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Aquatic Invertebrate Monitoring at Homestead National Monument of America

2005-2007 Trend Report

Natural Resource Technical Report NPS/HTLN/NRTR—2009/242

ON THE COVER
Cub Creek, Homestead National Monument of America, Nebraska
Photo from The Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program files

Aquatic Invertebrate Monitoring at Homestead National Monument of America, Nebraska

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Natural Resource Technical Report NPS/HTLN/NRTR—2009/242

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Abstract

To address concerns about water quality in Cub Creek, Homestead National Monument of America (HOME), Nebraska, the National Park Service (NPS) began monitoring the aquatic invertebrates of Cub Creek within HOME in 1989, although a concerted monitoring effort did not began until 1996. This report summarizes aquatic invertebrate monitoring data collected from 2005-2007 and further evaluates the data with respect to trend since monitoring began in 1989. Invertebrates were collected using Hester-Dendy multiplate samplers placed at two sampling sites on Cub Creek. Additionally, hourly readings of water quality (temperature, dissolved oxygen, specific conductance, pH, turbidity) were recorded at least 24 hours prior to sampling at both the upstream and downstream monitoring sites using data loggers. Water quality measurements were generally consistent and typical for streams of this size in the region although there was modest variation among years. Summary data for invertebrate community metrics from 2005-2007, including genus richness, Ephemeroptera, Plecoptera, Trichoptera (EPT) richness, Shannon Index, Shannon Evenness Index, and Hilsenhoff Biotic Index (HBI) generally did not exceed control chart limits based on historical data collected from 1996-2004. Cub Creek is a prairie stream ecosystem and the extant condition of its invertebrate community may not be too far from an undisturbed condition. The results of invertebrate monitoring clearly show that stream integrity has not diminished beyond that when monitoring first began in 1989, although annual data exhibited substantial variation. Given the known anthropogenic disturbances in Cub Creek upstream of the park it is likely that the aquatic invertebrate communities in Cub Creek within HOME are mildly impaired, however. There are few available options to park management for mitigating this situation, largely because the impacts to water quality originate upstream of the park boundaries. However, maintaining in-stream habitat and riparian zone integrity will aid in maintaining the integrity of Cub Creek in the park. Aquatic invertebrate monitoring in Cub Creek provides a sound tool to recognize both deterioration and chronic decline of water quality, and it will be useful to ensure water quality in the stream does not degrade further.

Acknowledgements

I thank David Peitz, Tyler Cribbs, Jesse Bolli, Hope Dodd, Jan Hinsey, Greg Wallace, and Lloyd Morrison for assisting with this project.

Introduction

The Cub Creek basin is located in the loess plains of southeastern Nebraska and encompasses 374 km2 (Harris *et al*. 1991). Homestead National Monument of America is located in Omernick's (1987) Central Great Plains ecoregion. Natural vegetation of the park is bluestem prairie (Kuchler 1964, Stubbendieck and Willson 1986). The riparian zone within HOME jurisdictional boundaries consists primarily of restored tallgrass prairie covering approximately 40 ha. Twenty-five hectares of hardwood forest immediately border Cub Creek within park boundaries. Cub Creek meanders through the western half of HOME, exiting the park twice before finally leaving the park and joining the Big Blue River approximately 3 km downstream. Flood control and sediment dams have been constructed upstream of the park. Additionally, development and agricultural practices in the basin upstream and adjacent to Cub Creek, including row crops and their associated management and water removal, have a significant potential for disrupting the ecological integrity and functioning of the Cub Creek ecosystem. To address these concerns, the National Park Service (NPS) began monitoring the aquatic invertebrates of Cub Creek within Homestead National Monument of America (HOME), Nebraska in 1989 (Harris *et al*. 1991). During the period 1992-1995, the Midwest Regional Office of NPS funded an aquatic invertebrate sampling effort 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 HOME 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. For a summary of field and laboratory methods used prior to 2005, refer to Peitz and Cribbs (2005). Five Hester-Dendy multiplate samplers (0.09 m^2) were used at each of two sampling sites on Cub Creek (Figure 1). Hester-Dendy samplers were placed in the stream for approximately 30 days, retrieved, and field processed by HOME staff. Samples were then 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. Because the Hester-Dendy samplers are an artificial medium, qualitative physical habitat variables were not collected. During 2006-2007, hourly readings of water quality parameters (temperature, dissolved oxygen, specific conductance, pH, turbidity) were recorded at least 24 hours prior to sampling at both the upstream and downstream monitoring sites using calibrated data loggers or sondes.

