EXAMINING HABITAT ASSOCIATIONS WITH STREAM FISH ASSEMBLEGES IN THE UPPER PENINSULA OF MICHIGAN/WISCONSIN

BIOS 569: Practicum in Field Biology

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ABSTRACT

I sampled fish and measured physical habitat at seven sites on Tenderfoot Creek which flows out of Tenderfoot Lake in the Upper Peninsula of Michigan/Wisconsin to document the relationships among fish assemblages, habitat type and abiotic habitat characteristics. The objectives of my study were to (1) survey the fish species present in Tenderfoot Creek, (2) determine how Tenderfoot Creek's unique lack of habitat heterogeneity affects its fish assemblages, (3) test how physical characteristics influence fish assemblages, and (4) establish if distance from Tenderfoot Lake has an effect on fish population composition. I hypothesized that the lack of habitat variation (riffles, runs, and pools) would override any effects that the physical variables may have on fish abundances and species distributions, thus causing fish populations to be uniform throughout the creek. ANOVA results indicated that fish species richness was significantly greater in riffles than in deep runs. Regressions determined that larger percentages of boulder, smaller percentages of silt, and higher current velocity promote higher fish abundance, diversity, and richness. Distance from the lake had no effects on fish assemblages. Fish populations were influenced by physical habitat variables despite the lack of habitat variation. This suggests that for creeks with habitat homogeneity, heterogeneous geomorphic characteristics are the primary factors that influence fish assemblages.

INTRODUCTION

Information concerning which fish species are present in Tenderfoot Creek is lacking. A previous study affirmed that yellow perch, *Perca flavescens,* and the common shiner, *Notropis cornutus*, are found in the creek (Gray and Langenau 1996). However, information on the entire spectrum of species present in Tenderfoot Creek has not been recorded. A list of species that are known to exist on the UNDERC property where Tenderfoot Creek is located states that the species of fish most commonly found there are: pumpkinseed (*Lepomis gibbosus)*, bluegill (*Lepomis macrochirus)*, mudminnow *(Umbra limi)*, creek chub *(Semotilus atromaculatus)*, northern red-bellied dace *(Phoxinus eos)*, brook stickleback *(Culaea inconstans),* yellow perch , rock bass *(Ambloplites rupestris)*, and walleye *(Stizostedion vitreum)* (UNDERC website, 2004). Of these fish, the creek chub is only found in streams, and all the other fish species can be found in both lakes and streams (Fishes of Wisconsin website 1983). Thus, my study's first aim was to compile a complete survey of all fish species found in Tenderfoot Creek. In so doing, I specified which of the aforementioned species are particular to this stream and recorded every other fish species that are present there.

Tenderfoot Creek, which is within the Ontonagon River drainage basin, is the most prominent stream on UNDERC property in the Upper Peninsula of Michigan/Wisconsin and eventually flows north out of Tenderfoot Lake. A unique feature of the stream is that it has few riffles and even fewer pools (Crowl personal communication). Hollowell (2003) observed that it has only two riffles throughout its entire stretch. By surveying the stream before beginning my study, I found that in addition to its two riffles, it has one beaver pond. The rest of the stream consists of homogenous deep and shallow runs. Habitat heterogeneity has been found to influence distributional patterns of stream fish (Buhrnheim and Fernandes 2003). Matthews (1998) found that fish distribution, richness and abundance may differ between riffles and pools. Thus, the second objective of my study was to determine how Tenderfoot Creek's unique lack of variation in habitat affects its fish assemblages.

The effects of geomorphic habitat characteristics on fish populations were also tested in this study since associations between North American fish and physical attributes of streams can be traced back to some of the earliest surveys of ichthyofauna (Rafinesque 1820 as cited by Powers et al. 2003). Stream width, depth, current velocity, substrate, woody debris and channel incision have been identified as having major influences on stream fish assemblages (Angermeier and Karr 1984, Benke et al. 1985, Gorman and Karr 1978, Schlosser 1982, Shields et al. 1994 as cited by Powers et al. 2003). Thus, I tested the effects of creek width, depth, velocity, substrate type, bank steepness, and presence of woody debris on fish assemblages.

