	4.9
9	5.7	8.0	Medium gravel	6.9
10	8.0	11.3	Coarse gravel	9.7
11	11.3	16.0	Coarse gravel	13.7
12	16.0	22.6	Small pebble	19.3
13	22.6	32.0	Small pebble	27.3
14	32.0	45.0	Large pebble	38.5
15	45.0	64.0	Large pebble	54.5
16	64.0	90.0	Small cobble	77.0
17	90.0	128.0	Small cobble	109.0
18	128.0	180.0	Large cobble	154.0
19	180.0	256.0	Large cobble	218.0
20	256.0	362.0	Boulder	309.0
21	362.0	512.0	Boulder	437.0
22	512.0	1024.0	Boulder	768.0
23	> 1024		Boulder	
24	Bedrock	Bedrock	Bedrock	

Appendix 2. List of species and numbers caught at mainstem reaches in 2006-2007.

Family	Common Name	Scientific Name	2006	2007
		B1		
Catostomidae	Black redhorse	*Moxostoma duquesnei*	0	1
Catostomidae	Northern hog sucker	*Hypentelium nigricans*	1	5
Catostomidae	Redhorse spp.	*Moxostoma sp.*	1	0
Centrarchidae	Green sunfish	*Lepomis cyanellus*	13	23
Centrarchidae	Longear sunfish	*Lepomis megalotis*	26	26
Centrarchidae	Ozark bass	*Ambloplites constellatus*	9	2
Cottidae	Banded sculpin	*Cottus carolinae*	115	136
Cyprinidae	Bigeye chub	*Notropis amblops*	0	1
Cyprinidae	Bigeye shiner	*Notropis boops*	12	60
Cyprinidae	Bluntnose minnow	*Pimephales notatus*	3	4
Cyprinidae	Duskystripe shiner	*Luxilus pilsbryi*	63	23
Cyprinidae	Ozark minnow	*Notropis nubilus*	115	68
Cyprinidae	Ozark shiner	*Notropis ozarcanus*	3	0
Cyprinidae	Southern redbelly dace	*Phoxinus erythrogaster*	13	28
Cyprinidae	Stoneroller spp.	*Campostoma spp.*	467	293
Cyprinidae	Striped shiner	*Luxilus chrysocephalus*	3	6
Cyprinidae	Telescope shiner	*Notropis telescopus*	2	0
Cyprinidae	Whitetail shiner	*Cyprinella galactura*	0	1
Fundulidae	Northern studfish	*Fundulus catenatus*	18	1
Ictaluridae	Slender madtom	*Noturus exilis*	31	38
Ictaluridae	Yellow bullhead	*Ameiurus natalis*	2	2
Percidae	Greenside darter	*Etheostoma blennioides*	18	5
Percidae	Orangethroat darter	*Etheostoma spectabile*	34	58
Percidae	Rainbow darter	*Etheostoma caeruleum*	397	284
Percidae	Stippled darter	*Etheostoma punctulatum*	41	48
Petromyzonidae	Ichythyomyzon ammocoete	*Ichthyomyzon spp.*	19	44
		B2		
Atherinidae	Brook silverside	*Labidesthes sicculus*	0	2
Catostomidae	Black redhorse	*Moxostoma duquesnei*	5	9
Catostomidae	Golden redhorse	*Moxostoma erythrurum*	6	7
Catostomidae	Northern hog sucker	*Hypentelium nigricans*	7	4
Catostomidae	River redhorse	*Moxostoma carinatum*	4	0
Centrarchidae	Bluegill	*Lepomis macrochirus*	5	1
Centrarchidae	Green sunfish	*Lepomis cyanellus*	28	36
Centrarchidae	Longear sunfish	*Lepomis megalotis*	338	141
Centrarchidae	Ozark bass	*Ambloplites constellatus*	27	23
Centrarchidae	Smallmouth bass	*Micropterus dolomieu*	5	16
Cottidae	Banded sculpin	*Cottus carolinae*	5	13
Cyprinidae	Bigeye chub	*Notropis amblops*	76	1
Cyprinidae	Bigeye shiner	*Notropis boops*	247	50
Cyprinidae	Bluntnose minnow	*Pimephales notatus*	53	27
Cyprinidae	Carmine shiner	*Notropis percobromus*	9	4
Cyprinidae	Duskystripe shiner	*Luxilus pilsbryi*	20	24
Cyprinidae	Hornyhead chub	Nocomis biguttatus	8	0

