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Aquatic Invertebrate Monitoring at Wilson's Creek National Battlefield

1996–2016 Status Report

Natural Resource Report NPS/HTLN/NRR—2020/2204



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ON THE COVER
Terrell Creek at Wilson's Creek National Battlefield, Missouri.
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Aquatic Invertebrate Monitoring at Wilson's Creek National Battlefield

1996–2016 Status Report

Natural Resource Report NPS/HTLN/NRR—2020/2204

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Abstract

Aquatic invertebrates are an important tool for understanding and detecting changes in ecosystem integrity over time. Invertebrate and habitat samples were collected from Wilson's Creek, Skegg's Branch, and Terrell Creek at Wilson's Creek National Battlefield, and data were compared to previous years. Three invertebrate samples were collected per riffle, resulting in nine samples per stream. A Surber stream bottom sampler was used to collect the samples. Diversity and community metrics calculated for the invertebrate communities included taxa richness; Ephemeroptera, Trichoptera, Plecoptera (EPT) richness; EPT ratio (EPT/[EPT + Chironomidae]); Shannon diversity index; Shannon evenness index; and Hilsenhoff biotic index (HBI). These metrics are considered sufficiently sensitive to detect potential pollution problems in streams throughout the region. Additionally, the Missouri Stream Condition Index (SCI) was used to compare the invertebrate communities to reference stream conditions in the region. Metric and diversity values for samples collected in 2016 fell within their respective control limits, with the exception of the Shannon evenness index for Skegg's Branch. SCI values for all three streams exceeded 16, indicating the streams were fully biologically supporting at the time of sampling. Urbanization in the Wilson's Creek and Skegg's Branch watersheds continues to threaten those resources.

Acknowledgments

We thank David Peitz, Tyler Cribbs, Gary Sullivan, Carla Stark, Hope Dodd, Jake Waters, Angela Bandy, Mike DeBacker, Greg Wallace, Jessica Luraas, Sherry Middlemis-Brown, and Lloyd Morrison for assisting with this project at various stages of its development.

Introduction

Aquatic invertebrates are an important tool for understanding and detecting changes in ecosystem integrity over time. The monitoring objectives of this study (DeBacker et al. 2005) are to

1. determine the status and trends of invertebrate species diversity, abundance, and community metrics, and
2. relate the invertebrate community to overall water quality through quantification of metrics related to species richness, abundance, diversity, and region-specific multimetric indices as indicators of water quality and habitat condition.

Peitz and Cribbs (2005) reported on status and trends of the aquatic invertebrate community at Wilson's Creek National Battlefield from inception of monitoring through 2004. Bowles (2010) reported on the period from 2005 to 2007, and Bowles (2015) provided a summary of data for 1996 to 2013. See Bowles (2010) for a description and history of the streams sampled during this monitoring. The purpose of this report is to summarize aquatic invertebrate monitoring data collected through 2016.



An adult mayfly (Ephemeroptera, Heptageniidae). Photograph by Milo Bostoc/Flickr/CC by-2.0; cropped.

Methods

Methods and procedures used in this report follow the Bowles et al. (2008) Monitoring Protocol for Aquatic Invertebrates of Small Streams in the Heartland Inventory & Monitoring Network. Samples were collected from Wilson's Creek, Skegg's Branch, and Terrell Creek (Figure 1) during a late spring (May–June) index period.

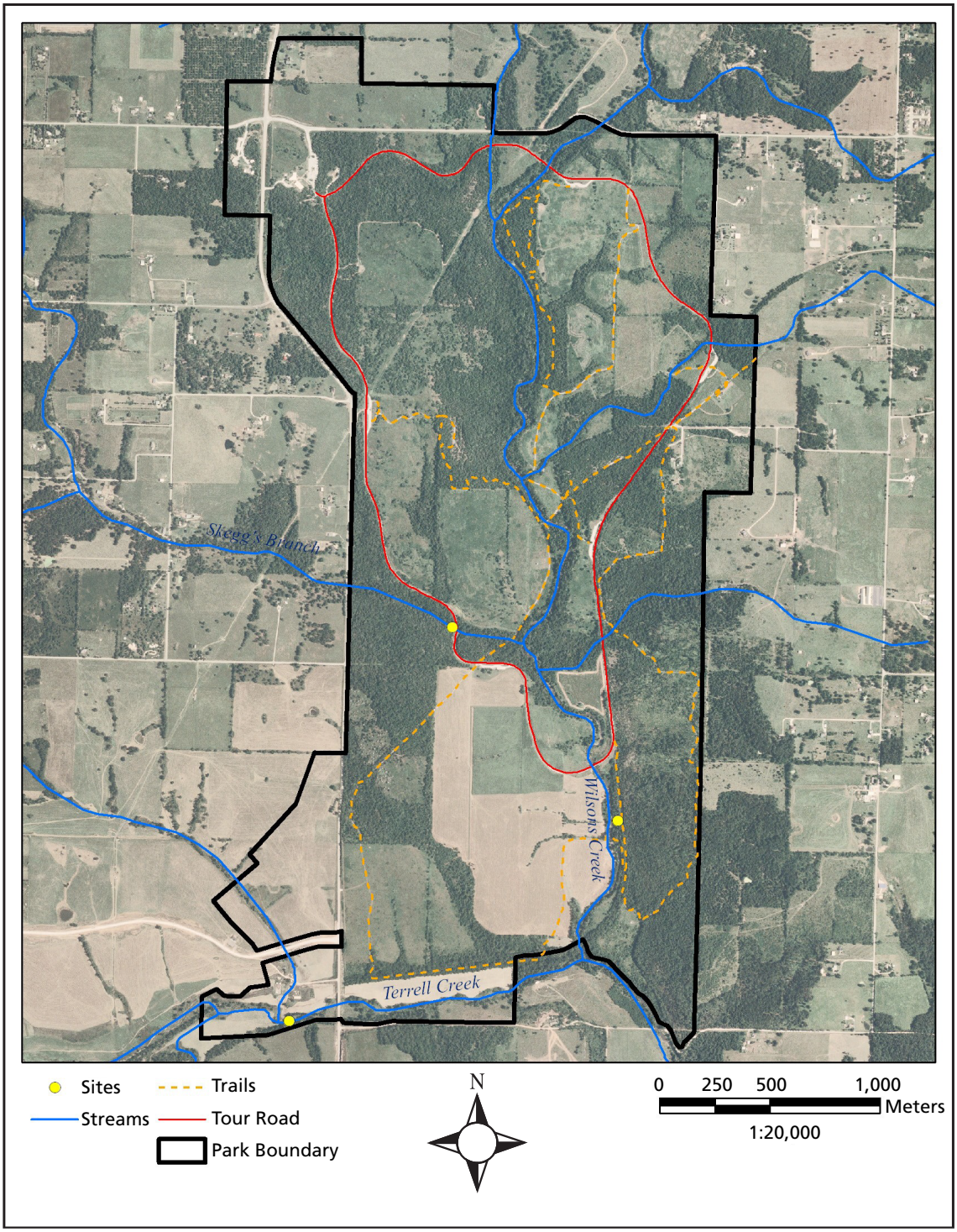


Figure 1. Aquatic invertebrate monitoring sites (yellow dots) at Wilson's Creek National Battlefield, Missouri.

Sample Collection

For each sample, current velocity (m/sec) and depth (cm) were recorded immediately in front of the sampling net frame. Beginning in 2006, qualitative habitat variables (embeddedness, periphyton, filamentous algae, aquatic vegetation, deposition, and organic material) were visually estimated within the sampling net frame as percentage categories (0, <10, 10–40, 40–75, >75). Habitat data were analyzed as midpoints of each category. Dominant substrate size from the area within the sampling net frame was visually assessed using the Wentworth scale (Wentworth 1922). Stream discharge was measured immediately upstream of the sampling site after invertebrate collections were completed. Discharge estimates illustrate the general flow characteristics for the respective streams for a given sampling year and are not intended to be exact measurements. Discharge was not measured in 2005, and the data for Wilson's Creek were obtained from the U.S. Geological Survey Water Resources database (http://waterdata.usgs.gov/mo/nwis/uv?site_no=07052152).

