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Aquatic Invertebrate Monitoring at Ozark National Scenic Riverways, 2005-2014

Natural Resource Data Series NPS/OZAR/NRDS—2016/1063

ON THIS PAGE
Photograph of the lower Current River, Ozark National Scenic Riverways, Missouri.
Photograph courtesy of the National Park Service, Heartland Inventory and Monitoring Network.

ON THE COVER
Photograph of the upper Current River, Ozark National Scenic Riverways, Missouri.
Photograph courtesy of the National Park Service, Heartland Inventory and Monitoring Network.

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Executive Summary

In 2005, the National Park Service Heartland Inventory and Monitoring Network began intensively monitoring the condition of streams at Ozark National Scenic Riverways (OZAR) by assessing aquatic invertebrate community structure following a monitoring protocol developed specifically for the park. Two broad objectives are addressed by this protocol: 1) determine the status and trends of invertebrate species diversity, abundance, and community metrics, and 2) relate the invertebrate community to overall stream condition through quantification of metrics (species richness, abundance, and diversity) and to region-specific multi-metric indices as indicators of water quality and habitat condition. This report summarizes the results of monitoring from 2005 through 2014.

Nine mainstem river sites (6 Current River, 3 Jacks Fork) and 6 tributary sites (sampled on a rotational basis) were sampled during a November-February index period. At each sampling site, three benthic invertebrate samples were collected from each of three successive riffles using a Slack-Surber sampler. Taxa were identified to the lowest practical taxonomic level (usually genus) and counted.

Aquatic invertebrate metrics calculated for the samples included taxa richness; Ephemeroptera, Plecoptera, Trichoptera (EPT) richness; Shannon Diversity Index; and Hilsenhoff Biotic Index. The invertebrate metrics calculated for sampling sites were generally consistent with those previously reported for unimpaired streams in the Ozark region. Missouri Stream Condition Index (SCI) scores for all mainstem river sites across years indicated they were largely fully biologically supporting (SCI $\geq$16). These streams have the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region. Tributaries also generally had SCI scores that indicated they were fully biologically supporting. Anthropogenic activities along the Current River and Jacks Fork and the majority of their respective tributaries generally have not reduced SCI index scores below biologically supporting. Ozark Rivers Stream Invertebrate Multimetric Index (ORSIMI) scores demonstrated a wide range of variation between 2012 and 2014 relative to the baseline. More data will be required to fully evaluate the utility of this metric. The general assessment of this report is that OZAR streams are of high quality. Aquatic invertebrate monitoring at OZAR provides a sound tool for early detection of a decline of water quality at OZAR.

Acknowledgments

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Introduction

Ozark National Scenic Riverways (OZAR), located in southeastern Missouri, is one of the two largest units of the National Park Service in the Ozark Plateaus. OZAR was established to protect the corridor of the Current River and its major tributary, the Jacks Fork. OZAR is located in the Salem Plateau, 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. These features 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 m^3/s). The area protected within the park boundary encompasses only 4% of the watershed, leaving much of the watershed unprotected from human activities (i.e., such as agriculture, urbanization, and logging), which could result in alteration of water quantity and quality in OZAR streams. Although wadeable streams in the Ozark region, including those at OZAR, are generally considered to be in good condition, the previously noted stressors threaten their integrity (United States Environmental Protection Agency 2006). Presently, all new permit discharges to the catchments of the Current River and Jacks Fork are prohibited as part of the anti-degradation strategy for these rivers.

Aquatic invertebrates are an important tool for understanding and detecting changes in lotic ecosystem integrity, and they can be used to reflect cumulative impacts that cannot otherwise be detected through traditional water quality monitoring. The broad diversity of invertebrate species occurring in aquatic systems similarly demonstrates a broad range of responses to different environmental stressors. Benthic invertebrates are relatively easy to collect, and they can be analyzed at many different levels of precision. They are sensitive to a wide variety of impacts that occur in the Ozark Highlands, such as changes in chemical constituents (including metals), hydrological alterations, sedimentation and bank erosion, land use, and other changes in the watershed. Furthermore, changes in the diversity and community structure of benthic invertebrates are relatively simple to communicate to resource managers, administrators, and park visitors because the loss of biological communities is of interest and concern to these groups.