Family	Common Name	Scientific Name	2006	2007
Cyprinidae	Ozark chub	*Erimystax harryi*	1	0
Cyprinidae	Ozark minnow	*Notropis nubilus*	175	21
Cyprinidae	Ozark shiner	*Notropis ozarcanus*	30	13
Cyprinidae	Stoneroller spp.	*Campostoma spp.*	23	71
Cyprinidae	Striped shiner	*Luxilus chrysocephalus*	7	0
Cyprinidae	Telescope shiner	*Notropis telescopus*	8	1
Cyprinidae	Wedgespot shiner	*Notropis greenei*	3	1
Cyprinidae	Whitetail shiner	*Cyprinella galactura*	25	9
Fundulidae	Blackspotted topminnow	*Fundulus olivaceus*	9	3
Fundulidae	Northern studfish	*Fundulus catenatus*	14	3
Ictaluridae	Channel catfish	*Ictalurus punctatus*	1	0
Ictaluridae	Checkered madtom	*Noturus flavater*	1	0
Ictaluridae	Flathead catfish	*Pylodictis olivaris*	2	3
Ictaluridae	Ozark madtom	*Noturus albater*	1	0
Ictaluridae	Slender madtom	*Noturus exilis*	3	0
Ictaluridae	Yellow bullhead	*Ameiurus natalis*	1	0
Lepisosteidae	Longnose gar	*Lepisosteus osseus*	1	1
Percidae	Arkansas saddled darter	*Etheostoma euzonum*	13	2
Percidae	Banded darter	*Etheostoma zonale*	2	2
Percidae	Greenside darter	*Etheostoma blennioides*	15	4
Percidae	Orangethroat darter	*Etheostoma spectabile*	1	0
Percidae	Rainbow darter	*Etheostoma caeruleum*	77	16
Percidae	Stippled darter	*Etheostoma punctulatum*	0	1
Percidae	Yoke darter	*Etheostoma juliae*	20	0
Petromyzonidae	Ichythyomyzon ammocoete	*Ichthyomyzon spp.*	0	5
Petromyzontidae	Chestnut lamprey	*Ichthyomyzon castaneus*	5	0
		B3		
Atherinidae	Brook silverside	*Labidesthes sicculus*	1	7
Catostomidae	Black redhorse	*Moxostoma duquesnei*	13	25
Catostomidae	Golden redhorse	*Moxostoma erythrurum*	4	19
Catostomidae	Northern hog sucker	*Hypentelium nigricans*	6	8
Catostomidae	Redhorse spp.	*Moxostoma sp.*	0	39
Centrarchidae	Bluegill	*Lepomis macrochirus*	6	0
Centrarchidae	Green sunfish	*Lepomis cyanellus*	20	21
Centrarchidae	Longear sunfish	*Lepomis megalotis*	332	388
Centrarchidae	Ozark bass	*Ambloplites constellatus*	30	34
Centrarchidae	Smallmouth bass	*Micropterus dolomieu*	14	26
Cottidae	Banded sculpin	*Cottus carolinae*	0	21
Cyprinidae	Bigeye chub	*Notropis amblops*	20	5
Cyprinidae	Bigeye shiner	*Notropis boops*	122	77
Cyprinidae	Bluntnose minnow	*Pimephales notatus*	56	19
Cyprinidae	Carmine shiner	*Notropis percobromus*	5	22
Cyprinidae	Duskystripe shiner	*Luxilus pilsbryi*	29	110
Cyprinidae	Golden shiner	*Notemigonus crysoleucas*	0	1
Cyprinidae	Luxilus spp.	*Luxilus spp.*	4	254
Cyprinidae	Non-carp minnow spp.	*Cyprinidae spp.*	3	9
Cyprinidae	Notropis spp.	*Notropis spp.*	1	0
Cyprinidae	Ozark chub	*Erimystax harryi*	5	7
Cyprinidae	Ozark minnow	*Notropis nubilus*	120	202

