



# Aquatic Invertebrate Monitoring at George Washington Carver National Monument

## *2005–2016 Status Report*

Natural Resource Report NPS/HTLN/NRR—2020/2203



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**ON THE COVER**

Carver Branch, George Washington Carver National Monument, Missouri  
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# Aquatic Invertebrate Monitoring at George Washington Carver National Monument

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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 Carver, Williams, and Harkins branches at George Washington Carver National Monument, 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. SCI values for all three streams exceeded 16, indicating the streams were fully biologically supporting at the time of sampling. Presently, streams at George Washington Carver National Monument are at reference stream level condition based on state of Missouri criteria. The long history of aquatic invertebrate monitoring that continues at the park provides a sound tool to recognize both deterioration and chronic decline of water quality.

# Acknowledgments

We thank David Peitz, Hope Dodd, Jake Waters, Angela Bandy, Greg Wallace, and Lloyd Morrison for assisting with this project.

# 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.

Water quality data represent only a snapshot of the broad temporal range of chemical and physical conditions and should be cautiously interpreted. Due to the limitations of using periodically obtained water quality data, invertebrate communities are used here as a surrogate of the long-term water quality

condition of streams at George Washington Carver National Monument. Invertebrates are exposed to the chemical and physical conditions of the stream over the long term and can serve as an important tool for understanding and detecting changes in stream integrity over time. Various metrics calculated from species richness, abundance, diversity, species tolerance to disturbance, and region-specific multimetric indices can provide clues to the overall water quality conditions for biological support in the stream.

Harris et al. (1991) reported on data collected from Carver Branch and Williams Branch in 1989, and Peterson (1997) reported on data collected from Carver Branch and Harkins Branch in 1996. Bowles (2009) reported on the data collected from all three streams from 2005 to 2007. This report summarizes all data collected from 2005 to 2016.



A stonefly (Plecoptera, Perlidae). Photograph by Bob Hendricks/Flickr/[CC by-SA-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 Carver Branch, Williams Branch, and Harkins Branch at George Washington Carver National Monument (Figure 1) during a late spring index period (May–June).