There have been several previous studies conducted on stream invertebrate communities at OZAR (see Bowles et al. 2007 for review). However, these studies were all single event studies that did not assess inter-annual variation in samples or assess trends in data to detect potential water quality degradation. Bowles et al. (2007) published a stream invertebrate monitoring protocol to assess annual aquatic invertebrate community structure at fixed sites on the Current River, Jacks Fork, and their respective tributaries at OZAR. This protocol was designed to incorporate the spatial relationship of invertebrates with their habitat. Local variables, such as conductivity, water temperature, pH, dissolved oxygen, turbidity, current velocity, and substrate size can strongly influence invertebrate distributions.

Two broad objectives are addressed by this protocol: 1) determine the status and trends of invertebrate species diversity, abundance, and community metrics, and 2) relate the invertebrate community to overall stream condition through quantification of metrics related to species richness, abundance, diversity, and region-specific multi-metric indices as indicators of water quality and habitat condition (DeBacker et al. 2005, 2012). The results for monitoring conducted from 2005 to 2014 are summarized in this report.

Methods

Methods and procedures used in this report follow Bowles et al. (2007), and DeBacker et al. (2012). Sampling was conducted annually at nine permanent, randomly selected mainstem river sites on the Current River and Jacks Fork from 2005 to 2009, and also in 2012 and 2014. In addition, 6 tributary sites were sampled on a rotational basis from 2006-2014. All samples were collected during a November through February index period, with most samples collected during November and December.

Invertebrate Sampling

Three benthic invertebrate samples were collected from each of three successive riffles at each sampling site using a Slack-Surber sampler (500 µm mesh, 0.25 m^2). The sample area was agitated for 2 minutes with a garden cultivation tool, and large pieces of substrate were scrubbed with a brush as necessary. Bulk samples were placed in plastic jars and preserved with either 99% isopropyl or 95% ethyl alcohol. Samples were sorted in the laboratory following a subsampling routine described in Bowles et al. (2007), and taxa were identified to the lowest practical taxonomic level (usually genus) and counted.

Water Quality and Habitat Assessment

Water quality and habitat data were collected in conjunction with invertebrate samples (see Bowles *et al*. 2007), but those data are not presented here because they do not allow additional insight into invertebrate community structure at this time. Those data will be presented later in a more exhaustive analysis.

Invertebrate Metrics

For each benthic sample, taxa richness; Ephemeroptera, Plecoptera and Trichoptera (EPT) richness; Shannon's Index of Diversity; and Hilsenhoff's Biotic Index (HBI) were calculated. These and other community metrics are described in Barbour et al. (1999). They are generally considered sufficiently sensitive to detect a variety of potential disturbances in Ozark streams. Mean metric values were established by averaging the values for each of three samples per riffle and then averaging the means for the three riffles to establish a site mean (n=3).

Stream Condition Index (SCI)

Using the mean values of these four metrics for each monitoring site, the Stream Condition Index (SCI) was calculated (Sarver et al. 2002). The SCI is a multimetric index founded on the reference site approach based on data collected from 26 streams in the Ozark region (Rabeni et al. 1997). The SCI is based on scores from the previously listed four metrics, which were chosen as sound measures of community structure and balance (Rabeni et al. 1997). All metric values are normalized so that they become unitless and can be compared and have equal influence on the SCI results following the suggestion of Barbour et al. (1999). The lower or upper quartile of the distribution for each metric is used as the minimum value representative of reference conditions (Table 1). SCI scores presented are the mean of the individual riffle SCI scores for each site (n=3).

