# FISH ASSEMBLAGES AND HABITATS IN GLENDIVE CREEK, DAWSON COUNTY, MONTANA

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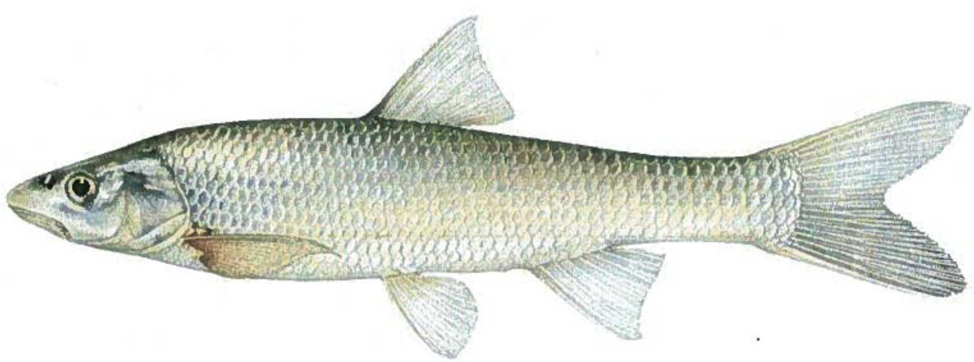

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**A SURVEY OF FISH ASSEMBLAGES AND HABITATS IN GLENDIVE CREEK, DAWSON COUNTY, MONTANA**

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**Cover Illustration:** flathead chub (*Platygobio gracilis*), a dominant species in Glendive Creek, Montana (with permission, by Joseph Tomelleri, www.americanfishes.com).

## ABSTRACT

Until recently, little research has inquired into distribution and habitat relationships of fishes in small prairie streams in Montana. These streams may support diverse native fish communities and species of special concern, but they are threatened by current land uses such as grazing, irrigation water requirements, and coal-bed methane production. Baseline surveys of these streams are essential to (1) identify fish species present, (2) to quantify habitat factors that affect community density, diversity, and distribution, and (3) to predict effects of land use changes. We have analyzed fish communities and habitats in four prairie streams in Montana since 1997. Our results indicate that fish communities in small prairie streams are affected by relatively fixed habitat factors such as stream width-depth ratio, extent of riparian vegetation, and instream cover, as well as contingent events such as storm flow flushing, beaver (*Castor canadensis*) activity, and summer dewatering. This report summarizes results of the study in Glendive Creek, Dawson County, during 2010.



**Keywords:** stream fish communities, prairie streams, habitat relationships, Montana


**美國蒙大拿州道森縣格倫代夫溪魚類群落和棲息地之初步調查**


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## 摘要

只有小量的研究探討了美國蒙大拿州草原小溪流魚類的分佈與棲息地的關係。這些溪流可能擁有多種多樣原生種魚類群落以及特別關注的物種，但是這些群落與物種正受目前土地利用的威脅，例如放牧、 灌溉需要水、 與開採煤層甲烷氣。這些溪流之基線調查對以下項目是必需的：(1) 辨識所有魚類種，(2) 量化影響魚類群落密度、 多樣性、 與分佈之棲息地因素，(3) 預測土地利用變遷的影響。自從 1997 開始，我已經針對四條蒙大拿州草原小溪流魚類群落與棲息地的分析。我分析的成果指出這些草原小溪流魚類群落被兩類因素影響：(1) 相對不變的棲息地因素，例如溪流寬深比例、 濱溪植被程度、 與溪內遮蔽，與 (2) 偶發性的現象，例如暴雨流沖刷、 美洲河狸 (*Castor canadensis*) 的活動、 與夏天之缺水。這份報告概述了本研究在蒙大拿州道森縣格倫代夫溪 2010 年調查的結果。



**關鍵詞：**溪流魚類群落，草原小溪流，棲息地關係，蒙大拿州

## 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 to 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). Bramblett et al. (2004) also 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 several persistent habitat factors as well as random contingent phenomena both strongly influenced density and longitudinal distribution of fishes in that system. The most important persistent 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 may more strongly influence density and longitudinal distribution of fishes in that system than more persistent habitat factors such as stream width-depth ratio and riparian vegetation. In this intermittent system, fish moving upstream or downstream may be trapped, often in high densities, in shrinking pools with low quality habitat (low dissolved oxygen concentrations, high total suspended solids concentrations, relatively shallow depths, and lack of riparian or instream vegetation) 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, 2005, and 2006, 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, Barnes et al. 2006, Barnes et al. 2007), and during the summers of 2007, 2008, and 2009 to Thirteen Mile Creek, an intermittent tributary of the Yellowstone River near Intake, Dawson County, Montana (Barnes et al. 2008, Barnes et al. 2009, Barnes et al. 2010). This report summarizes results of fish assemblage studies in Glendive Creek during 2010.

## STUDY AREA

Glendive Creek originates in eastern Wibaux County, Montana, in the badlands east of State Route 7 and flows northwest 81 km through Dawson County to its confluence with the Yellowstone River at river kilometer 138 near Glendive (Figures 1, 2a). Channel elevation ranges from 855 m at the main stem headwaters to 622 m at the mouth, with a mean gradient of 2.9 m/km. Glendive Creek (Figure 2d) is a third order stream (Strahler 1952) with two major intermittent tributaries: (1) Griffith Creek and (2) Hodges Creek. Total channel length (all stream orders) of the system is 183.2 km. The whole system drains 414.8 km$^2$ and has a drainage density of 0.4 km/km$^2$ (MFIS 2011, Morris et al. 1981, NRIS 2011).

