FISH COMMUNITIES AND HABITATS IN UPPER SEVENMILE CREEK, DAWSON COUNTY, MONTANA

Mark D. Barnes
Department of Natural Resources, Chinese Culture University
Hwa Kang, Yang Ming Shan, Taipei, Taiwan 11192, R.O.C.

Shad K. Mahlum
College of Forestry and Conservation, The University of Montana
Missoula, MT 59812

Huang Zhi-Jun
Department of Natural Resources, Chinese Culture University
Hwa Kang, Yang Ming Shan, Taipei, Taiwan 11192

May 2006

Montana Department of Fish, Wildlife & Parks
Miles City, Montana 59301

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INTRODUCTION

Until recently, little research has inquired into the distribution, habitat requirements, and ecological relationships of fishes in small prairie streams in eastern Montana. Clancey (1978) conducted a study of longitudinal distribution of fishes and aquatic habitats in Sarpy Creek, Big Horn and Treasure counties, to provide baseline information for the assessment of potential impacts of coal mining in the area. Barfoot (1993, 1999) studied longitudinal distribution of fishes and aquatic habitats in Little Beaver Creek, Carter and Fallon counties, Montana, and Bowman and Slope counties, North Dakota, in order to test the hypothesis that longitudinal zonation of fish communities in streams is related primarily changes in stream geomorphology.

Several wider surveys have sought to develop baseline data on fish communities and habitats in eastern Montana in order to assess the potential impacts of future energy development, particularly strip mining of coal and on-site power generation, on these communities. The results of these studies were collected and summarized by Elser et al. (1980).

Of these extensive surveys, two generated data on fish communities in smaller prairie streams. Elser et al. (1978) conducted an inventory of fishes and aquatic habitats in Beaver Creek, three of its tributaries, and seven north-flowing tributaries of the lower Yellowstone River. Morris et al. (1981) conducted a similar inventory of 45 tributaries of the lower Yellowstone River and assigned value ratings to each stream based on habitat and species value and recreational fishery potential.

More recently, the Montana Department of Fish, Wildlife, and Parks and the Montana Cooperative Fish and Wildlife Research Unit initiated extensive surveys of Montana prairie streams covering 305 sites in 240 drainages east of the Rocky Mountain region (Jones-Wuellner and Bramblett 2004, McDonald 2003). In addition, Bramblett et al. (2004) developed a multimetric index of biological integrity for Montana prairie streams using fish assemblages.

Given the potential impacts of current land uses, including livestock grazing and irrigated agriculture, and of future energy development, including coal bed methane production, on stream fish communities in eastern Montana, it would be desirable to learn more about the distribution and habitat requirements of stream fishes in the region. Moreover, from the perspective of basic ecological research, it would be interesting to further explore factors that influence longitudinal zonation of fish communities in small prairie streams.

From 1997 to 2000, Barnes (1997, 1999), Barnes and Westlind (2000), and Barnes and Silbernagle (2001) conducted a quantitative study of fish population densities, longitudinal distribution, and habitat variables in Burns Creek, a perennial groundwater driven stream in Dawson and Richland counties, Montana. Results of this study suggested that a few relatively "fixed" habitat factors as well as random contingent phenomena both strongly influenced density and longitudinal distribution of fishes in that system. The most important "fixed" factors were stream width-depth ratio, riparian vegetation height and overhang, and instream cover, whereas the most important contingent phenomena were storm flow flushing and changing patterns in number and location of beaver (*Castor canadensis*) dams.

Because it is perennial and groundwater driven, Burns Creek may not typify small prairie streams in eastern Montana, most of which are runoff driven and highly seasonal. Therefore, during the summers of 2001, 2002, and 2003, the sampling methodology developed for Burns Creek was applied to O'Fallon Creek, a largely runoff driven tributary of the lower Yellowstone River in Prairie, Custer, Fallon, and Carter counties, Montana (Barnes et al. 2002, Barnes and Siegle 2003, Barnes 2004). Results of the O'Fallon Creek studies suggested that contingent phenomena also strongly influenced density and longitudinal distribution of fishes in that system. In this intermittent system, fish moving upstream or downstream may be trapped, often at very high densities, in shrinking pools with low quality habitat as riffles dry up and interrupt the hydrologic continuity of the stream. Similarly, drying riffles may exclude fish from preferred habitats. The overall "flashiness" of the system probably prevented fish communities from stabilizing and efficiently partitioning available habitats.

During the summers of 2004 and 2005, we applied the sampling methodology developed for Burns Creek and O'Fallon Creek to Upper Sevenmile Creek, an intermittent tributary of the Yellowstone River near Glendive, Dawson County, Montana (Barnes et al. 2005). This report summarizes the results of that study during 2005.

STUDY AREA

Upper Sevenmile Creek originates in western Dawson County, Montana, and flows east 88.5 km to its confluence with the Yellowstone River at river kilometer 154.3 near Forest Park, a suburb of Glendive (Figure 1). Channel elevation ranges from 1056.7 m at the main stem headwaters to 626.4 m at the mouth, with a mean gradient of 4.8 m/km. Upper Sevenmile Creek is a third order stream (Strahler 1952) with three major intermittent tributaries: (1) Timber Fork, with main channel length of 20.5 km and confluence at kilometer 35.1 (on the main stem); (2) Spring Creek, with main channel length of 26.5 km and confluence at kilometer 43.4; and (3) Hay Creek, with main channel length of 16.9 km and confluence at kilometer 61.0. Total channel length (all stream orders) of the system is 193.1 km. The whole system drains 434.9 km^2 and has a drainage density of 0.4 km/ km^2 (Shi 2005, Appendix 1). There are three artificial impoundments on the main stem of Upper Sevenmile Creek: (1) a marshy pond of indeterminate surface area at Fisher Sand and Gravel at approximately kilometer 12; (2) Malkuch Reservoir (12.2 ha) just downstream of the Timber Fork confluence at approximately kilometer 30; and (3) Lindsay Reservoir (23.8 ha) in Lindsay at approximately kilometer 54 (NRIS 2006). The Main Siphon Canal diverts irrigation water from the Yellowstone River at Fallon, passes through a siphon under Upper Sevenmile Creek near the I-94 overpass, and empties into Hollecker Lake at Glendive.

The Upper Sevenmile Creek watershed occupies the edge of the glaciated Missouri Plateau, Short Grass Region, Great Plains Province. The climate is semiarid continental, with mean maximum temperature of 14.6°C and mean minimum temperature of -0.05°C (daily extremes range from -45.4°C on 16 February 1936 to 47.2°C on 20 July 1893), mean annual precipitation of 35.4 cm (mean annual range from 12.3 cm in 1934 to 66.1 cm in 1916), and mean annual snowfall of

73.4 cm (maximum of 117.3 cm in 1967), with mean annual snow depth of 2.5 cm (as measured at Glendive, Montana, 1893-2005) (WRCC 2006). Upland terrain consists of rolling hills that have been dissected into badlands by the stream system. Downstream of I-94, O'Fallon Creek cuts through alluvial terraces and emerges onto the floodplain of the Yellowstone River. Land use on the watershed is 51.7% grass rangeland, 40.4% crop/pasture, 7.1% mixed rangeland, and 0.8% other (primarily mine/quarry and other agriculture) (NRIS 2006).

Non-crop upland vegetation of the Upper Sevenmile Creek watershed consists predominantly of grasses (Poaceae) and sagebrush (*Artemesia* spp.) with scattered stands of ponderosa pine (*Pinus ponderosa*) and Rocky Mountain juniper (*Juniperus scopulorum*). Valley floors also support scattered stands of eastern cottonwood (*Populus deltoides*), green ash (*Fraxinus pennsylvanica*), Russian olive (*Eleagnus angustifolia*), and buffaloberry (*Shepherdia canadensis*). Riparian and littoral vegetation is dominated by sedges (*Carex* spp.), rushes (*Juncus* spp.), cattails (*Typha* spp.), snowberry (*Symphoricarpos albus*), milkweed (*Asclepias* spp.), and willow (*Salix* spp.).

The Upper Sevenmile Creek watershed is underlain by Cretaceous and Paleocene sedimentary rocks consisting primarily of highly erodible sandstones and shales. Exposed rocks in the watershed consist of non-marine sediments of the Fort Union Formation, which contains economically extractable deposits of coal and discharges significant amount of groundwater (Alt and Hynd 1986, Morris et al. 1981). The lower 20 km of main stem channel has eroded through thick deposits of glacial outwash that are commercially exploited by Fisher Sand and Gravel (Figure 3a). Except for a three-month period of record in 1921-1922, stream discharge has not been recorded in Upper Sevenmile Creek (USGS 2006).

