



Fish Community Monitoring at Ozark National Scenic Riverways

2005-2010 Summary Report

Natural Resource Data Series NPS/HTLN/NRDS—2013/599



ON THE COVER

Backpack electrofishing in Shafer Spring at Ozark National Scenic Riverways, Missouri.
Photograph by: Heartland Inventory and Monitoring Network

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Executive Summary

The Current River watershed lies in the Ozark Highlands and is known for the direct interaction between ground water and stream flow. Ozark National Scenic Riverways (OZAR) was established to protect the corridor of the Current River and its major tributary, the Jacks Fork. However, only a small percent of the watershed is located within the park boundary, leaving most of the watershed unprotected from human disturbances that may degrade water quality and stream habitat. In addition, direct interactions between ground water and surface flow create added factors such as a lack of nutrient or contaminant filtration by soil that may place the water quality and biotic community of the Current River and Jacks Fork at risk.

Fish communities of the Current River and its tributaries are good indicators of water quality and stream integrity due to their different ecological roles in streams and varying tolerances to anthropogenic disturbances. Fish are also longer-lived than many other aquatic organisms; thus fish community composition can be indicative of past environmental conditions. Beginning in 2005, the Heartland Inventory and Monitoring Network monitored fish and corresponding physical habitat and water quality to assess the status and obtain baseline information on fish community health and stream integrity of the Current River and Jacks Fork. Six sites on the mainstem of the Current River and three sites on the Jacks Fork were sampled annually from 2005-2009, and 14 tributaries were sampled once each during 2006-2010. Electrofishing methods were used to collect fish community data and a point-transect based habitat module was used to assess physical habitat.

High community diversity and good to excellent Index of Biotic Integrity scores indicate a high quality and healthy fish community at OZAR. Species richness, diversity, and relative abundance were consistent among years, indicating a good baseline data set. On average, richness was greater in the middle and lower sections of the Current River, while relative abundance (catch per minute) was greater in the upper Current River. A majority of the tributaries sampled had a diverse community and good or excellent stream integrity with several tributaries having species richness and relative abundance comparable to mainstem sites. Those tributaries that had low diversity, richness, or IBI scores were either sampled under very low flow conditions (i.e. pooled) or were smaller in size.

This five year data set for mainstem sites provides an excellent baseline for tracking trends in fish communities and water quality over time, allowing managers to adaptively respond to changes in resource condition. Additional information collected through this long-term monitoring program will equip park managers with scientific data, allowing for informed decisions on the aquatic resources they manage.

Acknowledgments

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Introduction

Ozark National Scenic Riverways (OZAR) is located in the Salem Plateau of the Ozark Highlands in southeastern Missouri, which consists of limestone and dolomite geologic formations. Karst features, such as sinkholes, caves, springs, and gaining/losing reaches of streams, are common in the Salem Plateau and create direct interactions between ground water and stream flow. The Current River is one of the few remaining free-flowing rivers in the U.S. with much of its base flow coming from six large springs (spring discharges $> 2.8 \text{ m}^3/\text{s}$). OZAR was established to protect the corridor of the Current River and its major tributary, the Jacks Fork. The park boundary encompasses only 5% of the watershed, however, leaving much of the watershed unprotected from human disturbances that could result in alteration of water quality and stream habitat. The direct interaction between ground water and surface flow in this region, coupled with the small area of the watershed protected by the park, may place the water quality and biotic community of this river system at risk.

The Ozark Plateaus is one of the richest areas of the United States for fish species. Over 100 species are reported or suspected to occur in or around OZAR, with several of these species endemic to the Ozark Plateaus and 17 species of conservation concern (Master *et al.* 1998, Wilkerson 2003, Petersen *et al.* 2008). The fish communities of the Current River and Jacks Fork and their 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. 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 and recreational value also can be associated with several fish species of the park because of money and time spent by anglers fishing for species such as bass, sunfishes, suckers, and catfish.

The primary goal for fish community monitoring at OZAR is to detect changes and assess trends in stream integrity using fish as biotic indicators and relating these trends to stream habitat and water quality. Information obtained from this long-term monitoring program provides the basis for informed decision making to better evaluate potential effects of management on the fish community and to protect the integrity of the resource. The specific objectives for fish community monitoring at OZAR 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, bank/riparian characteristics, substrate characteristics, and water quality. The primary purpose of this report is to establish a baseline data set with which to compare future data collection of fish communities at OZAR.

Methods

Study Area

OZAR is approximately 327 km², encompassing 217 km of the Current River and Jacks Fork. Sample reaches at OZAR were randomly selected using the Generalized Random Tessellation Stratified (GRTS) method allowing for spatially balanced locations of sample reaches along the Current River and Jacks Fork (Stevens and Olsen 2004). From 2005-2009, nine mainstem reaches were sampled annually: six reaches on the Current River (C1-C6) and three reaches on the Jacks Fork (J1-J3; Figure 1). Because the Jacks Fork drains a considerable amount of the watershed (18%), it was treated as a mainstem river rather than a tributary. In 2006, tributaries were added to the monitoring program with three different tributaries sampled each year during the five year period (panel 1 -5) for a total of 15 tributaries (Figure 1; see Appendix B for list of tributaries). However, one tributary, Thorny Creek, was dry and could not be sampled. Therefore, 14 tributaries were sampled between 2006-2010. Reach lengths were based on 20 times mean wetted stream width. For detailed methodology on site selection, fish collection, and habitat assessment see Petersen *et al.* (2008).

Fish Collection

Fish communities were sampled in October/November. Pulsed DC electrofishing gear was used to collect fish at each site. Mainstem reaches were sampled using boat electrofishing supplemented by towed barge or backpack electrofishing. Tributaries were generally narrow and shallow and were sampled with either backpack or towed barge electrofishing gear.

Fish were identified to species in the field, if possible, and counted. *Compostoma* sp. were identified only to genus level due to the difficulty in species level identification of the two known species (Central Stoneroller, *C. anomalum* and Largescale Stoneroller, *C. oligolepis*) in the field. A subsample of 30 individuals per species were measured and weighed at each sample reach, and any diseases or anomalies were recorded. Fish that were too small to identify in the field were preserved for identification in the laboratory. All other fish were released back into the sample reach.