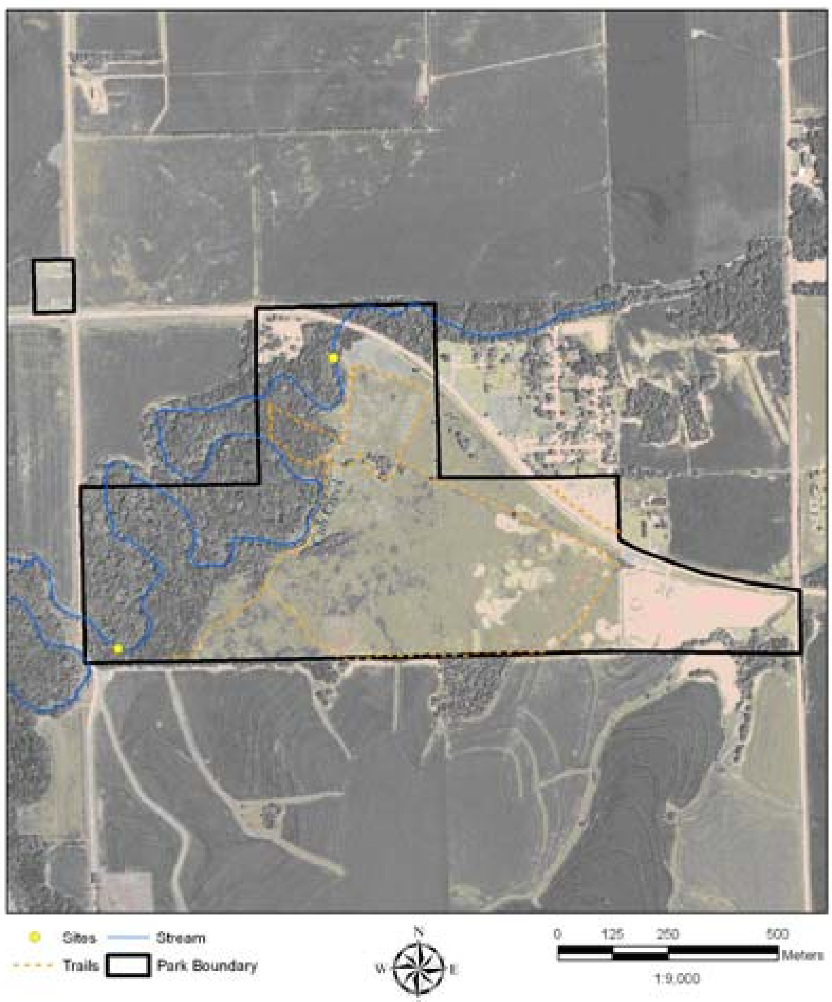

Figure 1. Aquatic Invertebrate monitoring sites at Homestead National Monument of America.

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 ± 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 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 approach and indicates that one out of every 20 data points will exceed this limit if the population is not changing, which is our assumption. The specified control limit serves as an indicator to suggest biologically important change may be occurring. Control limits may need to be reset after more data are accumulated.

Only data collected from 1996-2004 during the July-August index period were used to construct control charts because the field methods used to collect samples and sampling periods are most similar to those described in the present protocol (Bowles *et al*. 2008). This contrasts with the approach used by Peitz and Cribbs (2005) who summarized all historical data, including that collected outside of the current index period. The single exception was for 1998 when the only available data where from September. However, the data used was from samplers retrieved on September 10 so the plates were colonized largely during the index period. Data from 1989 are included in the plots of the historical data only as a reference. 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.

