



Vulnerability of Stream Communities to Climate and Land Use Change at Wilson's Creek National Battlefield (WICR)

Biotic communities are useful indicators of aquatic ecosystem health because a high quality, diverse, and functioning community reflects a high quality and functioning ecosystem. Stream habitats and communities are dynamic. Therefore, it is important to understand the natural variability of communities through time, such that changes from that natural variability may be used to make inferences of instability and the susceptibility to future climate and land use change. In addition, alterations in environmental conditions due to climate and land use change are major contributors to stream variability and degradation, but the extent that these impacts have on various regions and streams likely differ. Determining a stream's susceptibility to change from human caused impacts is necessary to determine stream communities that are most likely to experience a decrease in diversity, abundance, and function in the future. Data collected through monitoring equips park managers with the ability to understand the natural fluctuations in communities over time and among locations such that changes in future settings may be used to infer instability and, thus, vulnerability. Identifying locations where species are more vulnerable to degradation and determining the types of degradation that increases a community's vulnerability allows for an efficient science-based prioritization to manage and protect aquatic resources.

Methods:

For details on methods of site selection, fish/aquatic invertebrate sampling, habitat and water quality data collection, and data analysis see Bowles et al. (2008), Dodd et al. (2008), and Schwoerer (2016).

- Sites at Wilson's Creek, Terrell Creek, and Skeggs Creek were sampled annually for aquatic invertebrates from 1988-1990, 1996-2007, and 2010 and sampled for the fish community from 2006, 2007, 2010 and 2013 (Figure 1).
- Aquatic invertebrates were sampled using a surber sampler and identified to the lowest taxonomic level, usually genus. Either backpack or barge electrofishing was used to capture fish depending on stream size. Fish were identified to species and measured for length and weight.
- The fish Index of Biotic Integrity (IBI; Dauwalter et al. 2003) was used to assess stream health based on

fish community data and ranges from 0-100 with higher values indicating higher health. This index uses seven metrics for scoring and includes: percent of individuals as algivorous, invertivorous, and piscivorous; percent of individuals with black spot anomaly; percent individuals as green sunfish, bluegill, yellow bullhead, and channel catfish; percent of individuals as invertivorous; percent of individuals as top carnivores; number of darter, sculpin, and madtom species; and number of lithophilic spawning species.

- The aquatic invertebrate Hilsenhoff Biotic Index (HBI; Hilsenhoff 1987) was used for stream health assessment based on all invertebrate taxa collected. The HBI uses taxa tolerance values to calculate a weighted community tolerance score based on abundances and ranges from 0-10 with *lower values indicating higher health*.
- Community variability was assessed by calculating the range in the biotic index scores (quantitative measure of stream health) at each site over each of the years it was sampled.

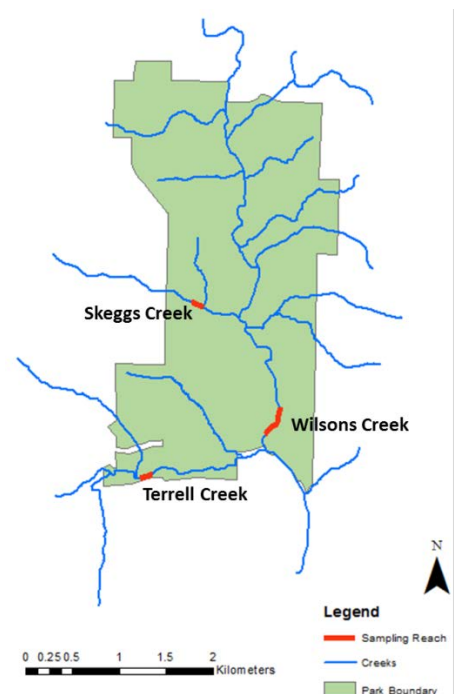


Figure 1. Map of sample sites within Wilson's Creek National Battlefield.

- Fish community vulnerability was calculated using methods found in Table 1. Fish vulnerable to habitat degradation (rock or gravel spawners or stream bed invertivores), warming temperatures (cool and cold-water species), altered flow regime (species requiring steady or variable yet predictable flow), or were a poor disperser (members in the topminnow, sculpin, and darter family) received a score of 1 in that category and all others received a 0. Scores range from 0 to 5. Fish species vulnerability scores can be found in Appendix 1.
- Aquatic invertebrate community vulnerability was calculated using methods found in Table 1 but did not take into account dispersal ability or persistence. Only mayfly, stonefly, and caddisfly (Ephemeroptera, Plecoptera, Trichoptera or EPT) taxa were used since they were best represented in available trait databases. Aquatic Invertebrates vulnerable to habitat degradation (taxa with < 4.5 HBI value), warming temperatures (stenotherm (< 5°C) or cold-cool eurytherm (0-15°C)), or an altered flow regime (species found in only one flow velocity classification of moderate or higher) received a 1 and all others received a 0. Scores range from 0 to 3. Invertebrate taxa vulnerability scores are in Appendix 2.