MATERIALS AND METHODS

Fish population densities and habitat variables were determined at 20 sites in Upper Sevenmile Creek from 26 July to 8 August 2005 (Figures 1 and 2, Table 1). A site was defined as a contiguous unit of riffle, run, and pool habitats as defined by Armantrout (1998). Low flow during the sampling period made riffles and runs difficult to distinguish, so these two habitat types were merged and are referred to as riffles (Figure 3b). Only 40-m lengths of extremely long riffles and pools were included in fish and habitat sampling. Sites 4, 5, 6, 7, and 9 consisted of pools isolated by dry riffles, and Sites 16, 18, 19, and 20 lacked riffle-pool development, consisting of isolated spring pools (Figure 3c). Sites 7 and 17 were dry during the sampling period (Figure 3d).

On arrival at each site, a metric Hip Chain distance measurer (No. 06220, Legend, Inc., Reno, NV) was used to measure total site length and the lengths of component riffles and pools. Orange DayGlo ribbon (DayGlo Color Corp., Cleveland, OH) was tied to conspicuous littoral vegetation every five meters to serve as a baseline for installing block seines, determining flow velocity, and spacing habitat sampling transects. A water sample for total suspended solids (TSS) was then collected, dissolved oxygen, conductivity, and pH were measured, and initial water and air temperatures were recorded as described below. Next, block seines were installed for fish sampling. After fish sampling was completed, habitat variables were measured or estimated as described below.

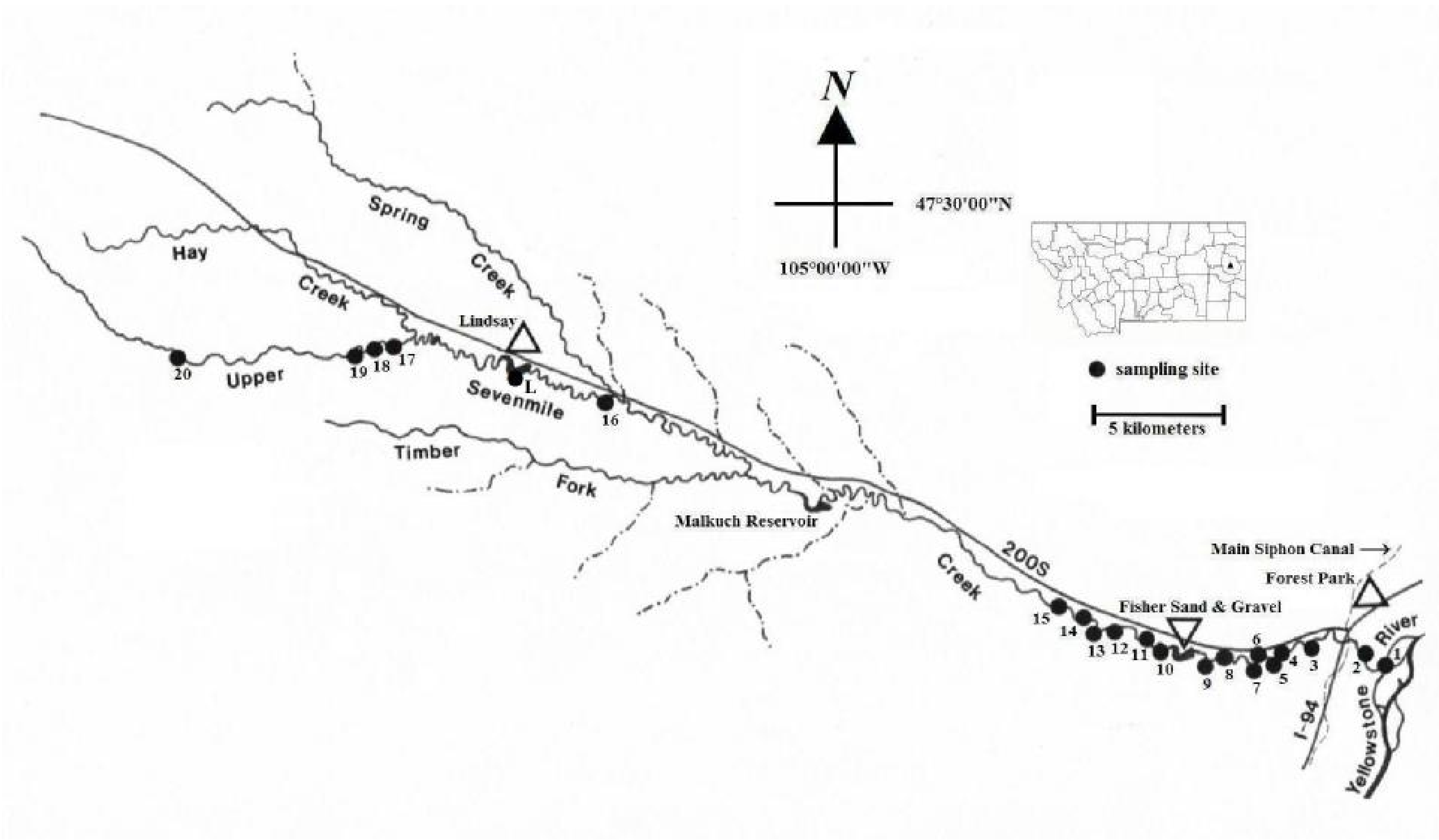

Figure 1. **Map of the Upper Sevenmile Creek system, Dawson County, Montana, showing sites sampled in 2005.**

Table 1. Locations of sampling sites in Upper Sevenmile Creek, Dawson County, Montana, 2005.

Site No.	County	Quadrangle*	Township	Range	Section	Latitude	Longitude	Stream Km	Elevation (m)	Date Sampled
1	Dawson	Forest Park	15N	55E	4	47°05'26"	104°45'16"	0.0	626.4	8/08/2005
2	Dawson	Forest Park	16N	55E	33	47°05'41"	104°45'41"	1.0	634.0	8/05/2005
3	Dawson	Forest Park	16N	55E	32	47°06'06"	104°47'28"	4.8	647.2	7/29/2005
4	Dawson	Forest Park	16N	54E	36	47°05'43"	104°48'56"	8.0	658.9	7/27/2005
5	Dawson	Forest Park	16N	54E	36	47°05'49"	104°49'07"	8.2	659.0	7/26/2005
6	Dawson	Forest Park	16N	54E	36	47°05'49"	104°49'21"	8.8	661.1	7/27/2005
7	Dawson	Forest Park	16N	54E	36	47°05'49"	104°49'31"	9.1	665.0	7/27/2005
8	Dawson	Forest Park	16N	54E	35	47°06'05"	104°50'46"	11.5	677.9	8/04/2005
9	Dawson	Forest Park	16N	54E	35	47°05'59"	104°50'59"	11.8	679.7	8/03/2005
10	Dawson	Forest Park	16N	54E	34	47°06'16"	104°51'33"	13.0	684.5	7/29/2005
11	Dawson	Forest Park	16N	54E	34	47°06'23"	104°51'50"	13.4	690.1	7/28/2005
12	Dawson	Pleasant View	16N	54E	28	47°06'40"	104°53'02"	15.7	701.4	7/28/2005
13	Dawson	Pleasant View	16N	54E	28	47°06'40"	104°53'22"	16.2	703.2	8/02/2005
14	Dawson	Pleasant View	16N	54E	28	47°06'51"	104°53'26"	16.6	705.4	8/02/2005
15	Dawson	Pleasant View	16N	54E	28	47°06'55"	104°53'55"	17.4	708.3	8/01/2005
16	Dawson	Woodrow	16N	52E	28	47°12'15"	105°06'28"	47.7	796.3	8/01/2005
L**	Dawson	Lindsay	17N	51E	24	47°13'06"	105°08'30"	54.9	817.5	8/3-4/2005
17	Dawson	Lindsay	17N	51E	16	47°13'42"	105°13'01"	64.2	837.7	7/26/2005
18	Dawson	Lindsay	17N	51E	16	47°13'37"	105°13'14"	65.0	842.0	7/26/2005
19	Dawson	Lindsay	17N	51E	16	47°13'37"	105°13'41"	66.1	846.3	7/26/2005
20	Dawson	Union School	17N	50E	13	47°13'44"	105°17'53"	75.7	890.0	7/26/2005

*U.S. Geological Survey, 7.5 Minute Series (Topographic).

