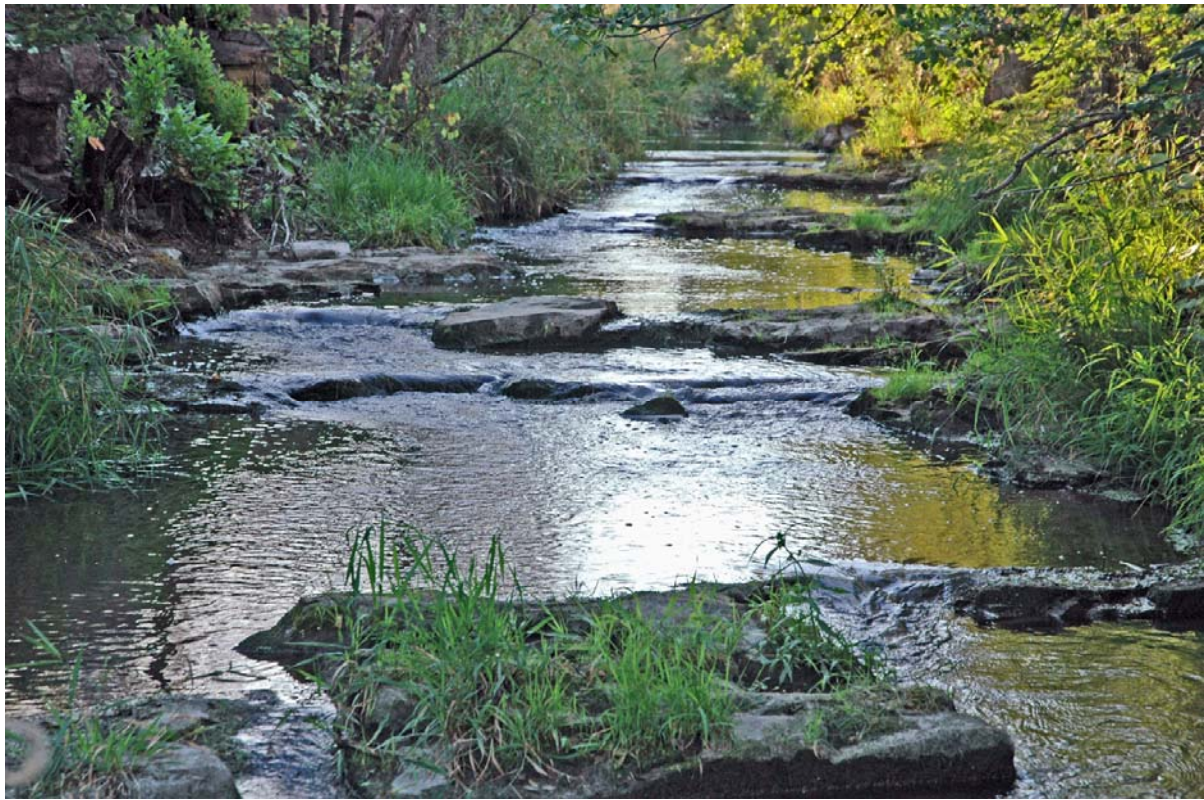




Aquatic Invertebrate Monitoring at Pipestone National Monument

2005-2007 Trend Report

Natural Resource Technical Report NPS/HTLN/NRTR—2009/241



ON THE COVER

Pipestone Creek, Pipestone National Monument

Photo from The Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program

Aquatic Invertebrate Monitoring at Pipestone National Monument

2005-2007 Trend Report

Natural Resource Technical Report NPS/HTLN/NRTR—2009/241

David E. Bowles

National Park Service
The Heartland I&M Network and Prairie Cluster Prototype Monitoring Program
Wilson's Creek National Battlefield
6424 West Farm Road 182
Republic, MO 65738

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Abstract

In the late 1980's, the National Park Service (NPS) began an intensive program to monitor water quality and invertebrate community structure in prairie streams at several midwestern parks. Included in this baseline study was Pipestone National Monument (PIPE). Preliminary monitoring was conducted at PIPE in 1989. Following this baseline year, monitoring was not conducted again until 1996, but it has since been conducted annually. Since 2006, monitoring at PIPE has been based on a monitoring protocol developed by the Heartland Network using revised methodology from previous protocols. The objectives of current monitoring 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 multi-metric indices as indicators of water quality and habitat condition. Pipestone Creek is impacted from a combination of agricultural practices and urbanization and is listed as a 303d stream by the Minnesota Pollution Control Agency due to elevated turbidity and fecal coliform levels. Water quality, habitat, and invertebrate community metrics were generally consistent among sampling years. Although some minor differences were observed, they are likely not biologically important. Based on the invertebrate community metrics reported here, the water quality of Pipestone Creek within PIPE has not diminished beyond that reported in earlier studies. It appears that stream condition is generally good, although there is mild impairment attributed to activities in the watersheds outside the park boundaries. There are few available options to park management for mitigating this situation, largely because the impacts to the invertebrate community and water quality originate upstream of the monument boundaries. Continued establishment and widening of riparian buffer zones along Pipestone Creek above the park will aid in protecting aquatic life in Pipestone Creek as well as in-stream habitat from local chemical runoff and sedimentation.

Acknowledgements

I thank David Peitz, Tyler Cribbs, Gia Wagner, Hope Dodd, Jan Hinsey, Mike DeBacker, Greg Wallace, and Lloyd Morrison for assisting with this project.

Introduction

Pipestone Creek, a tributary of the Big Sioux River, meanders from east to west about 100 km through southwestern Minnesota. The creek originates 19.3 km northeast of Pipestone National Monument (PIPE) 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 the park on the south end. Pipestone Creek flows through the center of the monument and widens twice within its boundaries to form Lake Hiawatha and an unnamed pond. A recreational lake on Pipestone Creek borders the Monument 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 the park was lowered 2.5 to 3.0 m in the early 1900's (Harris *et al.* 1991). Above the falls, Pipestone Creek is channelized, essentially without meanders, and with a largely bedrock substrate.

