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Natural Resource Stewardship and Science

Aquatic Invertebrate Monitoring at Pipestone National Monument, 1989–2016

Natural Resource Data Series NPS/HTLN/NRDS—2019/XXX

ON THIS PAGE
The falls of Pipestone Creek at Pipestone National Monument, Minnesota
Photography by Amy Meredith/Flickr/CC by-ND-2.0

ON THE COVER
Pipestone Creek flowing through restored prairie at Pipestone National Monument, Minnesota
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Aquatic Invertebrate Monitoring at Pipestone National Monument, 1989–2016

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on an established, peer-reviewed protocol and were analyzed and interpreted within the guidelines of the protocol. This report was approved by the Heartland Inventory and Monitoring Network Peer Review Manager.

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NPS XXX/XXXX, Month 2019

Contents

Figures

Tables

Abstract

Pipestone Creek, a tributary of the Big Sioux River, flows through Pipestone National Monument. The city of Pipestone, Minnesota lies on the south side of the creek and borders the park on the south end resulting in some anthropogenic impacts to water quality and aquatic life. A natural waterfall occurs within the park, and upstream of the waterfall, the creek is channelized, essentially without meanders, and with a largely bedrock substrate. To assess the various anthropogenic disturbances occurring in the creek, the NPS monitors aquatic invertebrates as a surrogate of the long-term water quality condition. Benthic invertebrate samples were collected from 1989 to 2016 using a Surber stream bottom sampler, and associated habitat parameters (depth, current velocity, dominant substrate, and percent embeddedness, periphyton, filamentous algae and aquatic vegetation) were recorded for each sample. Water quality parameters (temperature, dissolved oxygen, specific conductance, pH, and turbidity) were measured using a calibrated water quality data logger. Benthic invertebrate diversity and community metrics largely remained within previously defined control limits. The sole exceptions were the Ephemeroptera, Plecoptera, Trichoptera (EPT)/Chironomidae ratio, which barely surpassed the control limit for this sampling event, and the Hilsenhoff Biotic Index (HBI). These exceedances are not of concern at this time given the responses of the other metrics. Water quality measurements met state standards in most instances. A summary of habitat parameters is presented.

Acknowledgments

We thank Hope Dodd, Jeff Williams and Seth Hendriks for assisting with this project.

Introduction

Pipestone Creek, a tributary of the Big Sioux River, meanders about 100 km from east to west through southwestern Minnesota. The creek originates 19.3 km northeast of Pipestone National Monument (NM) as a drainage ditch near Holland, Minnesota (Harris et al. 1991). The city of Pipestone, Minnesota lies on the south side of the creek and borders Pipestone NM on the south end. Pipestone Creek flows through the center of the park and widens twice within its boundaries to form Lake Hiawatha and an unnamed pond. A recreational lake on Pipestone Creek borders the park on the west side. Natural vegetation of the area is native and restored bluestem prairie (Kuchler 1964; Stubbendieck and Willson 1986), but agriculture (e.g., row crops) is the primary land use in the watershed. A natural waterfall within Pipestone NM was lowered 2.5 to 3.0 m in the early 1900s (Harris et al. 1991). Upstream of the waterfall, Pipestone Creek is channelized, essentially without meanders, and with a largely bedrock substrate.

Due to the temporal limitations of using periodically obtained water quality data, aquatic invertebrate communities often are used as a surrogate of the long-term water quality condition. Since they often are exposed to the chemical and physical conditions of the stream over the long term, aquatic invertebrates can serve as an important tool for understanding and detecting changes in stream integrity over time (Barbour et al. 1999). Various metrics calculated on species richness, abundance, diversity, tolerance to disturbance, and region-specific multimetric indices can provide clues to the overall water quality conditions for supporting biological life in the stream.

Pipestone Creek flowing through Pipestone NM has previously been shown to have undesirable water quality (NPS Water Resources Division 1999) that is related to both urban and agricultural stressors. In addition, Pipestone Creek is listed by the state of Minnesota as a 303(d) waterway due to exceeding limits of fecal coliform contamination and turbidity (Minnesota Pollution Control Agency 2008). The various anthropogenic disturbances described above have a significant potential for disrupting the ecological integrity and functioning of the Pipestone Creek ecosystem.

To assess these potential threats, the NPS began monitoring the aquatic invertebrates of Pipestone Creek within the park beginning in 1989 (Harris et al. 1991). From 1992 to 1995, the NPS Midwest Regional Office funded additional aquatic

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


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

invertebrate sampling efforts within the creek. However, sampling was sporadic and mostly outside the collection season of interest (summer) for this report. Concerted monitoring efforts began in 1996 and 1997. Peitz and Cribbs (2005) reported on status and trends of the aquatic invertebrate community at Pipestone NM from inception of monitoring through 2004. Bowles (2009) reported on the trend in the resource from 2005 to 2007, Bowles et al. (2013) reported on the data collected through 2010, and Bowles (2015) reported on the data collected through 2013. The purpose of this report is to summarize aquatic invertebrate monitoring data collected from 1989 through 2016 but will not include trend analysis results.