Results

Water quality measurements (Table 1) were generally consistent although there was modest variation among years. Observed differences are likely a result of natural variation among years and other undetermined factors. However, the parameter values in all cases are generally typical for streams in this region (Harris *et al*. 1999, Poulton *et al*. 2007) although dissolved oxygen for 2007 was below state standards for surface water (Table 2). Because turbidity was high when dissolved oxygen readings were taken, fouling of the sensor membrane that was not apparent during post-calibration cannot be ruled out as a cause for this low reading. Turbidity was consistently high among years, but Nebraska does not have a turbidity standard for surface waters. The observed turbidity in Cub Creek is unlikely to be similar to historic, pre-settlement levels and should generally be viewed as abnormally high (Rabeni 1996). Water quality measurements related to invertebrate monitoring at Cub Creek historically were taken as static readings using hand-held water quality meters, and therefore comparison of the historical data with the most recently collected data is not appropriate. Peitz and Cribbs (2005) summarized water quality data for monitoring years 2002 and 2003, and their data are generally comparable to those presented in Table 1.

Table 1. Water quality characteristics for Cub Creek, Homestead National Monument of America, 2006-2007. Data were collected continuously with a calibrated data logger. Values are mean, standard deviation, and range.

Year	Sampling Site	Temperature (°C)	Specific Conductance (µm/cm)	Dissolved Oxygen (mg/liter)	pH	Turbidity (NTU)
2006	Site 2	19.94	350.71	7.10	7.50	146.07
		1.14	5.94	0.12	0.01	5.57
		18.61-21.92	341-358	6.94-7.33	7.49-7.53	139.5-157.6
2007 (upstream)	Site 1	26.42	231.25	2.08	7.55	166.36
		1.20	10.26	0.76	0.02	3.89
		24.99-28.61	219-247	1.09-3.54	7.52-7.58	160.7-172.6
2007 downstream)	Site 2	26.80	233.56	5.34	7.61	178.97
		1.50	7.93	0.75	0.03	3.43
		24.79-28.91	219-249	4.16-6.79	7.55-7.65	174.3-183.5

Table 2. Acceptable ranges for water quality parameters in Nebraska streams. Adapted from Nebraska Department of Environmental Quality (2009).

Water Quality Parameter	Acceptable Range
Temperature	0-32 °C
Dissolved Oxygen	24 hr minimum of 3 mg/liter for all life stages other than early life stages
Specific Conductance	<2,000 µS/cm
pH	6.5-9.0
Turbidity	No state standard

Average annual densities of invertebrates were recorded and analyzed prior to 2005, but because densities are notoriously variable, they are difficult to interpret and can be misleading. Because of this constraint, invertebrate densities are no longer analyzed as part of monitoring at HOME. Summary data from 1989-2007 for other metrics, including genus richness, Ephemeroptera, Plecoptera, Trichoptera (EPT) richness, Shannon Index, Shannon Evenness Index, and Hilsenhoff Biotic Index (HBI), are presented in Table 3. Metric values were highly variable among sampling years.

Control charts created for each metric show that the annual means for 2005-2007 generally did not exceed control limits (Figures 2-6). The exception was EPT richness in 2006 although this metric was at an acceptable level in 2007. No other mean metric values exceeded their respective control limits. Values for some years were near the warning threshold, but this likely only reflects the natural variability of the data rather than an indication of impairment.

Table 3. Mean and standard error (in parentheses) of invertebrate metrics collected from Cub Creek, Homestead National Monument of America,1989 and 1996-2007 during the July-August index period.