Water pollution within the watershed is primarily agricultural in origin, but the city of Pipestone, Minnesota releases effluent into Pipestone Creek below the monument boundary. The National Park Service (NPS), Water Resources Division, conducted an extensive review of historic water quality data for an area 4.8 kilometers upstream and 1.6 kilometers downstream of the park (NPS Water Resources Division 1999). This report noted that since 1974 dissolved oxygen, pH, cadmium, copper, lead, and zinc have periodically exceeded their respective EPA criteria for freshwater aquatic life use. Additionally, concentrations of nitrate, nitrite plus nitrate, chloride, cadmium, lead and methylene chloride have exceeded EPA drinking water criteria during monitoring events since 1974 (Water Resources Division 1999). In addition, Pipestone Creek is listed by the state of Minnesota as a 303d waterway due to fecal coliform contamination and elevated turbidity (Minnesota Pollution Control Agency 2007), because concentrations of these contaminants have exceeded limits for freshwater bathing and aquatic life uses, respectively.

The various anthropogenic disturbances described above have a significant potential for disrupting the ecological integrity and functioning of the Pipestone Creek ecosystem. To address these concerns, the NPS began monitoring the aquatic invertebrates of Pipestone Creek within PIPE beginning in 1989 (Harris *et al.* 1991). From 1992-1995, the NPS Midwest Regional Office funded additional aquatic 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 1996-1997, following creation of the Prairie Cluster Prototype Long-term Ecological Monitoring Program, now known as the Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program. Peitz and Cribbs (2005) reported on status and trends of the aquatic invertebrate community at PIPE from inception of monitoring through 2004. The purpose of this report is to summarize aquatic invertebrate monitoring data collected from 2005-2007 and assess that data with respect to trend since the inception of monitoring in 1989.

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. Three benthic invertebrate samples were collected from each of three successive riffles using a Surber stream bottom sampler (500 μm mesh, 0.093 m^2). 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 (meters/second) and depth (cm) were recorded directly in front of the sampling net frame. Qualitative habitat variables (percent embeddedness, periphyton, filamentous algae, aquatic vegetation, deposition, and organic material) were 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 based on the Wentworth scale (Wentworth 1922). Stream discharge was measured upstream of the sampling site after invertebrate collections were completed in 2007. Water quality data for 2005 represent static readings taken with hand-held meters. For 2006-2007 hourly readings of water quality parameters (temperature, dissolved oxygen, specific conductance, pH, turbidity) were recorded continuously at least 24 hours prior to sampling using calibrated data loggers or sondes. The water quality data collected for this study are intended to describe the prevailing conditions that influence the structure of invertebrate communities. As such, they 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). Moreover, the water quality data represent only a small snap-shot of the broader range of possible conditions over longer periods, and should be cautiously interpreted. Due to the limitations of using water quality data obtained with data loggers, the invertebrate community is used here as a surrogate of the long-term water quality condition in Pipestone Creek.

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). Therefore, 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. 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 of (mean $\pm$ 1.86 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 1.86 standard deviations is analogous to significance tests at a critical value of 0.05 for one-tailed tests (since we are only interested in change in one direction). 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. Control limits may need to be reset after more data are accumulated.

Data from 1996-2004 serve as a baseline and were used to construct thresholds based on standard deviations of the mean of these data points. The data addressed in this report are only those collected during the July-August index period from the general sampling reach described in Bowles *et al.* (2008), and it does not include all historical data summarized in Peitz and Cribbs (2005). A critical value of 0.05 indicates that one out of every 20 data points will exceed this limit if the population is not changing, which is our assumption. Thus, the primary purpose of sampling to date with respect to control chart construction has been to establish a baseline and evaluate natural variability. Data collected from 2005-2007 are evaluated against this baseline period.