**Lindsay Reservoir as measured at dam.

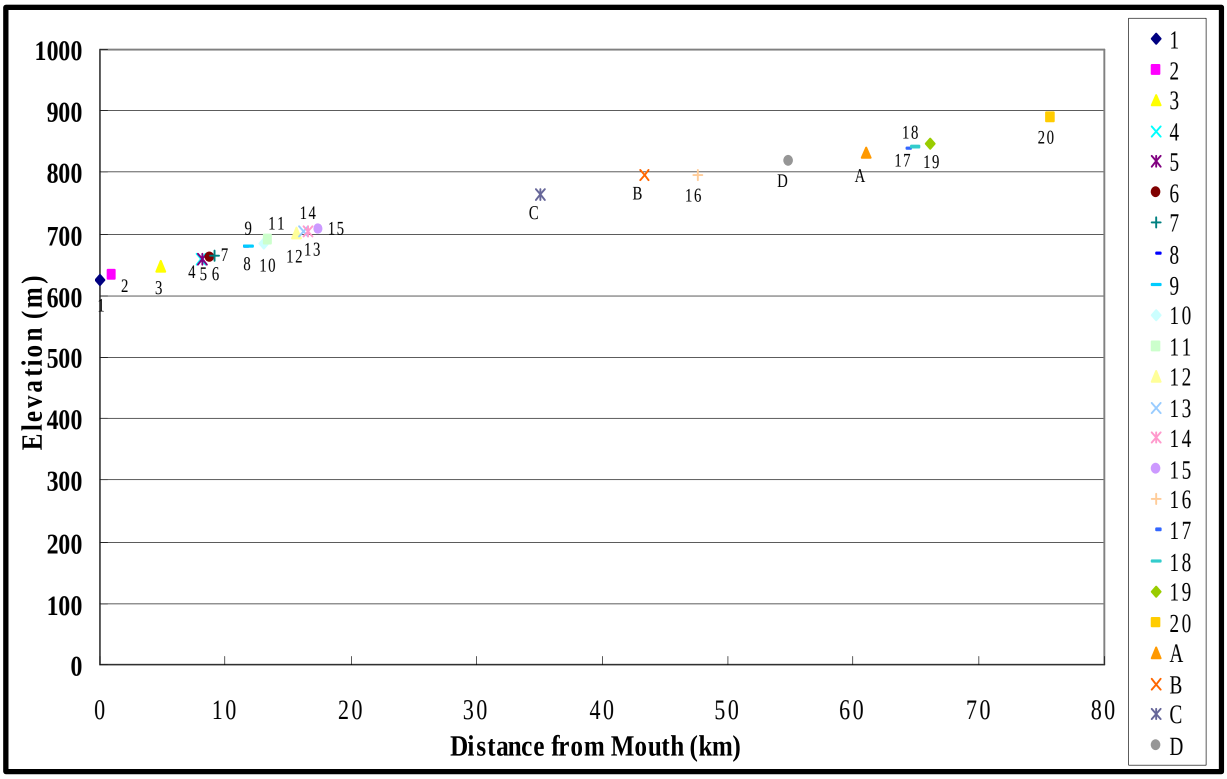

Figure 2. Sampling profile, Upper Sevenmile Creek, Dawson County, Montana, July-August 2005 (1-20: sampling sites; A , B, C: confluences of Hay Creek, Spring Creek, Timber Fork; D: Lindsay).

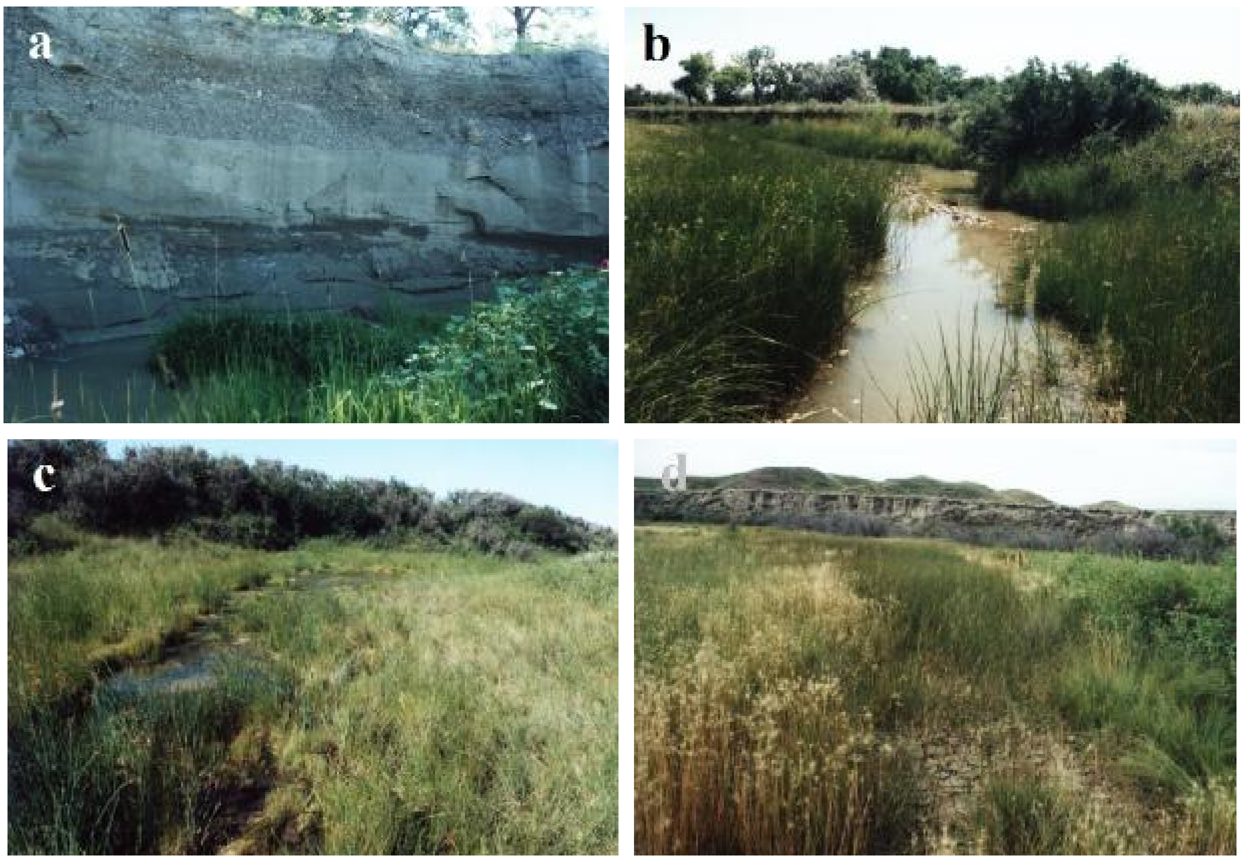

Figure 3. Upper Sevenmile Creek, Dawson County, Montana, July-August 2005: (a) glacial outwash (site 2); (b) typical riffle-pool unit (site 12); (c) spring pool (site 19); (d) dry channel (site 7).

Fish. Minnow traps (length = 38.1 cm; outer diameter = 17.8 cm; entry port diameter = 5.0 cm) were used to semi-quantitatively sample fish communities at sites 16-20. These upstream spring pool sites contained dense submerged aquatic vegetation and deep mucky sediment that made seining impractical. Ten traps were baited with commercial dry dog food and set equidistantly in each site overnight on the sampling dates indicated (Table 1). Fish, if any, were subsequently removed from the traps, identified with the aid of Holton and Johnson (1996) and Gould (1998), counted, and returned to the stream.

At sites 1-15 we used a simple DeLury (1947) type capture-removal approach to estimate fish community densities in adjacent riffle and pool habitats. Block seine installation and fish sampling were done before habitat evaluation in order to minimize movement of fish out of the disturbed site. Two 7.5-m x 1.2-m x 6.3-mm mesh straight seines, one 8.2-m x 1.5-m x 6.3-mm mesh bag seine, and one 12.1-m x 1.8-m x 6.3-m straight seine were used as block seines. Block seines were installed at the upstream and downstream ends of each site and between adjacent riffles and pools (i.e., three block seines per site).