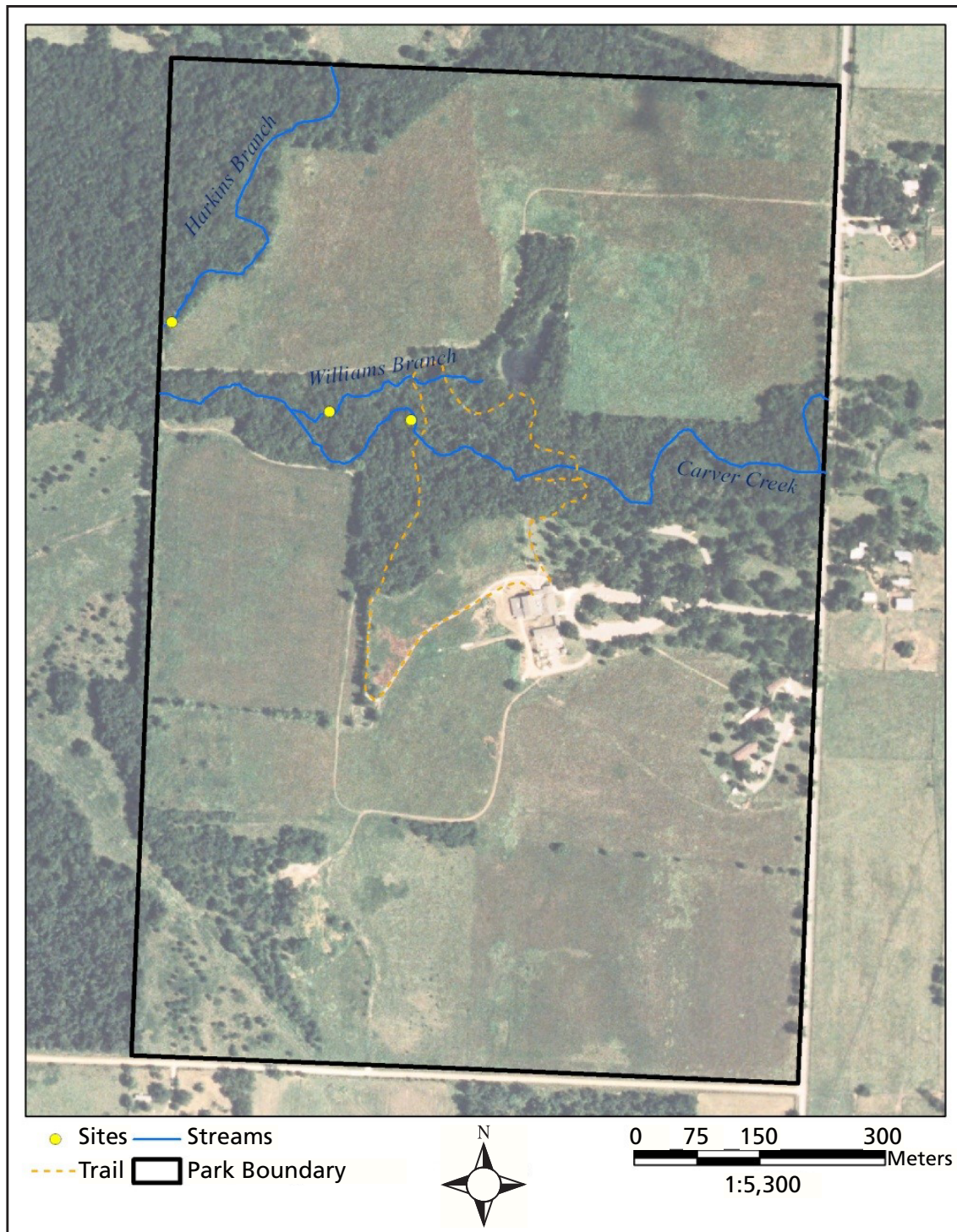


**Figure 1.** Map showing the approximate lower sampling reach boundaries for Carver Branch, Williams Branch, and Harkins Branch, George Washington Carver National Monument, Missouri.

## Sample Collection

Hourly readings of water quality parameters (temperature, dissolved oxygen, specific conductance, pH, and turbidity) were recorded continuously for a minimum of 24 hours in each stream prior to sampling using calibrated data loggers or sondes. The water quality data presented in this report are only intended to describe the prevailing conditions that influence the structure of invertebrate communities. These data may help explain variability between sampling periods, but they should not be used as an analytical tool in the strictest sense (Bowles et al. 2008).

A Surber stream bottom sampler (500- $\mu\text{m}$  mesh, 0.09  $\text{m}^2$ ) was used to collect the invertebrate samples. Three successive riffles were sampled for each stream with three benthic invertebrate samples collected per riffle, resulting in nine samples per stream. Samples were sorted in the laboratory following a subsampling routine described in Bowles et al. (2008), and taxa were identified to the lowest practical taxonomic level (usually genus) and counted.

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 upstream of the sampling site after invertebrate collections were completed. Discharge estimates are intended to illustrate the general flow tendencies for the respective streams for a given sampling year and are not intended to be exact measurements.

## Invertebrate Metrics and Stream Condition Index

Metrics calculated for the invertebrate communities included taxa richness; family richness; Ephemeroptera, Trichoptera, Plecoptera (EPT) richness; EPT ratio ( $\text{EPT}/[\text{EPT} + \text{Chironomidae}]$ ); 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;



Collecting invertebrates with a Surber sampler. NPS.

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 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 (unimpaired, score 16–20), (2) partially biologically supporting (impaired, scores 10–14), and (3) non-biologically supporting (very impaired, scores 4–8). Unimpaired or reference infer a stream that is fully biological supporting. 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. Impaired sites have stream reaches that are partially biologically supporting, with species composition, diversity, and functional organization indicative of a disturbed system. Sites scored as very impaired lack conditions necessary for a sustainable, adaptable community. Both partially biologically supporting and non-biologically supporting categories indicate impaired 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.

### Data Analysis

Univariate control charts were established 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 (Morrison 2008). Control charts plot a characteristic through time with reference to its expected value. 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  $\pm$  2.92 standard deviations) for those community metrics that respectively decrease or increase due to stressors. This specified threshold serves as an indicator to suggest a biologically important change may be occurring. Setting a control chart threshold equal to 2.92 standard deviations is analogous to significance tests at a critical value of 0.05 for one-tailed tests. The Student's t-distribution (df = 2) was used to determine the one-tailed area because of the relatively small sample size. Data from 2005 to 2007 served as a baseline and were used to construct thresholds. Only lower control limits are graphed in this report as they indicate minimum acceptable conditions, with the exception of HBI (the upper control limit is presented for HBI).

**Table 1.** Descriptive statistics and scores of metrics for the spring index period based on single habitat coarse substrate (riffle) data. Stream Condition Index (SCI) scoring: 16–20 not impaired, 10–14 impaired, 4–8 very impaired.

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

# Results

Metric and diversity values for samples collected in 2016 fell within their respective control limits (Figures 2–4). SCI values for all three streams exceeded 16, indicating that they were fully biologically supporting at the time of sampling (Table 2). 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. Habitat data collected for the three streams (Tables 3–7 and Figures 5–7) were similar to those reported in previous years but are not analyzed further here. Water quality data (Tables 3–5) fall within the acceptable ranges for water quality parameters in southwestern Missouri streams (Table 6).

