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SPATIOTEMPORAL VARIATION OF FISH ASSEMBLAGES IN MONTANA PRAIRIE STREAMS

JASON A. MULLEN

ROBERT G. BRAMBLETT

CHRISTOPHER S. GUY

ALEXANDER V. ZALE

MONTANA COOPERATIVE FISHERY RESEARCH UNIT

MONTANA STATE UNIVERSITY-BOZEMAN

BOZEMAN, MT 59717

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Abstract.—There is little information on the spatiotemporal variation of fish assemblages in Montana prairie streams. This information is important for managers to better understand the ecosystem they manage and to allow them to design more efficient sampling regimes. We used stratified random sampling to selected five tributaries of the Yellowstone River from Forsyth to Glendive that represent a gradient of steam size as measured by watershed area. We sampled fishes from these five streams during the 2005 field season at nine or ten (dependent on access and permission) longitudinal sites per stream arrayed from the confluence to the headwaters during June and July. From the set of longitudinal sites, a lower, middle, and upper site were established as temporal sites on each stream and we sampled these temporal sites again during August and October. (In general, species richness decreased from downstream to upstream sites, whether assessing all species or only main river guild species. Trends in temporal variation of species richness should become more apparent as more data is collected; however, it appears that increases in species richness at lower sites may be associated with high flow events. Future evaluations will focus on the spatiotemporal variation of species composition and its relationship to longitudinal position, season, watershed size, and habitat variables.

Introduction

Information on spatiotemporal variation of prairie fish assemblages is necessary to develop a greater understanding of fish assemblages in Montana prairie streams. Prior surveys have defined the distribution of fish species in Montana prairie streams; however, we lack information on how fish assemblages vary spatially and temporally within prairie streams because most of these surveys were single visits to a single site on each stream during summer. This study focuses on spatiotemporal variability of prairie fish assemblages in a subset of Montana prairie streams, which will help place the overall prairie fish database into context. Our study design will provide insight into spatial trends and temporal variation of prairie fish assemblages within and across drainages. We will also determine the extent of spatial and temporal use of prairie streams by main river fish. By studying five streams across a gradient of size we will be able to assess relationships between drainage size and the fish assemblage. Native prairie fishes will benefit from more informed management and conservation decisions by addressing the information gap on the spatiotemporal dynamics of prairie stream fishes. Our findings will indicate where, when, and how often to sample prairie streams for the purposes of determining species richness, composition, and trend monitoring. This information will be useful to fisheries managers who need to know where, when, how many, and which fish species occur in streams in their region. We will also begin to reveal links between large river ecosystems and prairie streams, which is vital information for those charged with managing and preserving large river fishes. This study will not only provide a better understanding of prairie fishes and their ecosystems, but will also provide guidance for day-to-day management, such as how human disturbances (e.g., culverts and streambed alteration projects) can be managed to minimize deleterious effects.

Study Area

The study site is located in the Northwestern Great Plains region of the Yellowstone basin with the Missouri plateau, river breaks, and central grassland geological features dominating the area (Woods et al. 1999). The five streams are Cabin Creek, Cedar Creek, O'Fallon Creek, North Sunday Creek, and Sweeney Creek. All of the streams connect directly to Yellowstone River between the towns of Forsyth and Glendive, Montana. Study streams are characteristic of typical prairie streams, being often highly turbid, with warm summer temperatures and isolated pools during low discharge. The terrestrial ecosystem is northwestern mixed grasslands (Galat et al. 2005). Grazing and row crop agriculture dominate the land use activities. Oil extraction occurs in the Cedar and Cabin creek drainages.

Methods

Site selection.—Longitudinal sites (*N* = 9-10 on each of the 5 streams; dependent on access and permission) were established using a stratified random design for each creek; strata were formed by dividing the main channel of each creek into 10 equal-length reaches beginning at the confluence with the Yellowstone River and extending to the headwaters (Figure 1). Longitudinal sites 1 and 9 served as the lower and upper temporal sites, respectively. The middle temporal site was established by random selection from either longitudinal site 5 or 6. Longitudinal sites were sampled in June and July and temporal sites were sampled in June, July, August, and October (Table 1).

Fishes.—Fishes were sampled at each site by seining a 300-m reach of stream. All fishes captured were identified to species, and lengths of at least 30 randomly selected individuals were recorded for each species. Up to ten voucher specimens for each species were preserved, and voucher specimens were examined in the laboratory to verify field identifications.