The Glendive 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 11.5°C and mean minimum temperature of -10.4°C (daily extremes from -45.6°C on 16 February 1936 to 47.2°C on 20 July 1893), mean annual precipitation of 35.4 cm (annual range from 12.3 cm in 1934 to 66.2 cm in 1916), and mean annual snowfall of 72.4 cm (maximum of 177.3 cm in 1964), with mean annual snow depth of 2.5 cm (as measured at Glendive, Montana, 1893-2010) (WRCC 2011). Upland terrain consists of rolling hills that have been dissected into badlands by the stream system. Downstream of Interstate Route 94, Glendive Creek cuts through alluvial terraces and emerges onto the floodplain of the Yellowstone River. Land use on the watershed is approximately 50% grass rangeland, 40% crop/pasture, 9% mixed rangeland, and 1% other (primarily mine/quarry and other agriculture) (NRIS 2011).

Non-crop upland vegetation of the Glendive 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 Glendive 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). Stream discharge has not been systematically recorded in Glendive Creek (USGS 2011).

## MATERIALS AND METHODS

Fish populations and habitats were evaluated at 15 sites in the Glendive Creek system and adjacent Yellowstone River from 23 July to 6 August 2010 (Figure 1, Table 1). A site was defined as a contiguous unit of riffle-pool or riffle-glide habitat as defined by Armantrout (1998). Only 40-m lengths of very long riffles, glides, and pools were included in fish and habitat sampling. Three sites lacked riffle habitat: site Y, the Yellowstone River, a long, continuous pool at the confluence of Glendive Creek; site 13, an isolated pool in an intermittent upstream section of Glendive Creek near the Wibaux County line; and site 14, a low gradient, apparently spring-fed section of Griffith Creek, a second-order tributary of Glendive Creek (Figure 2d). Three sites lacked pool habitat, consisting of long continuous riffles or glides with high flow velocity but too deep to be classified as riffles: site 1, a long glide at the approach of Glendive Creek to its confluence with the Yellowstone River (Figure 2a); site 2, a long riffle-glide unit between the Dawson County Fairgrounds and the Glendive Sewage Treatment Plant; and site 10, a long glide-sandbar unit adjacent to the Burlington Northern Railroad that follows the Glendive Creek valley across Dawson County. All other sites sampled consisted of riffle-pool units.

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, glides, 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. Block seines were then installed for fish sampling. After fish sampling was completed, habitat variables were assessed as described below.

**Fish.** 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 or riffles and glides (i.e., three block seines per site at riffle-pool or riffle-glide sites and two block seines per site at sites consisting of only riffles, glides, or pools).

In pools we 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 landed at a convenient upstream location.

In riffles and glides towing the seine was ineffective due to shallow depths and the tendency of riffle-glides species to hide under cobbles and boulders. 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, while the second operator "kicked down" the riffle from upstream to downstream, agitating the substrate with his feet. The seine was then 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 (2003) 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 $m^2$.

**Habitat Variables.** The following habitat variables were evaluated 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 (2009). 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.