Water quality data for 2005 represent static readings taken from each sampled riffle with calibrated hand-held meters. In comparison, water quality readings since 2006 were recorded hourly for at least 24 hours prior to sampling for each stream using calibrated data loggers or sondes. Due to equipment failure, no data for dissolved oxygen and pH were collected at some sites in 2007. The water quality data presented in this report are only intended to describe the prevailing conditions for the 24 hours prior to sampling. These data may help explain variability between sampling periods, but they should not be used as an analytical tool in the strictest sense. Moreover, the water quality data represent only a snap-shot of the broad temporal range of conditions and should be cautiously interpreted.

Due to the limitations of using water quality data periodically obtained with data loggers, invertebrate communities are used here as a surrogate of the long-term water quality condition of Wilson's Creek National Battlefield streams. For each stream, three successive riffles were sampled with three benthic invertebrate samples collected per riffle, resulting in nine samples per stream. A Surber stream bottom sampler (500-µm mesh, 0.09 m^2) was used to collect the samples. Samples were sorted in the laboratory following a subsampling routine described in Bowles et al. (2008). Taxa were identified to the lowest practical taxonomic level (usually genus) and counted.



Aquatic invertebrate monitoring at Terrell Creek in Wilson's Creek National Battlefield, Missouri. NPS.

Invertebrate Metrics and Stream Condition Index

Metrics calculated for the invertebrate communities included taxa richness; family richness; Ephemeroptera, Trichoptera, Plecoptera (EPT) richness; EPT ratio (EPT/[EPT + Chironomidae]); Shannon diversity index; Shannon evenness index; and Hilsenhoff biotic index (HBI). They are considered sufficiently sensitive to detect a variety of potential pollution problems in streams throughout the region (Barbour et al. 1999; Bowles et al. 2008). 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).

The Shannon diversity index accounts for both abundance and evenness of the species present and index values are higher when all taxa in a sample are equally abundant or have high evenness. The Shannon diversity index for biological communities generally ranges from 1.5 (low species richness and evenness) to 3.5 (high species evenness and richness; McDonald 2003). The Shannon evenness index values range from 0 = minimum evenness to 1 = maximum evenness.

Higher metric values are associated with better stream conditions, except for HBI. HBI values may range from 0 to 10 where 0 indicates no disturbance and 10 indicates heavily disturbed. Thus, an increase in HBI is undesired because that would reflect increasing tolerance of the community to disturbance. HBI values of 5.5 or less are generally considered good, although some organic pollution may be present (Hilsenhoff 1982, 1987, 1988).

The Stream Condition Index (SCI) was calculated for each stream and sampling year using the mean values of four metrics (taxa richness, EPT richness, Shannon diversity index, and HBI) for a spring index period (Rabeni et al. 1997; Sarver et al. 2002). It is is a multimetric index founded on the reference site approach and is based on data collected from streams in the prairie region of Missouri (Rabeni et al. 1997). The SCI is recognized by the state of Missouri as a means of assessing stream integrity. The individual metrics comprising the SCI were chosen as sound measures of community structure and balance (Rabeni et al. 1997). The upper quartile value from the distribution for each metric in the SCI is used as the minimum value representative of reference conditions (Table 1).

SCI scores produce three possible levels of stream condition: (1) fully biologically supporting (scores 16–20), (2) partially biologically supporting (scores 10–14), and 3) non-biologically supporting (scores 4–8). Fully biologically supporting infers the stream is not impaired. These streams have the capability of supporting and maintaining a balanced, integrated, and adaptive community of organisms that have a species composition, diversity, and functional organization comparable to that of the natural habitat of the region. Stream reaches that are partially biologically supporting may have some level of impairment relating to species composition, diversity, and functional organization indicative of a disturbed system. Sites scored as not biologically supporting lack conditions necessary for a sustainable, adaptable community. Both partially biologically supporting and non-biologically supporting categories indicate streams that do not meet the beneficial use of protecting aquatic life. See Rabeni et al. (1997) and Sarver et al. (2002) for further details on how these metrics and the SCI are calculated.

Table 1. Descriptive statistics and scores for the spring period index metrics based on single habitat coarse substrate (riffle) data (from Rabeni et al. 1997). Stream Condition Index (SCI) scoring: 16–20 fully biologically supporting, 10–14 partially biologically supporting, 4–8 not biologically supporting.

	Statistics						Scores	
Metrics	**1%**	**25%**	**50%**	**75%**	**99%**	**5**	**3**	**1**
Taxa Richness	10	15	18	20	29	≥15	14–8	<8
EPT Richness	3	4	5	7	11	≥4	3–2	<2
Biotic Index	5.6	5.8	6.3	6.6	7	≤6.6	6.7–8.3	>8.3
Shannon Diversity Index	1.48	1.77	2.05	2.49	2.6	≥1.77	1.76–0.88	<0.88

Data Analysis

The primary interest in the analysis and interpretation of the data presented in this report is the magnitude of change rather than change per se (Bowles et al. 2008), and whether it represents something biologically important. Null hypothesis significance testing in the strict sense may not be the best approach given these goals (Morrison 2007). Thus, the primary analysis of sampling to date has been to construct control charts, which establish a baseline and evaluate natural variability. Univariate control charts were established for Wilson's Creek and Skegg's Branch to illustrate the general trend of invertebrate community metrics and provide a visual tool for managers to determine which variables may require more in-depth analyses or management action in the future.

Data from 1996 to 2004 serve as a baseline for constructing thresholds based on standard deviations of the mean of these data points for Wilson's Creek, while data from 1997 to 2004 served as the baseline for Skegg's Branch. The former two periods were chosen because the methods used were most similar to those used in Peterson et al. (1999) and the current protocol. The control limits for Terrell Creek are based on all available data for that stream collected from 2006 to 2016. Future comparisons of collected data will follow the control thresholds. The data addressed in this report are only those collected during the May to June index period from the general sampling reach described in Bowles et al. (2008), and do not include all historical data summarized in Peitz and Cribbs (2005).

Control charts plot a characteristic through time with reference to its expected value. Expected values were determined using statistical procedures that determined natural variability within baseline data, setting a range of values that represent the baseline. For example, upper or lower thresholds specify amounts of variability beyond what would normally be expected and indicate when a system is going out of control (Morrison 2008). Control charts, as used here, contain a control limit (mean ± 1.86 standard deviations for Wilson's Creek and mean ± 2.02 standard deviations for Skegg's Branch) for those community metrics that respectively decrease or increase due to stressors. For Terrell Creek, the mean ± 2.13 standard deviations was used. The threshold indicated in the control chart serves to suggest biologically important change may be occurring when thresholds are exceeded (Morrison 2008). Setting a control chart threshold as indicated above is analogous to significance tests at a critical value of 0.05 for one-tailed tests. The Student's t-distribution (df = 8 for Wilson's Creek, df = 5 for Skegg's Branch, df = 4 for Terrell Creek) was used to determine the one-tailed area because of the relatively small sample size. The graphs in this report only indicate the lower threshold that indicates the minimum acceptable value, with the exception of HBI (the upper threshold is depicted for HBI).

Results

Metric and diversity values for samples collected in 2016 fell within their respective control limits with the exception of the Shannon evenness index for Skegg's Branch (Figures 2–7). The SCI values for all three streams exceeded 16, indicating the streams were fully biologically supporting at the time of sampling (Figure 8). The occurrence of rare and environmentally sensitive species in all three streams also suggests they are not impaired, but occasional mild to moderate disturbances cannot be ruled out. Water quality (Table 2) generally fell within acceptable ranges for water quality parameters in southwestern Missouri streams (Table 3) with the exception of specific conductance. Habitat data collected for the three streams (Table 4 and Figures 9–12) were similar to those reported in previous years but are not analyzed further here.



A caddisfly larva (Trichoptera, Phiolopotamidae). Photograph by Bob Hendricks/Flickr/CC by-SA-2.0.