Habitat and Water Quality

Physical habitat data and water quality were collected in conjunction with fish sampling. From 2006-2010, 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 size, *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 for both banks at each transect. From 2005-2010, discrete measurements of temperature, dissolved oxygen, pH, and conductivity were collected before and after fish sampling at each reach using hand-held meters.

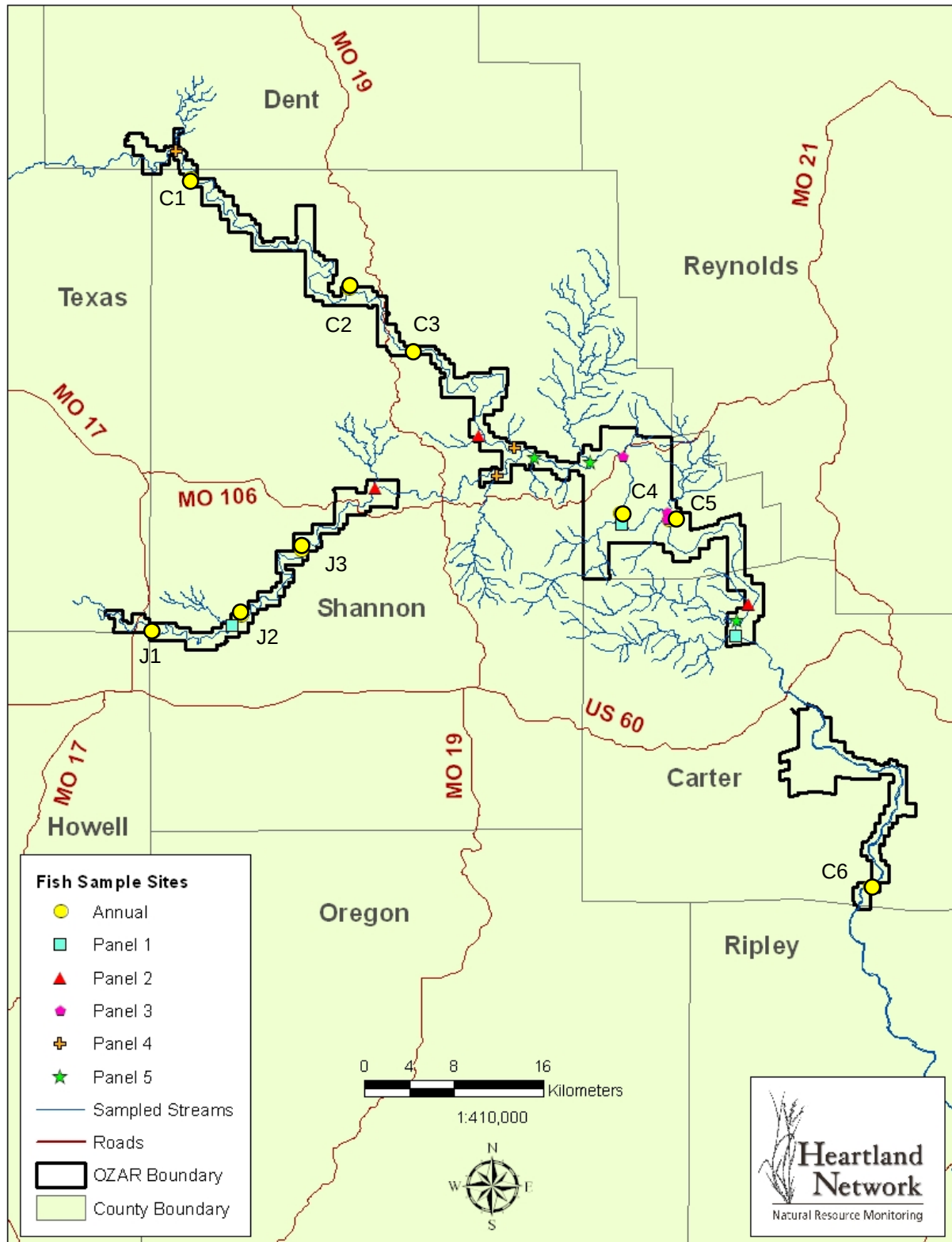


Figure 1. Location of annually sampled mainstem sites (yellow circles) and tributaries (panels 1-5) sampled at Ozark National Scenic Riverways, 2005-2010.

Data Analysis

Biological metrics were calculated for each reach sampled during 2005-2010. These metrics reflect fish community diversity (species richness and Simpson's Diversity Index), abundance (catch per unit effort), and overall stream integrity (Index of Biotic Integrity). Community diversity was assessed using Simpson's Diversity Index (range = 0 – 1), which gives the probability that two individuals picked at random from the site are the same species. Because this index has an inverse relationship to diversity (index decreases with increasing diversity), the inverse of Simpson's Index (1-SI) was used in analyses. The IBI developed by Dauwalter *et al.* (2003) was used to assess overall stream health/integrity and includes seven metrics: 1) percent of individuals as algivorous/herbivorous, invertivorous, and piscivorous (generalist); 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. Based on this IBI score, the overall stream integrity was classified from very poor to excellent: very poor = 0-20; poor = 20-40; fair = 40-60; good = 60-80; excellent (reference condition) = 80-100.

For mainstem sites, the Friedman test was employed to determine temporal variability in the five years of baseline fish community data and a Wilcoxon Signed Ranks test was used to find specific pairwise differences between years. For comparisons of spatial variability of fish communities among mainstem sites, Analysis of Variance (ANOVA) and pairwise T-tests were employed. An alpha value of 0.05 was used to determine significant differences among years or sites for the Friedman and ANOVA tests. A Bonferroni adjustment was used to adjust the experiment-wise error rate for multiple pairwise T-tests.