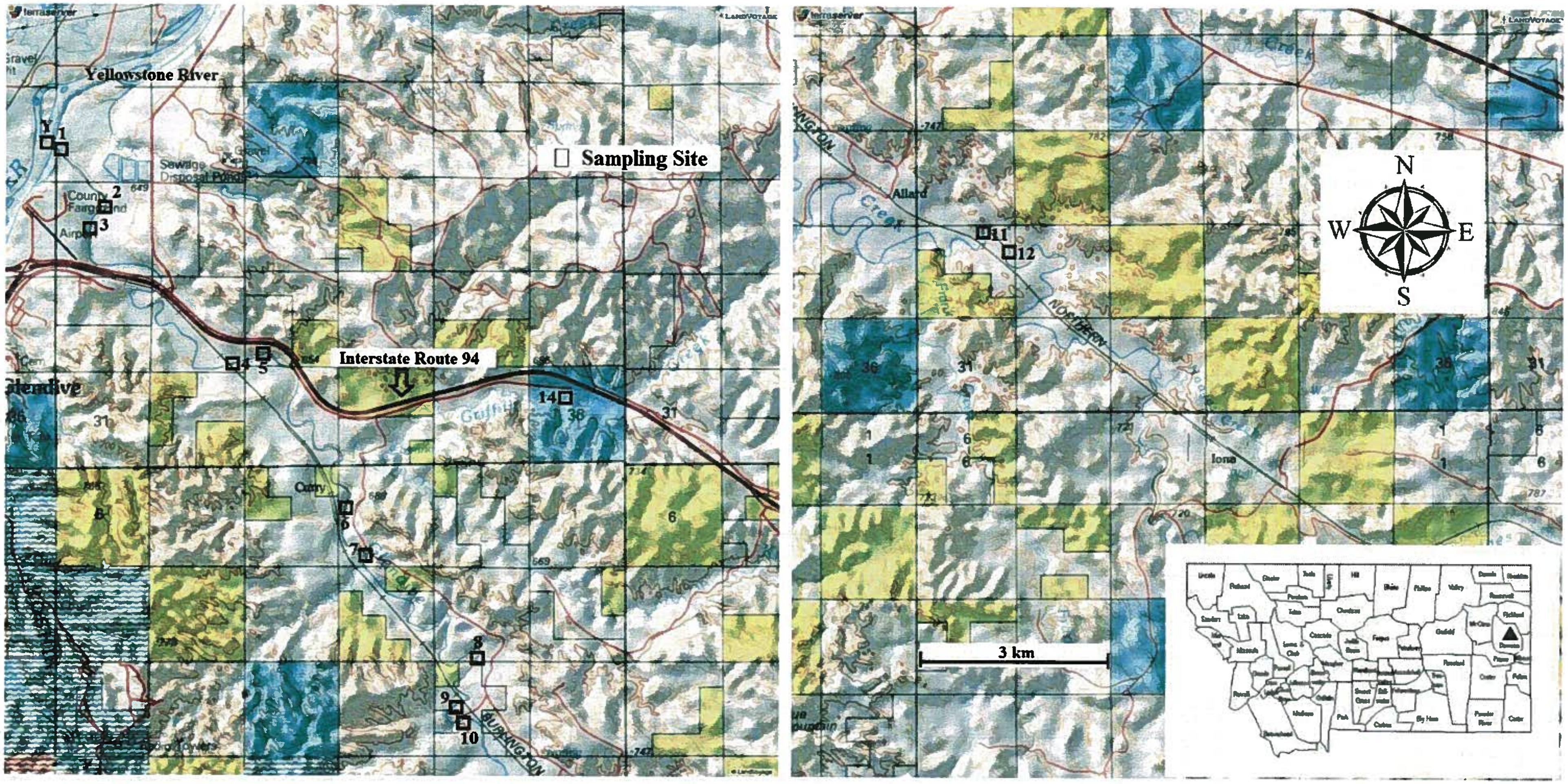


**Figure 1.** Map of the Glendive Creek system, Dawson County, Montana, showing 14 of 15 sites sampled in 2010; upstream site 13 near Wibaux county line not shown (based on U.S. Geological Survey, 7.5 Minute Topographic Series, Stipek, Glendive, Red Top, and Allard (Montana) Quadrangles; digital imagery provided by TerraServer 2011). Geographic coordinates of sites Y and 1 (Glendive Creek/Yellowstone River confluence) are 47.143°N and 104.688°W.

Table 1. Locations of sampling sites in the Glendive Creek system, Dawson County, Montana, 2010.

| Site No. | County | Quadrangle[a] | Township | Range | Section | Latitude (N) | Longitude (W) | Stream Km | Elevation (m) | Date Sampled |
|---|---|---|---|---|---|---|---|---|---|---|
| Y[b] | Dawson | Stipek | 16N | 56E | 18 | 47.143 | 104.688 | 0.0 | 622 | 08/03/2010 |
| 1 | Dawson | Stipek | 16N | 56E | 18 | 47.143 | 104.688 | 0.0 | 622 | 08/03/2010 |
| 2 | Dawson | Stipek | 16N | 56E | 19 | 47.132 | 104.677 | 1.1 | 628 | 08/05/2010 |
| 3 | Dawson | Stipek | 16N | 56E | 19 | 47.130 | 104.680 | 3.5 | 630 | 07/31/2010 |
| 4 | Dawson | Glendive | 16N | 56E | 29 | 47.109 | 104.647 | 4.9 | 632 | 08/02/2010 |
| 5 | Dawson | Glendive | 16N | 56E | 28 | 47.110 | 104.642 | 6.0 | 632 | 08/02/2010 |
| 6 | Dawson | Allard | 15N | 56E | 3 | 47.094 | 104.624 | 6.2 | 634 | 07/24/2010 |
| 7 | Dawson | Allard | 15N | 56E | 3 | 47.080 | 104.619 | 6.8 | 641 | 07/25/2010 |
| 8 | Dawson | Allard | 15N | 56E | 11 | 47.065 | 104.594 | 9.6 | 656 | 07/23/2010 |
| 9 | Dawson | Allard | 15N | 56E | 14 | 47.057 | 104.599 | 11.6 | 659 | 07/26/2010 |
| 10 | Dawson | Allard | 15N | 56E | 14 | 47.054 | 104.597 | 11.8 | 663 | 08/04/2010 |
| 11 | Dawson | Allard | 15N | 57E | 30 | 47.032 | 104.546 | 13.7 | 673 | 07/28/2010 |
| 12 | Dawson | Allard | 15N | 57E | 30 | 47.030 | 104.540 | 14.7 | 684 | 07/28/2010 |
| 13 | Dawson | Hodges | 14N | 58E | 32 | 46.923 | 104.402 | 15.8 | 698 | 07/29/2010 |
| 14 | Dawson | Allard[c] | 16N | 56E | 36 | 47.104 | 104.575 | 16.2 | 668. | 08/06/2010 |

[a]U.S. Geological Survey, 7.5 Minute Series (Topographic); [b]Yellowstone River; [c]Griffith Creek.