Methods

Methods and procedures used in this report follow Bowles et al. (2008, Monitoring Protocol for Aquatic Invertebrates of Small Streams in the Heartland Inventory & Monitoring Network). Samples were collected from Pipestone Creek (Figure 1) during a summer index period.

Sample Collection

Aquatic invertebrates were collected from three successive riffles with three benthic invertebrate samples collected per riffle, resulting in nine samples. A Surber stream bottom sampler (500 μm mesh, 0.09 m^2) was used to collect the samples, and a hand-held

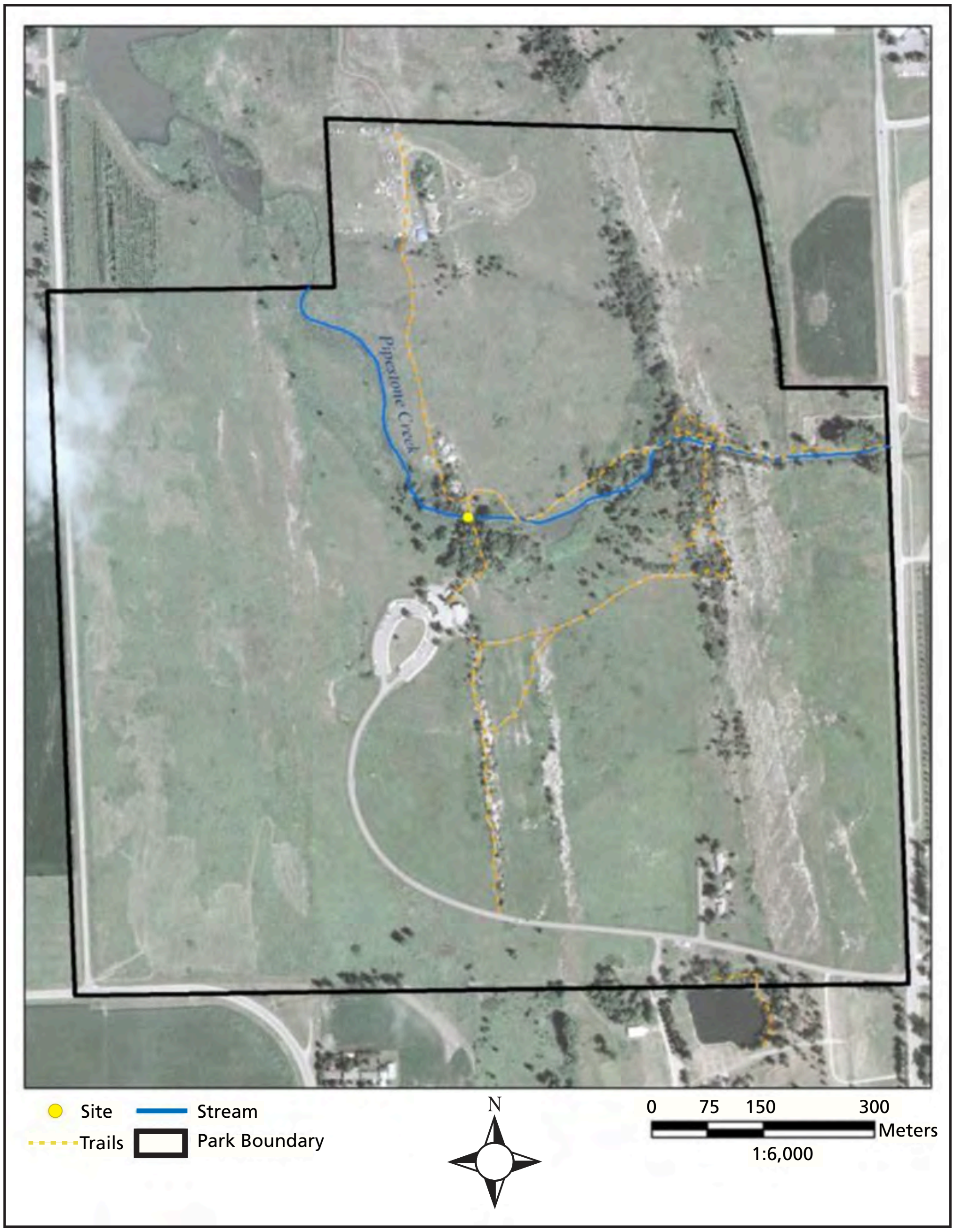

Figure 1. Map of Pipestone National Monument, Minnesota, showing the lower boundary of the invertebrate monitoring site (yellow dot) on Pipestone Creek.