Based on results from a nonmetric multidimensional scaling analysis using five years of fish and habitat monitoring data at OZAR (see DeBacker *et al.* 2012), a subset of physical habitat and water quality parameters were found to be more important in explaining variation in fish community structure at mainstem and tributary sites. Therefore, only this subset is analyzed in this report. For OZAR mainstem sites, habitat variables analyzed were width, dissolved oxygen, and large woody debris fish cover. Habitat parameters for tributaries include: two variables on site size (wetted width, depth), six fish cover variables (filamentous algae, hydrophytes/moss, small woody debris, trees/roots, overhanging vegetation, undercut banks), canopy cover, and bank angle. Physical habitat and water quality data were summarized using averages with standard errors (SE) or using percentages, where appropriate.

Results

Mainstem Sites

On average, species richness ranged from 24.2 to 36.8 at mainstem sites. Over the five year sampling period, there was no significant difference in average richness among years ($\chi^2 = 5.37$, $P = 0.25$, $df = 4$). Richness was significantly different among mainstem sites ($F = 9.84$, $P < 0.01$, $df = 8, 36$) with higher richness in the middle and lower sites (C3, C4, and C6) of the Current River compared to site C2 and the three Jacks Fork sites ($P < 0.05$; Figure 2). Richness was least variable (lower standard error) at the middle Jacks Fork site (J2) site and most variable (higher standard error) in the middle Current River at sites above (C3) and below (C4) the confluence of the Jacks Fork (Figure 2).

Average abundance did not significantly differ among years at the $\alpha = 0.05$ level, but could be considered marginal. ($\chi^2 = 9.33$, $P = 0.053$, $df = 4$). Relative fish abundance in the Current River appears to decline from upstream to downstream and showed higher variability (i.e., standard error) at the two upstream most sites (Figure 3). Analysis of Variance determined that mean abundance in at least one site was significantly different ($F = 2.30$, $P = 0.042$, $df = 8, 36$). However, pairwise T-test comparisons did not determine any significant differences between mainstem sites ($P > 0.05$), likely due to higher variability at the upper Current sites coupled with the adjustment in the alpha level due to multiple pairwise tests. The seeming decline in abundance is probably due to the wider and deeper nature of the middle and lower Current River (Appendix A) making fish capture more difficult rather than a true decline in fish abundance from upstream to downstream sites. Although the site size of the Jacks Fork (Appendix A) and species richness (Figure 2) were similar to the upper Current River, abundance at the Jacks Fork sites was more similar to the middle and lower Current River (Figure 3).

Diversity was consistently high (> 0.8) with little annual variability at mainstem sites, regardless of the variability in either richness or relative abundance at a site (Figure 4). During the baseline period, mean diversity did not differ among years ($\chi^2 = 4.89$, $P = 0.30$, $df = 4$). There was also no significant difference in diversity between mainstem sites ($F = 1.34$, $P = 0.25$, $df = 8, 36$).

Mean IBI scores ranged from 62 to 89 with all mainstem sites rated as having good or excellent stream integrity (Figure 5), likely due to suitable habitat (large woody debris cover) and water quality (dissolved oxygen > 8 mg/L) conditions (Appendix A). Mean IBI differed significantly between years within this baseline period ($\chi^2 = 12.52$, $P = 0.014$, $df = 4$), with higher mean IBI scores in 2005 than 2006 ($Z = -2.31$, $P = 0.021$) and 2009 ($Z = -2.67$, $P = 0.008$). Stream integrity was also significantly different between mainstem sites ($F = 5.87$, $P < 0.001$, $df = 8, 36$). Site C2 had significantly lower mean IBI than the lower Current (C5 and C6) and all three Jacks Fork sites ($P < 0.05$). This lower score for site C2 was due to the low percent of invertivorous fish and top carnivores collected at the site. In 2009, this site fell into the “fair” category ranking (IBI = 56) due to a higher percentage of generalist feeders in addition to the low percent of invertivores and top carnivores.

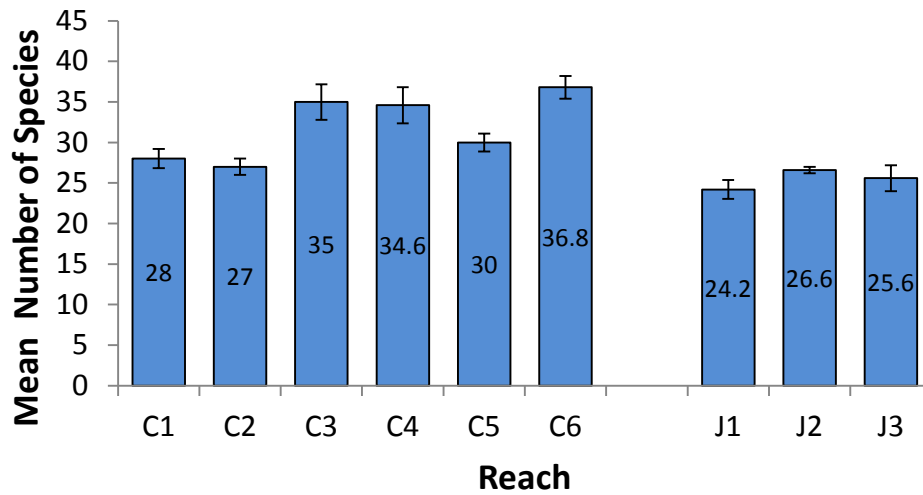


Figure 2. Mean species richness ± 1 standard error (N = 5 years) for mainstem sites on the Current River (C1-C6) and Jacks Fork (J1-J3) at Ozark National Scenic Riverways, 2005-2009.