Table 1. Framework for developing species/taxa vulnerability scores (Sievert et al. 2016) that was used to calculate the community vulnerability score (mean of species/taxa vulnerability scores). Aquatic invertebrate vulnerability did not take into account dispersal ability or persistence. See above for vulnerability classifications.

Species Vulnerability Template		
Scoring	Habitat Degradation	0 or 1
	Warming Temperature	0 or 1
	Altered Flow Regime	0 or 1
	Dispersal Ability	0 or 1
	Species Persistence	1- (# Years Species Present/Total # Years Sampled)
Calculating	Environmental Tolerance	Habitat + Temperature + Flow
	Sensitivity	Dispersal Ability + Species Persistence
	Vulnerability	Environmental Tolerance + Sensitivity

Summary of Findings:

- A total of 34 fish species have been sampled at this park. Wilson's Creek had highest fish richness (32 species) and Skegg's Creek had lowest fish richness (9 species) among sites. 140 aquatic invertebrate taxa (genus level) have been historically sampled at this park. Terrell Creek had highest taxa richness (94 taxa) and Skegg's Creek had lowest taxa richness (87 taxa).
- 49% of fish species were present in the park each time it was sampled while 88% of fish species were present in more than half of the years it was sampled. 10% of invertebrate taxa (family level) were present in the park each time it was sampled while 41% of taxa were present in more than half of the years it was sampled.
- Wilsons Creek had the highest mean IBI score, rated as good condition, and ranged from 73 to 83

while Terrell Creek had the lowest mean IBI, rated as fair condition, and ranged from 45 to 63 (Figure 2). Terrell Creek had the highest variability in IBI scores.

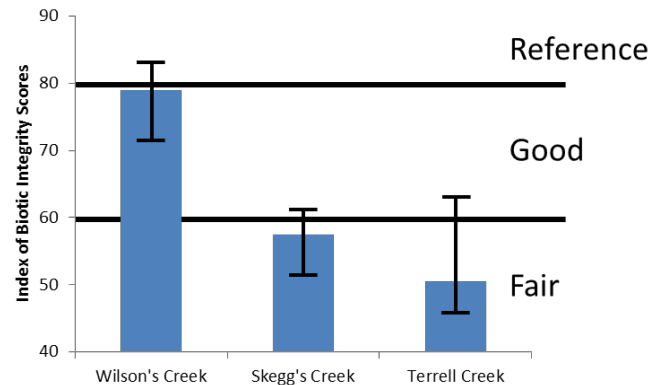


Figure 2. Mean Index of Biotic Integrity scores for fish communities at three sites within Wilsons Creek National Battlefield. Bars represent ranges in scores in 2006, 2007, 2010 and 2013. Horizontal lines indicate stream integrity categories based on IBI scores.

- Skegg's Creek had the highest mean HBI (lowest stream health based on invertebrate data) and ranged from 5.32 to 6.78 while Terrell Creek had the lowest HBI (highest stream health) and ranged from 2.45 to 6.34 (Figure 3). Terrell Creek had the highest variability in HBI scores.

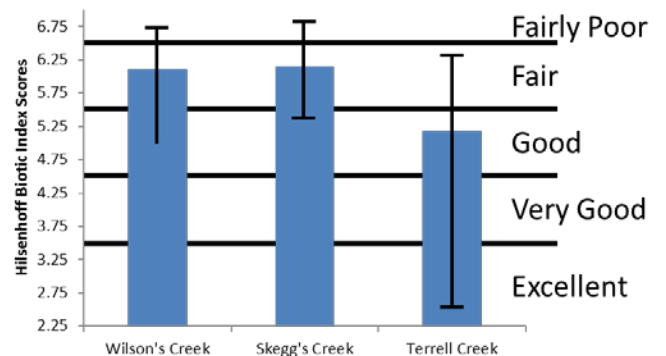


Figure 3. Mean Hilsenhoff Biotic Index scores for aquatic invertebrate communities at three sites within Wilsons Creek National Battlefield. Bars represent ranges in scores during the 16 sampling events in 1988-1990, 1996-2007, and 2010. Horizontal lines indicate stream integrity ratings based on HBI scores.

- For fish species found within this park, 66% were vulnerable to habitat degradation, 51% were vulnerable to warming temperature, 46% were vulnerable to a change in flow regime, and 29% were poor dispersers (Table 2). Of the EPT taxa found within this park, 64% were vulnerable to habitat degradation, 16% were vulnerable to warming temperature, and 80% were vulnerable to a change in flow regime (Table 3).

