LONGITUDINAL DISTRIBUTION OF FISHES AND HABITAT IN LITTLE BEAVER CREEK, MONTANA

by

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APPROVAL

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ABSTRACT

The fish populations and habitat of Little Beaver Creek were inventoried to investigate longitudinal changes in fish communities and habitat. Additionally, relations between habitat variables and relative abundance of fish species were examined. Twenty-two species representing eight families were collected. The most abundant and species-rich family was Cyprinidae. Individual species showed distinct patterns of relative abundance between stream segments. The three study segments exhibited a weak longitudinal continuum. Community changes were reflected primarily by the downstream addition of species; replacement was of less importance. Two fish assemblages were identified: a midstream assemblage composed of species representing several families, and a downstream assemblage dominated by cyprinids. Major gradients in habitat involved changes in substrate composition, riparian zone characteristics, water clarity, and features related to stream size. Several habitat variables were significantly correlated with the relative abundance of fish species found in Little Beaver Creek. Generally, species typical of the downstream segment (goldeye, western silvery minnow, plains minnow, flathead chub, longnose dace, and sand shiner) were correlated with physical features characteristic of erosional habitats. Fishes characteristic of the upstream and midstream segments (shorthead redhorse, white sucker, creek chub, brassy minnow, black bullhead, brook stickleback, and green sunfish) were correlated with features associated with more lentic-like or depositional environments.

INTRODUCTION

Longitudinal distribution of stream fishes is usually characterized by continual downstream addition of species (Sheldon 1968; Evans and Noble 1979). This increase in species richness has generally been attributed to the increased environmental stability and habitat complexity of downstream areas (Schlosser 1982; Harrel et al. 1967). Other studies (Moyle and Nichols 1973) have attributed changes in community composition to the process of zonation. This process results in relatively distinct communities due to fairly abrupt changes in stream geomorphology or temperature (Rahel and Hubert 1991; Platts 1979). Rahel and Hubert (1991) found that longitudinal changes in community composition in a Great Plains-Rocky Mountain stream reflected a combination of downstream addition and biotic zonation.

This study examined the hypothesis that fish communities reflect changes in stream geomorphology. Also, since little information is available on fish community composition and physicochemical characteristics of small, prairie streams in Montana (Clancey 1978; Elser et al. 1978), describing habitat characteristics which may influence fish distribution and abundance may be helpful to managers in evaluating future proposed land use changes.

In 1990 fish populations and physicochemical attributes of the Little Missouri River Basin were sampled. In 1991 the study was narrowed, focusing on Little Beaver Creek. The objectives of the study were to: (1) inventory the habitat and fish populations of Little Beaver Creek, (2) determine if there is a recognizable change in community composition and habitat along the stream gradient, and (3) determine the importance of habitat features upon the distribution, composition and relative abundance of fish species.

STUDY AREA

Little Beaver Creek is a second order prairie stream located in southeastern Montana (Figure 1). It originates in northeastern Carter County, near Ekalaka, and flows northeasterly for about 123 km before joining the Little Missouri River at Marmath, North Dakota. Elevations range from 1021 m at the source to 823 m at the mouth; the average gradient is 1.61 m/km. The predominant land use patterns in its watershed of approximately 1,550 km^2 are dryland farming and livestock grazing (Montana Statewide Mapping Program 1977). Average annual precipitation is about 41 cm, the majority falling as rain between April and July (U. S. Weather Bureau 1990).

The stream was divided into three segments based on area geology and channel morphology. The upstream-midstream boundary was established at a tributary entrance. The midstream-downstream boundary was determined by a major change in geologic and stream channel features.

The mid- and upstream study segments are underlain by the Fort Union Formation. These strata are coastal and alluvial deposits of the Paleocene Era (Vicke-Foster et al. 1986), and consist of relatively well-cemented, fine-grained sandstone and prominent coal beds. Depth of the deposits is variable, ranging up to 40 m (Vicke-Foster et al. 1986). The Fort Union Formation and alluvial beds of Little Beaver Creek store and release water throughout the year, resulting in permanent flow in the midstream segment (S. G. Custer, Earth Science Department, Montana State University, personal communication). The lentic-like environment of this reach is characterized by low, heavily vegetated banks, permanent flow, and abundant instream vegetation.

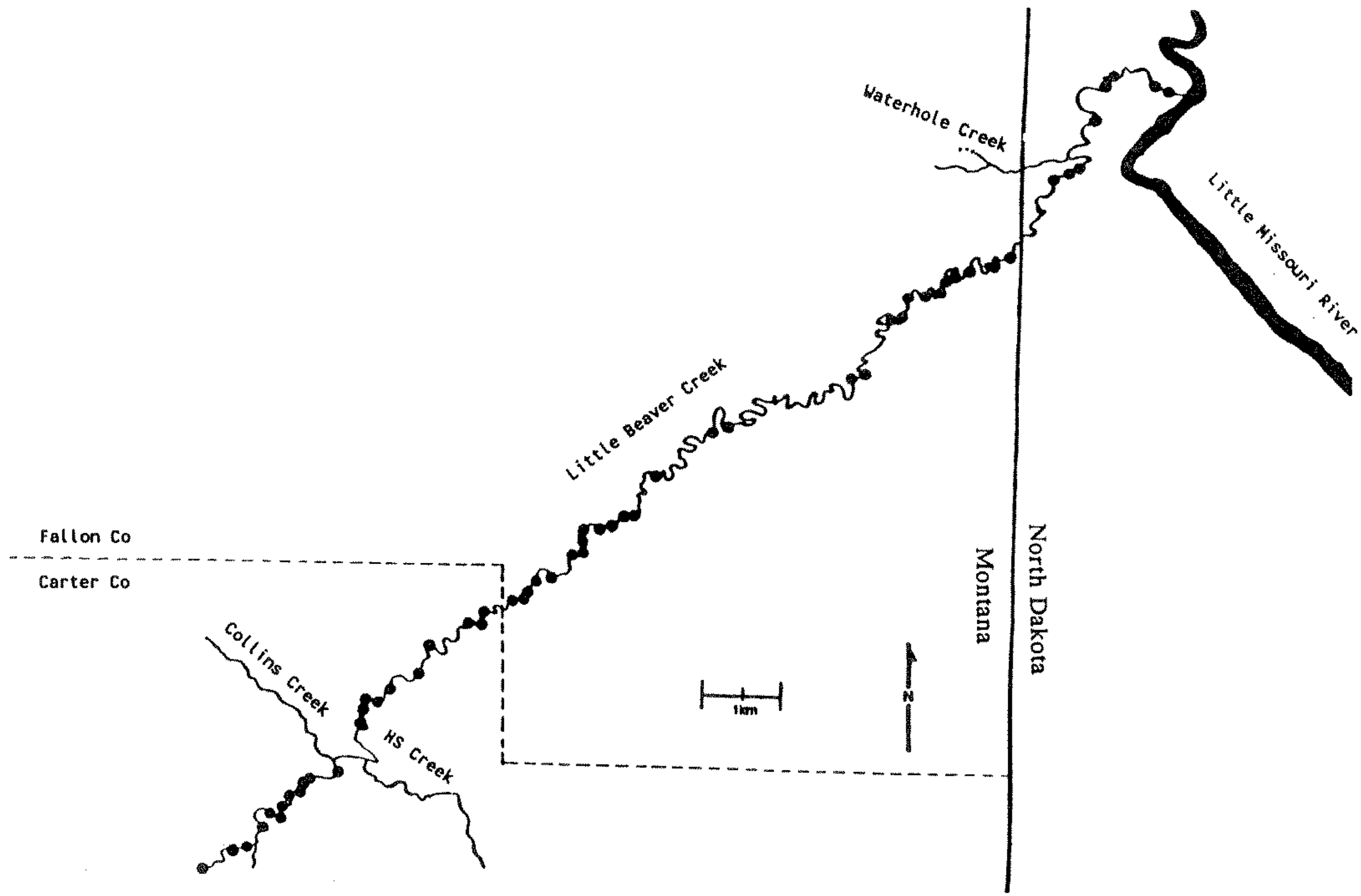

Figure 1. Little Beaver Creek study area in southeastern Montana. Circles indicate sample sites.

The upstream segment consists of a series of isolated pools, which are apparently connected only in years of substantial runoff. Some pools are sustained by groundwater input and hold fish throughout the year. Others recede during spring and early summer and are replaced by a sedge meadow.

Riparian vegetation of the upstream and midstream segments consists largely of grasses, sedges, sweet clover, *Melilotus* spp., and wild rose, *Rosa* spp. Common genera of submerged vegetation in the midstream segment include *Potamogeton, Ceratophyllum, Myriophyllum* and *Ranunculus.* One species of emergent vegetation, water speedwell *Veronica catenata* (Penn.), was found only in this segment. This species is characteristic of slow, permanently flowing streams (Hitchcock et al. 1959).

The demarcation between the midstream and downstream segments lies in a region where the Cedar Creek anticline bisects the stream. This is also a region of complex faulting (Vicke-Foster et al. 1986). The downstream segment is underlain by the Hell Creek and Pierre Shale Formations. These sediments were deposited in marine offshore and prodeltal environments of the upper Cretaceous, and were subsequently exposed during a period of uplift (Vicke-Foster et al. 1986).

The Hell Creek Formation consists primarily of medium-grained sandstone and bentonitic silty shale (Vicke-Foster et al. 1986) and is a known aquifer (Fetter 1988). The area of complex faulting at the contact between the Fort Union and Hell Creek Formations is probably a recharge zone for the Hell Creek Formation (S. G. Custer, Earth Science Department, Montana State University, personal communication).

The Pierre Shale Formation is composed of dark-gray and black, bentonitic mudstone and shale (Vicke-Foster et al. 1986; Fetter 1988), resulting in very limited porosity and poor water storage (Fetter 1988). These features contribute to the shifting substrate, fluctuating flow and high turbidity of the downstream segment. In both 1990 and 1991, flow became intermittent by mid to late July.

The downstream segment drains an area located in the heavily eroded badlands topography of western North Dakota and has channel characteristics similar to those of the nearby Little Missouri River. The Little Missouri River is an intermittent prairie stream with frequent fluctuations in flow, high suspended sediment loads, and shifting bed materials; there is virtually no aquatic vegetation (Van Eekhout 1974).

There is a general paucity of streamside vegetation in the lower segment of Little Beaver Creek. The walls of the deeply incised channel are relatively bare. Bankside plants are more characteristic of upland vegetation and include big sagebrush *Artemesia tridentata* (Nutt.), silver sagebrush *A. cana* (Pursh), and broom snakeweed *Gutierrezia sarathrae* (Pursh).