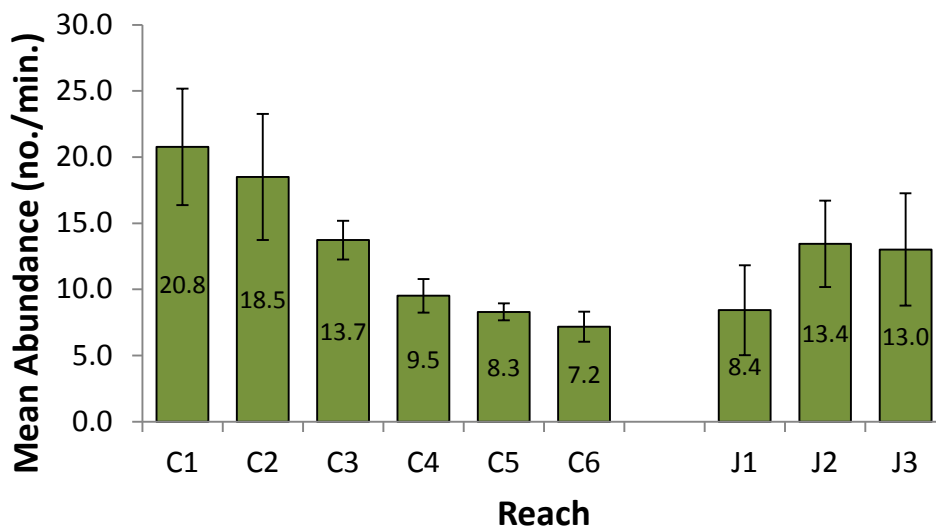


Figure 3. Mean abundance ± 1 standard error (N = 5 years) for mainstem sites on the Current River (C1-C6) and Jacks Fork (J1-J3) at Ozark National Scenic Riverways, 2005-2009.

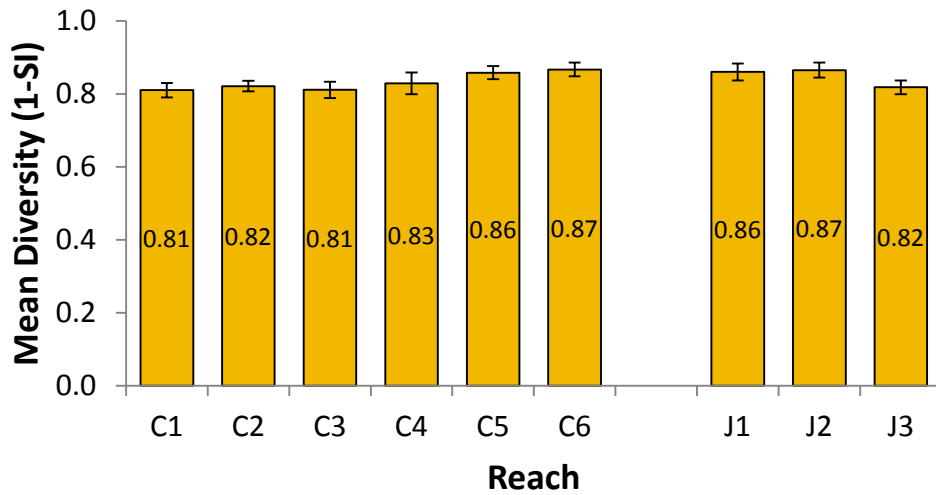


Figure 4. Mean diversity $\pm$ 1 standard error (N = 5 years) for mainstem sites on the Current River (C1-C6) and Jacks Fork (J1-J3) at Ozark National Scenic Riverways, 2005-2009.

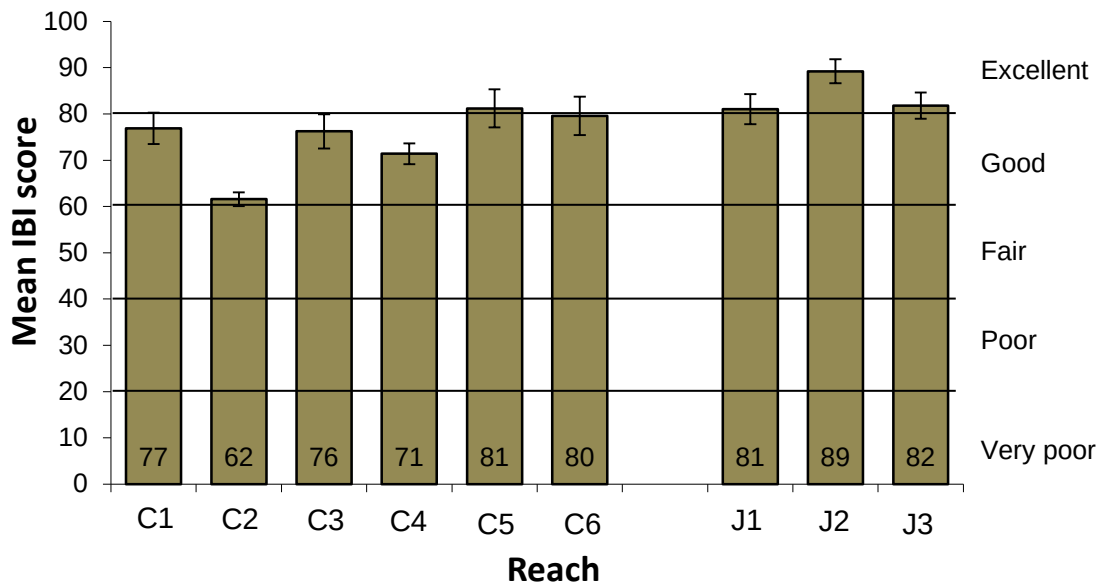


Figure 5. Mean IBI score $\pm$ 1 standard error (N = 5 years) for mainstem sites on the Current River (C1-C6) and Jacks Fork (J1-J3) at Ozark National Scenic Riverways, 2005-2009. Lines designate IBI rankings of very poor to excellent scores.

Tributaries

Rocky Creek, the largest tributary sampled (Appendix B), contained the most species of any tributary (Figure 6). Species richness was low at both Powder Mill and Chilton creeks (Figure 6), with Chilton Creek also having low fish abundance (Figure 7) and Powder Mill having low diversity (Figure 8). Both of these creeks are small (Appendix B) and Chilton was nearly pooled with low dissolved oxygen concentrations (5.2 mg/L) during the time of sampling. Shafer Spring had the highest abundance (Figure 7) due to large numbers of species common to spring-fed streams (Knobfin sculpin, *Cottus immaculatus*; Bleeding shiner, *Luxilus zonatus*; and Southern redbelly dace, *Phoxinus erythrogaster*). Although Sutton Creek was moderately species rich with relatively low fish abundance (Figures 6 and 7), this creek showed high diversity (Figure 8) due to the evenness of abundance across species.

