PERENNIAL-WARMWATER FISH COMMUNITIES OF THE CHEYENNE RIVER DRAINAGE: A SEASONAL ASSESSMENT

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ABSTRACT

We surveyed fish faunas of perennial-warmwater streams of the Cheyenne River drainage, South Dakota, downstream from Angostura Dam and the Belle Fourche Diversion Dam to describe each fish fauna, including the population structure of characteristic fish species, and to summarize broad-scale spatial and temporal trends in fish distributions. We selected our sample stations based on previous data on habitat conditions and fish distributions and sampled five stations monthly from May through October 2004. We determined the characteristic fish species of each sampling station based on five criteria: persistence, dominance, habitat association, population structure, and tagged recaptures. There was much variation in species composition among streams. Of 24 characteristic species, only stonecat was characteristic of all five stations and only longnose dace was characteristic of four stations. Nine species were characteristic of only one station. This indicates a strong relation between stream type and fish faunal composition. We also documented range contractions of large-river fishes (western silvery minnow, plains minnow, sturgeon chub, flathead chub), which were absent from the Upper Cheyenne River, presumably due to drought and perhaps exacerbated by Angostura Dam upstream. In contrast, plains topminnow and smallmouth bass increased in the Upper Cheyenne River, presumably because they were favored by stable flows. The Cheyenne River drainage downstream from Angostura Dam and the Belle Fourche Diversion Dam in South Dakota has a diverse fish community that is a product of habitat diversity and the absence of physical barriers to dispersal, which allows fishes to respond to changing conditions and locate suitable habitats via dispersal.

Keywords

Fish distributions, population structure, faunal turnover, seasonal change, recruitment

INTRODUCTION

In South Dakota, the distribution of stream fishes is being increasingly well documented (e.g., Hampton and Berry 1997, Doorenbos 1998, Duehr 2004), as is the pattern of species change (or lack thereof) over time, as conditions change (Schmulbach and Braaten 1993, Dieterman and Berry 1994, 1998, Shearer and Berry 2003). However, these studies rely upon data from broad surveys that, in most cases, visited each sample location once. Aside from catch per effort data, these studies usually provide limited information regarding fish populations and they do not incorporate seasonal changes. This is largely because detailed population studies and seasonal (rather than single visit) surveys require relatively high effort. However, as a result, little is known about the population structure of most South Dakota stream fishes.

There have been very few detailed studies of stream fish faunas in South Dakota. A notable exception is Kazmierski (1966), who studied the fishes of Say Brook of the Vermillion River drainage between April and October 1965 and, in so doing, provided much more information for that stream and time than is available for any other South Dakota stream. One obvious advantage that Kazmierski had was that he studied a very small stream that was easy to characterize. It would be beneficial to have detailed information on fish faunas of larger stream systems, but it is difficult to adequately sample such systems intensively due to their size.

In this study, we characterize fish faunas of perennial warmwater streams within the Cheyenne River drainage of South Dakota. Our goal was to provide a detailed summary of fish populations that incorporated seasonal variations and corresponded to differences in habitat conditions. We used previous information on habitat conditions and fish distributions (summarized by Duehr 2004) to select a small number of sample stations that would allow us to sample intensively and yet make generalizations about patterns throughout the study area. Our goal was to accurately represent each fish fauna, including the population structure of each characteristic fish species, and to summarize broad-scale spatial and temporal trends in fish distributions.

METHODS

The Cheyenne River watershed lies entirely within the Great Plains and has an area of 65,398 km^2, primarily in Wyoming and South Dakota, U.S.A. There are two main forks of the Cheyenne River, the Belle Fourche River and Upper Cheyenne River. Both begin in highlands of the western Powder River Basin in northeastern Wyoming and they encircle the Black Hills near the South Dakota–Wyoming border with the Belle Fourche River to the north and Upper Cheyenne River to the south. Downstream, the forks join to form the Lower Cheyenne River. Major dams and reservoirs were constructed on both forks near the Black Hills and additional dams are present on tributary streams within the Black Hills, but there are no major dams downstream from the Black Hills (Figure 1). Thus, Black Hills streams, the two forks, and the Lower Cheyenne River

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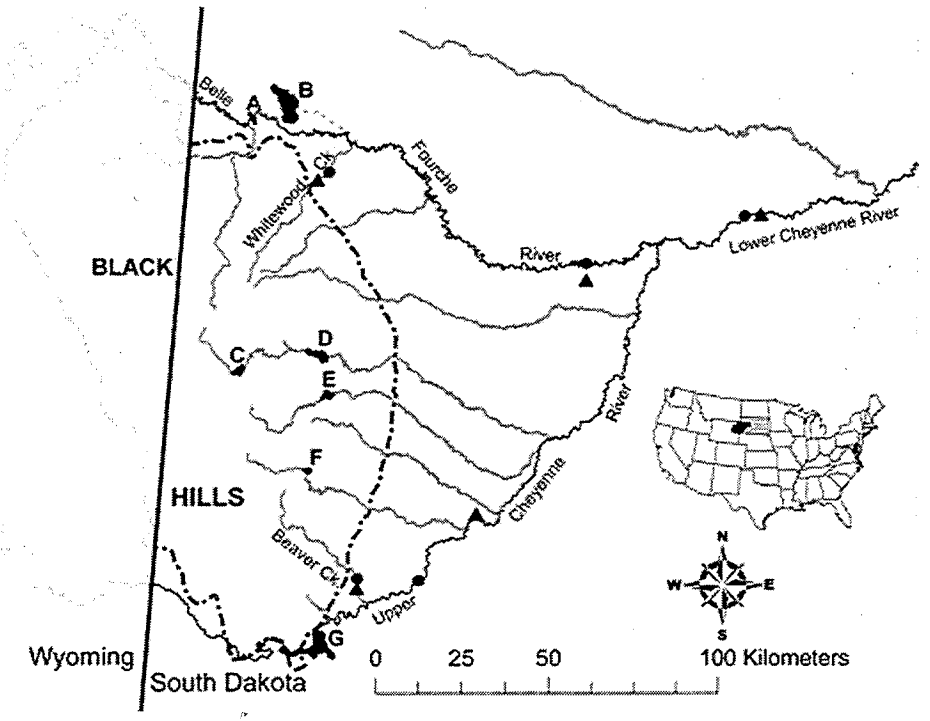

Figure 1. Map of the Cheyenne River watershed of South Dakota, USA with the 48 contiguous United States inset. Circles indicate fish sampling stations and triangles indicate U.S. Geological Survey gaging stations. Letters correspond to dams and reservoirs: A = Belle Fourche Diversion Dam, B = Orman Dam, C = Deerfield Dam, D = Pactola Dam, E = Sheridan Dam, F = Stockade Dam, G = Angostura Dam.

constitute two undammed stream segments. Both segments are approximately 360 km in length.

In a recent study, Duehr (2004) grouped streams of the Cheyenne River drainage into four major categories. We studied the major stream types that were present along both undammed stream segments of the Cheyenne River drainage. The north segment included Whitewood Creek, the Belle Fourche River, and the Lower Cheyenne River. The south segment included Beaver Creek (near Buffalo Gap, South Dakota), the Upper Cheyenne River, and the Lower Cheyenne River. According to the classification of Duehr (2004) Whitewood Creek and Beaver Creek are 'steep streams', the Upper Cheyenne River is a 'flat stream', the Belle Fourche River is a 'small river', and the Lower Cheyenne River is a 'large river'.

Whitewood Creek is the first major tributary that joins the Belle Fourche River below the Belle Fourche Diversion Dam near Belle Fourche, South Dakota. We sampled Whitewood Creek downstream from Whitewood, South Dakota, where it had a width of less than 3 m and maximum depth of less than 2 m. Habitat was primarily a series of riffle-pool sequences and the presence of pools was facilitated by scour below inactive beaver dams. Beaver Creek is the second major tributary that joins the mainstem Upper Cheyenne River below Angostura

Dam, near Hot Springs, South Dakota. It is also depleted by upstream diversions (Burr et al. 1999). We sampled Beaver Creek near Buffalo Gap, South Dakota, where it had riffle-pool habitat, a width of less than 3 m, and maximum depth of less than 2 m. We sampled the Upper Cheyenne River east of Buffalo Gap, South Dakota. The habitat was a series of riffle-pool sequences, river width was roughly 5 to 8 m, and maximum depth was less than 2 m. We sampled the Belle Fourche River near Elm Springs, South Dakota. The habitat was riffle-run-pool, river width was 5 to 8 m, and maximum depth was roughly 2 m. Finally, we sampled the Lower Cheyenne River near Howes, South Dakota. The habitat was run-riffle-pool, river width was roughly 10 m, and maximum depth was less than 2 m, except during high flows in May.

Our study was conducted during a drought period that began in 2001. Based on mean annual discharge in the Lower Cheyenne River (U.S. Geological Survey Gage 06438500), water years 2002 through 2004 were three of the eight driest years on record. During this drought period, mean discharge varied among the streams we studied based on an Analysis of Variance test of $\log_e$-transformed mean daily discharge data ($F = 5013$, $df = 4, 5475$, $P < 0.001$). Beaver Creek had lowest discharge, followed by Whitewood Creek, the Upper Cheyenne River, the Belle Fourche River, and the Lower Cheyenne River (Figure 2). Tukey HSD tests indicated all stream pairs had significantly different mean discharge ($P < 0.001$) except the Upper Cheyenne River and the Belle Fourche River were similar ($P = 0.312$).

We sampled one station on each stream (Figure 1). Stream sites were selected to be representative of each stream type. Fish collections were carried out monthly at all stations from May through October 2004. Fish sampling was conducted using a mesohabitat approach in order to representatively sample fish species (Taylor et al. 1996; Vadas and Orth 1998). We visually identified mesohabitats as regions with relatively uniform water depth and velocity (Jackson 1975) and sampled all available mesohabitats at each station.

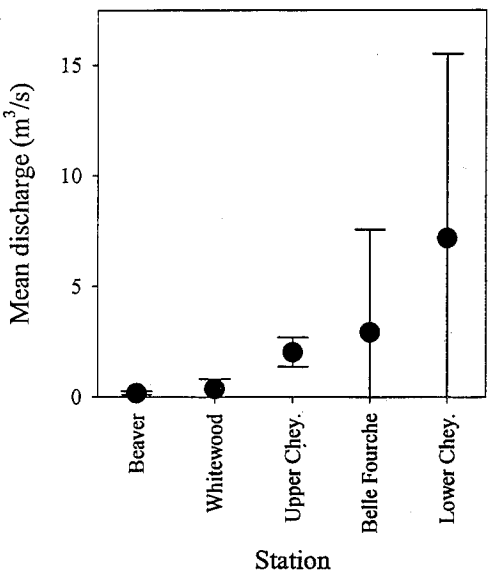

Figure 2. Mean discharge with standard deviation (error bars) for each sampling station based on nearby U.S. Geological Survey gaging stations shown on Figure 1.