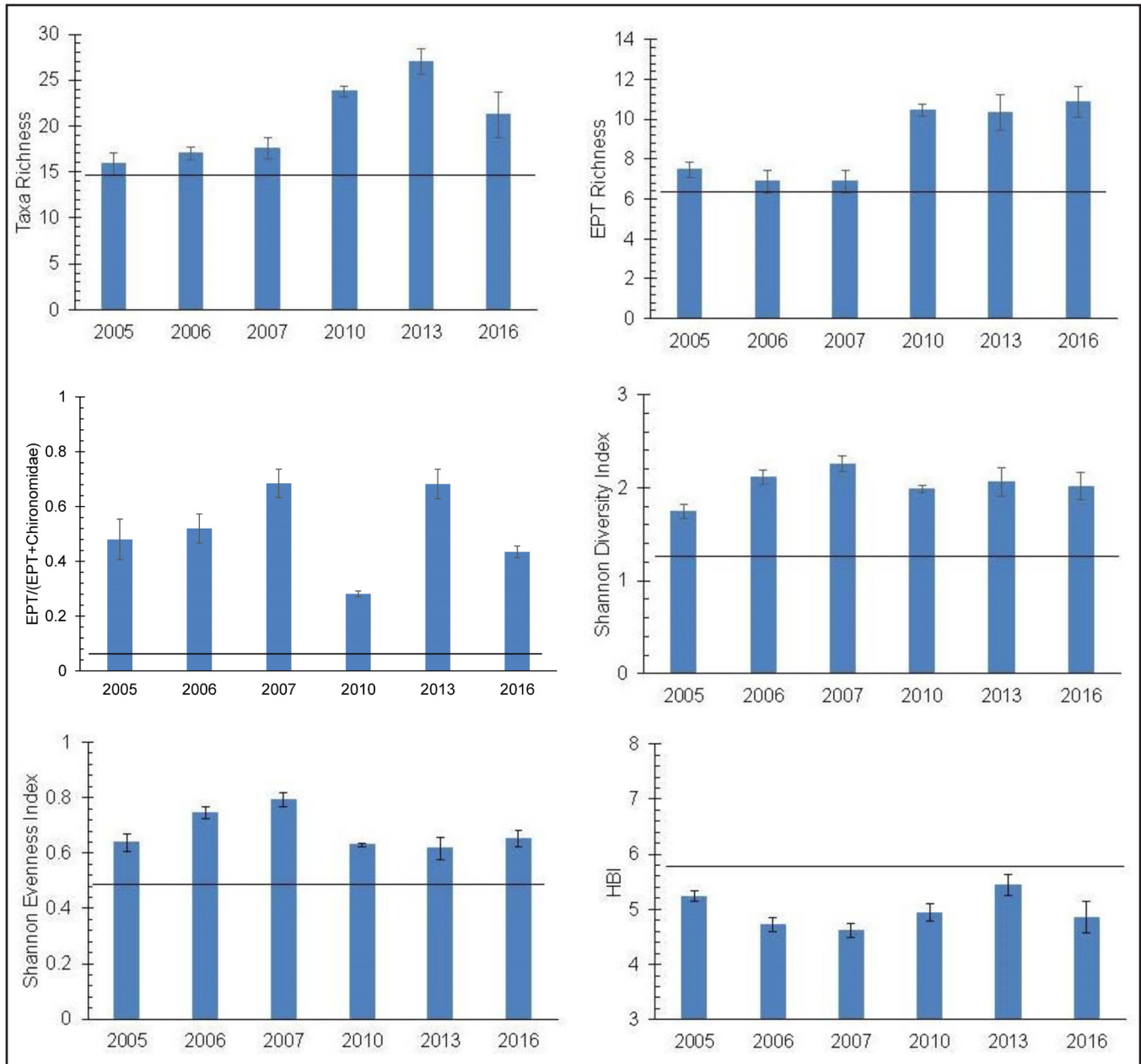


**Figure 2.** Invertebrate metric control charts for Carver Branch, George Washington Carver National Monument, Missouri. Bars are means for a given sampling date, and error bars are standard errors ( $n = 3$ ). The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