Thirteen of the fourteen tributaries sampled rated as having good (60-80) or excellent (>80) biotic integrity with Powder Mill and Shafer Spring ranking at the bottom of the ‘good’ range. A low percentage of invertivores and absence of top carnivores at both creeks along with low numbers of lithophilic spawners at Powder Mill was the reason for the lower integrity scores. Prairie Hollow received a rating of fair (IBI = 57) due to the high percentage of anomalies and tolerant Green sunfish present. During sampling, Prairie Hollow was pooled which may have likely resulted in a more stressful and harsh environment. It is important to note that tributaries were sampled only once within a five year period; therefore, results may reflect variability at the time of sampling rather than the true status of the fish community.

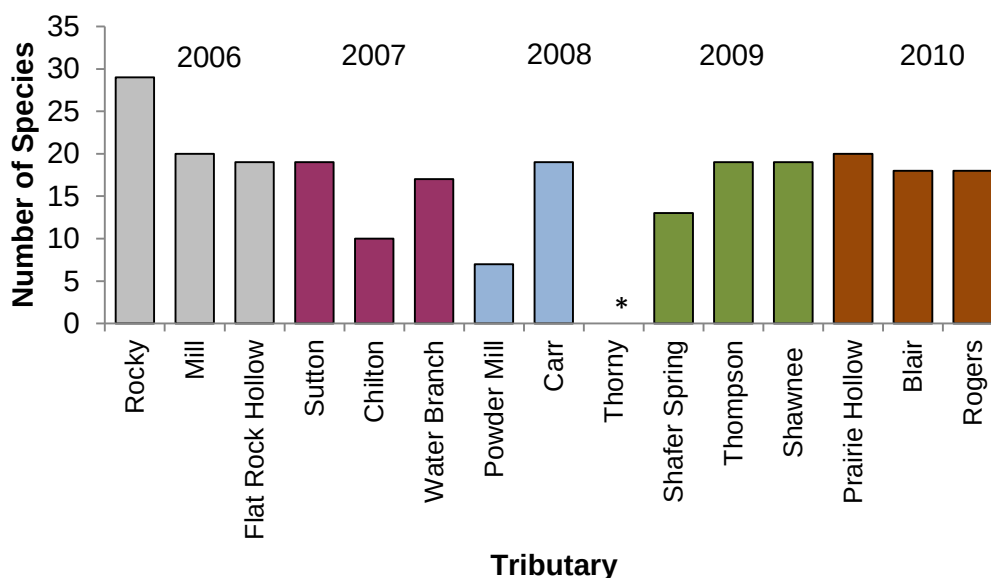


Figure 6. Species richness for tributaries at Ozark National Scenic Riverways, 2006-2010. * Thorny Creek was not sampled due to dry conditions.

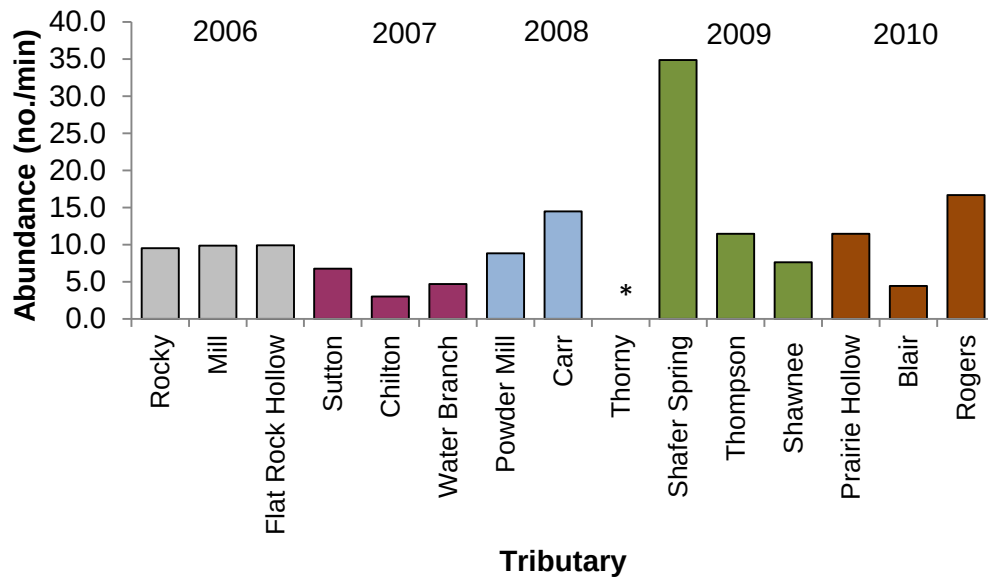


Figure 7. Abundance for tributaries at Ozark National Scenic Riverways, 2006-2010. * Thorny Creek was not sampled due to dry conditions.