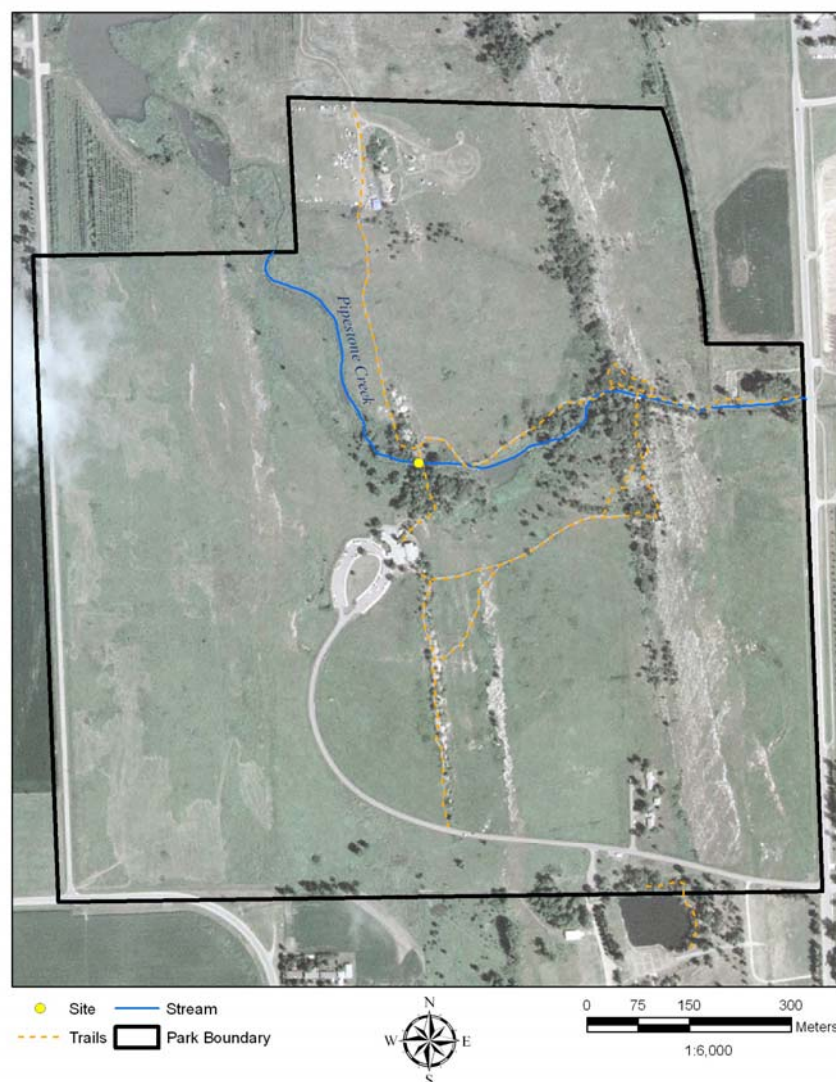


Figure 1. Map of Pipestone National Monument, Minnesota showing the lower boundary of the invertebrate monitoring site (yellow dot) on Pipestone Creek.

Results

Water quality data for Pipestone Creek were generally consistent among years sampled (2005-2007) (Table 1). Generally, the water quality data reported here, exclusive of turbidity, fell within acceptable ranges for water quality parameters in Minnesota streams (Table 2). Turbidity was substantially higher than the acceptable range of 25 NTU or less.

Although only a single set of useable habitat variables have been collected at Pipestone Creek using the current protocol, it appears that embeddedness in the sample area was moderately high (~40%) while periphyton and deposition were relatively low at about 25% (Figure 2). Percent vegetation (18%) is attributed to aquatic mosses that grow in the creek. Percent filamentous algae and organic material were both low (<10%). Mean substrate size increased from upstream to downstream, although there was considerable overlap in observed particle sizes (Figure 3). In general, dominant substrate ranged in size from Wentworth Sizes 11-15 (11-64 mm), which corresponds to gravel and pebble substrate. Mean depth and current velocity among samples in 2007 were 12.4 +/- 2.39 cm (mean +/- standard error) and 0.19 +/- 0.05 cm/second, respectively. Discharge for Pipestone Creek in 2007 was 0.05 m³/second.

Summary data from 1989-2007 for invertebrate community metrics, including family and genus richness, Ephemeroptera, Plecoptera, Trichoptera (EPT) richness, ETP/Chironomidae ratio, Shannon Index, Shannon Evenness Index, and Hilsenhoff Biotic Index (HBI) are shown in Table 3. Control charts created for each metric generally showed that most annual means did not exceed the control limits and no means have exceeded the warning thresholds for management action since 1998 (Figures 4-11). The reasons for the consistently low scores among some metrics in 1998 are not known, but potentially this could be a result of samples being collected too soon following a spate that year, sampler error, or other unknown factors. Because the corresponding metric values were generally higher before and following 1998, the low values for that year are not likely to be biologically meaningful.

Table 1. Water quality characteristics for Pipestone Creek, Pipestone National Monument, 2005-2007. Data in 2005 were collected with hand-held instruments, and data for 2006-2007 were collected continuously with a data logger. Values are mean, standard deviation, and range.

Year	N	Statistic	Temperature (°C)	Specific Conductance (µm/cm)	Dissolved Oxygen (mg/liter)	pH	Turbidity (NTU)
2005	10	Mean	20.32	653.8	7.78	7.84	n/a
		Standard Deviation	0.09	1.95	0.11	0.02	n/a
		Range	20-20.9	647-661	7.3-8.2	7.66-7.89	n/a
2006	10	Mean	20.32	653.80	7.78	7.84	n/a
		Standard Deviation	0.29	6.18	0.33	0.07	n/a
		Range	20.0-20.9	647-661	7.3-8.2	7.66-7.89	n/a
2007 (upstream)	40	Mean	17.05	783.2	9.44	7.98	180.27
		Standard Deviation	2.23	39.74	0.54	0.11	410.73
		Range	14.03-21.18	710-839	8.30-10.29	7.82-8.19	5.4-1411.3
2007 (downstream)	35	Mean	21.54	710.64	7.72	8.09	8.84
		Standard Deviation	2.38	26.12	0.49	0.10	3.90
		Range	17.09-26.82	632-742	6.72-8.69	7.9-8.36	3.0-18.3

Table 2. Acceptable ranges for water quality parameters in Minnesota streams. Adapted from Minnesota Administrative Rules (2009).

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	25 NTU

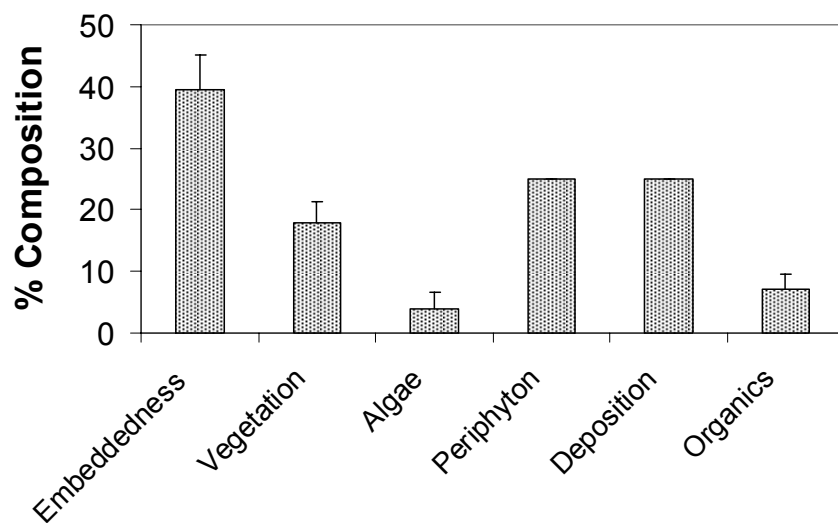


Figure 2. Means and standard errors for habitat variables recorded for Pipestone Creek, Pipestone National Monument, 2007.