Figure 2. Collecting invertebrates with a Surber sampler. NPS.

garden cultivation tool was used to dislodge invertebrates from the substrate (Figure 2). A soft bursh was used to dislodge invertebrates attached to large substrate. 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.

Metrics calculated for each sample included percent intolerant taxa (tolerance value ≤3.0), percent EPT taxa (Ephemeroptera, Plecoptera, Trichoptera), EPT/ Chironomidae ratio (EPT density/ (EPT density + Chironomidae density)), taxa richness, EPT richness, Shannon's diversity index, taxa evenness (where 0 = minimum evenness and 1 = maximum evenness), and the Hilsenhoff Biotic Index (HBI; Bowles et al. 2008). 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. Shannon's 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), but the actual value is contingent on the number of species in the community. Tolerance values (TV) used for calculating the HBI follow Bowles et al. (2008). Tolerance values range from 0 (most intolerant) to 10 (most tolerant).

For details on calculating and interpreting metrics used in this report refer to Bowles et al. (2008). 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).

For each sample, current velocity (m/sec) and depth (cm) were recorded immediately in front of the sampler. Beginning in 2006, qualitative habitat variables (embeddedness, periphyton, filamentous algae, aquatic vegetation) 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 (Bowles et al. 2008). Discharge measurements serve to illustrate the general flow characteristics for Pipestone Creek in a given sampling year and are not intended to be exact measurements. Discharge was not measured in 2010.

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 at least 24 hours prior to sampling for each stream using calibrated data loggers or sondes. The data logger is placed upstream of the riffles sampled. 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.

Data Analysis

The data addressed in this report are only those collected during the summer index period (July–September) from the general sampling reach described in Bowles et al. (2008). Univariate control charts were established for Pipestone Creek 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). Data from 1996 to 2004 serve as a baseline for constructing thresholds based on standard deviations of the mean of these data points. This period was chosen because the methods used were most similar to those used in Peterson et al. (1999) and the current protocol. Data collected from 2005 to 2016 are evaluated against this baseline period.

Control charts plot a characteristic through time with reference to its expected value. Expected values were developed by determining the natural variability within the baseline data, and setting a range of values based on that 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 those community metrics that respectively decrease or increase due to stressors. 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 equal to 1.86 standard deviations is analogous to significance tests at a critical value of 0.05 for one-tailed tests. The student's t-distribution (df = 8) was used to determine the one-tailed area because of the relatively small sample size. A critical value of 0.05 is widely accepted as the 'standard' in significance testing approaches.

Pipestone Creek at Pipestone National Monument, Minnesota. Photograph by Amy Meredith/Flickr/CC by-ND-2.0.

Results

Diversity and community metrics largely remained within previously defined control limits (Figures 3–9). The sole exceptions were for the Ephemeroptera, Plecoptera, Trichoptera (EPT)/Chironomidae ratio, which barely exceeded the control limit for this sampling event, and Hilsenhoff Biotic Index (HBI). Water quality measurements (Table 1) met state standards (Table 2) except for dissolved oxygen, which frequently was below 7 mg/litter at the site located above the falls. A summary of habitat parameters is shown in Table 3, but they are not analyzed further here with respect to trend or correlation with invertebrate metrics.