Family	Common Name	Scientific Name	2006	2007
Cyprinidae	Ozark shiner	*Notropis ozarcanus*	4	27
Cyprinidae	Stoneroller spp.	*Campostoma spp.*	54	154
Cyprinidae	Striped shiner	*Luxilus chrysocephalus*	2	0
Cyprinidae	Telescope shiner	*Notropis telescopus*	2	0
Cyprinidae	Wedgespot shiner	*Notropis greenei*	46	10
Cyprinidae	Whitetail shiner	*Cyprinella galactura*	16	21
Fundulidae	Blackspotted topminnow	*Fundulus olivaceus*	7	10
Fundulidae	Northern studfish	*Fundulus catenatus*	4	5
Ictaluridae	Checkered madtom	*Noturus flavater*	2	2
Ictaluridae	Flathead catfish	*Pylodictis olivaris*	4	3
Ictaluridae	Ozark madtom	*Noturus albater*	4	1
Ictaluridae	Slender madtom	*Noturus exilis*	2	13
Ictaluridae	Yellow bullhead	*Ameiurus natalis*	2	2
Lepisosteidae	Longnose gar	*Lepisosteus osseus*	0	11
Percidae	Arkansas saddled darter	*Etheostoma euzonum*	1	1
Percidae	Banded darter	*Etheostoma zonale*	5	7
Percidae	Greenside darter	*Etheostoma blennioides*	11	17
Percidae	Logperch	*Percina caprodes*	1	2
Percidae	Rainbow darter	*Etheostoma caeruleum*	19	93
Percidae	Stippled darter	*Etheostoma punctulatum*	0	1
Percidae	Yoke darter	*Etheostoma juliae*	80	11
Petromyzonidae	Ichythyomyzon ammocoete	*Ichthyomyzon spp.*	13	18
		B4		
Atherinidae	Brook silverside	*Labidesthes sicculus*	0	1
Catostomidae	Black redhorse	*Moxostoma duquesnei*	6	10
Catostomidae	Golden redhorse	*Moxostoma erythrurum*	16	5
Catostomidae	Northern hog sucker	*Hypentelium nigricans*	3	7
Catostomidae	Redhorse spp.	*Moxostoma sp.*	0	1
Centrarchidae	Bluegill	*Lepomis macrochirus*	0	1
Centrarchidae	Green sunfish	*Lepomis cyanellus*	2	3
Centrarchidae	Largemouth bass	*Micropterus salmoides*	1	1
Centrarchidae	Longear sunfish	*Lepomis megalotis*	263	348
Centrarchidae	Ozark bass	*Ambloplites constellatus*	41	80
Centrarchidae	Smallmouth bass	*Micropterus dolomieu*	9	22
Cottidae	Banded sculpin	*Cottus carolinae*	0	11
Cottidae	Ozark sculpin	*Cottus hypselurus*	1	0
Cyprinidae	Bigeye chub	*Notropis amblops*	41	28
Cyprinidae	Bigeye shiner	*Notropis boops*	129	141
Cyprinidae	Bluntnose minnow	*Pimephales notatus*	32	29
Cyprinidae	Carmine shiner	*Notropis percobromus*	12	3
Cyprinidae	Duskystripe shiner	*Luxilus pilsbryi*	69	108
Cyprinidae	Hornyhead chub	*Nocomis biguttatus*	0	1
Cyprinidae	Luxilus spp.	*Luxilus spp.*	0	8
Cyprinidae	Non-carp minnow spp.	*Cyprinidae spp.*	1	4
Cyprinidae	Ozark chub	*Erimystax harryi*	1	10
Cyprinidae	Ozark minnow	*Notropis nubilus*	112	139
Cyprinidae	Ozark shiner	*Notropis ozarcanus*	1	4
Cyprinidae	Stoneroller spp.	*Campostoma spp.*	189	250
Cyprinidae	Striped shiner	*Luxilus chrysocephalus*	23	17