The final variable investigated was how distance from Tenderfoot Lake affected fish populations in Tenderfoot Creek. Because I used distance from the lake as a variable, I also surveyed the species composition of Tenderfoot Lake to obtain a baseline of comparison that showed how the lake's biota affects the creek. The *Wisconsin Lakes Book* (Wisconsin Department of Natural Resources 2005) and the *Guide to U.N.D.E.R.C.: University of Notre Dame Environmental Research Center* (University of Notre Dame 1993) were used as additional resources in determining the fish species present in Tenderfoot Lake.

Distance from the lake was examined because the general theory of landscape ecology holds that heterogeneous spatial patterns set the context for ecological processes such as fluxes of organisms, materials, and energy among landscape elements (Fausch et al. 2002). Schlosser (1991) states that this landscape theory also applies to stream and fish ecology. Schlosser and Kallemyn (2000) found that species richness and abundance of fish in tributaries to a very large lake were often related less to local stream habitat (riffles, runs, and pools) than to the proximity, direction, successional state, and landscape context of pond habitats. Thus, certain species of fish could inhabit only some stream reaches of Tenderfoot Creek and the fish's choice of location could be determined by the reach's distance from Tenderfoot Lake. However, the lack of habitat (riffles, runs, and pools) in Tenderfoot Creek may neutralize any impacts that lake distance could have on the fish, for rare or unique features in the riverscape, either in space or time, can have overriding effects on stream fishes (Fausch et al. 2002).

Therefore, the lack of habitat variability could counteract any species segregating affect that lake distance may have on the fish.

This study was conducted to test the relationships between habitat type, creek velocity, width, depth, substrate type, bank steepness, presence of woody debris, and distance from the lake on fish assemblages in Tenderfoot Creek. The effect of these variables on fish abundance, species richness, and species diversity were analyzed. As runs make up most of the stream, the category of run was further divided into deep and shallow types. Given the study by Fausch et al. (2002), I hypothesized that the lack of habitat variation (riffles, runs, and pools) would override any effects that the physical variables may have on fish abundances and species distributions, thus causing fish populations to be uniform throughout the creek.

MATERIALS AND METHODS

Study sites and sampling procedure

I collected fish from seven sites on Tenderfoot Creek in June 2005: two riffles, two deep runs, two shallow runs, and one beaver pool (Fig. 1). Each site was sampled once. I collected fish using an 11.5 x 2.5 m seine net. All fish that could be identified in the field were identified, tallied, and released. Those fish unable to be identified in the field were preserved in 70% ethanol and identified in the laboratory where voucher specimens were stored.

The first four sites were seined on 9 June 2005, but the interference of a storm prevented me from sampling the remaining sites. The last three sites were sampled on 16 June 2005. Physical habitat data was collected on 21 June 2005.

At each site, the angle of the bank was visually estimated. Five measurements of the stream's depth and current velocity were then taken across the channel of each site and averaged. Velocity was calculated with the use of a flow probe. I took one measurement of the width of the channel at each site. Substrate type (percent silt, sand, gravel, cobble, and boulder) and the presence of large woody debris (LWD) were also recorded. The coordinates of each site were recorded by a Garmin12 GPS unit and their distances from the creek's mouth were later determined using ArcView GIS 3.3 software.

Data analysis

For each site, three dependant variables were calculated: fish abundance (total number of individuals), species richness (total number of species), and species diversity (calculated by the Shannon-Weiner Diversity Index).

For each dependant variable, a one-way ANOVA was conducted to determine if fish abundance, richness, and diversity differed significantly across habitat types (deep run, riffle, and shallow run). Data concerning fish collected at the beaver pool was disregarded due to lack of replicates in this analysis, but was used for all other tests.

ANOVA single factor tests were also used to analyze how presence of woody debris influenced fish abundance, species diversity, and species richness. Multiple regressions determined how distance from the mouth, left and right bank angles, channel depth and width, current velocity, and percentages of silt, sand, gravel, cobble, and boulder influenced each dependant variable.

SYSTAT 11 (2004) was used for all data analysis. The significance level for every test was $p<0.05$. Any significance found during ANOVA tests were further analyzed using a Tukey HSD multiple comparison *post hoc* test.