Monthly sampling was conducted over a 36-hour period at each station. During each monthly sample we conducted the maximum number of mesohabitat collections possible within the time period. We conducted night seining and electrofishing from May through July and determined that fish assemblage composition did not vary be-

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Monthly sampling was conducted over a 36-hour period at each station. During each monthly sample we conducted the maximum number of mesohabitat collections possible within the time period. We conducted night seining and electrofishing from May through July and determined that fish assemblage composition did not vary between day and night (unpublished data). We used multiple capture methods to collect fishes, depending upon habitat conditions, because our goal was to accurately determine fish species composition (Smith and Hubert 1989; Bramblett and Fausch 1991; Quist et al. 2005b).

Our primary capture method was a flat 3.0 mm mesh minnow seine, 3.7 m in length and fitted with weights every 15.2 cm along the lead line. A 3.0-mm mesh bag seine, 10.6 m in length with one weight every 30.4 cm was used in deep, sluggish pools. A backpack electrofisher (Smith-Root Model LR-24) was used to supplement seine collections from creek stations. Overnight sets of hoop nets with 25.4-mm mesh (bar measure), 0.8 m in diameter and 3.6 m in length, were used in pools and overnight sets of Gee minnow traps with 3.0-mm mesh were used along vegetated stream margins. Light fishing tackle (hook and line) with various live and artificial baits was used in deep, sluggish pools of river stations. Finally, 20-hook trotlines (size 10/0 and 12/0 Circle Sea hooks) baited with chicken gizzards were used in deep, sluggish pools of river stations. Fish collection effort included at least four capture methods at each station (Table 1). All fishes were identified and measured to the nearest 1.0 mm standard length (SL). Except for voucher specimens, all fishes were released alive. We floy tagged all fishes that were at least 250 mm standard length so that we could identify recaptured individuals.

We identified characteristic fish species of each stream using five criteria: (1) the species was persistent, being present in at least 5 of 6 monthly collections,

Table 1. Total sampling effort for each study station by gear type. Sampling gears included a 3.7-m long flat seine with 3.0-mm mesh and lead weights every 15.2 cm, a 10.6-m long bag seine with 6.0-mm mesh, a battery powered backpack electrofisher, 25.4-mm mesh bar measure mini hoop nets that were 3.6 m long with 0.8-m hoops, Gee minnow traps with 3.0-mm mesh, light fishing tackle with artificial lures and earthworms, and 20-hook trot lines, size 10/0 to 12/0 Circle Sea hooks, baited with chicken gizzards. Stations are ordered by mean discharge.

STUDY STATION	FLAT SEINE (m^2)	BAG SEINE (m^2)	ELECTRO-FISHING (HOURS)	HOOP NET (HOURS)	MINNOW TRAP (HOURS)	FISHING POLE (HOURS)	TROT LINE (HOURS)
Beaver Creek	6,073.9	0.0	3.2	49.7	86.1	0.0	0.0
Whitewood Creek	4,274.2	0.0	3.9	112.0	114.6	0.0	0.0
Upper Cheyenne River	9,376.3	7,466.8	0.0	299.0	364.7	52.4	57.0
Belle Fourche River	3,732.8	2,428.5	0.0	415.3	498.9	43.5	165.0
Lower Cheyenne River	10,420.2	4,822.1	0.0	379.9	282.4	4.5	153.0

(2) the species was dominant within collections, representing at least 1% of all individuals collected, (3) habitat occupancy was predictable, that is, the presence of a species in a given habitat was consistent among sampling trips, (4) the population of each species included multiple length classes, indicating that multiple age-groups were present, and (5) tagged individuals were recaptured. We considered a species to be characteristic of a station if it fit at least three of the five criteria. We calculated percent shared characteristic species among streams as the number of unshared species divided by the total number of species, multiplied by 100 (Russell 1998). We assembled a summary of the distribution and length structure of each characteristic species among our study streams. If characteristic species were represented by more than 50 individuals in multiple streams, we compared standard length structure using Analysis of Variance to compare means, with Tukey Honestly Significant Difference tests for post-hoc pairwise comparisons and we used two-sample Kolmogorov-Smirnoff tests to compare standard length distributions (Sokal and Rohlf 1995).

RESULTS AND DISCUSSION

We collected a total of 18,690 fish of 28 species. White sucker *Catostomus commersonii*, stonecat *Noturus flavus*, and green sunfish *Lepomis cyanellus* were present in all five stations. Species richness increased with stream size (mean discharge, Figure 3). The number of characteristic species also increased with stream size (Tables 2– 6), except Whitewood Creek had fewer characteristic species (5) than Beaver Creek (7). High percent-unshared species (> 40%) among all streams indicated high species turnover (Table 7).

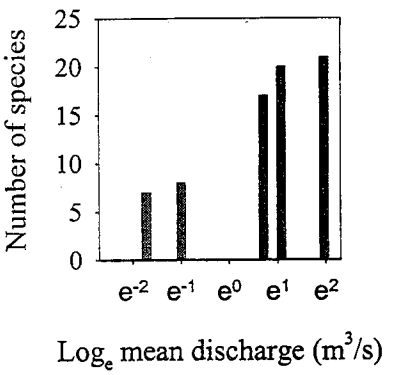

Figure 3. Fish species richness for each sampling station by mean discharge (Figure 2). Stations are (from left to right) Beaver Creek, Whitewood Creek, Upper Cheyenne River, Belle Fourche River, and Lower Cheyenne River.

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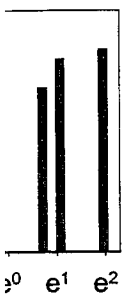

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Table 2. Characteristic fishes of Whitewood Creek near Whitewood, South Dakota. A total of 4,769 fish was collected. Five criteria were used to define characteristic fishes: persistence (percent presence > 80%), dominance (percent species composition > 1%), predictable habitat association, presence of multiple length groups, recapture (recap.) of floy-tagged individuals (percent recapture rate). Species that fit three or more of the five criteria were considered characteristic inhabitants of Whitewood Creek. NA = not applicable (no fish tagged).

SPECIES	PRESENCE (%)	DOMINANCE (%)	HABITAT	LENGTH-GROUPS	RECAP. (%)
Fathead minnow *Pimephales promelas*	83	6	Pools	2	NA
Longnose dace *Rhinichthys cataractae cataractae*	100	41	All	2	NA
Creek chub *Semotilus atromaculatus*	100	49	All	3+	NA
White sucker *Catostomus commersonii*	100	1	Pools	3+	4
Stonecat *Noturus flavus*	100	< 1	Riffles	2	NA

Table 3. Characteristic fishes of Beaver Creek near Buffalo Gap, South Dakota. A total of 3,058 fish was collected. Five criteria were used to define characteristic fishes: persistence (percent presence > 80%), dominance (percent species composition > 1%), predictable habitat association, presence of multiple length groups, recapture (recap.) of floy-tagged individuals (percent recapture rate). Species that fit three or more of the five criteria were considered characteristic inhabitants of Beaver Creek. NA = not applicable (no fish tagged).

SPECIES	PRESENCE (%)	DOMINANCE (%)	HABITAT	LENGTH-GROUPS	RECAP. (%)
Longnose dace *Rhinichthys cataractae cataractae*	100	21	All	2+	NA
Creek chub *Semotilus atromaculatus*	100	60	All	3+	NA
White sucker *Catostomus commersonii*	100	13	Pools	4+	16
Mountain sucker *Catostomus platyrhynchus*	83	1	All	2+	NA
Stonecat *Noturus flavus*	100	1	All	2+	NA
Plains topminnow *Fundulus sciadicus*	100	3	Pools	2	NA
Green sunfish *Lepomis cyanellus*	100	2	Pools	3+	NA

Table 4. Characteristic fishes of the Upper Cheyenne River near Buffalo Gap, South Dakota. A total of 1,721 fish was collected. Five criteria were used to define characteristic fishes: persistence (percent presence > 80%), dominance (percent species composition > 1%), predictable habitat association, presence of multiple length groups, recapture (recap.) of floy-tagged individuals (percent recapture rate). Species that fit three or more of the five criteria were considered characteristic inhabitants of the Upper Cheyenne River. NA = not applicable (no fish tagged).

SPECIES	PRESENCE (%)	DOMINANCE (%)	HABITAT	LENGTH-GROUPS	RECAP. (%)
Goldeye *Hiodon alosoides*	100	3	Pools	1+	10
Red shiner *Cyprinella lutrensis lutrensis*	100	20	Runs	2	NA
Common carp *Cyprinus carpio*	83	1	Pools	2	0
Plains sand shiner *Notropis stramineus missuriensis*	100	25	Runs	2	NA
Shorthead redhorse *Moxostoma macrolepidotum*	100	22	All	3+	0
Stonecat *Noturus flavus*	100	3	Riffles	2+	NA
Plains topminnow *Fundulus sciadicus*	100	5	Pools	2	NA
Smallmouth bass *Micropterus dolomieu*	100	18	All	3+	9%

Table 5. Characteristic fishes of the Belle Fourche River near Elm Springs, South Dakota. A total of 5,609 fish was collected. Five criteria were used to define characteristic fishes: persistence (percent presence > 80%), dominance (percent species composition > 1%), predictable habitat association, presence of multiple length groups, recapture (recap.) of floy-tagged individuals (percent recapture rate). Species that fit three or more of the five criteria were considered characteristic inhabitants of the Belle Fourche River. NA = not applicable (no fish tagged).

SPECIES	PRESENCE (%)	DOMINANCE (%)	HABITAT	LENGTH-GROUPS	RECAP. (%)
Goldeye *Hiodon alosoides*	83	< 1	Pools	1	17
Red shiner *Cyprinella lutrensis lutrensis*	100	38	Runs	2	NA
Plains sand shiner *Notropis stramineus missuriensis*	100	33	Runs	2	NA
Flathead chub *Platygobio gracilis*	100	5	Runs, pools	2+	NA
Longnose dace *Rhinichthys cataractae cataractae*	100	4	Riffles	2	NA
Shorthead redhorse *Moxostoma macrolepidotum*	100	4	Runs, Pools	3+	0
Channel catfish *Ictalurus punctatus*	100	9	Runs, Pools	4+	0
Stonecat *Noturus flavus*	100	2	Riffles	2+	NA
Northern plains killifish *Fundulus kansae*	100	1	Backwaters	2	NA

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II- CE	HABITAT	LENGTH-GROUPS	RECAP. (%)
	Pools	1+	10
	Runs	2	NA
	Pools	2	0
	Runs	2	NA
	All	3+	0
	Riffles	2+	NA
	Pools	2	NA
	All	3+	9%

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II- CE)	HABITAT	LENGTH-GROUPS	RECAP. (%)
	Pools	1	17
	Runs	2	NA
	Runs	2	NA
	Runs, pools	2+	NA
	Riffles	2	NA
	Runs, Pools	3+	0
	Runs, Pools	4+	0
	Riffles	2+	NA
	Backwaters	2	NA

Table 6. Characteristic fishes of the Lower Cheyenne River near Four Corners, South Dakota. A total of 3,533 fish was collected. Five criteria were used to define characteristic fishes: persistence (percent presence > 80%), dominance (percent species composition > 1%), predictable habitat association, presence of multiple length groups, recapture (recap.) of floy-tagged individuals (percent recapture rate). Species that fit three or more of the five criteria were considered characteristic inhabitants of the Lower Cheyenne River. NA = not applicable (no fish tagged).

