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Aquatic Invertebrate Monitoring at Hot Springs National Park, 2009–2015

Natural Resource Data Series NPS/HTLN/NRDS—2017/1126

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Bull Bayou, Hot Springs National Park
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ON THE COVER
Gulpha Creek, Hot Springs National Park
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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 at Bull Bayou and Gulpha Creek, Hot Springs National Park, Arkansas in 2009, 2012 and 2015 for the purpose of assessing water quality. Monitoring data are insufficient to fully characterize the integrity of Bull Bayou and Gulpha Creek, but the available data suggest some disturbances may be occurring in the watersheds of the streams. In comparison to least disturbed streams in the Ouachita Mountain Ecoregion, preliminary data for both streams indicate they may be mildly impaired, but such effects may be from historic physical disturbance in the watershed rather than on-going disturbances. However, potential threats to stream integrity do occur in the watershed, including a landfill in the upper watershed of Bull Bayou, and urbanization and other land use practices in the Gulpha Creek watershed (e.g., golf course, lawn care, pest management, fuel storage and commercial activities).

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Introduction

The National Park Service began monitoring water quality and invertebrate community structure in Bull Bayou and Gulpha Creek at Hot Springs National Park, Arkansas in 2009 following the guidance of Bowles et al. (2008). Monitoring was initiated because aquatic invertebrates are an important biological assessment tool for understanding and detecting changes in stream ecosystem integrity. They are used to reflect cumulative impacts that cannot be detected through traditional water quality monitoring. Gulpha Creek and Bull Bayou are relatively small drainage basins with greater than 95% of each being forested (Petersen and Mott 2002). Both have their headwaters located outside park boundaries, making them susceptible to anthropogenic disturbances, including impacts associated with urbanization (Walsh et al. 2005; Paul et al. 2009). Previous studies of aquatic invertebrates at Hot Springs National Park include work by Luraas and Bowles (2012) and Bowles (2014). The purpose of this report is to present a summary of aquatic invertebrate monitoring data collected at Hot Springs National Park in 2009, 2012 and 2015, and compare these results to regional reference streams containing high-quality reaches that are representative of the best possible conditions (Galloway et al. 2008).

Gulpha Creek, Hot Springs National Park, Arkansas. (NPS)

Methods

Methods and procedures used in this report follow Bowles et al. (2008). Samples were collected at one 150-m reach of Gulpha Creek and at one 150-m reach of Bull Bayou (Fig. 1). Three successive riffles were sampled, with three benthic invertebrate samples collected at each riffle, resulting in nine total samples for each stream. A Surber stream bottom sampler (500-µm mesh, 0.09 m^2) was used to collect samples while the substrate was agitated by a hand-held garden cultivation tool. 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 taxa richness, Shannon diversity index, EPT (Ephemeroptera, Plecoptera, Trichoptera) richness, EPT ratio [EPT density/(EPT density + Chironomidae density)], Shannon evenness (where 0 = minimum evenness, 1 = maximum evenness), and the Hilsenhoff Biotic Index (HBI). Tolerance values (TV) are from Bowles et al. (2008). 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 where smaller values indicate better conditions. An increase in HBI is undesired because that would reflect increasing tolerance of the community to disturbance. The HBI is calculated using taxon-specific tolerance values ranging from 0 to 10, were 0 is the most intolerant and 10 is the most tolerant (Barbour et al. 1999).

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) 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 using the Wentworth scale (Wentworth 1922). Stream discharge was measured upstream of the sample site for both streams. Water quality readings (conductance, dissolved oxygen, temperature, pH, and trurbidity) were recorded hourly using a calibrated YSI 6920 or YSI 6600 data logger.

The water quality and habitat data presented in this report represent only a snapshot of the broad temporal range of conditions 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 Gulpha Creek and Bull Bayou.