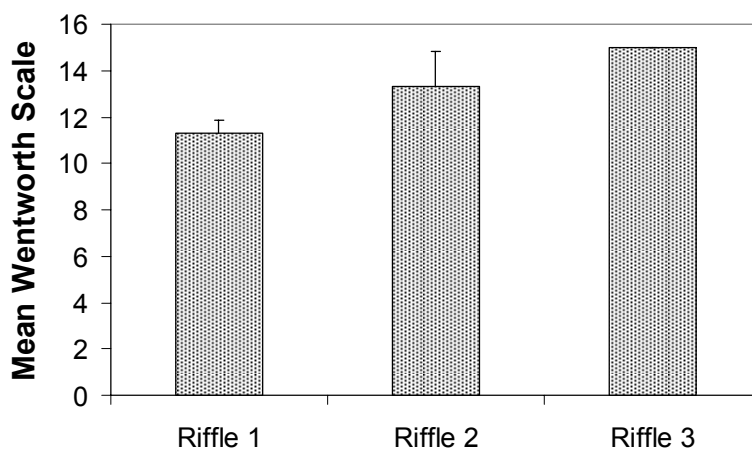


Figure 3. Mean substrate size and standard deviations for riffles sampled at Pipestone Creek, Pipestone National Monument, 2007.

Table 3. Mean and standard error (in parentheses) of invertebrate metrics collected from Pipestone Creek, Pipestone National Monument, 1989 and 1996-2007. N= number of samples collected. Hilsenhoff Biotic Index was based on family-level scores prior to 2005.

Year	1989	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
N	10	10	30	30	30	30	30	30	30	20	19	17	9
Family Richness	8.8 (0)	6.6 (2.2)	5.27 (1.57)	3.33 (0.27)	9.43 (0.96)	9.33 (1.02)	6.87 (0.74)	8.4 (0.88)	6.83 (1)	6.6 (0.73)	7.37 (0.50)	8.41 (0.45)	10 (0.73)
Taxa (Genus) Richness	12.5 (0.3)	9.2 (3)	8.33 (2.45)	4.22 (0.53)	15.03 (1)	14 (1.49)	10.73 (1.09)	13.87 (0.94)	9.6 (1.2)	11.4 (1.19)	9 (0.59)	9.18 (0.36)	11.44 (0.78)
EPT Richness	3.1 (0.1)	3.2 (0)	2.67 (1.23)	1.23 (0.2)	6.2 (0.38)	4.53 (0.47)	4.2 (0.21)	5.7 (0.51)	4.23 (0.42)	5.45 (1.07)	3.84 (0.31)	3.65 (0.19)	5 0.17
EPT Ratio	0.63 (0.05)	0.62 (0.13)	0.36 (0.06)	0.53 (0.11)	0.32 (0.05)	0.23 (0.06)	0.4 (0.03)	0.4 (0.05)	0.77 (0.09)	0.65 (0.05)	0.74 (0.04)	0.21 (0.03)	0.58 (0.06)
Shannon Index (Family)	1.66 (0.03)	1.44 (0.27)	0.94 (0.17)	0.9 (0.1)	1.16 (0.14)	1.09 (0.16)	1.19 (0.13)	1.3 (0.1)	1.24 (0.15)	1.28 (0.12)	n/a	n/a	n/a
Shannon Index (Genus)	n/a	1.73 (0.16)	1.03 (0.14)	0.92 (0.11)	1.18 (0.19)	1.59 (0.12)	1.43 (0.09)	1.48 (0.16)	1.4 (0.10)	1.82 (0.05)	1.49 (0.07)	1.24 (0.06)	1.73 (0.08)
Genus Evenness	n/a	0.79 (0.05)	0.76 (0.05)	0.79 (0.06)	0.47 (0.07)	0.64 (0.03)	0.66 (0.03)	0.66 (0.07)	0.70 (0.06)	0.77 (0.03)	0.68 (0.03)	0.59 (0.05)	0.71 (0.03)
Hilsenhoff Biotic Index	5.32 (0.14)	4.85 (0.14)	5.12 (0.21)	4.67 (0.33)	5.34 (0.12)	5.59 (0.11)	5.38 (0.1)	5.17 (0.07)	4.43 (0.32)	4.65 (0.13)	4.13 (0.18)	5.52 (0.08)	5.64 (0.16)

