Rio Grande Sucker Conservation Strategy

by the

Rio Grande Chub and Rio Grande Sucker Conservation Team

Photo courtesy of Rob Arlowe, New Mexico.

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I. BACKGROUND

Summary

Cooperative efforts to manage and conserve Rio Grande Sucker *Catostomus plebeius* have been ongoing for decades and were officially formalized in 2016. This Conservation Strategy is a voluntary recommitment to implement these conservation actions that will provide for the long-term viability of Rio Grande Sucker by maintaining sufficient secure populations and range-wide genetic integrity of the species, while recognizing existing land uses, resource uses (including angling and other recreational opportunities), tribal sovereignty, and private property rights. The purpose of this document is to provide specific direction that, when implemented, will conserve this species and minimize or remove the threats to its viability. This will be accomplished through an adaptive management process of implementing, monitoring, and adjusting conservation approaches by the Rio Grande Chub and Rio Grande Sucker Conservation Team (Team).

Rio Grande Chub and Rio Grande Sucker Conservation Team

The Team was established in 2018, when the Conservation Agreement for the Rio Grande Chub and Rio Grande Sucker (Agreement) was first signed. The Team is comprised of individuals from agencies, tribes, non-profit and private organizations. While the Team has no authority to mandate agency actions, team members develop range-wide priorities, review annual work plans, coordinate agency actions, and update and maintain a status assessment database.

Participants in the Rio Grande Chub and Rio Grande Sucker Conservation Team are listed below.

Signatories:

- Colorado Division of Parks and Wildlife (CPW)
- New Mexico Department of Game and Fish (NMDGF)
- U.S. Forest Service (USFS)
- U.S. Fish and Wildlife Service (FWS)
- Taos Pueblo
- Texas Parks and Wildlife Department (TPWD)
- Jicarilla Apache Nation
- National Park Service (NPS)
- Bureau of Land Management (BLM)
- Turner Enterprises, Inc.
- Pueblo of Santa Ana
- Coalition of Colorado Counties

Supporting Organizations:

- Trout Unlimited New Mexico Council
- Rio Grande Water Conservation District
- Fishes of Texas Project

Purpose

The Team was formed to assure the long-term viability of Rio Grande Chub and Rio Grande Sucker throughout their historical range and reduce the likelihood that those species would require listing under the Endangered Species Act (ESA) of 1973, as amended. This Conservation Strategy (Strategy) was developed in accordance with the rgc and is intended to remove and/or minimize threats to the species and guide restoration efforts for the maximum benefit of the Rio Grande Sucker. Conservation approaches outlined in this Strategy are designed to meet the guidelines set forth by the U.S. Fish and Wildlife Service[1] (FWS) in their Policy for Evaluation of Conservation Efforts (PECE) standards. This Strategy[2] is a complement to the Agreement in which the Signatories agree to implement the conservation and monitoring approaches described herein.

The information contained in this Strategy is intended to serve as a set of guidelines for agencies, tribal entities, non-profit and private organizations to conserve Rio Grande Sucker. It is neither a National Environmental Policy Act (NEPA) decision document nor a federal or state recovery plan. Any future federal actions based on this Strategy will include NEPA compliance and compliance with other laws and regulation as needed.

Past and Existing Conservation Agreements

This Strategy is the implementation document for the Conservation Agreement for Rio Grande Chub and Rio Grande Sucker that was signed by the parties in 2018. The Agreement is a collaborative and cooperative effort among state, federal, tribal resource agencies, non-profit and private organizations. The Agreement was designed to provide a framework for the long-term conservation of Rio Grande Sucker by guiding the implementation of actions that reduce threats to the species. Additional information regarding authorities, governing documents, and policies may be found in the accompanying Agreement.

Duration of the Conservation Strategy

This Strategy was written to guide conservation approaches for the next 10 years (2021–2030), although it is expected that participants will continue working on conservation of the species beyond that timeframe. The Strategy was also designed and written to be a dynamic document that can be adapted and updated to incorporate new information regarding local and regional

[1] Participation by FWS in this Conservation Strategy and the related Conservation Agreement does not constitute a PECE review of any conservation efforts included in this Strategy, nor does it predetermine any subsequent status review and listing determination by FWS under the ESA.

[2] Compliance with this strategy by agencies, private enterprises, and private individuals is strictly voluntary.

needs of Rio Grande Sucker populations and habitats. Minor modifications may be made to the Strategy so long as they do not change the Goals and Objectives. This will allow the Team to respond to changing conditions on the ground, taking advantage of conservation opportunities that may arise. The Team will annually re-evaluate the status of Rio Grande Sucker populations and habitats across its range and review progress of the approaches listed in the Strategy.

Annually, the parties involved will review the Strategy and its effectiveness to determine whether it should be revised and to update the annual work plan (see VI. Monitoring and Adaptive Management). By the end of the tenth year (2030), the Strategy must be reviewed and either modified, renewed, or terminated.

II. RIO GRANDE SUCKER INFORMATION

Taxonomy

The Rio Grande Sucker was first described as a distinct species by Baird and Girard in 1854 based on specimens from the Mimbres River, New Mexico (Baird and Girard 1854). It was also described under the name *Pantosteus jarovii* (Cope and Yarrow 1875, Jordan 1891) and *Minomus jarovii* (Smith et al. 1983). The Rio Grande Sucker is a small-bodied member of the mountain sucker subgenus *Pantosteus,* within the genus *Catostomus*, family Catostomidae, and order Cypiniformes (Smith 1966). This family is comprised of 12 genera and 60 species in the United States and Canada (Robins et al. 1991) and is characterized by soft fin rays and a fleshy, subterminal protractile mouth. The genus *Catostomus* is the most diverse genus of fishes in western North America (Smith et al. 2013). Rio Grande Sucker was first placed in the genus *Pantosteus* and later moved to the genus *Catostomus* when *Pantosteus* was reduced to a subgenus (Smith 1966, Smith and Koehn 1971). *Pantosteus* differ from *Catostomus* primarily by the inclusion of trophic specializations: cartilaginous scraping edges on the jaws, lateral notches at the upper and lower lip, a posterior median incision on the lower lip, a long intestine (four times standard length in adults), and a black peritoneum (Smith 1966). These specializations are adaptations for scraping algae, diatoms and organic matter from the substrate (Smith 1966).

Rio Grande Sucker superficially resembles other Catostomids, but differs in modality of morphometric and meristic characteristics (Sublette et al. 1990). The taxonomy of *Pantosteus* has been unusually difficult (Smith 1966) and research on phylogenetic relationships continues (McPhee et al. 2008, Smith et al. 2013, Unmack et al. 2014, Corona-Santiago et al. 2018, Turner et al. 2019). Understanding biogeography and phylogeography is important for understanding the evolution, ecology and conservation biology implications of aquatic biota in arid regions (Turner et al. 2019).

Historically, Rio Grande Sucker was reported to hybridize in nature with White Sucker *Catostomus commersoni* (Rinne 1995, Zuckerman and Langlois 1990), although hybrids were believed to be infertile as there was no evidence of introgression (Swift-Miller et al. 1999b). In a study employing mitochondrial DNA and microsatellite markers, no evidence of hybrid offspring was found across their sympatric range in New Mexico, suggesting that hybridization is rarely if ever occurring (McPhee and Turner 2004). Desert Sucker *Catostomus clarkii* and Rio Grande Sucker have been documented to hybridize at low levels (Turner et al. 2019).

Historical Distribution

The first written record of Rio Grande Sucker, called "matalote *del Rio Bravo*" (meaning "sucker-like fish of the Rio Grande"), was by Father Morfi on the 1779 Comanche expedition (Thomas 1969). First described in 1854, early reports suggest Rio Grande Sucker (hereafter RGS) were historically common throughout the Rio Grande and associated tributaries (Baird and Girard 1854). In 1874, RGS were found to be "very abundant in the tributaries of the Rio Grande as far as we explored it, i.e. from Fort Garland, Colorado to Santa Fe, New Mexico" (Cope and Yarrow 1875). In Colorado, Jordan (1891) collected RGS from the Rio Grande in Del Norte and Alamosa and from the Rio Conejos at McIntyre's Ranch and described them as "...very abundant everywhere, especially in the deeper places and eddies…". Rio Grande Sucker was "quite abundant throughout its range" (from the San Luis Valley, Colorado south into Chihuahua, Mexico; Ellis 1914).

The historical range of RGS is widely accepted to include low-gradient, cool-water stream habitats in the Rio Grande drainage of both Colorado and New Mexico and the Mimbres drainages of New Mexico (Sublette et al. 1990). The distribution extended southward into Mexico through the endorheic Guzman basin (Rios Casas Grandes, Santa Maria, and Del Carmen), into the upper Rio Conchos in Chihuahua and Durango; and in one tributary of the Rio Bavispe (Pacific Slope, Rio Yaqui basin) in Chihuahua (Miller 2005, Corona-Santiago et al. 2018). For many years the extant populations in the Gila, Pecos, and San Francisco drainages were believed by some to be the result of introductions (Minckley 1973; Anderson and Turner 1977, Propst et al. 1988, Bestgen and Propst 1989). Recent research using rapidly evolving molecular markers and new computational approaches concluded that RGS is native to the Gila Basin and that all Gila Basin populations share recent common ancestry and haplotypes with the Mimbres River population (Turner et al. 2019). These findings document a natural geographic range expansion and previously unrecognized diversity in the species, making the Gila Basin populations important in conservation efforts for RGS (Turner et al. 2019).

Current Distribution

The range-wide distribution of RGS has declined from its historical levels (Langlois et al. 1994; Rees and Miller 2005; Calamusso et al. 2002). As of 1995, Hot Creek was the only water in Colorado known to contain an aboriginal RGS population (Swift 1995). In 2004, an additional RGS population was discovered in Crestone Creek on the newly established Baca National Wildlife Refuge (Alves 2005). Despite nearing extirpation in Colorado, reintroduction efforts since the 1990s have resulted in restoration of RGS to many Colorado streams (Rees and Miller 2005, Jones 2018).

In New Mexico, RGS are rare in the Rio Grande mainstem (Rinne and Platania 1995) and declining in the tributaries of the Middle and Upper Rio Grande Basins (Calamusso and Rinne 1996, Calamusso and Rinne 1999). The species has not been reported from the Rio Grande in the Middle Rio Grande Basin since prior to 1984 (Hoagstrom et al. 2010). However, recent survey efforts in Colorado (Cammack 2019) and New Mexico (Caldwell 2017) found that the species is still present within 15 of 17 historically occupied drainages (USGS 8-digit hydrologic cataloguing units or HUC-8), except the Rio Grande-Albuquerque in New Mexico and the Rio Grande Headwaters in Colorado.

In Arizona, RGS have been found in the upper San Francisco River and until recently were not considered native but from human mediated introduction. Recent genetic and phylogeographic analysis supports RGS are native from a natural geographic range expansion (Turner et al. 2019). Given they are native to the upper San Francisco River, further survey efforts are needed to determine if other populations exist within the San Francisco and Blue River drainages.