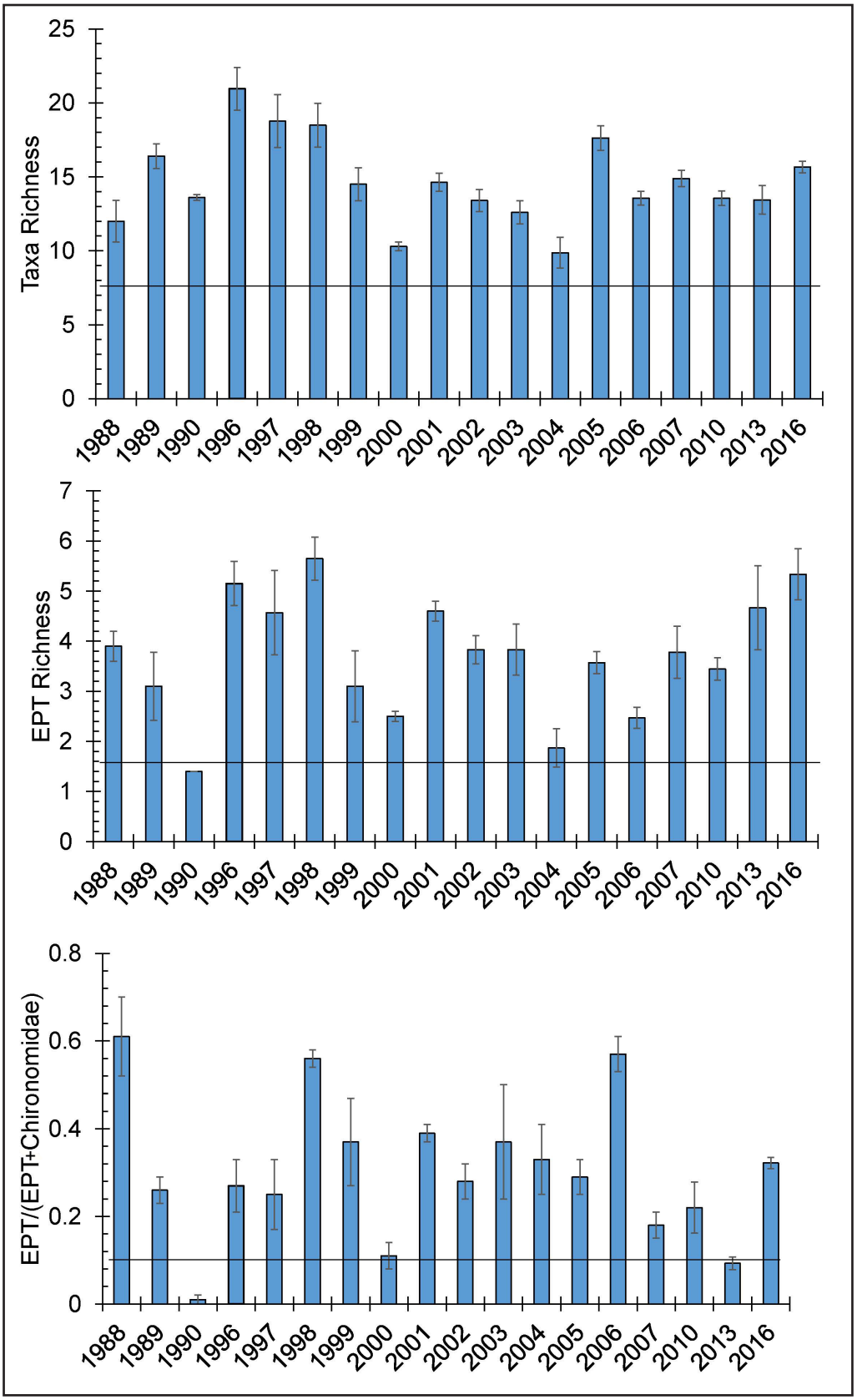


Figure 2. Control charts for taxa richness, EPT richness, and EPT ratio at Wilson's Creek, Wilson's Creek National Battlefield, Missouri. Bars are means for a given year and vertical bars are standard errors. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

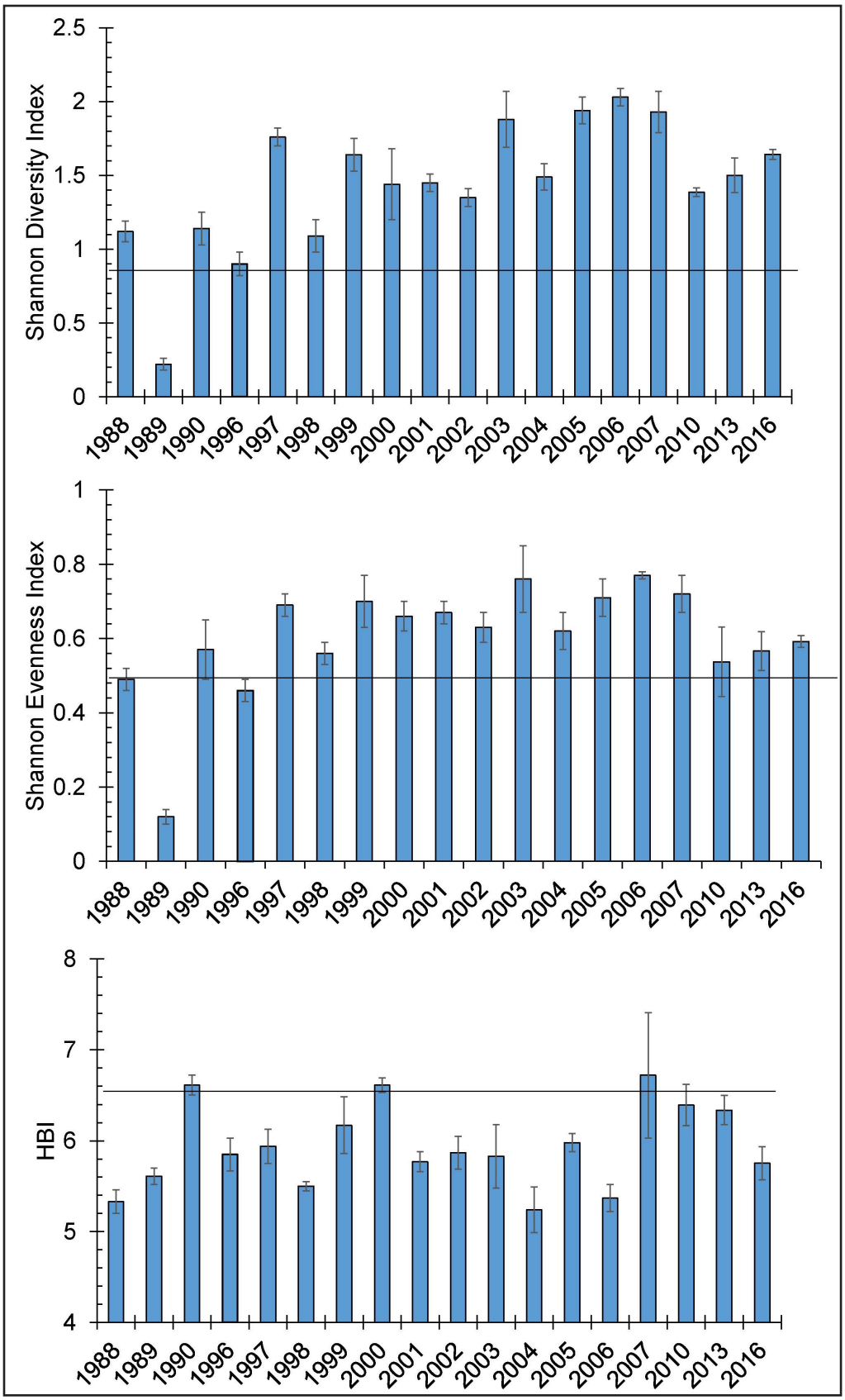


Figure 3. Control charts for Shannon diversity index, Shannon evenness index, and HBI at Wilson's Creek, Wilson's Creek National Battlefield, Missouri. Bars are means for a given year and vertical bars are standard errors. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