In pools, we usually used a short, straight minnow seine (3.6-m x 1.5-m x 6.3-mm mesh) to make successive removal passes through each isolated section. In wider pools, a bag seine (8.2-m x 1.5-m x 6.3-mm mesh) was used to make removal passes. In all pools, two operators towed the working seine from the downstream end to the upstream end of each isolated section. The lead line was kept on the stream bottom, and the seine was landed at a convenient upstream location.

In riffles, towing the seine was ineffective due to extremely shallow depths and the tendency of riffle species to hide under cobbles. Therefore, one operator held the working seine stationary at the downstream end of the isolated section, across the whole wetted channel and with the lead line on the stream bottom. The second operator then "kicked down" the riffle or run from upstream to downstream, agitating the substrate with his feet. Finally, the seine was lifted quickly by both operators in midstream. We were unable to make fish population estimates on several riffles due to extremely low flow; riffles were either dry or reduced to shallow trickles that we were unable to seine. If small fish were present, they were sampled qualitatively with a dip net.

The number of removal passes (by towing or kicking) ranged from three to five and depended on how quickly we achieved a noticeable reduction in catch. After each removal pass, fish were removed from the seine, held in a bucket of aerated water, identified using Holton and Johnson (1996) and Gould (1998), counted, and returned to the stream downstream of the lowest block seine. To estimate the density of fish in isolated riffles and pools, we regressed catch per pass on sum of catches to yield a gross population estimate. This estimate was then divided by the measured surface area of the habitat unit (length x mean width) to yield number of individuals per 100 m^2.

On 3-4 August 2006 we assisted Roy Molstad and Brad Tribby of Montana Department of Fish, Wildlife, and Parks in sampling fish populations in Lindsay Reservoir. Two seine hauls were conducted on 3 August using a 45.7-m x 2.5-m beach seine with 6.3-mm mesh, and two experimental gill nets (38.1 m x 2.5 m with 12.7-mm, 25.4-mm, 38.1-mm. and 50.8-mm mesh panels) were set overnight on 3-4 August. All fish captured were counted and returned to the reservoir: lengths and weights were determined for a subsample of thirty fish of each species.

Habitat Variables. The following habitat variables were measured or estimated at each site after fish sampling was completed unless otherwise noted.

Location:
- latitude and longitude
- landmark photography and notation on USGS 7.5-min quadrangle map

Water Quality:
- water temperature and air temperature (initial and final)
- dissolved oxygen
- pH
- conductivity
- total suspended solids

Stream Flow:
- flow velocity
- discharge

Channel Morphology:
- total site length and lengths of component riffle, run, and pool habitats
- stream width (wetted width and channel width)
- stream depth

Streambed Composition:
- relative substrate composition
- sediment depth
- embeddedness

Riparian Conditions:
- adjacent land use (left and right banks)
- buffer width (left and right banks)
- bank erosion (left and right banks)
- bank height and angle at water's edge (left and right banks)
- entrenchment bank height and angle (left and right banks)
- channel canopy shading

Cover:
- vegetative height at water's edge (left and right banks)
- vegetative overhang (left and right banks)
- bank undercut (left and right banks)
- woody and other debris
- emergent and submerged aquatic vegetation

Habitat variables were measured or visually estimated using a transect approach based on Simonson et al. (1994). Using a Hip Chain distance measurer as described above, transects were spaced at five-meter intervals perpendicular to the direction of stream flow, beginning one meter above the lower end of each site and ending at the last five-meter interval below the upper end of each site. For riparian variables, transects were extended 10 meters inland from water's edge. Transects were numbered and worked from downstream to upstream, with the left bank and the right bank designated facing downstream. Variables were measured or visually estimated along a 0.3-m wide band centered on the transect line. A 20-m length of 0.25-in (31.8-mm) white nylon line and two metal stakes were used to mark transects while they were worked.

Location. Each site was marked on a standard USGS 7.5-min quadrangle map, and landmarks were noted. Latitude and longitude of each site were determined with a GPS Pioneer Satellite Navigator (Magellan Systems Corporation, San Dimas, CA); site coordinates were verified by direct measurement on 7.5-min quadrangle maps as described by NASA (2006). For reference and future identification, four color photographs were taken at each site: (1) upper end facing upstream; (2) upper end facing downstream; (3) lower end facing upstream; (4) lower end facing downstream.

Water Quality. Water and air temperatures were measured with a pocket field thermometer at the lower end of the pool at each site at the beginning and at the end of sampling. Dissolved oxygen concentration, water temperature, and conductivity were determined with a YSI Model 85 oxygen, conductivity, salinity, and temperature meter (Yellow Springs Instruments, Inc., Yellow Springs, OH) and pH with a pHep 3 pH meter (Hanna Instruments, Woonsocket, RI) at the lower end of the pool of each site before fish sampling. Whole water samples were collected in one-pint (0.48-liter) glass jars before fish sampling at the upper ends of sites 1, 2, 3, 4, 6, 8, 11, 12, 15, 16, 18, and 20. These samples were analyzed for total suspended solids (TSS) by Amatec Services, Inc. (Billings, MT) using SM 2540D (Clesceri et al. 1999).

Stream Flow. Flow velocity was measured at each site by timing three times the transit of a plastic fishing float over a measured distance of riffle or run (usually 10 m). An ExTech Digital Stopwatch/Clock (ExTech Instruments Corporation, Waltham, MA) was used for timing, and the results of three runs were averaged to yield mean flow velocity. Discharge was calculated by multiplying the cross-sectional area of the water column (using depth and width measurements as described below) by mean flow velocity (McMahon et al. 1996). Flow velocity through pools was usually too slow to measure using the buoyant object method, especially with wind interference, and low flow or no flow in riffles at many sites made estimating flow velocity and discharge impractical.

Channel Morphology. Total length of each site and lengths of component riffle and pool habitats were measured using a Hip Chain distance measurer as described above. Wetted width and channel width were measured to the nearest inch (2.54 cm) using a six-foot (1.83-m) SECO wooden grade stick graduated in inches (No. 43428, Forestry Suppliers, Inc., Jackson, MS) or a 300-ft (91.4-m) fiberglass measuring tape graduated in inches (Model KL-300-18, Keson Industries, Inc., Naperville, IL) along transects at each site. When different from wetted width, channel width was delimited by the presence of matted or silt-covered vegetation that had obviously been recently submerged or by the presence of white evaporite deposits. Water depths were measured by grade stick at five equidistant points along transects at each site, beginning at channel center and proceeding shoreward to within 10 cm of the left and right banks. This created six equal-width cells for calculation of mean depth and channel cross-sectional area.

Streambed Composition. Substrate material definitions of Simonson et al. (1994) were used. Substrate composition and embeddedness were estimated visually to the nearest five percent along transects at each site. Sediment depth was defined as the depth of yielding material (silt or muck) overlaying a non-yielding substrate (bedrock, boulders, rubble, cobbles, gravel, or sand). In the field, stream bottom material which could be penetrated with the grade stick was considered sediment, and its depth was measured by grade stick along transects at each site at the same points used for measuring water depth. Embeddedness was defined as percent of rubble, cobble, or gravel particles covered by sediment.

Riparian Conditions. The land use classification and riparian definitions of Simonson et al. (1994) were used. Riparian land use and canopy shading were estimated visually to the nearest five percent along transects at each site. Buffer width, bank erosion, bank slumping, bank height at water's edge, and entrenchment bank height were measured by grade stick, measuring tape, or 25-ft (7.62-m) extension pole (Model 90180, Crane Enterprises, Inc., Mound City, IL) to the nearest foot (0.30 m) at each site, except for bank height at water's edge, which was measured to the nearest inch (2.54 cm). Bank angle (with respect to horizontal) of both water's edge and entrenchment banks was measured with a modified industrial protractor (No. 3791N, Hempe Manufacturing Co., New Berlin, WI). Buffer width was defined as the width of undisturbed riparian vegetation extending from water's edge to a point 10 m inland. Bank erosion was defined as the width of bare riparian soil from water's edge to a point 10 m inland, and slumping was defined as the width of detached whole riparian soil masses, vegetated or not, from water's edge to a point 10 m inland. An entrenchment bank was defined as a bank higher than the water's edge bank and separated from water's edge by a distance of 10-30 m. Entrenchment banks obviously contained stream flow during peak flow periods and often coincided with water's edge banks on outside meander bends.