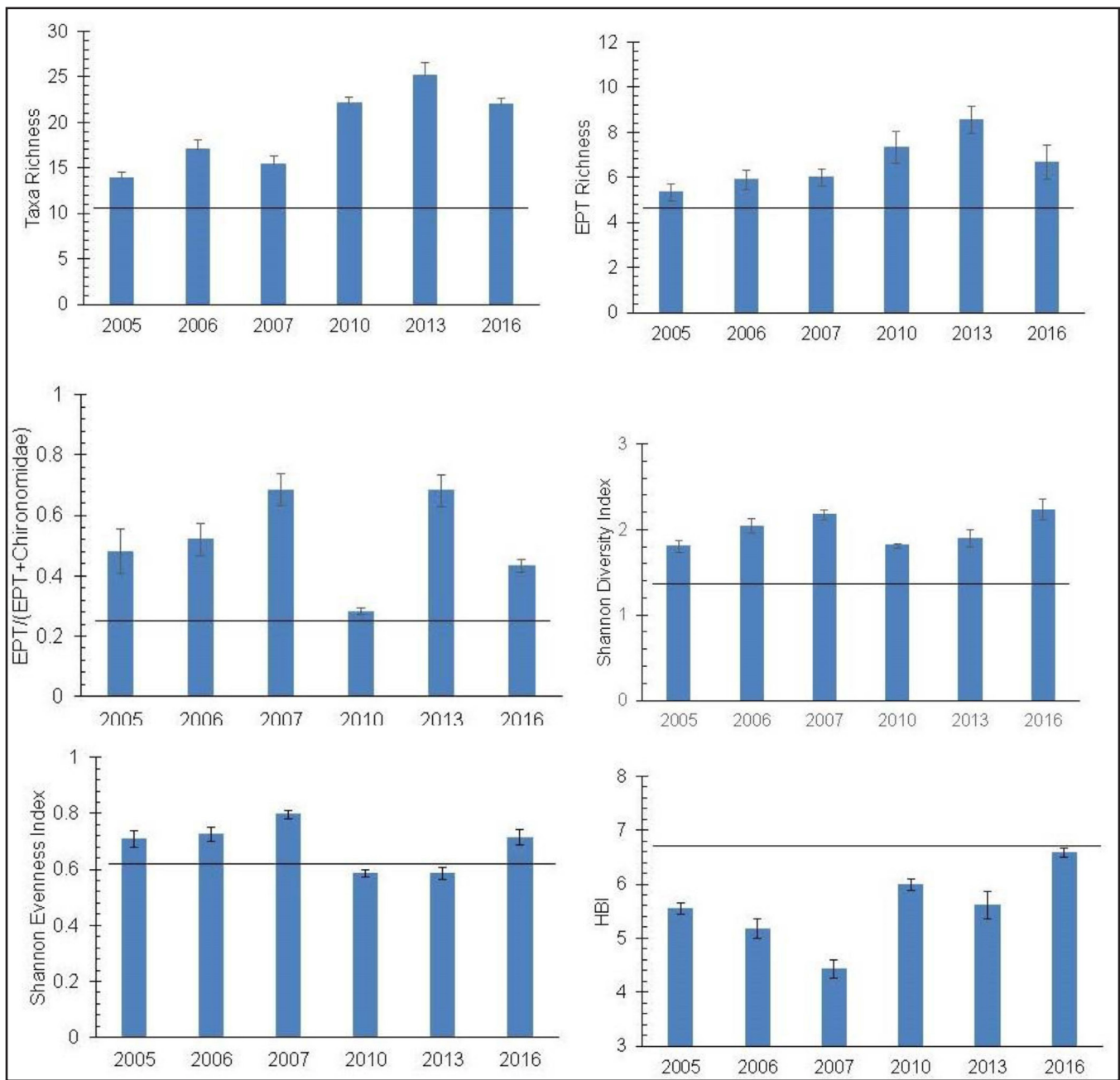


**Figure 3.** Invertebrate metric control charts for Williams Branch, George Washington Carver National Monument, Missouri. Bars are means for a given sampling date, and the vertical bars are standard errors ( $n = 3$ ). The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