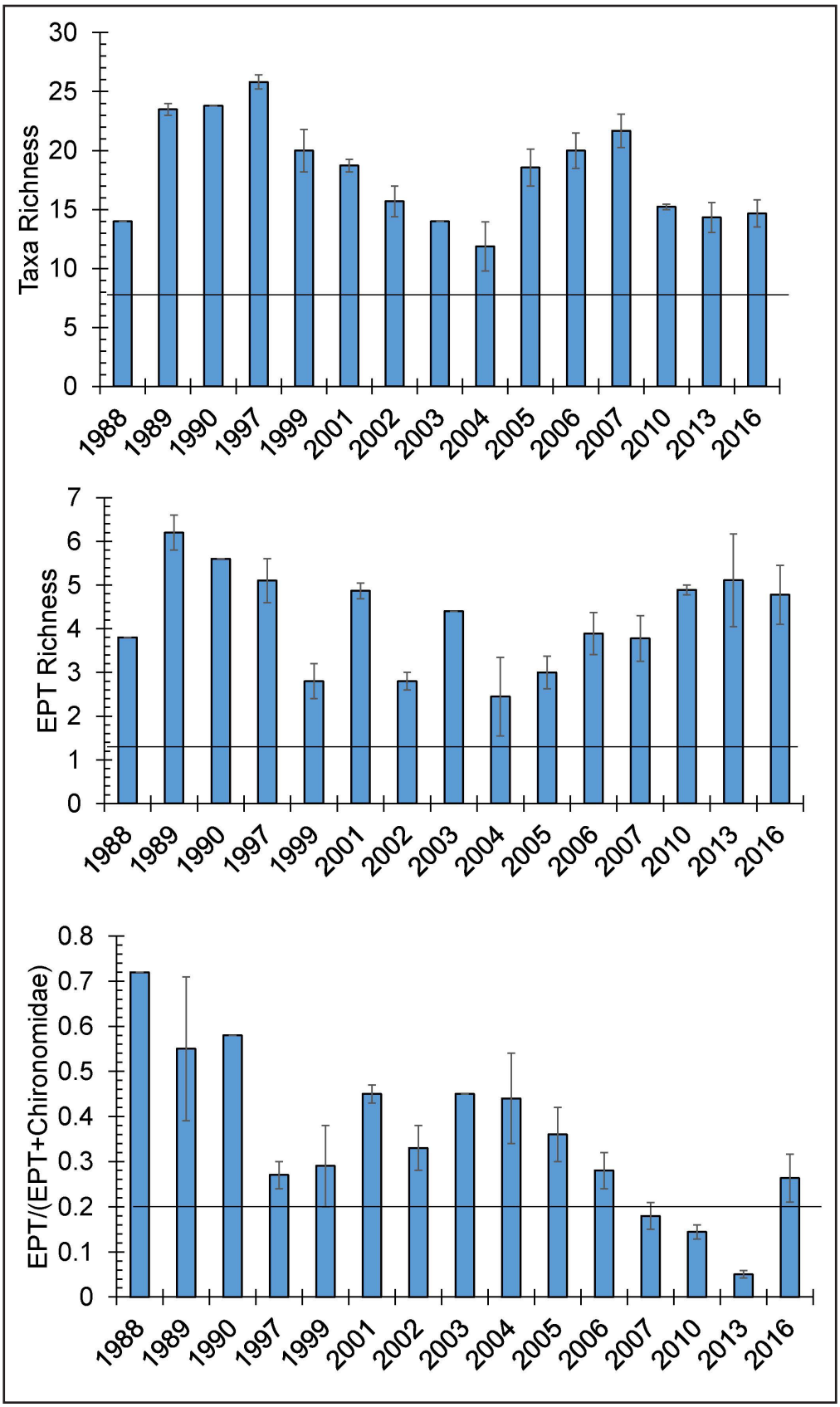


Figure 4. Control charts for taxa richness, EPT richness, and EPT ratio at Skegg's Branch, Wilson's Creek National Battlefield, Missouri. Bars are means for a given year and vertical bars are standard errors. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

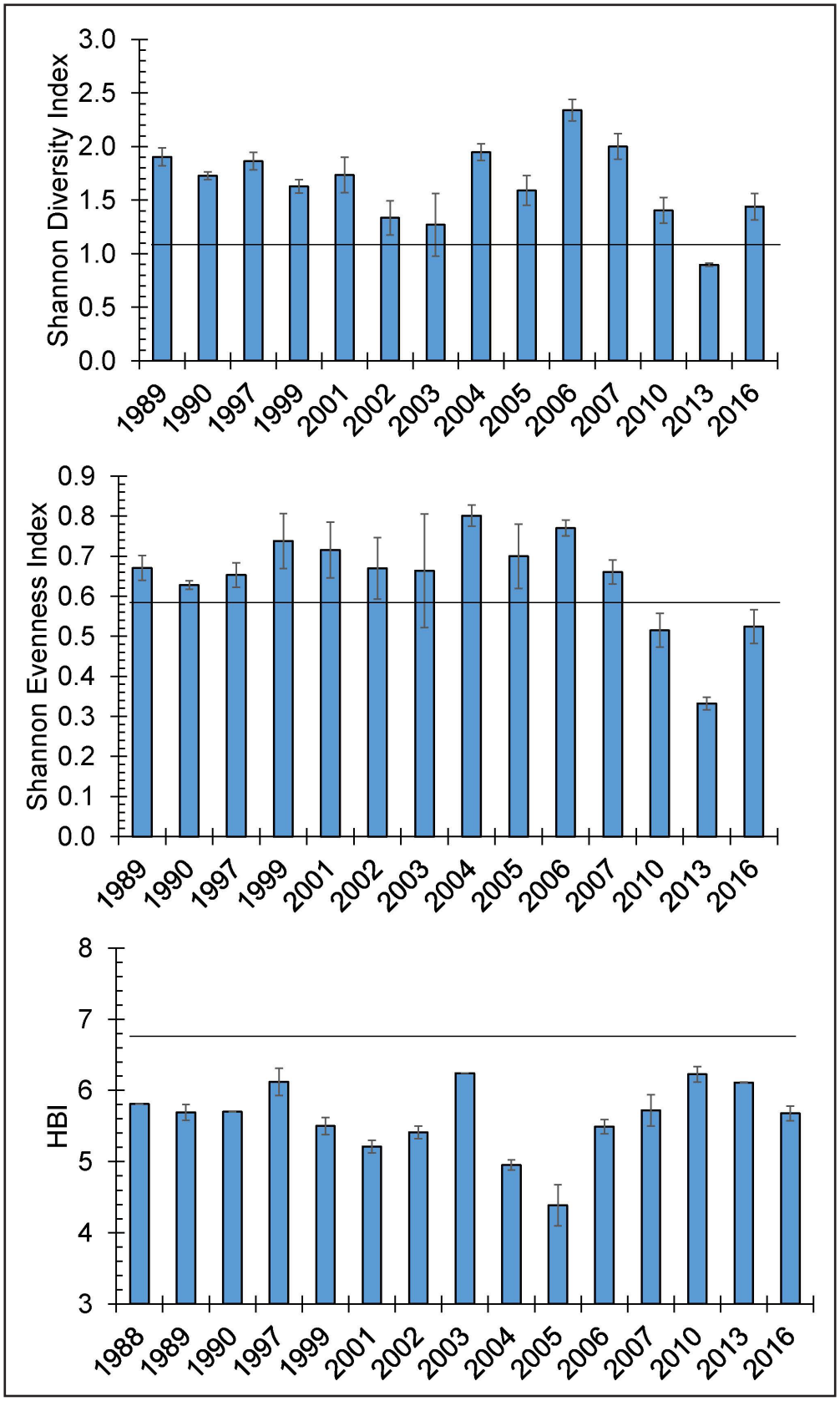


Figure 5. Control charts for Shannon diversity index, Shannon Evenness index, and HBI at Skegg's Branch, Wilson's Creek National Battlefield, Missouri. Bars are means for a given year and vertical bars are standard errors. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

