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Aquatic Invertebrate Monitoring at Pea Ridge National Military Park, 2009–2015

Natural Resource Data Series NPS/HTLN/NRDS—2018/1146

ON THE COVER
Lee Creek, Pea Ridge National Military Park.
Photography by: Heartland Inventory & Monitoring Network, NPS

Aquatic Invertebrate Monitoring at Pea Ridge National Military Park, 2009–2015

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David E. Bowles, J. Tyler Cribbs, Janice A. Hinsey

National Park Service
Heartland Inventory and Monitoring Network
Wilson's Creek National Battlefield
6424 West Farm Road 182
Republic, Missouri 65738

Editing and Design by

Tani Hubbard

National Park Service &
Northern Rockies Conservation Cooperative
12661 E. Broadway Blvd.
Tucson, AZ 85748

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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 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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Abstract

Stream invertebrates were monitored in three streams located at Pea Ridge National Military Park, Arkansas in 2009/2010, 2012 and 2015 for the purpose of assessing water quality. Monitoring data are insufficient to fully characterize the integrity of these streams, but the available data suggest some mild disturbances may be occurring in the watersheds of the streams. Community metrics indicate moderate to low diversity among the benthic communities. Both intolerant and tolerant taxa (tolerance values ≥5) were present in most samples, and several genera of environmentally sensitive Ephemeroptera, Trichoptera and Plecoptera (EPT) occurred in each stream. All water quality parameters measured in this study were well within the Arkansas surface water standards. Habitat conditions were typical for regional streams. In comparison to least disturbed streams in the region, data for these streams indicate they may be mildly disturbed, but such disturbance may be from historic physical disturbance in the watershed and periodic intermittent flows rather than on-going disturbances. Potential threats to stream integrity do occur in the watershed, including agricultural activities and urban encroachment. There are few available options to park management for mitigating water quality impairment of streams flowing through Pea Ridge National Military Park, largely because impacts to water quality and associated effects on the invertebrate communities originate upstream of the park boundaries.

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Introduction

Pea Ridge National Military Park, Arkansas is located in an area where the Ozark Mountains transition to the Great Plains and is characterized by ridges separated by valleys and ravines, and gently rolling areas of grasslands. Three streams flow through the park. Pratt Creek originates in the eastern part of the park south of the Elk Horn Tavern historical site. It flows in a southwest direction for approximately 2.3 kilometers through restored prairie grasslands and forest; it exits the southern park boundary and flows another 5.1 kilometers before its confluence with Little Sugar Creek.

Winton Spring Branch issues from a limestone outcropping approximately 25 meters north of the park road and flows through a forested area for approximately 130 meters to its confluence with Pratt Creek. Lee Creek originates in the center of the park and flows through a forested area for approximately 3.25 kilometers to its confluence with Pratt Creek. Both Winton Spring Branch and Lee Creek flow into Pratt Creek outside of the southern park boundary. Although spring fed, portions of Pratt and Lee Creeks occasionally become losing reaches during the summer season and are dewatered or have only isolated pools.

The National Park Service began monitoring water quality and invertebrate community structure in 2009 for Pratt Creek and its tributary, Winton Spring Branch, following the guidance of Bowles et al. (2008). Monitoring was initiated in Lee Creek in 2010. Monitoring is conducted because aquatic invertebrates are an important biological assessment tool for understanding and detecting changes in stream ecosystem integrity. They can be used to reflect cumulative impacts that cannot otherwise be detected through traditional water quality monitoring.

The streams at Pea Ridge National Military Park have relatively small drainage areas and flow mostly through restored grasslands and forested areas. Regardless, much of the watersheds of these streams, especially the recharge zone for Winton Spring, are located outside the jurisdictional boundaries of the park. This makes them susceptible to anthropogenic disturbances, including impacts associated with agricultural practices and urbanization (Walsh et al. 2005; Paul et al. 2009).

The purpose of this report is to present a summary of aquatic invertebrate monitoring data collected at Pea Ridge National Military Park through 2015 and compare the results to regional reference streams containing high-quality stream reaches that are representative of the best possible stream condition (Rabeni et al. 1997). Hinsey and Bowles (2012) and Bowles (2014) previously reported on invertebrate monitoring results for Pea Ridge National Military Park.