In summary, Little Beaver Creek possess three relatively distinct segments: an upstream segment consisting of a series of isolated pools, a midstream segment characterized by clear, stable conditions provided by groundwater input, and a downstream segment having turbid, fluctuating conditions more characteristic of a western, Great Plains stream.

METHODS

Sampling Sites

The 123 km study area was subdivided into three segments (Figure 1): I) an 18 km segment, extending from the upper reaches of Little Beaver Creek to the entrance of HS and Collins Creeks; II) a 52.5 km midstream segment terminating at an area of abrupt change in geological features and stream channel morphology; and III) the lower 52 km of Little Beaver Creek to the confluence with the Little Missouri River at Marmath, North Dakota.

Sampling sites were limited to areas accessible by road since nearly all land along the stream is privately owned. U. S. Geological Survey topographic maps (7.5 minute series; scale 1:24,000) were utilized to determine access points and stream order. Stream length and the distance from each site to the confluence with the Little Missouri River were measured with a cartometer.

Fifty-eight study sites were sampled in 1991: 12 in the upstream segment, 25 in the midstream segment, and 21 in the downstream segment. Legal descriptions of all sites appear in the appendix (Table12). A site consisted of a pool-riffle sequence, with the exception of sites occurring in regions where flow was intermittent and the stream was a series of isolated pools. To reduce sampling bias and avoid measuring stream characteristics that had been influenced by low water crossings and bridges, the third pool-riffle sequence downstream of access points was sampled.

Measurement of Habitat

Habitat features of each pool and riffle were sampled separately. Length of each pool and riffle was measured on the right bank when facing downstream. Each pool or riffle was then divided into 10 equally spaced transects which were placed perpendicular to flow. A measuring tape was stretched across the stream and wetted width was recorded. Physical characteristics along each transect were measured at seven equally spaced points (Hubert and Rahel 1989). If a habitat feature (pool or riffle) was less than 10 m in length, five equally spaced transects were used.

At each sampling point, water depth was measured to the nearest centimeter using a meter stick. A marked wooden dowel was used to measure depths that exceeded 1 m. The dominant substrate type was visually identified and placed into one of six categories (Table 1).

Table 1. Substrate types and codes used in channel substrate classification (modified from Platts et al. 1983).

Substrate type	Size (mm)	Code
Fine sediment	<4.7	1
Gravel	4.8-76.0	2
Cobble	76.1-304.0	3
Small boulder	305.0-609.0	4
Large boulder	>609.0	5
Bedrock		6

Percent of instream cover along each transect in the form of submergent and emergent aquatic vegetation was visually estimated and assigned to one of five categories. Bankside measures recorded at each end of each transect included undercut bank, overhanging vegetation, streamside vegetative cover rating (Table 3) and shoreline water depth (Platts et al. 1983). Current velocities were measured at 0.6 of the water depth at three evenly spaced points along each transect using a model 201 Marsh-Mcbirney current meter.

Table 2. Categories of instream cover based on estimated percent of stream bottom covered by aquatic vegetation along transects.

Percent cover	Category
0	0
<25%	1
25-50%	2
50-75%	3
75-100%	4

Table 3. Streamside cover types and categories recorded at both ends of each transect.

Streamside cover type	Category
Over 50% bare ground	1
Dominated by grasses and forbs	2
Dominated by trees	3
Dominated by shrubs	4

Water Quality

At each site, surface temperature and dissolved oxygen were measured using an Otterbine-Barebo Sentry III oxygen/temperature monitor. Monthly maximum-minimum temperatures were recorded from one site within each reach for the months of May through August using Taylor maximum-minimum thermometers.

Fish

Pulsed direct-current electroshocking was used to sample fish communities. Each pool and riffle was blocked at both ends with 6-mm mesh seines. Two passes were then made with a Coffelt model Bp-1c backpack electroshocking unit. Fish samples from both passes were combined. Larvae and young-of-the-year fish were excluded. Fish were enumerated and identified to species except for plains minnows *Hybognathus placitus* Girard, and western silvery minnows *H. argyritis* Girard, which were combined into a single category and labeled as ws/plns minnow because of difficulty in separating them in the field. Sample specimens were preserved and later identified to ensure that both species occurred in Little Beaver Creek. These species are often found in association with one another (Pflieger 1975).

Catch-per-unit-effort (CPUE) was used as a measure of relative abundance. Catch-per-unit-effort for each species was calculated by dividing the number of fish captured by the electroshocking time. To eliminate fractions, fish/minute calculations were multiplied by 100.

Data Analysis

The following features were determined for pools and riffles at each sample site.

1. Elevation (m).
2. Distance from the mouth of the Little Missouri River (km).
3. Length (m).
4. Water surface area (m^2).
5. Mean wetted width (m).
6. Mean depth (cm).
7. Coefficient of variation (SD/mean) in depth.
8. Mean shoreline depth (cm).
9. Width-to-depth ratio.
10. Pool-riffle ratio.
11. Mean velocity (cm/sec).
12. Coefficient of variation in velocity.
13. Substrate type (in %).
14. Streamside vegetative cover rating (in %) calculated from transect intercept points.
15. Mean undercut bank calculated at transect intercept points (cm).
16. Mean overhanging vegetation calculated at transect intercept points (cm).
17. Overall instream cover rating (emergent and submerged vegetation).
18. Secchi depth.
19. Dissolved oxygen.
20. Temperature.

Statistical analyses were performed using STATVIEW software on a Macintosh SE 30 and on an IBM PC AT using programs written by Daniel Gustafson, Montana State University. Catch-per-unit-effort data were analyzed with a Chi-square test to determine if individual species were selecting for pools or riffles and to determine if individual species were selecting for a particular stream segment.

Principal components analysis was used to identify species assemblages. This analysis reveals sites where species are behaving in similar fashions (Gustafson 1990). Principal components analysis allows the investigator to identify sites with similar communities and assists in determining which species are having the greatest influence (Carpenter et al. 1981).

A Kruskal-Wallis test was used to determine if habitat features differed significantly among stream segments. Correlations of habitat variables with individual fish species were computed using a non-parametric Spearman-Rank analysis. Habitat variables were assessed for intercorrelation using Spearman-Rank analysis to reduce redundancy reported in fish-habitat associations. If two variables were highly multicolinear ($R \geq 0.75$), one was excluded (Lanka et al. 1987).

RESULTS

Fish

A total of 4924 individuals representing 22 species in eight families was collected in Little Beaver Creek. Taxonomic names of these species and families are listed in Table 4. Five species were non-native and the status of a sixth was undetermined (Holton 1990). The most abundant and species-rich family was Cyprinidae. Green sunfish, creek chub, white sucker, fathead minnow, and sand shiner were the five most abundant species; of these, only the green sunfish is introduced.

The three study segments exhibited a weak longitudinal continuum in fish species composition with considerable overlap between segments (Figure 2). Community changes were reflected primarily by the downstream addition of species; replacement was of less importance.

Ten species (white sucker, common carp, creek chub, fathead minnow, brassy minnow, black bullhead, brook stickleback, green sunfish, yellow perch, and Iowa darter) occurred in the upstream segment. Five species (northern pike, shorthead redhorse, longnose dace, sand shiner, and stonecat) were added in the midstream segment and one species (yellow perch) was lost. Five additional species (goldeye, golden shiner, flathead chub, western silvery minnow, and plains minnow) were added in the downstream segment, while two species (brassy minnow and Iowa darter) were lost (Table 5).

Table 4. Fish species collected in Little Beaver Creek, Montana, March-August 1990 and 1991.

Family and species	Common name
Esocidae	
Esox lucius[b]	Northern pike
Hiodontidae	
Hiodon alosoides	Goldeye
Catostomidae	
Moxostoma macrolepidotum	Shorthead redhorse
Catostomas commersoni	White sucker
Carpoides carpio[a]	River carpsucker
Cyprinidae	
Cyprinus carpio[b]	Common carp
Notemigonus crysoleucas[c]	Golden shiner
Phoxinus eos[a]	Northern redbelly dace
Semotilus atromaculatus	Creek chub
Platygobio gracilus	Flathead chub
Rhinichthys cataractae	Longnose dace
Pimaphales promelas	Fathead minnow
Hybognathus hankinsoni	Brassy minnow
Hybognathus argyritis	Western silvery minnow
Hybognathus placitus	Plains minnow
Notropis stramineus	Sand shiner
Ictaluridae	
Ameiurus melas[b]	Black bullhead
Noturus flavus	Stonecat
Gasterostidae	
Culaea inconstans	Brook stickleback
Centrarchidae	
Lepomis cyanellus[b]	Green sunfish
Percidae	
Perca flavescens[b]	Yellow perch
Etheostoma exile	Iowa darter

[a] These species were each collected at only one site duing the 1990 stream inventory and were represented by only a few individuals.

[b] Introduced species.

[c] May be native to eastern Montana, native to the Dakotas.