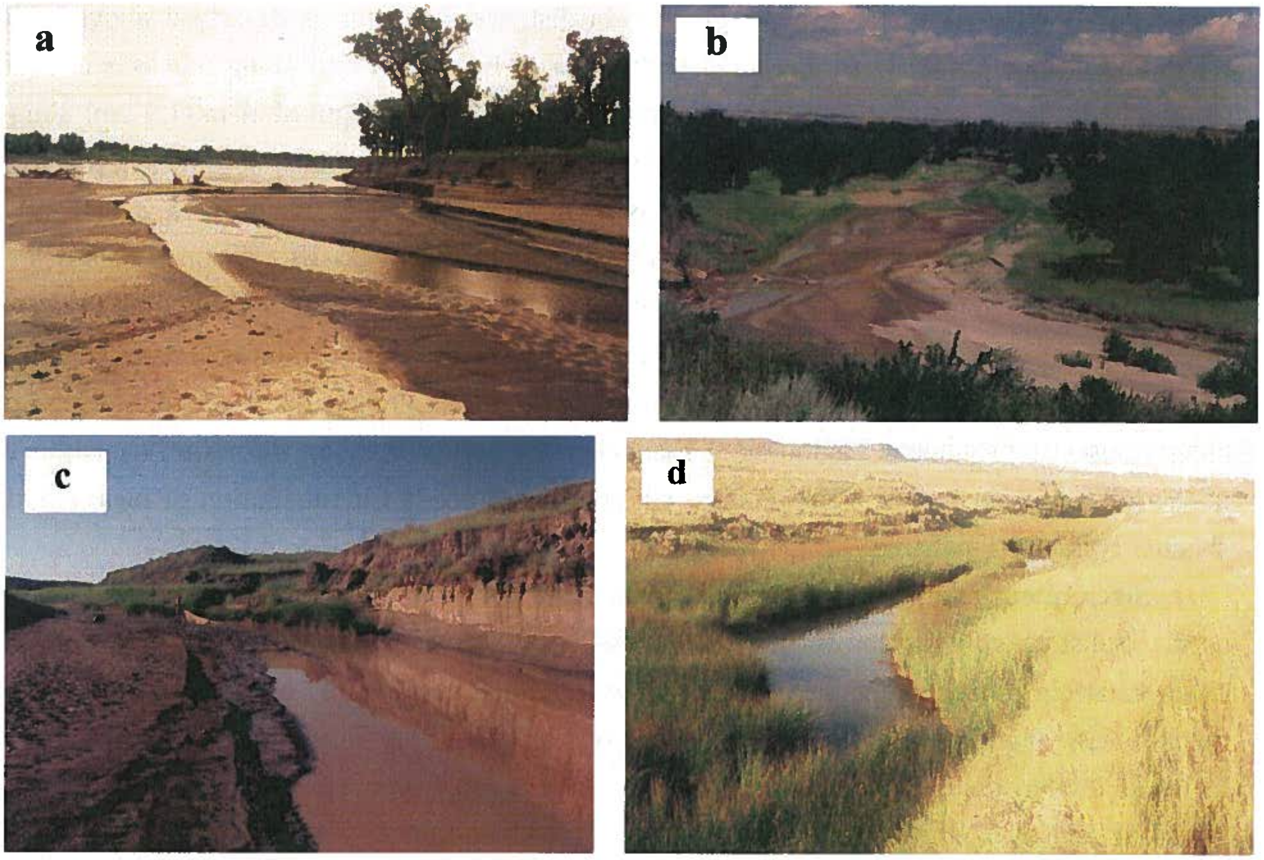


**Figure 2. Photographs of selected features of the Glendive Creek system, Dawson County, Montana, July-August 2010: (a) site 1 at confluence with Yellowstone River; (b) overview of Glendive Creek looking downstream toward site 3 from State Street in north Glendive; (c) representative section of Glendive Creek at site 7; (d) vegetated coldwater section of Griffith Creek at site 14.**

**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 pools or glides at each site. 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 glide (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 in pools was usually too slow to measure using the buoyant object method, especially with wind interference.

**Channel Morphology.** Total length of each site and lengths of component riffle, glide, 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) along transects at each site using a home-made grade stick fabricated from a 10-ft (3.05-m) length of ¾-in (1.9-cm) aluminum electrical conduit to which an equal length of steel measuring tape graduated in inches was attached with transparent duct tape and hose clamps. At very wide sites we used a 300-ft (91.4-m) fiberglass measuring tape graduated in inches (Model KL-300-18, Keson Industries, Inc., Naperville, IL). 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 an industrial clinometer (Model No. 78555, Shinwa Rules Co., Ltd., Tsubame City, Niigata Pref., Japan 959-1276, http://www.shinwasokutei.co.jp/index.html). 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 Glendive 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.

## RESULTS AND DISCUSSION

**Stream Flow.** Upstream of site 13 Glendive Creek consisted of long sections of dry channel separating isolated pools. This reach of the system exhibited no active flow during the sampling period, although it is probably responsive to storm events and surface runoff because the associated drainage area is relatively large. The dry channel sections were frequently occupied by terrestrial vegetation, indicating that duration of flow in these channels is brief. Glendive Creek was hydrologically continuous from site 13 downstream to the Yellowstone River, and active flow was evident, but it was barely measurable using the buoyant object method, ranging from <0.1 $m^3/s$ to 1.9 $m^3/s$ (Table 2). Griffith Creek (site 14, Figure 2d) was lentic habitat during the sampling period, and water in the channel probably originated from groundwater seepage.

**Water Quality.** Water quality was relatively uniform longitudinally during the sampling period. Water temperature averaged 15.8°C (range 10.0°C to 13.5°C) and generally responded daily to air temperature, which averaged 16.6°C (range 13.0°C to 22.0°C) (Table 2).

Dissolved oxygen (DO) averaged 5.0 mg/l (range from 4.1 mg/l to 5.9 mg/l) and was marginal for support aerobic aquatic life (Table 2). Low DO concentrations may have been a result of high air temperatures and shallow average pool depth.. Average pH was 9.1 with little variation longitudinally (Table 2).

Concentrations of total suspended solids (TSS) varied little longitudinally, averaging 263.3 mg/l (range 195.3 mg/l to 1850 mg/l, the latter at site 13, where cattle were in the channel during sampling). TSS concentrations probably reflected local disturbances such as bank erosion, beaver activity, or cattle use (site 13) rather than downstream accumulation of TSS (Table 2). Glendive Creek probably receives a relatively high natural inorganic sediment load due to weathering of the sparsely vegetated badlands that comprise a large part of its watershed.

Conductivity was relatively high, averaging 1678 μS (range 1295 μS to 2505 μS, the latter in the Yellowstone River) (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.