Cover. Cover was defined as any instream material, riparian material, or streambank configuration that could provide protection for most fishes of the size range (< 15 cm) found in Upper Sevenmile Creek. The amount of wetted channel bottom covered by woody debris, other debris, emergent vegetation (aquatic or flooded riparian), or submerged vegetation (aquatic or submerged riparian) was visually estimated to the nearest five percent along transects at each site. In order to qualify as cover, debris or vegetation had to occur in water at least 15 cm deep; Simonson et al. (1994) used a one-foot (30.5-cm) water depth criterion, but their approach emphasized cover requirements of larger game fishes. Riparian vegetative overhang, vegetative height at water's edge, and bank undercut were measured by grade stick to the nearest inch (2.54 cm) along transects at each site. In order to qualify as cover, vegetative overhang, vegetative height, and bank undercut had to be at least 15 cm**.**

Other. General observations on flora, fauna, hydrology, geology, and water quality and land use were noted at each site.

Table 2. Water quality, stream flow, and channel morphology variables for 20 sites in Upper Sevenmile Creek, Dawson County, Montana, 26 July to 8 August 2005.

Site*	Variable**								
	T (°C)	**DO (mg/l)**	**C (µS)**	**TSS (mg/l)**	**pH**	**Q (m^3/sec)**	**L (m)**	**W (m)**	**D (cm)**
1 R						0.5	25	4.3/>40	15.4
1 P	16.0	4.2	1500	323.3	9.2		>40	2.3/12.8	30.4
2 R						0.5	30	6.5/8.0	17.2
2 P	17.0	4.0	1700	378.7	9.4		>40	7.2/7.2	15.1
3 R						<0.1	3	0.7/3.1	1.2
3 P	20.0	5.2	1600	41.9	9.2		6	2.4/2.9	14.9
4 P	21.0	5.6	1700	144.4	9.0		>40	2.9/2.9	38.0
4 R†						0	16.2	0/0.9	0
5 P	20.0	6.0	1220		8.6	0	>40	2.3/2.3	18.3
6 P	21.0	5.1	1500	14.6	8.5	0	>40	1.7/4.9	7.6
7 P	no water						>40	0/9.9	0
8 P	28.0	4.3	2700	9.2	8.4		16.0	1.9/5.1	17.2
8 R						0.1	4.0	1.0/6.4	10.0
9 P	18.0	5.6	2600		9.2	0	41	8.5/10.3	17.3
10 R						0	11	3.6/4.6	5.6
10 P	21.5	4.4	2100		8.1		37	2.7/3.8	19.4
11 R						0.1	7	2.5/4.6	7.6
11 P	21.0	5.2	1150	6.3	9.4		>40	6.2/6.6	55.8
12 R						0.1	25	2.3/5.9	7.5
12 P	22.0	5.2	1400	9.6	8.2		>40	3.9/7.6	25.4
13 P	15.0	5.5	2100		8.0	0.1	>40	5.0/7.3	22.4
13 R							10	2.6/6.2	4.9
14 R						0.1	27	0.7/5.0	7.2
14 P	20.0	5.0	1750		9.0		>40	6.8/10.2	15.7
15 R						<0.1	2	2.5/5.1	6.1
15 P	23.0	3.2	1400	85.4	8.0		49	3.9/4.4	27.3
16 P	14.0	5.8	1500	8.5	9.4	0	>40	4.0/11.2	59.7
17 P	no water						>40	0/2.2	0
18 P	22.0	2.0	1550	19.6	8.1	0	>40	2.5/5.6	10.5
19 P	22.0	2.4	1150		7.6	0	>40	5.9/9.9	18.0
20 P	18.0	2.6	1200	19.2	7.5	0	>40	8.9/9.4	13.7

*Listed in order of downstream to upstream occurrence (R: riffle; P: pool).

** T: mean water temperature; DO: dissolved oxygen; C: conductivity; TSS: total suspended solids; Q: mean discharge; L: habitat unit length; W: mean wetted width/channel width; D: mean depth. A blank indicates that a variable was not determined at the site; a dash (-) indicates that the value was positive but that it was not measurable with the technique used.

†Riffle present during sampling period in 2004 but dewatered during sampling period in 2005.

Table 3. Mean values of riparian variables for 20 sites in Upper Sevenmile Creek, Dawson County, Montana, 26 July to 8 August 2005.

Site*	Variables**								
	LU	BW (m)	ER (m)	SL (m)	H-1 (m)	H-2 (m)	A-1 (◦)	A-2 (◦)	CS (%)
1 R	EX/EX	0/0	0/0	0/0	- / -	- / -	- / -	- / -	0
P	MI/MI	>10/>10	- / -	0/0	4.6/ -	1.1/0.8	55/15	60/65	0
2 R	EX/MI	>10/>10	0/0	0/0	0.6/ -	6.5/0.2	90/45	90/35	33.3
P	EX/MI	>10/>10	0/0	0/0	2.8/ -	1.8/0.9	50/25	90/80	100
3 R	ME/ME	>10/>10	0/0	0/0	- /0.5	0/1.5	80/60	- /25	0
P	ME/ME	>10/>10	0/0	0/0	0.5/0.5	0/1.6	76/90	- /25	0
4 P	PA/PA	0/0	0/ -	0/0	0.6/0.6	0/5.0	60/66	0/25	0
R†	PA/PA	0/0	0/ -	0/0	0.1/0.1	0/5.0	47/36	0/25	0
5 P	PA/PA	>10/>10	0/0	0/0	- / -	- /0.5	62/74	0/48	0
6 P	PA/PA	>10/>10	0/0	0/0	- / -	- / -	- / -	- / -	0
7 P	PA/PA	>10/>10	0/0	0/0	- / -	0.4/0.4	0/9.0	90/90	0
8 P	PA/PA	>10/>10	1.0/1.0	0/0	0.2/0.5	1.5/0.9	84/90	25/70	0
R	PA/PA	>10/>10	0.2/0.2	0/0	0.2/0.6	1.5/0	- / -	20/0	0
9 P	PA/PA	0/0	- /0	0/0	0.2/0.5	- / -	60/60	- / -	0
10 R	PA/PA	0/0	- / -	0/0	0.9/1.3	- / -	60/70	- / -	0
P	PA/PA	0/0	- / -	0/0	0.6/0.4	- / -	60/98	- / -	0
11 R	PA/PA	0/0	0/0	0/0	- / -	- / -	80/45	- / -	0
P	PA/PA	0/0	0/0	0/0	0.2/0.2	- / -	60/34	- / -	0
12 R	PA/PA	0/0	0/0	0/0	- / -	- / -	- / -	- / -	0
P	PA/PA	0/0	0/0	0/0	0.2/0.2	- / -	- / -	- /40	0
13 P	PA/PA	>10/>10	0/0	0/0	1.1/1.0	- / -	80/80	- / -	0
R	PA/PA	>10/>10	0/0	0/0	0.5/0.9	- / -	70/70	- / -	0
14 R	PA/PA	>10/>10	0/0	0/0	0.1/0.2	- / -	- /25	- / -	0
P	PA/PA	>10/>10	0/0	0/0	0.1/ -	- / -	45/85	- / -	0
15 R	MI/PA	>10/0	0/0	0/0	0.2/0.3	- / -	30/10	- / -	0
P	MI/PA	>10/0	0.1/0.1	0/0.1	0.5/0.5	0.7/ -	50/60	60/ -	0
16 P	ME/ME	- / -	2.5/2.5	0/0	1.7/2.0	3.0/2.8	60/50	50/30	0
17 P	PA/PA	>10/>10	0/0	0/0	- /0.2	- / -	20/20	- / -	0
18 P	PA/PA	>10/>10	0/0	0/0	0.3/0.7	1.8/1.8	50/20	20/20	0
19 P	PA/SH	>10/>10	0/0	0/0	- / -	0.5/2.5	- / -	88/70	0
20 P	PA/SH	0/0	0/0	0/0	0.4/0.2	0.8/0.7	86/56	87/69	0

* Listed in order of downstream to upstream occurrence (R: riffle; P: pool).

**Mean values per habitat unit [LU: land use (EX: exposed unvegetated rock or gravel bars; ME: meadow; MI: mixed meadow; OP: open marsh; PA: pasture; SH: shrubs); BW: buffer width; ER: erosion; SL: slumping; H-1: bank height at water's edge; H-2: entrenchment bank height; A-1: bank angle (with respect to horizontal) at water’s edge; A-2: entrenchment bank angle; CS: canopy shading]. A zero (0) indicates that the feature was absent. A dash (-) indicates that the value was positive but that it was negligible on the scale used; for entrenchment banks, a dash indicates that the bank was greater than 10 m from water’s edge. A slash (/) separates left bank/right bank values.

