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Fish Community Monitoring at Homestead National Monument of America

2004-2011Status Report

Natural Resource Data Series NPS/HTLN/NRDS—2012/276

ON THE COVER
Cub Creek, Homestead National Monument of America, Nebraska
Photograph by: Heartland Inventory and Monitoring Network

Fish Community Monitoring at Homestead National Monument of America

2004-2011 Status Report

Natural Resource Report NPS/HTLN/NRDS—2012/276

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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 established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Abstract

In 2004, the Heartland Inventory and Monitoring Network (HTLN) began monitoring fish communities in Cub Creek at Homestead National Monument of America (HOME). Seining was conducted in late summer of 2004, 2006, 2008, and 2011. In conjunction with fish sampling, physical habitat and water quality data was collected. The fish community in Cub Creek was moderately diverse and stream integrity rated as fair. With the exception of one species, fish present within HOME were moderately tolerant or tolerant to poor stream conditions. Total number of species present and numbers of fish collected declined over time, but this is likely due to the amount of the stream sampled decreasing over time rather than a true decline in richness or fish numbers. These results suggest that the fish community is in fair condition but remains somewhat impaired due to agricultural and industrial practices within the watershed.

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Introduction

Homestead National Monument of America (HOME) is located in the Central Great Plains Ecoregion of Nebraska. The park is 0.79 km^2, containing 0.40 km^2 of restored tallgrass prairie. Approximately 2 km of Cub Creek flows through the western portion of HOME with 0.24 km^2 of hardwood forest adjacent to the creek. Land use within the Cub Creek watershed is predominately agriculture. Historical water chemistry data (1960-1997) showed that Cub Creek water quality was negatively impacted by agricultural practices and industrial discharges in the watershed (NPS Water Resources Division 1999). Although water chemistry data is a good tool to assess stream health, use of a biological indicator, such as fish, along with assessment of physical habitat and water quality is a more robust approach. Fish communities are an important component of stream systems and are useful biological indicators of aquatic ecosystem health. Changes or shifts in stream habitat complexity and water quality often determine biotic communities, including fish (Lazorchak et al. 1998). Many fish species are considered intolerant of habitat alterations and poor water quality (Robison and Buchanan 1988; Pflieger 1997; Barbour et al. 1999), and therefore, composition of the community can indicate a decline in water quality or stream integrity. In 2004, the Heartland Inventory and Monitoring Network (HTLN) of the National Park Service (NPS) began monitoring fish communities as well as habitat and water quality to assess the biological integrity of Cub Creek within HOME.

The objectives of fish community monitoring at HOME are: (1) to determine the status and long-term trends in fish richness, diversity, abundance, and community composition and (2) to correlate the long-term community data to overall water quality and habitat condition.

Methods

Details on methods of site selection, fish sampling, and habitat and water quality data collection not listed in this report can be found in the Protocol for Monitoring Fish Communities in Small Streams in the Heartland Inventory and Monitoring Network (Dodd *et al.* 2008).

Study Area and Reach Selection

A reach near the downstream park boundary on Cub Creek was sampled for fish, physical habitat, and water quality (Figure 1). This fish reach corresponds to the downstream invertebrate site that has been historically monitored by both HTLN and the park. A sample reach is a section of stream that encompasses all channel units (riffles, runs, pools, glides) within the stream, resulting in a representative fish sample. The length was based on the ability to find areas of the stream with adequate water to collect fish from five sample sites within the reach or the ability to find areas where seining would be effective (large deep pools were excluded). Sampling was conducted in August/September of 2004, 2006, 2008, and 2011. An upstream reach on Cub Creek, corresponding to the upper historical invertebrate site, was also sampled in 2004 (see Peitz 2005). However this reach was removed from fish monitoring beginning in 2006 because it did not give additional information on fish community status that could not be obtained from sampling only the downstream reach (see Dodd *et al.* 2008). Therefore, only data from the downstream reach is presented in this report.