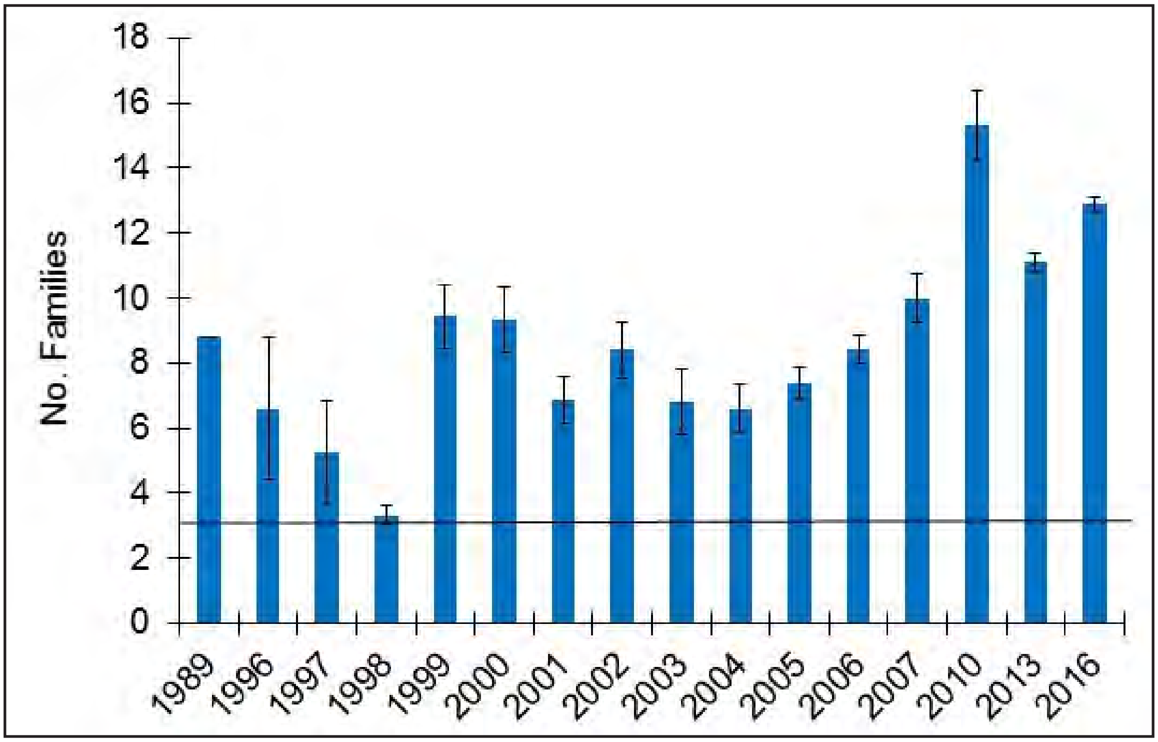

Figure 3. Control chart for family richness for Pipestone Creek, Pipestone National Monument, Minnesota. Points are means for a given year, and the vertical bars are standard errors (n = 3). Note the 7-year interval between 1989 and 1996, and 3-year intervals after 2007. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

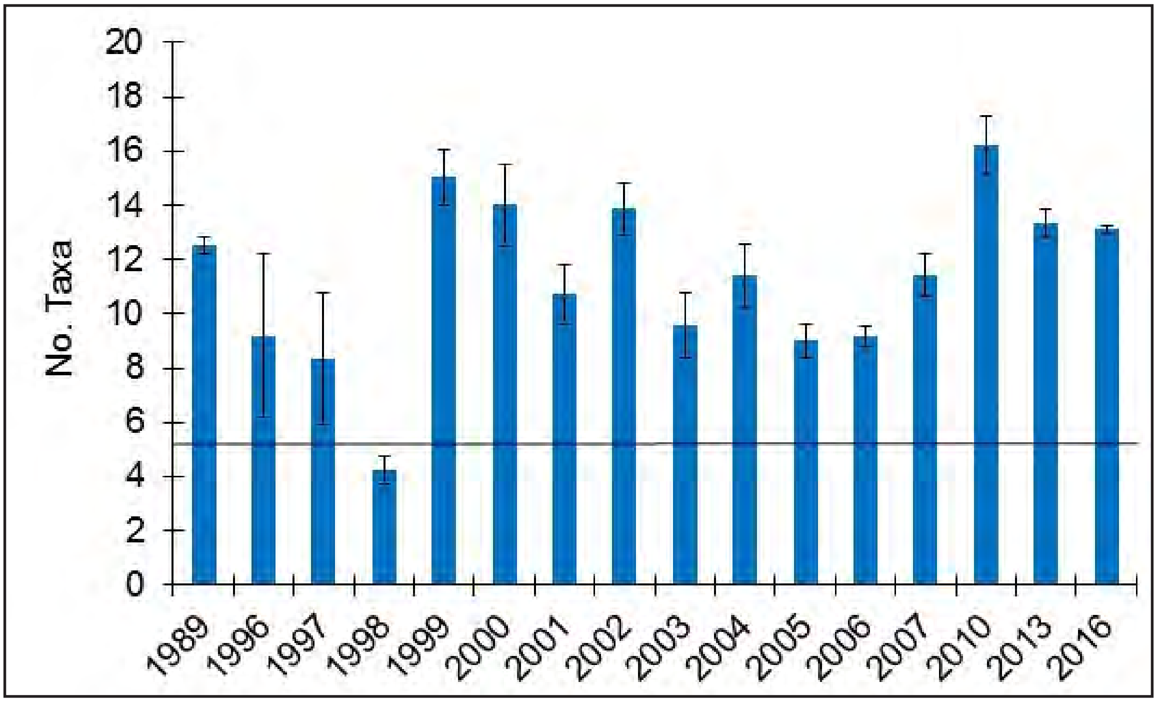

Figure 4. Control chart for taxa richness for Pipestone Creek, Pipestone National Monument, Minnesota. Points are means for a given year, and the vertical bars are standard errors (n = 3). Note the 7-year interval between 1989 and 1996, and 3-year intervals after 2007. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