Table 1. Descriptive statistics and metrics scores for the fall index period based on single habitat coarse substrate (riffle) data.

	Statistics					Scores*		
Metric	**1%**	**25%**	**50%**	**75%**	**99%**	**5**	**3**	**1**
Taxa richness	16	21	26	29	35	>=21	20-11	<11
EPT richness	5	9	11	12	14	>=9	8-5	<5
HBI	3.0	3.6	4.9	5.3	5.8	<=5.3	5.4-7.7	>7.7
Shannon's Diversity Index	1.33	2.29	2.44	2.61	2.96	>=2.29	2.28-1.15	<1.15

* Scoring: ≥16 fully biologically supporting, 10-14=partially biologically supporting, 4-8=non-biologically supporting.

SCI scores produce three possible levels of stream condition: 1) fully biologically supporting (unimpaired), 2) partially biologically supporting (impaired), and 3) non-biologically supporting (very impaired). Impairment as used in the SCI does not constitute impairment as defined by NPS policy section 1.4.4-5 as indicated in NPS Management Policies (2006). Unimpaired or reference sites typically score ≥16, so scores of 16-20 infer a stream that is fully, biologically supportive. These streams have the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region. Sites with scores of 10-14 indicate streams that are partially biologically supportive, and scores of 4-8 designate streams that are not biologically supportive. Partially biologically supportive and non-biologically supportive categories indicate streams that do not meet the beneficial use of protection of aquatic life as described by Sarver et al. (2002). The SCI provides an assessment of invertebrate community integrity at a given location as influenced by water and habitat quality in the watershed upstream of that location. See Rabeni et al. (1997), Sarver et al. (2002) and Bowles et al. (2007) for further details on how these metrics and the SCI are calculated.

Ozark Rivers Stream Invertebrate Multimetric Index (ORSIMI)

The ORSIMI is similar to the SCI in that it is based on four metrics: taxa richness, EPT richness, Shannon's Index, and the HBI. See DeBacker et al. (2012) for details on how to calculate the ORSIMI. This index is arbitrarily scaled to 100. The average of each metric value over the baseline period is multiplied by a constant so that each metric contributes a total of 25 toward the 100 score total. (The HBI score is subtracted from 10, because a lower HBI score indicates better water quality, and 10 is the maximum value for the HBI.) Each site is calculated independently from the rest, because sites are not directly comparable. Any change of any magnitude in any metric will result in a change in the overall OSIMI. That change can be negative or positive (i.e., total scores may be >100 if conditions improve).

Results

All metrics and SCI scores overlapped broadly among sampling years (Figures 1 through 10). SCI scores show that all of the sampling sites are fully biologically supporting. Exceptions noted for CURRM01 and Shawnee Creek suggests interannual variation at those sites due to unknown factors although disturbance cannot be ruled out entirely. Such variation among years likely is not biologically important. ORSIMI scores similarly demonstrated a wide range of variation between 2012 and 2014 relative to the baseline, but because the differences are all within about 20% they are likely not biologically important (Table 2). Data presently are not sufficient for conducting trend analysis, but given the broad overlap among sampling years, there is no concern these resources are being degraded.