Family	Common Name	Scientific Name	2006	2007
Cyprinidae	Telescope shiner	*Notropis telescopus*	4	2
Cyprinidae	Wedgespot shiner	*Notropis greenei*	8	3
Cyprinidae	Whitetail shiner	*Cyprinella galactura*	25	25
Fundulidae	Blackspotted topminnow	*Fundulus olivaceus*	1	8
Fundulidae	Northern studfish	*Fundulus catenatus*	10	0
Ictaluridae	Checkered madtom	*Noturus flavater*	0	1
Ictaluridae	Flathead catfish	*Pylodictis olivaris*	0	2
Ictaluridae	Ozark madtom	*Noturus albater*	11	1
Ictaluridae	Slender madtom	*Noturus exilis*	8	6
Ictaluridae	Yellow bullhead	*Ameiurus natalis*	7	2
Lepisosteidae	Longnose gar	*Lepisosteus osseus*	0	2
Percidae	Arkansas saddled darter	*Etheostoma euzonum*	36	33
Percidae	Banded darter	*Etheostoma zonale*	32	14
Percidae	Gilt darter	*Percina evides*	0	1
Percidae	Greenside darter	*Etheostoma blennioides*	65	81
Percidae	Rainbow darter	*Etheostoma caeruleum*	210	98
Percidae	Stippled darter	*Etheostoma punctulatum*	0	1
Percidae	Yoke darter	*Etheostoma juliae*	138	18
Petromyzonidae	Ichythyomyzon ammocoete	*Ichthyomyzon spp.*	0	1
Petromyzontidae	Chestnut lamprey	*Ichthyomyzon castaneus*	1	1
		B5		
Atherinidae	Brook silverside	*Labidesthes sicculus*	3	3
Catostomidae	Black redhorse	*Moxostoma duquesnei*	49	85
Catostomidae	Golden redhorse	*Moxostoma erythrurum*	3	26
Catostomidae	Northern hog sucker	*Hypentelium nigricans*	11	22
Catostomidae	Redhorse spp.	*Moxostoma sp.*	0	29
Catostomidae	River redhorse	*Moxostoma carinatum*	0	3
Centrarchidae	Bluegill	*Lepomis macrochirus*	2	1
Centrarchidae	Green sunfish	*Lepomis cyanellus*	4	6
Centrarchidae	Longear sunfish	*Lepomis megalotis*	449	442
Centrarchidae	Ozark bass	*Ambloplites constellatus*	28	29
Centrarchidae	Smallmouth bass	*Micropterus dolomieu*	13	15
Cottidae	Banded sculpin	*Cottus carolinae*	0	2
Cyprinidae	Bigeye chub	*Notropis amblops*	4	18
Cyprinidae	Bigeye shiner	*Notropis boops*	101	101
Cyprinidae	Bluntnose minnow	*Pimephales notatus*	40	50
Cyprinidae	Carmine shiner	*Notropis percobromus*	17	49
Cyprinidae	Duskystripe shiner	*Luxilus pilsbryi*	30	210
Cyprinidae	Hornyhead chub	*Nocomis biguttatus*	1	8
Cyprinidae	Luxilus spp.	*Luxilus spp.*	3	4
Cyprinidae	Non-carp minnow spp.	*Cyprinidae spp.*	5	27
Cyprinidae	Ozark chub	*Erimystax harryi*	9	4
Cyprinidae	Ozark minnow	*Notropis nubilus*	240	215
Cyprinidae	Ozark shiner	*Notropis ozarcanus*	6	5
Cyprinidae	Stoneroller spp.	*Campostoma spp.*	268	156
Cyprinidae	Striped shiner	*Luxilus chrysocephalus*	1	0
Cyprinidae	Wedgespot shiner	*Notropis greenei*	51	0
Cyprinidae	Whitetail shiner	*Cyprinella galactura*	63	29
Fundulidae	Blackspotted topminnow	*Fundulus olivaceus*	6	3