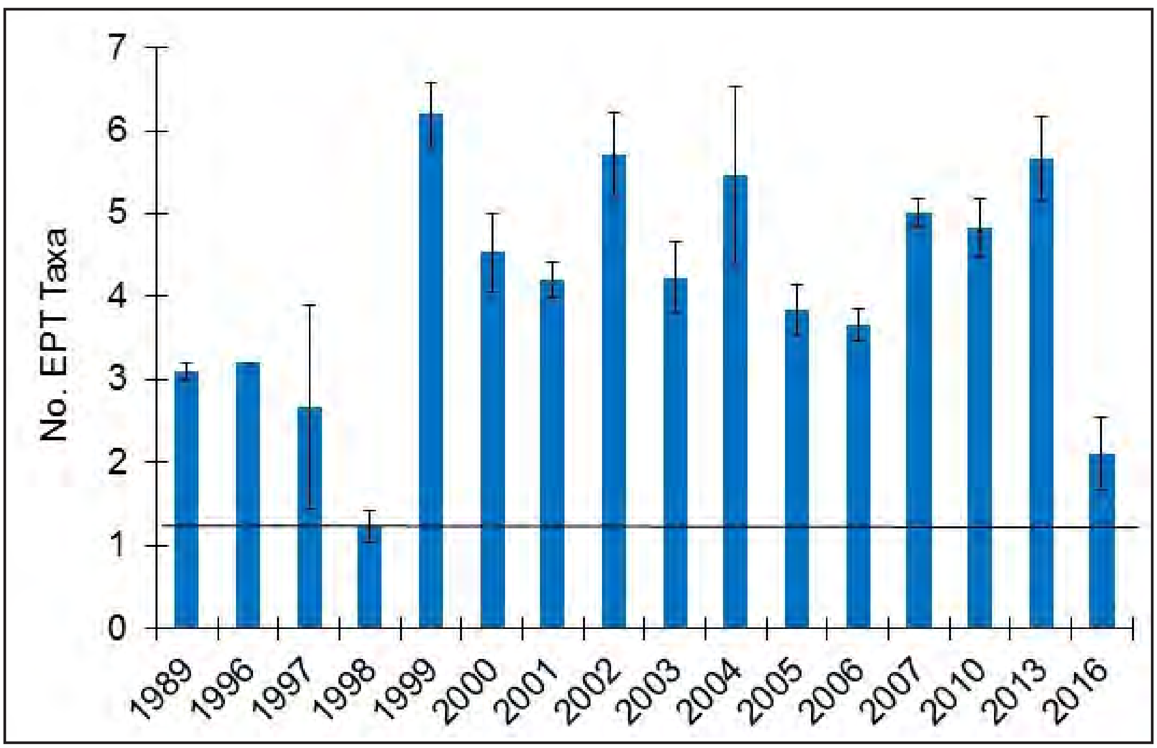

Figure 5. Control chart for Ephemeroptera, Plecoptera, Trichoptera (EPT) richness for Pipestone Creek, Pipestone National Monument, Minnesota. Points are means for a given year, and the vertical bars are standard errors (n = 3). Note the 7-year interval between 1989 and 1996, and 3-year intervals after 2007. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