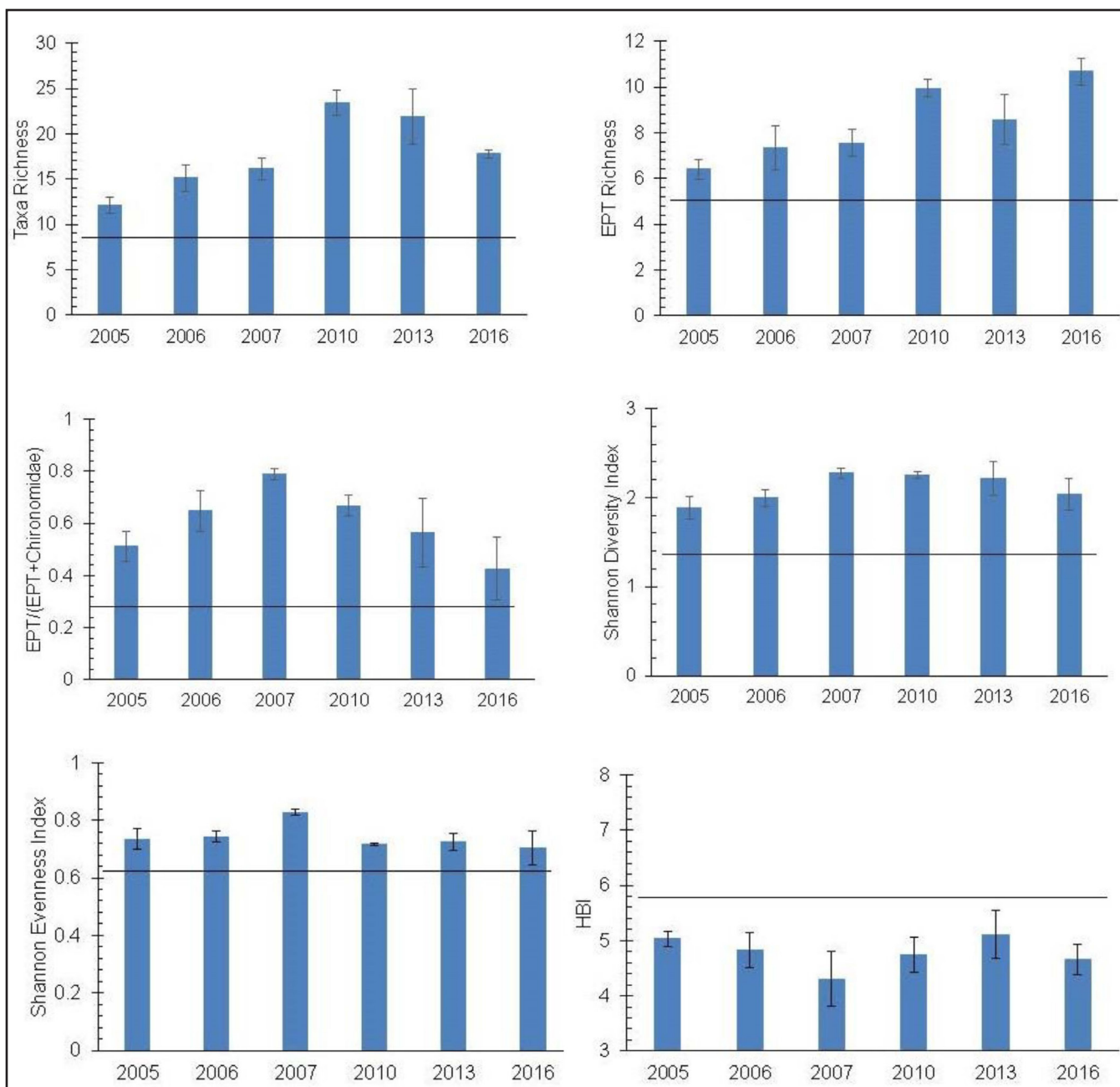


**Figure 4.** Invertebrate metric control charts for Harkins Branch, George Washington Carver National Monument, Missouri. Bars are means for a given sampling date, and the vertical bars are standard errors (n = 3). The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

**Table 2.** Missouri Stream Condition Index (SCI) for streams at George Washington Carver National Monument, Missouri, 2005–2016.

| Stream          | 2005 | 2006 | 2007 | 2010 | 2013 | 2016 |
|-----------------|------|------|------|------|------|------|
| Carver Creek    | 18   | 20   | 20   | 20   | 20   | 20   |
| Williams Branch | 18   | 20   | 20   | 20   | 20   | 20   |
| Harkins Branch  | 18   | 20   | 20   | 20   | 20   | 20   |

**Table 3.** Water quality parameters for Carver Branch, George Washington Carver National Monument, Missouri, with standard error in parentheses. Data in 2005 were collected as static readings using hand-held instruments, while all other data were collected hourly with data-loggers.

| Year | N   | Temperature (°C) | Dissolved Oxygen (mg/l) | Specific Conductance (µm/cm) | pH              | Turbidity (NTU) |
|------|-----|------------------|-------------------------|------------------------------|-----------------|-----------------|
| 2005 | 5   | 20.65<br>(3.23)  | 5.84<br>(0.55)          | 243.78<br>(30.14)            | 6.86<br>(0.28)  | n/a             |
| 2006 | 40  | 18.21<br>(0.14)  | 7.56<br>(0.04)          | 331.52<br>(0.14)             | 7.20<br>(0.003) | 1.14<br>(0.09)  |
| 2007 | 24  | 15.96<br>(0.18)  | 7.58<br>(0.17)          | 215.25<br>(3.46)             | n/a             | 9.28<br>(1.79)  |
| 2010 | 25  | 15.27<br>(0.28)  | 7.89<br>(0.10)          | 282.12<br>(0.47)             | 7.39<br>(0.004) | 2.19<br>(0.29)  |
| 2013 | 25  | 15.29<br>(0.40)  | 9.55<br>(0.26)          | 234.56<br>(1.95)             | 7.17<br>(0.02)  | 1.25<br>(0.08)  |
| 2016 | 146 | 14.86<br>(0.12)  | 7.38<br>(0.09)          | 242.01<br>(3.52)             | 7.15<br>(0.01)  | 3.25<br>(0.57)  |

**Table 4.** Water quality parameters for Williams Branch, George Washington Carver National Monument, Missouri, with standard error in parentheses. Data in 2005 were collected as static readings using hand-held instruments, while all other data were collected hourly with data-loggers. N for turbidity in 2006 was 39.

| Year | N   | Temperature (°C) | Dissolved Oxygen (mg/l) | Specific Conductance (µm/cm) | pH              | Turbidity (NTU) |
|------|-----|------------------|-------------------------|------------------------------|-----------------|-----------------|
| 2005 | 5   | 23.62<br>(1.44)  | 6.93<br>(0.26)          | 242.53<br>(10.61)            | 7.58<br>(0.19)  | n/a             |
| 2006 | 41  | 21.19<br>(0.23)  | 8.61<br>(0.06)          | 255.63<br>(0.16)             | 7.87<br>(0.003) | 4.29<br>(0.20)  |
| 2007 | 26  | 14.67<br>(0.08)  | 7.88<br>(0.05)          | 178.81<br>(0.43)             | 9.40<br>(0.005) | 4.99<br>(0.38)  |
| 2010 | 26  | 17.10<br>(0.27)  | 10.84<br>(0.09)         | 227.96<br>(0.10)             | 7.75<br>(0.003) | 2.95<br>(0.77)  |
| 2013 | 23  | 14.65<br>(0.23)  | 9.07<br>(0.12)          | 119.91<br>(7.25)             | 7.08<br>(0.01)  | 3.22<br>(0.29)  |
| 2016 | 131 | 15.65<br>(0.14)  | 10.57<br>(0.08)         | 200.07<br>(1.79)             | 7.26<br>(0.02)  | 5.21<br>(0.28)  |