Family	Common Name	Scientific Name	2006	2007
Fundulidae	Northern studfish	*Fundulus catenatus*	5	0
Ictaluridae	Checkered madtom	*Noturus flavater*	14	4
Ictaluridae	Flathead catfish	*Pylodictis olivaris*	0	2
Ictaluridae	Slender madtom	*Noturus exilis*	18	1
Ictaluridae	Yellow bullhead	*Ameiurus natalis*	5	8
Lepisosteidae	Longnose gar	*Lepisosteus osseus*	0	2
Percidae	Arkansas saddled darter	*Etheostoma euzonum*	58	2
Percidae	Banded darter	*Etheostoma zonale*	60	1
Percidae	Gilt darter	*Percina evides*	4	1
Percidae	Greenside darter	*Etheostoma blennioides*	66	32
Percidae	Orangethroat darter	*Etheostoma spectabile*	0	4
Percidae	Rainbow darter	*Etheostoma caeruleum*	178	56
Percidae	Stippled darter	*Etheostoma punctulatum*	0	6
Percidae	Yoke darter	*Etheostoma juliae*	20	0
Petromyzontidae	Chestnut lamprey	*Ichthyomyzon castaneus*	0	1
Poeciliidae	Mosquitofish	*Gambusia affinis*	3	0
		B6		
Atherinidae	Brook silverside	*Labidesthes sicculus*	3	0
Catostomidae	Black redhorse	*Moxostoma duquesnei*	6	15
Catostomidae	Golden redhorse	*Moxostoma erythrurum*	2	7
Catostomidae	Northern hog sucker	*Hypentelium nigricans*	2	13
Catostomidae	Redhorse spp.	*Moxostoma sp.*	0	4
Catostomidae	River redhorse	*Moxostoma carinatum*	0	1
Centrarchidae	Bluegill	*Lepomis macrochirus*	1	2
Centrarchidae	Green sunfish	*Lepomis cyanellus*	10	23
Centrarchidae	Largemouth bass	*Micropterus salmoides*	0	2
Centrarchidae	Longear sunfish	*Lepomis megalotis*	457	284
Centrarchidae	Ozark bass	*Ambloplites constellatus*	52	64
Centrarchidae	Smallmouth bass	*Micropterus dolomieu*	15	41
Cottidae	Banded sculpin	*Cottus carolinae*	0	3
Cyprinidae	Bigeye chub	*Notropis amblops*	3	4
Cyprinidae	Bigeye shiner	*Notropis boops*	260	49
Cyprinidae	Bluntnose minnow	*Pimephales notatus*	43	15
Cyprinidae	Carmine shiner	*Notropis percobromus*	73	6
Cyprinidae	Duskystripe shiner	*Luxilus pilsbryi*	31	155
Cyprinidae	Luxilus spp.	*Luxilus spp.*	28	28
Cyprinidae	Non-carp minnow spp.	*Cyprinidae spp.*	16	7
Cyprinidae	Ozark chub	*Erimystax harryi*	6	0
Cyprinidae	Ozark minnow	*Notropis nubilus*	216	41
Cyprinidae	Ozark shiner	*Notropis ozarcanus*	0	1
Cyprinidae	Stoneroller spp.	*Campostoma spp.*	100	54
Cyprinidae	Wedgespot shiner	*Notropis greenei*	88	0
Cyprinidae	Whitetail shiner	*Cyprinella galactura*	41	12
Fundulidae	Blackspotted topminnow	*Fundulus olivaceus*	11	1
Fundulidae	Northern studfish	*Fundulus catenatus*	4	0
Ictaluridae	Checkered madtom	*Noturus flavater*	1	2
Ictaluridae	Flathead catfish	*Pylodictis olivaris*	5	4
Ictaluridae	Ozark madtom	*Noturus albater*	21	5

Family	Common Name	Scientific Name	2006	2007
Ictaluridae	Slender madtom	*Noturus exilis*	2	5
Ictaluridae	Yellow bullhead	*Ameiurus natalis*	2	2
Percidae	Arkansas saddled darter	*Etheostoma euzonum*	27	12
Percidae	Banded darter	*Etheostoma zonale*	28	19
Percidae	Gilt darter	*Percina evides*	5	0
Percidae	Greenside darter	*Etheostoma blennioides*	99	31
Percidae	Logperch	*Percina caprodes*	3	0
Percidae	Rainbow darter	*Etheostoma caeruleum*	25	36
Percidae	Yoke darter	*Etheostoma juliae*	91	2
Petromyzonidae	Ichythyomyzon ammocoete	*Ichthyomyzon spp.*	0	2
Petromyzontidae	Chestnut lamprey	*Ichthyomyzon castaneus*	2	0

Appendix 3. List of species and numbers caught for tributary reaches sampled in 2006.