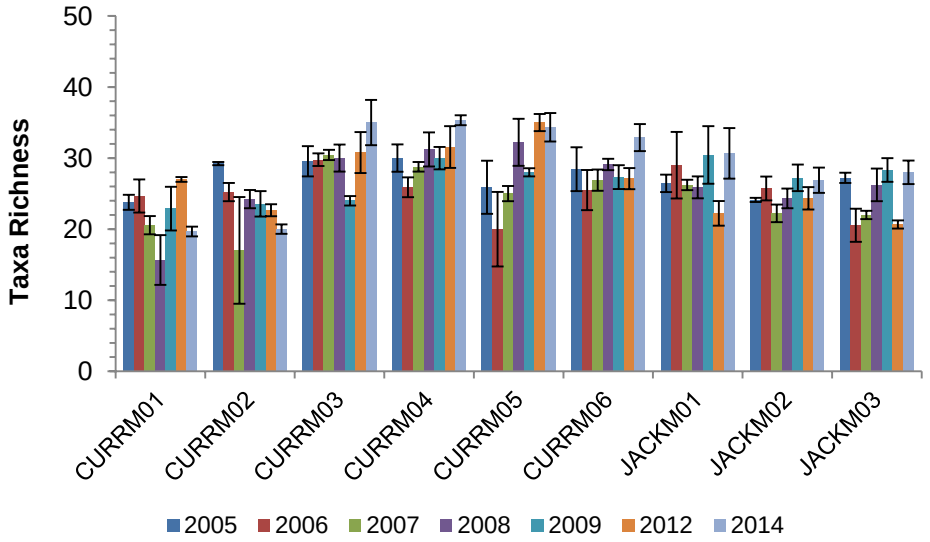

Figure 1. Mean taxa richness and standard errors (n=3) for mainstem river sampling sites at Ozark National Scenic Riverways.

Table 2. ORSIMI scores for the Current River and Jacks Fork, Ozark National Scenic Riverways, Missouri, 2012 and 2014. Percent change is from the 2010 baseline values.

Site	2010 (Baseline)	2012	% Change	2014	% Change
CURRM01	100	112.55	12.55	90.22	-9.78
CURRM02	100	93.59	-6.41	85.97	-14.03
CURRM03	100	104.38	4.38	111.47	11.47
CURRM04	100	106.84	6.84	115.90	15.90
CURRM05	100	122.11	22.11	118.81	18.81
CURRM06	100	99.07	-0.93	113.99	14.00
JACKM01	100	87.48	112.52	102.89	2.89
JACKM02	100	101.09	1.10	103.68	3.68
JACKM03	100	92.14	-7.86	106.21	6.21

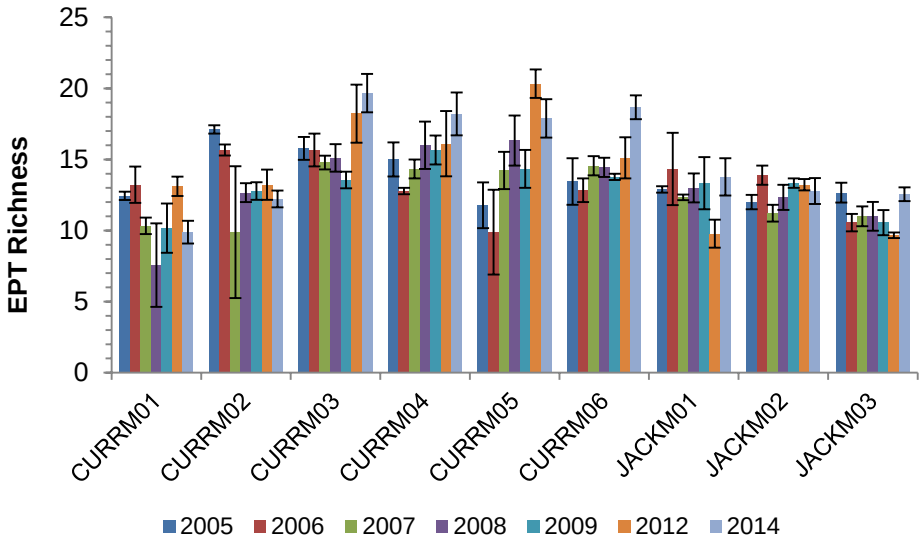

Figure 2. Mean EPT richness and standard errors (n=3) for mainstem river sampling sites at Ozark National Scenic Riverways.