Year	1989	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Density	3298.2 (1005.4)	1422 (33.37)	3232 (967.89)	4947.3 (979.78)	3805.7 (794.98)	2414.2 (380.05)	2651.2 (921.96)	2872 (220.8)	2774 (412.89)	3414.7 (937.31)	n/a	n/a	n/a
Genus Richness	11.9 (1.3)	9 (0.60)	9.50 (2.5)	7.20 (0.51)	9.86 (0.77)	10.07 (0.62)	7.88 (0.50)	8.31 (0.56)	8.90 (0.82)	6.19 (0.54)	7.89 (3.63)	6.53 (0.39)	8.83 (0.46)
EPT Richness	0.80 (0.42)	5.6 (0.48)	0.90 (0.60)	3.0 (0.45)	4.4 (1.07)	5.87 (0.49)	4.3 (0.59)	3.95 (0.58)	5.05 (0.54)	4.25 (1.57)	3.63 (0.27)	1.47 (0.16)	3.75 (0.37)
Shannon Index (Genus)	1.2 (0.10)	0.90 (0.11)	1.42 (0.44)	0.85 (0.10)	1.40 (0.09)	1.33 (0.09)	1.33 (0.11)	1.56 (0.07)	1.59 (0.05)	1.13 (0.08)	1.23 (0.05)	1.46 (0.06)	1.41 (0.06)
Shannon Evenness Index	0.57 (0.04)	0.41 (0.05)	0.64 (0.14)	0.61 (0.14)	0.63 (0.03)	0.56 (0.03)	0.67 (0.07)	0.70 (0.03)	0.65 (0.02)	0.60 (0.05)	0.61 (0.02)	0.82 (0.03)	0.65 (0.03)
Hilsenhoff Biotic Index (family)	7.75 (0.04)	4.27 (0.02)	5.76 (0.5)	5.76 (0.35)	4.56 (0.09)	4.48 (0.14)	4.49 (0.32)	4.61 (0.17)	5.10 (0.15)	5.33 (0.26)	5.12 (0.16)	5.87 (0.34)	5.14 (0.09)
Hilsenhoff Biotic Index (genus)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	6.51 (0.05)	6.43 (0.18)	6.55 (0.10)

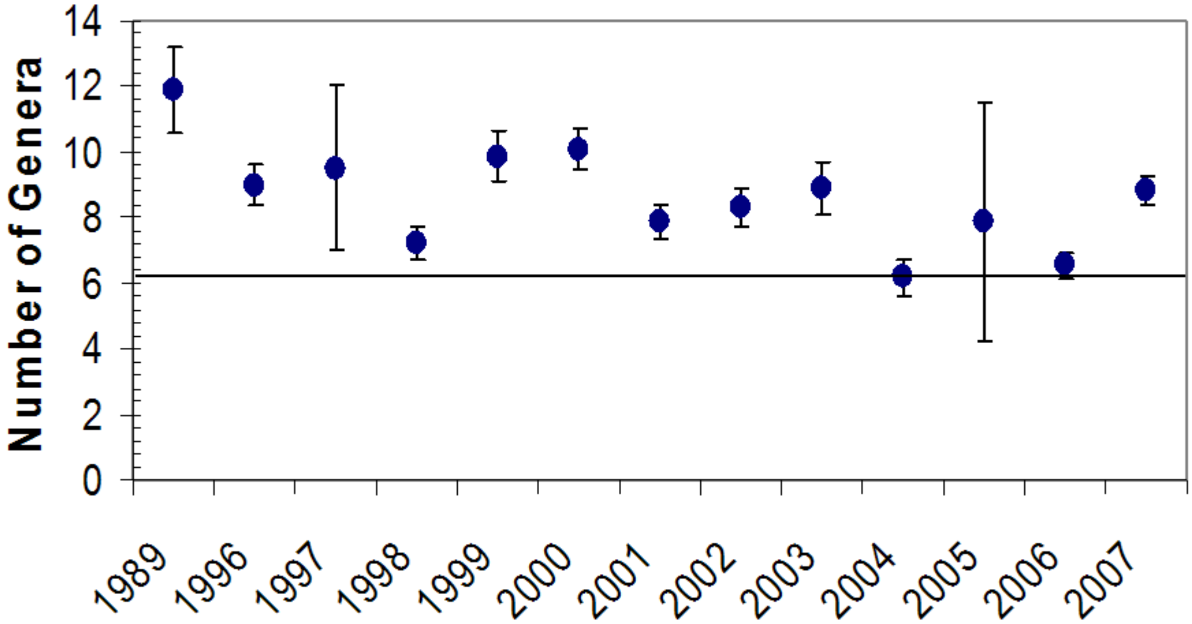

Figure 2. Control chart showing means and standard errors for genus richness at Cub Creek, Homestead National Monument of America. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