Fish Collection

Fish were collected using a common sense seine (also referred to as a minnow seine) of 1.8 m depth and a mesh size of 6.4 mm. Every year fish were collected from five sites (channel units) within the reach. Only pool or run channel units were available for sampling within Cub Creek. To collect fish, a two-person crew dragged the seine across the bottom, trapping fish against a bank or shallow water area until the seine could be raised out of the water. Block seines were deployed if flow between pools was present, in an attempt to isolate fish in the selected pool. Fish were retained in the net in water or in an aerated bucket of water until they could be examined. All fish were identified to species, if possible, and counted. Beginning in 2006, a subsample of 30 individuals per species were measured and weighed, and any diseases or anomalies were recorded. Fish that were too small or that were difficult to identify in the field were preserved for laboratory identification. All other fish were released back into the sample reach.

Habitat and Water Quality

Physical habitat and water quality were collected in conjunction with fish sampling. In-stream habitat (width, depth, site length, substrate, *etc*.), stream bank erosion, and riparian vegetation were collected at each site within the reach (see Dodd *et al*. 2008 for a list of all habitat parameters collected). In 2004, discrete water quality measurements (temperature, dissolved oxygen, pH, and conductivity) were collected at each site within the reach using calibrated hand-held meters. In 2006, continuous water quality sampling replaced discrete water quality sampling. Data loggers were deployed at the reach to obtain hourly temperature, dissolved oxygen, pH, specific conductance, and turbidity data over a diel period.

Data Analysis

Fish Metrics

Four biological metrics were calculated to reflect fish community diversity (species richness and diversity), abundance (catch per area), and overall stream integrity (Index of Biotic Integrity). Species richness was calculated as the total number of species present in the reach. Community diversity was assessed using Simpson's Diversity Index, which indicates the probability that two individuals picked at random from the reach are the same species. This index has an inverse relationship with diversity; the index decreases as diversity increases. Because it is more intuitive that an increasing index score correspond to increasing diversity, the inverse of the Simpson's Index (1-SI) is reported. Therefore, a diversity value (1-SI) of 1 corresponds to a completely diverse community while a value of 0 indicates no diversity. Abundance was calculated as catch per area sampled. The Index of Biotic Integrity (IBI) developed by Karr (1981) and used in Midwest steams by Fausch *et al.* (1984) was used to assess overall stream health and includes 12 metrics: 1) total number of fish species; 2) number and identity of sucker species; 3) number and identity of sunfish species; 4) number and identity of darter species; 5) number and identity of species intolerant to poor water quality and habitat conditions; 6) proportion of individuals as green sunfish; 7) proportion of individuals as omnivores; 8) proportion of individuals as insectivorous cyprinids; 9) proportion of individuals as top carnivores; 10) number of individuals in sample; 11) proportion of individuals as hybrids; 12) proportion with an anomaly (disease, eroded fins, lesions, or tumors). Each of the 12 raw metric values was scored as 1 (worst), 3, or 5 (best). The metric scores were added to calculate an IBI score that ranges from 0 to 60. Based on this IBI score, the overall integrity of the stream is classified from very poor to excellent: very poor = 0-20; poor = 21-30; fair = 31-40; good = 41-50; excellent (reference condition) = 51-60. More detailed methods on calculating biological metrics used in this report can be found in Karr (1981), Fausch *et al*. (1984), and Dodd *et al.* (2008).

Habitat and Water Quality

Physical habitat related to site dimensions was summarized using means and standard errors. A one way Analysis of Variance (ANOVA) with an alpha level of 0.05 was used to test for significant differences among years and a Tukey's HSD test (alpha = 0.05) was used for pair-wise comparisons of the means between years. Stream substrate and bank erosion were collected as percentage categories, and midpoints were used to calculate mean percent. Therefore, the total sum of percentages among substrate types will not equal 100%. For riparian vegetation, percent frequency of each vegetation type was calculated. Water quality data were summarized using means and standard errors.