SPECIES	PRES-ENCE (%)	DOMI-NANCE (%)	HABITAT	LENGTH-GROUPS	RECAP. (%)
Red shiner *Cyprinella lutrensis lutrensis*	100	3	Pools	1	NA
Plains minnow *Hybognathus placitus*	100	5	Pools	2	NA
Sturgeon chub *Macrhybopsis gelida*	100	1	Riffles	2	NA
Plains sand shiner *Notropis tramineus missuriensis*	100	12	Runs	2	NA
Flathead chub *Platygobio gracilis*	100	48	All	3	NA
Longnose dace *Rhinichthys cataractae cataractae*	100	10	Riffles	2+	NA
Northern river carpsucker *Carpiodes carpio carpio*	100	1	Backwaters	2+	0
Shorthead redhorse *Moxostoma macrolepidotum*	100	2	Pools	2+	0
Channel catfish *Ictalurus punctatus*	100	14	Runs, pools	5+	0
Stonecat *Noturus flavus*	100	1	Riffles	2	NA

Table 7. Percent unshared characteristic species (unshared species / total species) among streams.

STREAM	WHITEWOOD	UPPER CHEYENNE	BELLE FOURCHE	LOWER CHEYENNE
Beaver	50	85	86	87
Whitewood		92	83	85
Upper Cheyenne			58	71
Belle Fourche				42

Characteristic Species Accounts

Goldeye *Hiodon alosoides*—The goldeye was a characteristic species of the Upper Cheyenne and Belle Fourche river stations (Tables 4 and 5), where it inhabited large pools. It was also present, but rare, in the Lower Cheyenne River station (n = 1, 339 mm SL). The goldeye was difficult to capture by seine or net, but was relatively easy to capture by hook and line (Hoagstrom 2006). Given that young-of-year goldeye are normally less than 170 mm total length (Harlan and Speaker 1951, Kennedy and Sprules 1967, Brown 1971, Smith 1979, Trautman 1981, Becker 1983) all goldeye we collected were either juveniles or adults (Figure 4).

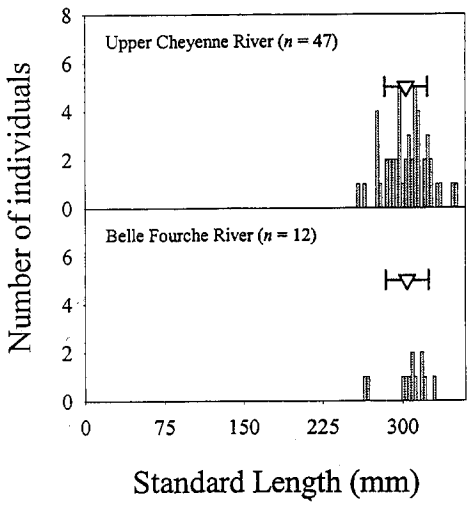

Figure 4. Length frequency histograms (3 mm categories) for the goldeye at sampling stations where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

The goldeye is widespread throughout central North America where it occupies large lakes and rivers (Scott and Crossman 1973, Trautman 1981, Becker 1983). It is widespread in the Cheyenne River drainage being present in large river and small stream habitats (Duehr 2004). The goldeye was the only characteristic fish species for which there was no sign of local spawning and recruitment. No young-of-year were collected and neither ripe females nor males were observed. Goldeye commonly undertake spawning migrations into tributary streams of lakes and large rivers (Scott and Crossman 1973, Eddy and Underhill 1974, Trautman 1981, Nelson and Paetz 1992). Lake Oahe goldeye primarily spawn in tributary rivers and goldeye eggs have been collected as far as 170 km upstream in the Cheyenne River (Nelson 1980). Elsewhere after spawning, adults reportedly continue to move upstream and feed (Scott and Crossman 1973). Perhaps the goldeye of the Upper Cheyenne River and Belle Fourche River were adults that moved upstream to feed after spawning further downstream in the Cheyenne River drainage or else their eggs and larvae were displaced downstream (June 1977). Nelson (1980) reported relatively high densities of larval goldeye in 1972-1975 from the mouth of the Cheyenne River.

Red shiner *Cyprinella lutrensis lutrensis*—The red shiner was a characteristic species of the Upper Cheyenne, Belle Fourche, and Lower Cheyenne river stations (Tables 4 through 6) and used all habitat types. It was absent in Beaver and Whitewood creek stations. Multiple age groups were present in all three rivers. Males in breeding coloration and gravid females were present in the Upper Cheyenne and Belle Fourche rivers. Young-of-year and adult red shiners were

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present at each river station, but population structure appeared to vary by river size, with larger adults present in the Upper Cheyenne River (Figure 5). Mean SL varied significantly among rivers (F = 187.7, df = 2, 2601, $P < 0.01$) with significant pairwise differences between all river station pairs (PMD > |4.4|, P < 0.01 for all comparisons). Standard length distributions were also significantly different for all pairwise comparisons ($D > 0.25$, $P < 0.01$).

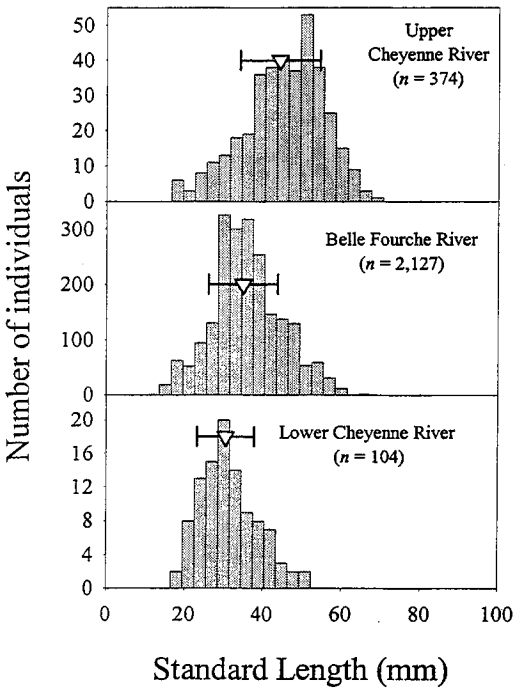

Figure 5. Length frequency histograms (3 mm categories) for the red shiner at sampling stations where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

The red shiner is widespread throughout south-central North America (Matthews 1987). It is one of the most widespread and abundant species in the Cheyenne River drainage (Newman et al. 1999, Duehr 2004). It is a highly tolerant generalist species that is most successful in medium-sized streams (Cross 1967, Baxter and Stone 1995). Absence of red shiner from Beaver and Whitewood creeks and prevalence in the medium-sized Upper Cheyenne and Belle Fourche rivers, support these generalizations as well as those of previous studies (Hampton and Berry 1997, Doorenbos 1998, Duehr 2004). The relatively small size distribution in the Lower Cheyenne River suggests larger river conditions were less favorable for red shiners.

Common carp *Cyprinus carpio*—The common carp was a characteristic species in the Upper Cheyenne River station (Table 4), where it occupied pools. It was also captured from the Belle Fourche (n = 15, mean SL = 103 mm ± 126.3 mm SD) and Lower Cheyenne (n = 30, mean SL = 98 mm ± 146.1 mm SD) river stations and large adults were observed but never captured from the Beaver Creek station. The Upper Cheyenne River population included young-of-year and adults (Figure 6).

The common carp is not native to North America, but is widespread due to introductions and subsequent range expansions (Trautman 1981, Becker 1983). The common carp is widespread in the Cheyenne River drainage, but is not typically abundant (Duehr 2004). Several factors may account for this. The species is commonly associated with organic pollution (Cross 1967, Trautman 1981), which is relatively uncommon in the Cheyenne River drainage, due to the low density of the human population. Also, common carp spawn in shallow water

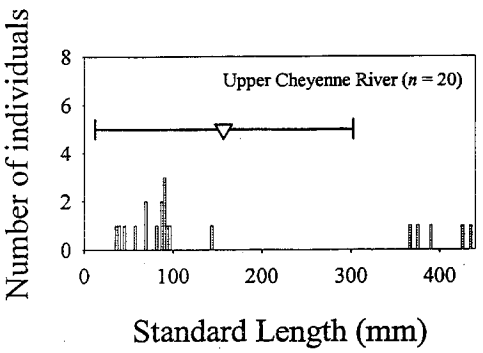

Figure 6. Length frequency histogram (3 mm categories) for the common carp at the sampling station where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

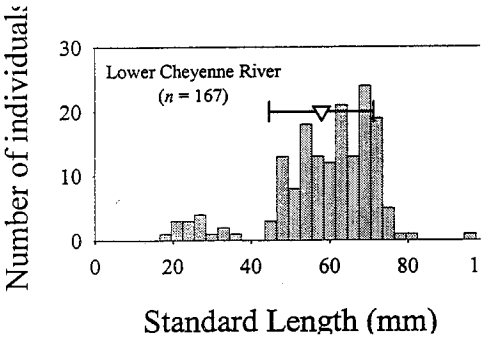

Figure 7. Length frequency histogram (3 mm categories) for the plains minnow at the sampling station where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

with emergent vegetation, which provides suitable nursery habitat for the young (Becker 1983), but it is uncommon in the Cheyenne River drainage.

Plains minnow *Hybognathus placitus*—The plains minnow was a characteristic species in the Lower Cheyenne River station (Table 6) where it occupied pools. It was absent from all other stations. The Lower Cheyenne River population included young-of-year and adults (Figure 7). On the night of 26 May 2004 (between 2300 and 0100 hours), we captured 15 plains minnow and numerous pelagic eggs similar to those produced by plains minnow (Sliger 1967) from a pool in the Lower Cheyenne River. This suggests that spawning was occurring at our sampling station and the subsequent presence of young-of-year suggests recruitment occurred as well.