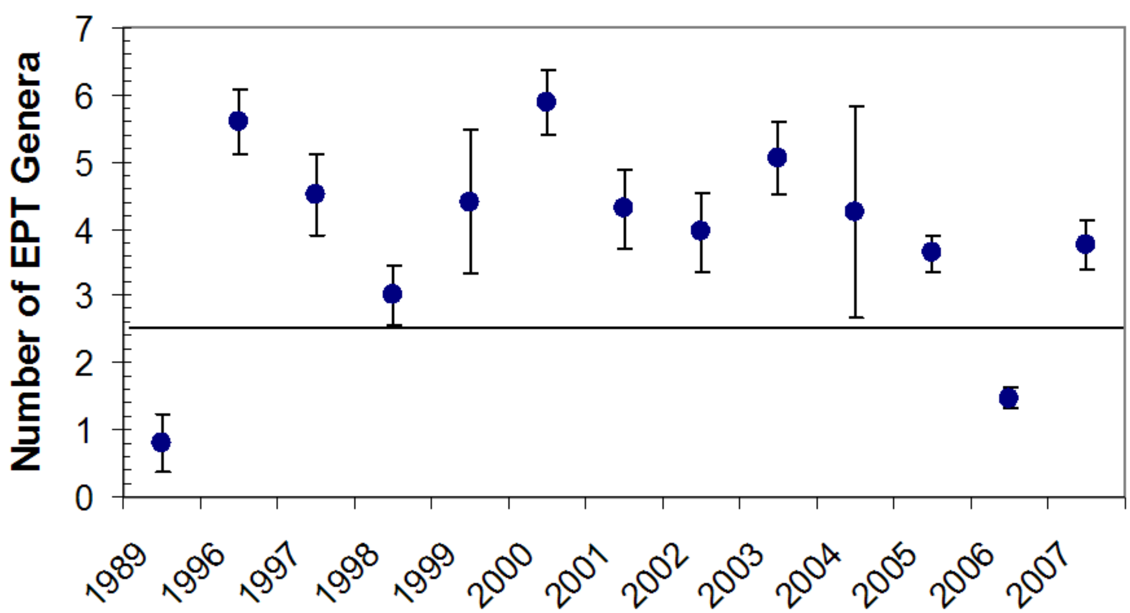

Figure 3. Control chart showing means and standard errors for Ephemeroptera, Plecoptera, Trichoptera richness at Cub Creek, Homestead National Monument of America. The horizontal line represents the control limit corresponding to the Type I error rate 0.05.