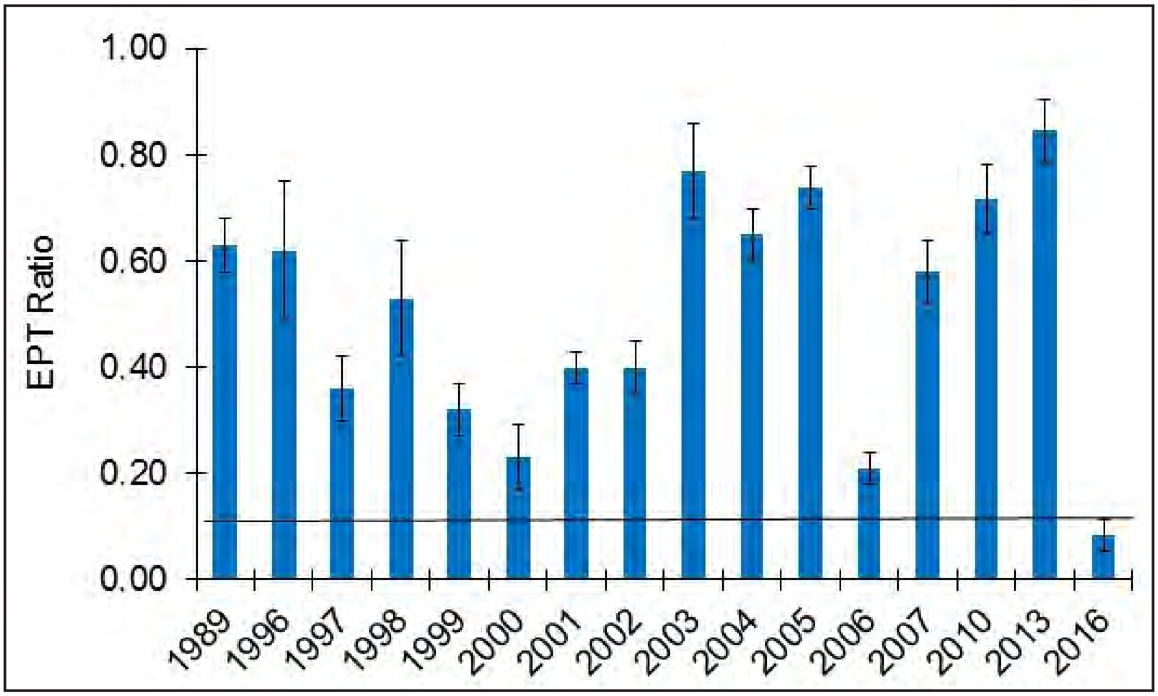

Figure 6. Control chart for Ephemeroptera, Plecoptera, Trichoptera (EPT)/Chironomidae ratio for Pipestone Creek, Pipestone National Monument, Minnesota. Points are means for a given year, and the vertical bars are standard errors (n = 3). Note the 7-year interval between 1989 and 1996, and 3-year intervals after 2007. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

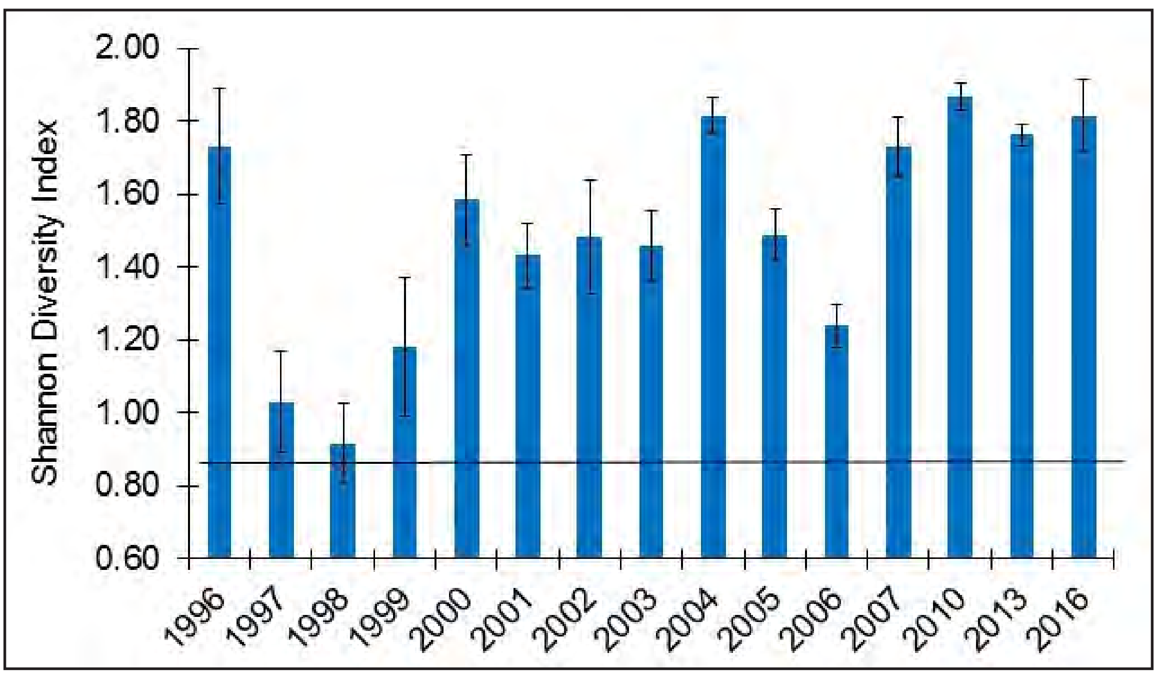

Figure 7. Control chart for Shannon's Diversity Index for invertebrate taxa for Pipestone Creek, Pipestone National Monument, Minnesota. Points are site means for a given year, and the vertical bars are standard errors (n = 3). Note the 7-year interval between 1989 and 1996, and 3-year intervals after 2007. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