**Table 5.** Water quality parameters for Harkins Branch, George Washington Carver National Monument, Missouri, with standard error in parentheses. Data in 2005 were collected as static readings using hand-held instruments, while all other data were collected hourly with data-loggers.

| Year | N   | Temperature (°C) | Dissolved Oxygen (mg/l) | Specific Conductance (µm/cm) | pH             | Turbidity (NTU) |
|------|-----|------------------|-------------------------|------------------------------|----------------|-----------------|
| 2005 | 5   | 24.20<br>(3.03)  | 6.64<br>(0.54)          | 229.2<br>(26.88)             | 7.09<br>(0.09) | n/a             |
| 2006 | 124 | 20.23<br>(0.07)  | 5.93<br>(0.07)          | 296.41<br>(0.37)             | 7.22<br>(0.01) | 0.74<br>(0.04)  |
| 2007 | 3   | 16.09<br>(0.10)  | 9.83<br>(0.08)          | 164.00<br>(0)                | 6.55<br>(0.01) | 5.17<br>(0.23)  |
| 2010 | 22  | 17.32<br>(0.28)  | 7.34<br>(0.19)          | 214.45<br>(0.42)             | 7.10<br>(0.01) | 3.6<br>(0.20)   |
| 2013 | 24  | 16.22<br>(0.57)  | 9.29<br>(0.26)          | 200.34<br>(2.00)             | 7.16<br>(0.04) | 0.80<br>(0.15)  |
| 2016 | 148 | 15.58<br>(0.16)  | 8.07<br>(0.10)          | 197.74<br>(3.13)             | 7.18<br>(0.01) | 9.08<br>(1.43)  |

**Table 6.** 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 7.** Discharge (m³/sec) measurements for streams at George Washington Carver National Monument, Missouri.

| Stream          | 2005 | 2006 | 2007 | 2010 | 2013  | 2016 |
|-----------------|------|------|------|------|-------|------|
| Carver Branch   | n/a  | 0.01 | 0.13 | 0.01 | 0.08  | 0.07 |
| Williams Branch | n/a  | 0.02 | 0.11 | 0.03 | 0.004 | 0.07 |
| Harkins Branch  | n/a  | 0.01 | 0.15 | 0.01 | 0.05  | 0.08 |

