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Fish Community Report for the Middle North Fork Cache la Poudre River

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Executive summary

Transition zone ecosystems on the Front Range of Colorado exist in a region undergoing drastic increases in human population. This increase in population has led to a need for more water and space to accommodate the growth. Water development, urbanization (i.e., fragmentation, channelization, decline in water quality, etc.) and introductions of fishes, primarily predatory sportfish, are major causes of the declines in native fishes. The North Fork Cache la Poudre River has been subjected to water development and species introductions since the 1900s. I designed a study and investigated reaches that had not been sampled since 1959 and 1960 to fill in spatial and temporal knowledge gaps concerning the fish community.

The fish community has been altered significantly including possible species extirpations and appearances likely a result of habitat modification, species introductions, and sampling methodology. Bigmouth shiner was the most abundant fish species in the North Fork fifty years ago. Common shiner was also relatively abundant, accounting for up to 12% of species composition in the first sampling efforts on the North Fork. Neither species have been collected since. Other notable observations include a decreased abundance of longnose sucker as white sucker abundance increased. Another more benthic fish species, the johnny darter has also increased, but these findings could be a function of different sampling methodology. The number of species collected has increased since 1960, probably due to sampling effort using different methods, fish introductions, and species dispersal from reservoirs. Additional species sampled after 1960 include brook stickleback, brown trout, rainbow trout, black bullhead, fathead minnow, green sunfish, and Iowa darter. Some of these species are native within the

South Platte drainage (black bullhead, green sunfish), others' presence is contentious (brook stickleback), and salmonids were introduced or invaded. Thermal data collected downstream of Phantom Canyon in 2010 demonstrated temperatures required for the fulfillment of all life histories found in the native fish species.

Based on the findings, proposed development in the watershed, and expressed desire to manage for native fishes by managers and stakeholders of the watershed, I propose the North Fork Cache la Poudre River between the two reservoirs be managed for the reintroduction and establishment of bigmouth and common shiners. The North Fork is a model stream for water-column fish studies because the scientific merit of ecosystem-wide studies is highly applicable over a larger geographical area (i.e., the Great Plains and Rocky Mountain interface) and stream conditions are controlled and modified through limited public access, the two dams, and the diversion. Continuous future monitoring of the fish community is advised due to the development scheduled for the coming decades.

Introduction

Aquatic ecosystems on the Front Range of Northern Colorado such as the North Fork of the Cache la Poudre have undergone over a century of anthropological influence (Wohl et al. 2009; Rathburn et al. 2009). Dams, reservoirs, and diversions have been created to benefit a myriad of land uses in the surrounding regions. These structures have led to increased fragmentation, water withdrawal, channelization, altered natural functions (flow, temperatures, etc.), and decreased water quality. The growing populace of the Front Range has led to an increased demand for water, prompting water managers

and municipalities to propose an expansion of both Halligan and Milton-Seaman reservoirs on the North Fork of the Cache la Poudre River (Figure 1). Contemporary water issues have led to an increased awareness and prioritization of the natural components that are affected, impelling collaborative efforts such as the Shared Vision Planning group that explored the ecological aspects of the Halligan-Seaman Project (Cathcart and Fausch 2010).

Modifications also include the addition of both fish and riparian plant species through invasion or plantings, and the loss of native species. Large-bodied salmonids such as brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) were introduced throughout the Front Range to establish sport-fishing opportunities. The main stem North Fork Cache la Poudre River presently supports one species listed by the state of Colorado as state threatened, the Iowa darter (*Etheostoma exile*), but historically contained at least two other species that have special conservation status; the common shiner (*Luxilus cornutus*) and greenback cutthroat trout (*Oncorhynchus clarkii stomias*; Hubert and Gordon 2007). Bigmouth shiner (*Notropis dorsalis*) also possibly disappeared but holds no special conservation status in Colorado. Based on fish sampling collections between 1960 and 2010, common shiner (state threatened) and bigmouth shiner have possibly disappeared from the stream and are potentially extirpated from the fish community of the North Fork watershed (Table 1).

Table 1. Fish species historically and currently present in the middle reaches of the North Fork Cache la Poudre River based on University of Kansas Division of Ichthyology, Colorado Division of Wildlife, and Colorado State University collections from 1959-2010. SC = Species of Concern. ST = State Threatened. FT = Federally Threatened. Species in bold were collected in 2010 sampling.