Collecting invertebrates with a Surber stream bottom sampler. (NPS)

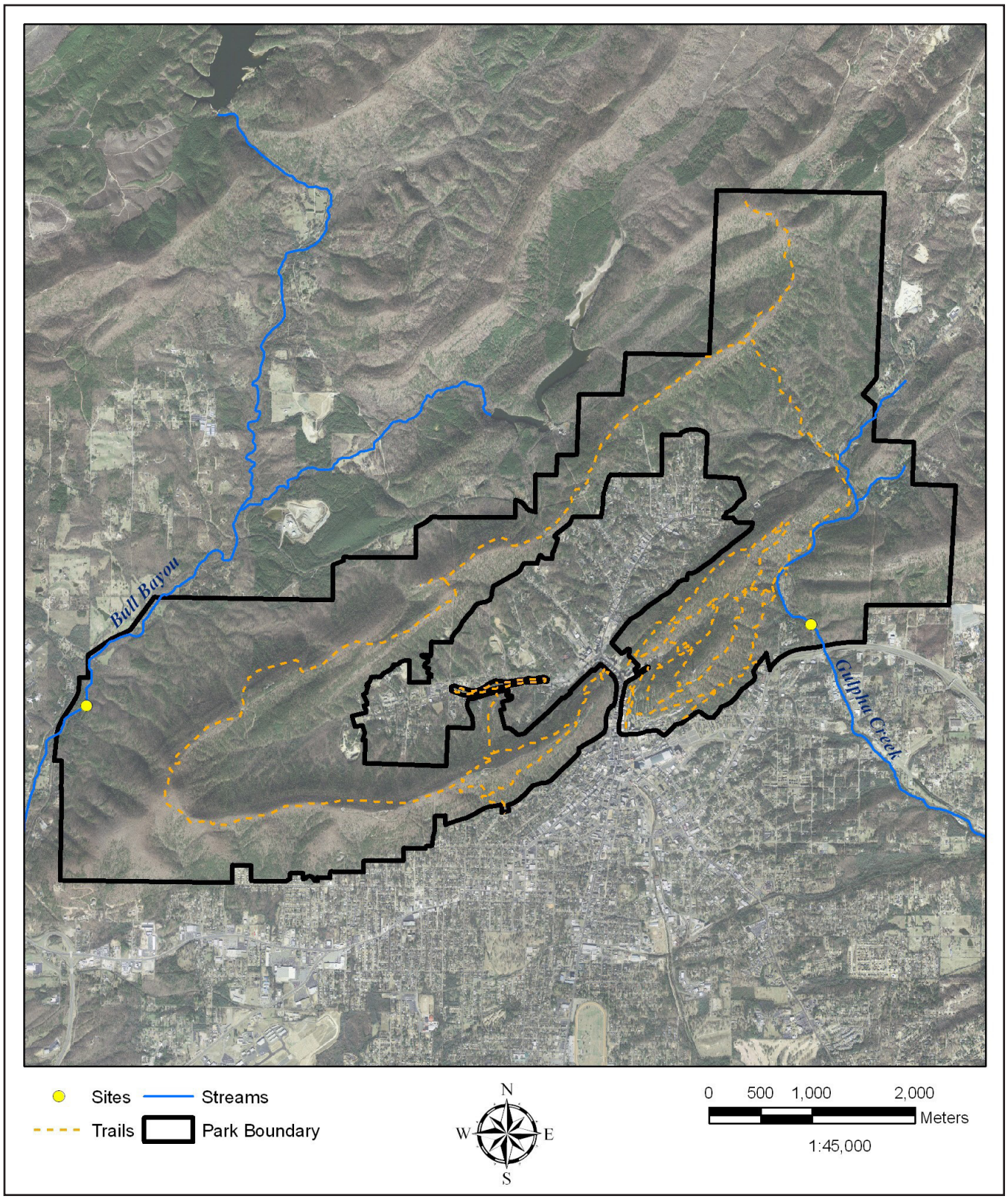

Figure 1. Map showing the approximate sampling location reach for Bull Bayou and Gulpha Creek, Hot Springs National Park, Arkansas.