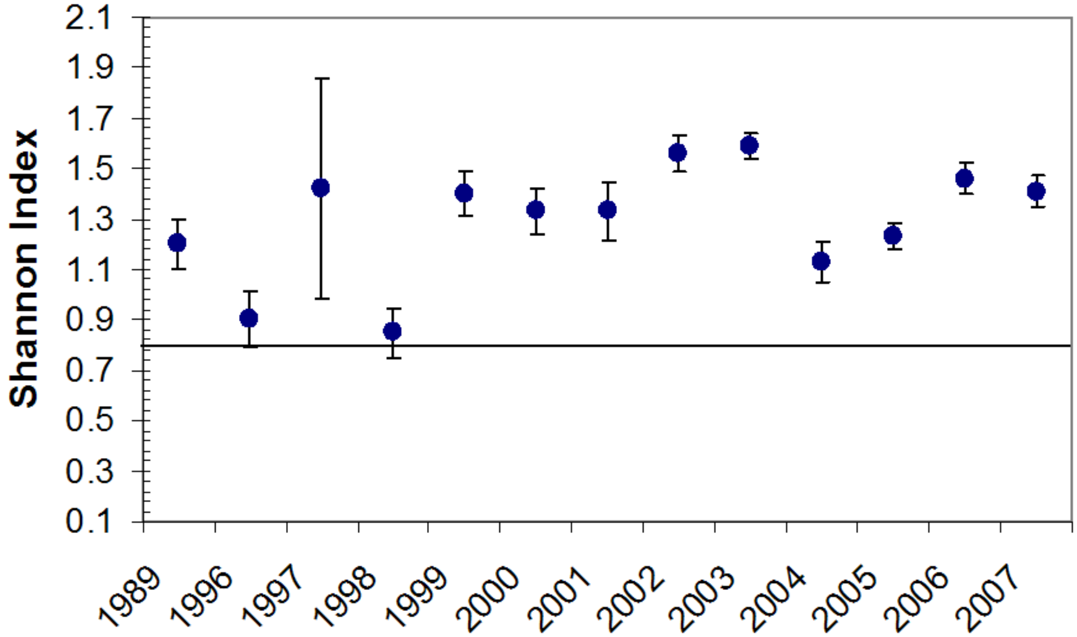

Figure 4. Control chart showing means and standard errors for Shannon Index at Cub Creek, Homestead National Monument of America, 2005-2007. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

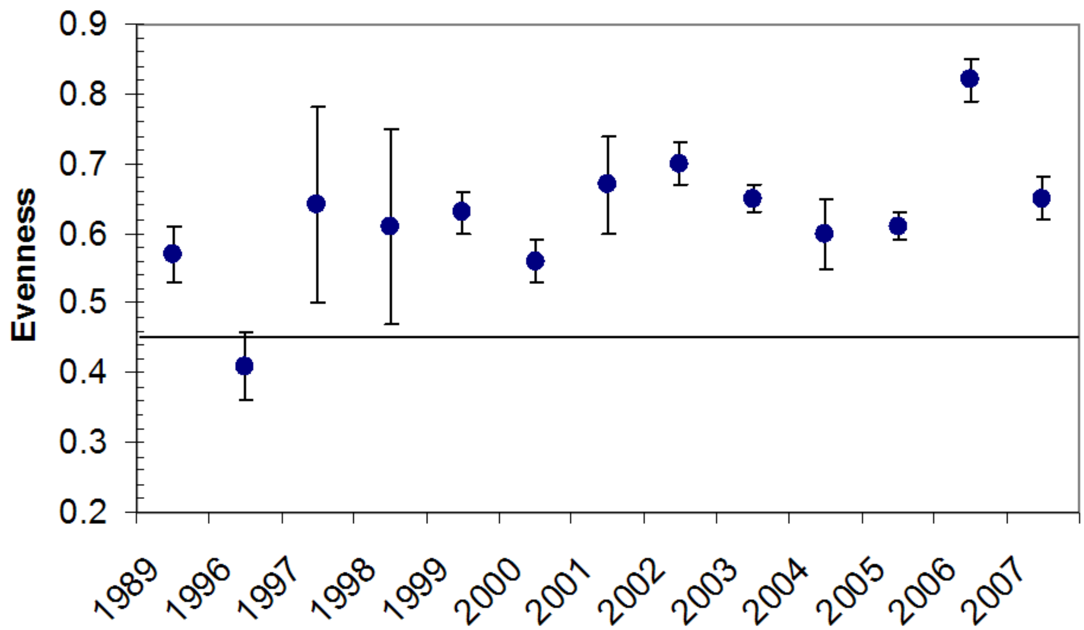

Figure 5. Control chart showing means and standard errors for Shannon Evenness at Cub Creek, Homestead National Monument of America. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