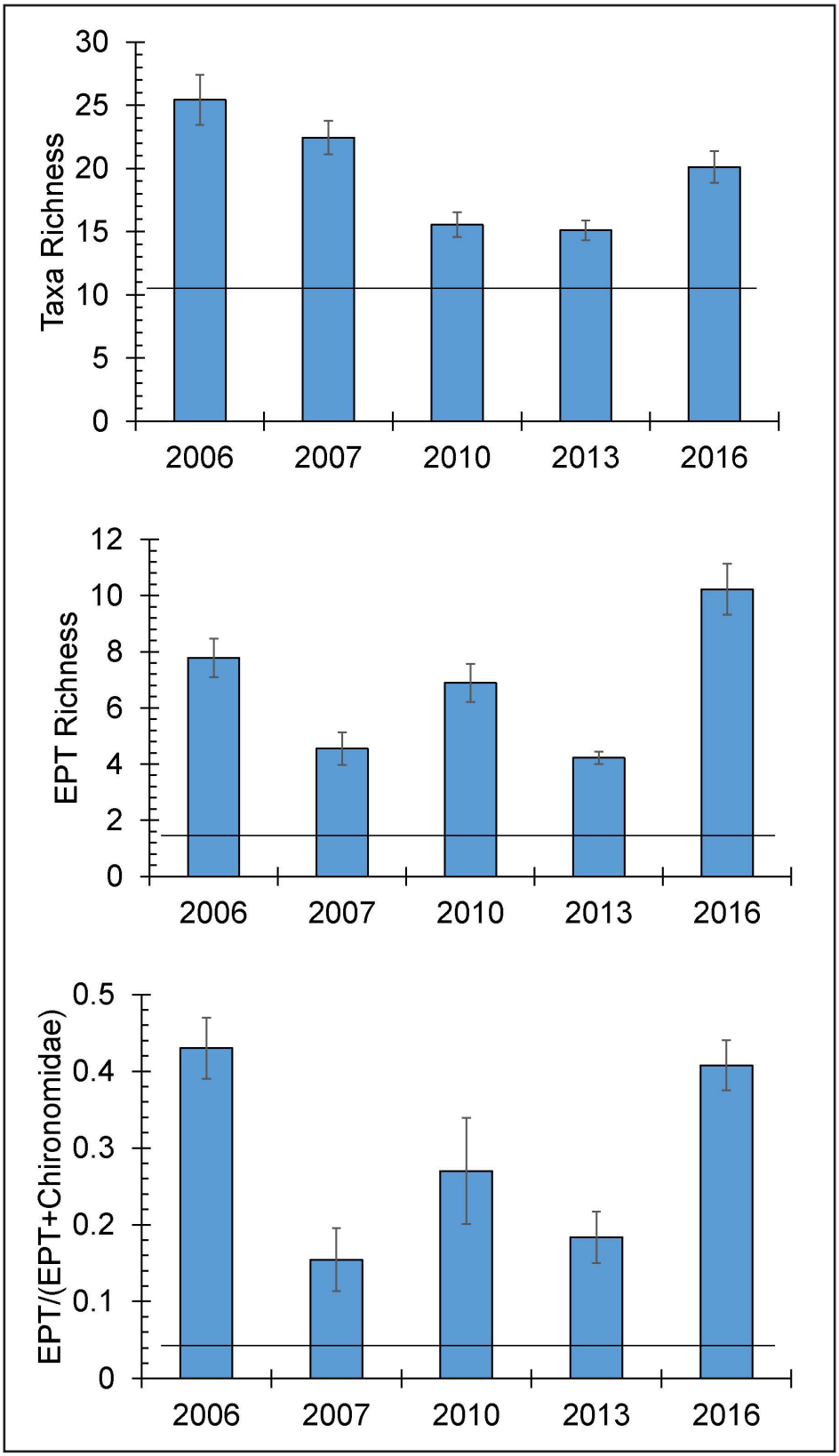


Figure 6. Control charts for taxa richness, EPT richness, and EPT ratio at Terrell Creek, Wilson's Creek National Battlefield, Missouri. Bars are means for a given year and vertical bars are standard errors. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

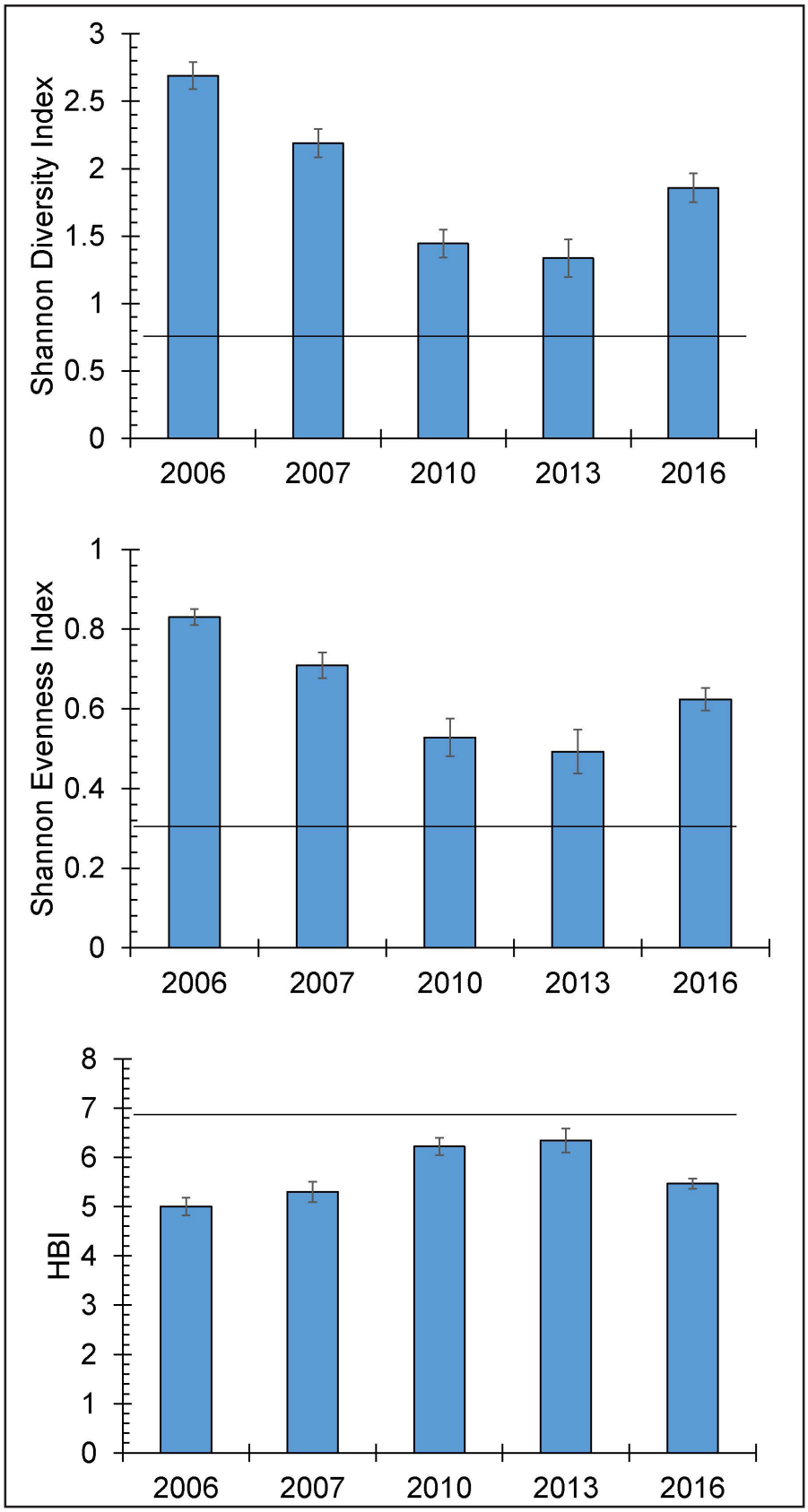


Figure 7. Control charts for Shannon diversity index, Shannon evenness index, and HBI at Terrell Creek, Wilson's Creek National Battlefield, Missouri. Bars are means for a given year and vertical bars are standard errors. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