**Table 2. Water quality, stream flow, and channel morphology variables for 15 sites in the Glendive Creek system, Dawson County, Montana, July – August 2010.**

| Site[a] | Variable[b] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | T (°C) | DO (mg/l) | C (µS) | TSS (mg/l) | pH | Q ($m^3$/sec) | L (m) | W (m) | D (cm) |
| Y[c] | 14.0 | 5.6 | 2505 | | 9.1 | | >40 | 59.1/75.5 | 27.2 |
| 1 G | 14.0 | 4.4 | 1420 | 611.3 | 9.4 | 0.4 | 40.0 | 3.6/41.8 | 6.8 |
| 2 G | 13.0 | 4.8 | 1750 | 410.5 | 9.0 | 0.1 | 40.0 | 5.4/37.7 | 7.5 |
| 2 R | | | | | | | 7.5 | 5.9/39.0 | 5.9 |
| 3 R | | | | | | 0.1 | 4.5 | 6.3/16.7 | 7.2 |
| 3 P | 15.0 | 5.2 | 1750 | 479.8 | 9.1 | | >40 | 9.1/9.5 | 8.2 |
| 4 R | | | | | | 1.9 | 36.3 | 6.2/29.6 | 31.4 |
| 4 P | 18.0 | 5.0 | 1690 | 395.1 | 9.1 | | >40 | 8.9/26.3 | 8.9 |
| 5 P | 19.0 | 4.1 | 1840 | 288.5 | 9.1 | 0.2 | >40 | 5.8/30.3 | 17.1 |
| 5 R | | | | | | | 23.0 | 10.8/3.1 | 16.0 |
| 6 P | 15.0 | 5.1 | 1460 | 315.9 | 9.1 | | >40 | 3.7/6.4 | 32.7 |
| 6 R | | | | | | 0.1 | 20.0 | 2.1/2.8 | 2.1 |
| 7 P | 13.0 | 5.3 | 1295 | 315.2 | 9.2 | | >40 | 5.1/13.4 | 11.0 |
| 7 R | | | | | | <0.1 | 15.0 | 7.6/10.8 | 10.9 |
| 8 P | 14.0 | 5.9 | 1450 | 195.3 | 9.1 | | 15.0 | 2.6/23.0 | 12.3 |
| 8 R | | | | | | <0.1 | 5.0 | 2.6/23.0 | 12.3 |
| 9 R | | | | | | <0.1 | >40 | 5.2/36.8 | 12.1 |
| 9 P | 18.0 | 5.1 | 1390 | 215.1 | 9.1 | | >40 | 6.1/29.8 | 11.2 |
| 10 G | 14.0 | 5.3 | 1740 | 310.4 | 9.0 | 0.3 | >40 | 2.9/22.1 | 9.9 |
| 11 P | 15.0 | 4.8 | 1845 | 295.2 | 9.1 | | 42.5 | 4.7/18.3 | 18.3 |
| 11 R | | | | | | 0.2 | 7.5 | 3.6/21.7 | 21.7 |
| 12 P | 20.0 | 4.8 | 1845 | 295.2 | 9.1 | | 22.4 | 3.7/9.8 | 23.5 |
| 12 R | | | | | | 0.1 | 5.1 | 2.5/7.9 | 8.1 |
| 13 P | 22.0 | 4.1 | 1745 | 1850.0 | 9.1 | 0 | >40 | 1.1/4.6 | 11.2 |
| 14 P | 13.0 | 4.9 | 1450 | 249.3 | 9.2 | 0 | >40 | 2.9/13.3 | 52.2 |

[a]In order of downstream to upstream occurrence (R: riffle; P: pool; G: glide; site Y: Yellowstone River).

[b]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 not measurable with the technique used.

[c]Sample not stratified into riffles, glides, and pools; habitats included glides, channel pools, and backwater pools.

**Channel Morphology.** Downstream of site 13, Glendive Creek exhibited well defined riffle-pool or riffle-glide development (Figures 2b, 2c). Pools and glides ranged from 15.0 m to greater than 40 m in length, averaging 4.7 m in wetted width and 16.5 cm in depth. Riffles ranged from 4.5 m to greater than 40.0 m in length, averaging 2.1 m in wetted width and 12.8 cm in depth. Because of lower summer flow conditions, channel width was usually greater than wetted width (Table 2).

**Riparian Conditions.** Adjacent land use at most sites on Glendive Creek was pasture or mixed meadow. Where entrenchment banks were relatively high and steep, undisturbed meadow or mixed meadow was 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, but in most locations this indicated reduction in vegetation height rather than the presence of bare soil or erosion (Table 3).

**Table 3. Mean values of riparian variables for 15 sites in the Glendive Creek system, Dawson County, Montana, July – August 2010.**

| Site[a] | Variable[b] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | LU | BW (m) | ER (m) | SL (m) | H-1 (cm) | H-2 (m) | A-1 (°) | A-2 (°) | CS (%) |
| Y[c] | MI/WO | >10/>10 | —/— | 0/0 | —/500 | —/— | —/90 | —/— | 5 |
| 1 G | MI/MI | >10/>10 | —/3.5 | 0/2.5 | —/140 | —/4.5 | —/92 | —/92 | 0 |
| 2 G | MI/MI | 0/>10 | —/0.2 | 0/0 | —/20 | —/0.2 | —/92 | —/92 | 0 |
| 2 R | MI/MI | 0/>10 | —/0.2 | 0/0 | —/20 | —/0.2 | —/88 | —/88 | 0 |
| 3 R | PA/PA | 0/0 | —/— | 0/0 | —/370 | —/3.7 | —/92 | —/92 | 0 |
| 3 P | PA/PA | 0/0 | —/— | 0/0 | —/150 | 1.5/1.5 | 73/69 | 49/59 | 0 |
| 4 R | PA/PA | 0/0 | 0/— | 0/0 | 20/— | 0.2/— | 79/— | —/— | 0 |
| 4 P | PA/PA | 0/0 | 0/— | 0/0 | —/60 | 0.8/— | —/— | —/— | 0 |
| 5 P | PA/PA | 0/0 | 5.7/— | 0/0 | 570/— | 5.7/— | 85/8 | 85/— | 0 |
| 5 R | PA/PA | 0/0 | 5.7/— | 0/0 | 570/— | 5.7/— | 85/8 | 85/— | 0 |
| 6 P | PA/PA | >10/>10 | 0/0 | 0/0 | 20/70 | 7.8/1.4 | 54/78 | 16/51 | 0 |
| 6 R | PA/PA | >10/>10 | 0/0 | 0/0 | 10/10 | 1.6/1.6 | —/— | 20/35 | 0 |
| 7 P | PA/PA | 0/0 | —/— | 0/0 | 390/— | 3.9/1.9 | 90/25 | 90/25 | 0 |
| 7 R | PA/PA | 0/0 | —/— | 0/0 | 50/158 | 2.3/1.9 | 42/11 | 78/42 | 0 |
| 8 P | PA/PA | 0/0 | —/— | 0/0 | 70/— | —/— | 90/— | —/— | 0 |
| 8 R | PA/PA | 0/0 | —/— | 0/0 | 70/— | —/— | 90/— | —/— | 0 |
| 9 R | PA/PA | >10/>10 | —/— | 0/0 | 39/200 | 9.0/— | 93/— | 73/44 | 0 |
| 9 P | PA/PA | >10/>10 | —/— | 0/0 | 56/200 | 8.5/— | 83/— | 80/30 | 0 |
| 10 G | PA/PA | 0/0 | —/2.8 | 0/0 | —/70 | 1.7/2.8 | —/61 | 45/90 | 0 |
| 11 P | PA/PA | 0/0 | 2.1/— | 0/0 | 210/— | 1.5/— | 89/— | 83/— | 0 |
| 11 R | PA/PA | 0/0 | 0.6/— | 0/0 | 60/— | 1.8/— | 80/— | 86/— | 0 |
| 12 P | PA/PA | 0/0 | —/1.3 | 0/0 | —/257 | 1.6/1.6 | 49/91 | 75/76 | 0 |
| 12 R | PA/PA | 0/0 | —/— | 0/0 | —/350 | 1.6/1.7 | 78/70 | 80/88 | 0 |
| 13 P | PA/PA | >10/>10 | —/— | 0/0 | 213/180 | 2.3/2.3 | 93/88 | 95/90 | 0 |
| 14 P | ME/ME | >10/>10 | 0/0 | 0/0 | 406/40 | 1.8/2.0 | 29/33 | 55/60 | 0 |