The plains minnow ranges throughout the Great Plains (Al-Rawi and Cross 1964). It is typical of large plains rivers (Cross 1967), but has also been collected from small tributary streams of the Cheyenne River drainage (Duehr 2004). It was widespread in the Upper Cheyenne River and Belle Fourche River during 1996 and 1997 (Hampton and Berry 1997, Doorenbos 1998), prior to the drought. This species has experienced widespread declines (Cross and Moss 1987, Pflieger and Grace 1987, Hesse et al. 1993, Patton et al. 1998) that are related to dewatering, habitat degradation, and population fragmentation caused by river impoundments (Cross and Moss 1987, Winston et al. 1991, Wilde and Ostrand 1999, Bonner and Wilde 2000, Quist et al. 2004b). Disappearance from the Upper Cheyenne and Belle Fourche Rivers between 1997 and 2004 suggests that drought conditions decreased habitat suitability.

Sturgeon chub *Macrhybopsis gelida*— Like plains minnow, the sturgeon chub was a characteristic species in the Lower Cheyenne River station (Table 6), where it was restricted to riffle and run habitats. It was absent from all other stations. The Lower Cheyenne River population included young-of-year and adults (Figure 8). We collected a gravid female sturgeon chub on 19 July 2004,

with emergent vegetation, which provides suitable nursery habitat for the young (Becker 1983), but it is uncommon in the Cheyenne River drainage.

Plains minnow *Hybognathus placitus*—The plains minnow was a characteristic species in the Lower Cheyenne River station (Table 6) where it occupied pools. It was absent from all other stations. The Lower Cheyenne River population included young-of-year and adults (Figure 7). On the night of 26 May 2004 (between 2300 and 0100 hours), we captured 15 plains minnow and numerous pelagic eggs similar to those produced by plains minnow (Sliger 1967) from a pool in the Lower Cheyenne River. This suggests that spawning was occurring at our sampling station and the subsequent presence of young-of-year suggests recruitment occurred as well.

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which along with the presence of young-of-year, suggests spawning and recruitment occurred at our sampling station.

The sturgeon chub is known from the Missouri River drainage and the lower Mississippi River (Werdon 1993). In the Missouri River drainage, it is restricted to rivers (Cross 1967, Brown 1971, Reigh and Elsen 1979). It was present in the Upper Cheyenne River during 1996 and 1997 (Hampton and Berry 1997), indicating that drought conditions caused a range contraction, similar to the range contraction of plains minnow. The sturgeon chub has declined from 45% of its native range (Bicknell 2001), presumably due to impoundments that inundate river valleys, fragment populations, alter downstream flow regimes, dewater downstream river reaches, and eliminate downstream sediment transport (Hesse et al. 1993, Kelsch 1994, Everett et al. 2004, Quist et al. 2004b, Welker and Scarnecchia 2004). Sturgeon chub disappeared from the Little Missouri during a drought, probably because a mainstem Missouri River reservoir (Lake Sakakawea) isolated the population (Kelsch 1994). If so, the sturgeon chub of the Cheyenne River could be at risk because they are isolated by Lake Oahe and their distribution has been reduced during the recent drought.

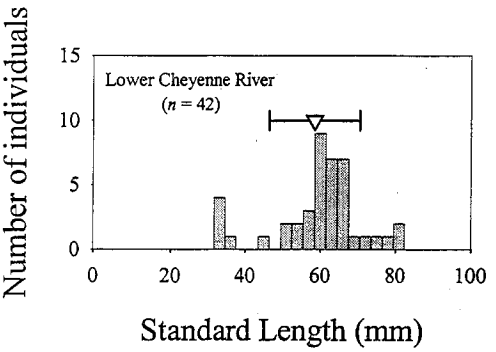

Figure 8. Length frequency histogram (3 mm categories) for the sturgeon chub at the sampling station where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

Plains sand shiner *Notropis stramineus missuriensis*—We analyzed sub-samples of collection for our sample stations and voucher specimens from collections throughout the Cheyenne River drainage (Table 8) to determine whether sand shiners fit descriptions of the plains subspecies (Bailey and Allum 1962, Metcalf 1966, Tanyolaç 1973). Average measurements fell within the ranges reported for plains sand shiner (Figure 9), but there was substantial variation of each character and some individuals were within ranges reported for the eastern sand shiner *Notropis stramineus stramineus* for each character.

The plains sand shiner was a characteristic species in the Upper Cheyenne, Belle Fourche, and Lower Cheyenne river stations (Tables 4-6) and it used primarily riffle and run habitats. It was not present in the Beaver or Whitewood creek stations. Multiple age groups and gravid females were present in all three rivers. Young-of-year and adult plains sand shiners were present at each river station, but population structure appeared to vary by river size, with larger adults present in the Upper Cheyenne River, but more young-of-year in the Belle Fourche River (Figure 10). Mean SL varied significantly among rivers ($F = 70.7$, df = 2, 2711, $P < 0.01$). It was significantly higher in the Upper Cheyenne River than in the Belle Fourche and Lower Cheyenne rivers (PMD > |5.5|, $P < 0.01$ for both comparisons), but similar between the Belle Fourche and Lower Cheyenne

Table 8. Summary of **Notropis stramineus missouriensis** *specimens by location within the Cheyenne River drainage, South Dakota.*

NO.	LOCATION	DATE	N	Standard Length (mm)		
				MIN.	MEDIAN	MAX.
1	Indian Creek[1], Mud Butte	7-23-96	11	41	49	53
2	Horse Creek[1], Newell	8-5-96	7	41	50	55
3	Willow Creek[1], Newell	8-12-96	6	43	54	58
4	Spring Creek[1], Sturgis	7-28-98	5	48	68	73
5	Spring Creek[4], Bear Butte Creek	6-3-04	62	38	51	61
6	Alkali Creek[1], Hereford	8-11-98	10	40	45	51
7	East Elm Creek[1], Union Center	8-12-98	1		58	
8	Elm Creek[4], Hereford	5-18-04	1		42	
9	Belle Fourche River[3]	7-15-96	6	52	55	58
10	Belle Fourche River, Elm Springs	5-24-04	54	25	38	59
11	Beaver Creek[4], Burdock	7-15-04	6	51	53	56
12	Cottonwood Creek[4], Edgemont	6-28-04	2	36		42
13	Fall River,[4] Hot Springs	6-28-04	5	54	57	64
14	Cheyenne River, Buffalo Gap	5-22-04	48	34	41	53
15	Battle Creek[4], Hermosa	6-27-04	55	39	44	50
16	Rapid Creek[4], Farmingdale	6-22-04	61	40	53	61
17	Cheyenne River or Rapid Creek[2]	8-1-94	8	40	48	67
18	Elk Creek[1], New Underwood	7-29-98	9	44	56	66
19	Elk Creek[4], Elm Springs	5-25-04	39	24	50	60
20	Sulphur Creek[4], Castle Rock	5-30-03	3	50	52	53
21	Cheyenne River, Howes	5-26-04	46	25	37	50

[1]Collections by J. Erickson, South Dakota Game Fish and Parks
[2]Collections by Cunningham et al. (1995)
[3]Collections by Doorenbos (1998)
[4]Collections by Duehr (2004)

rivers (PMD = -0.8, $P = 0.27$). Standard length distributions were significantly different for all pairwise comparisons ($D > 0.14$, $P < 0.01$).

The plains sand shiner inhabits shallow streams and rivers of the Great Plains that have permanent flow (Cross 1967, Brown 1971). It is widespread and abundant throughout the Cheyenne River drainage (Duehr 2004). High prevalence in the Upper Cheyenne and Belle Fourche rivers compared to the Lower Cheyenne River is consistent with previous studies (Hampton and Berry 1997, Doorenbos 1998) and similar to the red shiner. Absence from Whitewood Creek is consistent with former studies (Newman et al. 1999), but Whitewood Creek was heavily polluted prior to the earliest fish surveys (Evermann and Cox 1896). Plains sand shiners were historically present in Beaver Creek (Bailey and Allum 1962).

souriensis specimens by location within the

ATE	N	Standard Length (mm)		
		MIN.	MEDIAN	MAX.
3-96	11	41	49	53
5-96	7	41	50	55
2-96	6	43	54	58
8-98	5	48	68	73
3-04	62	38	51	61
1-98	10	40	45	51
2-98	1		58	
8-04	1		42	
5-96	6	52	55	58
4-04	54	25	38	59
5-04	6	51	53	56
8-04	2	36		42
8-04	5	54	57	64
2-04	48	34	41	53
7-04	55	39	44	50
2-04	61	40	53	61
1-94	8	40	48	67
9-98	9	44	56	66
5-04	39	24	50	60
0-03	3	50	52	53
6-04	46	25	37	50

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Fathead minnow *Pimephales promelas*—The fathead minnow was a characteristic species in the Whitewood Creek station (Table 2) where it occupied pools. It was also present in the Upper Cheyenne (n = 1, 64 mm SL), Belle Fourche (n = 41, mean SL = 35 mm ± 8.2 mm SD) and Lower Cheyenne (n = 1, 42 mm SL) river stations. Multiple length classes were present in Whitewood Creek including young-of-year (Figure 11).

The fathead minnow is widespread throughout North America (Trautman 1981, Becker 1983) and is abundant throughout the Great Plains (Cross 1967). It is common throughout the Cheyenne River drainage and most abundant in small streams (Newman et al. 1999, Duehr 2004). However, it has never been taken from Beaver Creek (Bailey and Allum 1962, Duehr 2004). The fathead minnow is a pioneering species and is tolerant of degraded habitat conditions including flow intermittence and pollution (Cross 1967, Trautman 1981). It is also dispersed by humans as a common baitfish, is commonly introduced to lakes and ponds as forage for sport-fish, and is sometimes stocked to fishless waters for mosquito control (Eddy and Underhill 1974, Trautman 1981, Becker 1983). Reportedly, the fathead minnow is a poor competitor and is usually most abundant in streams where few other species are present (Hubbs and Cooper 1936, Cross 1967). It is also highly susceptible to predation (Hubbs and Cooper 1936, Becker 1983).

Flathead chub *Platygobio gracilis*—The flathead chub was a characteristic species of the Belle Fourche and Lower Cheyenne river stations (Tables 5 and 6), using all habitat types. It was absent from all other stations. Both populations included multiple length classes,

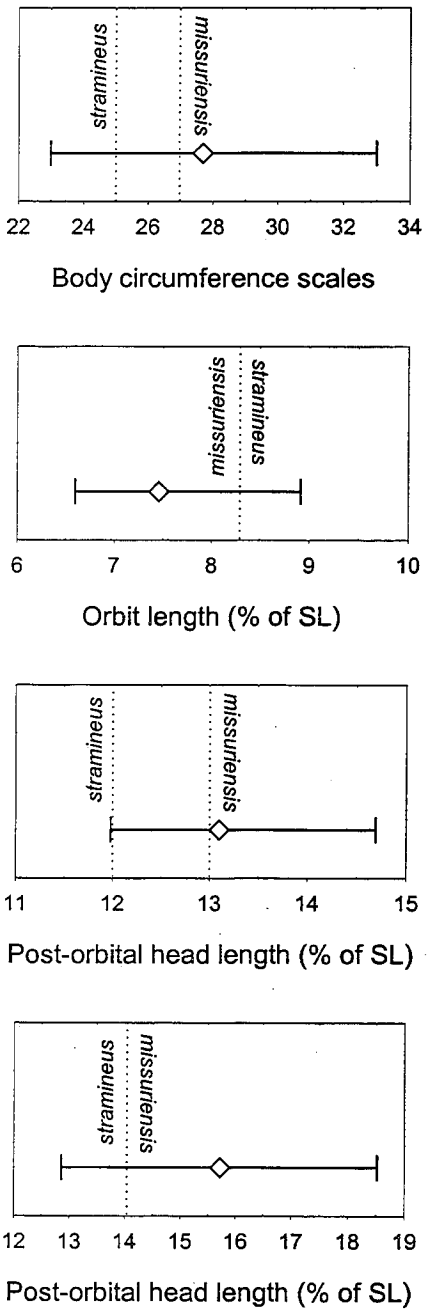

Figure 9. Mean and total range (error bars) of counts and measures from sand shiners of the Cheyenne River drainage (Table 8). The division between sand shiner subspecies is shown for each character.