Family	Common Name	Scientific Name	Whiteley	Little Buffalo	Spring	Hickory	Middle	Leatherwood
Catostomidae	Black redhorse	*Moxostoma duquesnei*	0	2	0	0	1	1
Catostomidae	Northern hog sucker	*Hypentelium nigricans*	0	8	0	0	0	0
Centrarchidae	Bluegill	*Lepomis macrochirus*	0	4	0	0	0	0
Centrarchidae	Bluegill x Green sunfish hyBrid	*Lepomis macrochirus x L. cyanellus*	0	1	0	0	0	0
Centrarchidae	Green sunfish	*Lepomis cyanellus*	8	23	2	0	19	20
Centrarchidae	Longear sunfish	*Lepomis megalotis*	0	344	51	10	101	105
Centrarchidae	Ozark bass	*Ambloplites constellatus*	0	21	2	0	2	0
Centrarchidae	Smallmouth bass	*Micropterus dolomieu*	0	5	0	0	0	0
Cottidae	Banded sculpin	*Cottus carolinae*	0	0	156	42	39	16
Cottidae	Ozark sculpin	*Cottus hypselurus*	0	0	87	264	0	0
Cyprinidae	Bigeye chub	*Notropis amblops*	0	32	0	0	0	0
Cyprinidae	Bigeye shiner	*Notropis boops*	0	42	0	0	0	0
Cyprinidae	Bluntnose minnow	*Pimephales notatus*	0	24	0	0	7	20
Cyprinidae	Creek chub	*Semotilus atromaculatus*	1	0	0	0	0	0
Cyprinidae	Duskystripe shiner	*Luxilus pilsbryi*	5	33	83	0	22	41
Cyprinidae	Hornyhead chub	*Nocomis biguttatus*	0	8	0	0	6	7
Cyprinidae	Luxilus spp.	*Luxilus spp.*	0	4	0	0	0	1
Cyprinidae	Ozark minnow	*Notropis nubilus*	0	201	28	0	65	38
Cyprinidae	Ozark shiner	*Notropis ozarcanus*	0	3	0	0	0	0
Cyprinidae	Southern redbelly dace	*Phoxinus erythrogaster*	223	0	2	0	0	0
Cyprinidae	Stoneroller spp.	*Campostoma spp.*	39	74	6	0	41	52
Cyprinidae	Striped shiner	*Luxilus chrysocephalus*	0	3	0	0	4	1
Cyprinidae	Telescope shiner	*Notropis telescopus*	0	1	0	0	0	0
Cyprinidae	Whitetail shiner	*Cyprinella galactura*	0	2	0	0	1	1
Fundulidae	Blackspotted topminnow	*Fundulus olivaceus*	0	12	2	0	24	9
Fundulidae	Northern studfish	*Fundulus catenatus*	146	5	13	0	5	23
Ictaluridae	Checkered madtom	*Noturus flavater*	0	1	0	0	2	4
Ictaluridae	Ozark madtom	*Noturus albater*	0	2	0	0	0	0
Ictaluridae	Slender madtom	*Noturus exilis*	0	1	1	0	13	5
Ictaluridae	Yellow bullhead	*Ameiurus natalis*	0	4	4	0	5	10
Percidae	Arkansas saddled darter	*Etheostoma euzonum*	0	8	0	0	0	0

Family	Common Name	Scientific Name	Whiteley	Little Buffalo	Spring	Hickory	Middle	Leatherwood
Percidae	Banded darter	*Etheostoma zonale*	28	1	0	0	0	0
Percidae	Greenside darter	*Etheostoma blennioides*	1	31	6	8	7	3
Percidae	Orangethroat darter	*Etheostoma spectabile*	15	1	0	1	2	6
Percidae	Rainbow darter	*Etheostoma caeruleum*	53	81	26	16	42	57
Percidae	Stippled darter	*Etheostoma punctulatum*	3	0	0	0	4	0
Percidae	Yoke darter	*Etheostoma juliae*	0	0	0	0	1	0
Petromyzonidae	Ichythyomyzon ammocoete	*Ichthyomyzon spp.*	0	2	7	12	6	12
Petromyzontidae	Chestnut lamprey	*Ichthyomyzon castaneus*	0	0	1	0	0	0
Poeciliidae	Mosquitofish	*Gambusia affinis*	0	0	1	1	6	15
Salmonidae	Rainbow trout	*Oncorhynchus mykiss*	0	0	2	0	0	0

Appendix 4. List of species and numbers caught for tributary reaches sampled in 2007.