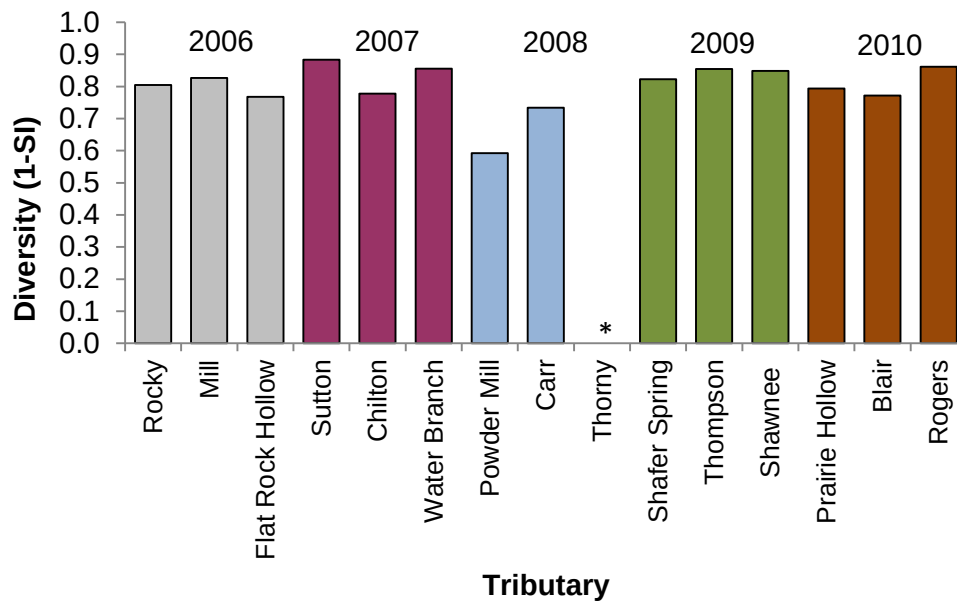


Figure 8. Diversity for tributaries at Ozark National Scenic Riverways, 2006-2010. * Thorny Creek was not sampled due to dry conditions.

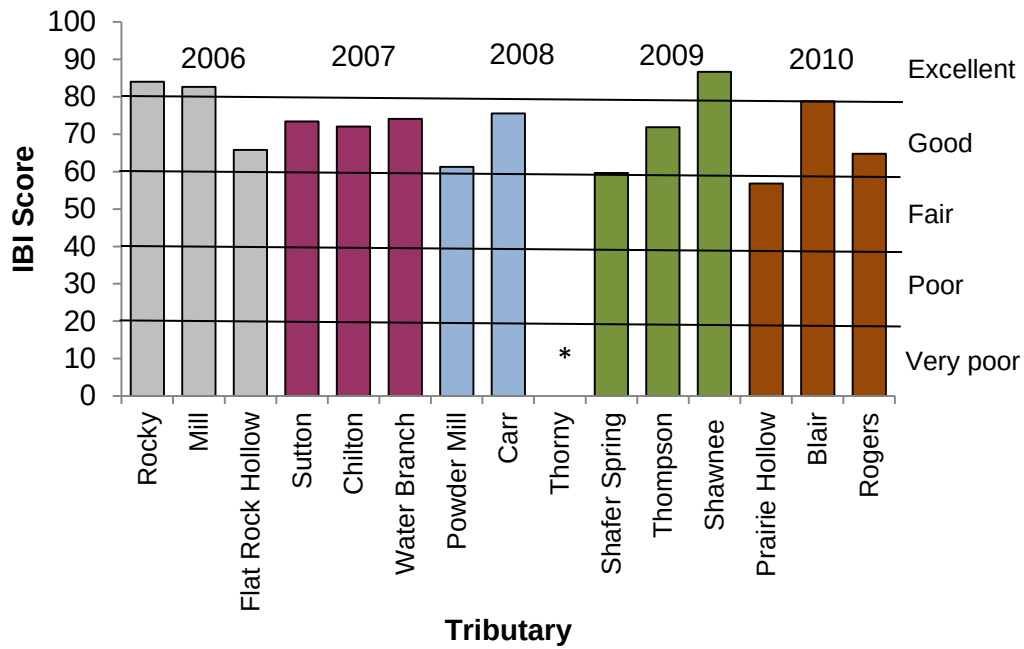


Figure 9. IBI scores for tributaries at Ozark National Scenic Riverways, 2006-2010. * Thorny Creek was not sampled due to dry conditions. Lines designate IBI rankings from very poor to excellent.

Discussion

High species richness, diversity, and stream integrity scores indicate a diverse and healthy fish community in the mainstem Current and Jacks Fork rivers. During the five year collection period, only stream integrity differed significantly among years with only one year, 2005, having significantly higher IBI scores than 2006 and 2009. Higher scores in 2005 were largely due to a lower percentage of fish with anomalies/diseases and a higher percentage of invertivores. Species richness and diversity were consistent among years and relative abundance was marginally consistent, indicating that fish communities were similar among years and the five year collection period is a good baseline in which to measure future changes in the community.

More species were collected in the middle and lower sections of the Current River where mean annual water temperatures are warmer (range = 16.1 – 17.2 °C in 2012) compared to the upper Current (range 14.2-15.5 °C in 2012; J. Westhoff, personal communication) due to the influence of several springs in the upper watershed. The warmer water temperatures coupled with the larger river size may possibly explain the higher number of species present in the middle to lower Current River. In the Jacks Fork which is similar in size to the upper Current sites but thermally similar to the middle/lower Current River (range = 16.7- 17 °C, J. Westhoff, personal communication), species richness was more comparable to the upper Current River while abundance resembled that of the middle/lower section of the Current River. We found consistently high fish diversity and good or excellent IBI scores, on average, at all mainstem sites. The invertebrate communities at these same sites were also found to have high taxa richness and numbers of sensitive EPT taxa (Ephemeroptera, Plecoptera and Trichoptera) and low Hilsenhoff's Biotic Index scores (i.e., 0 = excellent, 10 = very poor score) from 2005-2009. (D. Bowles, personal communication). The Current River site approximately 8 km downstream of Pulltite access (site C2; Figure 1) had consistently lower fish biotic integrity scores with a rating of fair in 2009, although invertebrate taxa richness and EPT richness was high at this site. Physical habitat and water quality conditions at this site are well within the range of other mainstem sites (Appendix A) and within ranges suitable for fishes (Huggins *et al.* 2005). Continued monitoring at site C2 will be important to determine if the trophic structure of the fish community is shifting from invertivores to generalist feeders, even though invertebrate richness is high at this site.