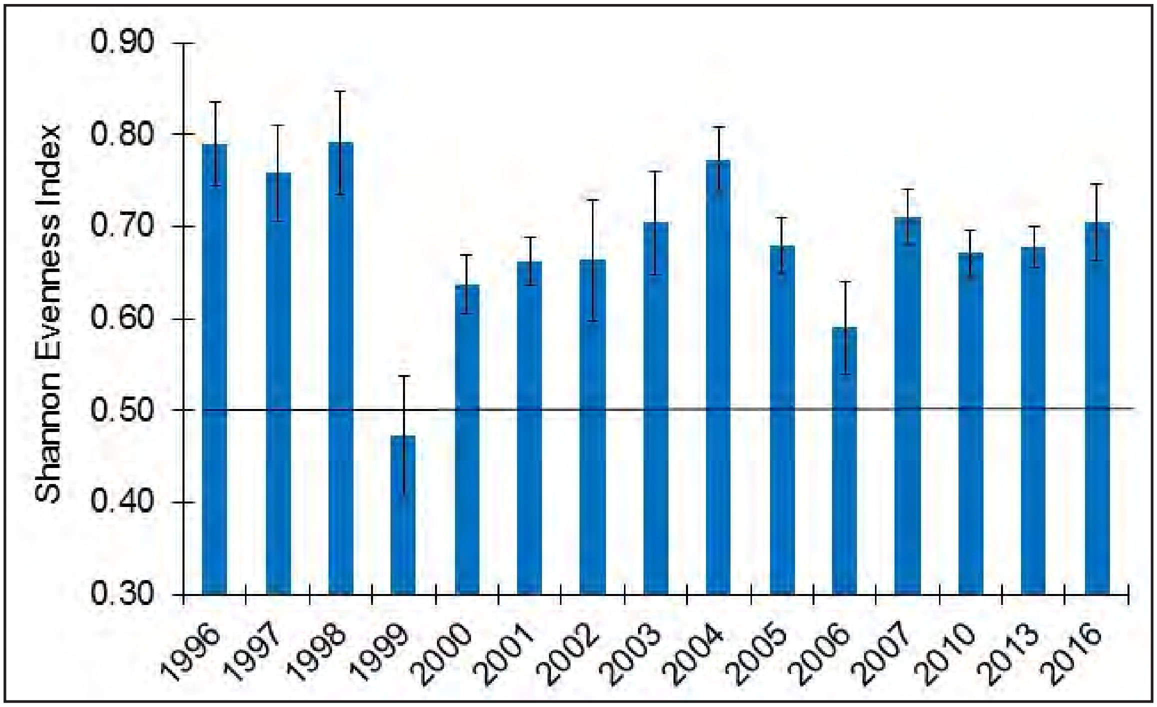

Figure 8. Control chart for Shannon's Evenness Index for invertebrate taxa for Pipestone Creek, Pipestone National Monument, Minnesota. Points are site means for a given sampling date, and the vertical bars are standard errors (n = 3). Note the 7-year interval between 1989 and 1996, and 3-year intervals after 2007. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

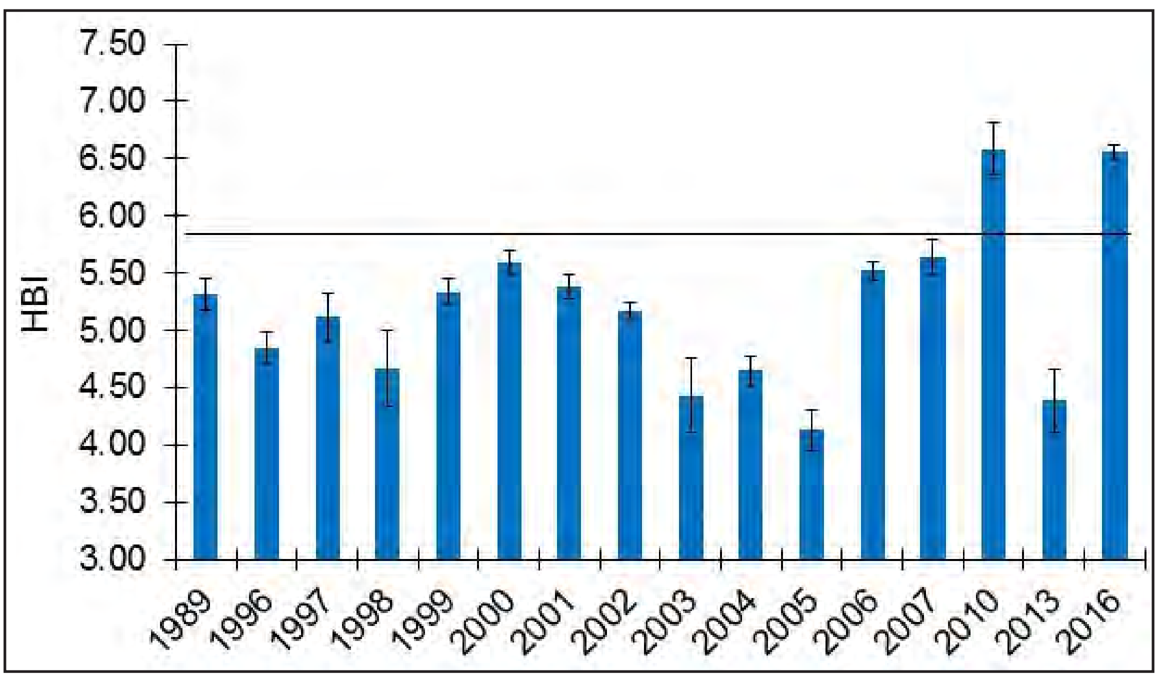

Figure 9. Control chart for Hilsenhoff Biotic Index for Pipestone Creek, Pipestone National Monument, Minnesota. Points are site means for a given year, and the vertical bars are standard errors (n = 3). Note the 7-year interval between 1989 and 1996, and 3-year intervals after 2007. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

Table 1. Water quality characteristics for Pipestone Creek, Pipestone National Monument, Minnesota, 2005–2016. Data in 2005 were collected with hand-held instruments, and all other data were collected continuously with a data logger. Values are means with standard errors in parentheses.