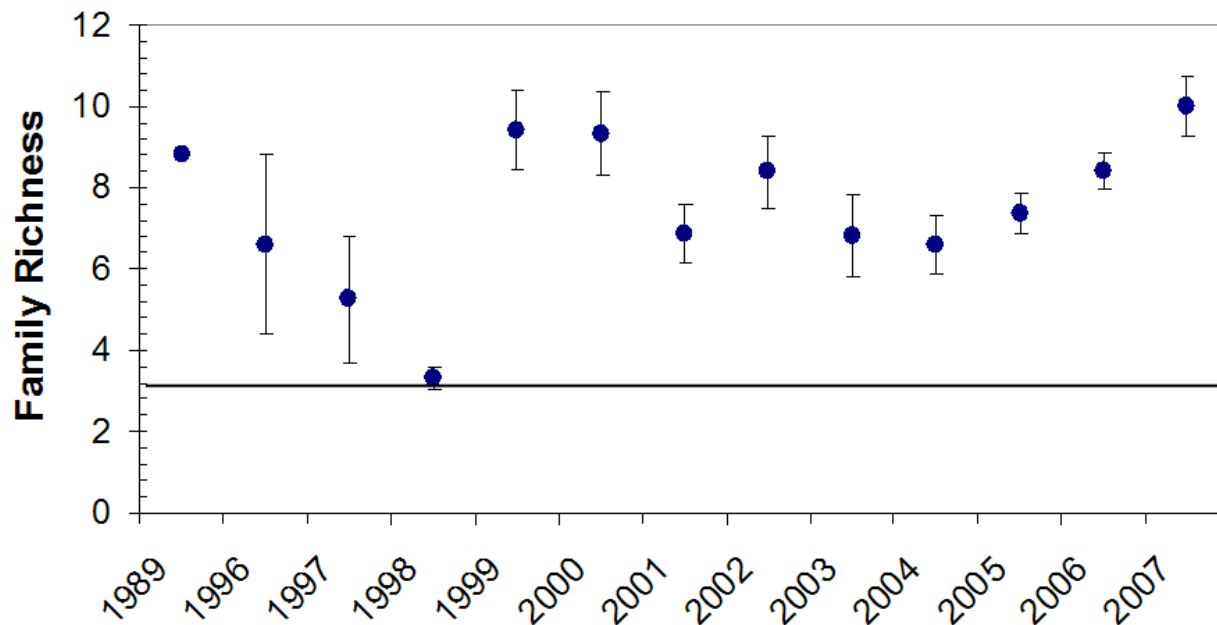


Figure 4. Control chart for family richness for Pipestone Creek, Pipestone National Monument. Points are means for a given sampling date, and the vertical bars are standard errors. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

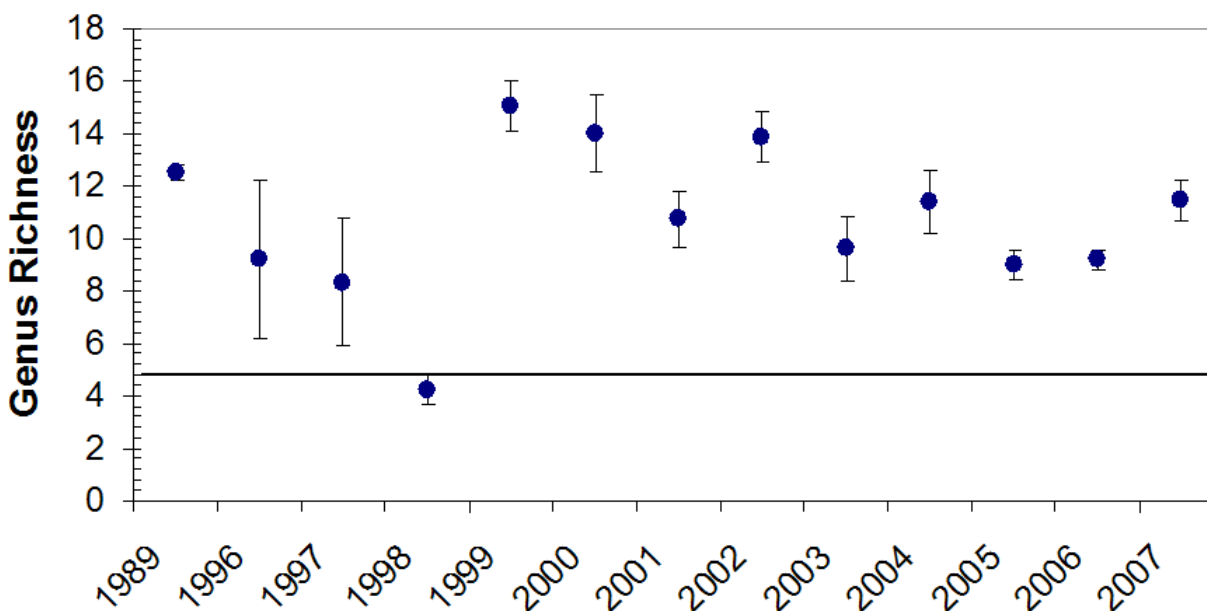


Figure 5. Control chart for genus richness for Pipestone Creek, Pipestone National Monument. Points are means for a given sampling date, and the vertical bars are standard errors. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

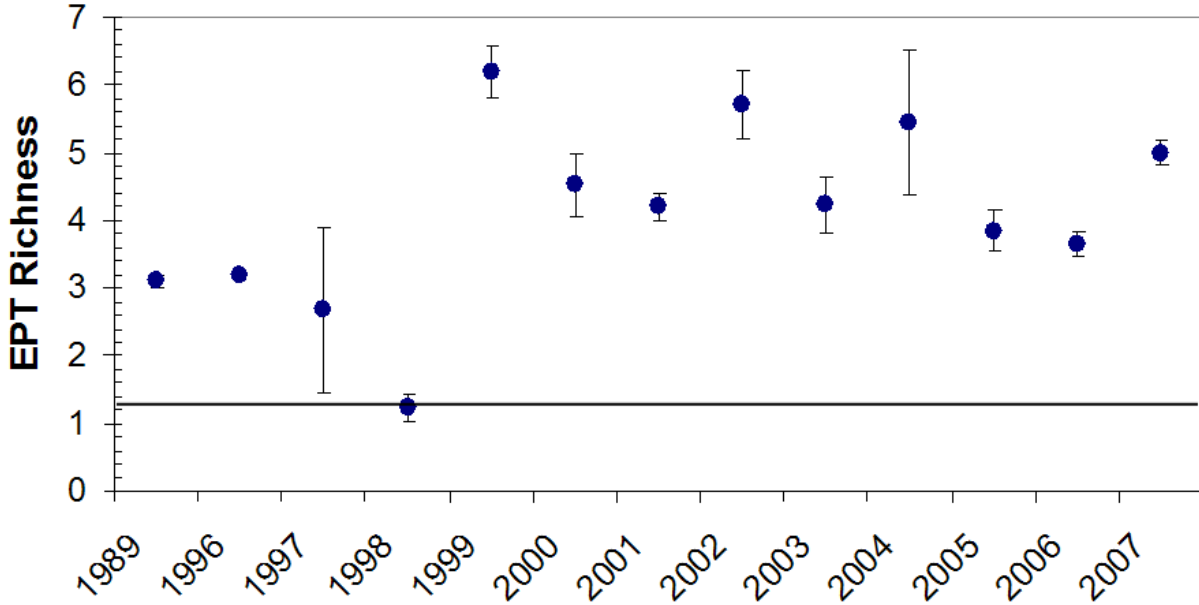


Figure 6. Control chart for Ephemeroptera, Plecoptera, Trichoptera (EPT) richness for Pipestone Creek, Pipestone National Monument. Points are means for a given sampling date, and the vertical bars are standard errors. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