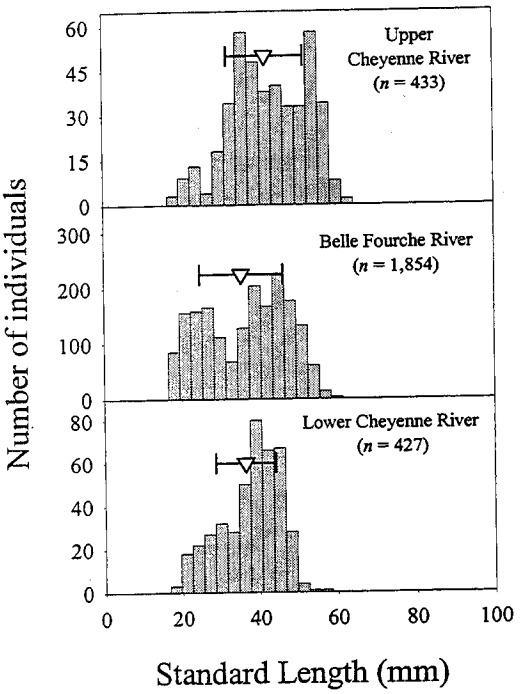

Figure 10. Length frequency histograms (3 mm categories) for the plains sand shiner at sampling stations where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

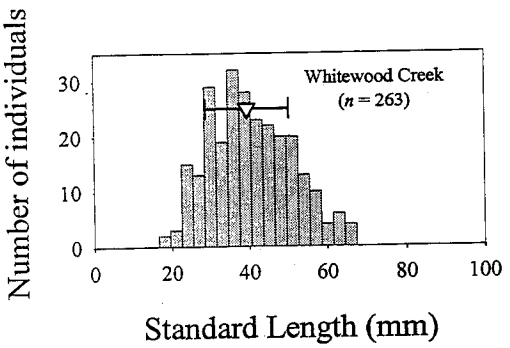

Figure 11. Length frequency histogram (3 mm categories) for the fathead minnow at the sampling station where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

including young-of-year, but there were more large adults in the Belle Fourche River (Figure 12). Mean SL varied significantly between stations (F = 21.0, df = 1, 2007, $P < 0.01$). It was significantly higher in the Upper Cheyenne River than in the Belle Fourche and Lower Cheyenne rivers (PMD = 6.0, $P < 0.01$). Standard length distributions were also significantly different ($D > 0.19$, $P < 0.01$).

The flathead chub is widespread across the Great Plains where it occupies permanent streams (Olund and Cross 1961, Brown 1971, Nelson and Paetz 1992). In the Cheyenne River drainage, it is most abundant in rivers, but is sometimes present in smaller streams (Bailey and Allum 1962, Duehr 2004). The species is unknown from Whitewood and Beaver creeks, but was formerly present throughout the Upper Cheyenne River (Bailey and Allum 1962, Hampton and Berry 1997). The flathead chub has declined throughout much of its range due to habitat modifications caused by dams and channelization (Cross and Moss 1987, Pflieger and Grace 1987, Hesse et al. 1993, Quist et al. 2004b, Welker and Scarnecchia 2004). The apparent range contraction we observed between 1997 and 2004 suggests that the Upper Cheyenne River was less suitable for the flathead chub during drought.

Longnose dace *Rhinichthys cataractae cataractae*—The longnose dace was a characteristics species in Beaver Creek, Whitewood Creek, the Belle Fourche River, and the Lower Cheyenne River stations (Tables 2, 3, 5, and 6), but was absent

including young-of-year, but there were more large adults in the Belle Fourche River (Figure 12). Mean SL varied significantly between stations (F = 21.0, df = 1, 2007, $P < 0.01$). It was significantly higher in the Upper Cheyenne River than in the Belle Fourche and Lower Cheyenne rivers (PMD = 6.0, $P < 0.01$). Standard length distributions were also significantly different ($D > 0.19$, $P < 0.01$).

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cataractae—The longnose dace was a ewood Creek, the Belle Fourche River, ables 2, 3, 5, and 6), but was absent

from the Upper Cheyenne River station. In the creeks, longnose dace used all habitats, but in the rivers, they were mostly restricted to riffles. All four populations included young-of-year and adults, but the Whitewood Creek population appeared to have less length-class diversity compared to other stations (Figure 13). Spawning coloration was observed at all four stations. Mean SL varied significantly between stations (F = 120.7, df = 3, 3201, $P < 0.01$). It was significantly higher in Beaver Creek than all other stations (PMDs > |6.9|, $P < 0.01$), but mean SL of the Belle Fourche River station was similar to Whitewood Creek (PMD = -0.5, P = 0.89) and the Lower Cheyenne River (PMD = -2.0, P = 0.12). Mean SL in the Lower Cheyenne River was higher than in Whitewood Creek (PMD = -2.5, $P < 0.01$). Nevertheless, standard length distributions varied among all stations ($D > 0.14$, $P < 0.01$).

The longnose dace is one of the most widely distributed fishes in North America and typically inhabits swift streams or turbulent habitats of larger rivers (e.g., riffles) and lakes (e.g., wave swept shorelines; Scott and Crossman 1973, Trautman 1981, Becker 1983). It is common throughout the Cheyenne River drainage and most abundant in steep streams (Newman et el. 1999, Duehr 2004). The longnose dace was present in the Upper Cheyenne River near our sampling station as recently as 1996 and 1997 (Hampton and Berry 1997). This suggests a range contraction that parallels apparent range contractions for plains minnow, sturgeon chub, and flathead chub and is presumably due to drought conditions.

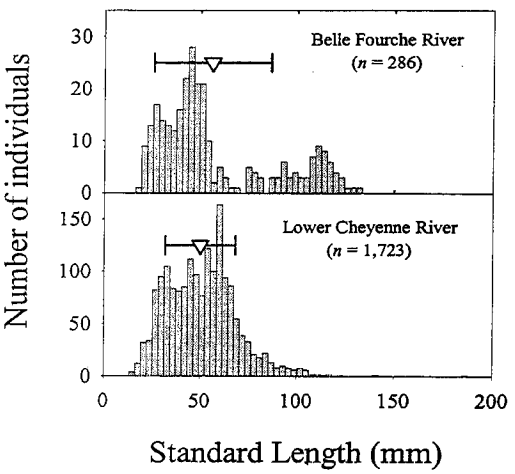

Figure 12. Length frequency histograms (3 mm categories) for the flathead chub at sampling stations where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

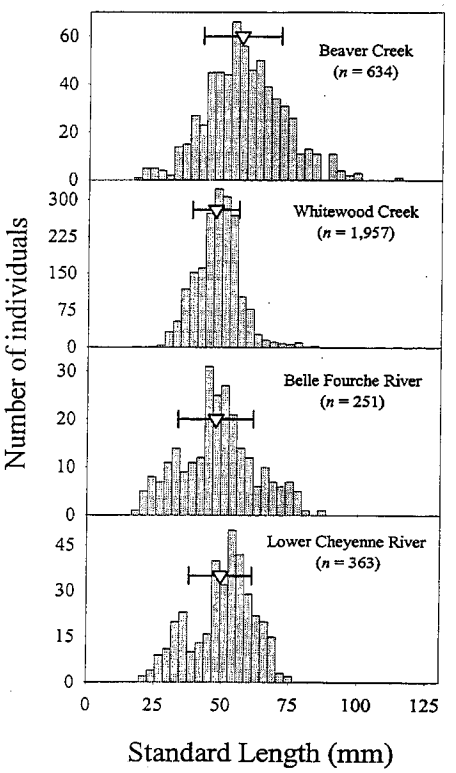

Figure 13. Length frequency histograms (3 mm categories) for the longnose dace at sampling stations where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

Creek chub *Semotilus atromaculatus*—The creek chub was a characteristic species in the Beaver Creek and Whitewood Creek stations (Tables 2 and 3), where it primarily occupied pools. Multiple length groups, including young-of-year, were present at each station. Young-of-year dominated the Whitewood Creek station whereas multiple length groups were important in Beaver Creek. As a result, mean SL was significantly higher in Beaver Creek (F = 1133.9, df = 1, 4145, $P < 0.01$; PMD = -25.3, $P < 0.01$) and standard length distributions varied between stations (D = 0.58, $P < 0.01$). The creek chub was also present, but rare, in the Upper Cheyenne (n = 5, mean SL = 49 mm ± 9.3 mm SD) and Belle Fourche (n = 3, mean SL = 58 mm ± 8.5 mm SD) river stations.

The creek chub is widespread and common in small streams throughout eastern North America (Cross 1967, Scott and Crossman 1973, Trautman 1981, Becker 1983). It has a patchy but broad distribution in the Cheyenne River drainage (Newman et al. 1999, Duehr 2004). The creek chub is able to disperse rapidly and dispersing individuals are often present as strays in atypical habitats such as large rivers (Cross 1967) and lakes (Trautman 1981). This behavior presumably accounts for the creek chubs we collected from our Upper Cheyenne and Belle Fourche river stations. The creek chub is highly tolerant of pollution (Ellis 1914, Becker 1983) and stream channelization (Trautman 1981).