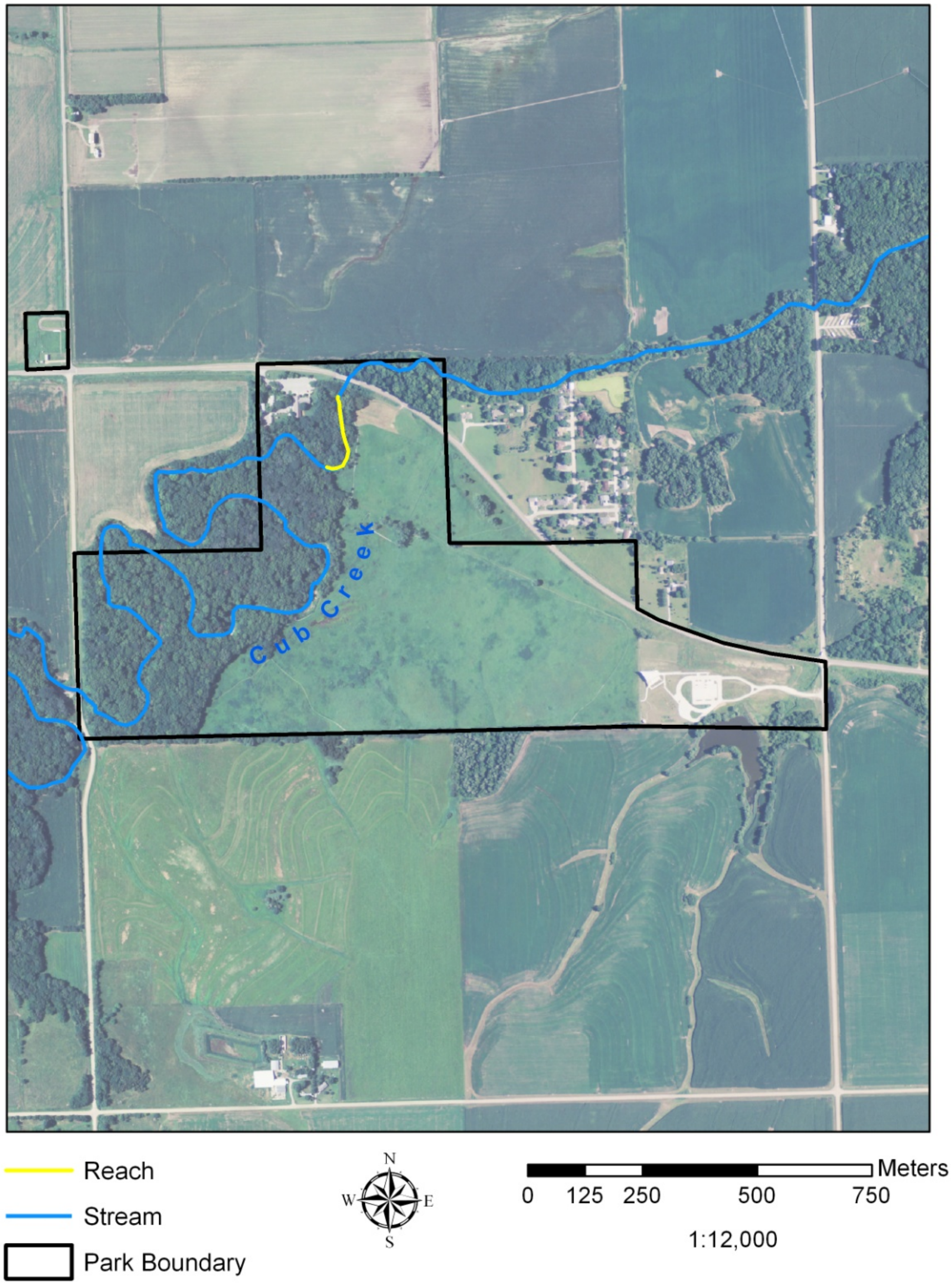

Figure 1. The reach location on Cub Creek monitored for fish communities in 2004-2011.

Results

Fish Community

Fifteen fish species were collected in Cub Creek from 2004-2011 (Table 1). Species richness (excluding unidentified minnow species) declined from 12 species in 2004 and 2006 to five species in 2011 (Table 1, Figure 2a, solid diamonds). With the exception of 2008, diversity and relative abundance increased over time (Table 1, Figure 2b, solid diamonds). Total catch decreased from 2004-2008 and then increased in 2011 (Table 1, Figure 2b, solid squares). The decline is species richness and total catch and increase in relative abundance across time may be a result of an apparent decline in sample area (Table 2, Figure 2c, solid diamonds). Although mean width and depth were similar between years, mean length of sample sites were significantly different among years (one-way ANOVA, $p = 0.005$, Table 2). Sites in 2004 were significantly longer than those sampled in 2008 and 2011(Tukey's HSD test, $df = 46$, $HSD = 18.87$). We found that one of the five sites sampled in 2004 was more than four times longer than other sites sampled, resulting in over twice the amount of area and more than three times the water volume being sampled that year compared to other years (Table 2).