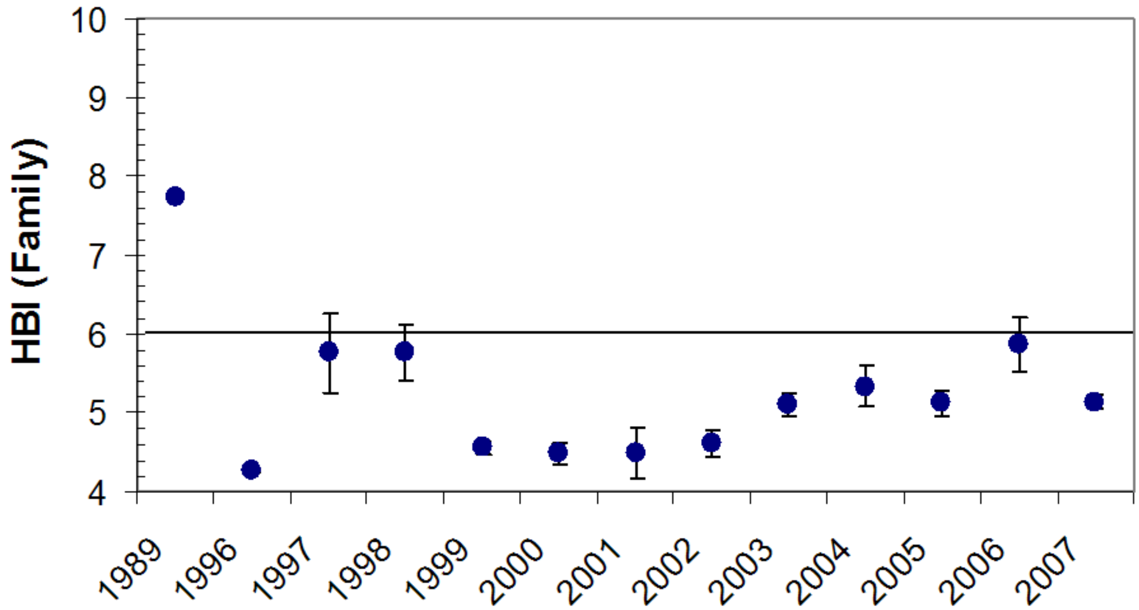

Figure 6. Control chart showing means and standard errors for Hilsenhoff Biotic Index for families at Cub Creek, Homestead National Monument of America. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

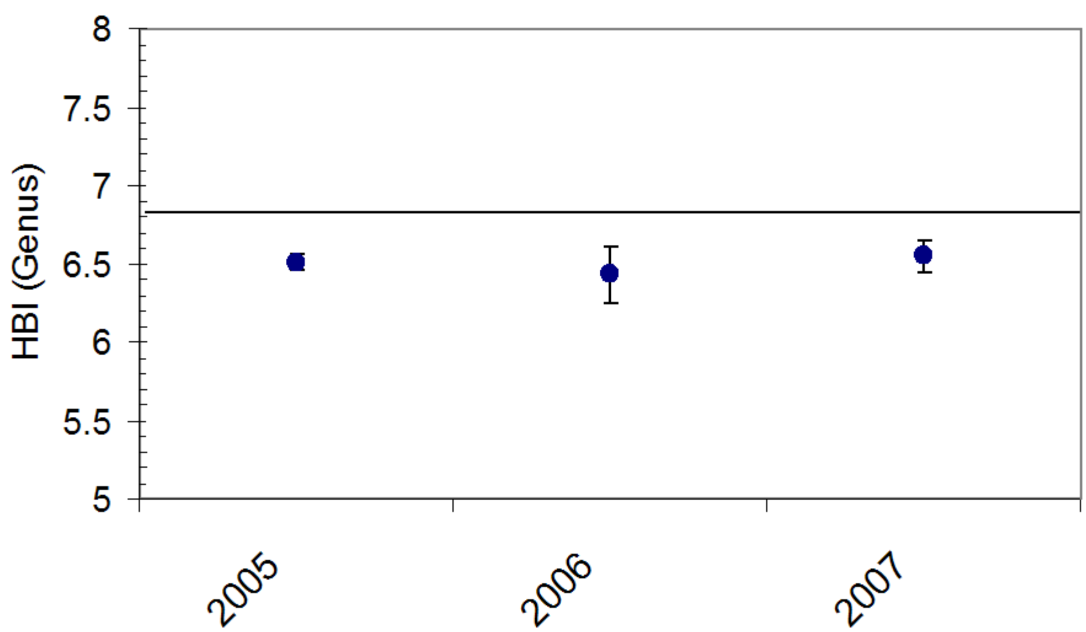

Figure 7. Control chart showing means and standard errors for Hilsenhoff Biotic Index for genera at Cub Creek, Homestead National Monument of America. The horizontal line represents the control limit corresponding to the Type I error rate of 0.05.