Most tributaries had a diverse community with good or excellent stream integrity. Species richness at several tributaries was comparable to sites on the Jacks Fork, and relative abundance (catch per minute) was similar to the lower Current River. Chilton Creek had low species richness and abundance, primarily due to the low flow conditions at the time of sampling, but this site had an overall integrity rating of good. Powder Mill had low diversity and richness, which may be a result of its small size. In comparison, the wider and deeper habitats and available fish cover in Rocky Creek is likely the reason for higher species richness in this stream. Prairie Hollow was the only tributary in which stream integrity rated as fair due to greater numbers of tolerant Green sunfish and fish with anomalies. However, the low flow conditions of this tributary (portions were pooled) during sampling likely created harsh conditions, increasing the number of fish with diseases/parasites and allowing for more tolerant fish to survive. From ordination analysis used to assess spatial and

temporal patterns in fish communities at OZAR (DeBacker *et al.* 2012), we found that the year in which tributaries were sampled was important, thus indicating a degree of temporal variability in tributaries. Although these results suggest multiple years of sampling are needed to make clear statements about stream quality and fish communities in these tributaries, the one-time baseline survey of 14 tributaries may give managers an idea of which tributaries need targeted for further study.

Based on five years of data collected at mainstem sites and tributaries, the Current and Jacks Fork river watersheds have high quality fish communities and have physical habitat and water quality conditions suitable for sustaining good biotic integrity. This data set will provide a good baseline in which to assess possible future changes in fish community structure and evaluate management of aquatic resources in the park.

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Appendix A: Physical habitat and water quality summaries for OZAR mainstem sites, 2005-2009.

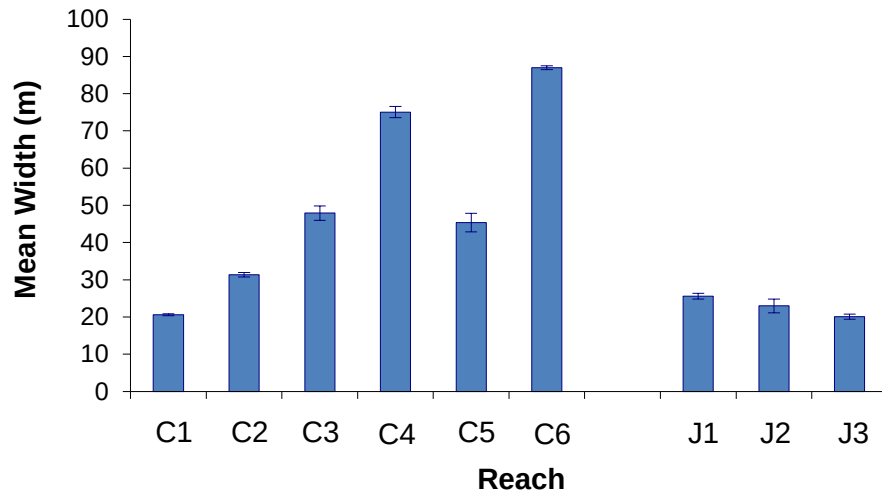


Figure A-1. Mean width $\pm$ 1 standard error (N = 4 years) for mainstem sites at Ozark National Scenic Riverways, 2006-2009.

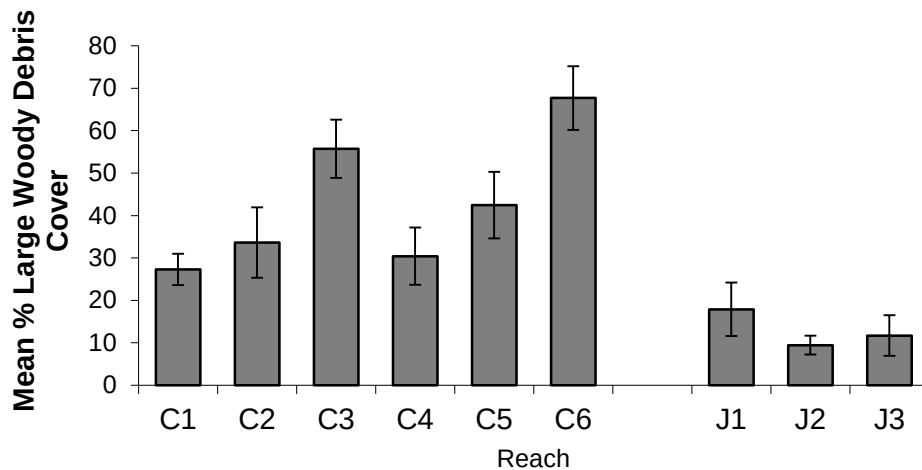


Figure A-2. Mean percentage of the reach covered by large woody debris $\pm$ 1 standard error (N = 4 years) at mainstem reaches at Ozark National Scenic Riverways, 2006-2009.

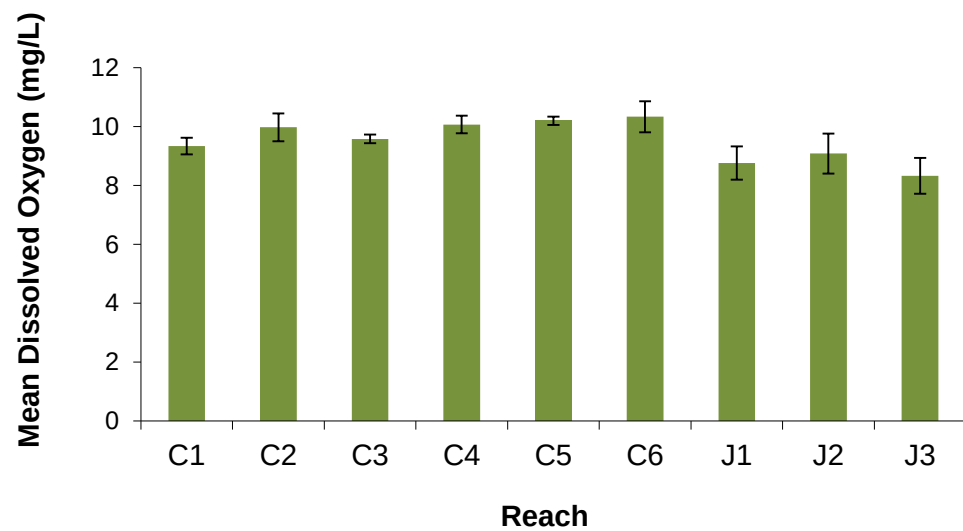


Figure A-3. Mean dissolved oxygen concentration $\pm$ 1 standard error (N = 5 years) for mainstem sites at Ozark National Scenic Riverways, 2005-2009.