Aquatic and riparian habitat.—We surveyed habitat in the same location where fish were sampled following the U. S. Environmental Protection Agency protocol for physical habitat characterization (Kaufmann and Robison 1998). Habitat variables measured included measures of channel dimensions, substrate size and type, habitat complexity and cover, riparian vegetation cover and structure, and anthropogenic alterations.

Water chemistry.—Water conductivity (µmhos/cm), dissolved oxygen (mg/L), pH, salinity (ppt), turbidity (NTU),water temperature (°C), and air temperature (°C), were recorded at each site.

Results and Discussion

Landowner contacts and site establishment.—A total of 33 different landowners were contacted and permission was obtained to sample fish. A friendly working relationship was established with all landowners and thank you letters were sent out in December 2005. Longitudinal sites were established and all were sampled in June and

July except for two sites on O'Fallon Creek (sites 2 and 5), which were not sampled in June due to high water. We were unable to establish four longitudinal sites due to a lack of access or permission. A total of 15 temporal sites (3 on each of the 5 streams) were established and all were sampled in June, July, August, and October. Thermographs, set to record water temperature every 6 hours, were installed at each temporal site in May 2005.

General fish summary.—Fish were present at 111 of 120 samples (92.5%). A total of 36,441 individual fishes of 24 species were captured (Table 3, total fishes differ due to juvenile *Hybognathus* spp. missing from table). Nineteen taxa and 33,337 individual fishes were native and the remaining five species and 3,104 individual fishes were introduced. A main river guild was established for additional analysis and includes; *channel catfish (Ictalurus punctatus), emerald shiner, flathead chub (Platygobio gracilis), goldeye, river carpsucker (*Carpiodes *carpio), shorthead redhorse (Moxostoma macrolepidotum), smallmouth buffalo, and western silvery minnow (Hybognathus argyritis).*

Fathead minnow (*Pimephales promelas*) were the most commonly occurring species; they were present at 108 of 111 sites (97.3%) that had fish present. Plains minnow (*Hybognathus placitus*) were the next most common species, present at 65 of the 111 sites (58.5%) that had fish present. Plains killifish (*Fundulus zebrinus*) were present at 56 of 111 sites (50.5%), while the remaining 21 species were present at less than 50% of the sites containing fish. Brassy minnow (*Hybognathus hankinsoni*), brook stickleback (*Culaea inconstans*), emerald shiner (*Notropis atherinoides*), goldeye (*Hiodon alosoides*), longnose sucker (*Catostomus catostomus*), smallmouth buffalo (*Ictiobus bubalus*), stonecat (*Noturus flavus*), and yellow perch (*Perca flavescens*) were present at less than 10% of the sites containing fish.

Longitudinal.— In general, there was a decrease in species richness moving from the confluence toward the headwaters for all streams (Figure 2). Preliminary examination suggests larger streams support greater species richness at greater distances upstream, before a distinct decline in species richness appears. The smaller streams in this study show a marked decline in species richness lower in the drainage. However, this decline may be associated with anthropogenic connectivity issues. For example, there are at least partial barriers in Cedar Creek and Sweeney Creek and the abrupt decline in species richness occurs at these locations.

Fishes in the main river guild declined more sharply from downstream to upstream sites, and often were rare or absent from the middle temporal sites and higher in the drainage (Figure 3). Species richness of main river fish appears to be positively related to drainage size as the greatest species richness ($N = 6$ species) occurred in O'Fallon Creek (greatest watershed size), while the smallest value of species richness ($N = 2$ species) occurred in Sweeney Creek (smallest watershed size). The absence of any main river species above Site 3 in Cedar Creek and Sweeney Creek further illustrates the impact of barriers.

The upper reaches often support species which are rare or absent throughout the remainder of the stream. Brook stickleback were present only in the upper two sites of O'Fallon Creek. Brassy minnow were largely limited to the upper half of O'Fallon Creek. Fathead minnow and green sunfish (*Lepomis cyanellus*) were often common in upper reaches of all streams and present at low levels or absent in the middle and lower reaches.

Temporal.—Our assessment of temporal variation of fish assemblages is incomplete at this point due to the lack of samples. However, preliminary evaluation of the temporal variation in species richness within sites suggests more stability at upper sites than lower sites (Figure 4). Species richness varied from 9 to 16 in lower O'Fallon Creek. The high species richness in June and October in O'Fallon Creek were likely associated with high flow events, which effectively "re-stocked" the potential species pool. Similarly, species richness was highest in October in lower Cabin Creek, a function of high flow prior to sampling. It appears that there is temporal variation in species richness and composition, and as we collect more data trends should become apparent.