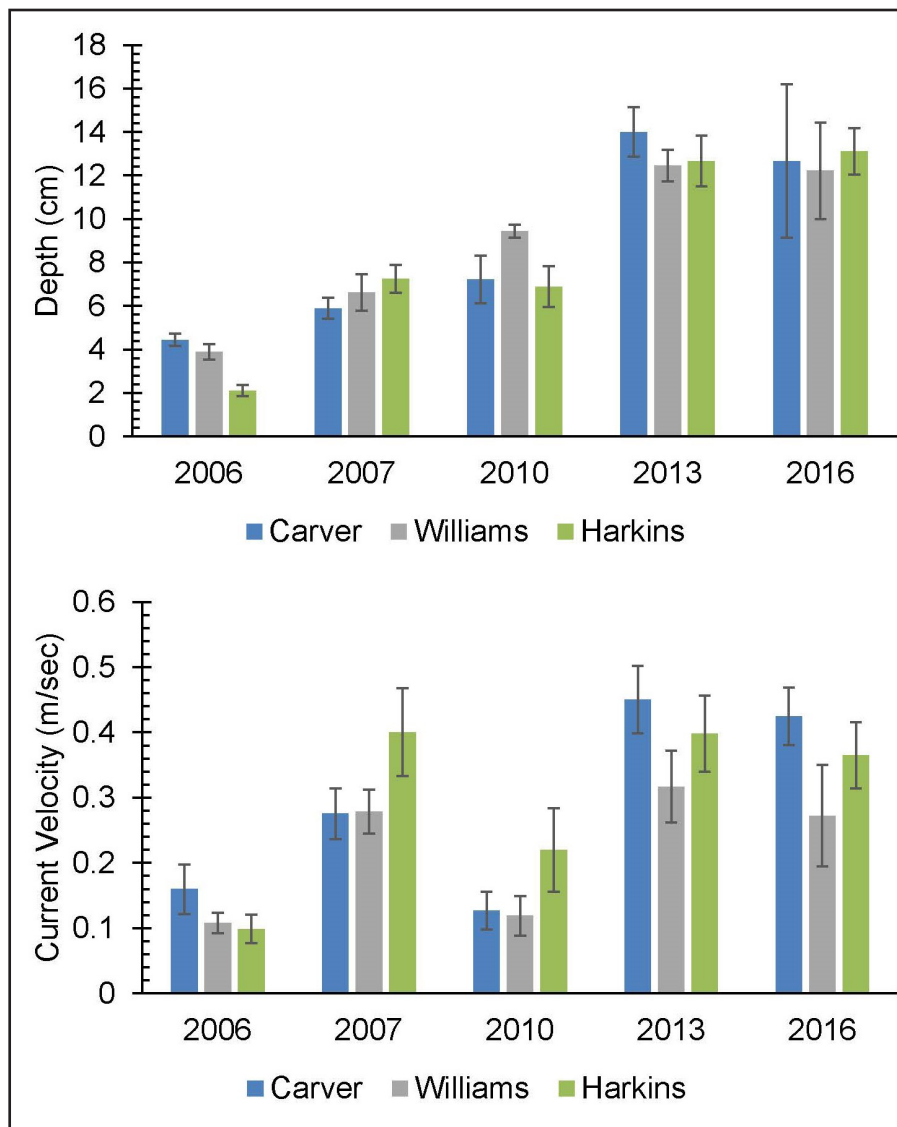


**Figure 5.** Mean depth (cm) and current velocity (m/sec) with standard errors (n = 3) of riffles where benthic samples were collected at George Washington Carver National Monument, Missouri.

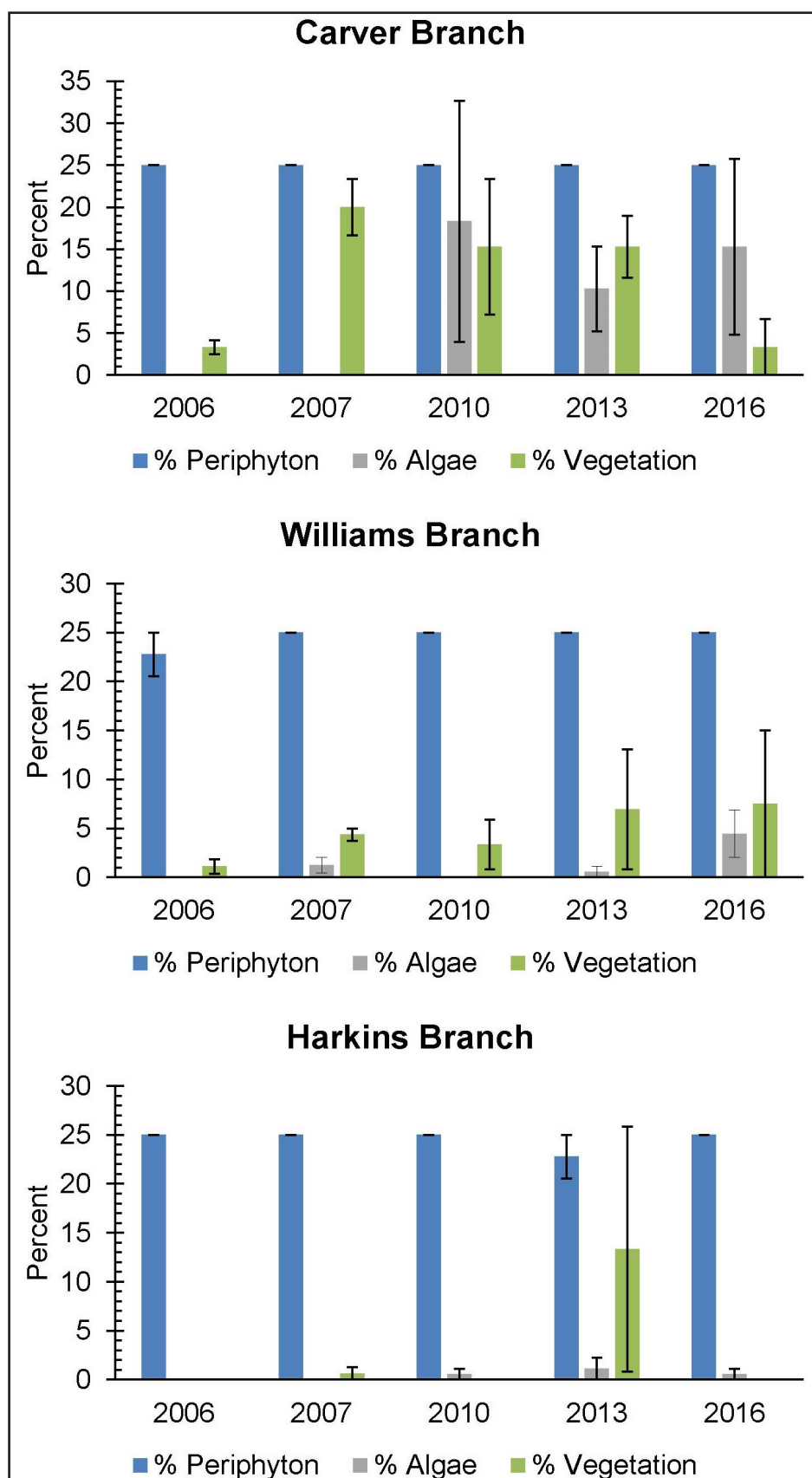


**Figure 6.** Mean percent periphyton, filamentous algae, and aquatic vegetation with standard errors ( $n = 3$ ) for riffles where benthic samples were collected at George Washington Carver National Monument, Missouri.