[a]In order of downstream to upstream occurrence (R: riffle; P: pool; G: glide; site Y: Yellowstone River).

[b]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.

[c]Sample not stratified into riffles, glides, and pools; habitats included glides, channel pools, and backwater pools.

Banks at water's edge varied from negligible to almost 6 m in height (typically on the order of 10-70 cm) and approximately vertical, while most of the channel meandered across a narrow floodplain with entrenchment banks, if present, ranging from 0.2-9.0 m in height. On the outer banks of meanders entrenchment banks often corresponded with water's edge banks (Table 3).

Eastern cottonwoods and other taller woody vegetation, which were frequently adjacent to the channels of Burns, O'Fallon, Upper Sevenmile, and Thirteen Mile creeks, were sparser along the Glendive Creek channel and never close enough to provide significant canopy shading during daylight hours.

**Table 4. Cover variables for 15 sites in the Glendive Creek system, Dawson County, Montana, July – August 2010.**

| Site[a] | Variable[b] | | | | | | |
|---|---|---|---|---|---|---|---|
| | VH (cm) | VO (cm) | BU (cm) | WD (%) | OD (%) | EV (%) | SV (%) |
| Y[c] | —/1350[d] | 0/— | 0/0 | 0 | 0 | — | — |
| 1 G | 0/0 | 0/0 | 0/0 | 0 | 0 | 0 | 0 |
| 2 G | 0/32 | 0/0 | 0/0 | 6.7 | 0 | 0 | 0 |
| 2 R | 0/86 | 0/0 | 0/0 | 0 | 0 | 0 | 0 |
| 3 R | 92/74 | 0/0 | 0/0 | 0 | 0 | — | 0 |
| 3 P | 62/73 | 0/0 | 0/0 | 0 | 0 | — | 0 |
| 4 R | 137/0 | 0/0 | 0/0 | 0 | 0 | 0 | 0 |
| 4 P | 156/99 | 0/0 | 0/0 | 0 | 0 | 0 | 0 |
| 5 P | 46/— | 0/0 | 4/0 | 0 | 0 | — | 0 |
| 5 R | 41/— | 0/0 | 0/0 | 0 | 0 | — | 0 |
| 6 P | 65/112 | 8/3 | 2/16 | 0 | 0 | — | 0 |
| 6 R | 28/48 | 0/0 | 0/0 | 0 | 0 | — | 0 |
| 7 P | 0/0 | 0/0 | 0/0 | 0 | 0 | 0 | 0 |
| 7 R | 137/70 | 0/0 | 0/0 | 0 | 0 | 0 | 0 |
| 8 P | 96/— | 0/0 | 0/0 | 0 | 0 | 0 | 0 |
| 8 R | 96/— | 0/0 | 0/0 | 0 | 0 | 0 | 0 |
| 9 R | 97/0 | 0/0 | 0/0 | 0 | 0 | — | 0 |
| 9 P | 117/0 | 0/0 | 0/0 | 0 | 0 | — | 0 |
| 10 G | 0/117 | 0/0 | 0/0 | 0 | 0 | 0 | 0 |
| 11 P | 118/0 | 0/0 | 0/0 | 0 | 0 | 0 | 0 |
| 11 R | 66/0 | 0/0 | 0/0 | 0 | 0 | 0 | 0 |
| 12 P | 89/111 | 21/22 | 11/0 | 0 | 0 | 0 | 0 |
| 12 R | 94/90 | 21/28 | 0/0 | 0 | 0 | 0 | 0 |
| 13 P | 245/231 | 0/0 | 0/0 | 0 | 0 | 0 | 0 |
| 14 P | 125/119 | 0/0 | 0/0 | 0 | 0 | 14 | 62 |

[a]In order of downstream to upstream occurrence (R: riffle; P: pool; G: glide; site Y: Yellowstone River).

[b]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.

[c]Sample not stratified into riffles, glides, and pools; habitats included glides, channel pools, and backwater pools.