Species richness of main river guild fishes decrease from low to upper sites (Figure 5). O'Fallon Creek had higher levels of species richness in June and October compared to July and August, possibly due to the flow events acting as an attractant to main river fish in the Yellowstone River. Interestingly, the lower Cabin Creek site had a constant species richness value of 3 in June, July, and August, before an increase to 4 in October (western silvery minnow).. Similarly, one western silvery minnow was caught on Cedar Creek in June, zero in July and August, and 107 individuals were caught in October. The increase in presence of western silvery minnow could again be the result of a flow event occurring in autumn, which acted as an attractant or alternatively the recruitment of juveniles to the sampling gear (6.4-mm mesh seines).

Species richness.—Our preliminary investigation has focused on species richness to gain a general understanding of spatiotemporal variation of fish assemblages. However, this is an incomplete representation of the fish assemblage because species richness does not account for species composition. For example, three main river species were present in the lower site of Cedar Creek in August and October (Figure 5). However, the fish species present in August were channel catfish, flathead chub, and river carpsucker, while the species present in October were flathead chub, river carpsucker and western silvery minnow. Assessing species richness alone does not capture the interesting information that western silvery minnow moved into the site and channel catfish left the site between August and October. Future evaluations will evaluate spatiotemporal variation not only in terms of species richness, but also in terms of species composition, as well as assemblage structure using a multivariate approach.

Plans for 2005

Temporal sites will be sampled in February or March (dependent on a late winter thaw), April, June, July, August, and October. The final round of sampling for the temporal sites will take place in April 2007, completing a two-year period with at least one sample per season (except possibly winter, due to frozen streams). Sampling of longitudinal sites will be repeated in June and July. Further analysis will assess spatiotemporal variation of species composition, and assemblage structure in relation to longitudinal position, season, watershed size, and reach-scale habitat variables.

References

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Table 1.—Work schedule for the seasonal and longitudinal sampling of the spatiotemporal prairie fish project.

Year	Month	Longitudinal Samples	Temporal Samples
2005	June	x	x
	July	x	x
	August		x
	October		x
2006	January		x
	April		x
	June	x	x
	July	x	x
	August		x
	October		x
2007	January		x
	April		x

Table 2.—Site locations for five Montana prairie streams. Sites are abbreviated by the first two letters of the stream, the number represents position in the drainage (1-lowest to 10-highest), and letters indicate the site serves as a temporal site (A-lower, B-middle, C-upper).

Stream	Site	HUC	Latitude	Longitude
O'Fallon	OF1A	10100005	46.81676	-105.14857
	OF2	10100005	46.73830	-105.08101
	OF3	10100005	46.68116	-104.97356
	OF4	10100005	46.54478	-104.83237
	OF5	10100005	46.46606	-104.75743
	OF6B	10100005	46.44203	-104.75623
	OF7	10100005	46.30962	-104.76370
	OF9C	10100005	46.10468	-104.74969
	OF10	10100005	46.05182	-104.79012
North Sunday	NS1A	10100001	46.49097	-105.78212
	NS2	10100001	46.47141	-105.83847
	NS3	10100001	46.45564	-105.90954
	NS4	10100001	46.47675	-105.93221
	NS5	10100001	46.52691	-106.00868
	NS6B	10100001	46.55384	-106.00863
	NS7	10100001	46.60155	-106.10889
	NS8	10100001	46.67052	-106.16468
	NS9C	10100001	46.72346	-106.24438
	NS10	10100001	46.77116	-106.32650
Cabin	CA1A	10100004	46.91118	-104.86131
	CA3	10100004	46.80269	-104.81576
	CA4	10100004	46.77330	-104.78348
	CA5B	10100004	46.72696	-104.72138
	CA6	10100004	46.69566	-104.66110
	CA7	10100004	46.68621	-104.59106
	CA8	10100004	46.65099	-104.46658
	CA9C	10100004	46.62666	-104.42926
	CA10	10100004	46.55330	-104.35271
Cedar	CE1A	10100004	46.95575	-104.78360
	CE2	10100004	46.92765	-104.74120
	CE3	10100004	46.90394	-104.70809
	CE4	10100004	46.88742	-104.66805
	CE5B	10100004	46.83597	-104.59270
	CE6	10100004	46.83062	-104.58775
	CE7	10100004	46.78935	-104.55449

	CE9C	10100004	46.76092	-104.45921
	CE10	10100004	46.77024	-104.42181
Sweeney	SW1A	10100001	46.26427	-106.32732
	SW2	10100001	46.25491	-106.32664
	SW3	10100001	46.23500	-106.32803
	SW4	10100001	46.23083	-106.33176
	SW5B	10100001	46.19838	-106.31174
	SW6	10100001	46.19102	-106.30596
	SW8	10100001	46.15088	-106.26561
	SW9C	10100001	46.13861	-106.26059
	SW10	10100001	46.11970	-106.24535

Table 3.—Fishes captured in five tributaries of the lower Yellowstone River, June – October 2005. Streams are organized by watershed size from largest to smallest, reading from left to right.