We removed this large sample site from the analyses of the 2004 data (retaining 4 sites for 2004) and found that site size became more similar to samples collected in 2006-2011. Mean site length decreased by 43% from 32.8 to 18.5 m, sample area was reduced by 57% (Figure 2c, open diamond), and volume was reduce by 67%. As a result, relative abundance (catch per area) increased by 45% from 0.88 to 1.6 fish/m^2 in 2004 (Figure 2b, open diamond) while total catch decreased by 23% from 830 to 643 fish (Figure 2b, open square). Species richness and diversity changed very little (1 species and 0.02, respectively) when this large site was removed from the 2004 data set (Figure 2a).

The IBI score was consistent among years (range: 35-38) with a stream integrity rating of fair (Table 3). Removing the large site from the 2004 data had little effect on the IBI score (increased from 35 to 37) and no effect on the stream integrity rating. High abundance and percent of insectivorous minnows and the low percent of generalist feeders (omnivores), tolerant Green sunfish (*Lepomis cyanellus*), and occurrence of anomalies/disease account for the moderate IBI score and condition rating of fair (Table 3). Because occurrence of anomalies/disease was not recorded in 2004, this metric could not be calculated resulting in an underestimation of the IBI. A high occurrence of anomalies (> 1%) would increase the 2004 IBI score by one and no occurrence of anomalies would increase the score by five, resulting in the same rating of fair (if increased by one) or a new rating of good (if increased by five).

The community consisted primarily of minnow species (Cyprinidae; 87 – 98%; Table 1) and species tolerant or moderately tolerant to poor stream conditions. Only one intolerant species, the Stonecat (*Noturus flavus*), was collected in 2004 and 2006. Sensitive darter species (*Percina* and *Etheostoma* spp.) were not collected in any years sampled.

Table 1. Numbers caught for each species collected and total catch, relative abundance, and diversity at Cub Creek from 2004-2011.

Common name	Scientific name	2004	2006	2008	2011
Bluegill	*Lepomis macrochirus*	3	3	2	0
Bluntnose minnow	*Pimephales notatus*	1	0	0	0
Central stoneroller	*Campostoma anomalum*	3	0	0	0
Channel catfish	*Ictalurus punctatus*	37	7	11	13
Creek chub	*Semotilus atromaculatus*	4	8	1	0
Fathead minnow	*Pimephales promelas*	31	21	0	11
Gizzard shad	*Dorosoma cepedianum*	0	0	2	0
Green sunfish	*Lepomis cyanellus*	15	2	0	0
Largemouth bass	*Micropterus salmoides*	0	1	0	0
Non-carp minnow spp.	*Cyprinidae spp.*	0	2	0	73
Red shiner	*Cyprinella lutrensis*	668	313	102	195
River carpsucker	*Carpiodes carpio*	0	1	1	0
Sand shiner	*Notropis stramineus*	57	136	16	331
Stonecat	*Noturus flavus*	6	10	0	0
Suckermouth minnow	*Phenacobius mirabilis*	4	17	2	1
Yellow bullhead	*Ameiurus natalis*	1	1	0	0
Total Catch		830	522	137	624
Abundance (catch/m^2)		0.88	1.18	0.42	2.19
Diversity (1-S)		0.34	0.57	0.43	0.62