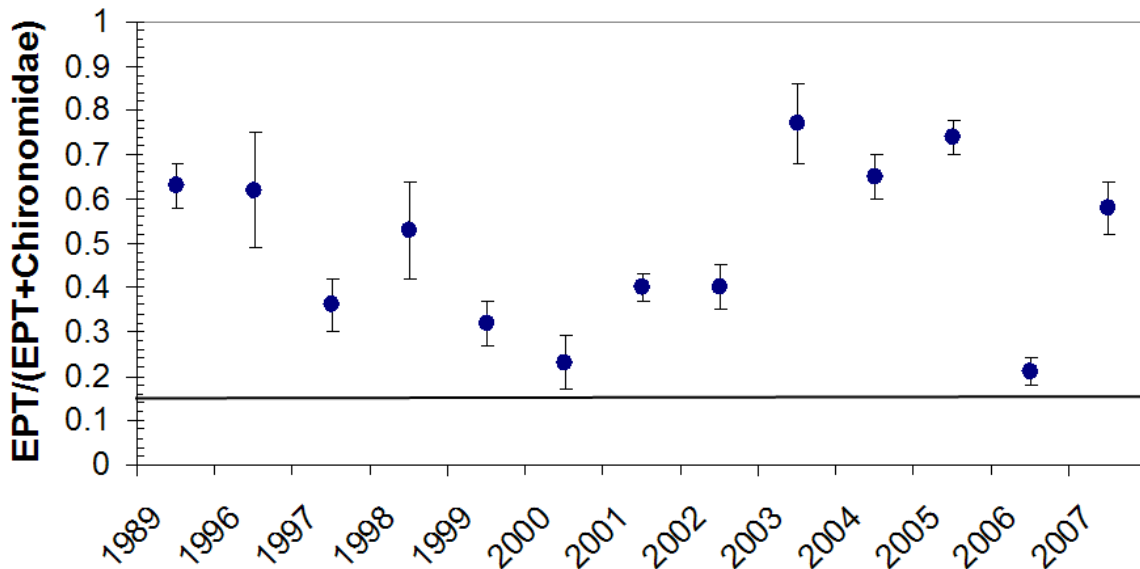


Figure 7. Control chart for Ephemeroptera, Plecoptera, Trichoptera (EPT)/Chironomidae ratio for Pipestone Creek, Pipestone National Monument. Points are means for a given sampling date, and the vertical bars are standard errors. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

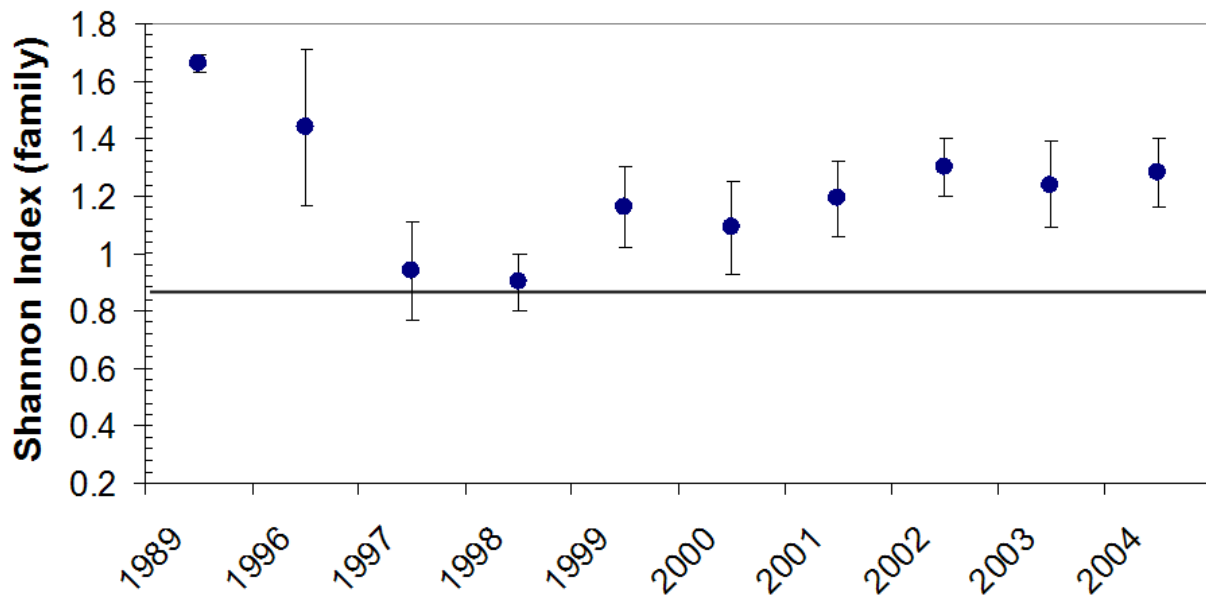


Figure 8. Control chart for Shannon Index for invertebrate families for Pipestone Creek, Pipestone National Monument. Points are means for a given sampling date, and the vertical bars are standard errors. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