Family	Species	Scientific name	Native	Status(North Fork, State)
Catostomidae	**longnose sucker**	***Catostomus catostomus***	**Yes**	**-**
Catostomidae	**white sucker**	***Catostomus commersonii***	**Yes**	**-**
Centrarchidae	**green sunfish**	***Lepomis cyanellus***	**Yes**	**-**
Cyprinidae	bigmouth shiner	*Notropis dorsalis*	Yes	Extirpated
Cyprinidae	**creek chub**	***Semotilus atromaculatus***	**Yes**	**-**
Cyprinidae	**longnose dace**	***Rhinichtyhs cataractae***	**Yes**	**-**
Cyprinidae	common shiner	*Luxilus cornutus*	Yes	Extirpated, ST
Cyprinidae	**fathead minnow**	***Pimephales promelas***	**Yes**	**-**
Gasterostidae	**brook stickleback**	***Culaea inconstans***	**No**	**-**
Ictaluridae	**black bullhead**	***Ameiurius melas***	**Yes**	**-**
Percidae	**Iowa darter**	***Etheostoma exile***	**Yes**	**SC**
Percidae	**johnny darter**	***Etheostoma nigrum***	**Yes**	**-**
Salmonidae	greenback cutthroat trout	*Oncorhynchus clarkii stomias*	Yes	Extirpated, FT
Salmonidae	**brown trout**	***Salmo trutta***	**No**	**-**
Salmonidae	**rainbow trout**	***Oncorhynchus mykiss***	**No**	**-**

With a focus on further establishing fish sampling data for the middle reach of the North Fork Cache la Poudre River, I sampled reaches between Halligan and Milton-Seaman reservoirs to further refine critical habitat designations created by the Shared Vision Planning group (Cathcart and Fausch 2010). Rediscovery of shiner populations was considered possible, owing to similar small-bodied Front Range fishes having seemingly disappeared for decades only to be rediscovered (Platania et al. 1986; Bestgen et al. 1991).

Methods

Study Area

The study site is within the transition zone between the Great Plains and the Rocky Mountains at elevations ranging from 1400 to 1850 m. The North Fork Cache la Poudre River flows through Northern Colorado into the Cache la Poudre River and is part of the headwaters of the South Platte River Basin. Because of the north to south direction of the stream, the North Fork principally courses through the transition zone. The reach between Halligan and Milton-Seaman reservoirs was the focus of this study (Figure 1).

Between the reservoirs, the North Fork flows approximately 20 km through lands owned and managed by the City of Fort Collins, North Poudre Irrigation Company, The Nature Conservancy, Larimer County, and private owners. The habitat changes from a narrow tailwater river in an extensive canyon with large, deep pools along steep rock faces before flowing out of the mouth of the canyon into open grasslands through banks of willow and cottonwood trees and is influenced by beaver activity. Substrates in the North Fork include bedrock, boulder, cobble, gravel, sand, and silt. Vegetation and large woody debris, primarily of fallen cottonwood trees (*Populus deltoides*), are also common.

The study reach included three tributaries: Rabbit, Lone Pine, and Stonewall creeks. These creeks flow through a mix of private and public lands before their respective junctions with the North Fork. State Wildlife Areas (SWA) exist on upper reaches of Rabbit and Lone Pine creeks whereas Stonewall Creek flows through private land west of US Hwy. 287. . Rabbit and Lone Pine creeks are runoff-driven streams with headwaters in higher elevations and steeper gradients over boulder, cobble, gravel,

and sand. Stonewall Creek is a low gradient, groundwater fed stream more characteristic of plains streams, flowing among cottonwood trees with gravel, sand, silt, and vegetation.

Figure 1. Sampling reach with locations of 2010 fish (red) and water temperature (blue) data collections on the North Fork Cache la Poudre River, Larimer County, Colorado.