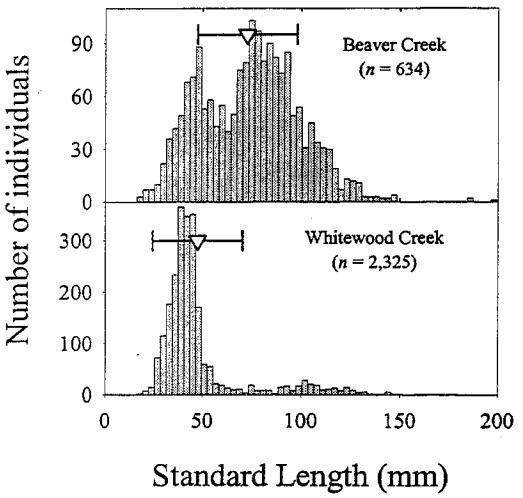

Figure 14. Length frequency histograms (3 mm categories) for the creek chub at sampling stations where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

Northern river carpsucker *Carpiodes carpio carpio*—The northern river carpsucker was a characteristic species in the Lower Cheyenne River station (Table 6). Multiple length classes were present but we primarily collected young-of-year (Figure 15), which were mostly restricted to slackwater habitats along shore. The northern river carpsucker was also present in the Upper Cheyenne (n = 13, mean SL = 297 mm ± 27.9 mm SD) and Belle Fourche (n = 25, mean SL = 132 mm ± 58.3 mm SD) river stations.

The northern river carpsucker is widespread throughout south-central North America where it typically occupies relatively large streams and rivers (Trautman 1981, Becker 1983). The species is migratory (Trautman 1981). Like the goldeye, it migrates into tributaries from Lake Oahe (Beckman and Elrod 1971), which may explain the low abundance of adults in our collections. The northern river carpsucker ranges throughout the Upper Cheyenne and Belle Fourche rivers (Hampton and Berry 1997, Doorenbos 1998). It also inhabits low gradient tributaries, but is

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and Belle Fourche rivers (Hampton and
inhabits low gradient tributaries, but is

most prevalent in riverine habitats (Duehr 2004). Given that the northern river carpsucker favors riverine habitat, it is possible that drought conditions during our study limited the distribution of the species, similar to plains minnow, sturgeon chub, and flathead chub. The species has declined from some portions of its native range (Patton et al. 1998).

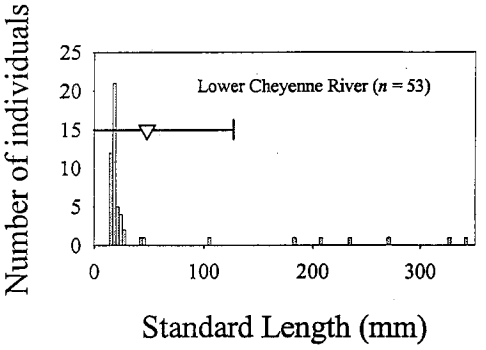

Figure 15. Length frequency histogram (3 mm categories) for the northern river carpsucker at the sampling station where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

White sucker *Catostomus commersonii*—The white sucker was a characteristic species in the Beaver Creek and Whitewood Creek stations (Tables 2 and 3), where it was mostly restricted to pools. In both creeks, it was present as multiple length classes, including young-of-year (Figure 16). Mean SL was similar between creeks (F = 1.2, df = 1, 567, P = 0.28; PMD = -6.4, P = 0.28), but standard length distributions varied between stations (D = 0.15, P < 0.01). The white sucker was also present, but rare, in the Upper Cheyenne (n = 15, mean SL = 73 mm ± 17.1 mm SD), Belle Fourche (n = 35, mean SL = 135 mm ± 55.4 mm SD), and Lower Cheyenne (n = 1, 138 mm SL) river stations. This distribution was similar to the creek chub.

The white sucker is widespread and abundant throughout northern North America, east of the Rocky Mountains (Scott and Crossman 1973, Trautman 1981, Becker 1983). It is widespread throughout the Cheyenne River drainage and is most abundant in smaller streams (Newman et al. 1999, Duehr 2004). Elsewhere, the species is migratory (Eddy and Underhill 1974, Trautman 1981, Becker 1983) and its presence in Lake Oahe (Lott et al. 2004) presents the possibility that migrations occur in the Cheyenne River drainage. However, the rarity of white sucker in riverine habitats suggests that white sucker populations are non-migratory and largely restricted to tributary streams, as they are in the southern Great Plains (Cross 1967, Sublette et al. 1990). In Lake Oahe, the

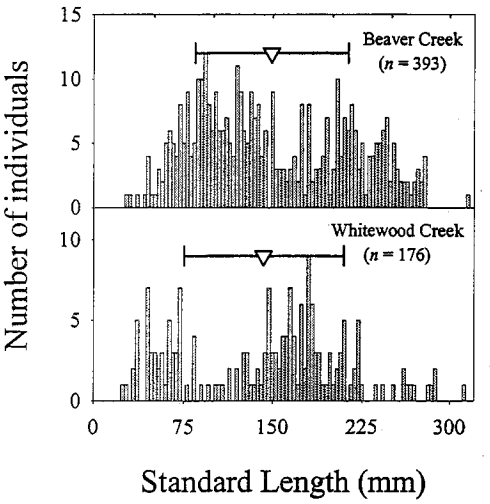

Figure 16. Length frequency histograms (3 mm categories) for the white sucker at sampling stations where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

white sucker is associated with small intermittent tributaries rather than larger tributaries such as the Cheyenne River (Beckman and Elrod 1971). The white sucker is highly tolerant of pollution (Ellis 1914, Trautman 1981, Becker 1983).

Mountain sucker *Catostomus platyrhynchus*—The mountain sucker was a characteristic species in the Beaver Creek station (Table 3). It was present as multiple length-classes including young-of-year (Figure 17) and was found primarily in pool habitats. The mountain sucker was also present in the Whitewood Creek station (n = 6, mean SL = 56 mm ± 13.3 mm SD), but was absent from riverine stations.

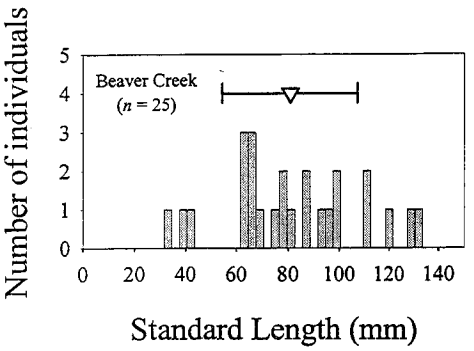

Figure 17. Length frequency histogram (3 mm categories) for the mountain sucker at the sampling station where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

The mountain sucker is present throughout the southern Rocky Mountains and typically inhabit mountain streams and lakes (Scott and Crossman 1973, Baxter and Stone 1995). In the Cheyenne River drainage it is mostly restricted to streams of the Black Hills (Bailey and Allum 1962, Isaak et al. 2003). The species has declined from the Upper Cheyenne River below Angostura Dam (Isaak et al. 2003) and from streams elsewhere (Patton et al. 1998).

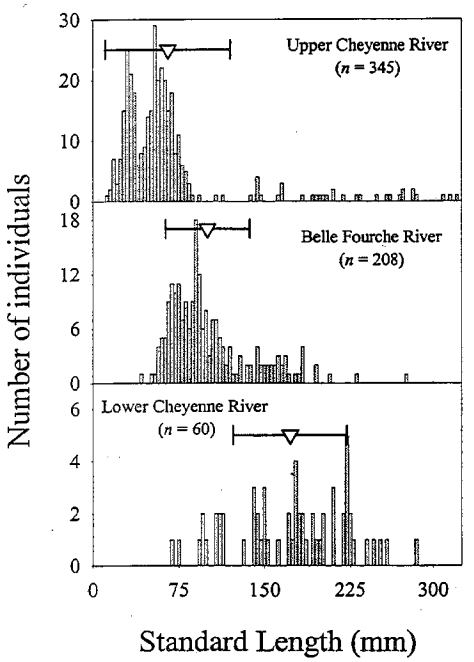

Figure 18. Length frequency histograms (3 mm categories) for the shorthead redhorse at sampling stations where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

Shorthead redhorse *Moxostoma macrolepidotum*—The shorthead redhorse was a characteristic species in the Upper Cheyenne, Belle Fourche, and Lower Cheyenne river stations where it occupied a variety of habitats (Tables 4-6), but the species was absent from creek stations. All populations included multiple length-classes, but population structure was highly variable with young-of-year abundant only in the Upper Cheyenne River and the Lower Cheyenne River only containing relatively large individuals (Figure 18). The Belle Fourche River population was intermediate between the other two. Mean SL varied

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Creek station (Table 3). It was present as multiple length-classes including young-of-year (Figure 17) and was found primarily in pool habitats. The mountain sucker was also present in the Whitewood Creek station (n = 6, mean SL = 56 mm ± 13.3 mm SD), but was absent from riverine stations.

The mountain sucker is present throughout the southern Rocky Mountains and typically inhabit mountain streams and lakes (Scott and Crossman 1973, Baxter and Stone 1995). In the Cheyenne River drainage it is mostly restricted to streams of the Black Hills (Bailey and Allum 1962, Isaak et al. 2003). The species has declined from the Upper Cheyenne River below Angostura Dam (Isaak et al. 2003) and from streams elsewhere (Patton et al. 1998).

Shorthead redhorse *Moxostoma macrolepidotum*—The shorthead redhorse was a characteristic species in the Upper Cheyenne, Belle Fourche, and Lower Cheyenne river stations where it occupied a variety of habitats (Tables 4-6), but the species was absent from creek stations. All populations included multiple length-classes, but population structure was highly variable with young-of-year abundant only in the Upper Cheyenne River and the Lower Cheyenne River only containing relatively large individuals (Figure 18). The Belle Fourche River population was intermediate between the other two. Mean SL varied significantly between stations (F = 132.0, df = 2, 610, P < 0.01). It was highest in the Lower Cheyenne River followed by the Belle Fourche River and the Upper Cheyenne River (PMDs > |34.8|, P < 0.01) and standard length distributions varied among all stations (D > 0.62, P < 0.01).

The shorthead redhorse has a wide range in east-central North America where it occupies larger streams and rivers and sometimes lakes (Scott and Crossman 1973, Becker 1983, Baxter and Stone 1995). It is widespread in the Cheyenne River drainage, being most abundant in riverine habitats, but present in smaller tributaries as well (Newman et al. 1999, Duehr 2004). The shorthead redhorse is a migratory species that spawns in clear streams (Smith and Hubert 1989, Nelson and Paetz 1992). Populations in Lake Oahe are associated with large tributaries such as the Cheyenne River, which they use for spawning (Beckman and Elrod 1971). Abundance of young-of-year in the Upper Cheyenne River suggested conditions there were better for spawning than in other river stations.

Channel catfish *Ictalurus punctatus*—The channel catfish was a characteristic species in the Belle Fourche and Lower Cheyenne river stations (Tables 5 and 6), where it was mostly found in pools. Multiple length-classes including young-of-year were present at both stations and relatively small individuals (< 200 mm SL) dominated both populations (Figure 19). Mean SL varied significantly between stations (F = 14.0, df = 1, 1002, P < 0.01, PMD = -16.5, P < 0.01) and standard length distributions varied (D = 0.25, P < 0.01). The channel catfish was also present in the Upper Cheyenne River station (n = 21, mean SL = 314 mm ± 111.1 mm SD), but was absent from both creek stations.