Results

Metric and diversity values reported across years did not meet those reported for least-disturbed Ouachita Mountains ecoregion streams (Galloway et al. 2008; ADEQ 2010) during a spring index period (Tables 1, 2, and 3). Mean taxa richness was slightly higher in Bull Bayou but did not exceed 18.7 at either site. Similarly, mean EPT richness values were fairly low (≤9.1) for both sites. Samples from Bull Bayou and Gulpha Creek contained both pollution tolerant and intolerant taxa. HBI values were slightly higher for Bull Bayou compared to Gulpha Creek, with values for both sites ranging from 4.19 to 5.86. HBI values of 5.5 or less are generally considered good, although some organic pollution may be possible (Hilsenhoff 1982, 1987, 1988).

Mean Shannon Diversity Index values for both streams ranged from 1.94 to 2.50. For biological data, Shannon's diversity index ranges generally 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. 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. EPT ratios were high for both streams (0.83 or higher) indicating that pollution tolerant Chironomidae did not represent a substantial portion of the benthic community among samples in either stream.

Table 1. Benthic invertebrate metric data for least-disturbed Ouachita Mountains ecoregion streams during a spring index period (from Galloway et al. 2008; ADEQ 2010).

Statistic	Taxa Richness	EPT Richness	HBI
Minimum	16.0	10.0	3.35
25th percentile	19.5	11.0	3.71
Mean	21.5	12.3	3.92
75th percentile	23.0	14.0	4.24
Maximum	28.0	14.0	4.54

Table 2. Summary statistics for invertebrate samples collected from Bull Bayou, Hot Springs National Park, 2009-2015.

Metric	Year	Mean	Standard Error	Min	Max	N
Taxa Richness	2009	18.11	1.48	8.00	23.00	9
	2012	18.67	0.77	17.33	20.00	9
	2015	12.89	0.80	11.33	14.00	9
EPT Richness	2009	7.56	0.75	5.00	12.00	9
	2012	9.11	0.29	8.67	9.67	9
	2015	7.00	0.33	6.67	7.67	9
EPT Ratio	2009	0.83	0.03	0.63	0.93	9
	2012	0.96	0.01	0.94	0.97	9
	2015	0.84	0.02	0.81	0.87	9
Shannon's Diversity Index	2009	2.15	0.11	1.46	2.51	9
	2012	2.38	0.05	2.29	2.45	9
	2015	2.03	0.15	1.82	2.33	9
Shannon's Evenness Index	2009	0.73	0.02	0.64	0.83	9
	2012	0.81	0.01	0.80	0.82	9
	2015	0.82	0.04	0.74	0.89	9
HBI	2009	5.86	0.09	5.30	6.16	9
	2012	4.96	0.33	4.42	5.56	9
	2015	4.88	0.02	4.85	4.90	9

Table 3. Summary statistics for invertebrate samples collected from Gulpha Creek, Hot Springs National Park, 2009–2015.

Metric	Year	Mean	Standard Error	Min	Max	N
Taxa Richness	2009	14.44	1.58	7.00	23.00	9
	2012	14.89	2.06	11.00	18.00	9
	2015	18.44	1.16	16.33	20.33	9
EPT Richness	2009	8.11	0.68	5.00	11.00	9
	2012	7.22	1.61	4.00	9.00	9
	2015	9.00	0.77	7.67	10.33	9
EPT Ratio	2009	0.92	0.02	0.84	1.00	9
	2012	0.97	0.01	0.95	0.99	9
	2015	0.89	0.01	0.88	0.90	9
Shannon's Diversity Index	2009	2.03	0.13	1.32	2.52	9
	2012	1.94	0.15	1.74	2.24	9
	2015	2.50	0.03	2.45	2.55	9
Shannon's Evenness Index	2009	0.76	0.03	0.63	0.87	9
	2012	0.75	0.05	0.66	0.82	9
	2015	0.85	0.01	0.83	0.86	9
HBI	2009	5.10	0.22	4.17	6.06	9
	2012	4.19	0.25	3.81	4.66	9
	2015	4.75	0.17	4.56	5.10	9