Populations are currently represented in the following Geographic Management Units (GMUs): Rio Grande Headwaters, Rio Grande-Elephant Butte, Rio Grande-Mimbres, Upper Gila, and Upper Pecos (Figure 1).

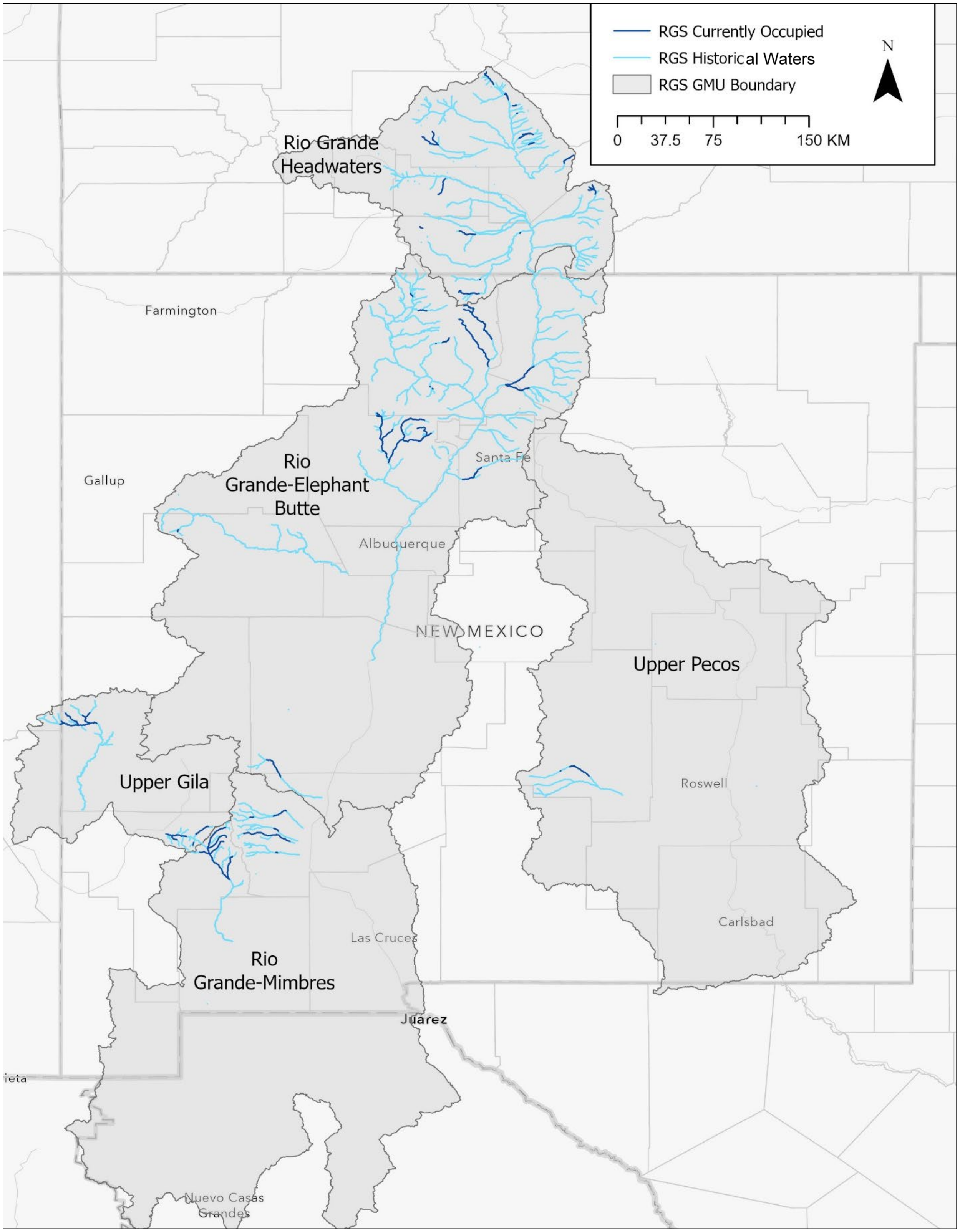

Figure 1. Range-wide distribution of Rio Grande Sucker populations in the United States organized by Geographic Management Unit (GMU).

The Team will complete a Range-wide Status Assessment for RGS by 2023. This Status Assessment will inform the current distribution of RGS and may provide information to update the number of populations known to occupy each GMU (Table 1). Additionally, all of the historical and current data on RGS distribution summarized by the Team will be entered into a comprehensive database in 2020. The information included in the database will in turn help to inform the initial development of the Status Assessment and 10-year Assessments thereafter.

Table 1. Range-wide distribution and status of Rio Grande Sucker populations organized by Geographic Management Units (GMUs) in the United States. A population is defined as one that "supports all life stages, is able to exist independent of other populations, and is not divided by complete barriers" (RGCS Working Group 2018).

GMU	Number of Populations
Rio Grande Headwaters	6
Rio Grande-Elephant Butte	12
Rio Grande-Mimbres	4
Upper Gila	4
Upper Pecos	1
Range-wide Total	**27**

Habitat and Life History

Habitat

Rio Grande Sucker is an obligate riverine species that favors low-gradient (<3.5%), low-velocity stream reaches, with a mosaic of pools, riffles and runs with clean gravels, instream woody debris and aquatic vegetation (Calamusso et al. 2002, Langlois et al. 1994, Rees and Miller 2005; Figures 2 and 3). In New Mexico, RGS were found in small to large, mid-elevation streams with cobble and small-boulder substrates (Calamusso and Rinne 1996). Velocities ranged from less than 20 cm and up to 113 cm per second and preferred depth ranged from 10–40 cm (Calamusso 1996). This species prefers pool and glide habitat, but riffles may be ecologically important at certain times (Calamusso and Rinne 1996). In Hot Creek, Colorado, RGS were captured in all major habitat types (i.e., pools, riffles, glides; Swift-Miller et al. 1999b). In reaches of Hot Creek where RGS were present, they were found in 80 percent of the riffle habitat sampled. Stream temperatures recorded in RGS occupied habitat have ranged from 3–28°C. Surveys in New Mexico suggested that RGS avoided stream reaches with a gradient greater than 3.2% and indicated an inverse relationship between abundance and gradient (Calamusso et al. 2002). Swift-Miller et al. (1999a) did not find any correlation between RGS catch rates and gradient across nine streams in Colorado and New Mexico, although gradients within the study did not exceed 1.5%. The species has rarely been collected above 2,743 m (Calamusso and Rinne 1996), except areas with gentle gradients, and a reintroduced population in Lake Fork (a tributary of the Conejos River in Colorado) includes elevations up to 3,000 m.

The deposition of fine sediments appears to have a negative effect on RGS abundance and condition (Swift-Miller et al. 1999a). Rio Grande Sucker occupied habitats with total percent of fine substrates (< 2mm) ranging from 4.5–38%, but condition was negatively related to the proportion of fine sediment (Swift-Miller et al. 1999a). Similarly, the amount of sand/silt substrate was inversely related to fish density in each habitat unit in Hot Creek (Swift-Miller et al. 1999b). The mechanism for this relationship is not well understood. It is possible that RGS prefer larger substrate because coarser materials provide for algal growth and macroinvertebrate production (Calamusso 1996), which comprise the majority of their diet (Zuckerman and Langlois 1990, Swift-Miller et al. 1999a).

Figure 2. Rio Grande Sucker habitat, Hot Creek, Colorado. Photo courtesy of Colorado Division of Parks and Wildlife.


Figure 3. Recently restored Rio Grande Sucker habitat on the Mimbres River, New Mexico. Photo courtesy of New Mexico Department of Game and Fish.

Life History

Rio Grande Sucker evolved as part of a community of endemic fishes that included Rio Grande Chub *Gila pandora* and Rio Grande Cutthroat Trout *Oncorhynchus clarkii virginalis* (Langlois et.al. 1994). Early explorers in Colorado found suckers associated with Rio Grande Chub and Rio Grande Cutthroat Trout (Cope and Yarrow 1875, Jordan 1891). In Colorado, RGS are often are associated with other native species such as Longnose Dace *Rhinichthys cataractae* and Fathead Minnow *Pimephales promelas* and less frequently with Red Shiner *Cyprinella lutrensis*, Black Bullhead *Ameiurus melas*, Green Sunfish *Lepomis cyanellus*, and Flathead Chub *Platygobio gracilis*. In New Mexico, RGS are also associated with Chihuahua Chub *Gila nigrescens*, Desert Sucker, Longfin Dace *Agosia chrysogaster*, and Western Mosquitofish *Gambusia affinis* (NMDGF database records). In the Rio Grande Basin, RGS are also associated with non-native fish such as White Sucker, Brown Trout *Salmo trutta*, Brook Trout *Salvelinus fontinalis*, Rainbow Trout *Oncorhynchus mykiss*, Brook Stickleback *Culaea inconstans*, Northern Pike *Esox lucius*, Largemouth Bass *Micropterus salmoides*, and Smallmouth Bass *Micropterus dolomieu*.

Range-wide abundance of RGS is variable in streams depending upon habitat quality and presence of non-native competitors and piscivorous fish species. In Colorado, abundance ranged from 30 fish/mile to 1,220 fish/mile (CPW 2019). In a range-wide study, relative abundance of RGS was significantly lower in streams with White Sucker (Swift-Miller et al. 1999a). In New Mexico, RGS abundance ranged from 16 fish/mile to 3,975 fish/mile in surveys conducted from 2009 to 2019 (NMDGF database records).

Rio Grande Sucker is more omnivorous than other suckers in the subgenus *Pantosteus* (Smith 1966). The species feeds largely upon filamentous algae, benthic macroinvertebrates, and other organisms scraped off rocks with its specialized jaws equipped with a cartilaginous ridge (Koster 1957, Smith 1966, White 1972, Sublette et al. 1990, Zuckerman and Langlois 1990). Intestines of RGS specimens collected from the Mimbres River contained small fingernail clams (Smith 1966). More recent research found that periphyton was the dominant food item in gut contents obtained from one location in Colorado and 12 locations in New Mexico (Swift-Miller et al. 1999a). In addition, invertebrates accounted for 16% of RGS diets when White Sucker were present and 23% of RGS diets when White Sucker were not present (Swift-Miller et al. 1999a). Chironomids, other dipterans, and ephemeropterans were the most commonly observed invertebrate food items. No differences in diet between size classes was observed (Swift-Miller et al. 1999a).