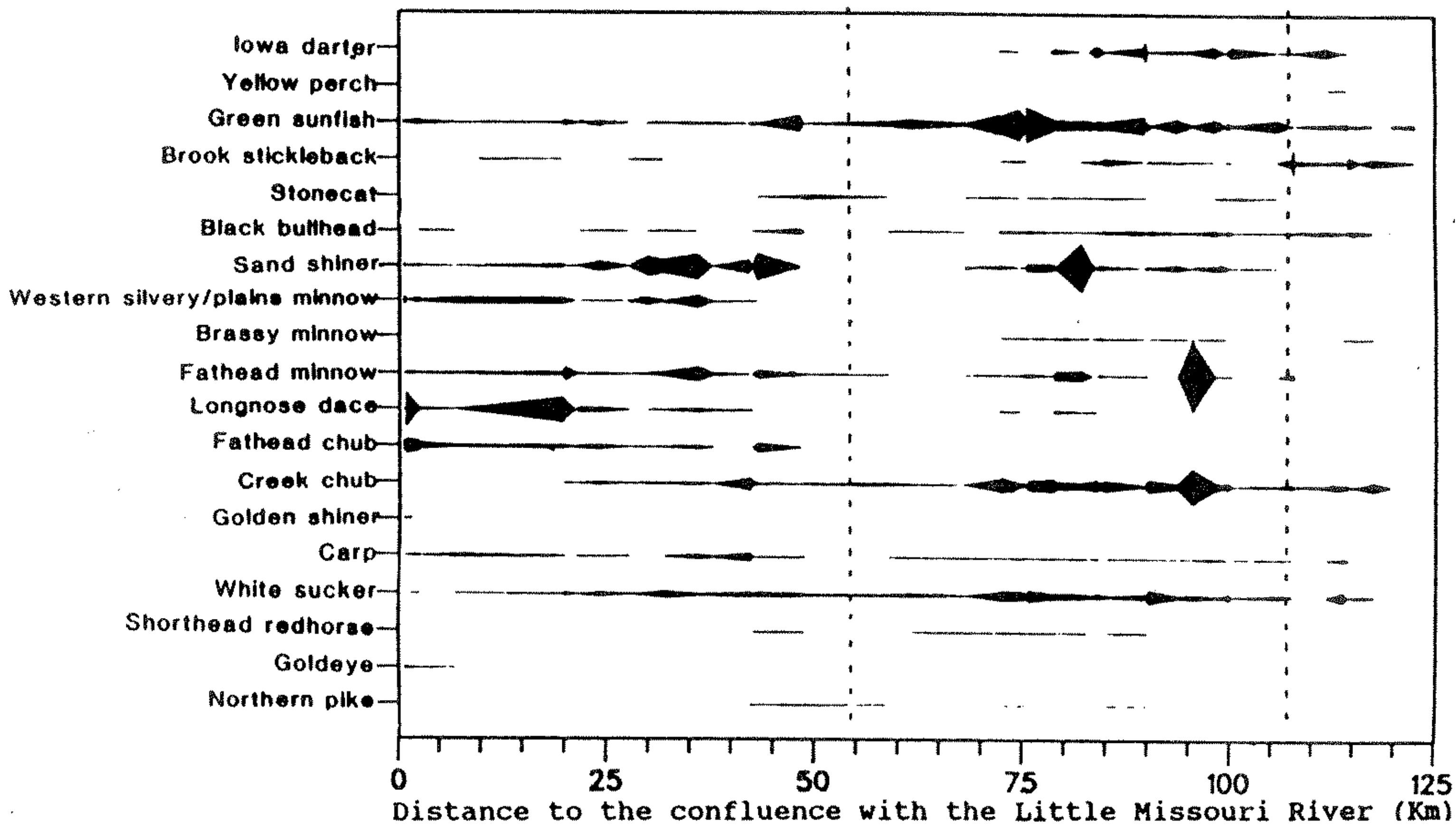

Figure 2. Longitudinal distribution and relative abundance of fishes collected in Little Beaver Creek, Montana, April-August 1991. Width of kite is proportional to relative abundance (CPUE) of individual species along the stream gradient. Dashed lines indicate stream study segments.

Table 5. Addition and replacement of fish species occurring in Little Beaver Creek.

Stream reach	Upper	Middle	Lower
Number of sites	12	25	21
Number of species	10	14	17
Number of unique species	1	1	5
Number of species added	10	5	5
Number of species lost	---	1	2

The species added in the downstream segment, with the exception of the golden shiner, are characteristic of turbid, Great Plains streams. The golden shiner was found at only one site. Six species (white sucker, common carp, creek chub, fathead minnow, black bullhead, brook stickleback, and green sunfish) were widespread and found in all three stream segments. Brook stickleback, however, were found at only two downstream sites in very limited numbers and, in both cases, were sampled following storm events.

Based on catch-per-unit-effort data, significant differences in the abundance of individual species occurred between stream segments (Table 6). Two species (brook stickleback and yellow perch) attained their greatest abundance in the upstream segment. Nine species (shorthead redhorse, white sucker, creek chub, fathead minnow, brassy minnow, black bullhead, stonecat, green sunfish, and Iowa darter) dominated the midstream segment, and nine species (northern pike, goldeye, carp, golden shiner, flathead chub, longnose dace, plains minnow, western silvery minnow, and sand shiner) reached their greatest abundance in the downstream segment.

Table 6. Chi-square analysis of fish species abundance (CPUE) between segments (1=upper) in Little Beaver Creek, Montana, 1991. Riffle and pool data are combined.

	Stream segment				
	1	2	3		
	Sample size				
Species	16	48	41	Chi^2	P
Northern pike	0	5	14	10.3	0.01
Goldeye	0	0	56	87.4	0.00
Shorthead redhorse	0	55	11	39.0	0.00
White sucker	229	1796	530	622.9	0.00
Carp	63	63	332	234.2	0.00
Golden shiner	0	0	8	12.5	0.00
Creek chub	426	2940	408	1664.6	0.00
Flathead chub	0	0	1135	1771.7	0.00
Longnose dace	0	62	1462	2073.3	0.00
Fathead minnow	72	1385	868	324.3	0.00
Brassy minnow	19	101	0	85.7	0.00
Ws/plns minnow	0	0	898	1401.8	0.00
Sand shiner	0	1684	1795	675.9	0.00
Black bullhead	138	526	96	231.9	0.00
Stonecat	0	157	95	53.7	0.00
Brook stickleback	979	242	13	3967.2	0.00
Green sunfish	432	3735	635	2023.0	0.00
Yellow perch	8	0	0	44.5	0.00
Iowa darter	144	1089	0	981.3	0.00

Fish data for both pools and riffles were examined using principal components analysis. Goldeye, golden shiner, northern pike and yellow perch were excluded from analysis, since they occurred at less than 10% of the sites and probably contributed very little to assemblage behavior.

Principal components analysis identified two species assemblages in pools (Figure 3) but none in riffles. The first two principal components explained 44.3% of the total variance in the pool data (Table 7). Most of the variation in the data occurred between downstream and midstream sites. Principal component 1 explained 25.6% of the total variance in the fish data, and separated midstream sites from downstream sites. Downstream sites 1-10 had similar communities and midstream sites 25-40 (except site 33) had similar communities. The midstream assemblage was composed of species representing several families, while downstream sites (1-10) were dominated by cyprinids.

Generally, species characteristic of the downstream segment received negative weightings on PC 1, while species characteristic of the midstream segment were weighted positively (Table 7). Those species most important in downstream sites 1-10 include ws/plns minnow, flathead chub, longnose dace, fathead minnow and carp. The white sucker, green sunfish, creek chub, black bullhead, shorthead redhorse, and stonecat were most important in the midstream assemblage.

Upstream sites and sites that could be interpreted as being transitional areas between segments tended to cluster around zero on the first principal component. Upstream sites generally had low species diversity and supported very few fish. Transitional sites occurred in regions of species overlap; no well defined assemblages were present.

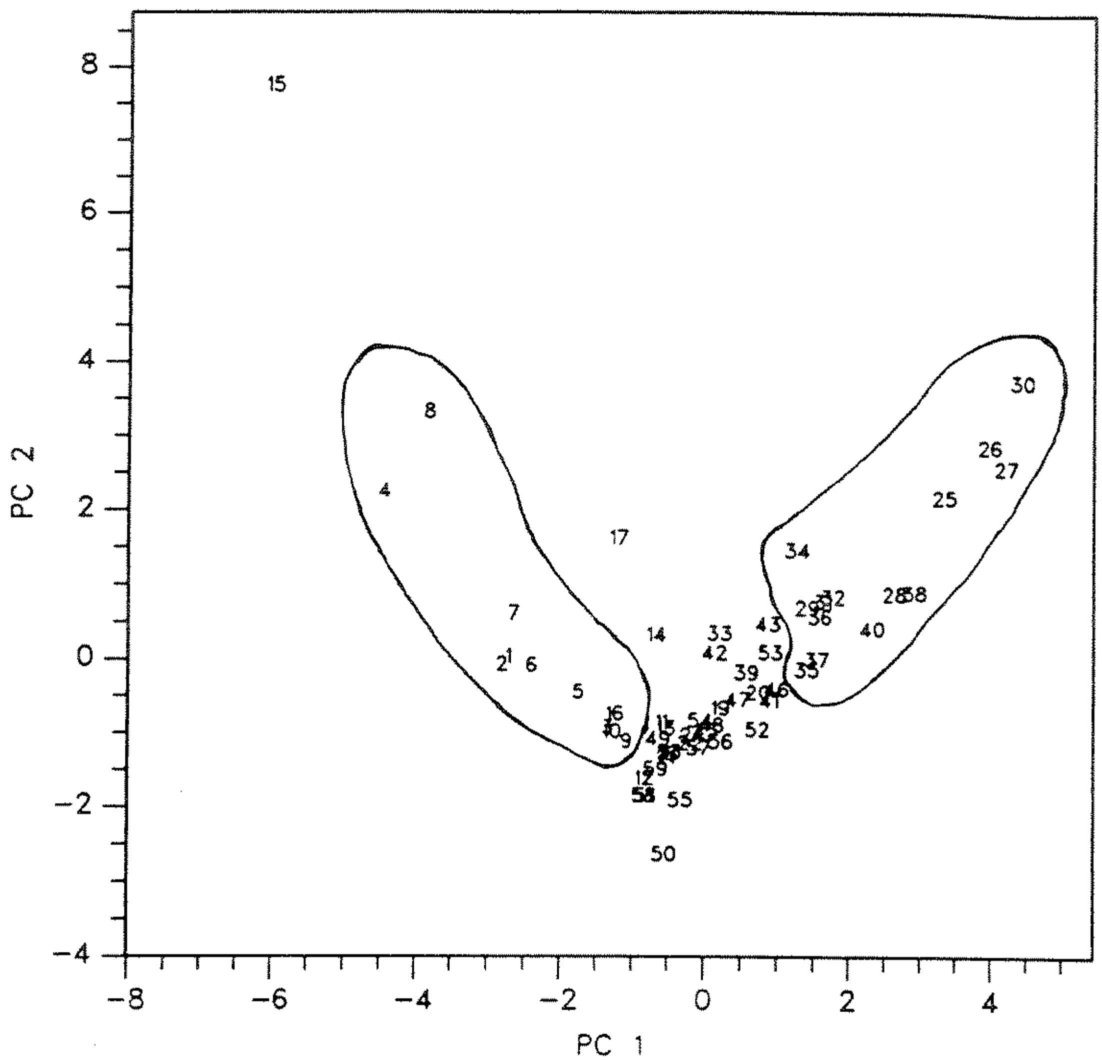

Figure 3. Study site groupings based on principal components analysis of species abundances (CPUE) in pools of Little Beaver Creek, Montana. Sites are plotted against the first and second principal component (PC) scores. Sites 1-21 downstream segment; sites 22-46 midstream segment; sites 47-58 upstream segment.

Table 7. Principal components analysis of fish data for pools, Little Beaver Creek, Montana 1991.