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

A list of the aquatic invertebrates collected in samples from Bull Bayou and Gulpha Creek are in Luraas and Bowles (2012) and are not repeated here. Dominant taxa in Bull Bayou included the caddisfly (order Trichoptera) genus *Cheumatopsyche* (family Hydropsychidae; TV = 6.6), the mayfly (order Ephemeroptera) genus *Caenis* (family Caenidae; TV = 7.6), and the dipteran family Chironomidae (TV = 6). Among samples in Gulpha Creek, the most dominant taxa were the intolerant snail genus *Elimia* (TV = 2.5), genus *Caenis* and genus *Cheumatopsyche*. The mayfly family Baetidae (order Ephemeroptera, genera *Acentrella* and *Baetis*) and genus *Stenonema* (family Heptageniidade) were commonly collected from both streams, with tolerance values of 4 or less. Intolerant stoneflies (order Plecoptera, genus *Neoperla*; TV 1.6) were also collected from both streams.

All water quality parameters measured in this study (Tables 4 and 5) were well within the Arkansas surface water standards (Table 6). Mean specific conductance was lower in Bull Bayou compared to Gulpha Creek, but did not exceed 153 µS/cm in any instance. Low specific conductance is expected for these streams because the regional geology is largely igneous formations and sandstones, which result in low buffering capacity of surface waters. Specific conductance values between 100-400 µS/cm are generally considered ideal for supporting stream life. Mean dissolved oxygen concentrations generally exceeded the state standard for these streams, and the lower value of 5.56 mg/l recorded in 2015 is not cause for concern, because it most likely was due to equipment error. The other data collected from that site indicate high water quality conditions. Both water temperature and pH are typical for regional streams. Turbidity was negligible for both streams. Stream discharge was 0.52 m^3/s or less for both streams.

Table 4. Water quality data for Bull Bayou, Hot Springs National Park, 2009–2015. Data were collected hourly with calibrated data loggers.

Year	Statistic	Water Temperature (°C)	Specific Conductance (µS/cm)	Dissolved Oxygen (mg/L)	pH	Turbidity (NTU)
2009	Mean	24.14	60.55	8.70	6.95	1.18
	Standard Error	0.20	0.12	0.07	0.02	0.05
	N	39	38	39	39	39
2012	Mean	24.52	68.30	7.50	7.15	0.53
	Standard Error	0.22	0.36	0.11	0.02	0.06
	N	23	23	23	23	23
2015	Mean	23.75	51.13	**5.56**[a]	6.75	0.99
	Standard Error	0.15	0.34	0.04	0.01	0.04
	N	16	16	16	16	16

[a] Value that fell below state water quality standards (also in bold).

Table 5. Water quality data for Gulpha Creek, Hot Springs National Park, 2009–2015. Data were collected hourly with calibrated data loggers.

Year	Statistic	Water Temperature (°C)	Specific Conductance (µS/cm)	Dissolved Oxygen (mg/L)	pH	Turbidity (NTU)
2009	Mean	24.05	119.31	7.91	7.69	0.64
	Standard Error	0.15	0.46	0.03	0.01	0.02
	N	42	42	42	42	42
2012	Mean	23.96	152.08	6.34	7.75	8.25
	Standard Error	0.19	0.27	0.05	0.01	0.01
	N	24	24	24	24	24
2015	Mean	23.66	69.10	7.76	7.19	1.66
	Standard Error	0.15	0.22	0.07	0.01	0.05
	N	20	20	20	20	20

Table 6. Water quality standards for surface waters in the Ouachita Mountains, from Arkansas Pollution Control and Ecology Commission (APCEC), 2017.