RESULTS

I captured a total of 3,633 fish (Table 1) of 21 species (Table 2) in Tenderfoot Creek. Species richness among sites ranged from 6 to 18 species (mean 10 +/- SE), fish abundance ranged from 53 to 2000 (mean 519 +/- SE), and species diversity according to the Shannon-Weiner Index (H) ranged from 1.49 to 2.38 (mean 1.81 +/- SE) (Table 2). Site 1 had the lowest values for fish abundance and species richness. Site 2 had the smallest H value. Site 4 had the greatest numbers in abundance, richness, and diversity. Site 4 yielded too many fish to count without having many of the captured fish dying, so it was estimated that 2000 fish were sampled. I also visually estimated how many fish of each species were present in the catch by assigning percentages.

The five most abundant species caught were river shiner (*Notropis blennius*), creek chub (*Semotilus atromaculatus*), common shiner, golden shiner (*Notemigonus crysoleucas*), and yellow perch. These five species accounted for 75% of all fish captured. Three species noticeably sparse were smallmouth bass (*Micropterus dolomieui,* N = 1), pumpkinseed sunfish (*Lepomis gibbosus*, N = 1), and mottled sculpin (*Cottus bairdi,* N = 2). Four species (*Semotilus atromaculatus*, *Notropis blennius*, *Ambloplites rupestris*, *Perca flavescens*) were found at every site. Seven species (*Notropis spilopterus*, *Micropterus dolomieui*, *Cottus bairdi*, *Lepomis gibbosus*, *Moxostoma macrolepidotum*, *Minytrema melanops*), and unknown *Notropis sp.1*) were found at only a single site (Table 1).

Concerning the effects of habitat type (deep run, riffle, shallow run), on the three dependant variables (fish abundance, richness, and diversity), habitat only had a significant effect on species richness (p = 0.052, F-ratio = 9.33, df =2; Fig. 2). However, the results of the Tukey test illustrated that although richness was significantly greater between riffles and deep runs, there was no significant difference in richness between any other habitat types (Fig. 2). There was no significant difference among habitats concerning species diversity (p = 0.125, F-ratio = 4.508, df = 2) or fish abundance (p = 0.103, F-ratio = 5.340, df=2). However, fish numbers and richness differed drastically across sites (Table 2).

Regarding physical habitat characteristics, there was a significant positive relationship between species diversity and the percentage of boulder in substrate matter (Table 3). Species richness had significant positive correlations with both percent boulder and average current velocity. Richness had significant negative relationships with percent silt and average channel depth. Percent boulder and average current velocity had positive significant influences on fish abundance. Conversely, percent silt had a significantly negative effect on fish abundance (Table 3).

Fish species diversity had marginally significant (p-values between 0.055 and 0.09) relationships with percent silt, channel depth, current velocity, and channel width (Table 3).

For my baseline concerning how distance from Tenderfoot Lake affects fish assemblages in the creek, my research confirmed at least ten species are in the lake. The species present documented by the *Guide to U.N.D.E.R.C.: University of Notre Dame Environmental Research Center* (University of Notre Dame 1993) with confirmation from *Wisconsin Lakes Book* (Wisconsin Department of Natural Resources 2005) are listed in Table 4. Fish species collected from personal sampling are also listed in Table 4. However, my regression analysis found that distance from Tenderfoot Lake did not significantly influence fish abundance, diversity, or species richness (Table 3).

Other nonsignificant correlations were as follows: Diversity was not significantly affected by presence of wood ($p = 0.148$, F-ratio = 2.926, df = 1), percent sand, gravel, or cobble, left bank angle or right bank angle (Table 3).

Species richness was not significantly related to presence of wood (p = 0.286, F-ratio = 1.429, df = 1), channel width, percent sand, gravel, or cobble, left bank or right bank angles. Fish abundance had no significant correlation with presence of wood (p = 0.236, F-ratio = 1.810, df = 1), channel depth, channel width, percent sand, gravel, or cobble, or left and right bank angles (Table 3).