Species	Principal component loadings	
	1	2
Shorthead redhorse	0.26	0.19
White sucker	0.35	0.28
Carp	-0.18	0.21
Creek chub	0.35	0.25
Flathead chub	-0.29	0.14
Longnose dace	-0.28	0.36
Fathead minnow	-0.24	0.36
Brassy minnow	0.15	0.05
Ws/plns minnow	-0.34	0.33
Sand shiner	-0.06	0.47
Black bullhead	0.30	0.09
Stonecat	0.24	0.21
Brook stickleback	-0.01	-0.19
Green sunfish	0.35	0.29
Iowa darter	0.12	-0.04
Eigen values	3.84	2.81
Percent of variance	25.56	18.73
Cummulative percent	25.56	44.29

The second principal component accounted for 18.7% of the variance and is a measure of species diversity in pool habitats. Species often found in association with several other species received positive weightings on this component, while those that occurred alone or in conjunction with few other species received negative weightings. Brook sticklebacks had the largest negative weighting. Sticklebacks were most abundant in the heavily vegetated, isolated pools of the upstream segment and generally occurred at species poor sites. Generally, midstream sites scored higher on PC 2 and tended to have higher numbers of species per site than did either of the other segments.

Habitat

In Little Beaver Creek the major longitudinal gradients in habitat involved changes in substrate composition, riparian zone characteristics, water clarity and features related to stream size (Figures 4 and 5; Appendix Tables 13 and 14). The general trend in bottom materials was a downstream decrease in the mean percentages of smaller substrate particles. Fine sediment in pools decreased from a mean of 87% in the upstream segment to 36% in the downstream segment. Fine sediments in riffles showed a similar trend with mean percentages of 73%, 30% and 7% in the upstream, midstream and downstream segments, respectively.

Streamside vegetative cover was heavier along upstream and midstream pools, and the percentage of bare ground (mean=6% and 12%) was less than along pools of the downstream segment (mean=28%). Additionally, midstream sites tended to have greater amounts of overhanging vegetation and undercut banks.

Mean Secchi depths of pools decreased from the upstream segment (64.8 cm) to the downstream segment (24.0 cm) (Figure 4). Lengths of pools and riffles increased with distance downstream (Figures 4 and 5). The same trend was true for other size-related features such as stream surface area, mean width, and mean depth.

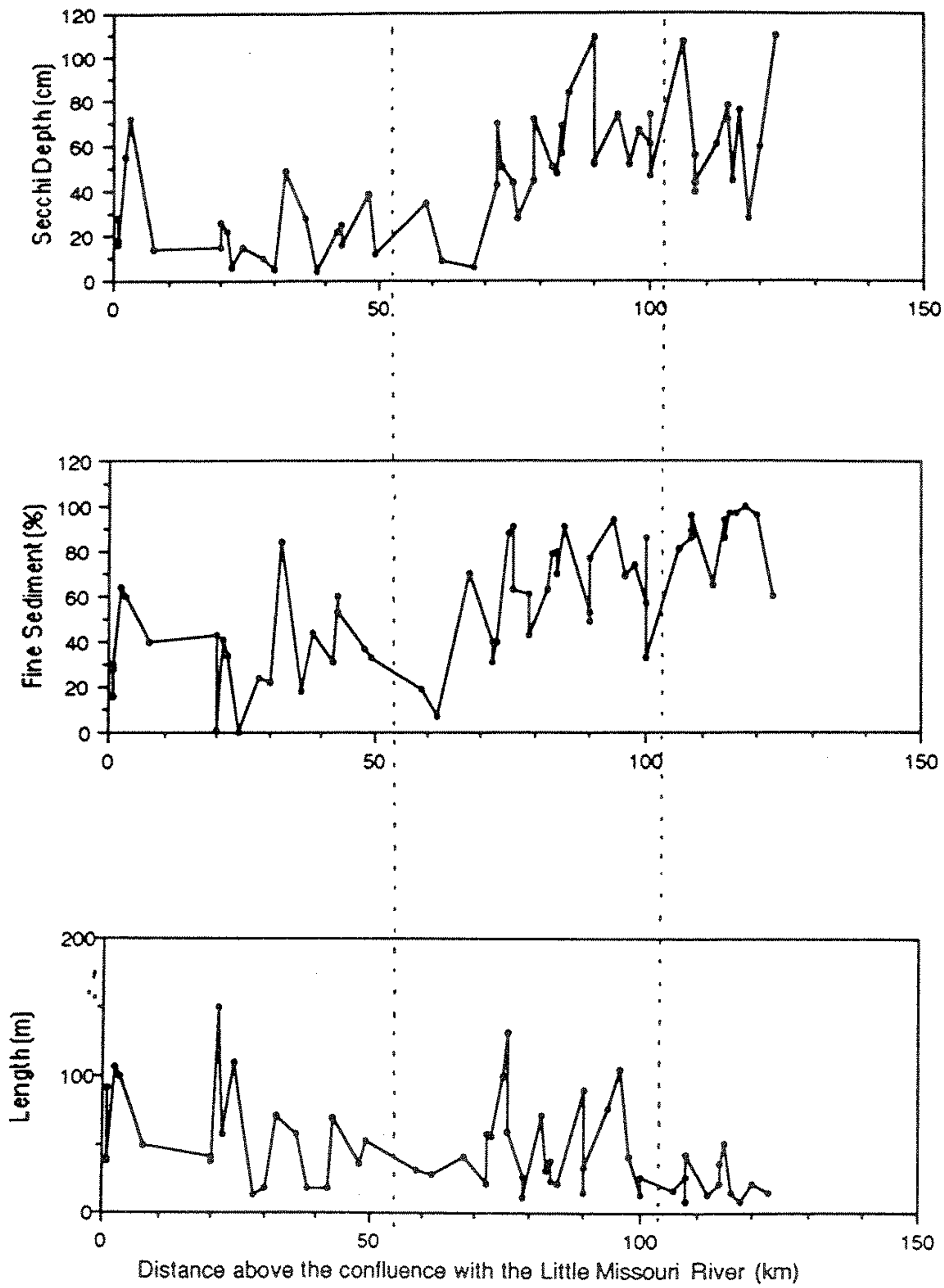

Figure 4. Longitudinal changes by stream segment in representative habitat characteristics measured in pools of Little Beaver Creek, Montana, April-August 1991.

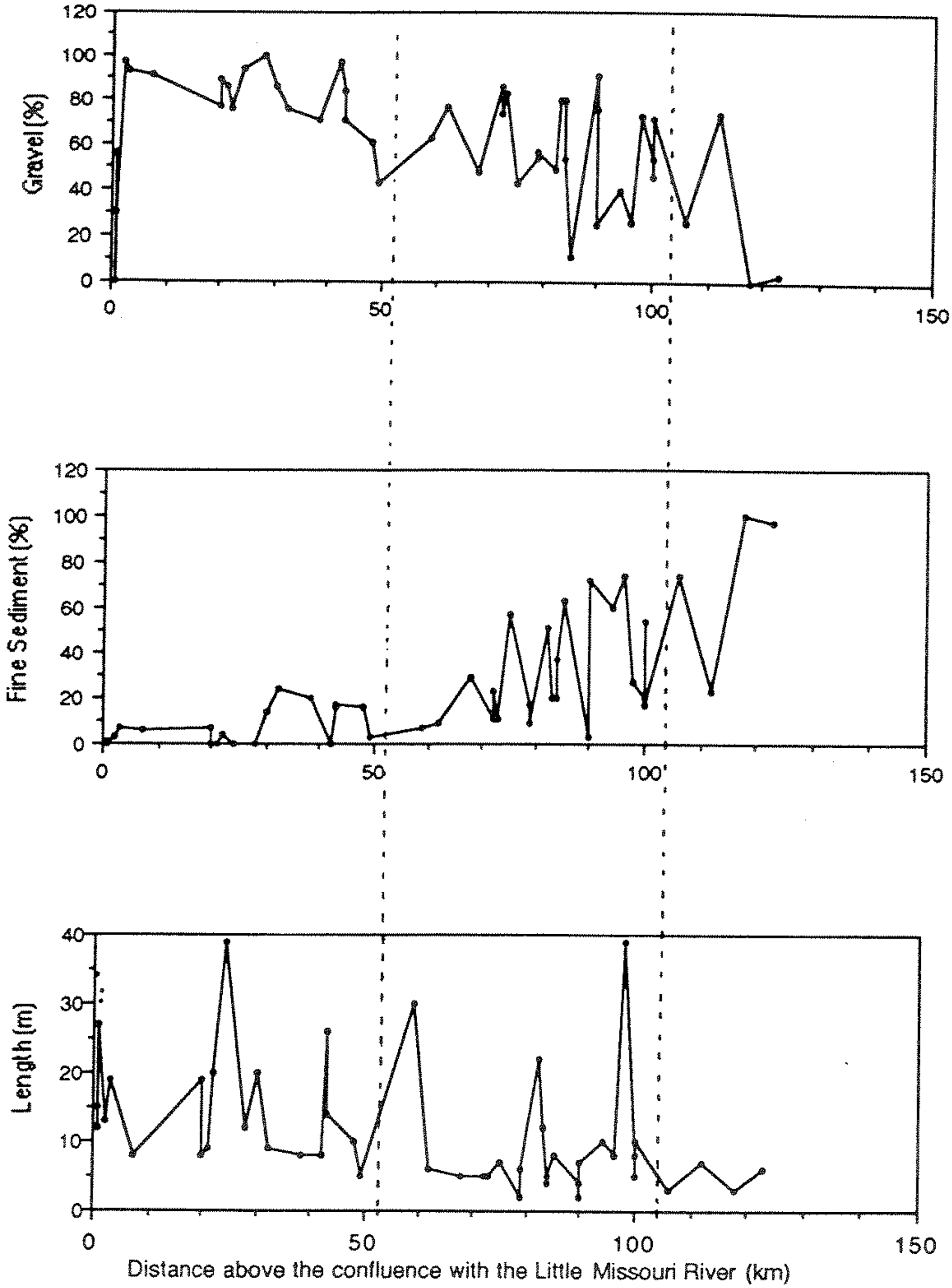

Figure 5. Longitudinal changes by stream segment in representative habitat characteristics measured in riffles of Little Beaver Creek, Montana, April-August 1991.

Monthly maximum-minimum water temperatures recorded for one pool within each segment were lowest (8-17 °C) in the upstream pool and highest (17-34°C) in the downstream pool (Table 8). Daily temperature and oxygen data were not analyzed since measurements were taken at various times throughout the day. Some pools, especially intermittent ones or those with abundant aquatic vegetation, exhibited large diel fluctuations in temperature and oxygen. This inconsistency confounds interpretation and analysis.

Table 8. Monthly maximum-minimum water temperatures (°C) recorded for one pool within each segment of Little Beaver Creek, Montana, May-August 1991.