- Skegg's Creek had the highest fish community vulnerability (highest percent vulnerable to habitat degradation and temperature increase) while Wilson's Creek had the lowest fish community vulnerability (lowest percent vulnerable to habitat degradation, temperature increase, and poor dispersers; Table 2). Wilson's Creek and Terrell Creek had the highest EPT invertebrate community vulnerability while Skegg's Creek had the lowest EPT invertebrate community vulnerability (Table 3).
- Of the seven parks analyzed in the Heartland I&M network (six for aquatic invertebrates), Wilsons Creek National Battlefield had the second most vulnerable fish community and the fourth most vulnerable aquatic invertebrate EPT community.

Table 2. Percent of fish species and EPT invertebrate taxa at seven National Park Service units within the central United States vulnerable to habitat degradation, warming temperatures altered flow regime or being a poor disperser (fish only) as well as overall park vulnerability score. Pipestone National Monument (PIPE), Tallgrass Prairie National Preserve (TAPR), Homestead National Monument of America (HOME), George Washington Carver National Monument (GWCA), Wilsons Creek National Battlefield (WICR), Ozark National Scenic Riverways (OZAR), and Buffalo National River (BUFF).

Park	Fish					Aquatic Invertebrate			
	Habitat	Temperature	Flow	Dispersal	Vulnerability (5)	Habitat	Temperature	Flow	Vulnerability (3)
HOME	27	27	53	0	1.45	48	14	90	1.52
TAPR	42	19	42	11	1.47	NOT SAMPLED			
OZAR	56	39	50	19	1.85	74	19	74	1.68
BUFF	64	47	45	25	1.95	72	19	74	1.65
PIPE	50	50	33	17	2.00	53	18	82	1.53
WICR	66	51	46	29	2.17	64	16	80	1.60
GWCA	69	63	44	38	2.31	67	25	83	1.75

Table 3. Percent of fish species and EPT invertebrate taxa at Wilson's Creek National Battlefield vulnerable to habitat degradation, temperature increase, flow modification, and dispersal ability (fish only) and the overall site vulnerability score.

Site	Fish					Aquatic Invertebrate			
	Habitat	Temp	Flow	Dispersal	Vulnerability (5)	Habitat	Temp	Flow	Vulnerability (3)
Wilson's Creek	0.66	0.50	0.41	0.31	2.14	0.43	0.21	0.86	1.50
Skegg's Creek	0.89	0.89	0.33	0.56	2.92	0.43	0.14	0.86	1.43
Terrell Creek	0.59	0.71	0.41	0.41	2.44	0.50	0.19	0.81	1.50

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Appendix 1. Fish species vulnerable (1) to habitat degradation, temperature increase, altered flow, and poor dispersal ability for species sampled in Wilson's Creek National Battlefield from 2006, 2007, 2010 and 2013. Reoccurrence is the inverse proportion of years a species was found in the park. Vulnerability is the sum of habitat, temperature, flow, dispersal, and reoccurrence columns (out of 5).

Scientific Name	Common Name	Habitat	Temp	Flow	Dispersal	Reoccurrence	Vulnerability
<i>Notropis anabrops</i>	Bigeye chub	1	1			0.75	2.75
<i>Notropis boops</i>	Bigeye shiner	1	1			0.75	2.75
<i>Pimephales notatus</i>	Bluntnose minnow		1			0.75	1.75
<i>Nocomis biguttatus</i>	Hornyhead chub	1	1	1		0.75	3.75
<i>Lepisosteus osseus</i>	Longnose gar			1		0.75	1.75
<i>Erimystax harryi</i>	Ozark chub	1				0.75	1.75
<i>Noturus albater</i>	Ozark madtom	1		1		0.75	2.75
<i>Moxostoma duquesnei</i>	Black redbhorse	1		1		0.5	2.5
<i>Gambusia affinis</i>	Mosquitofish					0.5	0.5
<i>Luxilus chrysocephalus</i>	Striped shiner	1				0.5	1.5
<i>Etheostoma juliae</i>	Yoke darter	1	1		1	0.5	3.5
<i>Lepomis macrochirus</i>	Bluegill			1		0.25	1.25
<i>Notropis percobromus</i>	Carmine shiner					0.25	0.25
<i>Moxostoma erythrurum</i>	Golden redbhorse	1		1		0.25	2.25
<i>Percina caprodes</i>	Loggerperch	1			1	0.25	2.25
<i>Notropis nubilus</i>	Ozark minnow	1	1			0.25	2.25
<i>Catostomus commersoni</i>	White sucker		1	1		0.25	2.25
<i>Etheostoma zonale</i>	Banded darter	1			1	0	2
<i>Cottus caroliniae</i>	Banded sculpin	1		1	1	0	3
<i>Fundulus olivaceus</i>	Blackspotted topminnow	1	1		1	0	3
<i>Semotilus atromaculatus</i>	Creek chub	1	1			0	2
<i>Luxilus pilsbryi</i>	Duskystripe shiner	1	1			0	2
<i>Lepomis cyanellus</i>	Green sunfish			1		0	1
<i>Etheostoma blennioides</i>	Greenside darter	1			1	0	2
<i>Lepomis megalotis</i>	Longear sunfish		1	1		0	2
<i>Hypentelium nigricans</i>	Northern hog sucker	1	1	1		0	3
<i>Etheostoma spectabile</i>	Orangethroat darter	1	1		1	0	3
<i>Ambloplites constellatus</i>	Ozark bass		1	1		0	2
<i>Cottus hypselurus</i>	Ozark sculpin	1	1	1	1	0	4
<i>Etheostoma caeruleum</i>	Rainbow darter	1	1		1	0	3
<i>Micropterus dolomieu</i>	Smallmouth bass			1		0	1
<i>Phoxinus erythrogaster</i>	Southern redbelly dace		1			0	1
<i>Etheostoma punctulatum</i>	Stippled darter	1	1		1	0	3
<i>Ameiurus natalis</i>	Yellow bullhead			1		0	1