Family Common name, *Genus species*	Stream O'Fallon	North Sunday	Cabin	Cedar	Sweeney	Abundance
Hiodontidae						
goldeye, *Hiodon alosoides*	X	X				5
Cyprinidae						
lake chub, *Couesius plumbeus*	X	X	X	X		1,746
common carp, *Cyprinus carpio*	X	X	X	X	X	143
western silvery minnow, *Hybognathus argyritis*	X	X	X	X	X	239
brassy minnow, *Hybognathus hankinsoni*	X					42
plains minnow, *Hybognathus placitus*	X	X	X	X	X	3,118
emerald shiner, *Notropis atherinoides*	X					3
sand shiner, *Notropis stramineus*	X	X	X	X	X	1,905
fathead minnow, *Pimephales promelas*	X	X	X	X	X	14,047
flathead chub, *Platygobio gracilis*	X	X	X	X	X	1,784
longnose dace, *Rhinichthys cataractae*	X	X	X	X	X	529
creek chub, *Semotilus atromaculatus*	X		X	X	X	735
Catostomidae						
river carpsucker, *Carpiodes carpio*	X	X	X	X		1,115
longnose sucker, *Catostomus catostomus*		X			X	4
white sucker, *Catostomus commersonii*	X		X		X	1,149
smallmouth buffalo, *Ictiobus bubalus*	X					1
shorthead redhorse, *Maxostoma macrolepidotum*	X		X		X	34
Ictaluridae						
black bullhead, *Ameiurus melas*	X	X	X	X	X	526
channel catfish, *Ictalurus punctatus*	X	X	X	X	X	536
stonecat, *Noturus flavus*	X	X	X	X	X	37
Cyprinodontidae						
plains killifish, *Fundulus zebrinus*	X	X	X	X	X	662
Gasterosteidae						
brook stickleback, *Culaea inconstans*	X					22
Centratchidae						
green sunfish, *Lepomis cyanellus*	X	X	X		X	1,768
Percidae						
yellow perch, *Perca flavescens*	X					5
Total						30,155