DISCUSSION

The high abundances of *Notropis cornutus* and *Perca flavescens* were expected because Gray and Langenau (1996) recorded that they were commonly found in the creek. *Notropis blennius, Semotilus atromaculatus,* and *Notropis cornutus* are also listed as being common to abundant minnow species in Wisconsin that inhabit medium to large streams and rivers (Becker 1983). The scarcity of *Micropterus dolomieui* and *Lepomis gibbosus* was not expected because Becker (1983) states that they are abundant in Wisconsin creeks and rivers. *Cottus bairdi*'s sparseness was also surprising because they are often the most common fish sampled in Wisconsin streams (Becker 1983). The deficit in *M. dolomieui, L. gibbosus, and C. bairdi* numbers may have occurred because seine netting was the only sampling technique used. Perhaps the high swimming velocities of *M. dolomieui* and *L. gibbosus* and the fact that *C. bairdi* inhabits the bottom of streams helped these species elude capture by seine netting (Crowl personal communication).

Tenderfoot Creek's lack of habitat variation seems to have caused large numbers of fish of many different species to congregate in one place: site 4, a riffle near a beaver dam. Fish may have concentrated there because the dam prevented them from swimming any farther downstream. The abundance of wood from the beaver dam may also have provided fish with a refuge because LWD provides habitat and food for aquatic organisms, increasing invertebrate and subsequently fish populations (Borden 2002). LWD was not significantly associated with increased fish abundance, diversity, or density in my study, but lack of replicates may have influenced this result. Future experimentation should be conducted by taking multiple samples at site 4 and other various sites to discover if site 4 is indeed significantly unique.

Along with LWD, bank angles, percent sand, gravel, silt, and channel width had no strong effects on fish assemblages. Of all the physical abiotic variables, only percent boulder present in substrate significantly increased fish abundance, diversity, and richness. Powers et al. (2003) noted that boulders are a stable habitat for insects and fishes. Because large substrate is usually found in riffle habitats (Gorman and Karr 1978), perhaps boulder presence caused riffles to have greater species richness than deep runs. Similarly, small percentages of silt and greater current velocity, variables that had at least a marginally significant association with high fish abundance, diversity, and richness are usually distinguishing characteristics of riffles.

Riffles were also found to have significantly greater species richness than deep runs. Such a difference may have occurred because these two habitat types have such diverse physical characteristics including substrate, depth, and current velocity (Gorman and Karr 1978). Increased statistical power (i.e. more replicates of each habitat type) may have resulted in stronger differences in fish abundance and species diversity between riffles and deep runs.

In contrast to Schlosser and Kallemyn (2000) and Wilkinson and Edds (2001) who found that spatial autocorrelation explained more of the variation in species composition than did habitat differences, the opposite occurred in my study. Distance from Tenderfoot Lake had no effect on species assemblages, but habitat differences, specifically their physical variables, caused variations in fish populations. Thus, my hypothesis was not supported. The lack of habitat variation (riffles, runs, and pools) did not override the effects that physical variables may have on fish abundances and species distributions. Fish populations were not uniform throughout the creek, but varied in numbers, diversity, and richness in correlation with differences in habitat characteristics.

Knowledge of habitat use by fishes and influential environmental gradients are necessary for biological conservation and habitat restoration (Barko et al. 2004). Tenderfoot Creek's homogenous characteristics make it a particularly interesting object of study.

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WORKS CITED

Angermeier, P.L., and J.R. Karr. 1984. Relationships between woody debris and fish habitat in a small warmwater stream. Transactions of the American Fisheries Society 113: 716-726.

Barko, V.A., M.W. Palmer, and D.P. Heerzog. 2004. Influential environmental gradients and spatiotemporal patterns of fish assemblages in the unimpounded Upper Mississippi River. American Midland Naturalist 152: 369-385.

Becker, G.C. 1983. Fishes of Wisconsin. The University of Wisconsin Press, Madison,Wisconsin.

Benke, A.C., R.L. Henry, III, D.M. Gillespie, and R.J. Hunter. 1985. Importance of snag habitat for animal production in southeastern streams. Fisheries 10(5): 8-13.

Borden, A.A. 2002. An exploration of the relationship between historical logging practices, large woody debris, and fish community structure in the streams of the Ottawa National Forest, Upper Peninsula of Michigan. UNDERC student paper.

Buhrnheim, C.M. and C.C. Fernandes. 2003. Structure of fish assemblages in amazonian rain-forest streams: effects of habitats and locality. Copeia 2: 255-262.

Crowl, T. 2005. Personal conversation through email.

Fausch, K.D., C.E. Torgersen, C.V. Baxter, and H.W. Li. 2002. Landscapes to riverscapes: bridging the gap between research and conservation of stream fishes. BioScience 52: 483-498.