**Table 5. Streambed composition variables for 15 sites in the Glendive Creek system, Dawson County, Montana, July – August 2009.**

| Site[a] | Substrate Composition[b] | | | | | | | Sedimentation[b] | |
|---|---|---|---|---|---|---|---|---|---|
| | BO (%) | RC (%) | GR (%) | SA (%) | SI (%) | CL (%) | MU (%) | SD (cm) | EM (%) |
| Y[c] | 5.0 | 40.0 | 50.0 | | 5.0 | | | — | 5 |
| 1 G | | | | 72 | 28 | | | 76 | 28 |
| 2 G | | | | 35 | 65 | | | 44 | 65 |
| 2 R | | | 65 | 21 | 14 | | | 8 | 30 |
| 3 R | | | | 60 | 40 | | | 66 | 40 |
| 3 P | | | | 60 | 40 | | | 21 | 40 |
| 4 R | | 20 | 20 | 40 | 20 | | | 1 | 24 |
| 4 P | | | | 60 | 40 | | | 14 | 58 |
| 5 P | 5 | 70 | | 15 | 10 | | | 3 | 14 |
| 5 R | | 90 | 5 | 5 | | | | 0 | 0 |
| 6 P | 5 | 5 | 50 | | 40 | | | 7 | 100 |
| 6 R | | 20 | 20 | 60 | | | | 0 | 100 |
| 7 P | | | | 40 | 60 | | | 16 | 60 |
| 7 R | | | | 30 | 70 | | | 26 | 70 |
| 8 P | | | | 60 | 40 | | | — | 40 |
| 8 R | | | | 60 | 40 | | | — | 40 |
| 9 R | 10 | 30 | | 20 | 40 | | | 4 | 40 |
| 9 P | | | | 60 | 40 | | | 21 | 40 |
| 10 G | | | | 35 | 65 | | | 28 | 60 |
| 11 P | | | 10 | 30 | 60 | | | 7 | 60 |
| 11 R | | | 90 | | 10 | | | 0 | 10 |
| 12 P | | | | 35 | 65 | | | 21 | 52 |
| 12 R | 90 | 10 | | | | | | 0 | 0 |
| 13 P | | | | 50 | 50 | | | 4 | 50 |
| 14 P | | | | | | 20 | 80 | 22 | 80 |

[a]In order of downstream to upstream occurrence (R: riffle; P: pool; G: glide; site Y: Yellowstone River).
[b]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.
[c]Sample not stratified into riffles, glides, and pools; habitats included glides, channel pools, and backwater pools.

**Cover.** Vegetative height at water's edge averaged 132.0 cm, (range 0.0 cm to 245.0 cm). Vegetative overhang was absent or negligible at most sites (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. Attached filamentous algae covered the streambed material in most riffles and shallow pools. The most important cover in Glendive Creek may consist of "virtual" cover provided by tall riparian vegetation.

**Streambed Composition.** The predominant substrate materials in Glendive Creek were sand silt; silt embeddedness was significant at deeper pool sites (Table 5). Riffles generally exhibited higher proportions of rubble, cobble, and gravel than did pools. Most pools were not deeply sedimented except for several lower gradient pools and glides at sites 1, 2, and 3 (Table 5).

In general, the Glendive Creek watershed, located south of the Yellowstone River, lacked the glacial outwash deposits that occupied lowland portions of the Burns, Upper Sevenmile, and Thirteen Mile creek watersheds to the north of the river. Consequently, substrates in Glendive Creek were dominated by finer sands and silts originating from weathering of the badlands terrain that dominated its watershed and generally lacked significant amounts of gravel associated with glacial outwash.

**Fish Communities.** Since 1975, 19 species of fishes have been collected in Glendive Creek and the immediately adjacent Yellowstone River, to which we added two new records: brassy minnow (*Hybognathus hankinsoni*) and longnose sucker (*Catostomus catostomus*) (Tables 2 and 3).

In 2010 we failed to collect 5 species previously reported in Glendive Creek, including lake chub (*Couesius plumbeus*), smallmouth buffalo (*Ictiobus bubalus*), black bullhead (*Ameiurus melas*), yellow bullhead (*Ameiurus natalis*), and channel catfish (*Ictalurus punctatus*) (Table 2). Smallmouth buffalo, black bullhead, yellow bullhead, and channel catfish are riverine species associated with the Yellowstone River and its larger tributaries; they may appear in small numbers in the lower reaches of Glendive Creek, especially during their spring spawning seasons. Lake chubs may occur in upstream beaver impoundments that we did not sample in 2010.

The most abundant and widely distributed species collected in Glendive Creek during sampling in 2010 were western silvery/plains minnow (*Hybognathus argyritus/placitus*), fathead minnow (*Pimephales promelas*), flathead chub (*Platygobio gracilis*), and longnose dace *Rhinichthys cataractae*). Brook sticklebacks (*Culaea inconstans*) were present only in the cooler water, densely vegetated habitat of Griffith Creek (site 14).

We were unable to estimate densities of fish communities in riffles and pools due to low flows, poor capture rates, or failure to achieve significant catch reduction. The greatest numbers of fish were collected at sites 1, 3, 4, 5, 6, 7, 11, and 12, consisting mostly of flathead chubs and western silvery/plains minnows.

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 such as riparian vegetation height/overhang, surface/depth ratio, and canopy or bank shading (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 have been 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 prevented fish communities from stabilizing and efficiently partitioning available habitats (Barnes 2004, Barnes et al. 2002, Barnes and Siegle 2003). Similar factors probably operated in Upper Sevenmile Creek and in Thirteen Mile Creek. Several sites featured significant riparian vegetation height/overhang, relatively low surface/depth ratios, and canopy or morning/evening bank shading, yet the densities of fish encountered were lower than would be expected in such relatively "good" habitat. The proliferation and random placement of beaver dams in time and space in the lower reaches of Upper Sevenmile Creek and Thirteen Mile Creek may have significantly limited movement of fish within these systems and between the systems and the Yellowstone River, as was hypothesized for Burns Creek (Barnes and Silbernagel 2001).