Discussion

The NPS previously reviewed water quality data (1960-1997) for Cub Creek in the general area of HOME (NPS Water Resources Division 1999). This review reported that water quality in Cub Creek had been adversely impacted by human activities. Potential anthropogenic sources of pollutants in Cub Creek include municipal and industrial wastewater discharge, agricultural practices, quarrying, storm-water runoff, and recreational use. Dissolved oxygen, pH, cadmium, copper, lead, and zinc all exceeded their respective EPA criteria for the protection of freshwater aquatic life one or more times (NPS Water Resources Division 1999). Pollutants including nitrates, beryllium, cadmium, chromium, lead, nickel, bis (2-ethylhexyl) phthalate, and atrazine exceeded their respective EPA drinking water criteria as well. Fecal-indicator bacteria concentrations and turbidity have also exceeded the WRD screening limits for freshwater bathing and aquatic life, respectively. The turbidity levels measured at Cub Creek were greater than 140 NTU. Pollutants in runoff and sedimentation typically have detrimental effects on less pollution tolerant aquatic invertebrate species. Although streams of the Great Plains region historically had seasonally turbid flows, agricultural practices over the past 150 years have degraded many small, perennial streams such as Cub Creek into constantly turbid, intermittent streams, to the detriment of the fauna inhabiting them (Rabeni 1996). The water quality data presented in this report are intended to describe the prevailing conditions that may influence the structure of invertebrate communities and may help explain variability between sampling periods (Bowles *et al*. 2008). The water quality data are not intended to be used as an analytical tool in the strictest sense. Moreover, the water quality data collected using data loggers over a 24-hour period represents only a small snap-shot of the broader range of conditions possible over longer periods, and thus should be cautiously interpreted. Due to the limitations of using water quality data obtained with data loggers, the invertebrate community is used as a surrogate of the long-term water quality condition in Cub Creek.

Given the known anthropogenic disturbances in Cub Creek upstream of the park, it is likely that the aquatic invertebrate community in Cub Creek within HOME is mildly impaired. Genus diversity is low at around 10 taxa per sample or less (this includes the large and tolerant family Chironomidae as a single taxon). Also, the diversity of Ephemeroptera and Trichoptera is low and those species that are present tend to be tolerant of disturbance. Plecoptera are not represented in Cub Creek. The biotic index indicates that the invertebrate community of Cub Creek is a tolerant one. However, the results of invertebrate monitoring reported here clearly show stream integrity has not diminished beyond that reported in earlier studies (Harris *et al*. 1991, Harris *et al*. 1999, Peitz and Cribbs 2005), although the data are clearly variable. The results reported here are generally consistent with previous studies of Cub Creek (Harris *et al*. 1999), other streams in Nebraska (Nebraska Department of Environmental Quality 2006, Zelt and Frankforter 2003), and the region (MacFarlane 1983, Whiles *et al*. 2000, Hall *et al*. 2003, Kosnicki and Sites 2007, Poulton *et al*. 2007). Therefore, the extant condition of the invertebrate community in Cub Creek may be close to pre-settlement conditions.

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 park boundaries. Continued establishment and widening of riparian buffer zones along Cub Creek upstream of the park will aid in protecting aquatic life in Cub 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 Cub Creek. A reduction in impervious surfaces (sidewalks, trails and parking lot) within the monument and mowing in the riparian buffer along Cub Creek would also help to stabilize the riparian zone and in-stream habitat. The long history and continuing efforts of aquatic invertebrate monitoring in Cub 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.

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Heartland Network

Natural Resource Monitoring

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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