	May	June	July	August
Upstream	8-16	8-13	10-14	11-17
Midstream	17-26	17-27	20-31	21-29
Downstream	No data	17-28	20-34	20-30

Kruskal-Wallis analysis of 22 pool and riffle variables indicated that several parameters differed significantly among the three segments (Appendix Tables 13 and 14). A multiple comparisons procedure was used to test for differences between segments. Features that differed among segments for both pools and riffles were primarily related to stream size, substrate composition, water clarity and riparian zone characteristics. Trends in the data are readily interpretable from mean rank scores for each segment.

Fish-Habitat Associations

Chi-square analysis of catch-per-unit-effort data from Little Beaver Creek indicated that six species (flathead chub, longnose dace, fathead minnow, sand shiner, stonecat, and Iowa darter) were characteristic of riffles, while the 13 remaining species were predominately found in pools (Table 9). Pools supported greater numbers of species (mean=6.3) than did riffles (mean=2.2). With increasing mean depth, the potential of a site for supporting additional species increased, at least up to 30 cm (Figure 6).

Several habitat variables were significantly correlated with the relative abundance of individual fish species found in Little Beaver Creek (Tables 10 and 11). Generally, species characteristic of the downstream segment (goldeye, ws/plns minnow, carp, flathead chub, longnose dace, and sand shiner) were correlated with features characteristic of erosional habitats. Many of these species (e.g., goldeye, carp, and flathead chub) were positively correlated with several stream size-related features such as surface area, mean width and width to depth ratio, and with larger substrate sizes. Several of these downstream species (e.g., flathead chub, longnose dace, and ws/plns minnow) were negatively correlated with Secchi depth, instream vegetation, and fine sediments.

Table 9. Chi-square analysis of fish species abundance (CPUE) between stream morphology types (pools and riffles) in Little Beaver Creek, Montana, 1991.

	Pools	Riffles		
	Sample size			
Species	58	47	Chi^2	P
Northern pike	19	0	13.66	0.00
Goldeye	56	0	43.66	0.00
Shorthead redhorse	66	0	51.77	0.00
White sucker	2331	234	1319.00	0.00
Carp	445	13	324.40	0.00
Golden shiner	8	0	4.81	0.03
Creek chub	2875	899	670.80	0.00
Flathead chub	577	558	8.56	0.00
Longnose dace	331	1193	689.50	0.00
Fathead minnow	1063	1262	84.10	0.00
Brassy minnow	112	8	69.03	0.00
Ws/plns minnow	725	173	235.70	0.00
Sand shiner	1479	2000	226.00	0.00
Black bullhead	656	104	296.30	0.00
Stonecat	106	146	17.06	0.00
Brook stickleback	1098	136	568.00	0.00
Green sunfish	4324	478	2356.00	0.00
Yellow perch	8	0	4.81	0.00
Iowa darter	385	845	285.00	0.00

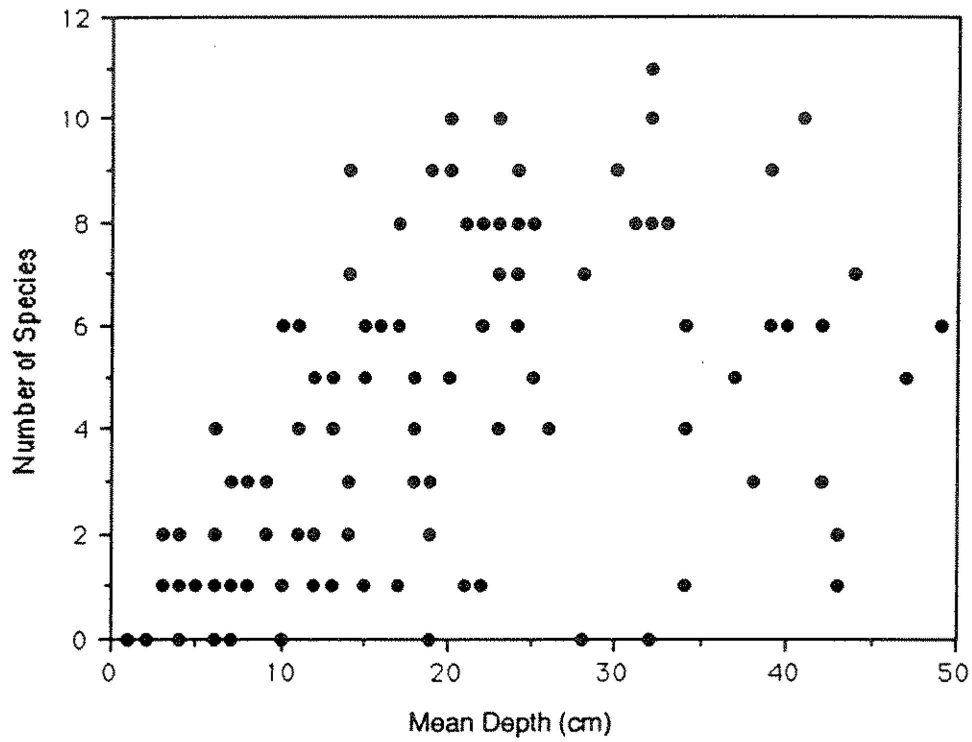

Figure 6. Relationship between mean depth of pools and riffles and number of fish species present in Little Beaver Creek, Montana, April-August 1991.

Fish species characteristic of the upstream and midstream segments (shorthead redhorse, white sucker, creek chub, brassy minnow, black bullhead, brook stickleback, and green sunfish) were correlated with features associated with more lentic-like or depositional environments. Habitat features positively correlated with the relative abundance of these species included secchi depth, submerged and emergent vegetation, fine sediment, grass-covered banks, undercut banks, overhanging vegetation, and pool-to-riffle ratio (Tables 10 and 11).

Table 10. Habitat features correlated (P≤0.05) with the relative abundance of fish species occurring in pools of Little Beaver Creek, Montana. + = a positive correlation; - = a negative correlation.

Variable	Species						
	Northern pike	Goldeye	Shorthead redhorse	White sucker	Carp	Creek chub	Flathead chub
Surface area	+	+	+		+	-	+
Mean width					+	-	+
Mean depth	+						
Mean shoreline depth							
Width to depth ratio							+
Pool-riffle ratio	+		+	+			
Mean velocity							
Secchi depth				+		+	-
Substrate							
Fine sediment						+	-
Gravel							
Cobble							+
Small boulder					+		+
Bedrock		+				-	+
Riparian zone							
Dominated by grass							-
Dominated by trees							
Cover							
Mean overhanging vegetation							
Mean undercut bank				+		+	
Submerged vegetation				+		+	-
Emergent vegetation							

Table 10. Continued.

Variable	Species						
	Longnose dace	Fathead minnow	Brassy minnow	Ws/pins minnow	Sand shiner	Black bullhead	Stonecat
Surface area		+		+			
Mean width		+					
Mean depth					+		
Mean shoreline depth							
Width to depth ratio		+		+	+		
Pool riffle ratio							
Mean velocity						-	
Secchi depth			+	-		+	
Substrate							
Fine sediment	-		+	-		+	
Gravel	+		-	+		-	
Cobble							
Small boulder				+			
Bedrock							
Riparian zone							
Dominated by grass		-		-			
Dominated by trees		+					
Cover							
Mean overhanging vegetation							
Mean undercut bank							
Submerged vegetation	-		+	-		+	
Emergent vegetation						+	+

Table 10. Continued.

Variable	Species		
	Brook stickleback	Green sunfish	Iowa darter
Surface area			
Mean width			
Mean depth	-		
Mean shoreline depth			
Width to depth ratio			
Pool riffle ratio		+	
Mean velocity	-		
Secchi depth	+	+	+
Substrate			
Fine sediment	+		
Gravel	-		
Cobble	-		
Small boulder			
Bedrock			
Riparian zone			
Dominated by grass	+		
Dominated by trees			
Cover			
Mean overhanging vegetation			
Mean undercut bank			
Submerged vegetation	+	+	+
Emergent vegetation			

Table 11. Habitat features correlated ($P \leq 0.05$) with the relative abundance of fish species occurring in riffles of Little Beaver Creek, Montana. + = a positive correlation; - = a negative correlation.

Variable	Species						
	White sucker	Carp	Creek chub	Flathead chub	Longnose dace	Fathead minnow	Ws/pins minnow
Surface area				+	+	+	+
Mean width				+			
Mean depth	+						
Mean shoreline depth							
Width to depth ratio							
Pool-riffle ratio						-	
Mean velocity				+	+		
Coefficient of variation in velocity			+		+		
Substrate							
Fine sediment					-		
Cobble			+	+	+		
Bedrock				+	+		
Riparian zone							
Dominated by grass				-	-	-	
Dominated by trees		+		+	+		
Cover							
Mean overhanging vegetation							
Mean undercut bank							
Submerged vegetation					-		
Emergent vegetation							

Table 11. Continued.

Variable	Sand shiner	Black bullhead	Stonecat	Brook stickleback	Green sunfish	Iowa darter
	Species					
Surface area	+				+	
Mean width		+			+	
Mean depth					+	
Mean shoreline depth		+				
Width to depth ratio						
Pool-riffle ratio						
Mean velocity						
Coefficient of variation in velocity		+				+
Substrate						
Fine sediment						
Cobble			+			
Bedrock						
Riparian zone						
Dominated by grass						
Dominated by trees						
Cover						
Mean overhanging vegetation						
Mean undercut bank		+				
Submerged vegetation		+				+
Emergent vegetation		+				

Mann-Whitney U tests were used to analyze habitat differences between sites that principal components analysis identified as having similar communities and the remaining sites in Little Beaver Creek. The downstream assemblage occurred in pools of sites 1-10 (Figure 3). These pools had significantly greater ($p \leq 0.05$) surface areas, lengths, mean widths and width-to-depth ratios, and lower Secchi depths than did other pools in Little Beaver Creek. Also, there were significantly greater quantities of cobble, small boulders and bedrock, and less fine sediment in these pools. Sites of the midstream assemblage (25-40, except 33) had significantly greater pool-riffle ratios and Secchi depths, and more cover in the form of undercut banks and submerged vegetation.

DISCUSSION

Although Little Beaver Creek is a small prairie stream, it is unique in possessing segments that exhibit physical characteristics common to the three major Great Plains stream types described by Cross and Moss (1987): (1) large streams having erratic flows, high levels of turbidity and dissolved solids, (2) small, clear and relatively stable streams sustained by ground water input, and (3) pools of intermittent streams not sustained by ground water input. Each stream type has a distinguishable fish community. The large stream type consists of several endemic species adapted to high turbidity, erratic flow, and elevated summer temperatures. The community of small, stable streams is composed of glacial relic species, while the intermittent community includes relatively few very widespread species.