Winton Spring Branch, Pea Ridge National Military Park. (NPS)

Methods

Methods and procedures used in this report follow Bowles et al. (2008). Samples were collected at one reach each during early May for Pratt Creek, Winton Spring Branch and Lee Creek (Figure 1). Pratt Creek and Winton Spring Branch were sampled in 2009, 2012, and 2015. Lee Creek was sampled in 2009 and 2012, but it was not sampled in 2015 because it had no surface flow. Three successive riffles were sampled within each reach with three benthic invertebrate samples collected at each riffle, resulting in nine samples per reach. A Surber stream bottom sampler (500-µm mesh, 0.09 m^2) was used to collect the samples.

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 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/s) and depth (cm) were recorded directly in front of the sampling net frame. Qualitative habitat variables (embeddedness, periphyton, filamentous algae, aquatic vegetation, deposition, and organic material) were estimated within the sampling net frame as percentage categories: Absent (0%), Sparse (<10%), Moderate (10-40%), Heavy (40-75%), and Very Heavy (>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).

Collecting invertebrates with a Surber sampler. (NPS)

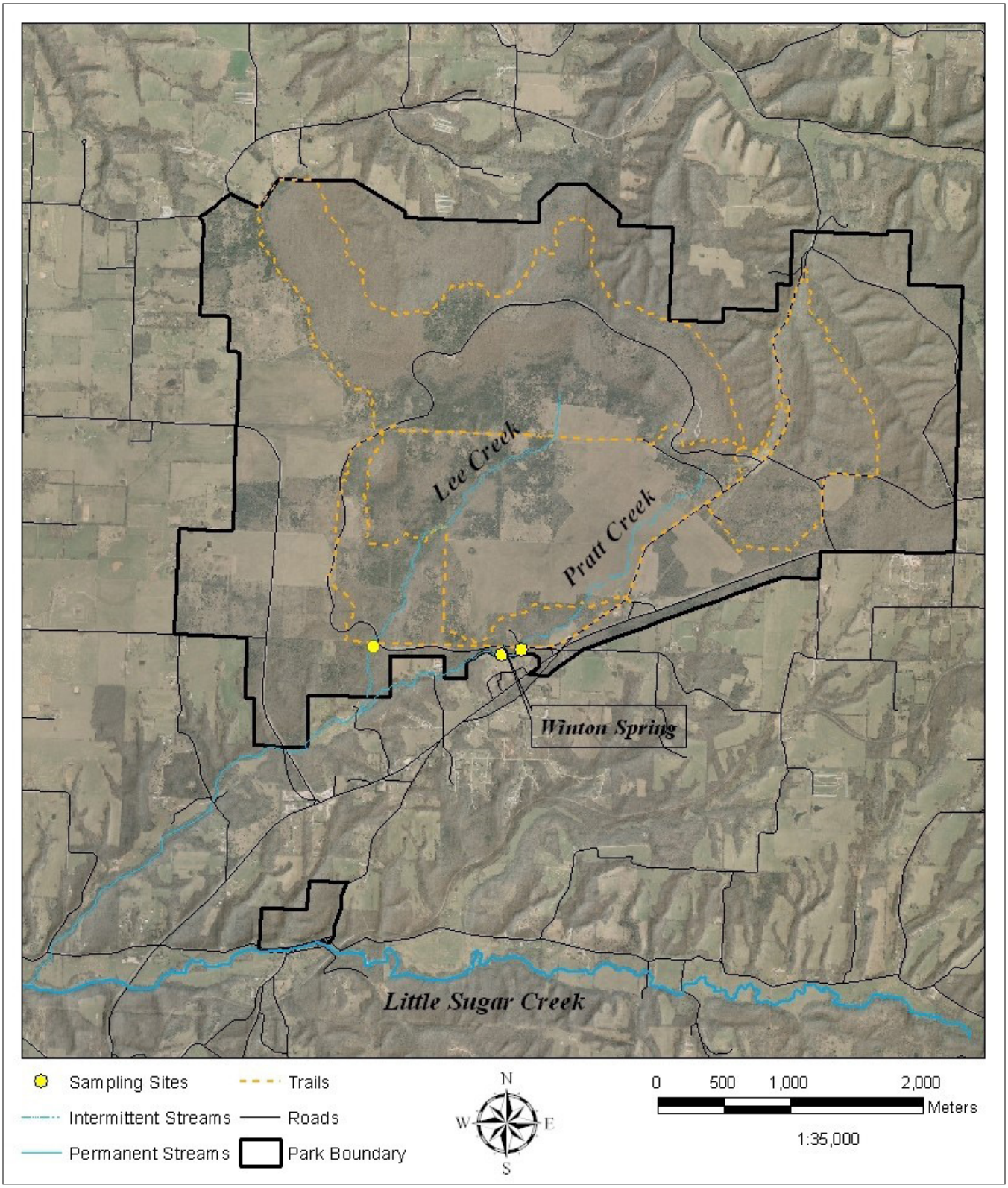

Figure 1. Map showing the approximate location of sampling sites for three streams at Pea Ridge National Military Park.

Stream discharge was measured upstream of the sampled riffles. Temperature (°C), dissolved oxygen (mg/liter), pH, specific conductance (µS/cm), and turbidity were recorded in each stream using a calibrated YSI 6920 data logger. Measurements were made hourly and included a diel period. For Lee Creek in 2010, measurements were made every 15 minutes during the time invertebrates were sampled and did not include a diel period.

The water quality and habitat data presented in this report represent only a snapshot of the broad temporal range of conditions and should be cautiously interpreted. They are intended to describe the prevailing conditions that influence the structure of invertebrate communities, and they may help explain variability between samples, but they should not be used as an analytical tool in the strictest sense (Bowles et al. 2008). 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 of the three streams.