Fishes of Wisconsin website. Fish of the Great Lakes: Wisconsin Sea Grant. 1983. The University of Wisconsin Press. Accessed 23 May 2005 <http://www.seagrant.wisc.edu/greatlakesfish/becker.html>

Gorman, O.T., and J.R. Karr. 1978. Habitat structure and stream fish communities. Ecology 59(3): 507-515.

Gray, N. and D. Langenau. 1996. The trophic cascade of a common stream environment and optimal feeding behavior in *Notropis cornutus.* UNDERC student paper.

Hollowell, T. 2003. Guide to the UNDERC stream network. UNDERC student paper.

Matthews, W.J. 1998. Patterns in freshwater fish ecology. Chapman and Hall, New York.

Powers, S.L., G.L. Jones, P. Redinger, and R.L. Mayden. 2003. Habitat associations with upland stream fish assemblages in Bankhead National Forest, Alabama. Southeastern Naturalist 2(1): 85-92.

Rafinesque, C.S. 1820. *Icthyologia ohioensis.* W. G. Hunt. Lexington, KY. 90 pp.

Schlosser, I.J. 1982. Fish community structure and function along two habitat gradients in a headwater stream. Ecological Monographs 52: 395-414.

Schlosser, I.J. 1991. Stream fish ecology: A landscape perspective. BioScience 41: 704-712.

Schlosser, I.J. and L.W. Kallemeyn. 2000. Spatial variation in fish assemblages across a beaver influenced successional landscape. Ecology 81: 1371-1382.

Shields, F.D. Jr., S.S. Knight, and C.M. Cooper. 1994. Effects of channel incision on base flow stream habitats and fishes. Environmental Management 8: 43-57.

U.N.D.E.R.C. website. Environmental Research Center-East. 2004. University of Notre Dame. Accessed 18 May 2005 http://www.nd.edu/~underc/east/about/visitors_guide.shtml.

University of Notre Dame. 1993. Guide to U.N.D.E.R.C.: University of Notre Dame Environmental Research Center. Unpublished.

Wilkinson, C.D. and D.R. Edds. 2001. Spatial Pattern and Environmental correlates of a Midwestern stream fish community: including spatial autocorrelation as a factor in community analyses. American Midland Naturalist 146: 271-289.

Wisconsin Department of Natural Resources. 2005. The Lake Book. PUB-FH 800, Wisconsin.

Table 1. Species and number of individuals collected from sites in Tenderfoot Creek.

Site	1	2	3	4	5	6	7	
Species			No. collected					Total no. fish
blue minnow (*Notropis spilopterus*)				60				60
bluntnose minnow (*Pimephales notatus*)			10	60	10	14	9	103
common shiner (*Notropis cornutus*)		4	30	400	40	21	125	620
creek chub (*Semotilus atromaculatus*)	15	8	23	400	32	13	280	771
fathead minnow (*Pimephales promelas*)	5		2	50	5		16	78
golden redhorse (*Moxostoma erythrurum*)				20	10			30
golden shiner (*Notemigonus crysoleucas*)		10	1	60	54	29	109	263
mimic shiner (*Notropis volucellus*)				60			31	91
mottled sculpin (*Cottus bairdi*)						2		2
pumpkinseed sunfish (*Lepomis gibbosus*)		1						1
river shiner (*Notropis blennius*)	20	9	25	400	46	121	214	835
rock bass (*Ambloplites rupestris*)	1	8	5	60	1	7	2	84
shorthead redhorse (*Moxostoma macrolepidotum*)				10				10
smallmouth bass (*Micropterus dolomieui*)					1			1
spotfin shiner (*Notropis spilopterus*)				60			22	82
spottail shiner (*Notropis hudsonius*)	4			60			15	79
spotted sucker (*Minytrema melanops*)				20				20
unknown *Notropis sp.1*				60				60
nknown *Notropis sp.2*				60		37	44	141
unknown *Notropis sp.3*				60			9	69
yellow perch (*Perca flavescens*)	8	43	17	100	31	27	7	233
Total number of fish caught at each site	53	83	113	2000	230	271	883	3633
Total number of species caught at each site	6	7	8	18	10	9	13	21

Table 2. Species abundance, diversity, and richness at each site in Tenderfoot Creek.