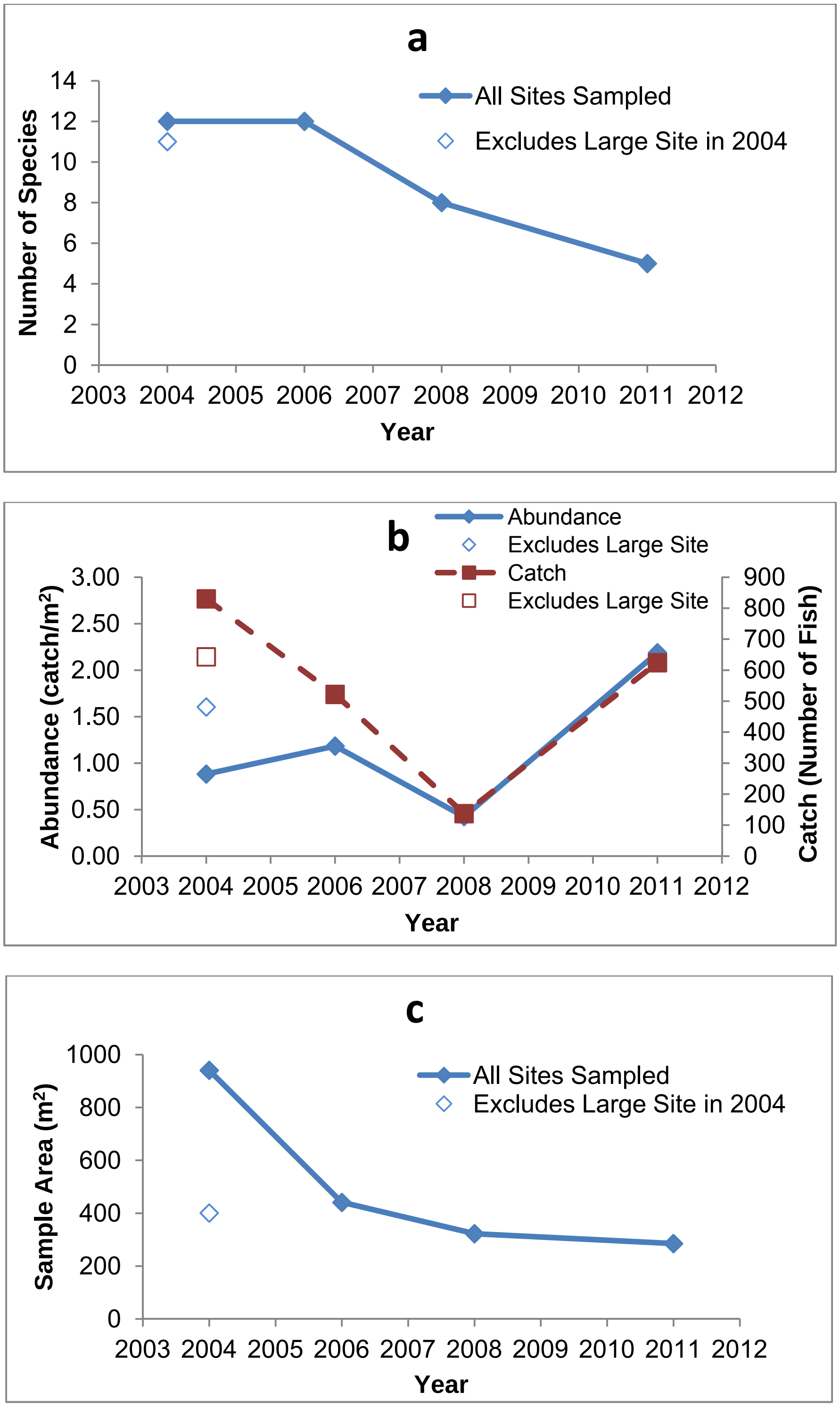

Figure 2. Species richness (panel a), abundance (panel b, diamonds), catch (panel b, squares), and sample area (panel c) of Cub Creek from 2004-2011. Data points represented by solid symbols includes analysis from all sites sampled. Data points represented by open symbols excludes the large site sampled in 2004.

Table 2. Mean site dimension characteristics (± one standard error) for Cub Creek from 2004-2011. NC = Not Collected. Lettered superscripts are used to designate significant differences among means.

	2004	2006	2008	2011	ANOVA
Mean Width (m)	5.7 ± 0.6	5.0 ± 0.4	5.2 ± 0.3	4.5 ± 0.3	$F_{(3, 46)}$ = 1.34, p = 0.273
Mean Depth (cm)	28.2 ± 7.3	17.6 ± 2.8	16.3 ± 2.4	23.3 ± 2.8	$F_{(3, 46)}$ = 2.15, p = 0.107
Mean Velocity (m/s)	NC	0.19 ± 0.03	0.22 ± 0.02	0.18 ± 0.03	$F_{(2, 42)}$ = 0.56, p = 0.575
Mean Site Length (m)	32.8^{x} ± 14.4	17.6^{xy} ± 2.8	12.3^{y} ± 1.0	12.7 ± 0.6	$F_{(3, 46)}$ = 4.84, p = 0.005
Area Sampled (m^2)	940.8	441.1	322.7	285.3	
Volume Sampled (m^3)	265.3	77.6	52.7	66.6	

Table 3. Fish metric values and Index of Biotic Integrity (IBI) score for Cub Creek from 2004-2011. NC = Not Collected.