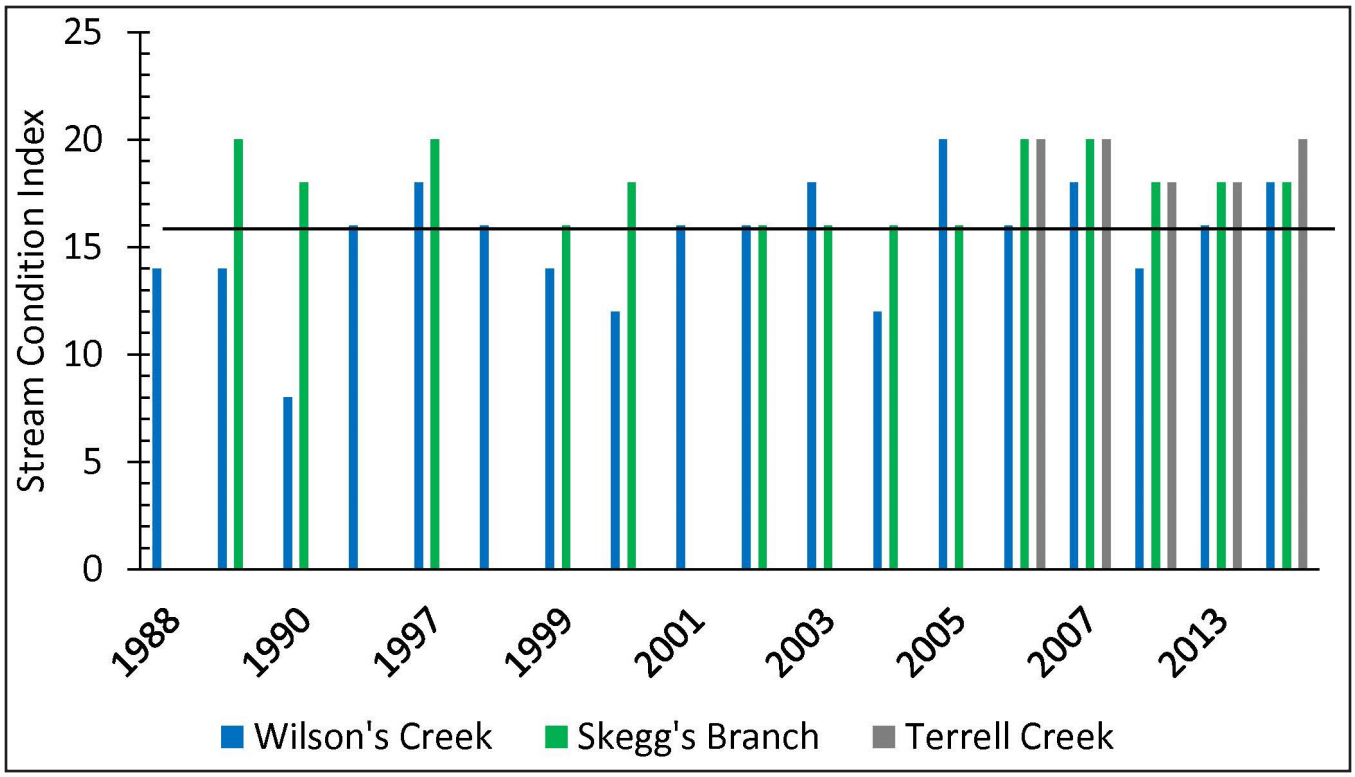


Figure 8. SCI scores for streams at Wilson's Creek National Battlefield, Missouri (1988–2016). Values: 16–20 = biologically supporting, 10–14 = partially biologically supporting, 4–8 = not biologically supporting. The horizontal line represents the minimum value of 16 required for biologically supporting.

Table 2. Water quality data for streams at Wilson's Creek National Battlefield, Missouri, 2005–2016. Data in 2005 were collected with hand-held instruments. Data for 2006–2016 were collected continuously with calibrated data loggers. Values are means with standard deviations in parentheses.

Year	Stream	N	Temperature (°C)	Specific Conductance (µm/cm)	Dissolved Oxygen (mg/liter)	pH	Turbidity (NTU)
2005	Wilson's Creek	9	19.82 (0.10)	774.40 (4.16)	9.23 (0.12)	7.51 (0.08)	n/a
2006	Wilson's Creek	139	22.49 (0.13)	486.48 (4.38)	9.16 (0.12)	7.77 (0.0.1)	9.57 (2.39)
2007	Wilson's Creek	26	18.49 (0.26)	642.96 (2.75)	n/a	n/a	4.25 (0.13)
2010	Wilson's Creek	23	18.11 (0.26)	775.65 (4.13)	9.39 (0.38)	7.95 (0.03)	1.30 (0.04)
2013	Wilson's Creek	117	12.73 (0.10)	433.61 (2.26)	10.56 (0.09)	7.64 (0.006)	3.30 (0.11)
2016	Wilson's Creek	69	16.79 (0.19)	652.20 (3.19)	11.81 (0.22)	7.78 (0.02)	2.49 (0.14)
2005	Skegg's Branch	9	16.42 (0.15)	399.00 (1.73)	9.25 (0.14)	7.43 (0.12)	n/a
2006	Skegg's Branch	139	18.68 (0.15)	495.83 (0.63)	8.82 (0.10)	7.92 (0.005)	0.69 (0.05)
2007	Skegg's Branch	90	15.27 (0.09)	489.51 (1.62)	n/a	n/a	2.07 (0.07)
2010	Skegg's Branch	27	14.54 (0.24)	455.59 (0.47)	11.08 (0.17)	7.72 (0.01)	0.54 (0.28)
2013	Skegg's Branch	117	13.19 (0.06)	442.62 (0.74)	11.07 (0.12)	7.43 (0.005)	1.01 (0.03)
2016	Skegg's Branch	45	14.45 (0.24)	472.73 (0.94)	9.77 (0.16)	7.75 (0.01)	0.45 (0.01)
2006	Terrell Creek	90	16.25 (0.09)	471.68 (0.24)	8.98 (0.15)	7.38 (0.01)	2.70 (0.22)
2007	Terrell Creek	25	14.70 (0.06)	477.64 (0.36)	6.45 (0.12)	n/a	0.76 (0.04)
2010	Terrell Creek	29	14.11 (0.17)	413.38 (0.19)	9.70 (0.15)	7.64 (0.01)	0.91 (0.17)
2013	Terrell Creek	118	12.25 (0.12)	400.39 (0.59)	10.84 (0.09)	7.73 (0.01)	0.68 (0.04)
2016	Terrell Creek	42	14.14 (0.12)	418.14 (0.17)	8.28 (0.11)	7.62 (0.01)	0.12 (0.03)

Table 3. Acceptable ranges for water quality parameters in southwestern Missouri streams; adapted from Missouri Department of Natural Resources (2019).

Water Quality Parameter	Acceptable Range
Temperature	0–34 °C
Dissolved Oxygen	5–15 mg/liter
Specific Conductance	100–400 µS/cm
pH	6.5–9.0
Turbidity	Variable, but generally <10 NTU dry weather

Table 4. Discharge for streams at Wilson's Creek National Battlefield, Missouri, 2005–2007 and 2010. Data from 2005 are from http://waterdata.usgs.gov/mo/nwis/uv?site_no=07052152.