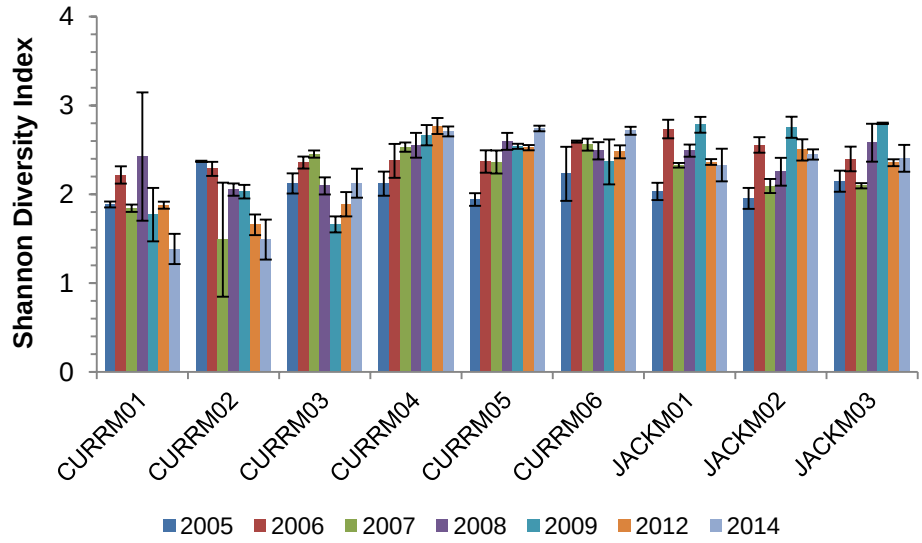

Figure 3. Mean Shannon diversity index and standard errors (n=3) for mainstem river sampling sites at Ozark National Scenic Riverways.

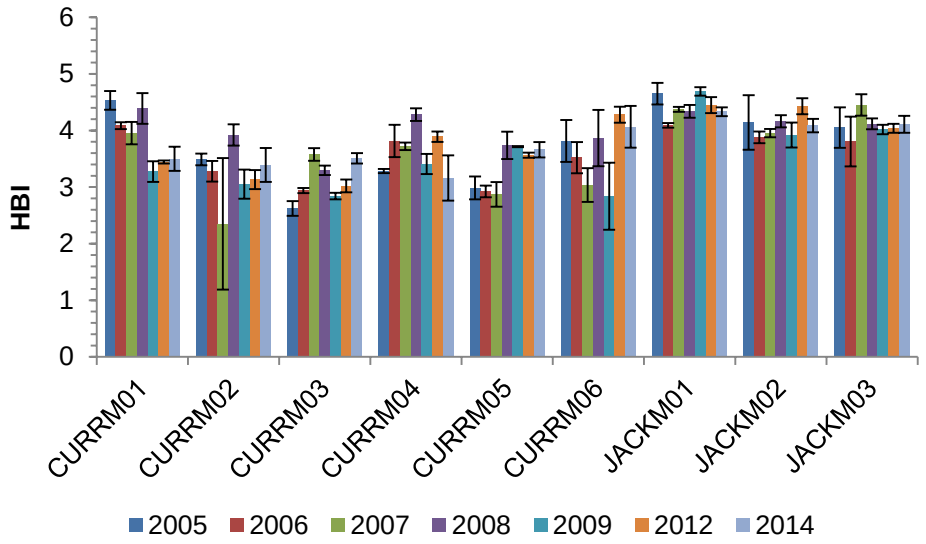

Figure 4. Mean HBI and standard errors (n=3) for mainstem river sampling sites at Ozark National Scenic Riverways.