Metric Value	2004	2006	2008	2011
Species Richness (excluding unknowns and hybrids)	12	12	8	5
Number of Sucker Species	0	1	1	0
Number of Sunfish Species (includes tolerant species)	2	2	1	0
Number of Darter Species	0	0	0	0
Number of Intolerant species	1	1	0	0
Percent Green Sunfish	1.8	0.4	0.0	0.0
Percent Omnivores	3.9	4.2	2.2	1.8
Percent Insectivorous minnows	87.8	89.3	87.6	84.5
Percent Top Carnivores	4.5	1.5	8.0	2.1
Catch per Unit Effort (# / 50 ft seine haul)	77.2	90.5	34.0	150.0
Percent Hybrids	0.0	0.0	0.0	0.0
Percent with disease/anomalies	NC	1.3	0.0	0.0
IBI Score	**35**	**38**	**38**	**38**

Habitat and Water Quality

Velocity was similar among years (one-way ANOVA, Table 2). Substrate in Cub Creek consisted primarily of sand (67-95%) in all years sampled along with other fine substrates such as muck, detritus, silt, and hardpan clay (Figure 4). On average, more than 85% of the banks were eroded in 2008 and 2011. Riparian vegetation consisted of trees or grasses/forbes (prairie) along the right bank. On the left bank, vegetation near the stream (within 50 m) was primarily mature trees with park lawn located within the riparian zone (from 50-100 m).

All water quality parameters measured in Cub Creek were within the Nebraska Department of Environmental Quality (NDEQ 2009) water quality standards for surface waters. Measurements in 2004 were collected at daytime in conjunction with fish sampling and, therefore, should not be compared to 2006 or 2011 which includes diel data. Higher average water temperature and lower dissolved oxygen concentrations in 2004 are likely a result of collecting water quality data exclusively during daylight hours.

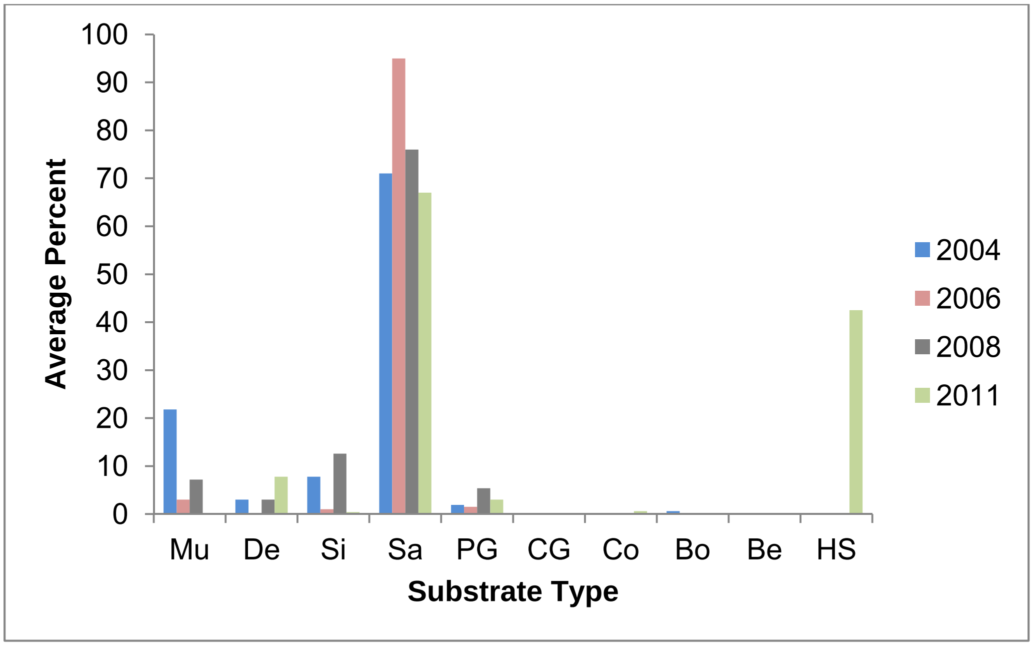

Figure 4. Average percent of substrate types found in Cub Creek from 2004-2011. Mu = Muck, De = Detritus, Si = Silt, Sa=Sand, PG = Pea Gravel, CG = Course Gravel, Bo = Boulder, Be = Bedrock, and HS = Hardpan clay/Shale. Because substrate was assessed using percent categories, percentages do not add up to 100%.