Parameter	Water Quality Standard
Temperature (^{o}C)	Not to exceed 30^{o}C
Dissolved Oxygen (mg/L)	Bull Bayou: not less than 6 mg/L primary; 6 mg/L critical Gulpha Creek: not less than 6 mg/L primary; 2 mg/L critical
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

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

Habitat among riffles in both streams was generally uniform (Tables 7 and 8). Both streams were shallow (mean riffle depth ≤17.89 cm), with relatively slow current velocities (mean ≤0.7 m/s). Substrate was consistent in size and consisted mainly of large pebbles and small cobble, and substrate embeddedness was low for both streams at less than or equal to 32%. Among biological parameters measured, mean periphyton was generally higher in Bull Bayou compared to Gulpha Creek, but in all cases across years it was less than about 43%. No aquatic vegetation or filamentous algae were found in Gulpha Creek while Bull Bayou had a small amount of aquatic vegetation (moss) in 2009 only (mean = 0.56%) and no filamentous algae. No habitat values were cause for concern, and they are considered typical for regional streams.

Table 7. Mean and standard error (in parentheses) for habitat variables associated with benthic samples collected from Bull Bayou, Hot Springs National Park, 2009–2015.

Metric	2009	2012	2015
Depth (cm)	12.33 (2.01)	14.56 (0.11)	17.89 (1.18)
Velocity (m/s)	0.50 (0.11)	0.42 (0.01)	0.70 (0.18)
Substrate (Wentworth scale)	60.94 (4.28)	109.44 (11.32)	77.67 (15.67)
Embeddedness (%)	25 (0)	11.67 (6.67)	28.61 (3.61)
Discharge (m^3/sec)	0.11	0.35	0.52
Vegetation (%)	0.56 (0.56)	0	0
Filamentous Algae (%)	0	0	0
Periphyton (%)	22.78 (2.22)	43.06 (9.55)	28.61 (3.61)

Table 8. Mean and standard error (in parentheses) for habitat variables associated with benthic samples collected from Gulpha Creek, Hot Springs National Park, 2009–2015.

Metric	2009	2012	2015
Depth (cm)	9.44 (1.24)	8.67 (1.45)	12.33 (0.69)
Velocity (m/s)	0.24 (0.03)	0.22 (0.01)	0.33 (0.04)
Substrate (Wentworth scale)	47.77 (12.49)	118.56 (6.78)	60.76 (4.20)
Embeddedness (%)	25 (0)	22.78 (2.22)	32.22 (3.61)
Discharge (m^3/sec)	0.07	0.33	0.19
Vegetation (%)	0	0	0
Filamentous Algae (%)	0	0	0
Periphyton (%)	6.67 (2.54)	25 (0)	25 (0)

Discussion and Conclusions

The data presented in this report are insufficient to fully characterize the integrity and trend of Bull Bayou and Gulpha Creek. In comparison to least disturbed streams in the Ouachita Mountain Ecoregion, preliminary data for both streams indicate they could be mildly impaired, but such effects may be from historic physical disturbance in the watershed rather than on-going disturbances. The relatively high proportion of EPT taxa in samples, especially the occurrence of stoneflies, suggests the streams remain in relatively good condition.

Potential threats to stream integrity do occur in the watershed including a landfill in the upper watershed of Bull Bayou, and urbanization and other land use practices in the Gulpha Creek watershed (e.g., golf course, lawn care, pest management, fuel storage and commercial activities; Petersen and Mott 2002). There are few available options to park management for mitigating water quality in streams flowing through Hot Springs National Park, largely because impacts to water quality and associated effects on the invertebrate communities originate upstream of the park boundaries. 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).

Maintaining and widening of 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. Riparian buffer zones can be improved by restoring them to native vegetation. Improved buffer zones will reduce bank erosion within Hot Springs National Park by reducing stream velocity and the amount of water entering the streams. A reduction in impervious surfaces (sidewalks, parking lots) within the park would also help to stabilize the riparian zone and in-stream habitat. Continued 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 impacts of anthropogenic disturbances in the Bull Bayou and Gulpha Creek watersheds.

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

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