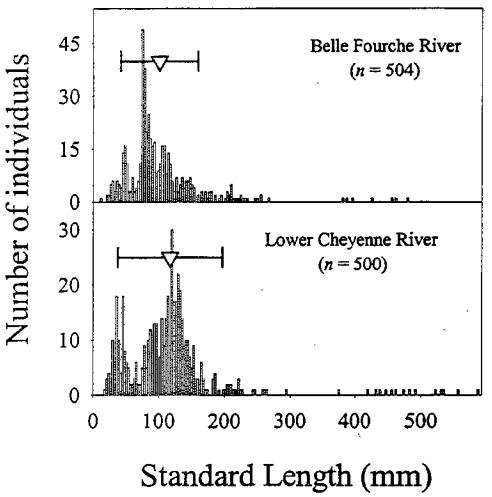

Figure 19. Length frequency histograms (3 mm categories) for the channel catfish at sampling stations where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

The channel catfish is widespread throughout southern North America where it occupies larger streams, rivers, and lakes (Trautman 1981, Becker 1983). It is widespread in the Cheyenne River drainage and is most abundant in riverine habitats (Newman et al. 1999, Duehr 2004). In 1996 and 1997, it was more abundant in the Belle Fourche River than the Upper and Lower Cheyenne rivers (Doorenbos et al. 1999). The channel catfish is highly migratory (Trautman 1981, Becker 1983). It is abundant in Lake Oahe (Doorenbos et al. 1999, Lott et al. 2004). The Cheyenne River drainage presumably provides important spawning habitat for the Lake Oahe population (June 1977), which is supported by the abundance of young-of-year and juveniles in our collections. Important spawning locations are unknown, but may be limited

in distribution and, in the Great Plains, may be most prevalent in tributaries (Smith and Hubert 1989, Gerhardt and Hubert 1990).

Stonecat *Noturus flavus*—The stonecat was the only species that was characteristic of the fish faunas of all five sampling stations (Tables 2-6). Multiple age classes, including young-of-year, were present at all stations (Figure 20). Like the longnose dace, the stonecat occupied pools and riffles in the creeks but was mostly confined to riffles in the rivers (with a few exceptions). The species was particularly abundant in riffles of the Belle Fourche River station. Few large individuals were collected from Whitewood Creek. The stonecat is relatively difficult to collect and our samples likely underestimate their abundance relative to other fishes.

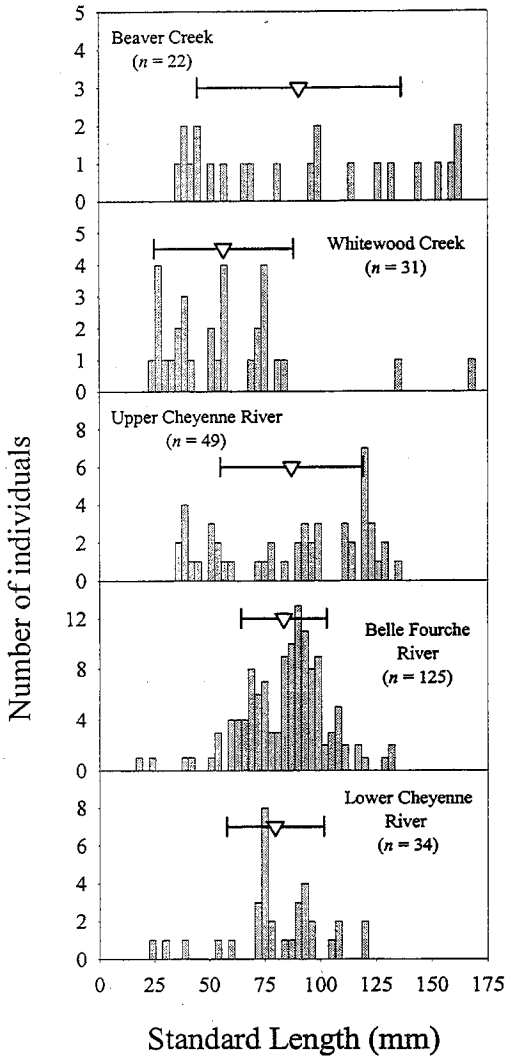

Figure 20. Length frequency histograms (3 mm categories) for the stonecat at sampling stations where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

The stonecat is widely distributed in central North America where it occupies permanent streams (Harlan and Speaker 1951, Trautman 1981, Becker 1983). It is present in all warmwater stream types of the Cheyenne River drainage (Newman et al. 1999, Duehr 2004) but is most abundant in large river habitats. The stonecat is tolerant of pollution (Becker 1983), yet it has declined in some portions of its range due to habitat degradation, especially siltation (Eddy and Underhill 1974, Trautman 1981) and drought (Cross 1967).

Northern plains killifish *Fundulus kansae*—The northern plains killifish was a characteristic species in the Belle Fourche River station (Table 5) where it occupied shallow-slackwater habitat. It was present in multiple length classes including young-of-year (Figure 21). The northern plains killifish was also present in the Lower Cheyenne River station (n = 13, mean SL = 38 mm ± 8.7 mm SD), but was absent from all other stations.

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The northern plains killifish is native to the central Great Plains and Ozark Plateau (Kreiser 2001, Kreiser et al. 2001). Many consider the species to be nonnative in South Dakota (e.g., Bailey and Allum 1962, Kreiser et al. 2001), but we consider them native because there is no evidence of their introduction and their native presence in the state is consistent with the biogeography of the Missouri River drainage (Hoagstrom 2006). The species is widespread in the Cheyenne River drainage where it is most prevalent in smaller streams (Newman et al. 1999, Duehr 2004). The northern plains killifish characteristically inhabits shallow habitats with relatively warm temperatures and is tolerant of high salinity (Griffith 1974). Northern plains killifish distribution and abundance may be highly variable (Fausch and Bestgen 1997). The northern plains killifish has declined from some portions of its native range (Cross and Collins 1995). Historically, it was present in the Upper Cheyenne River, downstream from Angostura Dam (Bailey and Allum 1962, Hampton and Berry 1997). It remains abundant upstream of Angostura Reservoir (Duehr 2004).

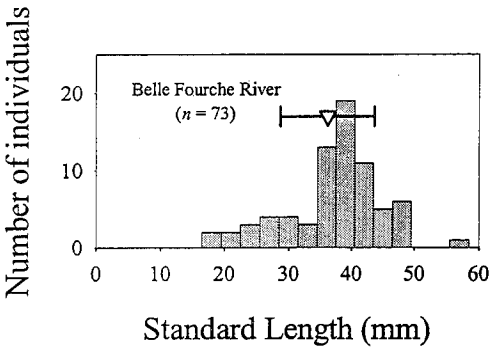

Figure 21. Length frequency histogram (3 mm categories) for the plains killifish at the sampling station where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

Plains topminnow *Fundulus sciadicus*—The plains topminnow was a characteristic species of the Beaver Creek and Upper Cheyenne River stations (Tables 3 and 4) where it was found in shallow pools or along shallow shorelines with slackwater habitat, often where algae or emergent vegetation were present. The species was present at both stations as multiple length-classes including young-of-year (Figure 22). Mean SL varied significantly between stations (F = 4.0, df = 1, 176, P = 0.05, PMD = -2.5, P = 0.05) and standard length distributions varied (D = 0.30, P < 0.01). The plains topminnow was absent from all other sampling stations.

The native range of the plains topminnow includes the central Great Plains and Ozark Plateau (Cross et al. 1986). The species

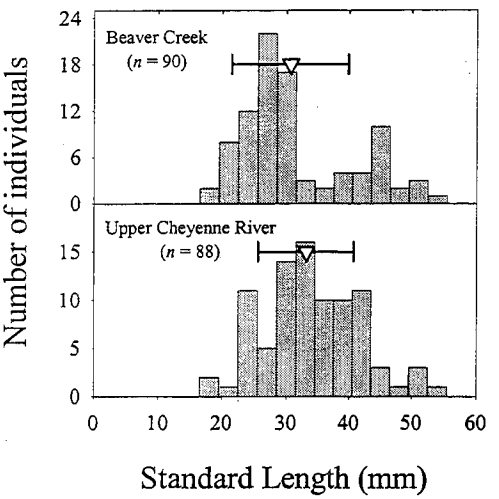

Figure 22. Length frequency histograms (3 mm categories) for the plains topminnow at sampling stations where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

is restricted to upstream portions of the Cheyenne River drainage, where it is widespread, and is absent from riverine habitats, being restricted to smaller streams (Duehr 2004). The plains topminnow was unknown from Beaver Creek until our survey (Bailey and Allum 1962) and first collected from the Upper Cheyenne River in 1996-1997 (Hampton and Berry 1997). Elsewhere, it has declined from portions of its native range (Harlan and Speaker 1956, Patton et al. 1998).

Green sunfish *Lepomis cyanellus*—The green sunfish was a characteristic species of the Beaver Creek station (Table 3). It was present as multiple length-classes (Figure 23) and was primarily found in pools. The green sunfish was also present in the Whitewood Creek (n = 9, mean SL = 58 mm ± 25.5 mm SD), Upper Cheyenne (n = 12, mean SL = 71 mm ± 13.2 mm SD), Belle Fourche (n = 4, mean SL = 45 mm ± 3.1 mm SD), and Lower Cheyenne (n = 1, 42 mm SL) stations.

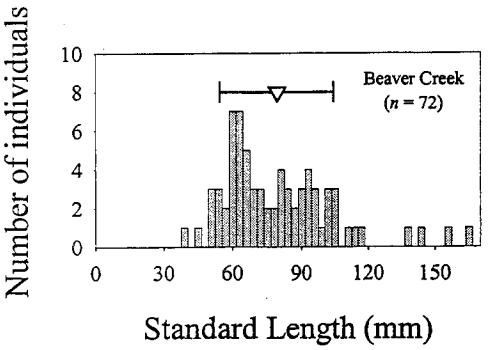

Figure 23. Length frequency histogram (3 mm categories) for the green sunfish at the sampling station where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

The green sunfish is a widespread species of south-central North America and most typically occupies small streams, ponds, and lakes (Trautman 1981, Becker 1983). It is a pioneering species that tolerates flow intermittence (Cross 1967). It is widespread in the Cheyenne River drainage and is most prevalent in small streams (Newman et al. 1999, Duehr 2004). The green sunfish is tolerant of pollution and habitat degradation (Trautman 1981, Becker 1983).

Smallmouth bass *Micropterus dolomieu*—The smallmouth bass was a characteristic species in the Upper Cheyenne River station (Table 4). It was present as multiple length-classes including young-of-year (Figure 24) and occupied all habitats. It was absent from all other stations.