Site	No. captured	Shannon-Weiner Index (H)	No. Species
1	53	1.5	6
2	83	1.49	7
3	113	1.78	8
4	2000	2.38	18
5	230	1.91	10
6	271	1.73	9
7	883	1.89	13
Average (+/- SE)	519	1.81	10

Table 3. Correlation analysis of distance from mouth, percent silt, sand, gravel, cobble, and boulder, left and right bank angles, average depth, average current velocity, and channel width against fish abundance, species richness, and species diversity in Tenderfoot Creek. Correlation (R^2) listed for each pair, with P-value indicated in parentheses ($P<0.09$ in bold).

	Distance from Mouth	% Silt	% Sand	% Gravel	% Cobble	% Boulder	Left bank angle	Right bank angle	Average channel depth	Average current velocity	Channel width
Fish abundance	0.146 (0.398)	**0.60 (0.041)**	0.024 (0.742)	0.051 (0.627)	0.400 (0.128)	**0.80 (0.006)**	0.066 (0.577)	0.134 (0.419)	0.446 (0.101)	**0.82 (0.005)**	0.208 (0.303)
Species richness	0.322 (0.184)	**0.67 (0.024)**	0.015 (0.795)	0.093 (0.507)	0.457 (0.095)	**0.89 (0.001)**	0.011 (0.821)	0.185 (0.336)	**0.58 (0.046)**	**0.77 (0.009)**	0.328 (0.179)
Species diversity	0.392 (0.133)	**0.497 (0.077)**	0.014 (0.800)	0.013 (0.806)	0.253 (0.249)	**0.79 (0.007)**	0.0003 (0.967)	0.444 (0.102)	**0.508 (0.072)**	**0.549 (0.057)**	**0.470 (0.089)**

Table 4. Lists of fish in Tenderfoot Lake as documented by the *Guide to U.N.D.E.R.C.: University of Notre Dame Environmental Research Center,* the *Wisconsin Lakes Book,* and personal sampling.

Fish Present as Cited by Literature	Fish sampled
muskellunge *(Esox masquinongy)*	mottled sculpin (*Cottus bairdi*)
northern pike *(Esox lucius)*	golden shiner (*Notropis cornutus)*
walleye *(Stizostedion vitreum)*	common shiner (*Notropis cornutus)*
yellow perch (*Perca flavescens*)	
crappie (*Pomoxis nigromaculatus*)	
rock bass (*Ambloplites rupestris*)	
largemouth bass (*Micropterus dolomieui*)	
smallmouth bass (*Micropterus dolomieui*)	
sunfish (family Centrarchidae)	