Appendix 2. Aquatic invertebrate taxa (EPT) vulnerable (1) to habitat degradation, temperature increase, and altered flow at Wilson’s Creek National Battlefield sampled from 1988-1990, 1996-2007, and 2010. Vulnerability is the sum of the habitat, temperature, and flow columns (out of 3).

Order	Family	Genus	Habitat	Temperature	Flow	Vulnerability
Ephemeroptera	Baetidae	Baetis		1	1	2
Ephemeroptera	Baetidae	Pseudocloeon	1		1	1
Ephemeroptera	Caenidae	Caenis			1	1
Ephemeroptera	Ephemeridae	Ephemera	1		1	1
Ephemeroptera	Ephemeridae	Hexagenia				0
Ephemeroptera	Heptageniidae	Heptagenia	1	1	1	2
Ephemeroptera	Heptageniidae	Stenacron			1	1
Ephemeroptera	Heptageniidae	Stenonema	1		1	1
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	1	1	1	2
Ephemeroptera	Tricorythidae	Tricorythodes				0
Plecoptera	Leuctridae	Leuctra	1		1	1
Plecoptera	Leuctridae	Zealeuctra	1		1	1
Plecoptera	Nemouridae	Amphinemura	1	1	1	2
Plecoptera	Nemouridae	Prostoia				0
Plecoptera	Perlidae	Acroneuria	1			0
Plecoptera	Perlidae	Perlesta	1			0
Trichoptera	Glossosomatidae	Agapetus	1		1	1
Trichoptera	Helicopsychidae	Helicopsyche	1		1	1
Trichoptera	Hydropsychidae	Ceratopsyche	1		1	1
Trichoptera	Hydropsychidae	Cheumatopsyche			1	1
Trichoptera	Hydropsychidae	Diplectrona	1		1	1
Trichoptera	Hydropsychidae	Hydropsyche	1		1	1
Trichoptera	Hydroptilidae	Hydroptila			1	1
Trichoptera	Hydroptilidae	Ochrotrichia			1	1
Trichoptera	Leptoceridae	Nectopsyche	1		1	1

Citations:

- Bowles, D. E., M. H. Williams, H. R. Dodd, L. W. Morrison, J. A. Hinsey, C. E. Ciak, G. A. Rowell, M. D. DeBacker, and J. L. Haack. 2008. Protocol for monitoring aquatic invertebrates of small streams in the heartland network inventory & monitoring network. Natural Resource Report NPS/HTLN/NRR – 2008/042. National Park Service, Fort Collins, Colorado.
- Dauwalter, D. C., E. J. Pert, and W. E. Keith. 2003. An index of biotic integrity for fish assemblages in Ozark Highland Streams of Arkansas. Southeastern Naturalist 2: 447-468.
- Dodd, H. R., D. G. Peitz, G. A. Rowell, D. E. Bowles, and L. W. Morrison. 2008. Protocol for monitoring fish communities in small streams in the heartland inventory and monitoring network. Natural Resource Report NPS/HTLN/NRR – 2008/052. National Park Service, Fort Collins, Colorado.
- Hilsenhoff, W. L., 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist 20: 31-39.
- Schwoerer, J. M., 2016. Assessing the vulnerability of stream communities and the consistency and use of biotic indices in least-disturbed streams. MS thesis. University of Missouri, Columbia.
- Sievert, N., C. Paukert, Y. Tsang, and D. Infante. 2016. Development and assessment of indices to determine stream fish vulnerability to climate change and habitat alteration. Ecological Indicators.

Heartland Inventory and Monitoring Network of the National Park Service. Visit <http://www.nps.gov/im/units/htln/index.htm>

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