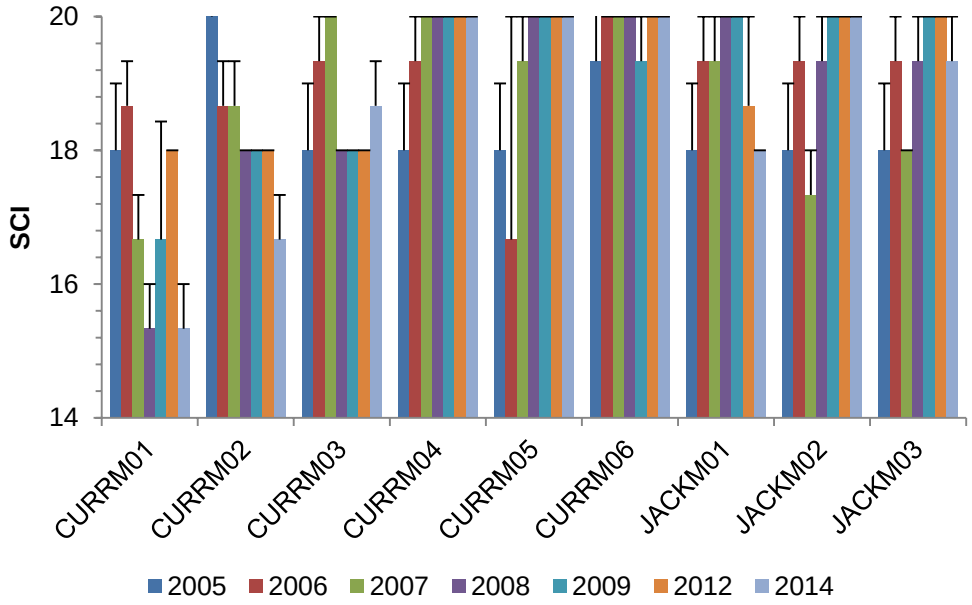

Figure 5. Mean SCI and standard errors (n=3) for mainstem river sampling sites at Ozark National Scenic Riverways.

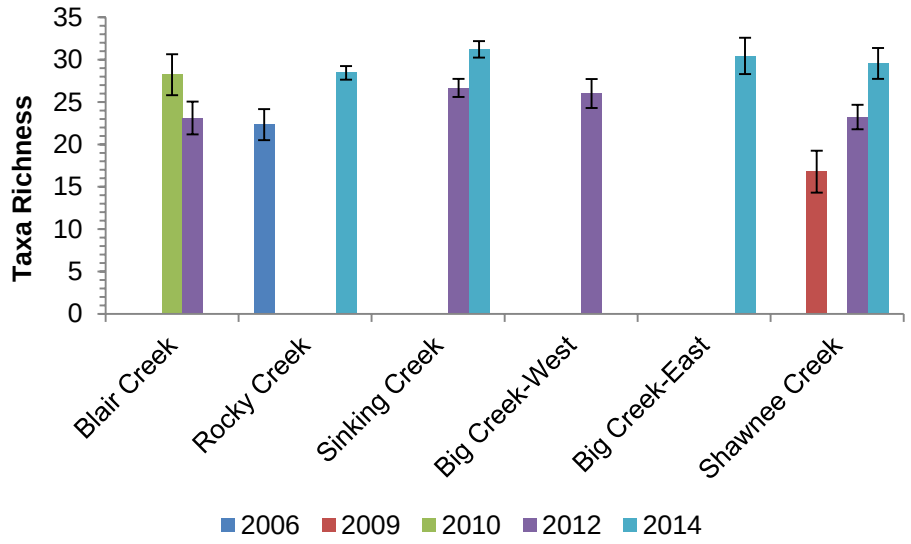

Figure 6. Mean taxa richness and standard errors (n=3) for tributary sampling sites at Ozark National Scenic Riverways.