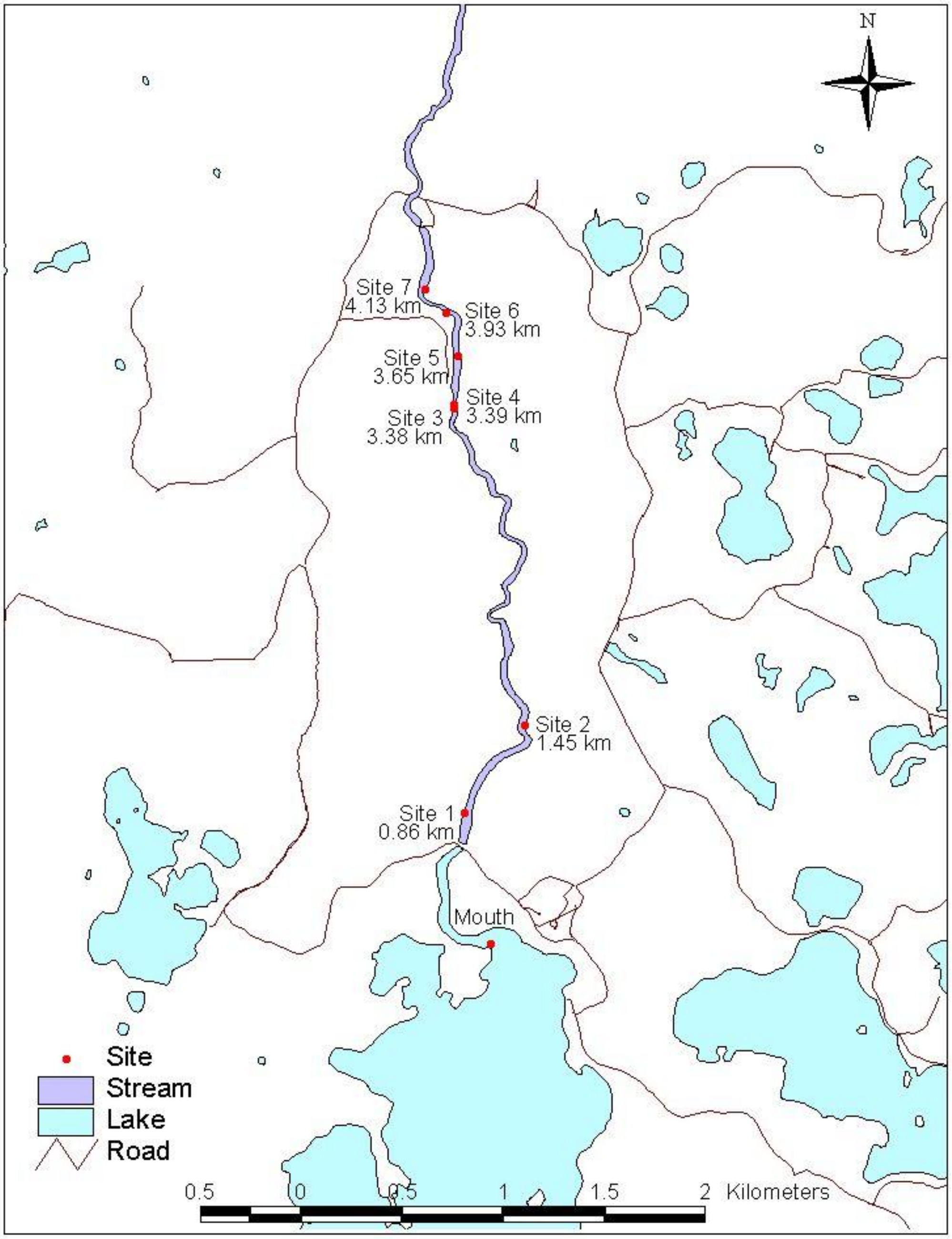

Figure 1. Map of Tenderfoot Creek indicating study sites and their distances from the creek's mouth.

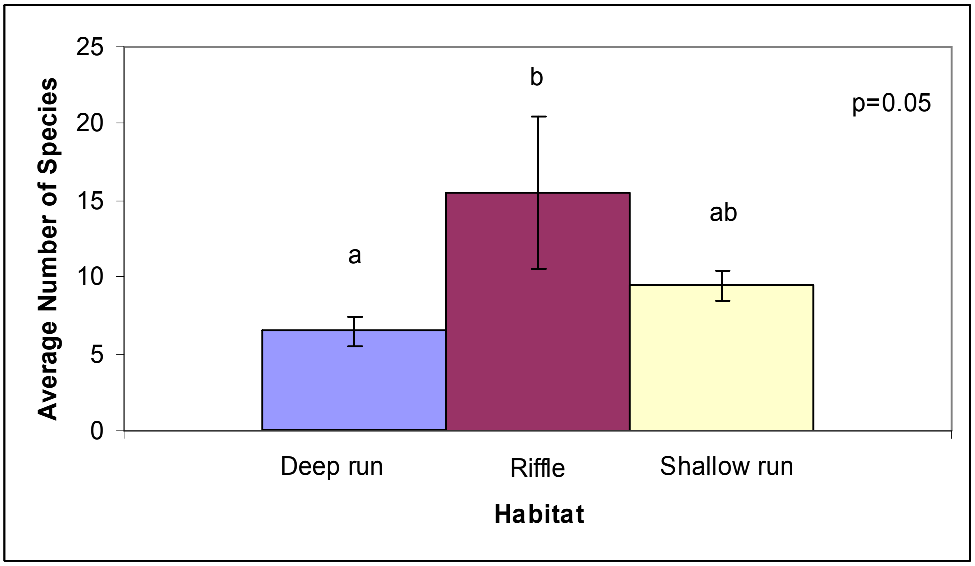

Figure 2. Species richness in deep run, riffle, and shallow run habitats. Error bars represent standard error. Letters above error bars show whether one habitat had significantly different species richness than another.