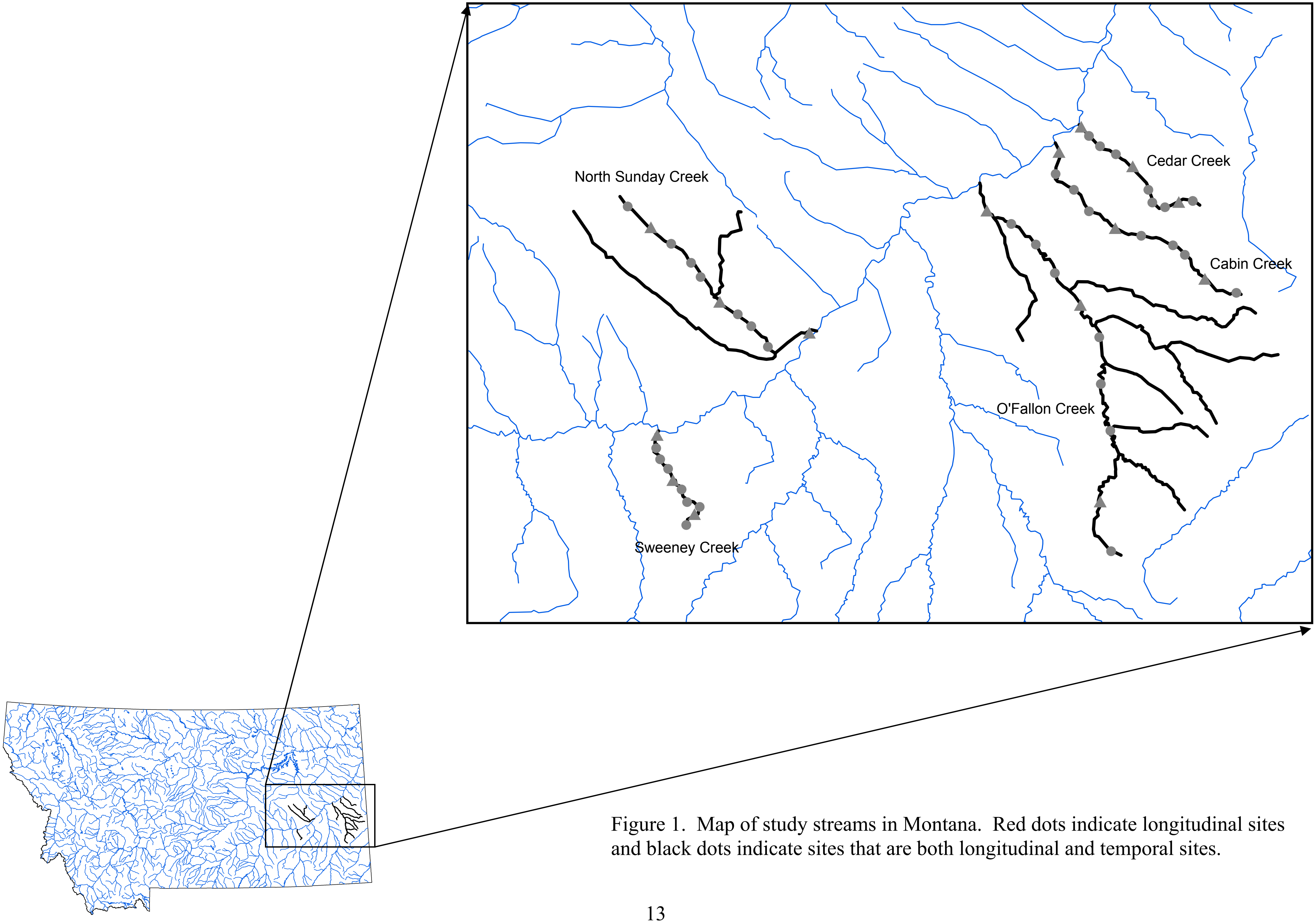

Figure 1. Map of study streams in Montana. Red dots indicate longitudinal sites and black dots indicate sites that are both longitudinal and temporal sites.