Spawning occurs over clean gravel in spring and sometimes fall (Koster 1957). Timing of spawning for western catostomids can be influenced by runoff patterns, thermal regime, and season (Rinne 1995). In New Mexico, RGS spawned on the waning side of the hydroperiod of peak flows in June and July in the Rio de las Vacas (Rinne 1995), while spawning further south in the Jemez River occurred in May (Raush 1963). In Mexico, spawning was reported as early as February (Smith 1966). Spawning in Colorado (Hot Creek and McIntyre Springs) occurred when water temperatures were between 11°C and 16°C, typically from late March through late May, although RGS were also observed in spawning condition and coloration in November (Zuckerman and Langlois 1990, Swift 1996). At the Mumma Native Aquatic Species Recovery Facility (NASRF) in Monte Vista, Colorado, different broodstock populations vary in their reproductive timing and the Hot Creek broodstock can come into reproductive condition anytime throughout the year (T. Mix, personal communication). Eggs hatch after 10 days at 13.3°C (T. Mix, personal communication). During the spawning season, adult RGS can develop tuberculation on the fins and caudal peduncle. Breeding males are also characterized by black coloration on the dorsum and a crimson red lateral stripe (Sublette et al. 1990). More research is needed describing RGS spawning activities and behavior.

Reports of age at sexual maturity ranges from two to three years, with streams in Mexico producing sexually mature fish at age 2 (Smith 1966) and Jemez Creek in NM at age 3 (Raush 1963). In northern New Mexico, 61% of age-2 RGS were found to be sexual mature (McPhee 2007). All individuals were sexually mature by age 3. Males tended to mature at smaller sizes than females, with the minimum size at maturity for males occurring at 60 mm (standard length) and females at 91 mm (standard length; McPhee 2007). Fecundity was found to be a function of body size and ranged from 1,100 to 2,900 eggs per female (McPhee 2007). In the Rio de las Vacas, female RGS greater than 100 mm in total length averaged 2,035 mature ova (Rinne 1995). More information is needed to better understand RGS reproduction across its distribution.

Thermal regime and food resources are likely important to the growth rate and lifespan of RGS (Rees and Miller 2005), in addition to the presence of other species, such as non-native competitors. In the Rio Vallecitos, RGS are sympatric with White Sucker and the oldest RGS detected was three years (McPhee 2007). In Jemez Creek, where White Suckers are not found, maximum life span for males was six years and seven years for females (Raush 1963). In captivity, one individual was documented to live to 16 years of age (T. Mix, personal communication). The literature regarding maximum length of RGS is inconsistent. Sublette et al. (1990) reported a maximum body size of 260 mm standard length (SL). More recent research from the upper Rio Grande indicated a maximum total length of 200–209 mm (Calamusso and Rinne 1996, Swift 1996) or approximately 170–178 mm SL (M. McPhee, unpubl. conversion). In Jemez Creek, adult males averaged 134 mm SL and adult females averaged 159 mm SL, and a reduction in growth rates during the fifth and sixth growing seasons was observed (Rausch 1963). In the Rio Vallecitos, mean total length of RGS larvae was 10.6 mm and mean young-of-year SL was 28.1 mm (McPhee 2007). Little is known about the size structure of RGS populations, however the presence of multiple size classes at a site likely represents relatively stable populations.

There is limited information available on the activity or movement patterns of RGS. During a survey of streams in Mexico, RGS occupied pool habitat during the day and moved into riffle habitat for feeding at night and in the early morning (Hendrickson et al. 1980). Habitat use studies conducted with Passive Integrated Transponder (PIT) tags at the Baca National Wildlife Refuge may provide important information regarding general movement patterns, including diurnal and seasonal movements and overall dispersal distances (FWS; SWCA Environmental Consultants 2015).

Nature and Extent of Threats

The following discussion includes the major threats affecting RGS. These factors will be addressed by conservation approaches identified in this Strategy. Threats are presented in categorical fashion for clarity though in reality multiple threats may act synergistically to negatively affect RGS.

Habitat Degradation
Historical records indicate that RGS were once widely distributed and abundant across the Rio Grande Basin, however, habitat degradation was already evident in 1889 (Jordan 1891, Zuckerman and Langlois 1990). Prolonged and systematic habitat degradation in combination with other factors played a major role in the widespread extirpation of RGS and can be attributed to three main categories—habitat loss, fragmentation, and modification (Rees and Miller 2005).

Habitat loss resulting from dewatering and reservoir construction is common in the Rio Grande Basin. Reductions in streamflow and alterations to the natural hydrograph have resulted from the construction of diversions and reservoirs (Rees and Miller 2005). Other forms of loss stem from contamination rendering habitats unsuitable (e.g., heavy metal pollution, agricultural runoff, sewage effluent etc.).

Many historical habitats are fragmented by anthropogenic barriers including irrigation diversions, dams and culverts. Entrainment of fish in irrigation ditches may serve as a major source of mortality in RGS, especially for larval fish who are weak swimmers and subject to drift (D. Cammack, personal communication). Habitats can also be isolated by dewatered sections of stream stemming from water extraction, drought, and their synergistic effects. Fragmentation threatens RGS population persistence by increasing the risks of genetic bottlenecks, creating vulnerability to stochastic events and reducing the ability for recolonization after local extirpations (Rees and Miller 2005). Additionally, short and isolated reaches rarely contain the full suite of habitats to support all life stages of fish and their ability to feed, grow, and reproduce. Connectivity of variable habitat types is critically important (Schlosser and Angermeier 1995).

Habitat modification is the most prevalent form of habitat degradation threatening RGS. Altered flow regimes resulting from agricultural and domestic water development are common in the Rio Grande Basin. Water extraction and storage modifies the natural flow regime as defined by the timing, frequency, magnitude and duration of flows (Poff et al. 1997). These natural flow dynamics formed and maintained the complex habitat types that created the evolutionary template for RGS. Consequently, deviations from the natural flow regime cause shifts in habitat types and loss of natural complexity. Under these new conditions, adaptive mismatches between the environment and life history strategies of RGS may exist. For example, sequestration of high spring flows may reduce inundation of floodplain areas that serve as refugia for larval RGS. Common changes in flow regime in the Rio Grande Basin include reduced magnitude and duration of spring peak flows and altered summer base flows. Flow reductions often lead to increased water temperatures, less dissolved oxygen, and changes to the algal community, which in turn reduce RGS fitness (Rees and Miller 2005).

Changes to geomorphology that threaten RGS populations include channelization, scouring, or sedimentation of streams resulting from nearby land use (Rees and Miller 2005). Channelization homogenizes physical habitat and reduces features such as pools and undercut banks, which are favored mesohabitats for young-of-year RGS (White 1972). It can also increase stream velocity and exacerbate channel incision, leading to reduced connectivity to the floodplain. Floodplain connectivity provides important biochemical processes, sediment storage, and fluxes of energy and nutrients for aquatic and terrestrial ecosystems (Helfman 2007, Wohl 2014).

Overgrazing of riparian areas influences stream geomorphology and can affect the quality of habitats occupied by RGS (Rees and Miller 2005). Common system responses to overgrazing include loss of riparian vegetation, destabilization of banks, increased channel width/depth ratios, and increased sedimentation (Rinne 1988). Sedimentation can decrease the suitability of spawning habitat by smothering eggs and can negatively affect periphyton loads through limiting light production, scouring, or smothering (Power 1984, Newcombe and MacDonald 1991, Waters 1995). Periphyton is an important food source for RGS and its availability may limit RGS populations when White Sucker are also present (Swift-Miller et al 1999a). Overgrazing may also affect water quality. For example, the synergistic effects of livestock grazing causes stream temperatures to warm, threatening populations living near the upper end of their thermal tolerance.

In addition to direct modification of the habitat or flow regime, a variety of human activities within a watershed can indirectly result in habitat degradation. Stream form and function integrates processes occurring not only at the scale of the stream channel, but also of the surrounding watershed (Wohl 2014). Consequently, physical, chemical, and biological components of habitat are influenced by a wide array of actions across the landscape. Road building and improper timber harvest (for example, without appropriate riparian buffers) can degrade water quality mainly through increased sedimentation in streams causing impaired reproduction, physiology and disease resistance, and reducing food availability and foraging efficiency. Overgrazing and/or urbanization of upland areas can increase compaction and reduce infiltration capacity of soils. These relationships have significant implications for groundwater recharge that provides cool and steady base flows to stream habitats. Given the climatic extremes in the Rio Grande Basin (interannual temperature range: -50°F to 93°F; Todd et al. 2016, Zuckerman and Langlois 1990), reliable groundwater inputs may help to maintain thermally acceptable conditions for RGS.

Non-native Species

The presence of non-native fishes threatens RGS populations through a variety of mechanisms including competition for resources, predation, and hybridization (Zuckerman and Langlois 1990, Calamusso and Rinne 1996, Rees and Miller 2005). Among these, interactions with non-native fish species (specifically, White Sucker) has been cited as a primary cause for decline in range and density of RGS (Zuckerman and Langlois 1990, Calamusso and Rinne 1996, Calamusso et al. 2002). The non-native White Sucker was first documented in the Upper Rio Grande Basin in the 1930's and has since spread throughout the basin, replacing RGS in most mainstem habitats (Platania 1991). At the local scale, RGS abundance and condition have been found to be negatively correlated with the presence of White Sucker (Swift-Miller et al. 1999b). Little trophic niche partitioning between the two species was found when they occurred in sympatry in the Upper Rio Grande Basin, leading to speculation that the larger White Sucker was outcompeting RGS for limited resources (e.g., food, spawning habitat, rearing areas; Swift-Miller et al. 1999a). Additional mechanisms that likely contribute to White Sucker dominance were documented by McPhee (2007), who found that White Suckers attained approximately twice the net reproductive output of RGS by living longer, growing larger, and attaining 15-fold higher fecundity. Hybridization with White Sucker also poses a potential risk to RGS populations, though hybrid offspring have not been documented (McPhee and Turner 2004).

Competitive interactions with other introduced species may also play a role in limiting RGS populations. In the San Luis Valley of Colorado alone, over 50 introduced species have been identified, many of which have the potential to directly compete with RGS (Zuckerman and Behnke 1986). These species may compete for food resources directly and/or modify food web structure in a way that indirectly affects RGS or compete for important habitat types (e.g., spawning, cover from predators, drought refugia). These negative interactions may be particularly strong in disturbed systems, as has been shown for a variety of other ecosystems (Helfman 2007). Introduced species with generalist life-history strategies may outcompete the more specialized RGS. Some commonly introduced species (e.g., Common Carp *Cyprinus carpio*) are known to modify habitats and cause cascading effects that may negatively affect various life stages of RGS (Weber and Brown 2009).

In addition to competition, predation by non-natives likely limits RGS populations. Survival of RGS in Colorado appeared to be inversely related to both biomass and size of predators (Jones 2017). Non-native salmonids, especially Brown Trout, are widespread in historical RGS habitat and may have similar thermal and habitat preferences. Some observations suggest that lower salmonid abundance may be mediated by warmer temperatures, providing more acceptable conditions for RGS survival even if temperatures are warmer than optimal. Brown Trout and Northern Pike have both been documented to prey on RGS (Langlois et al 1994, Zuckerman and Langlois 1990). However, Calamusso and Rinne (1999) did not find a relationship between the relative abundance of Brown Trout and RGS. Northern Pike are particularly voracious predators that inhabit the mainstem of the Rio Grande and its larger tributaries. Northern Pike have shown affinities for targeting soft-rayed fishes, have high consumptive demands, and are capable of consuming a wide breadth of prey sizes due to their large gape size (Johnson et al. 2008). Other non-native species that likely prey upon various life stages of RGS include Channel Catfish *Ictalurus punctatus*, Green Sunfish, Lake Trout *Salvelinus namaycush*, Largemouth Bass, and Walleye *Sander vitreus*, though these relationships are poorly understood.