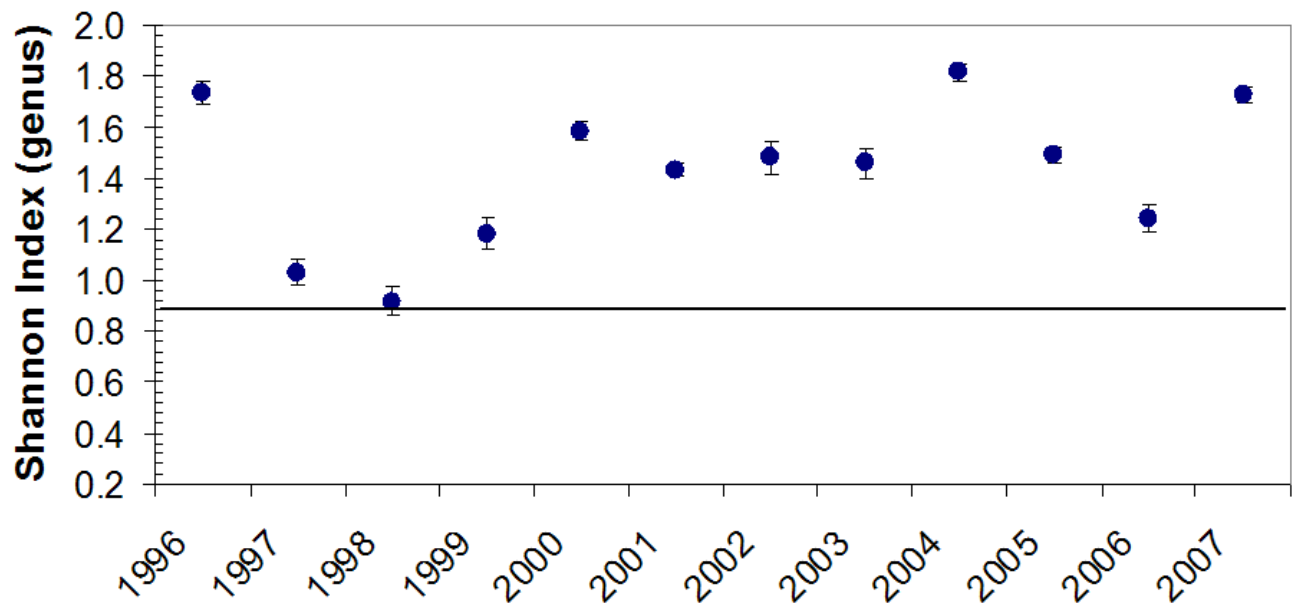


Figure 9. Control chart for Shannon Index for invertebrate genera for Pipestone Creek, Pipestone National Monument. Points are means for a given sampling date, and the vertical bars are standard errors. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

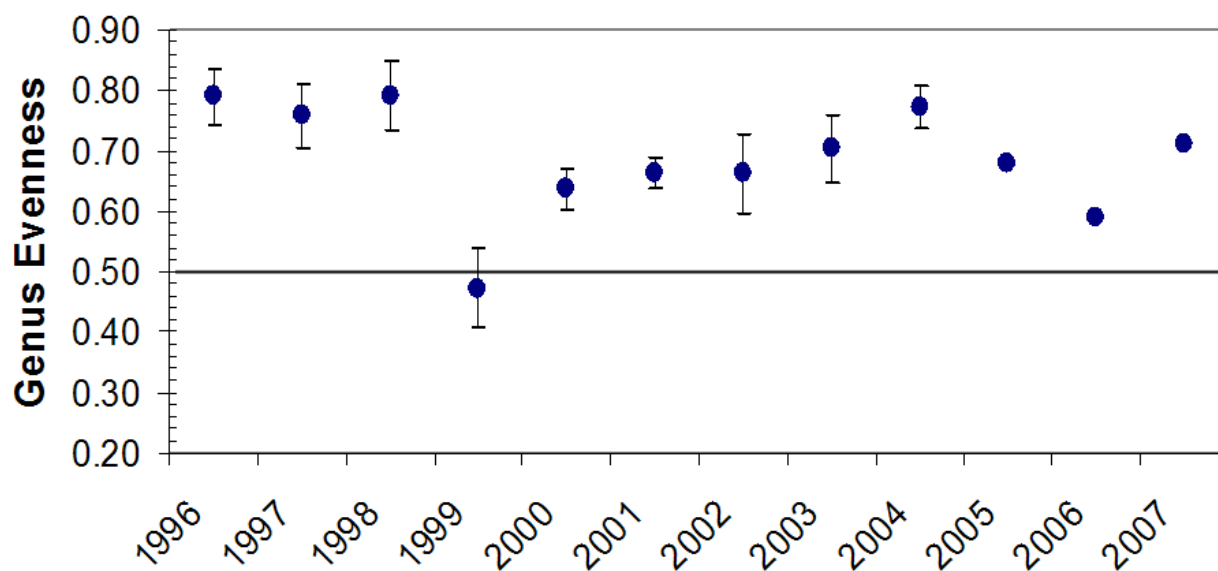


Figure 10. Control chart for Shannon Evenness Index for invertebrate genera for Pipestone Creek, Pipestone National Monument. Points are means for a given sampling date, and the vertical bars are standard errors. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