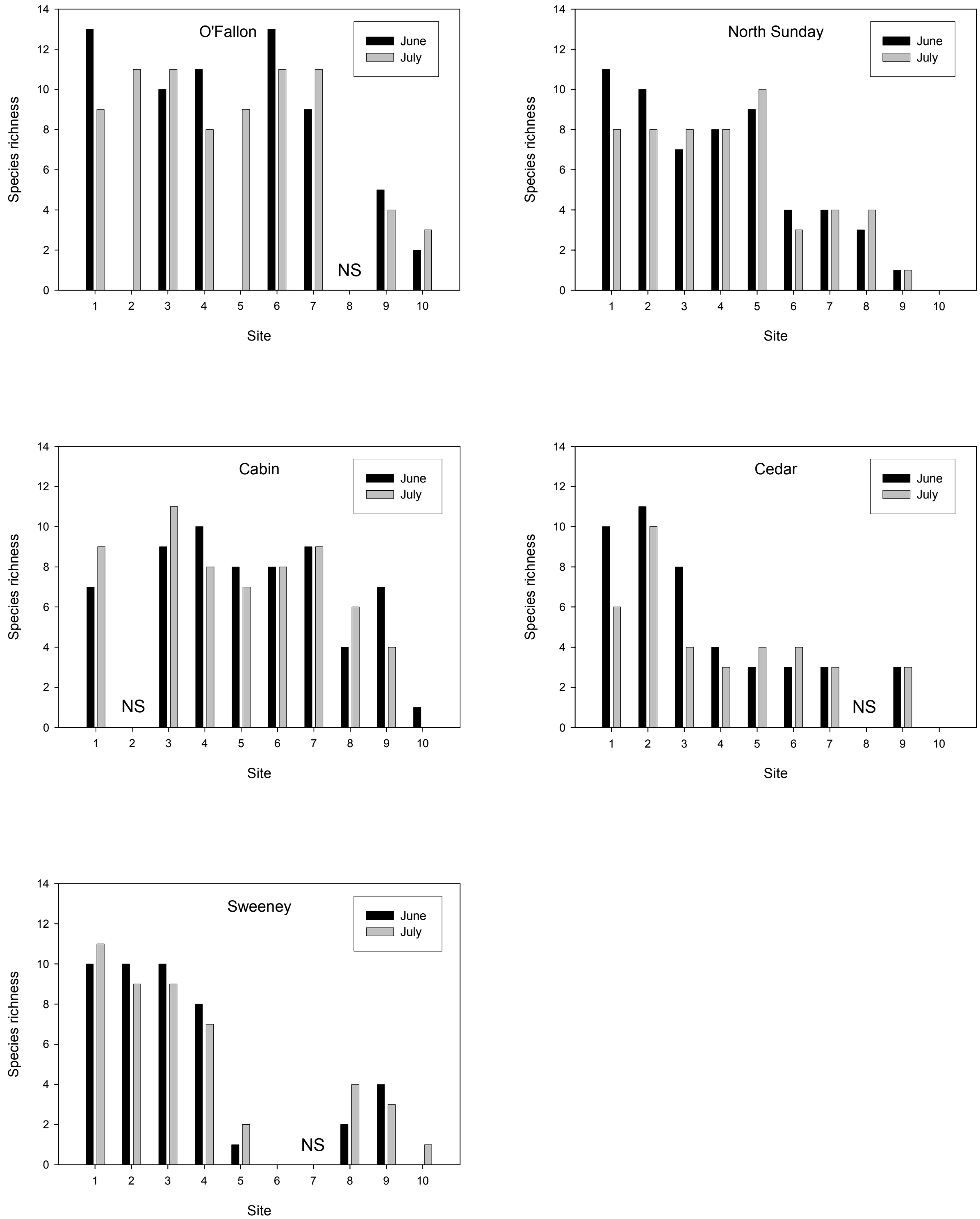

Figure 2. Species richness of fishes collected in June and July 2005 from five tributaries of the lower Yellowstone River. Streams are organized from largest to smallest, reading from left to right. Sites 1 through 10 represent longitudinal sites from the confluence to headwaters and NS represents sites where no collections were made.