Appendix B: Physical habitat and water quality summaries for OZAR tributaries, 2006-2010.

Table B-1. Mean width, depth, and canopy cover score ($\pm$ 1 standard error) for tributaries sampled at Ozark National Scenic Riverways, 2006-2010. Canopy cover was scored into percent categories. Categories were: 0 = 0%, 1 < 10%, 2 = 10-40%, 3 = 40-75%, 4 >75%. *Thorny Creek was not sampled due to dry conditions.

Tributaries	Mean Width (m)			Mean Depth (cm)			Mean Canopy Cover Score		
2006 - Panel 1									
Rocky	11.7	±	1.3	45.8	±	5.5	2.4	±	0.2
Mill	5.6	±	0.8	25.2	±	4.3	3.1	±	0.1
Flat Rock Hollow	4.3	±	0.5	20.0	±	5.0	2.2	±	0.1
2007 - Panel 2									
Sutton	4.8	±	0.4	11.7	±	0.9	2.7	±	0.1
Chilton	2.5	±	0.3	9.0	±	1.5	3.7	±	0.1
Water Branch	4.4	±	0.7	13.5	±	2.6	1.5	±	0.3
2008 - Panel 3									
Powder Mill	4.0	±	0.4	17.1	±	2.2	2.3	±	0.2
Carr	6.8	±	1.1	27.8	±	5.3	1.7	±	0.2
Thorny*									
2009 - Panel 4									
Shafer Spring	5.9	±	0.6	19.8	±	2.1	1.8	±	0.2
Thompson	5.1	±	0.6	18.9	±	2.8	3.5	±	0.1
Shawnee	12.8	±	2.4	24.0	±	1.9	1.4	±	0.3
2010 - Panel 5									
Prairie Hollow	5.2		0.7	22.4		2.6	2.4	±	0.2
Blair	11.3		0.9	25.4		2.5	2.2	±	0.3
Rogers	7.0		1.0	23.5		3.0	3.0	+	0.3

Table B-2. Percentage of the reach covered by each fish cover type at tributaries sampled in Ozark National Scenic Riverways, 2006-2010. Cover types are: filamentous algae (FA), hydrophytes (HY), small woody debris (SWD), large woody debris (LWD), trees/roots (TR), overhanging vegetation (OV), and undercut bank (UC). Percentages for a reach do not add to 100% because multiple cover types were present at each reach. *Thorny Creek was not sampled due to dry conditions.

Tributaries	%FA	%HY	%SWD	%TR	% OV	%UC
2006 - Panel 1						
Rocky	0.0	3.0	100.0	22.7	36.4	27.3
Mill	0.0	0.0	81.8	22.7	18.2	9.1
Flat Rock Hollow	0.0	6.1	86.4	36.4	4.5	4.5
2007 - Panel 2						
Sutton	0.0	9.1	77.3	18.2	22.7	9.1
Chilton	0.0	0.0	90.9	45.5	0.0	4.5
Water Branch	12.1	0.0	68.2	13.6	0.0	4.5
2008 - Panel 3						
Powder Mill	0.0	0.0	90.9	36.4	45.5	18.2
Carr	0.0	0.0	77.3	40.9	31.8	22.7
Thorny*						
2009 - Panel 4						
Shafer Spring	3.0	3.0	90.9	27.3	68.2	36.4
Thompson	0.0	0.0	100.0	36.4	36.4	9.1
Shawnee	0.0	0.0	63.6	27.3	36.4	13.6
2010 - Panel 5						
Prairie Hollow	0	21.2	100.0	22.7	63.6	27.3
Blair	0	0.0	100.0	22.7	27.3	9.1
Rogers	0	0.0	95.5	36.4	18.2	13.6

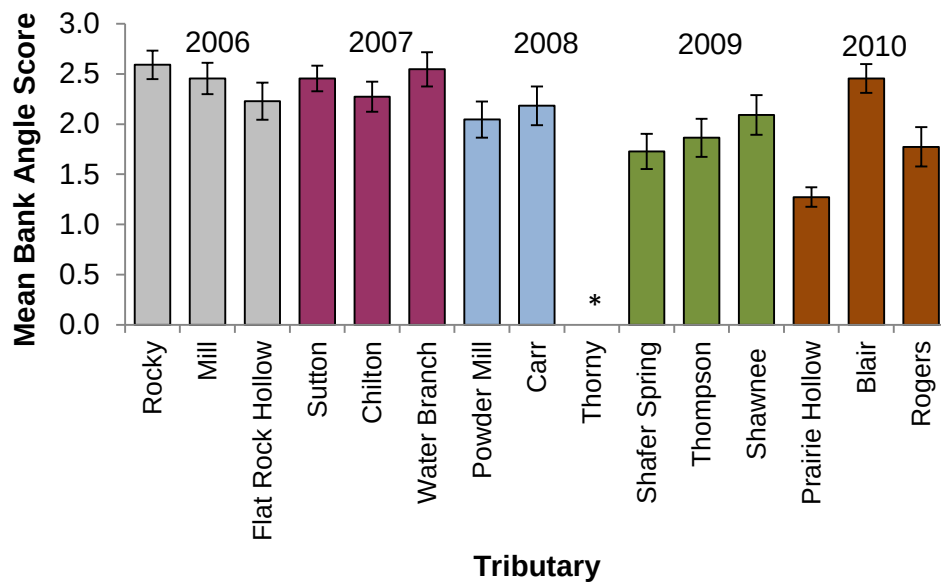


Figure B-1. Mean bank angle score (± 1 SE) for tributaries at Ozark National Scenic Riverways, 2006-2010. Bank angle was scored into categories. Categories were: 1 = 0-30°, 2 = 30-60°, 3 > 60°. *Thorny Creek was not sampled due to dry conditions.