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

| Species[a] | Pre-1981[b] | MFISH[c] | 2010[d] | Total |
|---|---|---|---|---|
| common carp (*Cyprinus carpio*) | ✓ | ✓ | 36 | 36 |
| brassy minnow (*Hybognathus hankinsoni*) | | | 74 | 74 |
| western silvery/plains minnow (*Hybognathus argyritus/placitus*) | ✓ | ✓ | 293 | 293 |
| emerald shiner (*Notropis atherinoides*) | ✓ | ✓ | 9 | 9 |
| sand shiner (*Notropis stramineus*) | ✓ | ✓ | 9 | 9 |
| fathead minnow (*Pimephales promelas*) | ✓ | ✓ | 108 | 108 |
| flathead chub (*Platygobio gracilis*) | ✓ | ✓ | 1295 | 1295 |
| lake chub (*Couesius plumbeus*) | ✓ | | | |
| longnose dace (*Rhinichthys cataractae*) | ✓ | | 74 | 74 |
| creek chub (*Semotilus atromaculatus*) | ✓ | ✓ | 11 | 11 |
| river carpsucker (*Carpiodes carpio*) | ✓ | ✓ | 27 | 27 |
| longnose sucker (*Catostomus catostomus*) | | | 1 | 1 |
| white sucker (*Catostomus commersoni*) | ✓ | ✓ | 3 | 3 |
| smallmouth buffalo (*Ictiobus bubalus*) | ✓ | | | |
| black bullhead (*Ameiurus melas*) | ✓ | | | |
| yellow bullhead (*Ameiurus natalis*) | ✓ | | | |
| channel catfish (*Ictalurus punctatus*) | | ✓ | | |
| plains killifish (*Fundulus zebrinus*) | ✓ | ✓ | 1 | 1 |
| brook stickleback (*Culaea inconstans*) | ✓ | ✓ | 7 | 7 |
| **TOTAL FISH** | — | — | 1948 | **1948** |
| **TOTAL SPECIES** | 16 | 13 | 14 | **19** |

[a]Common and scientific names according to Robins et al. (1991).
[b]Elser et al (1980); check (✓) means present but numerical data not available.
[c]MFIS (2011); check (✓) means present but numerical data not available.
[d]Present study (2010).

Glendive Creek is a highly variable system in which extreme high and low flow, occasional hydrologic discontinuity, and lack of cover and structure may 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 Glendive Creek would require several years of study under a full range of stream systems and natural (and anthropocentric) environmental variation.

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**Table 7. Species and numbers of fishes collected in the Glendive Creek system, Dawson County, Montana, July-August 2010.**

| Species | Site /Number | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Y[a] | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14[b] | Σ |
| common carp (*Cyprinus carpio*) | | | | 29 | 1 | 5 | 1 | | | | | | | | | **36** |
| brassy minnow (*Hybognathus hankinsoni*) | | | | 6 | | 5 | 45 | 5 | | 3 | | 3 | 6 | 1 | | **74** |
| western silvery/plains minnow (*Hybognathus argyritus/placitus*) | 1 | | 1 | 21 | 28 | 67 | 141 | 17 | | | | 3 | 11 | 3 | | **293** |
| emerald shiner (*Notropis atherinoides*) | | | | 1 | | 4 | 3 | 1 | | | | | | | | **9** |
| sand shiner (*Notropis stramineus*) | 1 | | | 2 | 2 | 2 | 1 | 1 | | | | | | | | **9** |
| fathead minnow (*Pimephales promelas*) | | | 1 | 3 | 1 | 11 | 16 | 13 | | | 63 | | | | | **108** |
| flathead chub (*Platygobio gracilis*) | 31 | 125 | 48 | 38 | 132 | 247 | 178 | 60 | 51 | 51 | | 233 | 101 | | | **1295** |
| lake chub (*Couesius plumbeus*)[c] | | | | | | | | | | | | | | | | **0** |
| longnose dace (*Rhinichthys cataractae*) | | | | | | 1 | | 2 | | 5 | | 23 | 43 | | | **74** |
| creek chub (*Semotilus atromaculatus*) | | | | | 7 | 4 | | | | | | | | | | **11** |
| river carpsucker (*Carpiodes carpio*) | | | | 15 | 1 | 9 | 2 | | | | | | | | | **27** |
| longnose sucker (*Catostomus catostomus*) | | | | | | | | 1 | | | | | | | | **1** |
| white sucker (*Catostomus commersoni*) | | | | 1 | | | 1 | 1 | | | | | | | | **3** |
| smallmouth buffalo (*Ictiobus bubalus*)[c] | | | | | | | | | | | | | | | | **0** |
| black bullhead (*Ameiurus melas*)[c] | | | | | | | | | | | | | | | | **0** |
| yellow bullhead (*Ameiurus natalis*)[c] | | | | | | | | | | | | | | | | **0** |
| channel catfish (*Ictalurus punctatus*)[c] | | | | | | | | | | | | | | | | **0** |
| plains killifish (*Fundulus zebrinus*) | | | | | 1 | | | | | | | | | | | **1** |
| brook stickleback (*Culaea inconsta* | | | | | | | | | | | | | | | 7 | **7** |
| **TOTAL (Σ)** | **33** | **125** | **50** | **116** | **173** | **355** | **388** | **101** | **51** | **59** | **63** | **262** | **161** | **4** | **7** | **1948** |

[a]Yellowstone River adjacent to mouth of Glendive Creek.
[b]Griffith Creek.
[c]Collected historically in Glendive Creek but not in present survey (Table 2)

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