	Discharge (m^3/sec)					
Stream	**2005**	**2006**	**2007**	**2010**	**2013**	**2016**
Wilson's Creek	1.16	0.93	4.56	2.3	7.56	1.55
Skegg's Branch	n/a	0.01	0.14	0.1	0.49	0.06
Terrell Creek	n/a	0.1	0.56	0.33	2.1	0.3

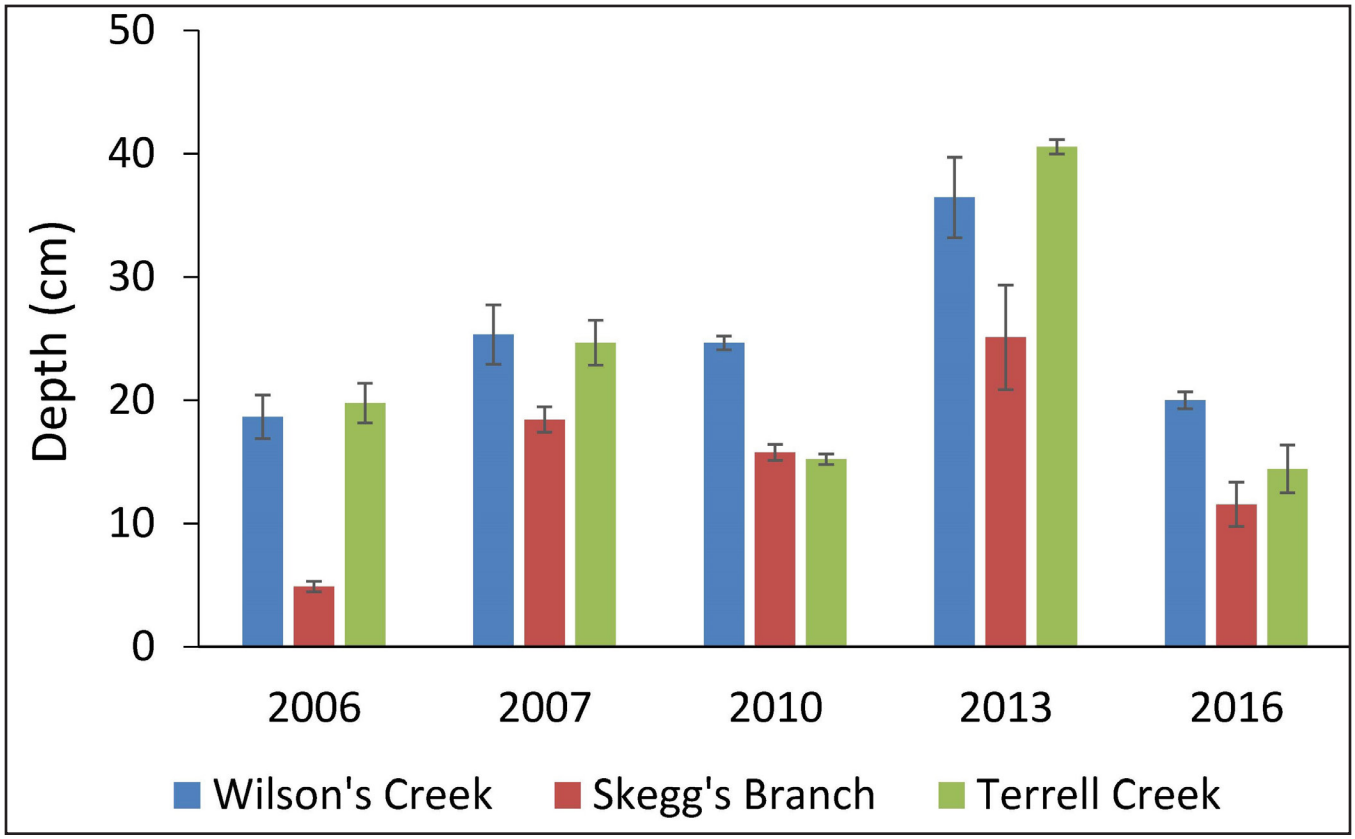


Figure 9. Mean depth (cm) and standard errors of riffles where benthic samples were collected at Wilson's Creek National Battlefield, Missouri.

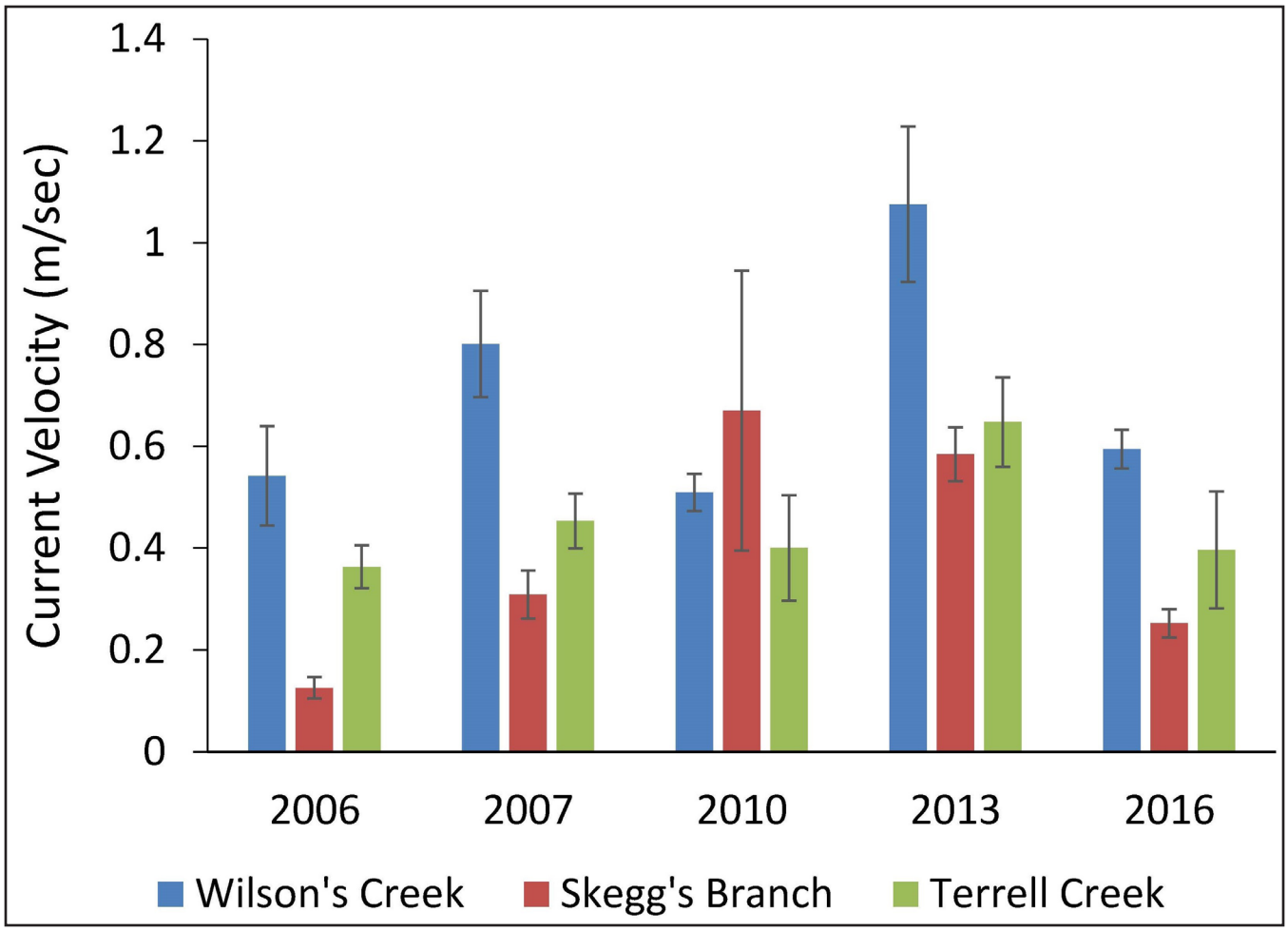


Figure 10. Mean current velocity (m/sec) and standard errors of riffles where benthic samples were collected at Wilson's Creek National Battlefield, Missouri.