Fish Sampling

I sampled the North Fork of the Cache la Poudre River from Eagle's Nest Open Space upstream to Halligan Dam within public and private lands in addition to Lone Pine, Rabbit, and Stonewall creeks. Except for Eagle's Nest Open Space, Lone Pine Creek and upper parts of Stonewall Creek, most of the study sites had either never been sampled before or had last been sampled in 1959 or 1964. Landowner refusal of access to two tributaries prevented a standard sampling methodology from being incorporated, likely influencing data on fish composition. Stonewall Creek was sampled at the mouth and upstream. Lone Pine Creek was sampled in its upper reaches inside the Lone Pine State Wildlife Area. Rabbit Creek was sampled in its middle reaches inside the Rabbit Creek Ranch.

Using backpack electrofishers, specifically a Coffelt 12V and a Smith-Root LR-24, the fish community of the North Fork was sampled at multiple reaches within eight sites between the two reservoirs. Both electrofishers were used in the North Fork sample sites with the technicians working upstream in parallel. A single electrofisher was used in tributaries in a zigzag manner upstream to cover the entire stream. Sampling reaches were selected to include all habitat types (i.e., pool, riffle, run). Electrofishing was performed with a single pass. Beach seines with a 5 mm mesh were also utilized in appropriate habitats (i.e., uniform fine substrates and backwaters). All sampled fish were identified, measured to the nearest mm in total length, and released unless they were unidentifiable such as fishes in early life stages and possible hybrids. Unidentifiable fish were labeled by location and date and preserved in 10% formalin for later identification.

Presence/absence, species composition within sites and habitats, and length-frequency data were summarized.

Water Temperature Sampling of the Watershed

Ten temperature loggers (eight Onset Tidbit temperature loggers and two Onset HOBO pendant temperature loggers) were deployed throughout the North Fork watershed including sites in Rabbit Creek and Stonewall Creek to record water temperatures. Temperature loggers were programmed to record the temperature every thirty minutes. Loggers were fastened to 24" steel pipe with cable and hammered into the substrate in areas out of sight to the general public. I selected in-stream locations by water depths that would allow approximately 90 days of data collection. Deployment dates varied due to runoff, differing models of temperature loggers and software; however, the general time frame was from early-July to early-October. By October, water levels had dropped considerably and some of the loggers were exposed to the air.

Results

Fish Sampling

I sampled over two kilometers of the North Fork Cache la Poudre between Eagle's Nest Open Space and the North Poudre Irrigation Company diversion. In addition, approximately 100 m in the three tributaries to the middle portion of the North Fork were sampled. I collected 12 species among all sites with bigmouth and common shiners being notably absent relative to historic collections (Table 1).

Temperature Sampling

Most sites provided sufficient data (around 90 days of submersion) throughout the sampling period however two sites, Rabbit Creek and on the North Fork above the diversion, were prone to highly variable flows and provided shorter term data due to intermittent exposure to air .

Discussion

Conclusions and Implications

Current and historical thermal data, when compared with the timeline of water development in the North Fork watershed, suggest that water development was not the direct cause for extirpation of shiners. It is more plausible that water development and management practices indirectly influenced native fishes through the introduction of non-native species such as brown and rainbow trout (Figure 3). The upstream reservoir - Halligan - was completed in 1910, the downstream reservoir - Milton Seaman - was constructed in 1941, and the inner-canyon diversion and tunnel complex were created in 1943. Because common and bigmouth shiners express such short generations (2-3 years on average), it is a stretch to suggest that the natural flow or thermal regimes were disrupted enough to lead to their extirpation. Fifty years after Halligan Dam closed off the North Fork, in 1959 and 1960, bigmouth shiner comprised the majority of the sampled fishes and common shiner were at least present and could have been considered relatively abundant (Figure 2). Within the next 50 years the two species disappeared. After 1960, the next recorded sampling period in the North Fork was in 1984.

Contemporary evolution to factors such as habitat alteration (thermal, flow regimes) could be a factor explaining persistence and delayed extirpations in species with short generations such as cyprinids (Calhoun et al. 1983; Stockwell et al. 2003). The two species of minnow may have been able to adapt to the changing environment but were then unable to cope with the increasing numbers of salmonids stocked and dispersing throughout the watershed. Nonnative fishes may push native fish, especially small-bodied ones, closer or over a specific threshold where extirpation occurs or is more likely to occur in the event of environmental extremes like drought (Matthews and Marsh-Matthews 2007).

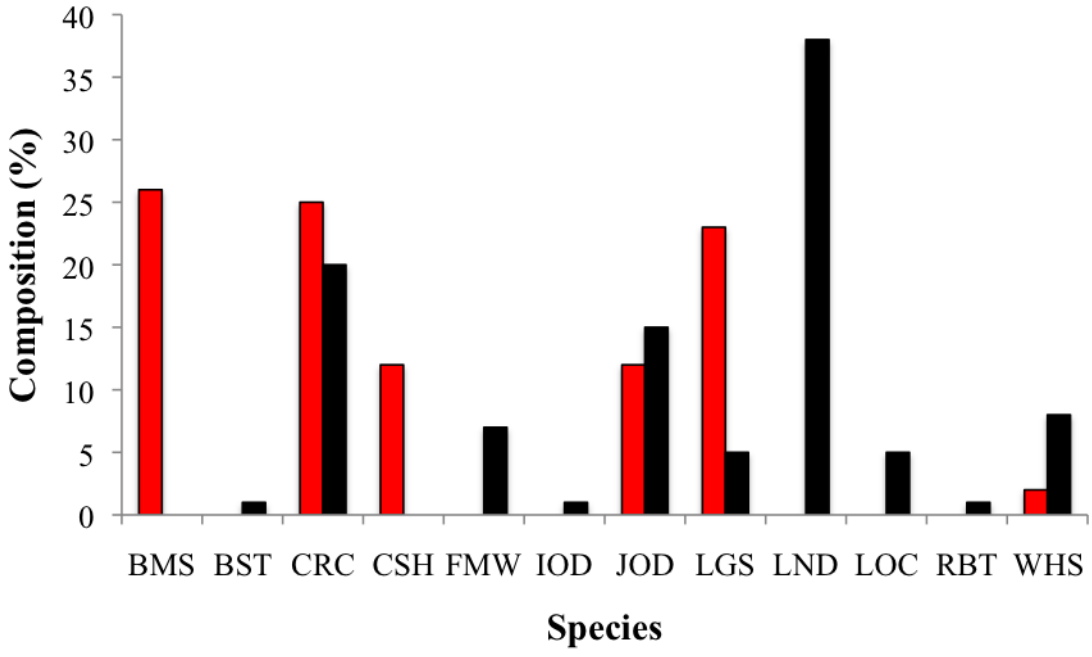

Figure 2. Comparison of fish species composition in the North Fork Cache la Poudre River, Colorado upstream of County Road 80 (Cherokee Park Road) in 1959 (Red) and 2010 (Black) based on fish sampling conducted by Cross et al. 1959 and Cathcart 2010. Species codes are as follows: bigmouth shiner (BMS); brook stickleback (BST); creek chub (CRC); common shiner (CSH); fathead minnow (FMW); Iowa darter (IOD); johnny darter (JOD); longnose sucker (LGS); longnose dace (LND); brown trout (LOC); rainbow trout (RBT); and white sucker (WHS).

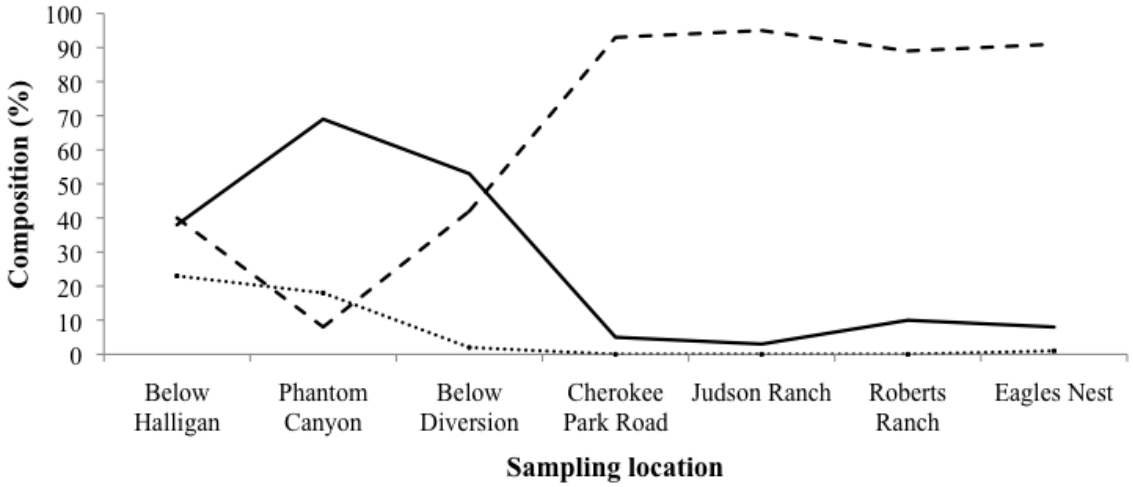

Figure 3. Fish composition based on abundance in the North Fork Cache la Poudre River, Colorado between Halligan Dam and Milton-Seaman Reservoir. Native fish composition (- - - dashed line), brown trout composition (— solid line), and rainbow trout composition (··· dotted line) at locations in the North Fork Cache la Poudre River, Colorado between Halligan Reservoir downstream to Eagles Nest Open Space based on 2010 sampling.

Generalist minnow species (like the bigmouth and common shiner) declines and extirpations following reservoir construction have been documented throughout the Great Plains and interior Rocky Mountains (Winston et al. 1991; Quist et al. 2005; Gido et al. 2010). Similarly, Matthews and Marsh-Matthews (2007) showed a delayed local extinction of the environmentally tolerant red shiner (*Cyprinella lutrensis*) in tributaries to Lake Texoma, OK. Being ubiquitous from the Great Lakes to the Rocky Mountains, disappearances of shiners warrant further investigation. Introduced predators have been implicated in declines and extirpations of small-bodied cyprinids (Knight and Gido 2005; Findlay et al. 1999). Falke and Gido (2006) observed low abundance in shiner species that shared life-history strategies in tributary streams of a Great Plains reservoir.

Green sunfish and black bullhead most likely dispersed upstream from Seaman Reservoir given that they had previously been sampled in CDOW surveys from 1967 and 2007, respectively. Upstream invasions of predators, like centrarchids, appear to coincide with fish community alteration and could potentially be yet another threat to the stability of native fish populations in the North Fork (Labbe and Fausch 1996; Quist et al. 2005; Falke and Gido 2006). While native to Colorado, it is unclear whether green sunfish and black bullhead would have existed in the North Fork without reservoirs being present.

In light of the recently proposed renovations to the two reservoirs on the North Fork, the flow and thermal regimes of the river have been areas of interest (Rathburn et al. 2009). Habitat associations, connectivity, and restricted sediment delivery are areas of further consideration but it appears that habitat is suitable for the remaining cyprinids.

Habitat heterogeneity was observed throughout the study reach including several sampling sites with substrates required by the extirpated species.

Management Implications

Based on the historical and current data, reintroductions of bigmouth and common shiners are cautiously proposed. This would necessitate some form of brown trout control. Trout Unlimited, The Nature Conservancy, and the CDOW have all supported a native fish based management strategy for the North Fork during the collaborative planning stage for the Halligan-Seaman expansion effort. This action would necessitate further research on the absent shiner species and interactions between predators and prey including the possible effects on the surrounding landscape.

Unlike common shiner, bigmouth shiner has not been extensively studied and basic data pertaining to thermal and spawning requirements are still unknown. Accordingly, much of the life history traits of bigmouth shiner are unknown including thermal tolerances for survival, growth, and reproduction. Spawning tactics are as of yet unknown and merely speculated upon. Spawning habits have been suggested to be similar to the Arkansas River shiner but no field observations or lab studies have been performed to date (Carlander 1969; Becker 1983).

Both shiners are at the fringe of their natural distribution and current data should not be considered absolute since many of the data were collected from populations in the Great Lakes region. These populations could face different selective pressures and conditions and vary morphologically, genetically, and ecologically (Sheurer et al. 2003). As such, region specific data of these widespread cyprinids are lacking.

I hypothesize that upon establishment of brown trout throughout the North Fork, population declines and eventual extirpation of both common and bigmouth shiners with nutrient cycling effects spreading out to the riparian zone and adjacent lands (i.e., historically the North Fork watershed supported higher abundances of fish predating mammals and birds). Diurnally active bigmouth and common shiners would have primarily used the water column, feeding on plants, detritus, and macroinvertebrates, thus being more exposed to predation by avian, mammalian, and aquatic predators. When brown trout became prevalent, the shiners' limited scope of activity at night likely made them susceptible to predation leading to a decline in populations. The loss of shiners in the system then shifted energy available to the local ecosystem. Brown trout essentially took energy from the water column and because of their habitat use and crepuscular activity patterns have now sent stream-derived energy to places like undercut banks and large woody debris, where it is no longer as available to avian, terrestrial, and other aquatic predators. The lower populations of common shiner in 1959 and 1960 compared to bigmouth and creek chub could have been due to similar habitat associations with brown trout since both species prefer coarse substrates like gravel rather than silt and sand which bigmouth shiner and creek chub prefer (Knight and Gido 2005, Quist et al. 2005).

Current thermal data provided adequate temperatures for all biological requirements (i.e., survival, growth, and spawning) of shiner species in reaches downstream of the canyon (consistent temperatures >19°C) while thermal regime disruption is evident in the North Fork below Halligan Dam consequently providing varying levels of survivability throughout the North Fork for shiner species (Figure 4).

Thermal regime depression by Halligan Dam probably contributed to the decline of cyprinids through constriction of habitats containing suitable temperatures needed to fulfill all life history strategies. This constricted zone would have been between the diversion and Eagle's Nest Open Space that I view as the critical habitat for native fishes based on species abundances and habitat.

Partnerships with private landowners should be continued and more rigorous and consistent sampling of the North Fork should be conducted. One extremely proactive approach is acknowledging climate change and the ecological applicability of present dams, namely Halligan, as a tool to incorporate conservation of native fishes by meeting – and even exceeding - increased water demand. The broad goal is to maintain thermal regimes and habitat for cool water fishes while providing the region with usable water. Balancing biodiversity and livelihoods with adaptive water management using dams is going to be a constant theme in the coming decades as water development continues on the Front Range and throughout the west (Strange et al. 1999; Olden and Naiman 2010).

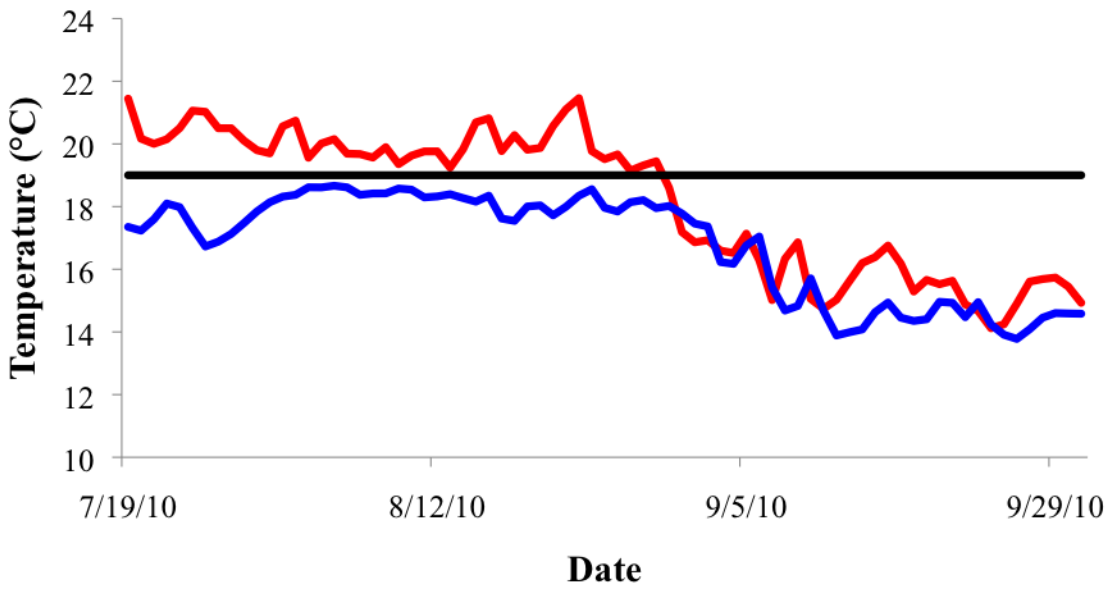

Figure 4. Thermal regimes of the most upstream site (Halligan Dam; blue line) and the most downstream site (Eagles Nest Open Space; red line) in the North Fork Cache la Poudre River in 2010. Mean optimal temperature for spawning observed in common shiner is shown for a reference of native fish thermal requirements (black line).

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