†Riffle present during sampling period in 2004 but dewatered during sampling period in 2005.

Table 4. Cover variables for 20 sites in Upper Sevenmile Creek, Dawson County, Montana, 26 July to 8 August 2005.

Site*	Variables**						
	VH (cm)	VO (cm)	BU (cm)	WD (%)	OD (%)	EV (%)	SV (%)
1 R	0/0	0/0	0/0	0	0	0	0
P	65/0	0/0	0/0	0	0	0	0
2 R	38.3/140.0	0/ -	0/0	0	0	10.0	0
P	112.5/117.5	- / -	0/0	20[††]	0	2.5	0
3 R	61.5/40.1	0/0	0/7.0	0	0	0	0
P	65.0/65.0	0/0	0/5.0	0	0	0	0
4 P	149.0/153.0	- / -	11.0/0	0	0	16.7	0
R[†]	53.4/34.8	- / -	0/0	0	0	21.0	0
5 P	93.0/92.0	- / -	0/0	0	0	-	0
6 P	89.0/90.0	- / -	0/0	0	0	100.0	0
7 P	75.0/82.0	- / -	0/0	0	0	90.0	0
8 P	56.8/57.0	- / -	0/0	0	0	24.0	0
R	82.0/60.0	- / -	0/0	0	0	5.0	0
9 P	23.6/98.6	0/ -	0/0	0	0	-	70.0
10 R	7.1/0	0/0	0/0	0	0	0	15.6
P	0/35.3	0/0	11.3/10.5	0	0	0	50.0
11 R	28.3/28.3	0/0	0/0	0	0	5.0	0
P	92.5/68.8	0/0	0/0	0	0	4.0	0
12 R	0/0	50.0/51.7	0/0	0	0	5.0	0
P	0/0	65.0/77.5	0/0	0	0	5.0	0
13 P	85.0/215.0	- / -	0/0	0	0	1.2	0
R	49.7/40.3	- / -	0/0	0	0	5.0	0
14 R	61.3/49.0	- / -	0/0	0	0	3.3	0
P	50.0/77.6	- / -	0/0	0	0	5.0	0
15 R	12.0/0	0/0	0/0	0	0	5.0	7.5
P	7.5/12.2	0/0	0/0	0	0	8.5	7.5
16 P	75.4/73.7	0/0	0/0	0	0	60.5	55.5
17 P	67.5/57.5	- / -	0/0	0	0	100	0
18 P	95.0/117.0	- / -	0/0	0	0	34.0	60.0
19 P	52.0/63.0	20.0/20.0	0/0	0	0	46.0	54.0
20 P	20.5/35.5	0/0	0/0	0	0	50.5	36.9

*Listed in order of downstream to upstream occurrence (R: riffle; P: pool).

**Mean values per habitat unit (VH: vegetative height; VO: vegetative overhang; BU: bank undercut; WD: woody debris; OD: other debris; EV: emergent vegetation; SV: submerged vegetation. A slash (/) separates left bank/right bank values. A zero (0) indicates that the feature was absent. A dash (-) indicates that the value was positive but that it was negligible on the scale used.

[†]Riffle present during sampling period in 2004 but dewatered during sampling period in 2005.

[††]beaver dam

Table 5. Streambed composition variables for 20 sites in Upper Sevenmile Creek, Dawson County, Montana, 26 July to 8 August 2005.

Site*	Substrate Composition**							Sedimentation**	
	BO (%)	RC (%)	GR (%)	SA (%)	SI (%)	CL (%)	MU (%)	SD (cm)	EM (%)
1 R		50.0	50.0					15.4	0
P					100.0			30.4	100.0
2 R		36.7	63.3		20.0			0.4	0
P					100.0			44.0	100.0
3 R		50.0	50.0					0	0
P		12.0	20.0		68.0			5.5	67.0
4 P					100.0			20.0	100.0
R†		10.0	75.0		15.0			1.5	20.0
5 P					100.0			19.7	100.0
6 P					100.0			100,5	100.0
7 P					100.0			12.6	100.0
8 P			32.0		68.0			7.1	66.0
R			20.0		80.0			8.7	80.0
9 P			10.0		90.0			27.1	90.0
10 R		10.0	76.7		13.3			0	3.3
P	1.3	11.3	22.5		64.0			10.0	77.5
11 R		20.0	73.3		6.7			0	0
P		7.5	52.5		40.0			9.4	73.8
12 P		10.0	10.0		80.0			10.5	75.4
13 P		3.75	3.75		92.5			39.3	95.0
R	86.7		13.3					0	3.3
14 R		40.0	60.0					0	30.0
P		11.0	16.0		73.0			17.1	82.0
15 R		45.0	45.0		10.0			0	10
P		12.5	38.8		48.8			8.4	48.8
16 P					100.0			>100	100.0
17 P					100.0			10.0	100.0
18 P					100.0			9.4	100.0
19 P					100.0			29.0	100.0
20 P					100.0			20.5	100.0

*Listed in order of downstream to upstream occurrence (R: riffle; P: pool).

**BO: boulders; RC: rubble/cobble; GR: gravel; SA: sand; SI: silt; MU: muck; SD: sediment depth; EM: embeddedness. A blank indicates that a component was not visually apparent.

†Riffle present during sampling period in 2004 but dewatered during sampling period in 2005.

Table 6. Species and numbers of fishes collected in the Upper Sevenmile Creek system, Dawson County, Montana.*

Species	Pre-1981	2004	2005	Total
goldeye (*Hiodon alosoides*)		2		2
common carp (*Cyprinus carpio*)	+	2	40	42
western silvery minnow/plains minnow (*Hybognathus argyritus/placitus*)	+	3		3
brassy minnow (*Hybognathus hankinsoni*)	+	42	13	55
emerald shiner (*Notropis atherinoides*)		7		7
sand shiner (*Notropis stramineus*)	+	124	68	192
fathead minnow (*Pimephales promelas*)	+	296	263	559
flathead chub (*Platygobio gracilis*)	+	28	38	66
longnose dace (*Rhinichthys cataractae*)	+	103	26	129
creek chub (*Semotilus atromaculatus*)	+	479	228	707
river carpsucker (*Carpiodes carpio*)	+	2		2
longnose sucker (*Catostomus catostomus*)	+		1	1
white sucker (*Catostomus commersoni*)	+	345	136	481
smallmouth buffalo (*Ictiobus bubalus*)	+	12	5	17
shorthead redhorse (*Moxostoma macrolepidotum*)	+			
black bullhead (*Ameiurus melas*)	+	1948	157	2105
yellow bullhead (*Ameiurus natalis*)		2		2
channel catfish (*Ictalurus punctatus*)	+	2	3	5
stonecat (*Noturus flavus*)	+	3	1	4
northern pike (*Esox lucius*)	+	2	14	6
burbot (*Lota lota*)		1		1
plains killifish (*Fundulus zebrinus*)	+	81	31	112
brook stickleback (*Culaea inconstans*)	+		1	1
green sunfish (*Lepomis cyanellus*)	+	15	19	34
pumpkinseed (*Lepomis gibbosus*)	+			
yellow perch (*Perca flavescens*)			37	37
TOTAL FISH		**3499**	**1081**	**4580**
TOTAL SPECIES	**21**	**21**	**18**	**27**

*Elser et al (1980), Morris et al. (1981); Barnes et al. (2005); present study (2006); common and scientific names according to Robins et al. (1991). A plus (+) means present but numerical data not available.

Table 7. Species and numbers of fishes collected in Upper Sevenmile Creek, Dawson County, Montana, 26 July to 8 August 2005.