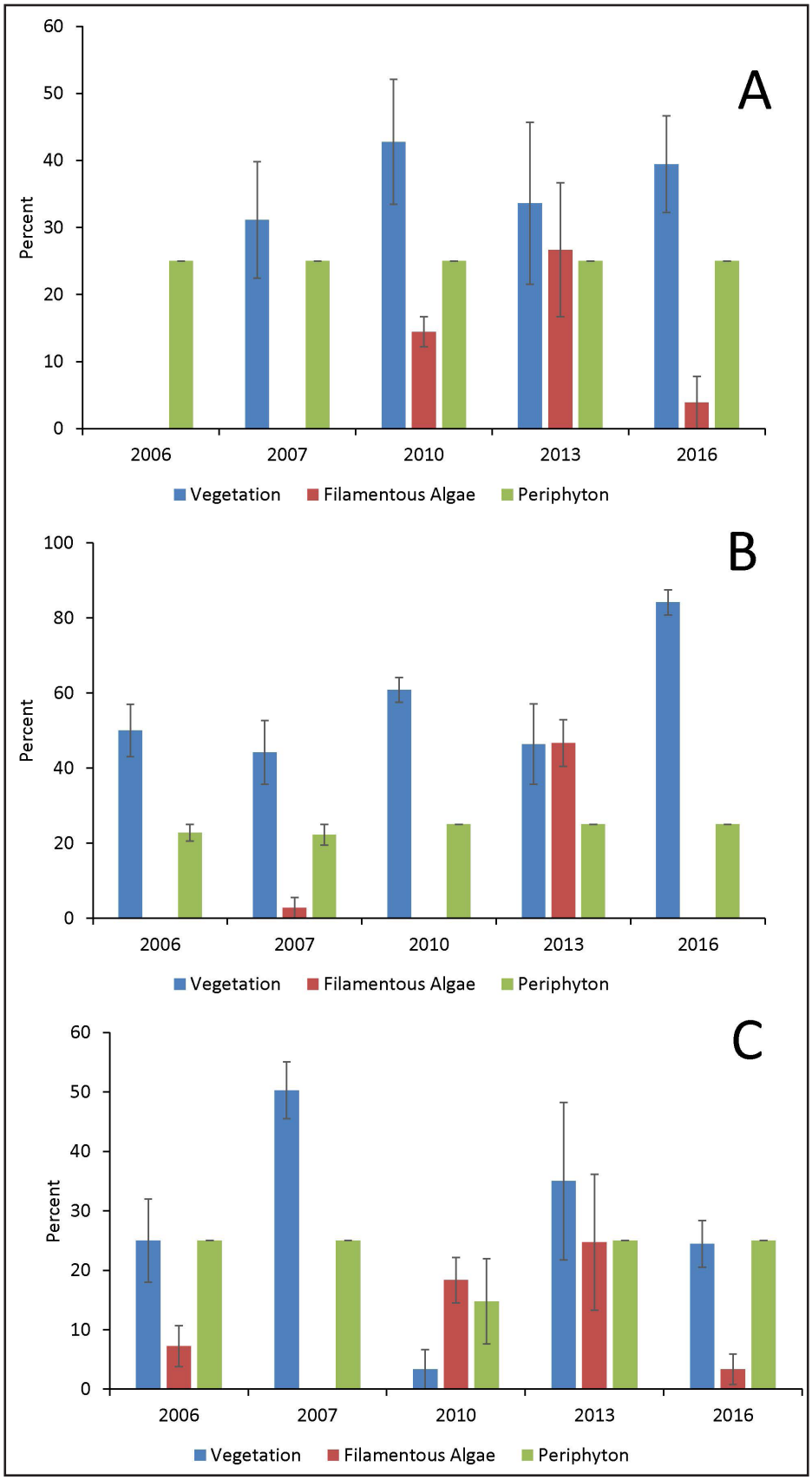


Figure 11. Mean percent and standard errors of habitat variables associated with benthic samples at Wilson's Creek National Battlefield, Missouri. Values are mid-point percentages. A = Wilson's Creek, B = Skegg's Branch, C = Terrell Creek.

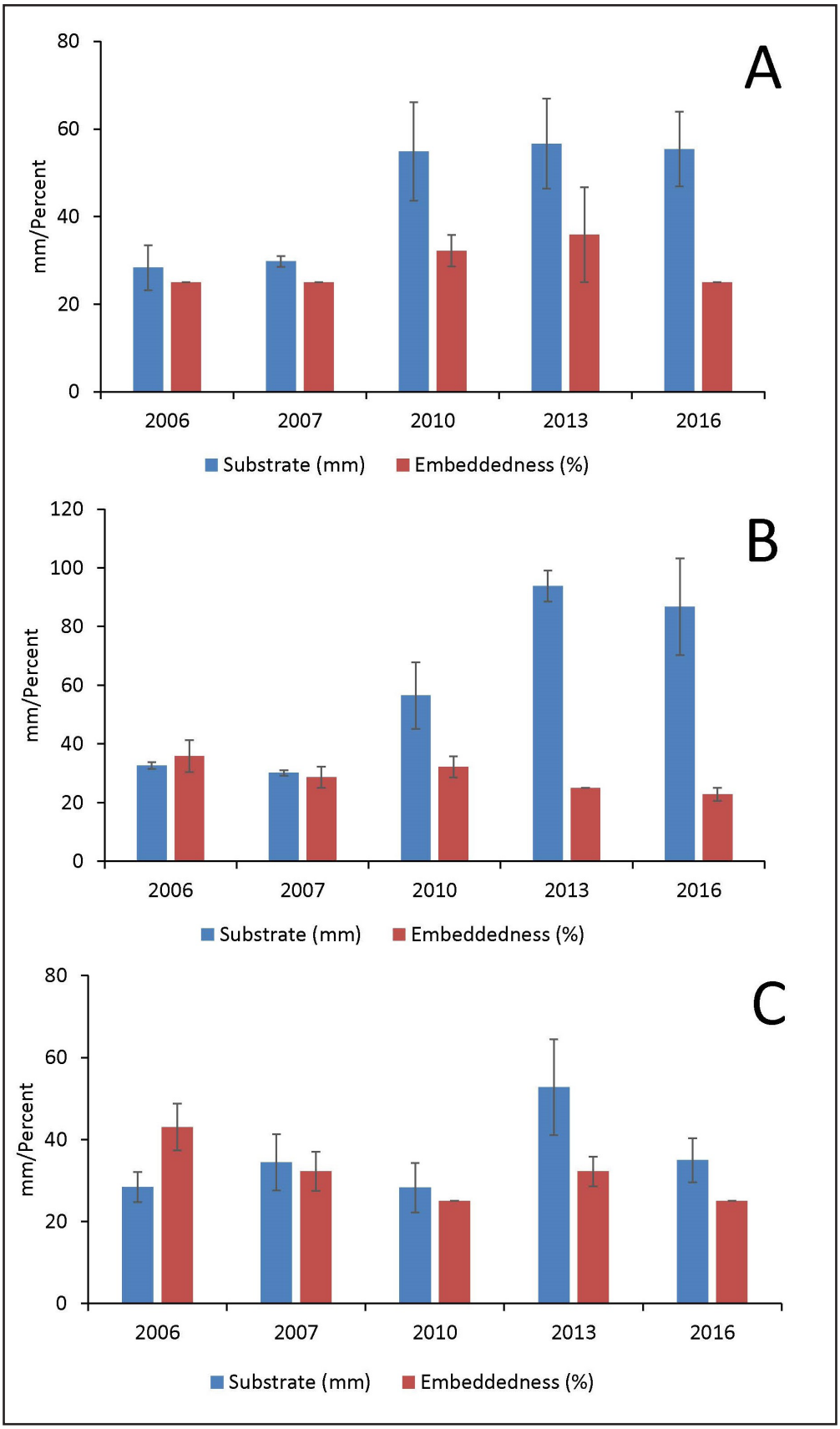


Figure 12. Mean substrate size (mm) and percent embeddedness with standard errors for streams at Wilson's Creek National Battlefield, Missouri. A = Wilson's Creek, B = Skegg's Branch, C = Terrell Creek.

Discussion

The streams at Wilson's Creek National Battlefield are in relatively good condition based on the analysis of the invertebrate metrics. Control charts showed that invertebrate metrics generally did not exceed their respective control limits, indicating the data are within the expected range of variation. The associated water quality data generally fell within acceptable limits for southwest Missouri streams.

There are few available options to park management for mitigating water quality impairment of streams inside the park because impacts to water quality originate upstream and outside of the park boundaries.

Watershed-level threats related to urbanization outside the jurisdictional boundary of the park may have negative consequences on water quality and invertebrate communities in Wilson's Creek and Skegg's Branch. Present management actions related to the riparian zone in the park aids in maintaining the integrity of those streams. The long history of aquatic invertebrate monitoring that continues at Wilson's Creek National Battlefield provides a sound tool to recognize both deterioration and chronic decline of water quality.



A stonefly (Plecoptera, Perlidae). Photograph by Bob Hendricks/Flickr/CC by-SA-2.0; cropped.

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