The intent of this study is to monitor community condition of these streams over time (Bowles et al. 2008). Because sample size presently is small (n=3 years), a statistical analysis of the data cannot be accomplished and only summary statistics are presented in this report.

Results

Metric and diversity values for Pratt Creek and Winton Spring Branch in 2015 were similar to those from other years (Table 1; Hinsey and Bowles 2012; Bowles 2014). Low diversity for Lee Creek in 2012 is probably due to the low flow conditions at the time of sampling, which likely impacted invertebrate populations. For example, Mean taxa richness for Pratt Creek ranged from 14.33 to 17.33 among years, while that of Winton Spring Branch ranged from 15.00 to 16.44. Mean Taxa richness for Lee Creek was 24.78 in 2010 compared to 12.67 in 2012.

Table 1. Summary statistics for invertebrate samples collected from streams at Pea Ridge National Military Park, Arkansas, 2009-2015. Values are means with standard errors in parentheses. N=3 for each metric.

Stream	Year	Taxa Richness	EPT Richness	% EPT	EPT Ratio	% Intolerant	Shannon Diversity Index	Shannon Evenness Index	HBI
Pratt Creek	2009	15.33 (0.69)	7.56 (0.56)	23.33 (4.67)	0.47 (0.13)	16.11 (5.41)	1.84 (0.16)	0.66 (0.05)	5.62 (0.22)
	2012	17.33 (1.53)	6.11 (0.87)	19.83 (1.52)	0.50 (0.01)	9.86 (2.57)	1.85 (0.17)	0.66 (0.03)	6.31 (0.16)
	2015	14.33 (0.33)	7.00 (0.38)	49.0 (2.08)	0.36 (0.08)	5.70 (0.47)	1.59 (0.03)	0.60 (0.01)	6.12 (0.04)
Winston Spring Branch	2009	15.00 (1.90)	6.11 (0.78)	42.11 (1.44)	0.79 (0.07)	9.67 (1.71)	2.17 (0.18)	0.82 (0.03)	5.48 (0.22)
	2012	16.44 (0.29)	6.44 (0.29)	53.00 (7.09)	0.73 (0.08)	9.33 (1.45)	2.04 (0.06)	0.73 (0.02)	5.71 (0.11)
	2015	15.44 (0.73)	5.67 (0.19)	36.67 (0.67)	0.58 (0.03)	3.67 (1.20)	1.79 (0.09)	0.65 (0.03)	5.54 (0.09)
Lee Creek	2010	24.78 (1.90)	15.89 (1.95)	37.22 (3.44)	0.72 (0.02)	13.22 (2.61)	2.48 (0.07)	0.73 (0.02)	5.79 (0.07)
	2012	12.67 (0.84)	3.11 (0.11)	59.22 (7.55)	0.27 (0.09)	6.32 (0.66)	1.94 (0.09)	0.76 (0.01)	6.53 (0.12)
	2015	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