Family	Common Name	Scientific Name	Cecil	Mill	Sheldon Branch	Brush	Panther	Stewart
Catostomidae	Black redhorse	*Moxostoma duquesnei*	0	3	0	0	0	0
Catostomidae	Northern hog sucker	*Hypentelium nigricans*	1	4	0	0	0	0
Centrarchidae	Green sunfish	*Lepomis cyanellus*	18	18	7	4	7	9
Centrarchidae	Longear sunfish	*Lepomis megalotis*	25	205	34	7	80	50
Centrarchidae	Longear sunfish x Green sunfish hyBrid	*Lepomis megalotis x L. cyanellus*	0	0	2	0	0	0
Centrarchidae	Orangespotted sunfish	*Lepomis humilis*	0	0	0	0	0	8
Centrarchidae	Ozark bass	*Ambloplites constellatus*	10	22	0	0	0	0
Centrarchidae	Smallmouth bass	*Micropterus dolomieu*	0	6	0	0	0	0
Cottidae	Banded sculpin	*Cottus carolinae*	40	33	18	3	554	0
Cottidae	Ozark sculpin	*Cottus hypselurus*	0	0	0	0	1	0
Cyprinidae	Bigeye chub	*Notropis amblops*	0	3	0	0	0	0
Cyprinidae	Bigeye shiner	*Notropis boops*	0	1	2	0	0	0
Cyprinidae	Bluntnose minnow	*Pimephales notatus*	1	62	6	0	0	0
Cyprinidae	Creek chub	*Semotilus atromaculatus*	0	0	5	0	0	0
Cyprinidae	Duskystripe shiner	*Luxilus pilsbryi*	17	43	13	23	0	0
Cyprinidae	Hornyhead chub	*Nocomis biguttatus*	2	11	4	1	0	4
Cyprinidae	Ozark minnow	*Notropis nubilus*	20	119	61	1	0	0
Cyprinidae	Southern redbelly dace	*Phoxinus erythrogaster*	4	0	4	48	13	8
Cyprinidae	Stoneroller spp.	*Campostoma spp.*	32	147	326	205	24	174
Cyprinidae	Striped shiner	*Luxilus chrysocephalus*	0	1	1	0	0	0
Cyprinidae	Telescope shiner	*Notropis telescopus*	0	7	0	0	0	0
Cyprinidae	Whitetail shiner	*Cyprinella galactura*	0	2	4	0	0	0
Fundulidae	Blackspotted topminnow	*Fundulus olivaceus*	8	29	0	0	0	2
Fundulidae	Northern studfish	*Fundulus catenatus*	0	4	17	0	0	8
Ictaluridae	Slender madtom	*Noturus exilis*	3	12	0	2	0	2
Ictaluridae	Yellow bullhead	*Ameiurus natalis*	0	6	0	0	2	3
Percidae	Banded darter	*Etheostoma zonale*	1	1	0	0	0	0
Percidae	Greenside darter	*Etheostoma blennioides*	4	22	0	1	0	1
Percidae	Orangethroat darter	*Etheostoma spectabile*	3	18	0	0	0	37
Percidae	Rainbow darter	*Etheostoma caeruleum*	77	348	103	1	0	6
Percidae	Stippled darter	*Etheostoma punctulatum*	3	2	7	0	0	0
Petromyzonidae	Ichythyomyzon ammocoete	*Ichthyomyzon spp.*	0	5	0	0	0	0

The NPS has organized its parks with significant natural resources into 32 networks linked by geography and shared natural resource characteristics. HTLN is composed of 15 National Park Service (NPS) units in eight Midwestern states. These parks contain a wide variety of natural and cultural resources including sites focused on commemorating civil war battlefields, Native American heritage, westward expansion, and our U.S. Presidents. The Network is charged with creating inventories of its species and natural features as well as monitoring trends and issues in order to make sound management decisions. Critical inventories help park managers understand the natural resources in their care while monitoring programs help them understand meaningful change in natural systems and to respond accordingly. The Heartland Network helps to link natural and cultural resources by protecting the habitat of our history.

The I&M program bridges the gap between science and management with a third of its efforts aimed at making information accessible. Each network of parks, such as Heartland, has its own multi-disciplinary team of scientists, support personnel, and seasonal field technicians whose system of online databases and reports make information and research results available to all. Greater efficiency is achieved through shared staff and funding as these core groups of professionals augment work done by individual park staff. Through this type of integration and partnership, network parks are able to accomplish more than a single park could on its own.

The mission of the Heartland Network is to collaboratively develop and conduct scientifically credible inventories and long-term monitoring of park "vital signs" and to distribute this information for use by park staff, partners, and the public, thus enhancing understanding that leads to sound decision making in the preservation of natural resources and cultural history held in trust by the National Park Service.

www.nature.nps.gov/im/units/htln/

Heartland Network

Natural Resource Monitoring

NPS D-139, March 2009

National Park Service
U.S. Department of the Interior

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