Fish species found within the three stream segments of Little Beaver Creek generally reflected Cross and Moss' (1987) community classifications. Fish species occurring in the downstream segment of Little Beaver Creek were characteristic of the large stream community type. These include goldeye, flathead chub, plains minnow, and western silvery minnow. The midstream segment supported the greatest abundance of species typical of the small stable stream community type. Examples of these species are the Iowa darter, northern redbelly dace, and creek chub. Black bullhead, green sunfish, and fathead minnow are widespread species characteristic of intermittent streams; these species were found throughout Little Beaver Creek.

Some authors (Propst 1982; Bailey and Allum 1962) have used geographic region of origin to explain patterns of longitudinal distribution and fish faunal associations. In general, fish species reaching their greatest abundance in the midstream segment and in spring-fed pools of the upstream segment of Little Beaver Creek are of Propst's (1982) northern and mixed origins. Examples of these species include Iowa darter, creek chub, brook stickleback, and brassy minnow; all prefer cool, clear, spring-fed streams (Propst 1982; Cross and Moss 1987; Brown 1971). Brook stickleback were collected at two locations in the downstream segment of Little Beaver Creek following storm events, and occurrence probably resulted from displacement from upstream areas. Two species common to the midstream segment and classified by Propst (1982) as being of southern origin were the introduced black bullhead and green sunfish. These species can occur in a wide array of habitats (Cross and Moss 1987).

Species characteristic of the downstream segment were generally of mixed and southern origins. Northern pike and longnose dace, species of northern origin, were exceptions (Propst 1982; Pflieger 1975) and were most abundant in the downstream segment. Longnose dace are riffle dwellers and are more often found in steep gradient foothill and mountain streams (Bramblett and Fausch 1991; Edwards et al. 1983).

The occurrence of longnose dace in the downstream segment of Little Beaver Creek is probably due to the larger area of riffle habitat and greater amounts of cobble and gravel substrate. Longnose dace shifted their habitat use to pools as downstream riffle habitat decreased in mid- to late summer. Northern pike occurred in the extreme upper end of the downstream segment but were never common.

Propst (1982) found that region of origin imposed limits to species distributions within the stream systems he studied in Colorado. Fishes of northern origin were typically most abundant in headwater reaches or in areas receiving spring influence; fishes of southern origin were most common in downstream areas. In general, this was true for the longitudinal distribution of individual fish species in Little Beaver Creek. The relative abundance of individual species along the stream gradient reflected this pattern: new species were added and others lost as transitions in physicochemical conditions occurred.

Warmwater streams may exhibit gradual transitional changes rather than abrupt zonation (Winger 1981). Community changes in Little Beaver Creek exhibited a weak longitudinal continuum with considerable overlap in fish species composition between segments. This pattern is probably due in part to the relatively minor amount of elevational change from headwaters to mouth (≈200 m), similar gradients between stream segments, and lack of a coldwater zone.

Two fish species assemblages were identified in Little Beaver Creek, although there was overlap in species composition between stream segments . Pools of downstream sites 1-10 had similar communities and pools of midstream sites 25-40 (except site 33) had similar communities. Previous studies (Pearsons et al. 1992; Ward and Nigro 1992; Fausch and Bramblett 1991; Meffe and Sheldon 1988; Degerman and Sers 1992) have reported that flow regime and habitat can influence fish assemblages. Habitat and flow probably exerted a strong influence on the fish communities present in Little Beaver Creek.

The downstream assemblage was primarily composed of native cyprinids adapted to the harsh physical conditions present in Great Plains streams. Flow conditions in the downstream segment of Little Beaver Creek were temporally variable. This contrasts with other studies (Schlosser 1987; Rahel and Hubert 1991) that found lower temporal variability in the physical conditions of downstream areas. Schlosser (1987) found that cyprinids dominated in shallow, temporally variable areas and catostomids and centrarchids became more abundant in stable downstream areas. In Little Beaver Creek, centrarchids and catostomids were most common in the more stable midstream segment.

Habitat complexity is another important factor in stream fish assemblage structure and persistence (Fausch and Bramblett 1991; Pearsons et al. 1992). Measures of habitat complexity include pool depth and cover in the form of coarse substrate, vegetation, and undercut banks (Fausch and Bramblett 1991).

In Little Beaver Creek, downstream pools with similar communities had significantly greater surface areas, lengths, and mean widths and more cobble and small boulders than did other pools. These large pools with cobble/boulder substrates might act as refugia during floods and sustain fish during periods of negligible flow. Recolonization from the nearby Little Missouri River may have also been important since the downstream assemblage occurred in the 10 most downstream pools sampled. All species in the downstream assemblage were common in the Little Missouri River.

Midstream pools with similar communities had significantly greater pool-to-riffle ratios and more cover in the form of undercut banks and submerged vegetation. These habitat conditions, along with permanent summer flow, probably contributed to the differences in fish communities in this stream segment compared to upstream and downstream segments. Ward and Nigro (1992) reported differences in physical habitat characteristics between areas where fish assemblages differred.

No well defined assemblages were identified in either riffles or upstream pools and in the remaining pools of the mid-and downstream segments. The lack of distinct assemblages in upstream pools and riffles may be due to space limitations or to the variability and physical harshness of these sites. Meefe and Sheldon (1990) found that small, shallow sites supported assemblages consisting of only 1-3 species. Finger (1982) found low species diversity in riffle habitats of a New York stream. In Little Beaver Creek, midstream and downstream sites that did not have similar communities occurred in areas of species overlap and probably represent transitional areas between stream segments.

Species addition was more important than biotic zonation in Little Beaver Creek; similar patterns have been observed in other warmwater streams (Evans and Noble 1979; Schlosser 1987). Rahel and Hubert (1991) studied a Great Plains-Rocky Mountain stream and determined that community changes involved both zonation and addition. A coldwater assemblage was replaced by a warmwater assemblage below 2000 m. Within the warmwater zone there was a downstream addition of species. The authors noted that distinct communities in streams are usually the result of abrupt changes in stream temperature or geomorphology.

In Little Beaver Creek, the limited data suggest that there were temperature gradients between stream segments. Ground water input in the midstream segment and in upstream pools sustained by subterranean flows moderated summer temperatures.

Other studies (Schlosser 1987; Rahel and Hubert 1991) have found lower temporal variability in the physical conditions of downstream areas. In Little Beaver Creek, however, there was a great deal of temporal variation in the physical environment of downstream areas. Species characteristic of the downstream assemblage are adapted to high turbidity and variable flow regimes, while species occurring in the midstream assemblage generally require more stable conditions.

No single factor acts independently in producing community changes along the stream gradient. Rather, community changes are the result of complex biological and physical factors operating simultaneously.

Fish-Habitat Relations

In Montana, and in the Great Plains region in general, there is relatively little information available on the relationship between warmwater fish distribution and relative abundance and physical habitat parameters. I examined relationships between the relative abundance of several fish species and macrohabitat variables in Little Beaver Creek.

Information on fish-habitat associations in Little Beaver Creek may help managers maintain these species in the face of possible future land use changes. In Kansas, turbid river species such as flathead chubs and plains minnows declined or were extirpated after rivers were impounded (Cross and Moss 1987). Fish species characteristic of small, cool streams, such as the brassy minnow and Iowa darter, disappeared following intensive agricultural development (Cross and Moss 1987). This development caused increased stream temperature and turbidity, and reduced aquatic vegetation in small highland streams of Kansas.

In general, correlations between habitat variables and the relative abundance of fish species in Little Beaver Creek agreed with field observations and published literature accounts.

Northern Pike

Northern pike occur most frequently in lakes but also inhabit pools of clear, slow-moving streams (Scott and Crossman 1973; Inskip 1982). The presence of aquatic vegetation is a key factor in pike distribution (Cook and Bergersen 1988). Northern pike utilize vegetation as spawning substrate and for ambush cover (Inskip 1982).

In Little Beaver Creek, northern pike were uncommon and were collected only in pools. Our 1990 survey of large pools upstream of bridges, road crossings, and beaver dams indicated that pike were much more abundant in these habitats than in unaltered sections of the stream randomly sampled in 1991. These pools were very large, some approaching 900 m in length, and supported an abundance of submerged aquatic vegetation. In the unaltered segments of the stream, northern pike were positively associated with surface area, mean depth, and pool-to-riffle ratio, indicating their association with larger pool habitats.

Goldeye

Goldeye are characteristic of large, turbid rivers (Scott and Crossman 1973) but are occasionally encountered in deeper pools of small streams (Pflieger 1975). They are especially tolerant of turbid habitats (Pflieger 1975) and their eyes, which possess only rods, are uniquely adapted to low light and turbid conditions (Scott and Crossman 1973).

In Little Beaver Creek goldeye were found only in downstream pools, never in riffles. There was a significant positive correlation between the relative abundance of goldeye and pool surface area and bedrock substrate. Possibly, large pools underlain by bedrock, that occurred occasionally in the downstream segment, ameliorated the effects of drought and intermittency. Bich and Scalet (1977) collected goldeye in the nearby Little Missouri River. They captured the greatest numbers of this species at a station where a road crossing had created a wide, deep pool.

Shorthead Redhorse

Despite their being widespread, not much is known of the biology of the shorthead redhorse (Scott and Crossman 1973). This species occurs in moderately large, clear rivers having permanent flow (Pflieger 1975; Cross 1967). Shorthead redhorse typically occur in riffles (Pflieger 1975; Cross 1967) but are adaptable, and are also found in pools without noticeable flow (Pflieger 1975).

Shorthead redhorse were never abundant in Little Beaver Creek but were most common in the permanently flowing, nonturbid midstream segment. They are an uncommon species in the nearby Little Missouri River (Bich and Scalet 1977).

In Little Beaver Creek, shorthead redhorse were never collected in riffles. This may be due to the lack of large, well-developed riffles in the midstream segment. The relative abundance of shorthead redhorse was positively correlated with surface area and pool to riffle ratio. This would agree with their apparent preference for larger streams. In Wisconsin streams, the distribution of this species was positively related to maximum stream depth and to mean width (Lyons et al. 1988).

White Sucker

The white sucker has been described as being a small creek fish (Pflieger 1975), although it can occur in a broad range of habitats (Hubert and Rahel 1989). In Missouri this species occurs in clearer streams and in heavily vegetated, spring-fed pools (Pflieger 1975).

In Little Beaver Creek white suckers were more abundant in pools than in riffles. Finger (1982) found this species to be the most characteristic fish of pools in a New York stream. The relative abundance of white suckers in pools of Little Beaver Creek was positively correlated with pool to riffle ratio, Secchi depth, and cover in the form of undercut banks and submerged vegetation. Hubert and Rahel (1989) found white sucker abundance was positively correlated with shade and cover in the form of woody debris and emergent vegetation. When found in riffles, they were positively associated with mean depth.