A stonefly larva (order Plecoptera, family Perlidae).
(© BÖHRINGER FRIEDRICH)

Mean EPT richness was generally around 6 to 7 for Pratt Creek and Winston Spring Branch, although it ranged from 3.11 to 15.89 for Lee Creek. Percent EPT was generally less than 50% of the entire community. Several EPT genera were found in each stream. Moreover, both intolerant and tolerant taxa (tolerance values ≥5) were present in most samples, but the percent intolerant taxa (TV>3) was low for all samples (≤16 percent). Across years, HBI values for Pratt Creek ranged from 5.62 to 6.31, while those of Winton Spring Branch and Lee Creek ranged from 5.48 to 5.71 and 5.79 to 6.53, respectively. EPT ratios were moderate to high for all streams (0.27-0.79) indicating that potentially pollution tolerant Chironomidae did not dominate their respective benthic communities in all three streams. Mean Shannon Diversity Index was moderately low for each stream and did not exceed 2.48, and the evenness index was 0.82 or less for all sites and years, which collectively indicate moderate to low diversity among the benthic communities.

All water quality parameters measured in this study were well within the Arkansas surface water standards (Tables 2 and 3). Turbidity was higher for Pratt Creek and Winton Spring Branch in 2009 due to a recent rain event, but values met Arkansas state standards for all flows. Although Arkansas surface

Table 2. Water quality data for streams at Pea Ridge National Military Park. Values are means with standard errors in parentheses. Data were collected hourly except for Lee Creek in 2010 where samples were taken every 15 minutes.

Stream	Year	N	Water Temperature (°C)	Specific Conductance (µS/cm)	Dissolved Oxygen (mg/liter)	pH	Turbidity (NTU)
Pratt Creek	2009	73	13.18 (0.05)	229.97 (8.52)	9.63 (0.05)	7.27 (0.02)	8.90 (1.50)
	2012	24	14.35 (0.11)	311.13 (1.34)	9.36 (0.13)	7.31 (0.00)	4.22 (0.46)
	2015	173	13.30 (0.05)	235.91 (4.55)	8.78 (0.06)	7.19 (0.01)	4.73 (0.25)
Winton Spring Branch	2009	69	13.45 (0.02)	215.93 (5.76)	9.64 (0.01)	6.84 (0.01)	10.75 (0.82)
	2012	23	13.90 (0.03)	294.13 (1.39)	9.71 (0.04)	7.25 (0.003)	1.57 (0.08)
	2015	171	12.21 (0.01)	224.68 (5.34)	11.97 (0.03)	6.92 (0.02)	6.38 (0.38)
Lee Creek	2010	9	14.84 (0.16)	314.89 (0.26)	9.61 (0.13)	7.64 (0.01)	1.72 (0.25)
	2012	23	15.70 (0.10)	290.30 (2.85)	9.53 (0.12)	7.36 (0.01)	2.42 (0.22)
	2015	n/a	n/a	n/a	n/a	n/a	n/a

A caddisfly larva (order Trichoptera,family Philopotamidae, genus *Chimarra).* (© ERIN HAYES-PONTIUS)

Table 3. Water quality standards for surface waters in Arkansas (Arkansas Pollution Control and Ecology Commission 2017). See methods for sampling details.

Parameter	Water Quality Standard
Temperature (°C)	Not to exceed 30°C
Dissolved Oxygen (mg/L)	Not less than 6 mg/L
pH	6.0 to 9.0; not to change >1.0 unit in 24 hours
Turbidity (NTU)	10 NTU base flow; 18 NTU all flow
Specific Conductance	N/A

water standards do not address specific conductance, values between 100-400 µS/cm are generally considered ideal for supporting stream life.

Habitat among riffles in all three streams was typical for regional streams (Table 4). All three streams were shallow (mean riffle depth ≤27 cm), with relatively slow current velocities (mean <0.7 m/s). Substrate ranged in size from small pebble to small cobble (>16 to <128 mm). Substrate embeddedness was higher for Winton Spring Branch (<47%) compared to the other two streams at <29%. Among biological parameters measured, mean periphyton was the same for all years and sites (25%). Aquatic vegetation was poorly represented in Lee Creek, but mean densities for the other two streams were as much as 39% in 2015. Vegetation in Pratt Creek was primarily moss while moss and watercress (*Nasturtium officinale*) were dominant in Winton Spring Branch. Filamentous algae occurred in low densities in all three streams (<0.6%).