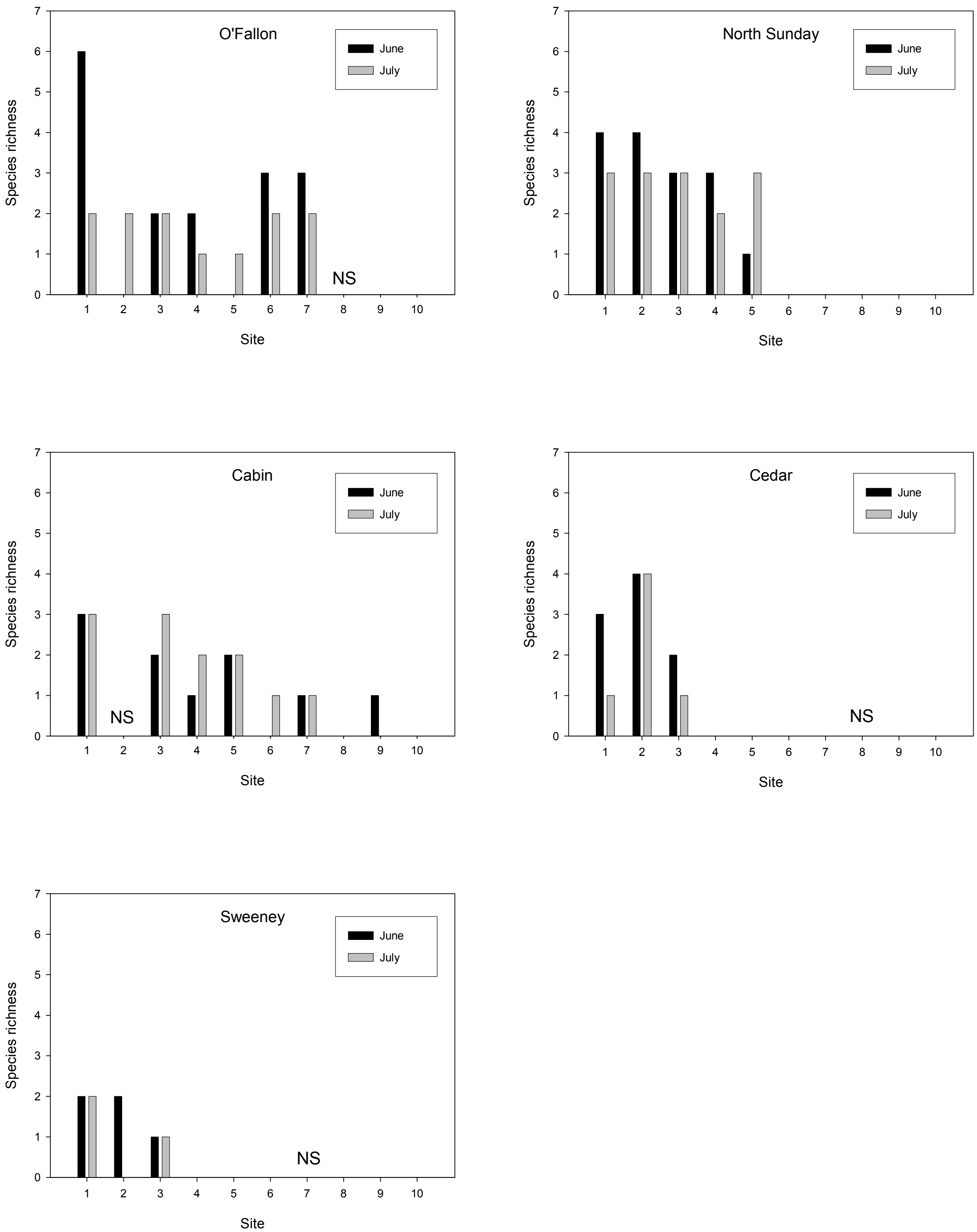

Figure 3. Species richness of main river guild fishes collected in June and July 2005 from five tributaries of the lower Yellowstone River. Streams are organized from largest to smallest, reading from left to right. Sites 1 through 10 represent longitudinal sites from the confluence to headwaters and NS represents sites where no collections were made.

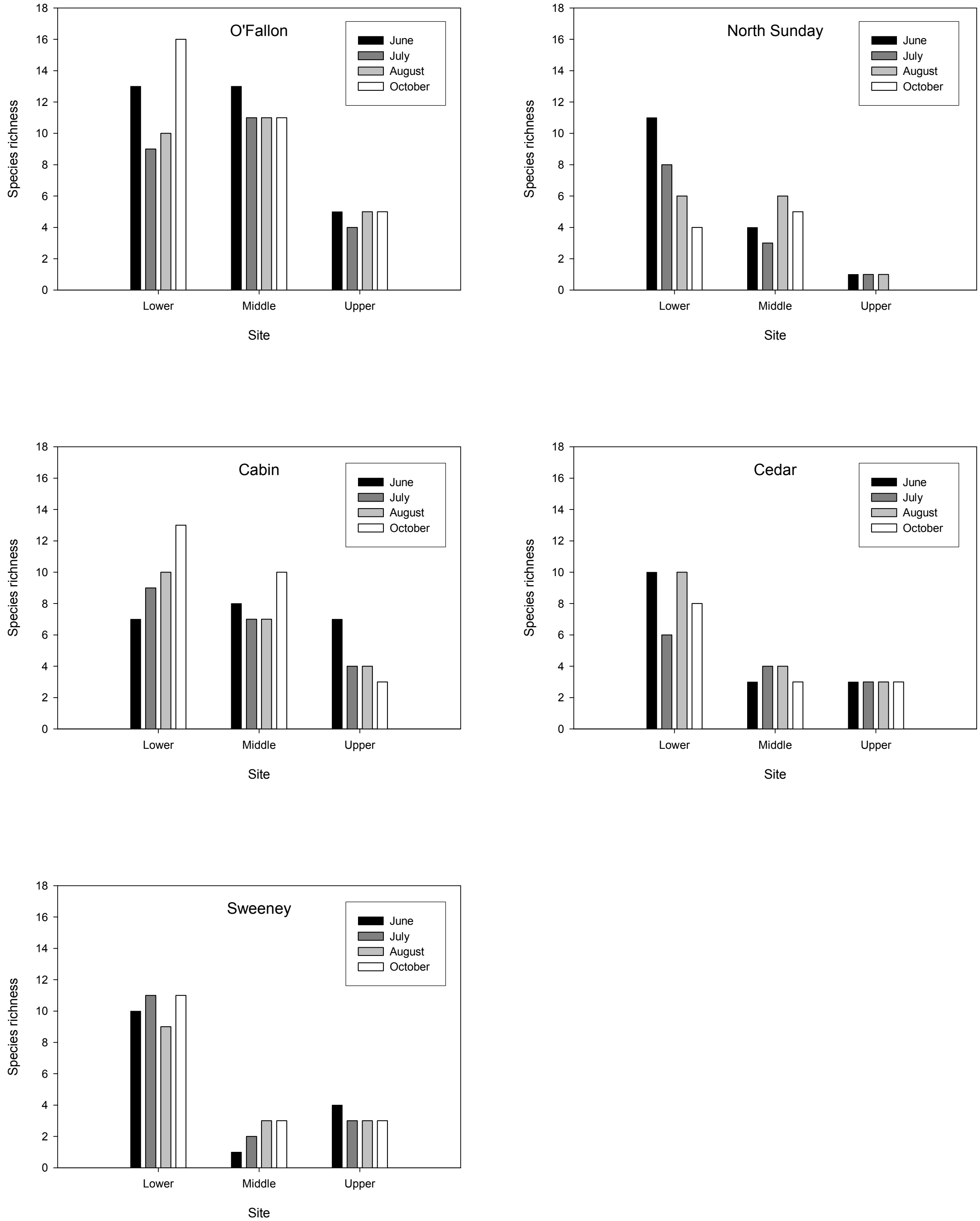

Figure 4. Species richness of fishes collected in June, July, August, and October 2005 from five tributaries of the lower Yellowstone River. Streams are organized from largest to smallest, reading from left to right.