Pflieger (1975) stated that white suckers and creek chubs require similar habitat conditions. In Little Beaver Creek, these species were most abundant in the midstream segment and were often found together. Their relative abundance was correlated with many of the same habitat variables. Both of these species are uncommon in the Little Missouri River (Bich and Scalet 1977).

Common Carp

Common carp are very adaptable (Cross 1967; Penak1987) but prefer relatively shallow, well-vegetated waters with silt substrates (Edwards and Twomey 1982; Penak 1987). In riverine settings, optimal conditions include 50% or greater pool area (Edwards and Twomey 1982). They are extremely tolerant of turbid water (Penak 1987; Edwards and Twomey 1982).

In Little Beaver Creek common carp were most abundant in pools of the downstream segment. In pools, their relative abundance was associated with surface area, and mean width, and small boulders. Although this substrate association differs from other accounts (Edwards and Twomey 1982; Bich and Scalet 1977; Penak 1987), common carp are adaptable and can be found over all types of bottom materials (Trautman 1957). When found in riffles, carp were positively associated with bank cover dominated by trees.

Creek Chub

Creek chubs are common in small, cool and clear streams having abundant cover (McMahon 1982; Pflieger 1975; Scott and Crossman 1975; Barber and Mincklley 1971; Hubert and Rahel 1989). Occasionally they occur in lentic habitats (McMahon 1982).

In Little Beaver Creek, creek chubs were associated with several habitat parameters. In pools, Secchi depth, fine sediment, undercut banks, and submerged vegetation were positively associated with the relative abundance of this species. Creek chubs are most abundant in small streams (McMahon 1982; Meffe and Sheldon 1988). In pools of Little Beaver Creek they were negatively correlated with surface area and mean width. Lyons et al. (1988) found a negative relationship between average stream width and the abundance of creek chubs in Wisconsin streams. This species can be found over many substrate types (McMahon 1982). In Little Beaver Creek they were positively associated with fines in both pools and riffles and negatively associated with bedrock in pools. This may indicate an affinity for slower velocity or depositional habitats. Pflieger (1975) states that creek chubs do not thrive in streams with continuous strong flows. Areas of bedrock would indicate scouring and would not provide substrate suitable for the establishment of cover in the form of aquatic vegetation. Also, invertebrate prey abundance would likely be lower in these areas. Hubert and Rahel (1989) found creek chubs preferred areas of slow velocity or areas with substantial variation in velocities. In riffles of Little Beaver Creek, they were positively associated with coefficient of variation in velocity. This would indicate a diversity of velocities were available in these areas.

Flathead Chub and
Western Silvery/Plains minnow

I will discuss flathead chubs and western silvery/plains minnows as a group because in Little Beaver Creek they were often found in mixed schools and relative abundances were correlated with many of the same habitat features. Other studies in Montana (Elser et al. 1978) and South Dakota (Bich and Scalet 1977) have found these species occurring at the same sites.

These fishes represent a fauna distinct to the Great Plains region (Cross and Moss 1987). Pflieger (1975) describes the habitat of all three species as being large, turbid rivers and their tributaries. In Beaver Creek, Montana, this minnow complex dominated the lower reaches (Elser et al. 1978).

The relative abundance of flathead chub was correlated with six habitat features in pools (surface area, mean width, width to depth ratio, cobble, small boulder, and bedrock). Relative abundance was negatively correlated with Secchi depth, fine sediment, riparian zone dominated by grass, and submerged vegetation. The relative abundance of ws/plns minnows was correlated with the same features except mean width and small boulder.

In riffles, correlations between habitat features and the relative abundance of flathead chubs differed somewhat from those of ws/plns minnows. Flathead chubs were positively associated with surface area, mean width, mean velocity, cobble, bedrock, and banks dominated by tree cover and negatively correlated with banks dominated by grass cover. Ws/plns minnows were positively correlated with surface area and negatively correlated with coefficient of variation in velocity and banks dominated by grass cover.

The relative abundance of flathead chubs was greatest in riffles, while ws/plns minnows were more common in pools. Pflieger (1975) states that flathead chubs can be found in areas of swift current. Morphologically the flathead chub may be better adapted to faster velocities. Its pointed snout and elongate fins aid it in the current (Scott and Crossman 1973). Some amount of ecological segregation would be expected when three species occur so often in the same habitats.

Longnose Dace

Longnose dace are most abundant in steep-gradient, foothill and mountain streams having gravel and boulder-strewn stream beds (Bramblett and Fausch 1991; Edwards et al. 1983). In pools of Little Beaver Creek, the relative abundance of longnose dace was positively correlated with gravel substrate and negatively correlated with fine sediment and submerged vegetation. In riffles, relative abundance was positively associated with surface area, pool-riffle ratio, coefficient of variation in velocity, cobble and bedrock substrates, and tree cover along the stream. Relative abundance was negatively correlated with fine sediment, submerged vegetation, and grass cover along the bank. These findings agree with those of Hubert and Rahel (1989), Edwards et al. (1983), and Lyons et al. (1988), although Hubert and Rahel (1989) reported that longnose dace were positively associated with submerged vegetation in a small Wyoming stream.

In Little Beaver Creek, longnose dace were most abundant in the downstream segment. This species requires coarse substrate for spawning (Edwards et al. 1983). Gravel and cobble substrate also provide habitat for their prey which includes mayflies and blackflies (Gerald 1966). Riffles in the downstream segment provided this habitat until mid to late summer when low flow caused a shift to pools. Gibbons and Gee (1972) found that dace will use quiet, shallow areas of pools, particularly in summer.

Fathead Minnow

Fathead minnows reach their greatest abundance in pools of intermittent streams that are free from predators and competitors (Pflieger 1975; Cross 1967; Scott and Crossman 1973). This minnow is very tolerant of hypoxic conditions (Pflieger 1975; Cross 1967) and high salinity (Scott and Crossman 1973; Cross 1967). Given these habitat associations, the downstream segment of Little Beaver Creek would be expected to harbor the greatest abundance of fathead minnows but this was not the case. Fathead minnows were most abundant in the midstream segment and reached their greatest relative abundance in riffles. This may have been due in part to sampling gear selectivity since fathead minnows are small and may avoid capture in deeper pool habitats.

In pools, relative abundance was positively associated with surface area, mean width, width-to-depth ratio, and bank cover dominated by trees, and negatively correlated with grass bank cover. In riffles they were positively correlated with surface area and negatively correlated with width-to-depth ratio and bank cover dominated by grasses. Possibly riffles and large, shallow pools supported fewer predators and competitors and allowed fathead minnows to flourish. Deeper pools often supported greater numbers of species.

Brassy Minnow

In Canada, the brassy minnow is most abundant in cool, acid-stained bog waters (Scott and Crossman 1973). In Kansas and Missouri they inhabit small, clear streams having bottoms overlain by organic sediments (Cross 1967; Pflieger 1975). Propst (1982) reported that brassy minnow occurred only in areas of stable flow in the South Platte River, Colorado. In Kansas, brassy minnows were extirpated from streams when subterranean flows were reduced (Cross and Moss 1987). This decline was attributed to high stream temperatures and reduced summer flow.

In Little Beaver Creek, brassy minnows reached their highest relative abundance in pools of the permanently flowing midstream segment. They were never collected in the turbid, highly variable downstream segment and were rare in riffles. In pools, they were positively associated with Secchi depth, fine sediment, and submerged vegetation, and negatively correlated with gravel. The presence of submerged vegetation probably served as both food and cover. Brassy minnows are herbivores and feed on organic sediment and plant material; they are rarely abundant in the presence of predators (Pflieger 1975; Scott and Crossman 1973; Brown 1971).

Sand Shiner

The sand shiner most often inhabits the mid-channel region of clear, permanently flowing prairie streams having sand and gravel bottoms (Pflieger 1975; Cross 1967), although they do occur in streams with variable flows (Summerfelt and Minkley 1969). They are less frequently found in intermittent streams (Brown 1971).

In Little Beaver Creek, sand shiners were most abundant in the highly variable downstream segment and were somewhat less abundant in the midstream segment. They were collected in riffles more often than in pools. In pools their relative abundance was positively correlated with mean depth and width to depth ratio. In riffles, sand shiners were positively correlated with surface area. These findings differ somewhat from other accounts (Pflieger 1975; Cross 1967). Sand shiners were the dominant species collected during a study of the Little Missouri River (Bich and Scalet 1977). Perhaps this fish is more common in turbid prairie streams than previously thought.

Black Bullhead

Ideal lotic habitat for black bullheads consists of an interspersion of pool and riffle areas (Stuber 1982). This species is usually associated with vegetative cover (Darnell and Meirerotto 1965; Stano and Hubert 1984) and is most abundant in silt-bottomed, low-velocity areas (Pflieger 1975).

In Little Beaver Creek, black bullheads were most abundant in pools of the midstream segment. A significant positive relationship existed between

Secchi depth, fine sediment, and submerged and emergent vegetative cover and the relative abundance of black bullheads in pools. They were negatively associated with mean velocity and gravel. In riffles, the relative abundance of this species was positively correlated with mean width, mean shoreline depth, coefficient of variation in velocity, undercut banks, submerged vegetation, and emergent vegetation.

Stonecat

Stonecats inhabit clear, permanently flowing streams and are found predominantly in rocky riffles (Trautman 1957; Scott and Crossman 1973; Cross 1967). In Little Beaver Creek they were found in both pools and riffles but were most abundant in riffles. Stonecats were most frequently collected in the midstream segment. In pools, their relative abundance was positively associated with emergent vegetation, and in riffles their relative abundance was positively correlated with cobble substrate. Trautman (1957) reported that stonecats were sometimes numerous in the presence of aquatic vegetation. Several authors (Trautman 1957; Pflieger 1975; Scott and Crossman 1973) report the importance of rocky cover to this species.

The permanent flow in the midstream segment is probably an important factor in the distribution of stonecat in Little Beaver Creek. Bich and Scalet (1977) listed the stonecat as an uncommon species in the Little Missouri River. They noted that stonecats were most common in shallow areas over gravel or rock bottoms. In Kansas, stonecats disappeared from streams when land use patterns led to a loss of continuous flow (Cross and Moss 1987). In southwestern Wisconsin streams, stonecat distribution was positively related to percent rocky substrate, and they were frequently found in the same habitats as smallmouth bass (Lyons et al. 1988).