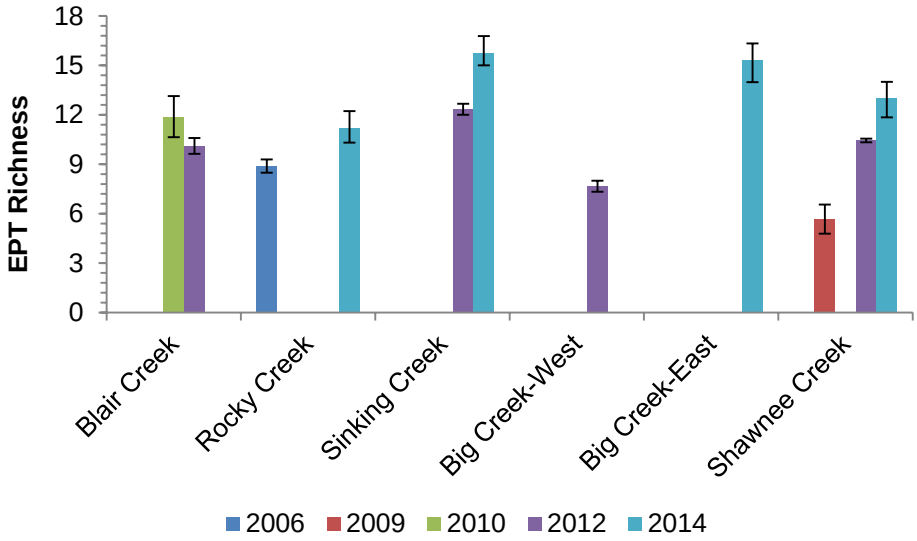

Figure 7. Mean EPT richness and standard errors (n=3) for tributary sampling sites at Ozark National Scenic Riverways.

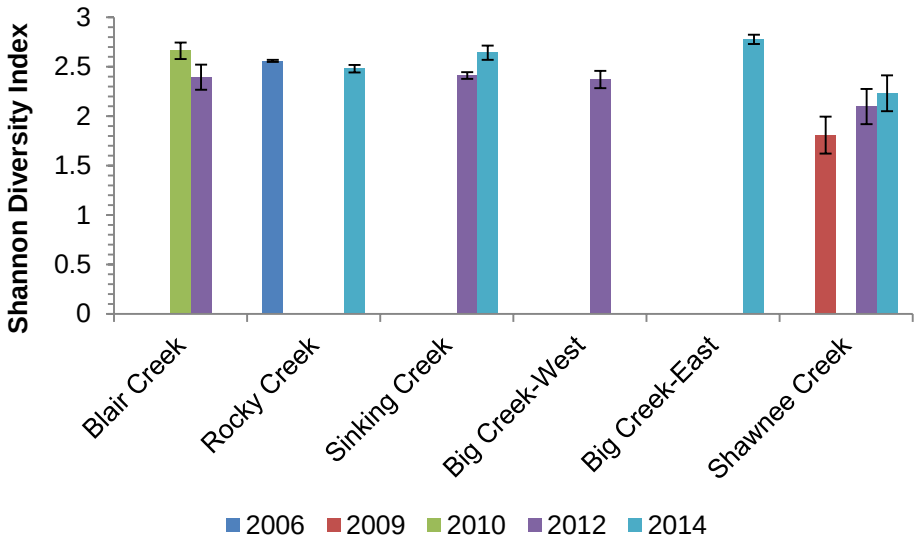

Figure 8. Mean Shannon diversity index and standard errors (n=3) for tributary sampling sites at Ozark National Scenic Riverways.