Drought

Drought conditions have the potential to affect RGS populations. The severity of the response to drought is largely dependent upon the specific characteristics of the affected waters. Larger streams are more resilient to drought effects than smaller systems, while small streams are susceptible to drying, freezing, and changes in water temperature and other critical water quality parameters (e.g., pH, dissolved oxygen). Habitat complexity adds to resilience and in many systems in Colorado and New Mexico, the removal of beavers and the complex habitat they create has likely made many streams less resilient to drought (Hood and Bayley 2008). Small streams already affected by habitat modification are particularly sensitive to drought effects. Stream geomorphology and the size and abundance of perennial pool habitats play a critical role in how populations of RGS respond to drought. Systems with numerous large and deep pools provide sufficient refugia until hydrologic conditions improve. Other important factors that can mitigate drought effects include watershed area, stream type, hydrology, geology, vegetation types, and aspect.

Fire

While wildfire is a natural landscape process, the frequency, intensity, size, and length of the fire season has increased in response to land management practices, fire suppression, and anthropogenic climate change (Abatzoglou and Williams 2016, Westerling et al. 2006). While fire plays an important role in maintaining habitat heterogeneity and biological diversity (Hurteau et al. 2014), larger, more intense fires and their indirect effects can threaten aquatic species. Wildfire-related population declines can be associated with direct fire effects (e.g., increased temperature, pH and nutrient concentrations), but are often attributed to post-fire, indirect effects such ash and debris flows after large rain events. This is particularly salient in the Southwest U.S, where monsoonal rain events typically follow the peak fire season (May–June). Landscapes devoid of vegetation become destabilized and vulnerable to large ash and debris flows that can kill fish, modify habitat, and alter food web structure (Rinne 1996). Populations of RGS may be negatively affected by large and/or consecutive fires especially in situations where suitable habitat is limited. The direct and indirect effects of fire are largely dependent on stream size, whereby larger volume streams are more buffered against negative effects (Whitney et al. 2015). Population resilience to the effects of fire will be greater in larger, complex, and well-connected systems as they are more likely to contain adequate refugia and more potential for dispersal and recolonization after isolated extirpations (Rieman and Dunham 2000). Evidence for this idea was confirmed by the recovery of RGS populations in Seco and Palomas Creeks after upland fires in 2003 affected the watershed (Turner et al. 2015).

Climatic/Stochastic Factors

Global climate change exerts an overarching effect on freshwater ecosystems that modifies and acts synergistically with hydrologic, thermal, fire and drought dynamics. According to the

Intergovernmental Panel on Climate Change (IPCC), anthropogenically derived greenhouse gas concentrations have risen drastically from pre-industrial levels and are extremely likely to have been the dominant cause of observed warming since the mid-20th century (IPCC 2014). Global temperatures have warmed approximately 1°C from pre-industrial times and, given the current trajectory, are expected to rise another 0.5°C by the year 2040 (IPCC 2018). In North America, mean annual stream temperatures have warmed at rates between 0.009 and 0.07°C per year, correlated with rising air temperatures (Kaushal et al. 2010). Changes in mean temperature may be accompanied by increased frequency of extreme climatic events, leading to more stochastic thermal and precipitation regimes that will in turn influence freshwater ecosystems (Lynch et al. 2016, Whitney et al. 2016). In the Southwest U.S., temperatures are projected to rise between 1.4 and 3.1°C by 2041–2070, while droughts and heat waves are predicted to become more frequent and intense. In addition, winter snowpack and streamflow are predicted to be reduced overall (Melillo et al. 2014).

Climate change is predicted to have four major effects on the habitat occupied by RGS:
- (1) increased water temperature;
- (2) decreased streamflow;
- (3) change in the flow regime; and
- (4) increased occurrence of extreme events (fire, drought, and floods).

Increased Water Temperature

Temperature has long been recognized as the most important variable affecting fish physiology, wherein metabolic rates and energy budgeting are directly tied to temperature in the vast majority of fishes (Brett 1971). Metabolic processes in fishes are evolutionarily linked to long-term, specific thermal regimes and alterations in these thermal regimes can lead to deleterious physiological changes (Pörtner and Knust 2007). Because biochemical reactions are temperature dependent, virtually all aspects of fish physiology are influenced by changing temperature including growth, reproduction, and activity (Ficke et al. 2007). Research about the temperature requirements of RGS is currently lacking, although some evidence suggests that temperature may limit RGS populations. Calamusso (2005) noted that water temperature appeared to be the main factor determining spawning timing. In many locations, RGS may be living near their upper thermal tolerance and further increases in temperature may cause populations to decline if thermal refugia are unavailable. Cooler temperatures may only be found at higher elevations where some habitat parameters may be inhospitable for RGS (e.g., steeper gradients) and negative interactions with non-native salmonids may exist. Conversely, range expansion could occur at the upstream end of streams, as water temperatures warm and potentially become more suitable. More information about RGS thermal requirements is needed to better understand these temperature relationships.

Decreased Streamflow

An analysis of the Upper Rio Grande Basin found that the precipitation has changed through time. April 1st snow water equivalent has declined by about 25% in the period of 1958–2015 and a greater percentage of the total precipitation falls as rain. Furthermore, models predict a reduction in late winter and spring snowpack, leading to depleted runoff and soil moisture (Melillo et al. 2014). Lower water yield could also be magnified by warming temperatures that would increase evapotranspiration rates. Synergistically, these conditions could lead to extended dry seasons which would be exacerbated by habitat modification in an already arid Rio Grande Basin (Whitney et al. 2016). Consequently, RGS habitat is likely to be reduced in size and complexity through time and this may eliminate populations already living in habitats with marginal flows.

Change in Flow Regime

Changes in temperature, precipitation, and extreme events could affect the magnitude, frequency, timing, and duration of flows (Poff et al. 2002). Spring peak flows shifted by 1–4 weeks earlier in the period from 1948 to 2002 in western North America, leading to lower late summer flows (Stewart et al. 2005). Life history strategies in RGS were evolved in response to natural flow regimes. Spawning phenology of fishes is largely governed by hormonal cascades mediated by photoperiod, temperature, and perhaps flow (Pankhurst and Munday 2011). A shift in the timing and magnitude of spring floods may cause RGS to spawn at suboptimal times as compared to historical conditions. Sensitive early life-stages of RGS (eggs and larvae) may be subject to scouring and entrainment in unsuitable habitats under this scenario. Lower base flows in late summer, especially under drought conditions, present a number of water quality problems (temperature, pH, dissolved oxygen) and in extreme cases, some streams may completely dry. In addition to changes in the timing of spring flows, more frequent high-intensity rain events may also present a threat to RGS populations. The IPCC determined that the frequency and intensity of heavy precipitation events has likely increased in North America (IPCC 2014). This increase in flashiness has the potential to flush various life stages of fish out of suitable habitat. Inundation of floodplain areas followed by rapid drops in flows may entrain fish in areas susceptible to drying.

Increased Extreme Events

According to the IPCC, climate change is likely to increase the frequency and magnitude of extreme events such as drought, fire, and floods (IPCC 2014, Melillo et al. 2014). Models predict that a doubling of burned area will occur in the southern Rockies by the end of the century (Litschert et al. 2012). High variability and the synergistic effects of extreme events is likely to threaten aquatic ecosystems and specifically RGS. It is uncertain how RGS populations will respond to increased extreme events, though outcomes will likely depend on the specific local conditions and population demographics. Characteristics such as stream size, elevation, aspect, shading, and hydrology will influence the response of individual populations. Populations living near their physiological tolerances or in already degraded habitats will be the most threatened by these events.

The extent to which climate change will affect RGS is not known with certainty at this time. Projections point to range-wide effects through increased water temperatures, decreased stream flow, change in hydrograph, and an increased occurrence of extreme events, but the effect on individual populations will depend on other factors such as aspect, shading, and stream size. Across the range, streams currently capable of supporting RGS are at elevations of 1,676 m (5,500 ft) to 3,000 m (9,842 ft). Climate change may affect RGS populations at lower elevations more markedly than at higher elevations, although other site-specific factors may influence the degree to which individual streams are affected. Again, more information on how hydrological conditions affect this species is needed to best predict the effects of a changing climate.

III. CONSERVATION GOALS AND OBJECTIVES

This Conservation Strategy's goal is to develop and implement the necessary conservation approaches for the Rio Grande Sucker to have sufficient resiliency, representation, and redundancy to provide for long-term viability.

Goals

The overall goal of this Strategy is to provide for the long-term viability of RGS throughout its historical range by minimizing or removing threats and promoting the conservation of the species. One of the main purposes of this Strategy is to provide a framework of objectives and associated management approaches that can be implemented to abate threats, address information gaps, and guide monitoring and restoration efforts. Areas that currently support RGS will be maintained, while other areas will be managed for increased abundance, if feasible. New populations will be established where ecologically and economically feasible to increase the number of populations and maintain the genetic diversity of the species. The Team envisions a future where sufficient numbers of wild RGS populations are adequately secured through ongoing management and stewardship that the risk of extinction of the species is negligible.

The 3Rs - Resiliency, Representation, and Redundancy

To assess RGS viability, we will use the three conservation biology principles of resiliency, representation, and redundancy. Beginning in the mid-1990s, conservation biologists introduced this conceptual framework for evaluating the viability of a species (Naeem 1998, Dunham et al. 1999, Shaffer and Stein 2000, Redford et al. 2011), referred to as the 3Rs. "Viability" in this context means the ability of a species to persist over the long term, and, conversely, to avoid extinction over the long term. A viable species has a sufficient degree of resiliency (self-sustaining populations), representation (genetic or environmental variability), and redundancy (multiple, strategically situated populations). Redford et al. (2011) articulated these concepts as "maintaining multiple populations across the range of the species in representative ecological settings, with replicate populations in each setting. These populations should be self-sustaining, healthy, and genetically robust---and therefore resilient to climate and other environmental changes." While these biodiversity principles (representation, resiliency, and redundancy) combine to provide security for a species to persist on the landscape, they also are a proxy of a species' viability. Viability describes the ability of a species to persist over time and avoid extinction.

Resiliency supports the ability of the species to withstand environmental and demographic stochasticity (for example, wet or dry, warm or cold years); representation supports the ability of the species to adapt over time to long-term changes in the environment (for example, climate changes); and redundancy supports the ability of the species to withstand catastrophic events (for example, droughts, wildfires). In general, the more redundant and resilient a species is and the more representation it has, the more likely it is to sustain populations over time, even under changing environmental conditions. With these principles, we will identify the species' ecological requirements for survival and reproduction at the individual, population, and species levels, and describe the beneficial and risk factors influencing the species' viability. This Strategy is designed to protect and enhance the characteristics of resiliency, representation, and redundancy, which would constitute the main components of RGS viability (Table 2).