		Number/Site*																					
Common Name	**Scientific Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**L**	**17**	**18**	**19**	**20**	**Σ**
goldeye	*Hiodon alosoides***																						
common carp	*Cyprinus carpio*	2								1								37					**40**
western silvery/ plains minnow	*Hybognathus argyritis/ Placitus***																						
brassy minnow	*Hybognathus hankinsoni*	1	1/1		8						2	1											**13**
emerald shiner	*Notropis atherinoides***																						
sand shiner	*Notropis stramineus*		2/2	63	3																		**68**
fathead minnow	*Pimephales promelas*	10		159	22						3	2	28	19	16	2		2					**263**
flathead chub	*Platygobio gracilis*	38/19																					**38**
longnose dace	*Rhinichthys cataractae*	18/18		2									4/4	1		1							**26**
creek chub	*Semotilus atromaculatus*	2	3/3	7			2		3		4	3	8	107	25	64							**228**
longnose sucker	*Catostomus catostomus*†	1																					**1**
white sucker	*Catostomus commersoni*	3		9							1		1	19	14	89							**136**
smallmouth buffalo	*Ictiobus bubalus*	5/1																					**5**
river carpsucker	*Carpiodes carpio***																						
stonecat	*Noturus flavus*		1																				**1**
black bullhead	*Ameiurus melas*		1		1					10								145					**157**
yellow bullhead	*Ameiurus natalis***																						
channel catfish	*Ictalurus punctatus*	3																					**3**
northern pike	*Esox lucius*																	14					**14**
burbot	*Lota lota***																						
plains killifish	*Fundulus zebrinus*			18					12					1									**31**
brook stickleback	*Culaea inconstans*†																			1			**1**
green sunfish	*Lepomis cyanellus*									3		3	3	10									**19**
yellow perch	*Perca flavescens*†																	37					**37**
TOTAL (Σ)		**83**	**8**	**258**	**34**	**0**	**2**	**0**	**15**	**14**	**10**	**9**	**44**	**157**	**55**	**156**	**0**	**235**	**0**	**1**	**0**	**0**	**1081**

*Number after slash (/) indicates number (out of total) captured in riffle.

**Captured in 2004 but not in 2005

†Captured in 2005 but not in 2004.

RESULTS AND DISCUSSION

Stream Flow. Upstream of Lindsay, Upper Sevenmile Creek (sites 17-20) consisted of a few densely vegetated spring pools isolated by long sections of dry channel (Figure 3c). This reach of the creek exhibited no active flow during the sampling period and is probably not very responsive to storm events and surface runoff because the associated drainage area is relatively small. The dry channel sections were occupied by terrestrial vegetation, indicating that duration of flow in these channels is brief. Downstream of site 17, where flow was evident, it was barely measurable using the buoyant object method, usually less than 0.1 m^3/s (Table 2). Discharge was highest near the mouth (Sites 1 and 2) due to overflow from the Main Siphon Canal. Where zero discharge was recorded, riffles were either dry or reduced to trickles. Pools at all sites downstream of Lindsay, except site 7, retained some water (Figure 3b).

Water Quality. Water quality was relatively uniform longitudinally during the sampling period. Water temperature averaged 13.6°C (range 8.0°C to 25.0°C) and generally responded daily to air temperature, which averaged 23.4°C (range 11.0°C to 35.0°C) (Table 2).

Excluding sites 18, 19, and 20, dissolved oxygen (DO) averaged 4.5 mg/l (range from 3.6 mg/l to 6.0 mg/l) and was adequate to support aerobic aquatic life (Table 2). Low DO concentrations (less than 3.0 mg/l) occurred in isolated spring at sites 18, 19, and 20. We sampled each of these pools shortly after sunrise, and the lower DO concentrations probably reflect respiratory consumption of DO by dense aquatic vegetation during the night with no compensating photosynthetic DO input. Average pH was 7.8 with little variation longitudinally (Table 2). Slightly lower pH values at sites 19 and 20 probably reflect higher CO_2 concentrations in the early morning.

Concentrations of total suspended solids (TSS) varied longitudinally, averaging 88.39 mg/l (range 6.3 mg/l to 378.7 mg/l); higher concentrations probably reflected local disturbances such as bank erosion, beaver activity, cattle use, or (at sites 1 and 2) sediment in return flow from the main Siphon Canal rather than downstream accumulation of TSS (Table 2). Upper Sevenmile Creek probably receives a relatively high natural inorganic sediment load due to weathering of the sparsely vegetated badlands and the unconsolidated glacial outwash that comprise a large part of its watershed.

Conductivity was relatively high, averaging 1491.0 μS (range 1150 μS to 2700 μS) (Table 2). High conductivity reflects high concentrations of total dissolved solids (TDS), which are derived from runoff inputs of a sparsely vegetated watershed in a highly evaporative climate.

On 20 September 2002, approximately 42,000 gal (159,000 liters) of unleaded gasoline were released into Upper Sevenmile Creek from a ruptured 8-in (20.3-cm) pipeline operated by the Cenex Pipeline (Terminal) near Glendive. The gasoline traveled about 4.8 km down the creek (affecting sites 1 and 2 of the present study) to a side channel of the Yellowstone River, where it was contained and about 21,000 gal (79,000 liters) recovered. The spill appeared to have killed over 2,000 fish in the affected areas (USEPA 2002, Brinkley 2002).

Channel Morphology. Downstream of site 17, Upper Sevenmile Creek exhibited well defined riffle-pool development, although riffles were often dry under prevailing low flow conditions. Pools ranged from 6 m to greater than 400 m in length, averaging 3.9 m in wetted width and 21.3 cm in depth (including dry pools). Riffles ranged from 2 m to 30 m in length, averaging 2.4 m in wetted width and 7.5 cm in depth (including dry riffles). Because of low flow conditions, channel width was usually more than wetted width (Table 2).

Riparian Conditions. Adjacent land use at most sites on O'Fallon Creek was pasture. Where entrenchment banks were relatively high and steep, undisturbed meadow, mixed meadow, and shrubs were usually evident, probably because cattle avoided these habitats. Riparian erosion and slumping were minimal and were largely restricted to high angle faces of entrenchment banks. At many sites we evaluated buffer width (width of undisturbed riparian vegetation) as 0 because grazing had modified natural riparian vegetation cover. However, in most locations this indicated a reduction in vegetation height rather than the presence of bare soil or erosion. Banks at water's edge were low, usually less than 0.5 m, and approximately vertical, while most of the channel was entrenched between secondary banks with an average height of 1.8 m and an average angle of 53° with respect to horizontal. We did not measure entrenchment banks farther than 10 m from water’s edge. Although eastern cottonwoods were frequently adjacent to the channel, they were never close enough to provide canopy shading during daylight hours. Significant "canopy" shading at site 2 was provided before noon by a vertical cliff six meters in height immediately adjacent to the channel (Table 3).

Cover. Vegetative height at water's edge averaged 89.3 cm, (range 0.0 cm to 149.0 cm) (Figure 10). Vegetative overhang was absent or negligible at many sites; where present, it averaged 47.3 cm (Table 4). Instream cover, including bank undercut, woody debris, other debris, emergent vegetation, and submerged vegetation, was generally scarce. Most pools had some submerged aquatic vegetation, mostly *Ceratophyllum* sp. and *Chara* sp., but it was difficult to visually assess its extent due to high turbidity. Significant amounts of emergent and submerged vegetation were associated with spring pools at sites 16, 18, 19, and 20 and with deep scour pools at sites 9 and 10 (Table 4). Attached filamentous algae covered the streambed material in most riffles and shallow pools. The most important cover in Upper Sevenmile Creek may consist of "virtual" cover provided by tall riparian vegetation.

Streambed Composition. The predominant substrate materials in O'Fallon Creek were rubble/cobble, gravel, and silt; silt embeddedness was significant at all pool sites (Table 5). Riffles generally exhibited higher proportions of rubble and cobble than did pools. Boulders were common only at site 13, where the creek has cut through a more resistant geological formation, leaving large slabs of sandstone in the channel and riparian areas. Most pools were deeply sedimented, especially at sites 4-9, where seining was extremely laborious and inefficient. Extensive sedimentation in Upper Sevenmile Creek appears to be associated with weathering of the unconsolidated glacial outwash that covers most of the floodplain downstream of Lindsay.

Fish Communities. Since 1975, 27 species of fishes have been collected in Upper Sevenmile Creek, to which we have added four new records: goldeye (*Hiodon alosoides*), emerald shiner (*Notropis atherinoides*), yellow bullhead (*Ameiurus natalis*), and burbot (*Lota lota*). These were all collected at sites 1 and 2 adjacent to the Yellowstone River (Table 6).