Table 4. Habitat variables associated with benthic samples collected from streams at Pea Ridge National Military Park, Arkansas. Values are means with standard errors in parentheses. N=3 for each variable.

Parameter	Year	Pratt Creek	Winton Spring Branch	Lee Creek
Depth	2009/2010	8.56 (0.73)	27 (1.17)	5.11 (0.29)
	2012	3.44 (0.40)	6.44 (0.22)	4.44 (0.48)
	2015	4.55 (0.61)	7.0 (0.19)	n/a
Current Velocity (m/sec)	2009/2010	0.29 (0.06)	0.69 (0.03)	0.13 (0.02)
	2012	0.13 (0.02)	0.14 (0.01)	0.12 (0.02)
	2015	0.19 (0.03)	0.19 (0.04)	n/a
Substrate Size (mm)	2009/2010	42.33 (7.95)	22.22 (4.42)	93.22 (5.56)
	2012	46.34 (2.49)	26.76 (2.13)	83.94 (12.65)
	2015	55.94 (3.72)	25.78 (1.52)	n/a
% Embeddedness	2009/2010	28.61 (3.61)	46.67 (6.25)	22.78 (2.22)
	2012	25 (0)	35.83 (6.25)	27.78 (10.20)
	2015	16.11 (2.22)	28.61 (3.61)	n/a
% Filamentous green algae	2009/2010	0.11 (0.11)	0.56 (0.56)	0 (0)
	2012	0.56 (0.56)	0 (0)	0 (0)
	2015	0 (0)	6.67 (3.47)	n/a
% Periphyton	2009/2010	25 (0)	25 (0)	25 (0)
	2012	25 (0)	25 (0)	25 (0)
	2015	25 (0)	25.0 (0)	n/a
% Aquatic Vegetation	2009/2010	1.11 (0.56)	27.78 (11.15)	7.78 (3.09)
	2012	26.39 (1.39)	26.39 (1.39)	3.33 (3.33)
	2015	39.44 (3.61)	39.44 (9.55)	n/a
Discharge (m^3/sec)	2009/2010	0.02	0.16	0.20
	2012	0.04	0.03	0.003
	2015	0.18	0.71	n/a

Discussion

Based on the aquatic invertebrate community, water quality, and habitat data reported here, the conditions of Pratt and Lee creeks and Winton Spring Branch have not changed appreciably since monitoring began (Hinsey and Bowles 2012; Bowles 2014).

The data presented in this report are insufficient to fully characterize the integrity and trend of these three streams. In comparison to least disturbed streams in the region (Rabeni et al. 1997), data for these streams indicate they may be mildly disturbed, but such disturbance may be from historic physical disturbance in the watershed and periodic intermittent flows rather than on-going disturbances. The relatively high proportion of EPT taxa in samples, especially the stoneflies, suggests the streams remain in relatively good condition. The occurrence of rare and environmentally sensitive invertebrate species in all three streams, in addition to a neotenic salamander (*Eurycea spelaea*) and the red alga *Batrachospermum*, further suggests that they are not disturbed.

Potential threats to stream integrity do occur in the watersheds of these streams, including agricultural practices, groundwater pumping, and urban encroachment. Impacts of urbanization on streams often are so pervasive that mitigation strategies are difficult and rarely fully effective (Bernhardt et al. 2005; Paul et al. 2009). There are few available options to park management for mitigating water quality in streams flowing through Pea Ridge National Military Park, largely because impacts to water quality and associated effects on the invertebrate communities originate outside of park boundaries, beyond the control of park management. For example, dewatering of the aquifer that supplies flow to the springs could have detrimental impacts on stream integrity in the park. In addition, nutrients and contaminants entering the recharge zone of Winton Spring are concerning.

Maintaining riparian buffer zones along these streams in the park will aid in protecting aquatic life as well as in-stream habitat from local chemical runoff and sedimentation. Restoring native vegetation of riparian buffers will improve their functionality, which will benefit stream condition. Assessment of long-term water quality conditions achieved through monitoring aquatic invertebrate community structure serves as a useful tool for providing park managers information on the potential impacts of anthropogenic disturbances to these streams.

A mayfly larva (order Ephemeroptera, family Baeidae). (© IAN ALEXANDER)

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Natural Resource Stewardship and Science
1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525