Table 2. Objectives and strategies needed to provide for long-term viability of the Rio Grande Sucker.

Viability Objective	Viability Strategy
Maximize Resiliency	Maintain large populations with sufficient genetic variation and minimize threats to these populations to increase their likelihood of persistence in the face of stochastic events.
Maximize Representation	Maximize the size and range of each highly resilient population within each of the five GMUs to maintain the species across the gradient of suitable habitats and thereby increase the likelihood that genetic diversity and adaptive capacity are retained.
Maximize Redundancy	Maximize the number of resilient populations within each of the five GMUs in order to increase the likelihood of species-level persistence across the range, if individual populations are extirpated.

Objectives

The following objectives are included in the 2018 Conservation Agreement and have been the objectives of the Team since the original Agreement was signed.

Objective 1: Identify and characterize all Rio Grande Chub and Rio Grande Sucker populations and occupied habitat. Identify all waters with RGS and Rio Grande Chub populations. Monitor known populations and their habitat to detect changes over time.

Objective 2: Secure and enhance populations. Secure and, if necessary, enhance all known populations.

Objective 3: Restore populations. Increase, as necessary, the number of populations by restoring RGS and Rio Grande Chub within their native range. Local restoration goals and approaches will be developed to meet this objective.

Objective 4: Secure and improve watershed conditions. Maintain and, if necessary, improve watershed conditions and instream habitat for RGS and Rio Grande Chub.

Objective 5: Conduct public outreach. Develop RGS and Rio Grande Chub public outreach efforts and combine with Rio Grande Cutthroat Trout outreach.

Objective 6: Share data. Build and maintain the RGS and Rio Grande Chub Geographic Information System (GIS) Database so that information can readily be shared between and among agencies and jurisdictions.

Objective 7: Facilitate and improve coordination. Maximize effectiveness of RGS and Rio Grande Chub conservation efforts by coordinating and increasing synergy of Signatory efforts toward achieving a common goal.

IV. CONSERVATION EFFORTS TO DATE

Team Coordination

Management of RGS has been ongoing for decades and conservation of the species is a high priority across its range. The RGS has been designated special status within multiple state and federal agencies. Since the Agreement was first signed in 2018, the Team has served to formalize the conservation efforts for the species and provided a forum for interstate and interagency coordination and management. Coordinated management has resulted in the restoration of four self-sustaining RGS populations. Restoration methods have been developed, formalized, implemented, and will continue to be adjusted collaboratively. The RGS database was established through the Agreement and will serve as a data repository for all surveys, restorations, habitat work, or barrier maintenance. The sharing and pooling of data among the signatories into a single database has allowed the Team to comprehensively assess the conservation status of RGS and adjust methods as necessary.

Range-wide Restoration

Through coordination among Team members, restoration efforts have occurred across the distribution of RGS. This collaboration has included research and monitoring of existing populations, hatchery broodstock development, and habitat improvements. Habitat improvement work that has been completed to date on federal, state, and private lands includes: fencing of riparian areas to protect them from grazing, installation of instream structures to enhance habitat complexity, stream bank stabilization, riparian plantings, construction of fish migration barriers, road closures or relocations, culvert removal and/or replacement, beaver transplants, improving road runoff and stabilizing road surfaces. These efforts are described below and can be found in Appendix A. Commitments to future restoration efforts are listed in Appendix B.

Restoration in Colorado

Rio Grande Sucker is a state-listed endangered species and listed as a Tier 1 Species of Greatest Conservation Need in the State Wildlife Action Plan for Colorado (CPW 2015). Conservation activities have been ongoing since 1992 including population monitoring, broodstock development, stocking, genetic testing, non-native species removal, barrier removals, and habitat improvements. From 1992 to 2020, CPW expended $1,727,884 on conservation and management activities. Colorado Division of Parks and Wildlife employs two biologists that place high priority on the management of RGS, including a Native Aquatic Species Biologist for the Southwest Region and an Area Aquatic Biologist for the San Luis Valley. Additionally, BLM, FWS, USFS, and NPS expended over $1.4 million on habitat improvement projects in Colorado. Since 1992, RGS have been reintroduced through stocking in multiple waters to create new populations. The maintenance of hatchery broodstocks and identification of potential habitats for reintroduction are ongoing.

Restoration in New Mexico

The Team and formalized Agreement have served to bolster RGS conservation efforts in New Mexico. From 2007 to 2020, NMDGF expended over $3 million on RGS conservation and management activities (Appendix A). New Mexico Department of Game and Fish employs one biologist and one supervisor that are responsible for managing and conserving RGS populations. The BLM in NM conducts annual population monitoring and habitat assessments throughout the state that include the Assessment, Inventory, and Monitoring National Aquatic Monitoring Framework (Aquatic AIM), Proper Functioning Condition (PFC), Multiple Indicator Monitoring (MIM), and USFS Region 3 Stream Inventory protocols. The National Forests in NM, Valles Caldera National Preserve (VALL), and Turner Enterprises, Inc. (TEI) also contribute to conservation of the species by conducting population and habitat monitoring (Appendix A). Collaboration among NMDGF, TEI, and USFS Rocky Mountain Research Station aided in the development of environmental DNA (eDNA) techniques for population monitoring. Finally, multiple signatories (e.g., TEI, VALL) have successfully repatriated historically occupied waters. Similar efforts are ongoing, as reclamation of the Rio Costilla drainage is almost complete and plans include repatriation of RGS.

Many projects in Arizona, New Mexico and Colorado have been conducted to improve watershed conditions across the range of RGS, including managed fire to decrease future wildfire risks, range management improvements, forest thinning, road improvements and decommissioning, and riparian and instream habitat improvements. For example, the Interagency Rio Chama Aquatic Habitat Project, including nearly one mile of BLM property, has increased instream habitat diversity, provided velocity refuges, and increased bank stability with native riparian plantings. Exclosure fences constructed by the BLM on Percha Creek will help to restore RGS habitat for future reintroduction efforts. On the Forests, the Watershed Condition Framework (WCF) has served to guide assessments of watershed condition and helped to prioritize and implement restoration work (USDA 2011), as was recently completed on San Antonio Creek in the Jemez drainage. Through a partnership with USFS, NMDGF conducted instream habitat restoration on the Mimbres River; RGS abundance has increased twofold since this work was completed. In all, Team members have expended over $5 million on habitat improvement projects in New Mexico (Appendix A).

Restoration in Arizona

Conservation activities thus far include genetic testing, population and habitat monitoring to assist academic research in determining whether RGS were native to the upper San Francisco River. Given the findings (Turner et al. 2019), future surveys are needed to define the distribution and habitat improvement projects will be developed based on this information. In Arizona, habitat improvement will require alteration of dam outflows to ensure stream flow and improve water quality.

Public Education and Outreach

In Colorado, CPW has produced a RGS factsheet that contains species descriptions, distributions, preferred habitat conditions, management recommendations and habitat scorecards (CPW 2019). This resource is intended to guide the development of wetland and riparian habitat improvement projects, assist grant writers in adequately describing project benefits to RGS, and facilitate project evaluation pre- and post-restoration. Colorado Parks and Wildlife also provides opportunities to students at Saguache High School to assist in electrofishing surveys in Saguache Creek. This field trip raises awareness for RGS conservation and other native species by educating local students about the value of native aquatic ecosystems and teaching students about the ecology of RGS. Other educational opportunities include tours of the Native Aquatic Restoration Facility in Alamosa, where RGS can be observed and staff can discuss the biology and culture of the species.

In Colorado, the BLM San Luis Valley Field Office provides environmental education programs both in schools and in the field, providing hands-on learning on the importance of healthy aquatic habitats for supporting native species, and uses native fish costumes (RGS, Rio Grande Chub and Rio Grande Cutthroat Trout) in local parades and festivals to promote awareness and appreciation of native fish. Within Colorado, Rio Grande National Forest staff facilitate outdoor education events for middle and high school students that include education and information on native fish that include RGS.

In New Mexico, NMDGF has produced multiple native fish posters that feature RGS. In addition, the NMDGF website and social media sites are available for reaching the public. The Information and Education Division of NMDGF has created educational pamphlets (Wildlife Notes) about New Mexico's native species, including RGS. Biologists with NMDGF also participate in other public outreach efforts including public meetings and classroom presentations at local schools.

The BLM Taos Field Office provides environmental education for high school students throughout northern New Mexico as part of the Envirothon discussing aquatic ecology and native aquatic species. BLM also mentors middle school students in aquatic ecology annually at the Taos Soil Water Conservation District Science Conservation Camp and the Taos Charter School Science Program.

Summary

Range-wide, the total estimated expenditures for RGS exceeds $11 million since 1992. The Team has demonstrated a longstanding commitment to RGS management that has resulted in the range-wide improvement in the viability of the species.

V. CONSERVATION APPROACHES

The specific conservation approaches that will be implemented by the Team are outlined below, organized under the seven Strategic Objectives. An itemized table of the conservation approaches for each objective and GMU are provided in Appendix B.

Objective 1: Identify and characterize all Rio Grande Chub and Rio Grande Sucker populations and occupied habitat

***Signatories Responsible*:** Primarily the states, with assistance from all signatories

Approaches:

1.1 Design and conduct surveys and monitoring with appropriate techniques for Rio Grande Sucker populations and their habitats.

1.2 Characterize Rio Grande Sucker populations (including size, distribution, demographics, and genetic diversity).

1.3 Determine life history, habitat requirements, and conservation needs for Rio Grande Sucker. This information includes the extent of threats posed by non-native species that compete with, prey upon, or hybridize with Rio Grande Sucker.

An understanding of the current distribution, habitat needs, and threats to RGS populations is the first step toward identifying and implementing meaningful conservation actions. This knowledge will be gained through characterizing all known populations and their associated habitats and monitoring these populations through time to detect any changes. Information on the size and genetic diversity of populations will help in evaluating the ability of individual populations to withstand stochastic events (i.e., resiliency). Determining the number and distribution of populations will aid in understanding the species' ability to preserve its genetic diversity and life histories (i.e., representation and redundancy). Furthermore, much information on the biological and ecological requirements of individuals and populations is still needed to inform management actions. These approaches will enable the Team to evaluate the long-term viability of the species and are essential to securing, enhancing, and restoring RGS populations and their habitats.

Objective 2: Secure and enhance populations

***Signatories Responsible*:** All signatories

***Approaches*:**

2.1 As warranted, restrict stocking of non-native species that are a known threat to Rio Grande Sucker and suppress or remove these species where they are sympatric with Rio Grande Sucker.

2.2 Construct in-channel fish barriers to restrict non-native fish movement and remove barriers to facilitate Rio Grande Sucker passage as needed.