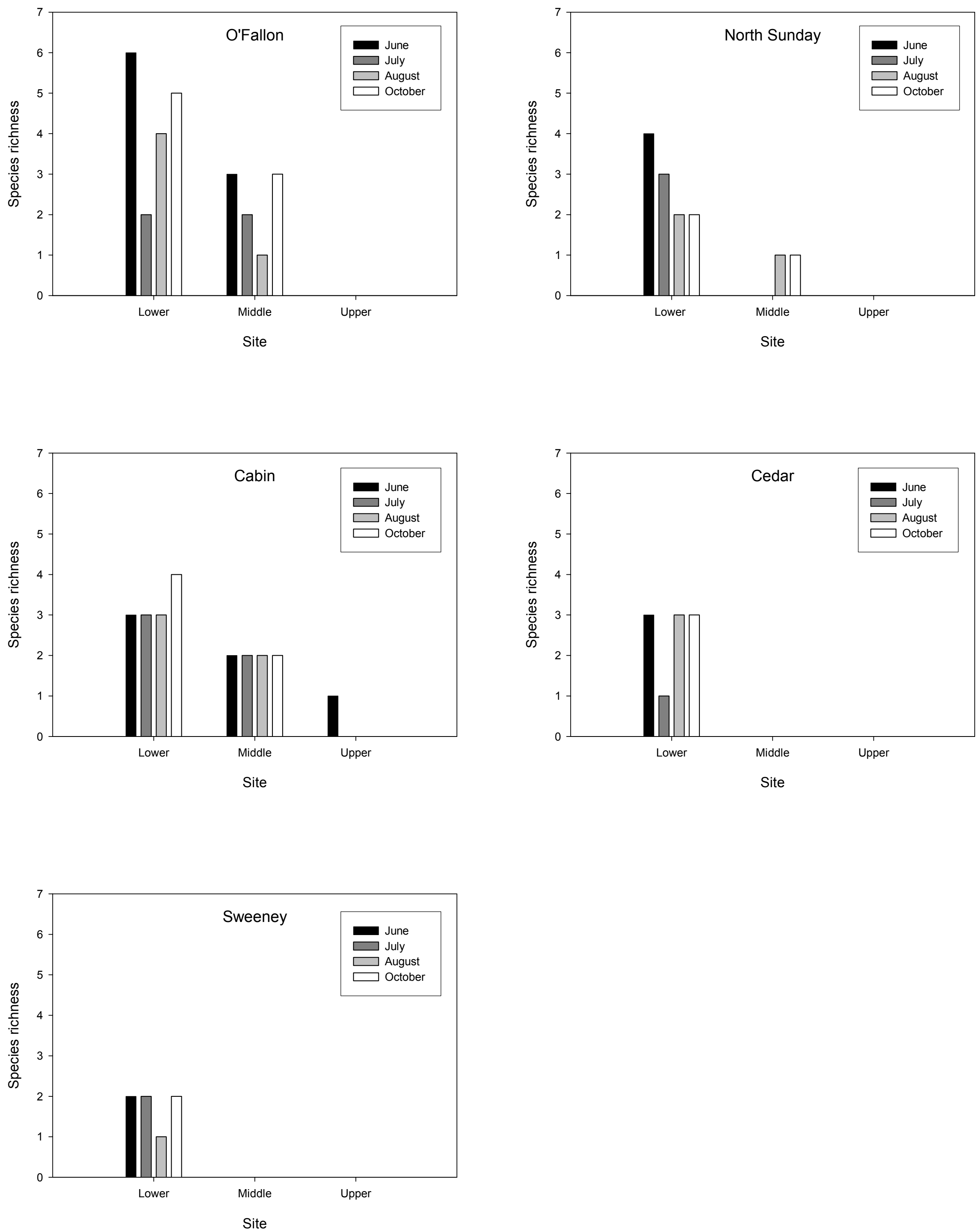

Figure 5. Species richness of main river fishes collected in June, July, August, and October 2005 from five tributaries of the lower Yellowstone River. Streams are organized from largest to smallest, reading from left to right.