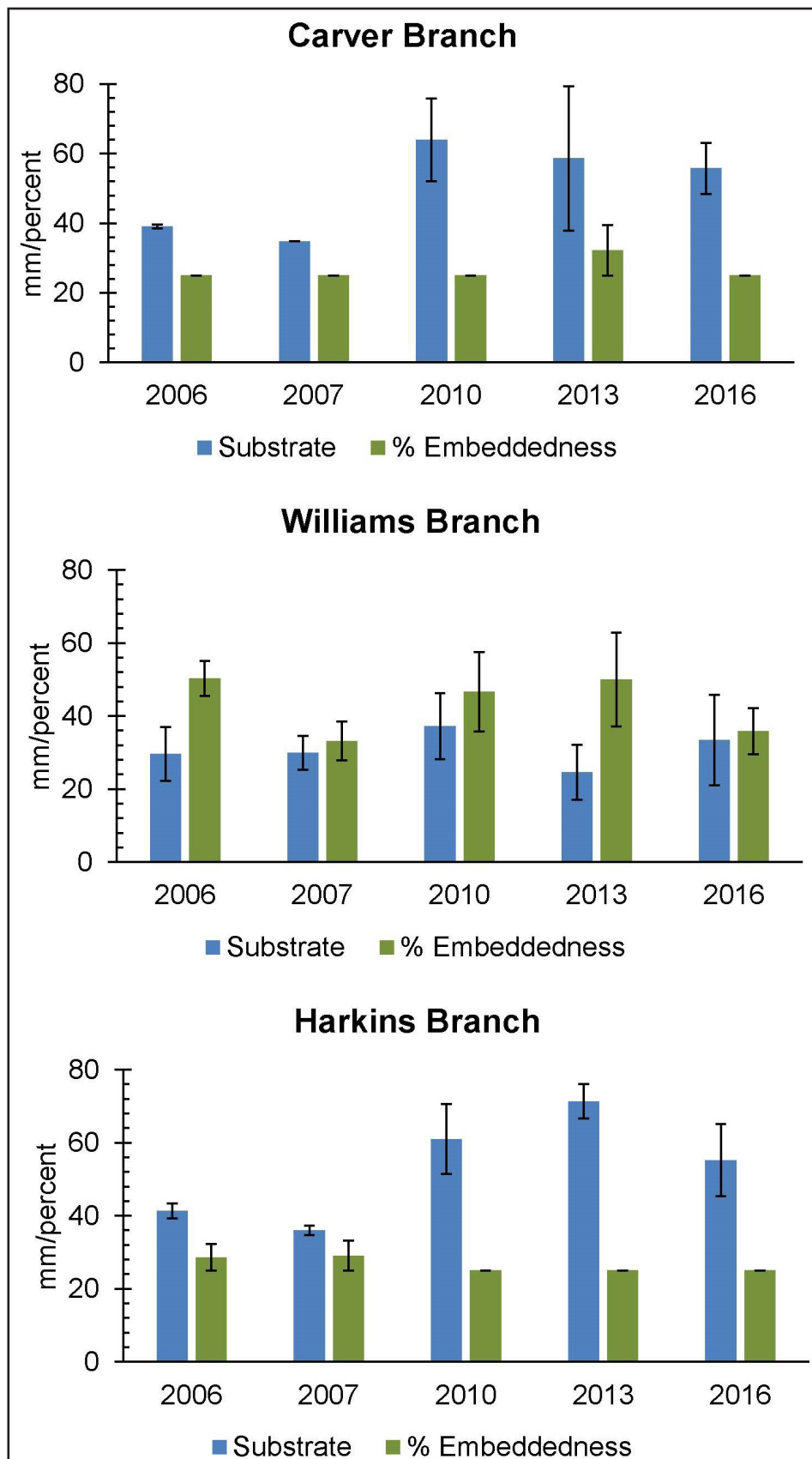


**Figure 7.** Mean substrate size (mm) and percent embeddedness with standard errors (n = 3) for stream riffles where benthic samples were collected at George Washington Carver National Monument, Missouri.

# Discussion

The streams at George Washington Carver National Monument are in good condition based on the analysis of the invertebrate metrics. Control charts showed that invertebrate metrics did not exceed their respective control limits indicating the data are within the expected range of variation. The associated water quality data also fell within acceptable limits for southwest Missouri.

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 outside the jurisdictional boundary of George Washington Carver National Monument remain the primary threats to water quality and invertebrates in the streams. Continued aquatic invertebrate monitoring at the park provides a sound tool to recognize both deterioration and chronic decline of water quality.



A caddisfly larvae (Trichoptera, Philopotamidae). Photograph by Bob Hendricks/Flickr/[CC by-SA-2.0](#).

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**Natural Resource Stewardship and Science**

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