2.3 Maintain existing captive populations of Rio Grande Sucker and evaluate the need for additional ones.

2.4 Restrict spread of disease and invasive species.

2.5 Regulate angling and baitfish collection and use to minimize effects on Rio Grande Sucker.

Though we are still working to fully understand the magnitude of threats, the Team believes that reducing threats from non-native and invasive species will help ensure population persistence of RGS across the range. Improving fish passage can result in population growth and increased connectivity between populations, thereby enhancing a population's resiliency. In addition, the establishment of refuge or hatchery populations will serve to enhance the long-term persistence of the species (redundancy and representation). The total number of known current populations within each GMU is identified in Table 1 and distribution of these populations is shown in Figure 1.

Objective 3: Restore populations

***Signatories Responsible*:** States as lead with assistance from all signatories

***Approaches*:**

3.1 Establish new, highly resilient, and secure Rio Grande Sucker populations distributed among the GMUs.

3.2 When restoring populations, ensure that genetic diversity is maintained within and among the GMUs.

Establishing populations among different GMUs will reduce the likelihood of the species being eliminated by stochastic events. Restoration efforts that result in larger and more complex populations across the range would provide geographic representation in occupied habitats and reduce the likelihood that any single catastrophic event will jeopardize the species. Population restoration goals will be developed after the initial status assessment is completed.

Restoration goals will reflect consideration of how the current species' distribution influences its long-term persistence. Large populations that encompass long stretches of habitat provide security from extirpation (resiliency and representation), while smaller populations provide the species security across the landscape (redundancy). Geographically isolated populations containing unique alleles or with low genetic diversity should be a top priority for restoration to increase redundancy. Various lengths of stream will be considered for restoration, depending on the distribution and status of other populations within the GMU.

Objective 4: Secure and improve watershed conditions

***Signatories Responsible*:** All land management signatories, with assistance from all signatories

***Approaches*:**

4.1 Protect and improve riparian and instream habitat conditions in locations that prioritize existing populations or could potentially support a new resilient population of Rio Grande Sucker. These actions could include instream and riparian habitat restoration and grazing, timber, and land management practices that secure or improve habitat quality for Rio Grande Sucker.

4.2 Update resource management plans during plan revision processes to address threats to Rio Grande Sucker habitat and enhance watershed conditions.

4.3 Conduct surveys to monitor Rio Grande Sucker habitat conditions using a standardized habitat monitoring protocol.

4.4 Develop and implement a fire and drought contingency plan (Appendix C).

4.5 Work with water managers to secure sufficient instream flow for all life stages.

Enhancing existing RGS habitat and maintaining high-quality habitat is important to the continued persistence of this species. Improvement and protection of existing habitat are necessary components of this Strategy and serve to maintain and increase resiliency of populations in changing climatic conditions. The Team is working with researchers to better understand specific habitat needs of RGS. The current theory is that watershed health and stream condition measures used by the land management agencies can provide a good indication of habitat conditions for RGS. A standardized habitat monitoring protocol will also be developed and implemented to assist in researching habitat requirements.

Healthy watersheds can minimize incidence of catastrophic or severe fire, flooding, and reduce the severity of drought, increasing the likelihood RGS populations would survive these events. With this consideration, land management activities will be conducted to protect all habitats, including occupied and potential RGS habitat, and minimize fire risk. During scheduled revisions, the Forests and BLM field offices will evaluate the current Land and Resource Management Plans and update as necessary to provide adequate protection for RGS with current best management practices. Land management activities that would result in the loss of habitat or cause a reduction in long-term habitat quality will be avoided.

All USFS Forests that contain native populations of RGS (Rio Grande, Carson, Santa Fe, Cibola, and Gila) are currently revising their Forest plans. The draft plans have categorized RGS as a Species of Conservation Concern (SCC). Species of Conservation Concern are those species that are native to and known to occur on the Forest and for which there is substantial concern about their ability to persist in the Forest based on best-available science. There are specific desired conditions, objectives, standards, and guidelines to enhance and protect the habitats that these SCC occupy. In addition, the Southwestern region of the USFS recently put forth a Riparian and Aquatic Strategy that helps guide and prioritize management.

Objective 5: Conduct public outreach

Signatories Responsible: All signatories

Approaches:

5.1 Increase awareness of Rio Grande Sucker conservation efforts and the importance of native fish.

5.2 Educate the public concerning baitfish regulations and the importance of restricting transportation of fish between waterbodies.

Public outreach is a critical component to the successful conservation and management of any species. It is vital that the public is informed and allowed to comment on efforts to conserve and manage RGS. Public outreach should not only inform and educate, but also elicit the public's ideas and (possibly) concerns about RGS conservation. Public outreach should convey information such as status of the species, restoration efforts, and regulations. Increasing public awareness of RGS and other native fish could reduce negative effects on these species (e.g., polluting, discarding of nongame fish, illegal transportation, etc.).

State fishing regulations provide strict rules for transportation of live game fish and the use of baitfish. Prohibiting the spread of disease and non-native competitors and predators will benefit RGS and other native aquatic species. Rio Grande Sucker cannot be used as baitfish in New Mexico or Colorado (NMAC 19.31.10.14; CPW Regulations, Ch 1, Art. I, #104(H)(2)) Harassment, taking or possession is prohibited in Colorado (CPW Regulations (2020), Ch. 10, Art. I, #1000(A).

Objective 6: Share data

Signatories Responsible: States as lead with assistance from all signatories

Approaches:

6.1 Establish and maintain a database of information on Rio Grande Sucker.

6.2 Update the database annually and share data among signatories. Data collected on current populations including distribution, habitat, genetic status, and conservation activities will be included in these updates.

The RGS database is a crucial component of the work of the Team. Because it is a central repository of all population and habitat information, it can be used for all manner of analyses of a single population, a GMU, or the species as a whole. This effort will aid in producing a Status Assessment with the most accurate information on the species. The coordination and collaboration that led to the database's development demonstrates the commitment of the signatories to RGS conservation.

Objective 7: Facilitate and improve coordination

Signatories Responsible: All signatories

***Approaches*:**

7.1 Attend the Annual Meeting. Every year of the Agreement, CPW and NMDGF will convene a meeting of the Team to review conservation activities.

7.2 Report results and coordinate monitoring and restoration activities among signatories.

7.3 Assess whether the Strategy is achieving its goals and make any changes necessary to ensure goals are being met.

7.4 Identify opportunities to coordinate with Rio Grande Cutthroat Trout Conservation Team.

The development of the Team and signing of the Agreement in 2018 formalized conservation efforts for the species and has provided a forum for coordination and management among agencies, tribal entities, non-profit and private organizations. The Annual Meeting provides an opportunity to further this collaboration through coordinated restoration efforts and is important to ensuring range-wide conservation of the species. Collaboration with other conservation groups, and specifically the Rio Grande Cutthroat Conservation Team, provides an opportunity to efficiently share resources across multiple species and translates into more successful conservation outcomes.

VI. MONITORING AND ADAPTIVE MANAGEMENT

Monitoring

Monitoring will be of two types: implementation and effectiveness. Implementation monitoring will consist of assessing the status and progress of all conservation approaches identified in this Strategy. This type of monitoring will be documented at the Annual Meeting to ensure the Team is making expected progress. Effectiveness monitoring will assess whether the conservation approaches are achieving the Conservation Goal and Objectives outlined in the Strategy (also see Conservation Approach 7.3). Both implementation and effectiveness monitoring will be reviewed at the Annual Meeting of the Team. Although this is not a formal Adaptive Resource Management Plan, the Team has the ability to respond to changing conditions and updates in scientific approaches. The Annual Meeting serves as the forum for adapting conservation approaches as necessary to changing conditions. Appendix B lists the monitoring actions that will be taken under this Strategy.

Annual Meeting

Every year of the Agreement, CPW and NMDGF will convene a meeting of the Team for an annual review of conservation activities. Additional meetings may be called as necessary to fulfill the commitments of this Strategy.

Annual Reporting

In cooperation with and approval by all involved parties, the Team will record and distribute an annual report that consists of:

A. The minutes of the Annual Meeting encompassing the discussion regarding status of the species and actions accomplished,
B. An updated Summary of Activities table (Appendix B) showing the past year's accomplishments,
C. Results of the annually updated status assessment database, and
D. Proposed or planned activities for the next field season (annual work plan).

In addition to the annual report, the Team will complete the RGS Range-wide Status Assessment every 10 years as described in the Agreement.

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APPENDIX A. Conservation Actions Ongoing and Completed for Rio Grande Sucker (RGS) by the Rio Grande Chub and Rio Grande Sucker Conservation Team

Project	Responsible Party	Timeframe	Cost Estimate	Project Status	Description
Conservation Actions in Colorado					
Public Education and Outreach	BLM	2004–	$25,000	Ongoing	Design and purchase of native fish costumes; attendance at festivals and water events; youth education days
Restoration Projects and Studies	CPW	1992–	$188,200	Ongoing	Operational costs for restoration and research
RGS Genetic Assessment	CPW/Turner, Probstel & Ellis, Johnson & Phillips	1992–	$15,000	Ongoing	Assess population genetic health of RGS
RGS Hatchery Production/Broodstock Maintenance	CPW/NASRF/ SW Region	1992–	$726,384	Ongoing	Operational costs to maintain brood, produce and stock progeny
RGS Outreach	CPW	1992–	$10,000	Ongoing	Development of brochure and educational programs
RGS Program Operational Costs (population monitoring)	CPW	1992–	$788,300	Ongoing	Operational costs associated with RGS program not specifically listed
Medano Creek, Great Sand Dunes National Park	NPS	1996–	$12,000	Ongoing	Annual stocking of Medano Creek at Great Sand Dunes to support the population
Middle Fork Carnero	USFS	2002	$12,000	Completed	Constructed fish migration barrier
Annual Monitoring	USFWS	2015–	$87,000	Ongoing	Includes both annual monitoring plus post construction salvage efforts
Baca NWR Research	USFWS	2018–2019	$45,000	Completed	USGS study to investigate water temperature and intermittent/ephemeral status across Baca NWR
Development of Population Estimates	USFWS	2018–	$34,000	Ongoing	Quantitative data analysis by CSU to generate population estimates for RGS
Engineering Design for Channel Work	USFWS	2016–	$12,500	Ongoing	Staff fish passage engineer to approve designs, field approval of projects

Project	Responsible Party	Timeframe	Cost Estimate	Project Status	Description
Conservation Actions in Colorado					
Fish Passage Study	USFWS	2015	$55,968	Completed	SWCA conducted a fish passage and habitat study on three of the creeks (Crestone, Cottonwood, and Willow)
Infrastructure Replacement	USFWS	2015–	$900,600	Ongoing	Replaced six culverts, two water control structures
Monitoring Equipment (sampling, antennas)	USFWS	2015–	$95,850	Ongoing	Equipment costs
Monthly Remote Antenna Maintenance/Download	USFWS	2015–	$7,200	Ongoing	Personnel costs to download/maintain remote antennas on Baca NWR
Personnel Costs: Director Fellow's Program	USFWS	2019	$24,000	Completed	Baca NWR hired a DFP intern to set up and implement a temperature study on Baca NWR
Riparian Vegetation Restoration – Crestone Creek	USFWS	2012–2018	$80,000	Completed	Constructed three ungulate-proof exclosures
Set up Remote Antenna Monitoring System; Development of Database	USFWS	2016	$52,905	Completed	Install, maintain (1 year) and download PIT tag readers; develop Access database, queries for all movement data
1992–2020 Total RGS Costs in Colorado			**$3,159,907**		

Project	Responsible Party	Timeframe	Cost Estimate	Project Status	Description
Conservation Actions in New Mexico					
Population Monitoring and Habitat Assessments	BLM	2004–	$440,000	Ongoing	Costs associated with annual population monitoring and habitat assessments
Public Education and Outreach	BLM	2007–	$30,000	Ongoing	Costs associated with environmental education including hours, travel, and supplies
Rio Chama Aquatic Habitat Project	BLM	2018–2020	$10,000	Completed	Costs associated with environmental compliance and travel
eDNA Marker Development	NMDGF/TEI	2016–2017	$40,000	Completed	Development of environmental DNA markers to assess presence of RGS
Mimbres River Habitat Improvements	NMDGF/USFS/ TNC	2015–2016	$1,200,000	Completed	Cost of instream improvements to habitat including channel shaping, substrate, plantings
RGS Database Development	NMDGF	2018–	$40,000	Ongoing	Creation and population of RGC and RGS database
RGS Genetic Assessments	NMDGF/UNM	2013–	$16,600	Ongoing	Assess genetic health of RGS populations
RGS Outreach	NMDGF	2016–	$20,000	Ongoing	Native Fish poster development; programs with local schools
RGS Program Operational Costs	NMDGF	2013–	$198,000	Ongoing	Operational costs associated with RGS program not specifically listed
Rio Costilla Habitat Improvement Project	NMDGF/USFS	2016–2017	$620,000	Completed	Cost of instream improvements to habitat including channel shaping, substrate, plantings
Rio Costilla Native Fish Restoration Project	NMDGF	2007–	$1,078,000	Ongoing	Barrier construction, personnel and equipment costs associated with removing all fish in the treatment area and reintroducing native RGS
Ladder Ranch Population and Habitat Monitoring	TEI	2007–	$50,000	Ongoing	Costs associated with annual population monitoring and habitat assessments
Native Fish in the Classroom Program	USFWS/USFS	2016–	$80,000	Ongoing	Implementing the Native Fish in the Classroom program in several local schools highlighting native fish species including RGS

Project	Responsible Party	Timeframe	Cost Estimate	Project Status	Description
Conservation Actions in New Mexico					
Annual Surveys (Spring/Fall) in the Mimbres Drainage	USFS/USFWS/ NMDGF	2018–	$50,000	Ongoing	Survey sites along the Mimbres River at TNC, NMDGF, and Forest sites for RGS and Chihuahua Chub (CC)
Barrier Repair on McKnight Creek	USFS/USFWS/ TU	2015–2016	$15,000	Completed	Repaired barrier/splashpad to McKnight Fish Barrier for RGS and CC restoration
RGS Distribution Monitoring in the Sapillo Drainage	USFS/USFWS/ NMDGF	2016–	$20,000	Ongoing	Determining the RGS distribution in the Sapillo drainage following the Signal Fire
RGS Distribution Monitoring in the Mimbres	USFS/USFWS/ NMDGF	2016–2018	$50,000	Completed	Determining the RGS distribution in the Mimbres River following the 2013 Silver Fire
Riparian and Stream Habitat Restoration Projects on USFS Lands	USFS	2013–	$3,700,000	Ongoing	Stream and riparian restoration work within RGS habitat (e.g., Rio San Antonio, Rio Cebolla, San Antonio Creek)
SSP Stream Temperature Monitoring Project	USGS-NMSU/USFS/ USFWS/ NMDGF/TU	2016–2019	$100,000	Completed	Deployed temperature loggers through the Mimbres and Gila River drainages for RGS and other native species
Stream Restoration at the Cooney Place, Mimbres River	USFS/USFWS/ BCI	2016	$158,000	Completed	Habitat improvement and road stabilization at the Cooney Place for RGS and CC
2004–2020 Total RGS Costs in New Mexico			**$7,915,600**		

Project	Responsible Party	Timeframe	Cost Estimate	Project Status	Description
Conservation Actions in Arizona					
RGS Genetic Assessments	UNM	2014–2015	$2,000	Completed	Assess genetics of RGS
2014–2020 Total RGS Costs in Arizona			**$2,000**		
1992–2020 TOTAL RGS COSTS			**$11,077,507**		

APPENDIX B. Conservation Approaches to be Implemented under the Conservation Strategy

1-Year Plan, 2021, Rio Grande Sucker Conservation Strategy

<table>
<tr><th colspan="2" rowspan="2">Conservation Approaches</th><th colspan="5">GMU</th></tr>
<tr><th>Rio Grande Hdws</th><th>Rio Grande-EB</th><th>Rio Grande-Mimbres</th><th>Upper Gila</th><th>Upper Pecos</th></tr>
<tr><td colspan="7">Objective 1: Identify and characterize all RGS populations and occupied habitat</td></tr>
<tr><td>1.1</td><td>Population and habitat monitoring</td><td>Monitor 3–5 RGS occupied waters

Continue to look for previously undiscovered extant populations</td><td>Conduct surveys on Santa Fe River, Ojo Caliente, and Upper Rio Grande</td><td>Conduct surveys on Palomas, Seco, and Las Animas Creeks, Mimbres River</td><td></td><td>Monitor Rio Bonito population in BLM’s habitat restoration reach</td></tr>
<tr><td>1.2</td><td>Characterize populations (e.g., size, distribution, genetic diversity)</td><td>Collect genetic samples as appropriate</td><td>Collect genetics samples on Rio Cebolla/Fenton Lake, Santa Fe River, and Rio Embudo</td><td>Determine occupancy on Palomas, Seco, and Las Animas Creeks</td><td>Conduct surveys to determine distribution of RGS in AZ</td><td>Conduct surveys to determine occupancy: Rio Hondo, Rio Ruidoso, Eagle Creek, Agua Chiquita</td></tr>
<tr><td>1.3</td><td>Determine life history, habitat requirements, and conservation needs</td><td></td><td>Conduct research on interspecific interactions with non-natives in Jemez drainage (Texas Tech)</td><td></td><td></td><td></td></tr>
<tr><td colspan="7">Objective 2: Secure and enhance RGS populations</td></tr>
<tr><td>2.1</td><td>Restrict stocking of nonnative fish species, as warranted; suppress or remove where sympatric</td><td>CPW Regulations: Chapter 0, Article VII, #013 Release of Aquatic Wildlife

Continue mechanical removal of White Suckers and Brown Trout in Hot Creek and White Suckers in Saguache Creek</td><td colspan="4">NMDGF Regulations: NMAC 19.35.7 - Importation of live non-domestic animals, birds, and fish

Physical removals of Green Sunfish, Largemouth Bass and Bluegill from lower Las Animas</td></tr>
</table>

<table>
<tr><th colspan="2" rowspan="2">Conservation Approaches</th><th colspan="5">GMU</th></tr>
<tr><th>Rio Grande Hdws</th><th>Rio Grande-EB</th><th>Rio Grande-Mimbres</th><th>Upper Gila</th><th>Upper Pecos</th></tr>
<tr><td>2.2</td><td>Construct in-channel fish barriers and remove barriers to facilitate passage</td><td>Evaluate potential for barrier at McIntire Spring and conduct NEPA analysis

Continue to remove culvert barriers at Baca NWR</td><td>Evaluate findings of 2020 Share with Wildlife project identifying barriers to movement</td><td></td><td>Replace FS bridge in Upper San Francisco drainage</td><td></td></tr>
<tr><td>2.3</td><td>Maintain existing captive populations and evaluate the need for additional</td><td>Continue to manage captive broodstock at NASRF and augment periodically</td><td colspan="4">Identify at-risk populations and possible repatriation locations</td></tr>
<tr><td>2.4</td><td>Restrict spread of disease and invasive species</td><td colspan="5">Colorado Parks and Wildlife Commission Police D-9; CPW Regulations: Chapter 0, Article VII, #014
NMAC 19.30.14: Providing for the control and prevention of the spread of aquatic invasive species in New Mexico</td></tr>
<tr><td>2.5</td><td>Regulate angling and baitfish enforcement</td><td colspan="5">CPW Regulations: Chapter 1, Article II, #108 Special Regulation Waters
NMAC 19.31.4.11: Daily bag, possession limits, and requirements or conditions; NMAC 19.31.10.14 Fishing</td></tr>
<tr><td colspan="7">Objective 3: Restore RGS populations</td></tr>
<tr><td>3.1</td><td>Establish new RGS populations</td><td>Continue to look for opportunities to establish populations

Work with Baca NWR staff to reintroduce RGS in Willow Creek</td><td>Identify source populations to translocate into Costilla Reservoir</td><td>Continued efforts to introduce RGS in Las Animas Creek

Identify source populations for translocation to Percha Creek, Gallinas Canyon</td><td></td><td></td></tr>
<tr><td>3.2</td><td>Ensure genetic diversity is maintained within and among GMUs</td><td colspan="5">Conduct genetic analysis on select populations, replicate populations with known genetic structure (e.g., Alamosa Creek)</td></tr>
</table>

Conservation Approaches		GMU				
		Rio Grande Hdws	Rio Grande-EB	Rio Grande-Mimbres	Upper Gila	Upper Pecos
Objective 4: Secure and improve watershed conditions						
4.1	Protect and improve riparian and instream habitat conditions	Work with Baca NWR staff to create enhanced refuge pools on Willow and Cottonwood Creeks	Creation and implementation of USFS - Southwestern Region Aquatic and Riparian Strategy Completion of compliance and implementation of projects on Carson, Santa Fe, and Cibola NFs under Northern NM Riparian Restoration Environmental Assessment Continue conducting assessments of watersheds under the Watershed Condition Framework (WCF) Continue discussions with ranch managers to consider riparian health when assessing livestock use of pasture			
4.2	Update resource management plans to address RGS threats	Updating USDA Forest Plans on all NM Forests with desired conditions and objectives for riparian habitat CO: RGNF – Revised Forest Plan completed in 2020, includes language to support RGS Conservation Complete BLM SLVFO Resource Management Plan Revision pre-analysis				
4.3	Conduct surveys using the habitat monitoring protocol	Develop standardized habitat monitoring protocol Conduct fish & habitat monitoring for RGS streams affected by wildfires				
4.4	Develop and implement a fire and drought contingency plan					
4.5	Work with water managers to secure sufficient instream flow	TEI: Continue discussions with ranch managers to consider riparian health when assessing livestock use of pasture				
Objective 5: Conduct public outreach						
5.1	Increase awareness of RGS conservation efforts	Conduct outreach efforts with local elementary-high schools (e.g., Saguache and Taos County High Schools), colleges, and on Taos Pueblo Use social media to promote conservation efforts				
5.2	Educate the public concerning baitfish regulations and restricting fish translocation between waters					
Objective 6: Share data						
6.1	Establish and maintain RGS database	Complete population of range-wide database				