Brook Stickleback

Optimal habitat for brook sticklebacks is cool, clear, spring-fed ponds and streams with abundant submerged aquatic vegetation (Propst 1982; Scott and Crossman 1973; Trautman 1957). Brook sticklebacks were characteristic of isolated spring-fed pools in the upstream segment of Little Beaver Creek. In these pools their relative abundance showed a significant positive correlation with Secchi depth, fine sediment, bank cover dominated by grass, and submerged vegetation. Their relative abundance was negatively correlated with mean depth, mean velocity, and gravel and cobble substrates. When found in riffles, they were negatively associated with mean width and width-to-depth ratio. Eddy and Underhill (1974) noted that brook sticklebacks used shallow habitats, and Trautman (1957) found them over "muck" substrates. In Wisconsin, brook stickleback occurrence was negatively related to mean stream width and depth, and rocky substrate (Lyons et al. 1988). The upstream segment of Little Beaver Creek met these habitat requirements.

Green Sunfish

Green sunfish occur in a wide array of habitats, ranging from small, intermittent streams to lakes (Brown 1971; Pflieger 1975), and are considered a very tolerant species (Karr 1981). Typically they are found in pools of streams, and optimal lotic habitat consists of at least 50% pool area (Stuber et al. 1982). Green sunfish abundance is associated with vegetative cover (Moyle and Nichols 1973) and moderate turbidities (Stuber et al. 1982).

In Little Beaver Creek the relative abundance of green sunfish was correlated with several of the above factors. They were collected most often in pools, but also occurred in the larger, deeper riffles. In pools they were positively associated with pool-to riffle-ratio (which would indicate their association with slow velocity pool habitat), secchi depth, and submerged vegetation. Their relative abundance in riffles was positively correlated with surface area, mean width, and mean depth. In Wisconsin streams there was a positive relationship between green sunfish abundance and average stream width (Lyons et al. 1988). The green sunfish's body morphology is well adapted to exploiting slow velocity areas where vegetative cover is present.

Iowa Darter

The Iowa darter is a northern species that prefers cool waters (Trautman 1957; Scott and Crossman 1973). Optimal habitat is clear, cool streams with abundant vegetation but they also occur in lentic habitats (Scott and Crossman 1973; Trautman 1957; Page 1983). Iowa darters are very intolerant of turbidity (Scott and Crossman 1973) and degraded habitats (Karr 1981). They disappeared from streams in Ohio and Kansas following land use changes that increased stream temperatures and turbidities (Cross and Moss 1987; Trautman 1957).

In Little Beaver Creek, Iowa darters were predominantly found in riffles and reached their greatest relative abundance in the midstream segment. In pools, their relative abundance was positively associated with secchi depth and submerged vegetation. In riffles, relative abundance was associated with submerged vegetation and coefficient of variation in velocity.

The midstream segment of Little Beaver Creek may act as a refugium for Iowa darters. This species is rare in the Little Missouri River, and was first reported by Bich and Scalet (1977). They collected small numbers after severe flooding, but none prior to the storm event. Several authors (Scott and Crossman 1973; Trautman 1957; Cross and Moss 1987) consider the Iowa darter to be a glacial relict.

SUMMARY

This study described the fishes and habitat of Little Beaver Creek, Montana. Information on small prairie streams in eastern Montana is important to insure that these habitats remain healthy. Some fish species present in Little Beaver Creek, such as the creek chub and sand shiner, have somewhat limited distributions in Montana (Elser et al. 1978). It is important that managers maintain populations of these native nongame fishes.

Further research is necessary on similar streams in Montana to determine if individual fish species and fish communities use similar habitats between streams. Identifying variables that may influence fish communities might allow agencies to manage on a community basis rather than individual species. In Wisconsin, managers used fish assemblage information to determine if an area had potential to support smallmouth bass (Lyons et al. 1988). Additional studies in Montana need to address the introduction of exotic predators, year-round habitat use, and long-term assemblage structure. The present study could not address these questions since data were limited to April-August of one year.

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APPENDIX

Table 12. Legal descriptions of sites sampled in Little Beaver Creek, Montana, April-August 1991.

Sample site	Legal description	Date sampled
1	T133N-R106W-Sec36	6-15
2	T133N-R106W-Sec36	7-14
3	T133N-R106W-Sec36	7-12
4	T133N-R106W-Sec35	7-25
5	T133N-R106W-Sec35	7-25
6	T133N-R106W-Sec34	4-21
7	T132N-R107W-Sec23	6-11
8	T132N-R107W-Sec23	5-30
9	T132N-R107W-Sec27	7-27
10	T5N-R61E-Sec10	7-3
11	T5N-R61E-Sec4	5-21
12	T5N-R61E-Sec8	4-15
13	T5N-R61E-Sec8	6-3
14	T5N-R61E-Sec7	4-7
15	T5N-R60E-Sec13	8-14
16	T5N-R60E-Sec13	6-28
17	T5N-R60E-Sec25	8-10
18	T5N-R60E-Sec25	5-23
19	T5N-R60E-Sec25	7-8
20	T5N-R60E-Sec34	6-19
21	T5N-R60E-Sec34	5-2
22	T4N-R60E-Sec2	5-10
23	T4N-R60E-Sec2	5-16
24	T4N-R60E-Sec16	7-1
25	T4N-R60E-Sec20	7-30
26	T4N-R60E-Sec20	8-12
27	T4N-R60E-Sec20	8-12
28	T4N-R60E-Sec30	4-22
29	T4N-R60E-Sec30	7-23
30	T4N-R60E-Sec30	7-23
31	T4N-R59E-Sec36	6-17
32	T4N-R59E-Sec36	6-17
33	T4N-R59E-Sec35	4-25
34	T3N-R59E-Sec2	4-6
35	T3N-R59E-Sec3	8-16
36	T3N-R59E-Sec3	8-16

Table 12. Continued.

Sample site	Legal description	Date sampled
37	T3N-R59E-Sec3	4-10
38	T3N-R59E-Sec8	8-18
39	T3N-R59E-Sec8	6-28
40	T3N-R59E-Sec8	4-18
41	T3N-R59E-Sec18	6-13
42	T3N-R59E-Sec19	7-10
43	T3N-R58E-Sec25	6-1
44	T3N-R58E-Sec25	6-23
45	T3N-R58E-Sec25	6-23
46	T3N-R58E-Sec25	6-6
47	T3N-R58E-Sec26	5-8
48	T3n-R58E-Sec34	6-25
49	T2N-R58E-Sec4	8-8
50	T2N-R58E-Sec4	8-8
51	T2N-R58E-Sec4	8-8
52	T2N-R58E-Sec8	6-5
53	T2N-R58E-Sec7	8-20
54	T2N-R58E-Sec7	8-20
55	T2N-R58E-Sec7	4-5
56	T2N-R58E-Sec7	6-21
57	T2N-R57E-Sec13	6-21
58	T2N-R57E-Sec13	4-5
59	T2N-R57E-Sec22	5-19

Table 13. Results of a Kruskal-Wallis analysis of pool habitat data in Little Beaver Creek MT., for variables that differed significantly ($P \leq 0.05$) among the three stream segments (1=upstream). Results of a multiple comparisons test between segments are also presented.

		Segment			
		1	2	3	
N		12	25	21	
Variable	Pair-wise	Mean rank			P
Length (m)		15.58	30.28	36.52	0.00
	1+2				0.01
	2+3				0.17
	3+1				0.00
Surface area (m^2)		15.58	28.76	38.33	0.00
	1+2				0.02
	2+3				0.04
	3+1				0.00
Mean width (m)		18.29	28.28	37.36	0.01
	1+2				0.07
	2+3				0.05
	3+1				0.00
Coefficient of variation in depth		41.83	23.78	29.26	0.01
	1+2				0.00
	2+3				0.23
	3+1				0.03
Mean shoreline depth (cm)		16.42	35.46	29.88	0.01
	1+2				0.00
	2+3				0.07
	3+1				0.08
Secchi depth (cm)		41.46	35.38	15.67	0.00
	1+2				0.20
	2+3				0.00
	3+1				0.00

Table 13. Continued.

		Segment			
		1	2	3	
N					
Variable	Pair-wise	Mean rank			P
Fine sediment (in%)		48.38	31.38	16.48	0.00
	1+2				0.01
	2+3				0.01
	3+1				0.00
Gravel (in%)		11.71	28.98	40.29	0.00
	1+2				0.00
	2+3				0.01
	3+1				0.00
Cobble (in%)		16.88	31.94	33.81	0.01
	1+2				0.01
	2+3				0.70
	3+1				0.00
Bedrock (in%)		26.00	26.00	35.67	0.00
	1+2				1.00
	2+3				0.00
	3+1				0.00
Bare ground along banks (in%)		19.33	26.70	38.64	0.00
	1+2				0.16
	2+3				0.01
	3+1				0.00
Grass cover along banks (in%)		41.38	32.44	19.21	0.00
	1+2				0.08
	2+3				0.00
	3+1				0.00

Table 14. Results of a Kruskal-Wallis analysis of riffle habitat data in Little Beaver Creek, MT., for variables that differed significantly ($P \leq 0.05$) among the three stream segments (1=upstream). Results of a multiple comparisons test between segments are also presented.

		Segment			
		1	2	3	
N		4	23	20	
Variable	Pair-wise	Mean rank			P
Length (m)		10.13	18.65	32.92	0.00
	1+2				0.17
	2+3				0.00
	3+1				0.00
Surface area (m^2)		4.00	20.09	32.50	0.00
	1+2				0.01
	2+3				0.00
	3+1				0.00
Mean width (m)		7.25	22.28	29.33	0.01
	1+2				0.03
	2+3				0.07
	3+1				0.00
Width-depth ratio		5.75	24.46	27.13	0.02
	1+2				0.01
	2+3				0.50
	3+1				0.00
Mean velocity (cm/sec)		11.00	21.24	29.77	0.02
	1+2				0.15
	2+3				0.03
	3+1				0.01
Coefficient of variation in velocity		37.25	27.57	17.25	0.01
	1+2				0.16
	2+3				0.01
	3+1				0.01

Table 14. Continued.

		Segment			
		1	2	3	
N		4	23	20	
Variable	Pair-wise	Mean rank			P
Fine sediment (in%)		42.50	29.72	13.73	0.00
	1+2				0.02
	2+3				0.00
	3+1				0.00
Gravel (in%)		9.38	20.85	30.55	0.01
	1+2				0.09
	2+3				0.01
	3+1				0.00
Bare ground along banks (in%)		11.00	21.17	29.85	0.01
	1+2				0.12
	2+3				0.02
	3+1				0.01
Grass cover along banks (in%)		37.50	27.57	17.20	0.00
	1+2				0.12
	2+3				0.01
	3+1				0.00