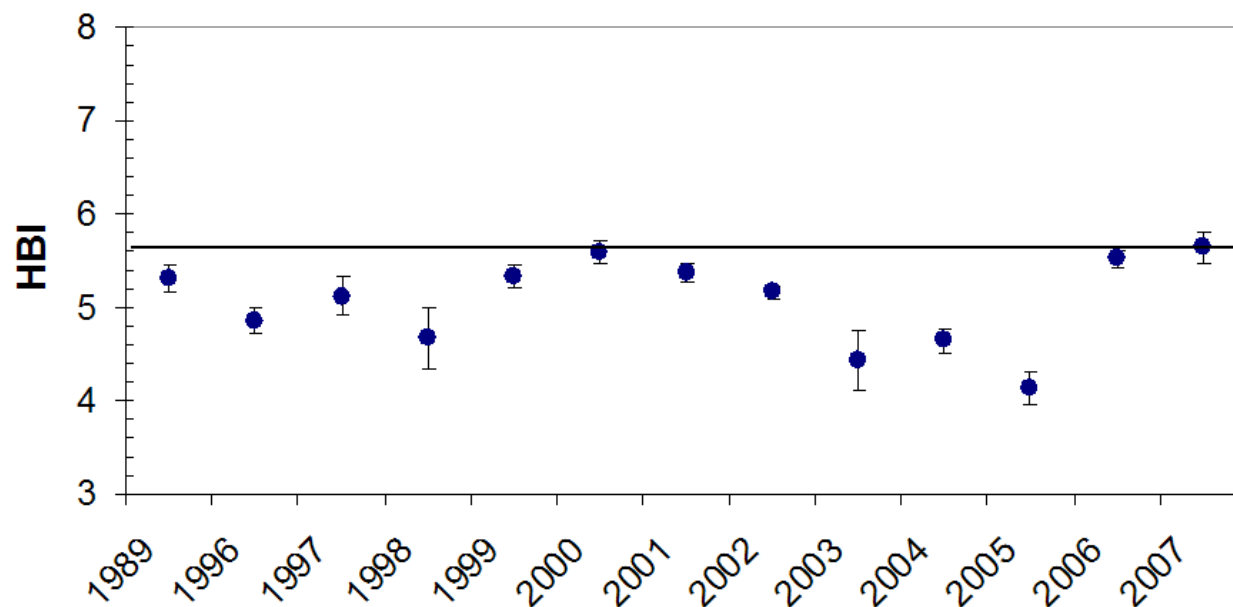


Figure 11. Control chart for Hilsenhoff Biotic Index for Pipestone Creek, Pipestone National Monument, Minnesota. Points are means for a given sampling date, and the vertical bars are standard errors. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

Discussion

Based on the invertebrate community metrics reported here, the water quality of Pipestone Creek within PIPE has not diminished beyond that reported in earlier studies (Harris *et al.* 1991, Harris *et al.* 1999, Peitz and Cribbs 2005). However, given the known anthropogenic disturbances in Pipestone Creek upstream of the park, it is likely that the aquatic invertebrate community within PIPE is mildly impaired. Many small, perennial streams of the Great Plains region, such as Pipestone Creek, historically had seasonally turbid flows, but agricultural practices over the past 150 years have degraded them into frequently turbid streams to the detriment of the fauna inhabiting them (Rabeni 1996). Pipestone Creek is listed as a 303d impaired waterway by the state of Minnesota (Minnesota Pollution Control Agency 2007) based on elevated turbidity and fecal coliform concentrations exceeding levels for aquatic consumption/aquatic recreation. Agricultural practices including row crops and livestock operations upstream of PIPE and runoff from impervious surfaces within the City of Pipestone are two of the main threats to water quality in Pipestone Creek and are largely responsible for the current 303d listing (Minnesota Pollution Control Agency 2007). The Minnesota Pollution Control Agency (2007) estimated that the overall magnitude of reduction needed to meet water quality standards for these impairments is approximately 77% and 26% for current fecal coliform bacteria and turbidity levels, respectively. Although the water quality of Pipestone Creek appears to be mildly impaired, the results reported here are generally consistent with studies of other streams in the region (MacFarlane 1983, Whiles *et al.* 2000, Hall *et al.* 2003, Kosnicki and Sites 2007, Poulton *et al.* 2007).

There are few available options to park management for mitigating this situation largely because the impacts to this invertebrate community and water quality in general originate upstream of the monument boundaries. Continued establishment and widening of riparian buffer zones along Pipestone Creek above the park will aid in protecting aquatic life in Pipestone Creek as well as in-stream habitat from local chemical runoff and sedimentation. Improved buffer zones will also reduce bank erosion within the monument by reducing stream velocity and the amount of water entering Pipestone Creek. A reduction in the impervious surfaces (sidewalks, trails and parking lot) in the monument and minimizing mowing in the riparian buffer along Pipestone Creek would also help to stabilize the riparian zone and in-stream habitat. The long history and continuing efforts of aquatic invertebrate monitoring in Pipestone Creek provide a sound tool to recognize both deterioration and chronic decline of water quality.

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The NPS has organized its parks with significant natural resources into 32 networks linked by geography and shared natural resource characteristics. HTLN is composed of 15 National Park Service (NPS) units in eight Midwestern states. These parks contain a wide variety of natural and cultural resources including sites focused on commemorating civil war battlefields, Native American heritage, westward expansion, and our U.S. Presidents. The Network is charged with creating inventories of its species and natural features as well as monitoring trends and issues in order to make sound management decisions. Critical inventories help park managers understand the natural resources in their care while monitoring programs help them understand meaningful change in natural systems and to respond accordingly. The Heartland Network helps to link natural and cultural resources by protecting the habitat of our history.

The I&M program bridges the gap between science and management with a third of its efforts aimed at making information accessible. Each network of parks, such as Heartland, has its own multi-disciplinary team of scientists, support personnel, and seasonal field technicians whose system of online databases and reports make information and research results available to all. Greater efficiency is achieved through shared staff and funding as these core groups of professionals augment work done by individual park staff. Through this type of integration and partnership, network parks are able to accomplish more than a single park could on its own.

The mission of the Heartland Network is to collaboratively develop and conduct scientifically credible inventories and long-term monitoring of park “vital signs” and to distribute this information for use by park staff, partners, and the public, thus enhancing understanding which leads to sound decision making in the preservation of natural resources and cultural history held in trust by the National Park Service.

www.nature.nps.gov/im/units/htln/



The Department of the Interior protects and manages the nation’s natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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U.S. Department of the Interior



Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov