

Green River Basin



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Watershed Description

Three of the nation's major river systems have their headwaters in Wyoming: the Missouri, Colorado, and Columbia Rivers. These watersheds provide a natural basis for delineating aquatic conservation areas. Six major watersheds were identified for conservation planning purposes under this State Wildlife Action Plan (SWAP) using hydrographic boundaries and fisheries assemblage and management considerations (Figure 3). These areas are consistent with the aquatic ecosystems identified for freshwater biodiversity conservation worldwide by Abell et al. (2008). The watershed areas are also synonymous with aquatic zoogeographical units and ecological drainage units identified under The Nature Conservancy's (TNC) hierarchical classification framework (Higgins et al. 2005). The watersheds each include one to four sub-regions (4-digit hydrologic unit code [HUC] watersheds). This approach allows the nesting of multiple spatial and temporal scales for planning and prioritizing conservation actions.

The Green River basin is based on, and exactly corresponds with, the Upper Colorado hydrologic unit in Wyoming (2-digit HUC 14). Major drainages corresponding to 8-digit HUCs include Upper Green, New Fork, Upper Green-Slate, Big Sandy, Bitter, Upper Green-Flaming Gorge, Blacks Fork, Muddy, Vermillion, Great Divide Closed Basin, Little Snake, and Muddy (in Little Snake drainage). The Great Divide Basin is a closed basin and is included. These watersheds span about 21,000 square miles in southwestern Wyoming's Carbon, Lincoln, Sublette, Sweetwater, and Uinta counties. Very small portions of Fremont and Teton counties occur in the basin as well. Land ownership is predominantly public (72%). Much of the 28% of privately-held lands occur in the "checkerboard" band of ownership along the Union Pacific railroad. Green River basin public land is managed primarily by the Bureau of Land Management (managing 56%) and U.S. Forest Service (managing 10%).

The Green River originates at over 10,500 feet in the Bridger Wilderness in the Wind River Mountains of Wyoming and flows for about 250 miles before leaving the state at Flaming Gorge Reservoir. Major tributaries include the New Fork, East Fork, Big and Little Sandy Rivers, LaBarge, Cottonwood, and Horse Creeks in the northern part of the basin, and the Little Snake, Hams Fork, Blacks Fork, and Henry's Fork Rivers in the south (Figure 3). From an analysis of the 2010 Version 2.0 National Hydrological Database (NHD) at 1:100,000, there are approximately 23,000 miles of streams in the Green River basin in Wyoming. This equates to a drainage density of about 1.1 stream miles per square mile land area. About 80% of these stream miles are first or second order streams.

The Wyoming Basins terrestrial-based ecoregion, as defined originally by Bailey (1995) and adapted by The Nature Conservancy, occupies most of the Green River basin, but the higher elevations along the periphery coincide with the Utah-Wyoming Rocky Mountain ecoregion. Elevations range from over 13,800 feet atop Gannett Peak, the highest point in Wyoming, to 6,040 feet where the Green River passes into Utah at Flaming Gorge Reservoir. Landforms are very diverse in this basin: much of the high desert basin is marked by mesas, buttes, and badlands with the higher peaks of the Wind River Range, Wyoming Range, Gros Ventre Range, Sierra Madre Range, and Uinta Range surrounding the basin. Sand dunes and playas of the Great Divide Basin contrast with the steep granitic and metamorphic slopes of the Wind River Range. The interior of the basin consists of sagebrush plains, floodplain terraces, and moderate to low gradient streams with finer gravel or sand substrates derived from shale (Chapman et al. 2004). Mountain glacial activity created cirques and shaped many of the valleys and streams at higher elevations, particularly in the Wind River Range (Knight 1994).

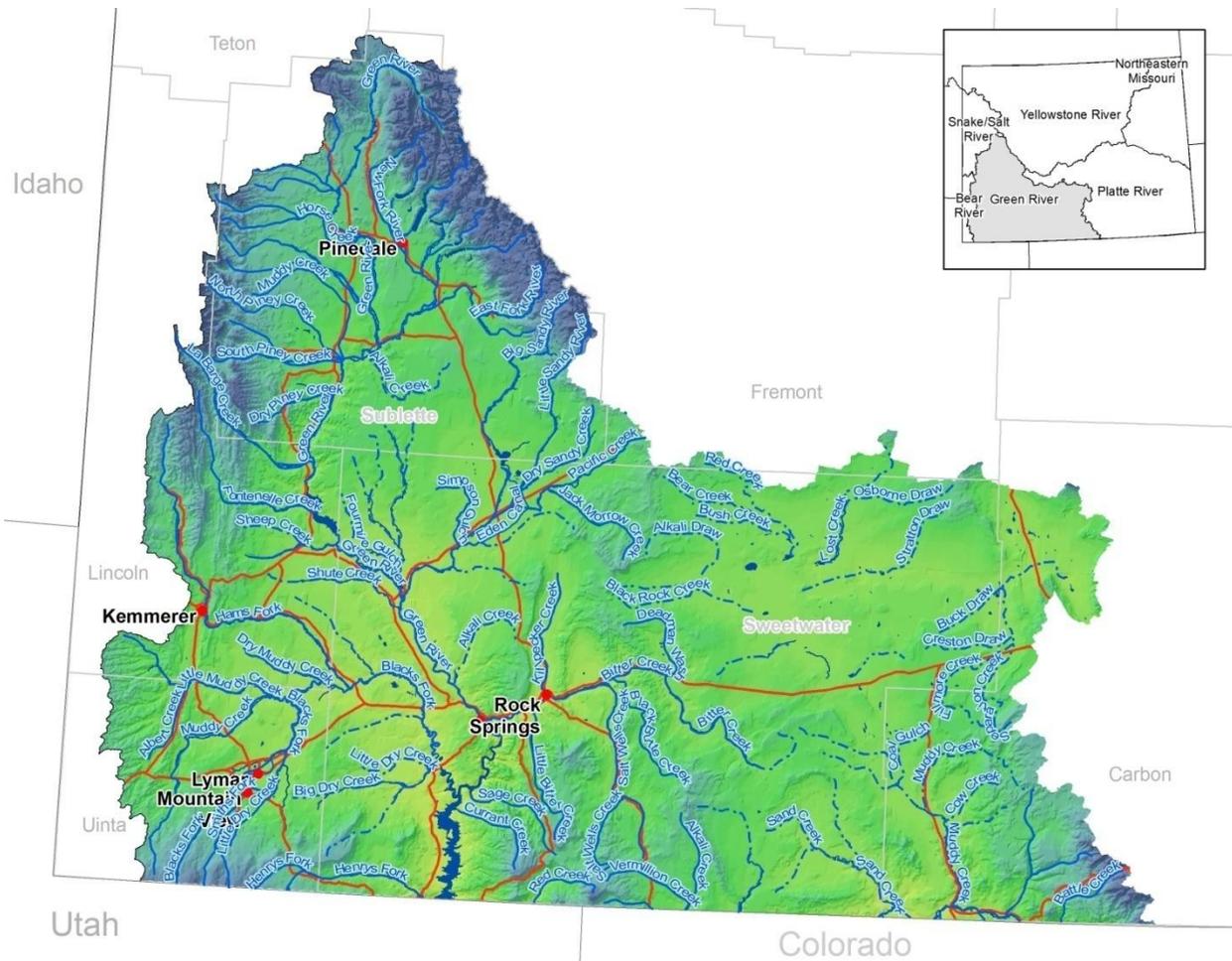


Figure 3. Green River Basin

The Green River Formation is a distinguishing geologic feature of the region (Lageson and Spearing 1988). This sedimentary rock is a remnant from the large Eocene Lake Gosiute and is associated with coal, uranium, saline minerals such as trona, and oil shale (Mason and Miller 2004). The folded strata of the Pinedale Anticline in the northern basin produce world-class quantities of natural gas, and extensive energy development fields are ongoing. Significant deposits of coal and oil exist in the basin. The Laney Member of the Green River Formation underlies central and eastern parts of the basin and contains oil shale (Clark and Davidson 2009). Other bedrock geology units of the southern watershed include the sedimentary Fort Union and Wasatch which have sandstone, shale, and thin coal beds. Coal

bed and conventional natural gas development are also extensive in the Muddy Creek area in the southeast portion of the basin (Clark and Davidson 2009).

The Green River basin largely overlaps Wyoming’s climate division 3 (Curtis and Grimes 2004). This climate division is the third coolest climate division of the ten climate divisions in Wyoming, warmer only than divisions 1 and 2 to the north. Monthly temperatures range from an average of about 15° F in January to about 63° F in July. The climate is one of the driest in the state, with annual precipitation of only about 10 inches. Peak precipitation occurs in May, while winters are cold and dry with the exception of snow at bordering mountain high elevations (Curtis and Grimes 2004). Annual precipitation ranges

from less than 8 inches at low elevations to more than 40 inches in mountainous areas; much of the basin receives less than 11 inches annually (Mason and Miller 2004).

Larger water bodies in the Green River basin include the Flaming Gorge Reservoir, which has 3,789,000 acre feet storage capacity (Jacobs and Brosz 2000), the Green River Lakes, New Fork Lake, Willow Lake, Fremont Lake, Halfmoon Lake, Burnt Lake, Boulder Lake, Big Sandy Reservoir, Eden Valley Reservoir, and Fontenelle Reservoir, in addition to numerous Wind River Range high mountain lakes. In the western part of the basin are Viva Naughton and Kemmerer No. 1 Reservoirs. To the south are Meeks Cabin and Stateline Reservoirs, and to the east is the High Savery Reservoir in the Little Snake River watershed.

Miller (2003) delineated six hydrologic regions in Wyoming on the basis of peak flow characteristics. Much of the Green River basin is in the High Desert Region under this delineation. Streams experience relatively lower peak flows. While runoff in upper portions of the basin at higher elevations are dominated by snowmelt, High Desert Region streams such as Bitter Creek are more strongly influenced by low to moderate intensity regional precipitation (Miller 2003). Due to the low precipitation, flows are commonly ephemeral or intermittent in many of these streams with sources not derived from mountainous regions (Mason and Miller 2004). Flows are commonly perennial for snowmelt streams derived from mountainous sources.

All 11 habitat types defined in this SWAP (e.g., sagebrush shrublands, riparian, etc.) occur in the watershed and are based on combinations of Ecological Systems (ES) developed by NatureServe (Comer et al. 2003, NatureServe Explorer 2009). The determination and delineation of ES is based on land cover maps produced by the Northwest Gap Analysis Project (NWGAP 2010). Land cover mapping under NWGAP for the Green River basin is in USGS mapping zone 22 (Wyoming Basins). Of the 173 ES identified under NWGAP, 66 occur in the Green River basin (excluding developed

and open water classes). The most prevalent class by far is Inter-Mountain Basins Big Sagebrush Steppe. The most common SWAP habitats are sagebrush shrublands (53%), desert shrubland (21%), and foothill shrubland (6%). Indeed, the Green River basin is defined by vast expanses of sagebrush. Associated species assemblages, threats, and conservation actions of these and other habitats in this watershed are addressed in separate SWAP chapters.

Land use includes all the customary western public lands players except that the degree of oil and natural gas development is extraordinary and particularly noteworthy. Two large energy development projects are ongoing in the upper basin: the Pinedale Anticline Oil and Gas Exploration and Development Project and the Jonah Infill Drilling Project (Bureau of Land Management 2006a, 2008c). These projects involve hundreds of well pads and hundreds of miles of access roads and pipeline. These projects re-inject produced water or use it for drilling and dust control, and extensive hydraulic fracking has occurred with unknown impacts to groundwater. The areas drain to the New Fork River, Green River, and Big Sandy. Many of these minor drainages are intermittent and ephemeral (Clark and Davidson 2009). Large energy developments in the Muddy Creek drainage basin include the Continental Divide-Creston Natural Gas Development Project and the Atlantic Rim Natural Gas Field Development Project (Bureau of Land Management 2006b, 2006c). Wind energy development projects have been pursued extensively in recent years and include the Chokecherry and Sierra Madre Wind Energy Project in the Muddy Creek drainage (Bureau of Land Management 2009). A water pipeline has been proposed to transfer water from the Green River across Wyoming to Colorado's Front Range, and an Environmental Impact Statement (EIS) is being prepared (U.S. Army Corp of Engineers 2010).

Land management in the Green River basin is dominated by three BLM District Offices: Pinedale, Rock Springs, and Rawlins. Resource Management Plans (RMPs) developed for these

districts describe land management direction, resources, and allocation of uses (Bureau of Land Management 1997, 2008a, and 2008b). In addition to mineral development, livestock grazing is one of the most obvious and long-term land uses in the basin. Irrigated acreage throughout the basin is primarily directed toward livestock forage, and alfalfa is grown where conditions allow (Green River Basin Water Plan 2001). Irrigation is almost exclusively via flood irrigation application, although localized areas of heavier sprinkler use occur around the communities of Farson and Eden in the Big Sandy drainage. Seasonal dewatering of tributary stream segments occurs (e.g., LaBarge, Middle Piney, Cottonwood, and South Piney creeks near their confluence with the Green River). Larger municipalities include Green River, Rock Springs, Pinedale, Kemmerer, and Baggs.

Like geology, water quality varies dramatically throughout the basin. Fremont Lake and the Green River upstream from the New Fork River confluence to the Wilderness boundary are designated by the Wyoming Department of Environmental Quality (DEQ) as class 1 water, recognizing their outstanding features and protecting them from water quality degradation (Wyoming Department of Environmental Quality 2001). Salinity control measures have been implemented to reduce input of salts into the Green River from irrigated agriculture, particularly in the Big Sandy sub-basin (Wyoming Department of Environmental Quality 2010). Water quality monitoring by the DEQ is ongoing in Dry Piney Creek in the LaBarge Creek sub-basin to determine if oil wells, seeps, and stream degradation are affecting aquatic resources. Bitter Creek and its tributary Killpecker Creek, both Green River tributaries, flow through Rock Springs and are on the 303(d) List for elevated fecal coliform (Wyoming Department of Environmental Quality 2010). High chloride concentrations in these streams are believed to derive from local soils and turf grass recreational areas in Rock Springs (Wyoming Department of Environmental Quality 2010). Another impaired water in the basin is a reach of the

Hams Fork River in Kemmerer, known for high pH, associated with nutrient enrichment. The Blacks Fork River is on the 303(d) List for exceeding *E. coli* criteria. Finally, the Smiths Fork and its tributary East and West Forks and Willow Creek were also listed for issues with *E. coli* and stream channel degradation. Habitat improvement efforts have improved conditions and resulted in removal of the East and West Forks from the 303(d) List (Wyoming Department of Environmental Quality 2010).

Aquatic Wildlife

Fish

The native fish community of the Green River basin in Wyoming is arguably the most imperiled in the state. Twelve species and subspecies were found historically in the basin, three of which have been extirpated. The basin is also home to four of Wyoming's five NSS1 fishes, the bluehead sucker *Catostomus discobolus*, flannelmouth sucker *Catostomus latipinnis*, roundtail chub *Gila robusta*, and the federally endangered Kendall Warm Springs dace *Rhinichthys osculus thermalis* (Table 3). The native community also included at least three of the four federally endangered species of the Colorado River basin, the Colorado pikeminnow *Ptychocheilus lucius*, razorback sucker *Xyrauchen texanus*, and bonytail *Gila elegans*, all of which have been extirpated from the state. The Colorado pikeminnow and razorback sucker were historically found in the torrential, big river habitat in canyon reaches of the Green River, downstream of the Wyoming/Utah state line, which are now inundated by Flaming Gorge Reservoir. Both species were likely seasonal residents in Wyoming waters of the Green River below the town of Green River. No conclusive observations of the humpback chub *Gila cypha* are known for the Green River in Wyoming. If present historically, the humpback chub was likely a rare migrant from steep gradient, canyon reaches of the Green River in Utah now inundated by Flaming Gorge Reservoir.

The native chub community of the Green River basin in Wyoming is known to have included bonytail and roundtail chub *Gila robusta*.

However, historic Wyoming accounts of bonytail and roundtail chub are impossible to discern because these species were not

consistently distinguished. Simon (1951) describes *Gila robusta robusta* as the “River

Table 3. Fishes present in the Green River Basin. * denotes Species of Greatest Conservation Need (SGCN). X denotes extirpated from Wyoming. E denotes federally endangered species. U denotes fishes that may have been present in Wyoming, but historic presence has not been confirmed.

| Native game | Native nongame | Nonnative game | Nonnative nongame |
|---------------------------------|---|-----------------------------|----------------------------|
| Colorado River cutthroat trout* | Razorback sucker ^{XE} | Bonneville cutthroat trout | Bonneville redbside shiner |
| Mountain whitefish* | Colorado Pikeminnow ^{XE} | Brook trout | Common carp |
| | Bonytail ^{XE} | Brown trout | Creek chub |
| | Humpback chub ^{EU} | Burbot | Fathead minnow |
| | Kendall Warm Springs dace ^{*E} | Channel catfish | Iowa darter |
| | Bluehead sucker* | Golden trout | Lake chub |
| | Roundtail chub* | Grayling | Longnose dace |
| | Speckled dace | Kokanee salmon | Longnose sucker |
| | Mottled sculpin | Lake trout | Northern leatherside chub |
| | Mountain sucker | Largemouth bass | Sand shiner |
| | | Rainbow trout | Utah chub |
| | | Smallmouth bass | Utah sucker |
| | | Snake River cutthroat trout | White sucker |
| | | Splake | |
| | | Tiger trout | |
| | | Yellowstone cutthroat trout | |

Roundtail; Bonytail” and his records probably included both species. Bosley (1960) refers to *Gila robusta robusta* as the “bonytail” and based on the photographs in his report, his records likely also include both the roundtail chub and the bonytail. He reported that “There appears to be a change in the physical characteristics of the fish in the extreme lower section of the study area, from Flaming Gorge downstream. Many of the fish taken in this section of the Green River had a very pronounced hump,” and he refers to these as “humpback bonytails.” The majority of Bosley’s “bonytail” were probably “roundtail chub,” and the fish he referred to as “humpback bonytails” were probably bonytail, but may have included a few humpback chub.

Based on Bosley (1960) and Binns (1967), it is likely that, prior to the Green River chemical treatment in 1962 and subsequent

impoundment of Fontenelle and Flaming Gorge reservoirs, roundtail chub were common in the mainstem Green River downstream from present-day Seedskaadee National Wildlife Refuge and in some tributaries, including the Little Snake River and Blacks Fork. Roundtail chub were also found in some of the headwater lakes near Pinedale. It is likely that the bonytail and razorback sucker were seldom found upstream of the steep, canyon sections of the Green River near the Utah border. The Colorado pikeminnow was once found as far upstream as the town of Green River, Wyoming. However, by the 1950s and 1960s, few fish were seen in the Green River downstream of the town of Green River due primarily to water pollution. Raw sewage from the towns of Green River and Rock Springs flowed directly to the Green River beginning in the 1920s or 1930s, as did effluent from a Union Pacific railroad maintenance facility

(Bosley 1960), fouling the river as far downstream as Brown's Park, Utah (Quartarone 1995). Any remaining bonytail, razorback sucker, and Colorado pikeminnow were extirpated at some point following the construction of Flaming Gorge Reservoir when any suitable big river habitat in Wyoming was inundated, and populations below Flaming Gorge were prevented from moving upstream. These three species were extirpated from Wyoming by 1970 (Baxter and Simon 1970) and are now federally listed as endangered, along with the humpback chub.

The bluehead sucker, flannelmouth sucker, and roundtail chub, commonly referred to as the Three Species, were historically distributed more widely than were the endangered Colorado River fishes. The Three Species inhabited a number of tributary streams and headwater lakes, in addition to the mainstem Green River and have persisted in the basin since the chemical treatment project and the construction of Flaming Gorge and Fontenelle reservoirs. However, the distributions and abundances of all three species have continued to decline. Bluehead suckers are now extremely rare in the Green River upstream from Fontenelle Reservoir. A single individual was sampled during electrofishing surveys on the Green River near the town of Daniel, Wyoming in 2008 (Darren Rhea, personal communication). Roundtail chub are no longer found in the mainstem Green River or in the Big Sandy subdrainage. Roundtail chub were last observed in the Big Sandy River at a site below Bone Draw in 1991 (Mark Fowden, personal communication). The species was last seen in the lower Green River (below Fontenelle Reservoir) in September 1986 (Johnson and Oberholtzer 1987), and a single individual was observed above Fontenelle Reservoir in 1993 (Dave Zafft, personal communication).

The WGFD initiated a detailed status assessment of the Three Species in the Green River basin in 2002. A total of 377 sites in 13 subdrainages throughout the basin were sampled over the next 5 years, 309 of which contained fish. This project provided

information needed to accurately assess the relative abundances of the Three Species, describe current distributions, and assess threats. Detailed results of this assessment and management recommendations for the Three Species are provided in Gelwicks et al. (2009). Although flannelmouth sucker were found at 84 sites across 13 subdrainages, and bluehead sucker were found at 22 sites in seven subdrainages, nearly all sites contained larger populations of the introduced white sucker. The persistence of both native catostomid species is threatened by hybridization with the white sucker. Flannelmouth sucker were found in the absence of white sucker only in upper Bitter Creek. Similarly, bluehead sucker were found in the absence of white sucker only in Ringdahl Reservoir, a 13-acre reservoir on the divide between the Blacks Fork and Henrys Fork sub-basins (Gelwicks et al. 2009). Roundtail chub were found at 10 sites in the Little Snake River drainage and 18 sites in the Blacks Fork drainage (Gelwicks et al. 2009). Lentic populations of roundtail chub and flannelmouth sucker are also known from New Fork, Willow, Fremont, Halfmoon, Little Halfmoon, and Burnt lakes in the Green River headwaters. The status assessment clearly indicated that immediate and aggressive management actions were necessary to conserve these species in the Green River basin in Wyoming.

The mountain sucker *Catostomus platyrhynchus* is the most widespread of the native sucker species in the basin. However, Simon (1951) did not consider the mountain sucker native to the Green River basin and likely attributed many early observations of this species to the meristically similar bluehead sucker (Gelwicks et al. 2009). The mountain sucker was sampled at 173 of the sites sampled from 2002–2006 and was present in 12 of the 13 sub-drainages sampled (Gelwicks et al. 2009). The species is also present in the six large headwater lakes mentioned above. Speckled dace *Rhinichthys osculus* and mottled sculpin *Cottus bairdi* were the two most common native species during the 2002–2006 surveys and were found at 226 sites

(13 basins) and 135 sites (11 basins), respectively.

The Kendall Warm Springs dace is endemic to Kendall Warm Springs, a 384 ft stream originating from thermal springs tributary to the upper Green River. The Federally Endangered species has been studied in detail, including investigations into life history, behavior, ecology, and habitat. Extensive monitoring is conducted to monitor the status of the species.

Two gamefish are native to the Green River basin, the mountain whitefish *Prosopium williamsoni* and the Colorado River cutthroat *Oncorhynchus clarkii pleuriticus*. The mountain whitefish was the most common species in the Green and New Fork rivers above their confluence prior to construction of Fontenelle Reservoir and were less abundant, but common in the Green River below the confluence (Bosley 1960, Binns 1977). Gelwicks (2009) collected mountain whitefish at 30 sites in 6 of the 13 sub-basins sampled, including the upper Green and New Fork rivers. Biologists are concerned that anecdotal observations suggest that mountain whitefish have been extirpated from some of the large glacial lakes on the southern slope of the Wind River range and populations in many other parts of the Green River basin have declined recently.

The Colorado River cutthroat is native only to the Green River basin in Wyoming. The subspecies was abundant in the Green River headwaters and many tributaries in the basin in the mid-1800s (Trotter 1987), but by the middle of the last century, this cutthroat was known to be rare and relegated to headwater streams in the Green and Little Snake drainages (Simon 1951). In 1972, Robert Rush Miller included the subspecies on his list of threatened freshwater fishes of the United States (Trotter 1987).

Beginning in 1964, the WGFD initiated a long-term study to determine the status of remaining Colorado River cutthroat populations in Wyoming. Forty tributary streams and two lakes were found to contain populations of native cutthroat trout, but only twelve streams

and two lakes contained populations with little or no evidence of hybridization with nonnative trout. All of the remaining populations of Colorado River cutthroat were on small tributaries of the Green, Blacks Fork and Little Snake rivers. Binns (1977) attributed the decline to hybridization and competition with introduced trout, as well as habitat changes associated with timbering, livestock, and irrigation practices. Soon after this assessment was complete, the WGFD began funding and initiating projects to further describe the remaining cutthroat populations, habitat needs, and threats (Jespersen 1981, Jespersen and Conder 1986, Oberholtzer 1987, Quinlan 1980, and Remmick 1981). The WGFD also began to develop plans to conserve the species. The first Colorado River cutthroat five-year management plan was completed in 1987 and included activities to conserve the subspecies within all of the major enclaves in Wyoming. A number of other interagency plans followed (CRCT Coordination Team 1994 and Little Snake River Working Group 1994), culminating in the preparation of the 2001 Conservation Agreement and Strategy developed by the WGFD, the Utah Division of Wildlife Resources, the Colorado Division of Wildlife, US Forest Service, and the Bureau of Land Management (CRCT Task Force 2001).

The Colorado River cutthroat trout was petitioned for listing as endangered in December 1999. In 2007, following years of inaction, lawsuits, and status reviews, the U.S. Fish and Wildlife Service determined that listing the subspecies as threatened or endangered under the Endangered Species Act was not warranted. The petitioner sued again in November 2009, challenging the 2007 ruling. A decision has not yet been issued.

The Green River basin is also home to nearly 30 species of nonnative fishes. Sixteen introduced gamefish species and thirteen introduced nongame species are now found in the basin (Table 3). These species sustain many of the most important sport fisheries in southwest Wyoming, including the Green River trout fishery and all of the important large reservoir

fisheries in the region. However, exotic fishes pose one of the primary threats to the persistence of native game and nongame species in the Green River basin.

Aquatic Reptiles

No turtles are native to the Green River basin, and none have been introduced.

Freshwater Mollusks and Crayfishes

Wyoming is still in the discovery phase in terms of its freshwater mussels and gastropods, and few published accounts exist (Beetle 1989, Henderson 1924, Hoke 1979, Hovingh 2004); however, no native mussels are known from the Green River basin.

Beetle (1989) contains some of the only published observations of gastropods in Wyoming, listing species occurrences by county. In 2009, the WGFD funded a project at the University of Wyoming (UW) to conduct a literature review, identifying the current and historical information on freshwater gastropod distributions in Wyoming and to develop gastropod collection methods for the WGFD, and assess the distribution of freshwater gastropods in the Bighorn and North Platte river drainages in Wyoming. This project did not include sampling in the Green River basin, but the UW research project will provide gastropod sampling protocols. Baseline survey data are needed for all gastropods in the Green River basin.

No crayfish species are known to be native to the Green River basin in Wyoming; however, during a 1985–1987 survey, *Orconectes immunis* and *O. virilis* were found in the Green River drainage where they have been introduced (Hubert 1988). A second survey in 2007–2009 verified the presence of *O. immunis* in Fontenelle Reservoir and the Big Sandy River. The distribution of *O. virilis* was much more widespread and included occurrences in the Green, Black's Fork and Hams Fork Rivers, Flaming Gorge Reservoir, Jim Bridger Pond, and the Little Snake River and a number of its tributaries. The species was also documented in Meadow Lake, in the headwaters of Pole Creek in the New Fork River drainage (Hubert 2010).

Table 4. Species of Greatest Conservation Need present in the Green River Basin

Fish

Bluehead sucker
Colorado River cutthroat
Flannelmouth sucker
Kendal Warm Springs dace
Mountain whitefish
Roundtail chub

Identification of Conservation Areas

Conservation areas have been identified for the Three Species and Colorado River cutthroat trout.

Five priority subdrainages for the management of Wyoming's Three Species were recently identified based on status and distribution assessments: 1) Muddy Creek (tributary to the Little Snake River), 2) Big Sandy River, 3) Little Sandy Creek, 4) Upper Bitter Creek, and 5) the Finger Lakes near Pinedale (Senecal et al. 2010).

Ringdahl Reservoir also supports an isolated population of bluehead sucker.

Priority conservation areas for the Colorado River cutthroat trout include multiple waters in the Little Snake River drainage, the Blacks Fork River drainage, and tributaries to the mainstem Green River. *Little Snake River enclave* conservation areas include: North Fork, West Branch of the North Fork, and the upper Roaring Fork of the Little Snake River; Dirtyman Creek watershed and upper Deep, Mill, Hatch, and Hells Canyon creeks in the Savery Creek watershed; Haggarty Creek; and Littlefield Creek in the Muddy Creek watershed. *Blacks Fork River enclave*: conservation areas include Muddy Creek, upper Sage and Gilbert creeks; and all tributaries to the upper Hams Fork River. Conservation areas in the *Green River Westside tributaries*: include the LaBarge, Horse, and Cottonwood creek watersheds, North Piney Lake and the Lake Creek watershed, upper Beaver Creek and Trail Ridge creeks in the South Piney watershed, Tosi,

Tepee, Rock, Klondike, Jim, and Gypsum creeks.

The Wyoming Game and Fish Department Strategic Habitat Plan (WGFC 2009) references multiple goals, two of which are to conserve and manage wildlife habitats that are crucial for maintaining terrestrial and aquatic wildlife populations for the present and future, and to enhance, improve, and manage priority wildlife

habitats that have been degraded. . Crucial habitat areas were identified to accomplish the first goal, and enhancement areas were identified to accomplish the second. . All of the conservation areas listed above are also identified as crucial habitat areas in the Strategic Habitat Plan.

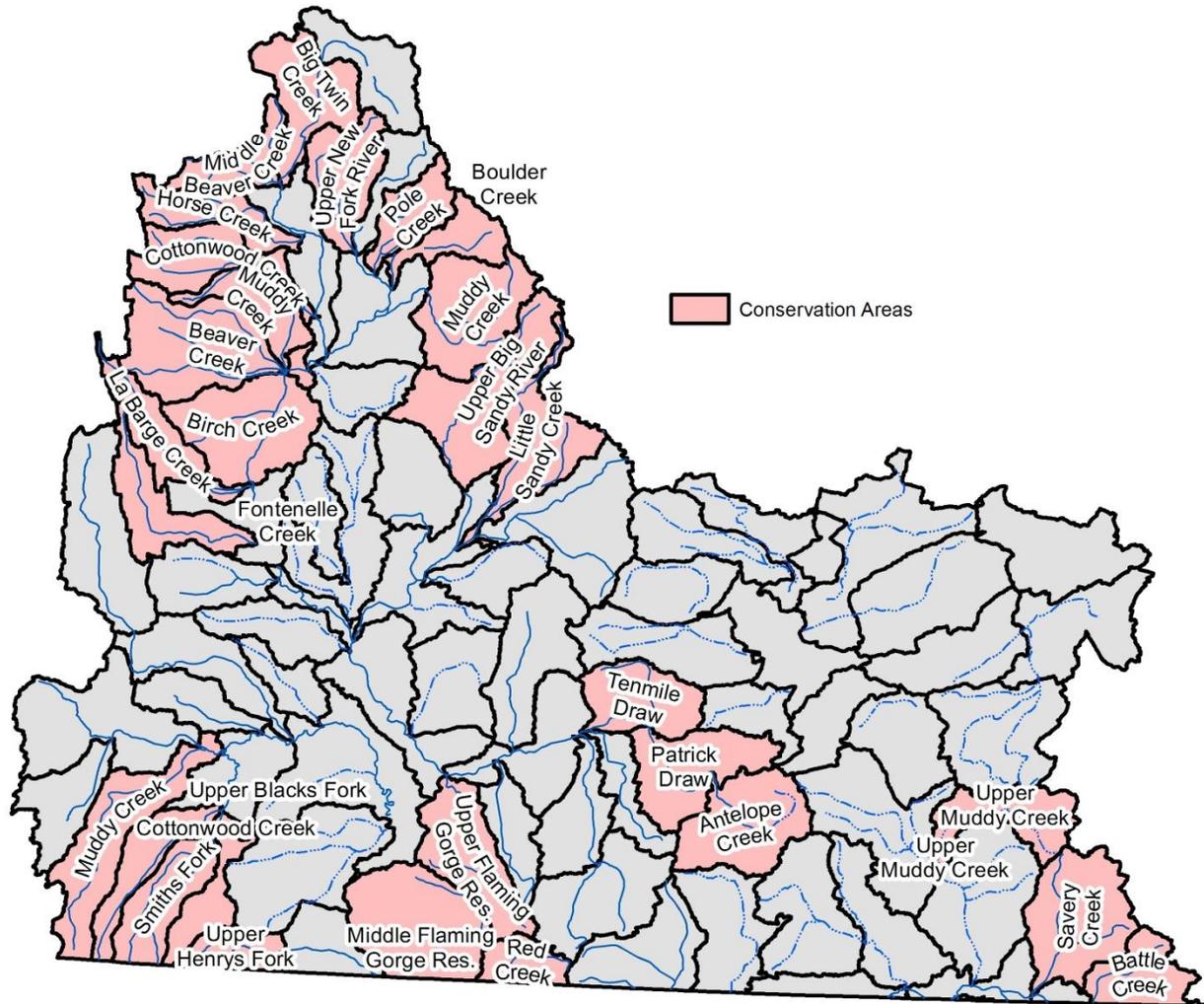


Figure 4. Aquatic Wildlife Conservation Areas in the Green River Basin.

Threats

Energy development – High

The diversity and intensity of ongoing and potential energy development constitutes a threat to the persistence of aquatic wildlife.

Energy development as a leading conservation challenge in Wyoming is explored in a separate chapter of this SWAP. Native fish distributions in sub basins like Muddy Creek, Bitter Creek, Blacks Fork, Currant Creek, Big Sandy and Upper Green River are all potentially threatened

by water quality, water quantity, sediment, fragmentation, or other effects from energy development activities. Exploration and development of natural gas, oil, coal bed methane, wind, and oil shale involve various degrees of road building and other surface disturbances that can directly or indirectly increase sediment supply. Runoff from road systems and hardened areas may enhance such sediment issues. Culvert crossings associated with new roads threaten fish passage and access to habitats if not installed correctly. Spills from pipelines or machinery can impair water quality. Surface or groundwater pumping for drilling, fracking, or other methods can result in localized habitat loss.

Invasive species – High

Although many of the introduced species in the basin compete with, prey upon, hybridize with, or otherwise negatively impact native species, the white sucker, burbot, and brook trout pose the most significant and immediate threats. White sucker are currently found throughout the basin and threaten the persistence of native flannelmouth and bluehead suckers through competition and hybridization. Burbot, a voracious exotic predator, are expanding in the basin and pose a significant threat to flannelmouth and bluehead suckers in the Green and Big Sandy Rivers and to the Three Species (bluehead sucker, flannelmouth sucker and roundtail chub) in the Blacks Fork and Hams Fork. Brook trout pose a significant threat to the important conservation populations of Colorado River cutthroat trout.

Aquatic invasive species (AIS) including fish, pathogens, plants, and mollusks are currently present in Wyoming, most notably the New Zealand mudsnail and the parasite that causes whirling disease. These AIS can alter the native species in a watershed through competition, disease, shifts in food availability, and direct mortality. While AIS currently in Wyoming can cause problems and need to be controlled, the most significant known threat to Wyoming's native species is from zebra and quagga mussels, based on their proximity to Wyoming and demonstrated negative impacts in other areas. Zebra and quagga mussels can out-compete

native mussels for space and resources and will attach to and smother native mussels causing mortality (Cummings and Mayer 1992, Strayer 2008). They filter plankton out of the water column at high rates (up to a liter per day per individual) so that little plankton remains available for fish populations, resulting in their decline (Benson 2009). In addition, invasive mussels produce pseudofeces which can lead to harmful algal blooms affecting numerous aquatic species.

The Wyoming Aquatic Invasive Species Act of 2010 allowed the WGFD to implement the Wyoming AIS Program with the goal of executing a coordinated strategy to prevent, control, contain, monitor, and whenever possible, eradicate aquatic invasive species from the waters of the state. The Wyoming AIS Management Plan of 2010 is the framework for this three-part strategy which includes 1) outreach and education, 2) inspection of watercraft to increase boater awareness of AIS threats and prevention and to intercept high risk watercraft that may be transporting AIS, and 3) monitoring of waters to allow for early detection and rapid response to any new AIS populations in the state.

Water development/ altered flow regimes – High

Natural flow regimes in stream segments around the state have been altered by human activities including irrigation diversions and water developments for more reliable water supply, hydropower, and flood control. These altered flow regimes are also a consequence of broad-scale changes in land use and management associated with agriculture, grazing, timber harvest, and housing development (see Wyoming Leading Wildlife Conservation Challenges – Disruption of Historic Disturbance Regimes). The majority of the Green River basin is publicly owned. Because it is such an arid region, the limited amount of irrigated cropland has a significant impact on aquatic wildlife in some areas. Besides the direct effects of dewatering, irrigation diversions impede movement, and some fish are lost to entrainment into the irrigation ditches. Lateral and longitudinal hydrologic connectivity and physical access by

fish populations to all habitats necessary to complete their life history is limited throughout the drainage. In-channel obstructions and increased dewatering have reduced some populations of native fishes.

The need for additional water for human use will intensify in the immediate future, and that trend will be especially evident in the western U.S. This trend has multi-faceted consequences for fish and wildlife and the habitats upon which they depend. In Wyoming, trans-basin water diversions are not uncommon and are likely to be further proposed and pursued. Energy diversification, including hydropower development, may increase as the nation's energy demands rise. Warmer conditions with more erratic precipitation—which some predict for Wyoming's future climate—may heighten the need for additional water development (water storage) for municipal and agricultural purposes.

The likely trend will be water development projects closer to the delivery point and conveyance via pipelines instead of stream channels. Additional emphasis will likely be placed on lining irrigation ditches and other practices to more efficiently use water for consumptive purposes. The net effect of all such water management practices will be to alter the timing, magnitude, and duration of natural hydrographs and reduce intra- and inter-annual variability in Wyoming's streams and associated riparian corridors (see Wyoming Leading Wildlife Conservation Challenges – Climate Change, and the Riparian habitat chapter).

Several water development projects have been proposed for the upper Green River Basin. Proposed sites are located on the Green River and Wyoming Range and Wind River tributaries (Green River Basin Water Plan 2001). Several of these proposals are located within CRC conservation areas. Dam construction has been proposed on the Green River and several tributaries in CRC conservation areas.

While water development can threaten native species, some introduced species, including those in popular sport fisheries, have thrived in the face of water development. The

simplification of natural systems by human development tends to favor species with generalized and broad habitat requirements. For example, the lake trout fisheries in Flaming Gorge Reservoir depends on the consistent deep water and forage production inherent in this man-made water body. Stable stream flow releases from dams, with relatively low peak flows and relatively high base flows, perpetuate productive sport fisheries like the Green River below Fontenelle Reservoir.

Drought and climate change – moderate

Climate change may increase air and surface water temperatures, alter the magnitude and seasonality of precipitation and runoff, and shift the reproductive phenology and distribution of plants and animals (Seavy et al. 2009) (see Wyoming Leading Wildlife Conservation Challenges – Climate Change).

Changes in precipitation patterns under various climate change scenarios are predicted to produce peak flows earlier in the yearly cycle and to lower base flows (Barnett et al. 2004). Drought lowers water tables, leading to reduced plant growth and reproduction. Riparian vegetation declines lead to lower bank stability, higher siltation and altered stream habitat quality and quantity. Lower water levels increase water temperatures and reduce the habitat available to fish and other aquatic wildlife. All these conditions can be detrimental to the health and reproductive success of all aquatic wildlife species.

Conservation Initiatives

The first Colorado River cutthroat trout five-year management plan in Wyoming covered the years 1987–1992. This plan included activities within all the major enclaves: the Green River, Blacks Fork, North Fork Little Snake River, and Big Sandstone Creek drainages. Status reports were prepared for each enclave, including the Green River westside tributaries (Remmick and Nelson 1992). Recommendations from this status report included the need for separate management plans for each enclave.

In 2001, a Conservation Agreement and Strategy was developed to reduce or eliminate threats to remaining populations of Colorado River cutthroat trout. This strategy was revised in 2006 (CRCT Coordination Team 2006).

The WGFD Pinedale and Green River fisheries management crews have actively worked to conserve populations of the Colorado River cutthroat trout in the westside tributaries to the Green River, the north tributaries to the Uinta Mountains, and in the headwaters of the Little Snake River basin. Chemical treatments and barriers have been used to remove nonnative salmonids from important conservation populations of cutthroat trout. The first chemical treatments in the Little Snake River drainage were conducted in Deep and Haggarty creeks in 1987 and in Mill Creek in 1988. Since that time, chemical treatments in the Little Snake sub-basin have been conducted to remove nonnative salmonids from the entire North Fork Little Snake drainage and portions of Deep Creek, the upper Roaring Fork, Littlefield Creek, and upper Muddy Creek.

In 2008 and 2009, WGFD personnel utilized State Wildlife Grant funding to evaluate the impacts of water diversion structures on Colorado River cutthroat populations in the headwater tributaries of the Little Snake River. Biologists investigated entrainment and evaluated impacts to upstream or downstream movements of cutthroat (Luginbill 2010).

The largest fish restoration project ever conducted in Wyoming was conducted in the LaBarge Creek drainage, a westside tributary to the Green River, to restore Colorado River cutthroat trout to approximately 58 miles of this stream and tributaries. The chemical treatment project culminated with the initial stocking of cutthroat in August 2007.

A detailed assessment of the status of the Three Species as of 2006 was completed by Gelwicks et al. (2009). Numerous other research projects have also been conducted to answer questions necessary to facilitate conservation of the Three Species in Wyoming (Beatty 2005, Bower 2005, Compton 2007, Douglas and Douglas 2008a,

Douglas and Douglas 2008b, Douglas and Douglas 2008c, Douglas et al. 2008, McDonald et al. 2008, Sweet 2007, Banks 2010, and Laske 2010), most of which were funded by the WGFD and U.S. Bureau of Reclamation. Information from these projects was used to develop conservation plans for the Three Species (Cavalli 2006, Senecal et al. 2010). Long-term plans include the removal of nonnative species from Big Sandy River and Little Sandy and Muddy Creeks.

Chemical treatments and temporary fish passage barriers have been used to eliminate nonnative fishes from the Muddy Creek drainage (Little Snake River) upstream of McKinney Creek to restore Colorado River cutthroat. Long-term plans include the restoration of native bluehead sucker and flannelmouth sucker populations downstream to the Weber head cut stabilization structure in this drainage.

The WGFD has utilized funding from the Wyoming Governor's office to begin removal efforts and planning for additional chemical treatment projects in priority drainages in the Green River basin. Fish weirs, seining, single- and three-pass electrofishing techniques were used to remove invasive fish and sample fish populations in 2009. More than 15,000 nonnative fish were removed from the Big Sandy River and the Little Sandy, Bitter, and Muddy Creek drainages, including nearly 12,000 white sucker and white sucker hybrids and more than 700 burbot. Mechanical removal efforts resumed in 2010. Department personnel are also investigating methods to salvage and hold native flannelmouth and bluehead suckers during chemical treatment. Native sucker-white sucker hybrids and mountain suckers are being used as surrogates in experimental holding operations at the University of Wyoming's Red Buttes Laboratory. The objectives of this project are to develop effective methods for transportation, holding, feeding, and eventual repatriation of native suckers following chemical treatments in priority drainages.

The WGFD is also planning to begin work on the design of a fish passage barrier on Big Sandy River to prevent recolonization of the area that

is slated for eventual chemical treatment to remove nonnative species. Funding from the Wyoming Governor's office was also used to fund a project conducted by the Colorado State University Larval Fish Laboratory to determine the abundance of flannelmouth and bluehead sucker larvae that might drift over the proposed barrier and be lost from the upstream population. Construction of the barrier is contingent upon the results of this research project.

Unique lentic populations of roundtail chub occur in a number of lakes. In 2009 WGFD transplanted roundtail chub from Little Halfmoon Lake to Scab Lake located in the southern foothills of the Wind River Mountain range. These populations are threatened by predation by introduced lake and brown trout. The WGFD has been working to identify potential refuge lakes for roundtail chub. In 2009, the WGFD transplanted roundtail chub to Scab Lake. Additional transplants may occur if suitable refugia are identified in the next couple years.

The WGFD's Fish Division has developed basin management plans to guide management across the state. These plans provide background and history of aquatic wildlife management as well as management direction for sportfish, SGCN, and aquatic habitat. The management direction includes reference to the SWAP and the Strategic Habitat Plan, attempting to incorporate management direction from those two plans that is relevant to each basin into each basin management plan.

The WGFD has the opportunity to comment on most environmentally sensitive construction or management actions submitted through the National Environmental Policy Act (NEPA) review process. Projects include state and federal lands and private ventures that require action by state or federal agencies. The WGFD regularly provides recommendations to protect habitat and populations of aquatic wildlife at the project level. Department efforts are guided by Wyoming Game and Fish Commission mitigation policy (WGFC 2008).

The WGFD has a rigorous collection permitting system that restricts commercial, scientific, and educational activities (WGFC 2005a) and provides protection to aquatic wildlife. The regional fisheries supervisor reviews all requests for permits and recommends either approval or rejection of the request based on merit and impacts to the resource in question.

The movement of fish by WGFD employees is critical to address many of the aspects, thus the intent, of our mission. However, the act of moving or importing fish also presents risks that could potentially jeopardize that mission. To address this conflict, a method to determine the relative level of risk associated with any proposed fish importation and/or transplant was developed. The WGFD utilizes Hazard Analysis and Critical Control Point (HACCP) procedures (Gunderson and Kinnunen 2001) and has developed a risk assessment matrix from these procedures to manage transplants, thereby protecting the aquatic resources within the state. Using these procedures and matrix, WGFD fisheries managers develop documentation that explains whether a transplant is nearly free of risk. The documentation must address all aspects of the transplant including, but not limited to, verifying that the fish being transplanted are disease free, the water source is disease free, and non-target species are excluded from transplant. Source populations of salmonids are verified disease free by collecting a standardized number of fish, having them inspected by an American Fisheries Society-certified Fish Health Inspector for all known pathogens, and receiving disease free certification. The resulting documentation is reviewed and either approved or denied by the WGFD Chief of Fisheries. No whirling disease-infected trout, native or nonnative, are stocked by the WGFD, and they are not allowed to be stocked by others (WGFC 2003).

In Wyoming, state Game and Fish Commission policy precludes the stocking of fish into waters that are capable of maintaining satisfactory, self-sustaining fisheries (WGFC 1998). A common sense, biologically based protocol for fish rearing and stocking has historically been

followed in Wyoming, with emphasis on management for native fish and wild fish wherever possible (Wiley 1995). Only 3% of the streams listed in the Wyoming Game and Fish Department database inventory are stocked annually. Maintenance of native cutthroat trout subspecies has been a management priority for more than 40 years (Stone 1995), and protection from stocked predators of native nongame fishes has been an important consideration for at least the last decade.

Wyoming has regulations prohibiting unauthorized stocking of fish or fish eggs. Private citizens can only stock waters in Wyoming following a WGFD permitting system that includes review by the responsible regional fisheries supervisor (WGFC 2005a). The WGFD has increased education efforts regarding the problems associated with illegal introductions of fish. The Wyoming Legislature increased the penalties for illegal fish stocking in 2010, and the Wyoming Wildlife Protectors Association has offered \$2,500 rewards for information leading to the conviction of individuals found illegally moving or stocking fish.

Habitat management efforts are guided by the Strategic Habitat Plan (SHP) that was adopted by the Wyoming Game and Fish Commission in January 2009. The SHP includes five goals: 1) Conserve and manage wildlife habitats that are crucial for maintaining terrestrial and aquatic wildlife populations for the present and future, 2) Enhance, improve, and manage priority wildlife habitats that have been degraded, 3) Increase wildlife-based recreation through habitat enhancements that maintain or increase productivity of wildlife, 4) Increase public awareness of wildlife habitat issues and the critical connection between healthy habitat and abundant wildlife populations, and 5) Promote collaborative habitat management efforts with the general public, conservation partners, private landowners, and land management agencies. Efforts are focused in priority areas in each of the management regions and include “crucial” areas essential for conservation of important species and communities, and

“enhancement” areas, which represent places where work should be conducted to manage or improve wildlife habitat.

Studies of relationships between stream flow and habitat for Colorado River cutthroat trout have occurred throughout the Green River basin. Thirty instream flow water rights have been filed by the WGFD and Wyoming Water Development Office and permits approved by the State Engineer. These instream flow water rights permits protect 107 miles of streams distributed among all of the Colorado River cutthroat trout enclaves from junior water appropriators (Paul Dey, personal communication).

Habitat enhancement and restoration work in recent years has increased the resiliency and improved the condition of aquatic habitats for Colorado River cutthroat trout and the Three Species. Watershed restoration work in the Little Mountain Ecosystem east of Flaming Gorge, including prescribed burns, grazing management, and beaver restoration, has improved portions of the Currant Creek, Red Creek, Trout Creek and Sage Creek watersheds. The Muddy Creek drainage, key for the Three Species, has been the focus of careful livestock management, riparian enhancement and protection efforts, and riparian monitoring to maintain or improve stream conditions.

The Kendall Warm Springs dace (KWD) is federally listed as an endangered species. The U.S. Fish and Wildlife Service is updating the recovery plan for KWD. WGFD is participating in the process to update that plan.

Aspen treatment projects in the Wyoming Range have been on-going for several years. The plan is to complete treatments along the entire Wyoming Front Range within the next 10 years.

Triple Peak Forage Reserve and Wyoming Range Allotment Complex are two forage reserves/closures that have occurred in the Wyoming Mountain Range in the last 5 years. Triple Peak Forage reserve is 58,675 acres and covers the headwaters of North Piney and

Cottonwood watersheds, important Colorado River cutthroat conservation populations. The Wyoming Range Allotment complex is 67,000 acres and protects the headwaters of North Horse and South Horse creek watersheds.

The Wyoming Landscape Conservation Initiative (WLCI) coalesced in the mid 2000s and is a long-term science-based effort to assess and enhance aquatic and terrestrial habitats at a landscape scale in Southwest Wyoming. To ensure Southwest Wyoming's wildlife and habitat remain viable in areas facing development pressure, the U.S. Bureau of Land Management, U.S. Fish and Wildlife Service, U.S. Geological Survey, USDA Forest Service, National Park Service, the U.S. Bureau of Reclamation, the Wyoming Department of Agriculture, the Wyoming Game and Fish Department, local conservation districts, and local counties are implementing the WLCI. Details about WLCI conservation actions and science in southwest Wyoming are available at <http://www.wlci.gov>.

The Wyoming Legislature created the Wyoming Wildlife and Natural Resource Trust (WWNRT) in 2005. Funded by donations, legislative appropriation, and interest earned on a permanent account, the purpose of the program is to enhance and conserve wildlife habitat and natural resource values throughout the state. Any project designed to improve wildlife habitat or natural resource values is eligible for funding. The WWNRT is an independent state agency governed by a nine-member citizen board appointed by the Governor. The WGFD has partnered with the WWNRT to successfully implement a wide range of projects to benefit a broad array of Wyoming's wildlife.

Landscape Conservation Cooperatives (LCCs) are a new program of the U.S. Fish and Wildlife Service. The vision is that they serve as applied conservation science partnerships focused on a defined geographic area that inform on-the-ground strategic conservation efforts at landscape scales. LCC partners include U.S. Department of Interior agencies, other federal agencies, states, tribes, non-governmental organizations, universities, and other

stakeholders. It is hoped that LCCs will enable resource management agencies and organizations to collaborate in an integrated fashion within and across landscapes. LCCs are intended to provide scientific and technical support to inform landscape-scale conservation using adaptive management principles. They are proposed to engage in biological planning, conservation design, inventory and monitoring program design, and other types of conservation-based scientific research, planning and coordination. It is hoped that LCCs will play an important role in helping partners establish common goals and priorities, so they can be more efficient and effective in targeting the right science in the right places. Products developed by LCCs should inform the actions of partners and other interested parties in their delivery of on-the-ground conservation. The WGFD will continue to participate in the LCC process as appropriate.

The National Fish Habitat Action Plan (NFHAP) was developed by a coalition of fisheries professionals, state and federal agencies, tribes, foundations, conservation and angling groups, businesses and industries, all determined to reverse the declines of America's fish habitats. In its design, the plan encompasses five important lessons that emerge from America's past efforts to protect and restore fish habitat: 1) Be strategic rather than merely opportunistic, 2) Address the causes of and processes behind fish habitat decline, rather than the symptoms, 3) Provide increased and sustained investment to allow for long-term success, 4) Monitor and be accountable for scientifically sound and measurable results, and 5) Share information and knowledge at all levels from local communities to Congress. The WGFD has been heavily involved with the development and implementation of the NFHAP. The WGFD is involved with three NFHAP partnerships: – the Great Plains Fish Habitat Partnership, the Western Native Trout Initiative, and the Desert Fishes Habitat Partnership. The latter two cover the Green River basin.

The mission of the Western Native Trout Initiative (WNTI) is: “To serve as a key catalyst for the implementation of conservation or management actions, through partnerships and cooperative efforts, resulting in improved species status, improved aquatic habitats, and improved recreational opportunities for native trout anglers across western states.” Their vision is: “An increase in healthy, fishable western native trout populations resulting from sharper focus and commitment to action on common conservation needs of western native trout; enhanced public benefit resulting from multiple partners working together, sharing resources, and speaking with a united voice about the conservation and value of western native trout; and increased funding to accomplish strategic actions as a result of greater community and financial support from initiative partners and collaborators.” By working together, the partners in WNTI are striving to implement the most strategic actions needed to benefit these trout. And by working together to establish secure populations, WNTI will also benefit anglers by enhancing recreational fishing opportunities for unique trout species across the West.

The Desert Fish Habitat Partnership’s purpose is to conserve aquatic habitat in the arid west for desert fishes for the American people by protecting, restoring, and enhancing these unique habitats in cooperation with and in support of, state fish and wildlife agencies, federal agencies, tribes, conservation organizations, local partners, and other stakeholders. The Desert Fish Habitat Partnership seeks to address fish and habitat issues over a broad geographic area that encompasses the entirety of the Great Basin and Mohave deserts, and those portions of the Sonoran and Chihuahuan deserts that lie within the United States. The benefits of aquatic habitat conservation extend beyond desert fishes to include humans and other animal and plant species. Riparian habitats that depend on surface water not only support a significant number of terrestrial and avian species identified as priority conservation species in SWAPs, but also function to store water that

supplements groundwater recharge. The declining status of so many desert fishes highlights the importance of preserving these aquatic habitats so that water is available not only for the native fish, but also for future generations of humans. The Partnership can play an important role in conserving water in the West for future generations.

Recommended Conservation Actions

Secure and enhance populations and habitats in SGCN priority areas.

Evaluate the feasibility of reducing populations of or removing nonnative fishes from priority conservation areas in the basin.

Determine the status and distribution of native aquatic wildlife assemblages with emphasis on Colorado River cutthroat trout, bluehead sucker, flannelmouth sucker, and roundtail chub.

Continue basin-wide surveys to identify fish distribution, relative abundance, and habitat preferences.

Conduct baseline surveys of aquatic gastropods in the Green River basin.

Assess the genetic purity of Colorado River cutthroat trout, bluehead sucker, flannelmouth sucker, and roundtail chub populations.

Collect and store tissue samples from individual populations for future genetic analysis.

Identify and reduce threats to native fish populations from nonnative species.

Eradicate burbot from conservation areas in the basin. Monitor burbot and white sucker distribution within the drainage.

Conduct annual monitoring of the Flaming Gorge Reservoir fish populations in order to assess the effects of burbot on the fishery.

Investigate feasibility and utility of building a barrier on the Big Sandy River to facilitate nonnative fish removal above the barrier.

Transplant native fish to areas of refuge from competing and hybridizing species.

Investigate options to reduce the spread of burbot to the Green River watershed upstream of Fontenelle Reservoir. Implement actions to suppress burbot throughout the basin.

Implement existing plans and agreements to conserve SGCN.

Implement the WGFD short-term plan for the Three Species in the Green River drainage (Senecal et al. 2010).

Represent the WGFD on the interagency Three Species conservation team and help implement the Range-wide Conservation Agreement and Strategy for the Three Species (Colorado River Fish and Wildlife Council 2004).

Represent the WGFD on the interagency Colorado River cutthroat trout conservation team and help implement the Range-wide Conservation Agreement and Strategy for Colorado River cutthroat trout (CRCT Coordination Team 2006).

Continue working with U.S. Fish and Wildlife Service on revising the recovery plan for Kendall Warm Springs dace. Continue working with U.S. Forest Service to protect Kendall Warm Springs.

Increase educational efforts about the ecological, economic, and social values of aquatic SGCN.

The importance and role of aquatic SGCN is poorly understood by the general public. Efforts should be enhanced to increase public education in this area.

Continue building voucher collections for all aquatic wildlife.

Continue to fill voids in voucher inventory for fish per WGFD protocol (Zafft and Bear, 2009).

Determine if there is interest in voucher specimens of gastropods. If so, expand the voucher program to include those organisms.

Continue aquatic habitat work in the basin.

Supply flow or other information to the State Engineer's Office and Water Development Office to facilitate adjudication of instream flow water rights.

Monitor instream flow segments for compliance with approved instream flow levels. Pursue compliance as needed when water is available and in priority.

Develop instream flow water rights recommendations and filings for streams in the Muddy Creek drainage to maintain habitat for Colorado River cutthroat trout and the Three Species. Investigate feasibility of a water right recommendation in Bitter Creek for flannelmouth suckers.

Ensure ongoing diversion rehabilitation work on the Little Snake River includes features to facilitate upstream passage of native adult flannelmouth sucker, bluehead sucker, roundtail chub and Colorado cutthroat trout.

Continue protecting and enhancing riparian willow and sedge communities in the Muddy Creek drainage.

Investigate the feasibility of obtaining a water right in Bitter Creek for flannel mouth sucker.

Continue working with the BLM and Grizzly Wildlife Habitat Unit lessees to develop and implement livestock grazing plans that protect and maintain thriving riparian vegetation and sustain Muddy Creek drainage stream channels.

Explore water management approaches that enhance fish habitat.

Identify opportunities to work with private water right holders to manage water diversions and uses with the goal of restoring natural flow regimes. Where opportunities exist, develop cooperative strategies with landowners and other partners to implement strategies that are beneficial to aquatic resources.

Identify stream segments where habitat and available flow regimes indicate a need to file instream flow water rights for SGCN. As opportunities are identified, conduct needed

studies and file for state-held instream flow water rights.

Identify fish and wildlife mitigation for new reservoirs as they are proposed including instream flow regimes and minimum fishery pools. Ensure that mitigation recommendations are included as conditions in applicable permits.

Follow up on recommendations from the graduate research project on gastropods.

The WGFD-funded graduate project at the University of Wyoming will provide direction for sampling methods. Those recommendations should be followed, and baseline gastropods surveys should be conducted in the Green River basin.

Monitoring

Establish standardized monitoring protocols and locations for native SGCN.

Monitor water quantity and temperature in areas containing important native SGCN populations.

Monitor the establishment and spread of invasive species.

Monitor burbot and white sucker distribution within the drainage. Conduct annual monitoring of the Flaming Gorge Reservoir fish populations in order to assess the effects of burbot on the fishery.

Monitor populations of Colorado River cutthroat trout, mountain whitefish, and the Three Species.

Monitor riparian and stream channel conditions in the Muddy Creek drainage to influence progressive grazing management and maintenance or improvement of riparian and stream channel habitat for the Three Species and Colorado River cutthroat trout.

Monitor instream flow segments for compliance with approved instream flow levels.

Literature Cited

- ABELL, R. AND 27 OTHER AUTHORS. 2008. Freshwater ecoregions of the world: a new map of biogeographic units for freshwater biodiversity conservation. *BioScience* 58(5):403–414.
- BAILEY, R. G. 1995. Descriptions of the ecoregions of the United States. US Forest Service. Miscellaneous Publication No. 1391.
- BANKS, D. T. 2010 In Draft. Movements, fragmentation, and abundance of bluehead sucker, flannelmouth sucker, and white sucker populations in Little Sandy Creek, a tributary to the Big Sandy River in Wyoming. Master's Thesis. University of Wyoming, Laramie.
- BARNETT, T., R. MALONE, W. PENNELL, D. STAMMER, B. SEMTNER AND W. WASHINGTON. 2004. The effects of climate change on water resources in the West: introduction and Overview. *Climatic Change* 62: 1–11.
- BAXTER, G. T., AND J. R. SIMON. 1970. Wyoming fishes. Wyoming Game and Fish Department, Cheyenne, WY.
- BEATTY, R. J. 2005. Catostomid spawning migrations and late-summer fish assemblages in lower Muddy Creek, an intermittent watershed in southern Carbon County, Wyoming. Master's Thesis. University of Wyoming, Laramie.
- BEEBLE, D. E. 1989. Checklist of recent Mollusca of Wyoming. *Great Basin Naturalist* 49(4): 637–645.
- BENSON, A. J. 2009. Zebra mussel sightings distribution. Retrieved April 17, 2009 from http://nas.er.usgs.gov/taxgroup/mollusks/zebra_mussel/zebramusseldistribution.asp.
- BINNS, N. A. 1967. Effects of rotenone treatment on the fauna of the Green River, Wyoming. *Fishing Technical Bulletin* No. 1. Wyoming Game and Fish Department, Cheyenne, WY.
- BINNS, N. A. 1977. Present status of indigenous populations of cutthroat trout, *Salmo clarki*, in southwest Wyoming. *Fisheries Technical Bulletin* No. 2. Wyoming Game and Fish Department, Cheyenne, WY.
- BOSLEY, C. E. 1960. Pre-impoundment study of the Flaming Gorge Reservoir. *Fisheries Technical Report* Number 9. Wyoming Game and Fish Commission, Cheyenne, WY.
- BOWER, M. R. 2005. Distributions and habitat associations of bluehead suckers, flannelmouth suckers, and roundtail chubs in the upper Muddy Creek watershed of southern Carbon County, Wyoming. Master's Thesis. University of Wyoming, Laramie, WY.

- BUREAU OF LAND MANAGEMENT. 1997. Record of decision and Green River resource management plan. Rock Springs Field Office, Wyoming. October 1997. Accessed July 22, 2010 at <http://www.blm.gov/pgdata/etc/medialib/blm/wy/programs/planning/rmps.Par.27940.File.dat/greenriver-rmp.pdf>.
- BUREAU OF LAND MANAGEMENT. 2006a. Final environmental impact statement, Jonah Infill Drilling Project, Sublette County, Wyoming. Pinedale and Rock Springs Field Offices. January 2006. v. 1 accessed July 22, 2010 at <http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/pfodocs/jonah.Par.7761.File.dat/01volume1.pdf>.
- BUREAU OF LAND MANAGEMENT. 2006b. Public scoping notice, Continental Divide-Creston natural gas development project environmental impact statement. Rawlins Field Office, Wyoming, April 2006. Accessed July 22, 2010 at http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/rfodocs/cd_creston.Par.34343.File.dat/scoping.pdf.
- BUREAU OF LAND MANAGEMENT. 2006c. Final environmental impact statement for the Atlantic Rim natural gas field development project: Carbon County, Wyoming. Rawlins Field Office, Wyoming. November 2006. Accessed July 22, 2010, at http://www.blm.gov/wy/st/en/info/NEPA/rfodocs/atlantic_rim.html.
- BUREAU OF LAND MANAGEMENT. 2008a. Record of decision and approved Pinedale resource management plan. Pinedale Field Office. November 2008. Accessed July 22, 2010, at <http://www.blm.gov/wy/st/en/programs/Planning/rmps/pinedale.html>.
- BUREAU OF LAND MANAGEMENT. 2008b. Record of decision and approved Rawlins resource management plan. Rawlins Field Office. December 2008. Accessed July 22, 2010, at <http://www.blm.gov/wy/st/en/programs/Planning/rmps/rawlins.html>
- BUREAU OF LAND MANAGEMENT. 2008c. Final supplemental environmental impact statement for the Pinedale Anticline oil and gas exploration and development project, Sublette County, Wyoming. Pinedale Field Office. June 2008. Accessed July 22, 2010, at <http://www.blm.gov/wy/st/en/info/NEPA/pfodocs/anticline.html>.
- BUREAU OF LAND MANAGEMENT. 2009. Scoping summary report for the Chokecherry and Sierra Madre wind energy project environmental impact statement. Rawlins Field Office. January 2009. Accessed July 22, 2010. <http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/rfodocs/chokecherry/report.Par.52243.File.dat/ScopingReport.pdf>.
- CAVALLI, P. 2006. Management plan for roundtail chub, flannelmouth sucker, and bluehead sucker in the State of Wyoming. Draft 4. Wyoming Game and Fish Department, Cheyenne, WY.
- CHAPMAN, S. S., S. A. BRYCE, J. M. OMERNIK, D. G. DESPAIN, J. ZUMBERGE, AND M. CONRAD. 2004. Ecoregions of Wyoming (color poster with map, descriptive text, summary tables, and photographs): Reston, VA, U.S. Geological Survey (map scale 1:1,400,000).
- CLARK, M. L. AND S. L. DAVIDSON. 2009. Specific conductance and dissolved-solids characteristics for the Green River and Muddy Creek, Wyoming, water years 1999–2008. U.S. Geological Survey Scientific Investigations Report 2009–5168.
- COLORADO RIVER FISH AND WILDLIFE COUNCIL. 2004. Rangewide conservation agreement for roundtail chub *Gila robusta*, bluehead sucker *Catostomus discobolus*, and flannelmouth sucker *Catostomus latipinnis*. Utah Department of Natural Resources, Salt Lake City.
- COMER, P., D. FABER-LANGENDOEN, R. EVANS, S. GALWER, C. JOSSE, G. KITTEL, S. MENARD, M. PYNE, M. REID, K. SCHULZ, K. SNOW, AND J. TEAGUE. 2003. Ecological systems of the United States: a working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.
- COMPTON, R. I. 2007. Population fragmentation and white sucker introduction affect populations of bluehead suckers, flannelmouth suckers, and roundtail chubs in a headwater stream system, Wyoming. Master's Thesis. University of Wyoming, Laramie, WY.
- CRCT COORDINATION TEAM. 1994. Colorado River cutthroat trout inter-agency five year management plan (1993–1997) Green River Westside tributary enclave.
- CRCT COORDINATION TEAM. 2006. Conservation strategy for Colorado River cutthroat trout (*Oncorhynchus clarkii pleuriticus*) in the states of Colorado, Utah, and Wyoming. Colorado Division of Wildlife, Fort Collins, CO.
- CRCT TASK FORCE. 2001. Conservation agreement and strategy for Colorado River cutthroat trout (*Oncorhynchus clarkii pleuriticus*) in the states of

- Colorado, Utah, and Wyoming. Colorado Division of Wildlife, Fort Collins, CO.
- CUMMINGS, K. S., AND C. A. MAYER. 1992. Field guide to freshwater mussels of the Midwest. Illinois Natural History Survey Manual 5.
- CURTIS, J. AND K. GRIMES. 2004. Wyoming Climate Atlas.
<http://www.wrds.uwyo.edu/sco/climateatlas/toc.html>
- DOUGLAS, M. R., AND M. E. DOUGLAS. 2008a. Genetic structure of roundtail chub (*Gila robusta*) in Wyoming. Final Report to the Wyoming Game and Fish Department, WGFD Agreement Number 100/06, Cheyenne, WY.
- DOUGLAS, M. R., AND M. E. DOUGLAS. 2008b. Genetic structure of flannelmouth sucker (*Catostomus latipinnis*) across the Colorado River basin, with emphasis on populations in the state of Wyoming. Final report to the Wyoming Game and Fish Department, WGFD Agreement Number 100/06, Cheyenne, WY.
- DOUGLAS, M. R., AND M. E. DOUGLAS. 2008c. Molecular genetic assessment of hybrid suckers (*Catostomidae*) in the upper Green River of Wyoming. Final report to the Wyoming Game and Fish Department, WGFD Agreement Number 100/06, Cheyenne, WY.
- DOUGLAS, M. R., M. E. DOUGLAS, AND M. W. HOPKEN. 2008. Genetic structure of bluehead sucker [*Catostomus (Pantosteus) discobolus*] across the Colorado River basin, with emphasis on drainages in the state of Wyoming. Final report to the Wyoming Game and Fish Department, WGFD Agreement Number 100/06, Cheyenne, WY.
- GELWICKS, K. R., C. J. GILL, A. I. KERN, AND R. KEITH. 2009. Current status of roundtail chub, flannelmouth sucker, and bluehead sucker in the Green River drainage of Wyoming. Wyoming Game and Fish Department Administrative Report, Cheyenne, WY.
- GREEN RIVER BASIN WATER PLAN. 2001. Final report prepared for the Wyoming Water Development Commission.
- GUNDERSON, J.L., AND R.E. KINNUNEN. Editors. 2001. Sea Grant Aquatic Nuisance Species. Hazard Analysis and Critical Control Point Training Curriculum Minnesota Sea Grant Publication Number: MNSG-F11, Minnesota Sea Grant, 2305 E 5th Street, Duluth, Minnesota.
- HENDERSON, J. 1924. Mollusca of Colorado, Utah, Montana, Idaho and Wyoming. University of Colorado Studies 13:65–223.
- HIGGINS, J. V., M. T. BRYER, M. L. KHOURY, AND T. W. FITZHUGH. 2005. A freshwater classification approach for biodiversity conservation planning. *Conservation Biology* 19:432–445.
- HOCKE, E. 1979. Wyoming mussel distributions as revealed by survey activities conducted during the summer of 1978. Wyoming Game and Fish Department, Cheyenne, WY.
- HOVINGH, P. 2004. Intermountain freshwater mollusks, USA (Margaritifera, Anodonta, Gonidea, Valvata, Ferrissia): geography, conservation, and fish management implications. *Monographs of the Western North American Naturalist* 2:109–135.
- HUBERT, W. A. 1988. Survey of Wyoming crayfishes. *Great Basin Naturalist* 48:370–372.
- HUBERT, W.A. 2010. Survey of Wyoming crayfishes: 2007–2009. US Geological Survey Report to the Wyoming Game and Fish Department, Cheyenne, WY.
- JACOBS, J. J. AND D. J. BROSZ. 2000. Wyoming's water resources. University of Wyoming Cooperative Extension Service B-969R.
- JESPERSEN, D. M. 1981. A study of the effects of water diversion on the Colorado River cutthroat trout (*Salmo clarkii pleuriticus*) in the drainage of the North Fork of the Little Snake River in Wyoming. Master's thesis, University of Wyoming, Laramie.
- JESPERSEN, D. M., AND A. CONDER. 1986. Colorado River cutthroat trout spawning and incubation habitat summary. Wyoming Game and Fish Department Administrative Report, Cheyenne, WY.
- JOHNSON, K., AND M. OBERHOLTZER. 1987. Investigation into possible occurrence of Colorado squawfish (*Ptchocheilus lucius*) and other federally threatened or endangered fish species in the lower Green River drainage and the Little Snake River drainage of Wyoming. Wyoming Game and Fish Department Administrative Report, Cheyenne, WY.
- KNIGHT, D. H. 1994. Mountains and plains—the ecology of Wyoming landscapes. New Haven, Connecticut, Yale University Press.
- LAGESON, D. R. AND D. R. SPEARING. 1988. Roadside geology of Wyoming. Missoula, MT. Mountain Press Publishing Company.
- LASKE, S. M. 2010. Lentic habitat use of roundtail chub and overlap with two nonnative piscivores, brown trout *Salmo trutta* and lake trout *Salvelinus namaycush*. Master's Thesis. University of Wyoming, Laramie.

- LITTLE SNAKE RIVER WORKING GROUP. 1994. Conservation plan for Colorado River cutthroat trout (*Oncorhynchus clarkii pleuriticus*) for the Little Snake River drainage, in southeastern Wyoming.
- LUGINBILL, J. S. 2010 In Review. Fish passage and entrainment of Colorado River cutthroat trout at water diversion structures in the North Fork Little Snake River drainage, Wyoming. Wyoming Game and Fish Department Administrative Report, Cheyenne, WY.
- MASON, J. P. AND K. A. MILLER. 2004. Water resources of Sweetwater County, Wyoming. U.S. Department of Interior, U.S. Geological Survey. Scientific Investigations Report 2004–5214.
- MCDONALD, D. B., T. L. PARCHMANN, M. R. BOWER, W. A. HUBERT AND F. J. RAHEL. 2008. An introduced and a native vertebrate hybridize to form a genetic bridge to a second native species. Proceedings of the National Academy of Sciences 105:10837–10842.
- MILLER, K. A. 2003. Peak-flow characteristics of Wyoming streams. U.S. Department of Interior, U.S. Geological Survey. Water-Resources Investigation Report 03-4107.
- NATURESERVE. 2009. NatureServe, Arlington, VA. Available <http://www.natureserve.org/explorer>.
- NORTHWEST GAP ANALYSIS PROJECT. 2010. <http://gap.uidaho.edu/index.php/gap-home/Northwest-GAP> accessed July 2, 2010.
- OBERHOLTZER, M. 1987. A fisheries survey of the Little Snake River drainage, Carbon County, Wyoming. Fish Division, Wyoming Game and Fish Department, Cheyenne. Project 5086-01-8501.
- QUARTARONE, F. 1995. Historical accounts of upper Colorado River basin endangered fish. The Upper Colorado River Endangered Fish Recovery Program. U.S. Fish and Wildlife Service, Denver, CO.
- QUINLAN, R. E. 1980. A study of the biology of the Colorado River cutthroat trout (*Salmo clarkii pleuriticus*) population in the North Fork of the Little Snake River drainage in Wyoming. Master's thesis. University of Wyoming, Laramie.
- REMMICK, R. 1981. A comprehensive survey of the Green River Westside tributaries. Wyoming Game and Fish Department Administrative Report, Cheyenne, WY.
- REMMICK, R., AND K. NELSON. 1992. Status report of accomplishments on the Colorado River cutthroat trout management plan 1987 through 1990 Green river westside tributary enclave. Wyoming Game and Fish Department and United States Forest Service status report. Project: 409-13-6401.
- SEAVY, N.E. T. GARDALI, G.H.GOLET, F.T. GRIGGS, C.A. HOWELL, R. KELSEY, S.L. SMALL, J.H.VIERS, AND J.F.WEIGAND. 2009. Why climate change makes riparian restoration more important than ever: recommendations for practice and research. Ecological Restoration 27:330-338.
- SENECAL, A. C., K. R. GELWICKS, P. A. CAVALLI, AND R. M. KEITH. 2010. WGFD short-term plan for the Three Species in the Green River drainage of Wyoming; 2009–2014. Wyoming Game and Fish Department Administrative Report, Cheyenne, WY.
- SIMON, J. R. 1951. Wyoming Fishes. Wyoming Game and Fish Department, Cheyenne, WY.
- STONE, M.D. 1995. Fish stocking programs in Wyoming: a balanced perspective. American Fisheries Society Symposium 15:47-51.
- STRAYER, D. L. 2008. Freshwater mussel ecology. University of California Press, Los Angeles.
- SWEET, D. E. 2007. Movement patterns and habitat associations of native and introduced catostomids in a tributary system of the Colorado River. Master's Thesis. University of Wyoming, Laramie.
- TROTTER, P. C. 1987. Cutthroat: native trout of the west. Colorado Associated University Press, Boulder, CO.
- U.S. ARMY CORP. OF ENGINEERS. 2010. Scoping summary report for the regional watershed supply project environmental impact statement. February 2010. Omaha District, Denver Regulatory Office. Accessed July 22, 2010. <https://www.nwo.usace.army.mil/html/od-tl/eis/rwsp.scoping.report.12-Feb-10.pdf>.
- WGFD. 2009. Strategic Habitat Plan. Wyoming Game and Fish Department, Cheyenne, WY.
- WILEY, R.W. 1995. A common sense protocol for the use of hatchery-reared trout. American Fisheries Society Symposium 15:465-471.
- WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY. 2001. Wyoming surface water classification list—Water Quality Division, Surface Water Standards: Wyoming Department of Environmental Quality, June 21, 2001, accessed July 21, 2010, at <http://deq.state.wy.us/wqd/watershed/surfacestandards/Downloads/Standards/2-3648-doc.pdf>.

- WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY. 2010. Wyoming water quality assessment and impaired waters list (2010 integrated 305(b) and 303(d) report). Wyoming Department of Environmental Quality Document #10-0230.
- WYOMING GAME AND FISH COMMISSION. 1998. Fish Stocking Policy. Cheyenne, WY.
- WYOMING GAME AND FISH COMMISSION. 2003. Chapter 10: Regulation for importation, possession, confinement, transportation, sale and disposition of live wildlife. Cheyenne, WY.
- WYOMING GAME AND FISH COMMISSION. 2005a. Chapter 33: Issuance of scientific research, educational or special purpose permits. Cheyenne, WY.
- WYOMING GAME AND FISH COMMISSION. 2005b. Regulation governing private fish stocking. Cheyenne, WY.
- WYOMING GAME AND FISH COMMISSION. 2008. Mitigation policy. Cheyenne, WY.
- WYOMING GAME AND FISH COMMISSION. 2009. Strategic Habitat Plan. Cheyenne, WY.
- ZAFFT, D.J. AND E.A. BEAR. 2009. Guidelines for the collection of fish voucher specimens. Wyoming Game and Fish Department Administrative Report, Cheyenne, WY.