Conservation Approaches		GMU				
		Rio Grande Hdws	Rio Grande-EB	Rio Grande-Mimbres	Upper Gila	Upper Pecos
6.2	Update the database annually and share data among signatories	Continue contract with database manager (WYGISC)				
Objective 7: Facilitate and improve coordination						
7.1	Attend Annual Meeting	Annual Meeting, January 2021, virtual meeting hosted by CPW				
7.2	Report results and coordinate monitoring and restoration	Maintain relationships and coordinate among agencies through personal communication and meeting attendance; compile annual report for 2020				
7.3	Assess Conservation Strategy goals and make changes as needed	Complete Conservation Strategy				
7.4	Identify opportunities to coordinate with RGCT Team	Discuss repatriation of RGS in recently restored habitats (e.g., Costilla Reservoir)				

10-Year Plan, 2021–2030, Rio Grande Sucker Conservation Strategy

Conservation Approaches		GMU				
		Rio Grande Hdws	Rio Grande-EB	Rio Grande-Mimbres	Upper Gila	Upper Pecos
Objective 1: Identify and characterize all RGS populations and occupied habitat						
1.1	Population and habitat monitoring	Monitor 3–4 occupied waters annually	Monitor at least four occupied waters annually	Monitor at least four occupied waters annually	Monitor two occupied waters at least biennially	Monitor one occupied water at least biennially
1.2	Characterize populations (e.g., size, distribution, genetic diversity)	Determine if natural recruitment exists in waters where RGS are reintroduced	Employ eDNA techniques to determine distribution Analyze genetic diversity of all known populations	Estimate abundance of populations every five years	Estimate abundance of populations every five years Analyze genetic diversity of all known populations	Estimate abundance of populations every five years
1.3	Determine life history, habitat requirements, and conservation needs	PIT tag study at Baca NWR, measure habitat parameters at survey sites	Continue to support research on life history, habitat suitability, and interactions with non-natives			
Objective 2: Secure and enhance RGS populations						
2.1	Restrict stocking of non-native fish species, as warranted; suppress or remove where sympatric	CPW Regulations: Chapter 0, Article VII, #013 Release of Aquatic Wildlife NMDGF Regulations: NMAC 19.35.7 - Importation of live non-domestic animals, birds, and fish Continue mechanical removal of White Suckers at Saguache, La Jara, and Hot Creeks, and Brown Trout at Hot Creek				
2.2	Construct in-channel fish barriers and remove barriers to facilitate passage	Remove and replace culverts on Crestone Creek (Baca NWR) Construct barrier on McIntire Spring	Improve, install, or remove other barriers to facilitate restoration, especially where White Sucker presence is a threat			
2.3	Maintain existing captive populations and evaluate the need for additional	Maintain and augment broodstocks at NASRF	Identify opportunities to maintain off-channel refugial populations and replicate at-risk populations in these habitats			

Conservation Approaches		GMU				
		Rio Grande Hdws	Rio Grande-EB	Rio Grande-Mimbres	Upper Gila	Upper Pecos
2.4	Restrict spread of disease and invasive species	Colorado Parks and Wildlife Commission Police D-9; CPW Regulations: Chapter 0, Article VII, #014 NMAC 19.30.14: Providing for the control and prevention of the spread of aquatic invasive species in New Mexico				
2.5	Regulate angling and baitfish enforcement	CPW Regulations: Chapter 1, Article II, #108 Special Regulation Waters NMAC 19.31.4.11: Daily bag, possession limits, and requirements or conditions; NMAC 19.31.10.14 Fishing				
Objective 3: Restore RGS populations						
3.1	Establish new RGS populations	Restore 1–2 populations Evaluate possible new habitats for native fish at Great Sand Dunes (including Sand Creek, Cold Creek, Big and Little Spring Creeks); McIntire Spring	Restore 3–5 populations (in particular replication of Alamosa Creek, Bluewater Creek, and other populations as identified)	Restore at least two populations (e.g., Gallinas Canyon, McKnight Creek, Percha Creek)	Restore at least one population (e.g., Stone Creek, if necessary)	Evaluate possible new habitats for replication of Rio Bonito population
3.2	Ensure genetic diversity is maintained within and among GMUs	Conduct genetic analysis on select populations, replicate populations with known genetic structure (e.g., Alamosa Creek)				

<table>
<tr><th colspan="2" rowspan="2">Conservation Approaches</th><th colspan="5">GMU</th></tr>
<tr><th>Rio Grande Hdws</th><th>Rio Grande-EB</th><th>Rio Grande-Mimbres</th><th>Upper Gila</th><th>Upper Pecos</th></tr>
<tr><td colspan="7">Objective 4: Secure and improve watershed conditions</td></tr>
<tr><td>4.1</td><td>Protect and improve riparian and instream habitat conditions</td><td>Maintain Hot Creek State Wildlife Area

Riparian vegetation restoration on Crestone Creek (Baca NWR)

Habitat restoration on McIntire Spring

Conduct erosion control work, gully restoration and Zeedyk projects

Habitat protection of four miles of the Rio San Antonio (Rio Grande del Norte Natl Monument)</td><td>Nine miles of stream habitat improvement on Carson (Rio Grande del Rancho), Cibola (Bluewater Creek), and Santa Fe NFs (Rio Cebolla, San Antonio Creek)

9,000 acres of thinning and prescribed burns and 220 acres of riparian treatments in the Rio Embudo watershed

15 acres of Watershed/riparian protection along the Rio Chama WSR</td><td>Continue to maintain Percha Creek riparian exclosure (2 miles)

Post-fire instream habitat improvements in Mimbres drainage (6 miles of RGS habitat)

Consider new land management approaches which may increase perennial water conditions to support RGS where they currently exist on TEI-owned properties and where appropriate to establish new populations (e.g., Costilla Creek)</td><td>Stream protections and improvements (e.g., exclosure fencing, diversion structure upgrades) on 10 miles of RGS habitat

Fuels reduction treatments and prescribed burns in upper SF and Sapillo drainages (30+ miles of habitat)</td><td>Watershed improvement projects on Lincoln NF within priority watersheds</td></tr>
<tr><td>4.2</td><td>Update resource management plans to address RGS threats</td><td colspan="5">Address RGS threats in Forest Management Plans, BLM Riparian Management Plans, Statewide Fisheries Management Plan, etc.
Complete BLM SLVFO Resource Management Plan Revision, include language to support RGS conservation</td></tr>
<tr><td>4.3</td><td>Conduct surveys using the habitat monitoring protocol</td><td colspan="5">Implement habitat monitoring protocol
Conduct fish & habitat monitoring for RGS streams affected by forest management activities or fires</td></tr>
<tr><td>4.4</td><td>Develop and implement a fire and drought contingency plan</td><td colspan="5">Implement fire and drought contingency plan
Conduct fish & habitat monitoring for RGS streams affected by wildfires</td></tr>
<tr><td>4.5</td><td>Work with water managers to secure sufficient instream flow</td><td colspan="5">Coordinate with the Colorado Water Conservation Board to implement instream flow rights where appropriate
Work with private landowners to utilize existing water rights to benefit RGS
Active FS programs to secure water rights
Implement BLM’s instream flow rights where appropriate</td></tr>
</table>

Conservation Approaches		GMU				
		Rio Grande Hdws	Rio Grande-EB	Rio Grande-Mimbres	Upper Gila	Upper Pecos
Objective 5: Conduct public outreach						
5.1	Increase awareness of RGS conservation efforts	Coordinate with Outreach divisions to develop RGS brochures, activities, articles, and media content; update/edit CPW brochures Seek opportunities to broaden programs like "Native Fish in the Classroom" to directly include RGS				
5.2	Educate the public concerning baitfish regulations and restricting fish translocation between waters	CPW: Chapter 1, Article 1,104.H.1 regulation regarding Take, Possession and Use of Fish, Amphibians, and Crustaceans for bait, personal or commercial use NMDGF: 2020–2021 NM Fishing and Rules Info				
Objective 6: Share data						
6.1	Establish and maintain RGS database	Continue contract with database manager (WYGISC)				
6.2	Update the database annually and share data among signatories	Provide data annually to update the range-wide database; share data at Annual Meeting				
Objective 7: Facilitate and improve coordination						
7.1	Attend Annual Meeting	Signatories and supporting organizations will attend Annual Meeting, hosted by CPW and NMDGF in alternating years Encourage attendance of other interested stakeholders				
7.2	Report results and coordinate monitoring and restoration	Maintain relationships and coordinate among signatories and engage outside stakeholders; compile annual reports				
7.3	Assess Conservation Strategy goals and make changes as needed	Complete Conservation Strategy and first Status Assessment; renew Conservation Agreement				
7.4	Identify opportunities to coordinate with RGCT Team	Restore habitat and populations of RGC & RGS (e.g., Costilla Reservoir, Sand Creek); broaden RGCT outreach to include RGC & RGS				

APPENDIX C. Fire and Drought Contingency Plans

Despite habitat enhancement and population restoration, fire and drought will still occur in the region. In the event of fire or drought, the consideration points presented below are a guide for resource managers; other strategies and options may be available. Points to consider prior to intervention include:

1) Is there an eminent threat to the population?
2) Is the population genetically unique (relic) or is it a replicated population?
   - If a relic population, have replicated populations been established and are they safe from the current threat?
3) Would the action cause more harm than good? (e.g., stress associated with electrofishing, handling and transport vs. likelihood of population extirpation)
4) What is the likely timeframe needed to hold Rio Grande Sucker prior to returning to the threatened water body?
5) Is it feasible to hold rescued Rio Grande Sucker for the time projected for recovery?
6) Can required policies and regulations be adhered to in a timeframe that will allow for salvage to occur? (e.g., fish health inspection)
7) How accessible are the salvage and secondary water locations?
8) Is the threatened area safe for personnel and will the Fire Incident Commander or Forest Service allow access to the area?

Fire

The available options during and after a wildfire are often limited at best. Not one approach is considered better than the other, but rather what will work best for the threatened population. Previous strategies used by the states of Colorado and New Mexico are:

1) No action
2) Salvage and isolate at a state fish hatchery (temporary)
3) Salvage and transplant to a fishless creek
4) Salvage and house in an isolation unit (Colorado)

Options 2 thru 4 will often require additional actions to comply with state fish health regulations, such as a complete health inspection, and genetic assessments.

Drought

The threats posed by drought can be less time sensitive, but the challenges for successful salvage are equally difficult. In a majority of cases, drought is not localized but rather widespread so the possibility of finding a water body not under the same stressors will be limited, if at all possible. Previous strategies used by the states of Colorado and New Mexico are:

1) No action
2) Salvage and isolate at a state fish hatchery (temporary)
3) Salvage and transplant to a fishless creek

4) Salvage and house in an isolation unit (Colorado)
5) Salvage and re-locate Rio Grande Sucker to a more stable part of the watershed

Options 2 thru 4 will often require additional actions to comply with state fish health regulations, such as a complete health inspection, and genetic assessments.