Table 5. Average water quality parameters (± one standard error) for Cub Creek from 2004-2011 and Nebraska Department of Environmental Quality (NDEQ 2009) state standards. Data from 2004 were discreet measurements collected with hand held meters during fish sampling. Data collected in 2006 and 2011 were measured hourly over the diel period. NC = Not Collected.

Water Quality Parameter	2004*	2006	2008	2011	Nebraska DEQ Standards
Water Temperature (^{o}C)	23.6 ± 0.1	19.9 ± 0.3	NC	16.1 ± 1.2	0-32
Specific Conductance (µS/cm)	581.8 ± 1.2	350.7 ± 1.6	NC	494.5 ± 2.0	< 2,000
Dissolved Oxygen (mg/L)	6.96 ± 0.23	7.10 ± 0.03	NC	9.27 ± 1.36	3 mg/L minimum in 24 hr
pH	8.04 ± 0.03	7.50 ± 0.00	NC	8.23 ± 0.11	6.5-9.0
Turbidity (NTU)	NC	146.1 ± 1.5	NC	9.9 ± 1.1	No standard

* Water quality measurements were collected with hand held meters during fish sampling

Discussion

Based on fish community composition and IBI scores, Cub Creek within HOME is generally in fair condition although remains mildly impaired. The community consisted primarily of insectivorous minnows, a low proportion of generalist feeders, and had a low incidence of disease/hybridization (a sign of stress). However, all but one fish species found at Cub Creek were moderately tolerant or tolerant to human disturbance.

We did find a decline in species richness and total catch (except in 2011), yet an increase in relative abundance (except in 2008) across time. However, these findings may be an artifact of sample area or volume rather than a true decline in richness or numbers of fish collected. Sample area was found to decrease across years while sample volume decreased from 2004 to 2008 and then increased in 2011. These results suggest that number of species collected in Cub Creek is associated with the amount of area sampled while number of fish caught is related to volume of water sampled. When area was adjusted by removing one substantially large site from the 2004 data set, there remained a relationship between sample area and species richness. However, the decline in species richness (8% from 12 to 11 species) after removing the site was not proportional to the change in sample area (decline of 57% from 941 to 401 m^2). This suggests that there is a direct relationship between area sampled and species richness, but only to a point where species richness asymptotes and sampling more stream does not result in collecting additional species. Our small data set of four years suggests that the asymptote is near 12 species. Additionally, the perceived decline in richness could be due to the several small Cyprinids that were collected in 2011 that could not be identified further than family (Cyprinidae spp.). It is possible that additional species are present within this group and would result in a species richness value more similar to 2008. Finally, those species that were present in 2004 and 2006 but not collected in the 2011 sample were uncommon (<2%) in the community. It is possible they were present in the stream but not collected within our sample sites. Based on the data we have collected from 2004-2011, physical habitat, water quality, and adjacent land use are consistent among years and the likely explanation for the seeming decline in species richness is a combination of decreased sample area of the stream across years and taxonomic resolution of fish identification in 2011. Using consistent site lengths in future monitoring efforts will clarify if species richness is truly declining in Cub Creek.

Although the water quality parameters collected during our monitoring met the standards set by Nebraska DEQ, previous water quality/chemistry assessments (1960-1997) reviewed by NPS Water Resources Division (1999) indicated degraded water quality conditions in Cub Creek. These historical conditions were primarily due to agricultural land use practices and industrial discharges within the watershed resulting in dissolved oxygen, pH, nitrates, and heavy metal contaminants exceeding criteria set by the US Environmental Protection Agency.

Due to continued agricultural land use and industrial discharges in the watershed, point source and non-point source pollution remains an issue for water quality and biological integrity of Cub Creek. However, a forested riparian area along the stream corridor within the park bordered by restored tallgrass prairie further upland serve to buffer runoff into the creek. Maintaining the integrity of the riparian corridor will help mediate anthropogenic disturbances to Cub Creek that originate upstream of the park boundary, resulting in adequate habitat to sustain a moderately diverse and moderately tolerant fish community.

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