In 2004 we failed to collect several species previously collected in Upper Sevenmile Creek, including longnose sucker (*Catostomus catostomus*), shorthead redhorse (*Moxostoma macrolepidotum*), brook stickleback (*Culaea inconstans*), and pumpkinseed (*Lepomis gibbosus*), although we collected one longnose sucker and one brook stickleback in 2005 (Table 6). Longnose sucker and shorthead redhorse are riverine species associated with the Yellowstone River and its larger tributaries; they may appear in small numbers in the lower reaches of Upper Sevenmile Creek, especially during their spring spawning seasons. Deep, densely vegetated spring pools provide ample habitat for brook stickleback in Upper Sevenmile Creek, but the abundance of this species may be limited by nocturnal anoxia when these pools become isolated and lack through flow during the summer. Records of pumpkinseed in many lower Yellowstone River tributaries may represent escapes from populations stocked in ponds and reservoirs in the watershed. However, we think that many of these records represent misidentification of green sunfish (*Lepomis cyanellus*), which bear orange and red spots superficially resembling pumpkinseeds during the first few years of life.

The extent of riffle habitat in Upper Sevenmile Creek during the sampling period was minimal, and the dominant species found in these habitats was longnose dace (*Rhinichthys cataractae*). Flathead chub (*Platygobio gracilis*) was also encountered in riffles at site 1 adjacent to the Yellowstone River (Table 7). The dewatering of riffles during the summer is probably a significant factor limiting abundance and diversity of riffle fauna in Upper Sevenmile Creek.

The most abundant and widely distributed pool species (excluding Lindsay reservoir) were brassy minnow (*Hybognathus hankinsoni*), sand shiner (*Notropis stramineus*), fathead minnow (*Pimephales promelas*), creek chub (*Semotilus atromaculatus*), white sucker (*Catostomus commersoni*), plains killifish (*Fundulus zebrinus*), and green sunfish (*Lepomis cyanellus*) (Table 7). A school of nearly 2,000 young-of-year black bullheads (*Ameiurus melas*) was collected at site 9 in 2004, artificially inflating the apparent abundance of this species in Upper Sevenmile Creek. Such schools were commonly observed in pools during sampling in 2005, but we did not manage to capture one.

As in 2004, we were again unable to estimate densities of fish communities in riffles and pools due to low flows, poor capture rates, or failure to achieve catch reduction (especially at deeply sedimented sites such as sites 4-9) (Table 9). The greatest numbers of fish were collected at sites 3, 13, and 15, consisting mostly of creek chubs, fathead minnows, and young-of-year white suckers. There was no clear relationship between numbers of fish captured at each site and the habitat variables we measured, as was observed in Burns Creek and O'Fallon Creek (Barnes 1999, Barnes 2004, Barnes and Siegle 2003, Barnes and Silbernagel 2001, Barnes and Westlind 2000, Barnes et al. 2002, Barnes et al. 2005).

Beach seine and gill net sampling at Lindsay Reservoir yielded 37 common carp (*Cyprinus carpio*), two fathead minnows, 145 black bullheads (mostly young-of-year), 14 northern pike (*Esox lucius*), and 37 yellow perch (*Perca flavescens*). Northern pike averaged 718.8 mm in length and 2832.6 g in weight (range 520-915 mm and 780-7030 g); exclusive of young-of-year, yellow perch averaged 165 mm in length and 19.3 g in weight (range 95-142 mm and 10-30 g).

In Burns Creek, contingent phenomena such as storm flow flushing and distribution of beaver dams in time and space were thought to influence fish community density and diversity as much as relatively "fixed" habitat factors (Barnes and Silbernagel 2001). However, Burns Creek exhibited perennial flow, so fish communities could at least partially stabilize.

In O'Fallon Creek, a similar contingent phenomenon may be the timing and extent of riffle dewatering in the summer. Fish moving upstream or downstream may be trapped, often at very high densities, in shrinking pools with low quality habitat as riffles dry up and interrupt the hydrologic continuity of the stream. Similarly, drying riffles may exclude fish from preferred habitats. The overall "flashiness" of the stream system probably prevents fish communities from stabilizing and efficiently partitioning available habitats (Barnes 2004, Barnes et al. 2002, Barnes and Siegle 2003). Similar factors probably operate in Upper Sevenmile Creek.

Upper Sevenmile Creek is clearly a highly variable system in which extreme high and low flow, hydrologic discontinuity, high sedimentation rates, and high TDS present survival challenges to the resident fish communities. These factors may override other macrohabitat variables, such as substrate composition and instream cover, in controlling density and distribution of these communities. An understanding of the relationships among fish communities, habitat variables, and contingent phenomena in small intermittent prairie streams such as Upper Sevenmile Creek would require several years of study under a full range of natural environmental variation.

General Work Plan for 2006. We would like to continue our study of fish communities and macrohabitat variables in Upper Sevenmile Creek during the summer of 2006 using the same basic approach and trying to sample at least 20 sites. A disadvantage of trying to understand a system like Upper Sevenmile Creek is its longitudinal and seasonal variability. Are the parameters measured at 20 sampling sites during the summer representative of processes in the whole system inter-seasonally and inter-annually? Although the Upper Sevenmile Creek system is smaller that the O’Fallon Creek system, the scale of longitudinal and seasonal habitat variability is still a major challenge to designing and implementing a effective sampling protocol.

Acknowledgments. We would like to thank the Montana Department of Fish, Wildlife, and Parks, particularly Brad Schmitz and Vic Riggs in Miles City, for logistical support of this research. Landowners in the Upper Sevenmile Creek area graciously provided access privileges and information without which this study would not have been possible.

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APPENDIX

Hydrographic Parameters of Upper Sevenmile Creek Watershed, Dawson County, Montana

Shi Jia-Yi (施佳宜)
Department of Natural Resources, Chinese Culture University, Taipei, Taiwan 111, R.O.C.

June 2005

前言：

本計畫所研究的 Upper Sevenmile Creek, Dawson County, Montana, 地區缺乏正確且絕對相關之水文資料，例如：總河道長度、各支流河道長度、流域面積、河網密度、各河口及採樣場的海拔高度及其相距河口之距離，上述之水文資料無法藉由查詢網路的方式及相關類似水文資料之報告來輔助本計畫的進行，於是採用傳統的計算方式，來呈現本研究計畫所欠缺的水文資料。

方法：

在此運用的相關工具有曲線儀、大範圍含本研究地區之 U.S. Bureau of Land Management Surface Management Status 1:100,000 地圖 (Glendive, Montana, 2001)、細部主支流 U.S. Geological Survey 1:24,000 (7.5-min) 等高線地形地圖 (Forest Park 1972, Pleasant View 1967, Poverty Flat West 1972, Woodrow 1983, Lindsay 1983, Union School 1983)。

計算方法利用 Scale 1:100,000 的地圖估算出流域面積有 434.9 平方公里並且使用曲線儀將蜿蜒河道以數據方式呈現出總河道長度爲 193.1 公里，分別 Upper Sevenmile Creek 主要河道長度爲 88.5 公里，各支流河道長度及其相距河口之距離如下 Hay Creek 爲 16.9 公里、相距河口之距離爲 61.0 公里， Spring Creek 爲 26.5 公里、 相距河口之距離爲 43.4 公里，Timber Creek 爲 20.5 公里、相距河口之距離爲 35.1 公里。有了以上總河道長度及流域面積的資料可以計算出河網密度爲 0.4 km/km^2。

海拔高度所採用的計算方法以 Scale 1:24000 地圖上之等高線間的距離來推估坡度如下，平均坡降爲 4.8 m/km，坡降區間在 1056.7 公尺 ～ 626.4 公尺，在本研究區域中有一小村落 Lindsay 海拔高度爲 817.5 公尺、相距河口之距離爲 54.9 公里而且研究區域採樣區共有 20 個採樣場，每一個採樣場的海拔高度亦是以上述計算方式計算之。

表一：Distance from Mouth

採樣場	河口到各點間的距離（km）
1	0.0
2	1.0
3	4.8
4	8.0
5	8.2

6	8.8
7	9.1
8	11.5
9	11.8
10	13.0
11	13.4
12	15.7
13	16.2
14	16.6
15	17.4
16	47.7
17	64.2
18	65.0
19	66.1
20	75.7

表二：Sampling Site Elevations.

Site	Elevation (m)
1	626.4
2	634.0
3	647.2
4	658.9
5	659.0
6	661.1
7	665.0
8	677.9
9	679.7
10	684.5
11	690.1
12	701.4
13	703.2
14	705.4
15	708.3
16	796.3
17	837.7
18	842.0
19	846.3
20	890.0