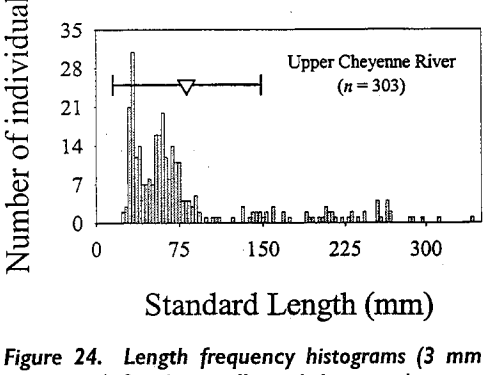

Figure 24. Length frequency histograms (3 mm categories) for the smallmouth bass at the sampling station where it was a characteristic species. Triangles indicate mean standard length with standard deviation (error bars).

The smallmouth bass is widespread throughout east-central North America where it inhabits streams and lakes (Trautman 1981, Becker 1983). The species is not native to the Cheyenne River drainage (Hoagstrom and Berry 2006). It commonly occupies cool streams with clean rocky substrate (Paragamian 1991). The smallmouth bass is sporadically distributed in upstream portions of the Cheyenne River drainage

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Additional Species

Gizzard shad *Dorosoma cepedianum*—The gizzard shad was present as young-of-year in the Upper Cheyenne (n = 1, 64 mm SL), Belle Fourche (n = 6, mean SL = 30 mm ± 6.8 mm SD), and Lower Cheyenne (n = 8, mean SL = 39 mm ± 13.4 mm SD) river stations. These individuals were presumably strays from Angostura and Orman reservoirs. The gizzard shad was absent from 1996-1997 surveys of the Upper Cheyenne, Belle Fourche, and Lower Cheyenne rivers (Hampton and Berry 1997, Doorenbos 1998) and from recent surveys of tributary streams (Newman et al. 1999, Duehr 2004). It is not native to the Cheyenne River drainage (Hoagstrom and Berry 2006).

Western silvery minnow *Hybognathus argyritis*—The western silvery minnow was present in the Belle Fourche (n = 32, mean SL = 107 mm ± 31.7 mm SD) and Lower Cheyenne (n = 18, mean SL = 74 mm ± 23.8 mm SD) river stations. This species is relatively widespread in the Cheyenne River drainage, being most abundant in riverine habitat (Duehr 2004). In 1996-1997 it was present throughout the Upper Cheyenne River. Its absence from our collections suggests that drought conditions have caused a range contraction.

Black bullhead *Ameiurus melas*—The black bullhead was present, but rare, in the Belle Fourche (n = 2, mean SL = 74 mm ± 9.2 mm SD) and Lower Cheyenne (n = 1, 180 mm SL) river stations. It is widespread throughout the Cheyenne River drainage and most abundant in small streams (Duehr 2004).

Brown trout *Salmo trutta*—The brown trout was present, but rare, in the Whitewood Creek station (n = 2, mean SL = 239 mm ± 76.4 mm SD). The individuals we captured were presumably strays from upstream, where habitat is more suitable for this species. The brown trout is not native to North America.

Rock bass *Ambloplites rupestris*—The rock bass was present, but rare, in the Upper Cheyenne River station (n = 1, 185 mm SL). The source of this individual was presumably Angostura Reservoir, or the Cheyenne River further upstream. The rock bass is not native to the Cheyenne River drainage (Hoagstrom and Berry 2006), where it is a rare inhabitant of streams (Duehr 2004).

Orangespotted sunfish *Lepomis humilis*—The orangespotted sunfish was present in the Belle Fourche (n = 8, mean SL = 47 mm ± 7.7 mm SD) and Lower Cheyenne (n = 3, mean SL = 41 mm ± 3.2 mm SD) river stations. It is widely distributed in the Cheyenne River drainage, but is most abundant in small streams (Newman et al. 1999, Duehr 2004). Individuals we collected were presumably strays from populations in tributaries.

Bluegill *Lepomis macrochirus macrochirus*—The bluegill was present in the Upper Cheyenne River (n = 1, 98 mm SL), presumably as a stray from Angostura Reservoir or the river upstream. It is not native to the Cheyenne River drainage (Hoagstrom and Berry 2006) and is rarely present in streams therein (Duehr 2004).

Sauger *Sander canadensis*—The sauger was present in the Belle Fourche (n = 3, mean SL = 364 mm ± 86.6 mm SD) and Lower Cheyenne (n = 4, mean SL = 334 mm ± 55.2 mm SD) river stations. Sauger in Lake Oahe congregate in the Cheyenne River arm and presumably migrate upstream to spawn (Beckman and Elrod 1971). Local ranchers reported that the sauger migrates up the Lower Cheyenne and Belle Fourche rivers in the fall, but we did not confirm it, perhaps due to drought.

Trends Among Species and Stations

High fish species turnover (Table 7) indicated that the faunas of each sampling station were unique. A summary of characteristic species by station supports this finding because, for example, nine species (common carp, plains minnow, sturgeon chub, fathead minnow, northern river carpsucker, mountain sucker, plains killifish, green sunfish, smallmouth bass) were characteristic of the fauna at only one station. Three of these species (plains minnow, sturgeon chub, smallmouth bass) were absent from all other stations, indicating strong segregation among streams types. However, trends in the distribution of characteristic species were variable. For example, the creek chub and white sucker were only characteristic in the Whitewood and Beaver creek stations, but other characteristic creek species (longnose dace and stonecat) were also characteristic of river stations. However, some species (red shiner, plains minnow, sturgeon chub, plains sand shiner, northern river carpsucker, shorthead redhorse, plains killifish, smallmouth bass) were restricted to river stations. In contrast, the plains topminnow was found only in the Beaver Creek and Upper Cheyenne River stations, which were geographically close and had high discharge stability (Hoagstrom 2006). Similarly, the flathead chub, channel catfish, and plains killifish were found only in the geographically close Belle Fourche River and Lower Cheyenne River stations, which also were relatively large streams that had low discharge stability (Hoagstrom 2006). In most cases, species that were characteristic of more than one station had variable length-class structure among them, indicating differing population status. Given these patterns, it appears that both habitat features and geographical proximity influence fish faunal composition and habitat diversity among stream types in the Cheyenne River drainage corresponds to fish species diversity.

Even though the fish faunas of each sampling station were unique and persistent during our study, it is evident from historical collections that the fish faunas of each stream are dynamic. Some species collected in 1996-1997 from the Belle Fourche, Upper Cheyenne, and Lower Cheyenne Rivers (emerald shiner *Notropis atherinoides*, spottail shiner *Notropis hudsonius*, yellow bullhead *Ameiurus natalis*, northern pike *Esox lucius*, white bass *Morone chrysops*, largemouth bass *Micropterus salmoides salmoides*, black crappie *Pomoxis nigromaculatus*, yellow perch *Perca flavescens*, freshwater drum *Aplodinotus grunniens*; Hampton and

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Species and Stations

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h sampling station were unique and persis- m historical collections that the fish faunas species collected in 1996-1997 from the Lower Cheyenne Rivers (emerald shiner *Notropis hudsonius*, yellow bullhead *Ameis*, white bass *Morone chrysops*, largemouth black crappie *Pomoxis nigromaculatus*, yel- lrum *Aplodinotus grunniens*; Hampton and

Berry 1997, Doorenbos 1998) were absent from our collections. Most likely, these species were either strays from upstream reservoirs and stock ponds (yellow bullhead, northern pike, largemouth bass, black crappie, yellow perch) or were upstream migrants from Lake Oahe that may have found the Cheyenne River drainage unsuitable under drought conditions (emerald shiner, spottail shiner, white bass, freshwater drum).

More specifically, the distribution of several fishes appeared to be reduced during our study than in 1996-1997, presumably due to drought. That is, large-river species that ranged near the Upper Cheyenne River or Belle Fourche River stations in 1996-1997 were absent, but still found in the Lower Cheyenne River station, suggesting reduced discharge caused a downstream retreat. The fish fauna of the Upper Cheyenne River station was the most dramatic example. Large-river species that were collected in the Upper Cheyenne River during 1996-1997 (western silvery minnow, plains minnow, sturgeon chub, flathead chub; Hampton and Berry 1997, Doorenbos 1998) were absent from our collections, while the abundance of plains topminnow and smallmouth bass increased. This is likely related to Angostura Dam, which controls the flow regime, because it may amplify the impacts of drought by eliminating floods downstream. There were fewer cases of range contractions of large-river species from the Belle Fourche River station (plains minnow), perhaps because floods still occurred there. Nonetheless, range contractions of large-river fishes during drought are to be expected and have been documented elsewhere (Cross and Moss 1987). If conditions in the Lower Cheyenne River remain suitable for the large-river species, they may be able to recolonize upstream when the drought ends. However, the persistence of large-river species could be hampered by Lake Oahe, which limits the downstream retreat (formerly, species could have retreated into the mainstem Missouri River). The combination of downstream reservoirs and drought has been implicated in the disappearance of large-river fishes from upstream river reaches elsewhere (Winston et al. 1991, Kelsch 1994, Pittenger and Schiffmiller 1997, Luttrell et al. 1999, Wilde and Ostrand 1999). In summary, the undammed segments of the Cheyenne River drainage have dynamic fish communities due to the ability of fishes to respond to changing environmental conditions and seek out suitable habitats, but downstream impacts of Angostura Dam and upstream impacts of Lake Oahe may be a threat to sensitive species, specifically, large-river fishes.

The absence of physical barriers to fish movement between the Belle Fourche Diversion Dam, Angostura Dam, and Lake Oahe clearly enhances the fish faunas of the Cheyenne River drainage. Migratory species (goldeye, northern river carpsucker, shorthead redhorse, channel catfish, sauger) added to the diversity of the faunas and, in many cases, were characteristic species in our sampling stations. At the same time, the ability of these species to use the Cheyenne River drainage presumably enhances their populations in Lake Oahe (Beckman and Elrod 1971, June 1977). Thus, it is appropriate to view the Cheyenne River drainage as an extension of Lake Oahe, and vice versa.

In conclusion, different stream types we studied corresponded to different fish faunas. This is no surprise, given that the distributions of fishes in the Great Plains commonly correspond to habitat conditions (Ostrand and Wilde 2002,

Quist et al. 2004a, 2004b, Brunger Lipsey et al. 2005). Further, the importance of free dispersal for Great Plains stream fishes is well documented (Smith and Hubert 1989, Fausch and Bramblett 1991, Fausch and Bestgen 1997, Labbe and Fausch 2000, Scheurer and Fausch 2003). Thus, relatively large stream segments and sub-watersheds that lack dispersal barriers (e.g., dams), but have high habitat diversity, are likely to sustain relatively diverse fish communities because as conditions change, which they often do in the Great Plains, fishes can respond by relocating as necessary, so long as some suitable habitat is present. At present, the Cheyenne River drainage downstream from Angostura Dam and the Belle Fourche Diversion Dam represents such a sub-watershed. The future of fish communities there will ultimately depend both on the interaction between climate change and human activities.

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