Year	Site	N	Temperature (°C)	Specific Conductance (µm/cm)	Dissolved Oxygen (mg/liter)	pH	Turbidity (NTU)
2005	All sites	10	20.32 (0.20)	653.8 (0.62)	7.78 (0.01)	7.84 (0)	–
2006	Above falls	41	18.33 (0.23)	–	8.30 (0.11)	8.05 (0.01)	–
2006	Above falls	32	17.58 (0.38)	776.53 (7.09)	9.35 (0.10)	8.01 (0.02	16.47 (2.49)
2007	Above falls	40	21.54 (0.40)	710.64 (4.35)	7.72 (0.08)	8.10 (0.02)	8.84 (0.65)
2007	Below falls	35	22.28 (0.36)	712.97 (2.38)	7.95 (0.14)	8.21 (0.01)	23.70 (0.13)
2010	Above falls	36	21.01 (0.26)	585.97 (22.08)	6.16 (0.18)	7.69 (0.02)	20.69 (3.16)
2010	Below falls	36	21.54 (0.28)	617.14 (24.21)	6.95 (0.11)	7.95 (0.01)	13.32 (1.83)
2013	Above falls	42	16.89 (0.20)	601.90 (1.39)	10.64 (0.15)	7.78 (0.01)	4.18 (0.11)
2013	Below falls	36	18.57 (0.31)	521.30 (2.36)	10.45 (0.38)	8.33 (0.03)	5.93 (0.15)
2016	Above falls	41	18.00 (0.29)	656.90 (11.03)	6.60 (0.08)	7.70 (0.01)	5.51 (0.49)
2016	Below falls	42	18.39 (0.28)	655.79 (9.82)	9.93 (0.18)	8.01 (0.01)	9.52 (0.40)

Table 2. Acceptable ranges for water quality parameters in Minnesota streams for aquatic life. From Minnesota Administrative Rules (2018).

Water Quality Parameter	Acceptable Range
Temperature	<30 °C
Dissolved Oxygen	24 hr minimum of 7 mg/liter
Specific Conductance	<1,000 µS/cm
pH	6.5-8.5
Turbidity	n/a

Table 3. Summary of habitat parameters for Pipestone Creek, Minnesota. Values are means with standard errors in parentheses.

Year	Depth (cm)	Current Velocity (m/sec)	% Vegetation	% Filamentous algae	% Periphyton	% Substrate embeddedness	Mean substrate size (mm)	Discharge (m^3/sec)
2007	12.44 (2.44)	0.19 (0.05)	17.78 (4.34)	3.88 (3.89)	25.0 (0)	39.44 (9.55)	34.58 (11.26)	0.05
2010	29.44 (0.94)	0.72 (0.05)	66.94 (15.82)	0	20.56 (2.22)	20.56 (2.22)	86.94 (18.54)	No data
2013	10.44 (1.60)	0.35 (0.08)	22.78 (2.22)	0	32.22 (7.22)	22.78 (2.22)	69.83 (6.93)	0.06
2016	20.67 (2.91)	0.19 (0.06)	28.61 (3.61)	3.33 (0.97)	25.0 (0)	18.33 (3.84)	149.33 (28.88)	0.11

Discussion

Invertebrate metrics largely remained within previously described control limits for Pipestone Creek, with Ephemeroptera-Plecoptera-Trichoptera (EPT)/Chironomidae ratio and Hilsenhoff Biotic Index (HBI) being the exceptions. Smaller EPT/Chironomidae ratios indicate that chironomids are more abundant in the stream relative to EPT taxa, which can indicate degradation of water quality. Higher HBI values also may indicate disturbance of the stream invertebrate community. The decrease in EPT values in 2016 coupled with the increases in EPT/Chironomidae ratio and HBI could possibly indicate increasing disturbance or degradation in the watershed. Conversely, these observations could be due to natural variation or other stressors that will self-resolve.

Because water quality met state standards with the exception of low dissolved oxygen in some years, the invertebrate community condition for the last sampling date are not of great concern. Regardless, future data should be scrutinized to determine if the invertebrate communities are trending toward degradation. Although the condition of Pipestone Creek at Pipestone National Monument is largely sound, it remains an urbanized stream and any observed perturbations in the invertebrate community and water quality are beyond the control of the park. Maintaining the integrity of the stream riparian area in the park will provide some localized offsets from impacts originating outside of the park.

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

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