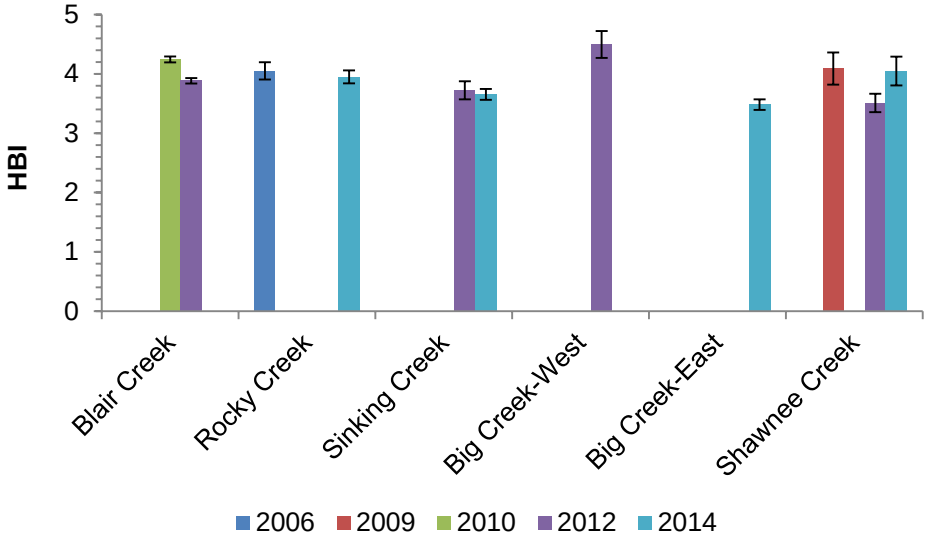

Figure 9. Mean HBI and standard errors (n=3) for tributary sampling sites at Ozark National Scenic Riverways.

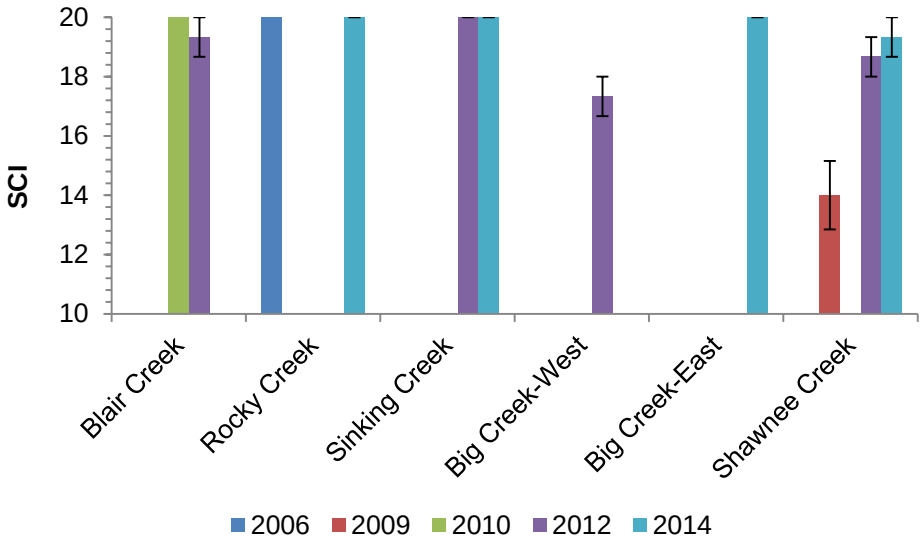

Figure 10. Mean SCI and standard errors (n=3) for tributary sampling sites at Ozark National Scenic Riverways.

Discussion

Aquatic invertebrate metrics calculated for the samples included taxa richness; Ephemeroptera, Plecoptera, Trichoptera (EPT) richness; Shannon Diversity Index; and Hilsenhoff Biotic Index. The invertebrate metrics calculated for sampling sites were generally consistent with those previously reported for unimpaired streams in the Ozark region. Missouri Stream Condition Index (SCI) scores for all mainstem river sites across years indicated they were largely fully biologically supporting (SCI ≥16). Tributaries also generally had SCI scores that indicated they were fully biologically supporting. Anthropogenic activities along the Current River and Jacks Fork and the majority of their respective tributaries generally have not reduced SCI index scores below biologically supporting. More data will be required to fully evaluate the utility of the ORSIMI. The general assessment of this report is that streams at OZAR are of high quality and the broad ranges of metric responses are not cause for concern. Aquatic invertebrate monitoring at OZAR provides a sound tool for early detection of a decline of water quality at OZAR.

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