Sustaining Wild Trout in a Changing World

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Restoration of Native Rio Grande Cutthroat Trout in the Upper Rio Costilla Basin, New Mexico: The Long Journey Home

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Abstract

The impact of nonnative salmonids on the native Rio Grande cutthroat trout *Oncorhynchus clarkii virginalis* in the upper Rio Costilla basin of northern New Mexico has long been a concern of managers as evidenced in a 1938 letter from biologists to the state game commission. In the 1970s a substantial, ultimately unsuccessful effort to remove nonnative trout in the watershed with electrofishing and sodium cyanide was implemented. In the late 1990s the New Mexico Department of Game and Fish, Colorado Division of Wildlife, and Vermejo Park Ranch initiated discussions regarding chemical renovation of upper Costilla Creek to restore native cutthroat trout, which culminated with a piscicide treatment of 22 km of stream and four small lakes in July 2002. The native cutthroat trout population was reestablished by stocking primarily juvenile fish, beginning in fall 2002. In 2004 during a supplemental stocking event, rainbow trout *O. mykiss* were inadvertently stocked into the renovated portion of the watershed. An immediate and intensive electrofishing effort removed as many of these fish as possible. During analyses of this error, it was discovered that the genetic history of the New Mexico portion of the broodstock source used to reestablish the cutthroat trout population included hybridization with Yellowstone cutthroat trout *O. c. bouvieri*. Annual surveys of the restored Rio Grande cutthroat trout population indicated that the restored fish began reproducing in 2005, and posttreatment population abundance and average individual size was similar to pretreatment estimates within 3 years. Random genetic sampling in 2005 did not detect the presence of rainbow trout or Yellowstone cutthroat trout genes in the restored population; however, in 2007 putative first generation rainbow x cutthroat trout hybrids were documented in the population. Regardless of the setback in recovery experienced here, the collaborative process for recovery of Rio Grande cutthroat trout in the upper Rio Costilla basin remains strong, and further, has initiated a proposal that, if fully implemented, would expand this native trout restoration effort to over 100 stream kilometers in the Rio Costilla basin over the next decade.

Introduction

Similar to the fate of many other North American salmonids across their native ranges, Rio Grande cutthroat trout *Oncorhynchus clarkii virginalis* currently occupy a much reduced portion of their historic range, primarily due to interactions with nonnative fishes and anthropogenically driven habitat degradation (see for example the discussions in Behnke 1992 and Young 1995). The subspecies, native to the upper basin portions of the Rio Grande, Pecos, and possibly Canadian river drainages in southern Colorado and northern New Mexico (Sublette et al. 1990; Calamusso and Rinne 2004), is now found in only about 5 to15% of historically inhabited range (Sublette et al. 1990; Stumpff and Cooper 1996; USFWS 1998). Because of this decline, both the Colorado Division of Wildlife (CDOW) and New Mexico Department of Game and Fish (NMDGF)

consider the Rio Grande cutthroat trout a species of special concern or management and are actively engaged in conservation and restoration activities regarding the subspecies, including, among other things, securing and expanding existing populations, monitoring contemporary population demographic and genetic attributes, improving and restoring habitat conditions, and establishing new populations in renovated habitats (Paroz et al. 2002; Alves et al. 2004). While these activities have generally focused on public waters, both agencies recognize the importance of incorporating the private land component into their conservation strategies and have strived to collaborate with private landowners when developing and implementing restoration and conservation objectives.

Vermejo Park Ranch, a 236,925-hectare remnant of the original 1841 Maxwell land grant, was purchased by Ted Turner in 1996. The ranch, situated in north central New Mexico on the New Mexico-Colorado state line, continues to operate as a working ranch with livestock, timber, methane, and guest service (hunting and fishing) enterprises; however, the Turner organization has implemented a land management philosophy focused on conservation of native species embodied by its mission statement: "*To manage Turner lands in an economically sustainable and ecologically sensitive manner while promoting the conservation of native species*." A renewed focus on native aquatic communities by the Turner organization established that while small core (of high genetic purity; UDWR 2000) populations of Rio Grande cutthroat trout persisted in the Vermejo (Canadian) River headwaters on the ranch, low-order tributaries in the Rio Costilla (Rio Grande drainage) basin supported only nonnative salmonids. Subsequently, in the late 1990s discussions among the NMDGF, CDOW, and Vermejo Park Ranch (founding members of the Costilla Watershed Working Group) laid the initial groundwork that culminated in chemical removal of nonnative trout and introduction of Rio Grande cutthroat trout in a portion of Costilla Creek in 2002.

History of Native Fish Conservation Efforts in the Upper Rio Costilla Basin

Costilla Reservoir, a 19,736,000-m^3 (16,000 acre-ft) irrigation impoundment formed when Costilla Dam closed in 1917, and its upstream tributaries lie entirely within Vermejo Park Ranch and form what is considered the upper Costilla basin (Figure 1). The valley floor of the basin approaches 3,000 m and stream hydrology is typified by spring snowmelt runoff and late summer low flows. Rio Grande cutthroat trout were likely the only native fish species in the basin; however, the Rio Grande sucker *Catostomus plebeius* and the Rio Grande chub *Gila pandora* may have historically resided in the lower portions. Stocking records of NMDGF indicate that nonnative brook trout *Salvelinus fontinalis* and rainbow trout *O. mykiss* were initially stocked into the upper basin in 1915 and 1917, respectively. Stocking of exotic salmonids continued until the early 1990s, in part to sustain a popular fee-fishing program on Vermejo Park Ranch.

Nonnative and hybrid trout were ubiquitous in the basin by the 1930s and in 1938 the New Mexico State Game Commission was urged to consider removing nonnative fish from Costilla Reservoir and its tributary streams in deference to the native cutthroat trout, which was rapidly disappearing from the watershed.

"Costilla Lake has great possibilities as a spawn producing lake, if it were stocked with the proper fish which should be rainbows or natives. I suggest the latter because it is a natural native water. The spawning conditions would be better since the natives spawn later than the rainbow and also there is a great shortage of this species and they should be propagated on a larger scale to meet the present and increasing demands.... The fish that now abound in the lake should be removed and the lake restocked with the New Mexico natives."

Letter from Jimmie Johnson, Fish Specialist, to the State Game Commission, July 11, 1938.

Unfort unately, no action was taken.

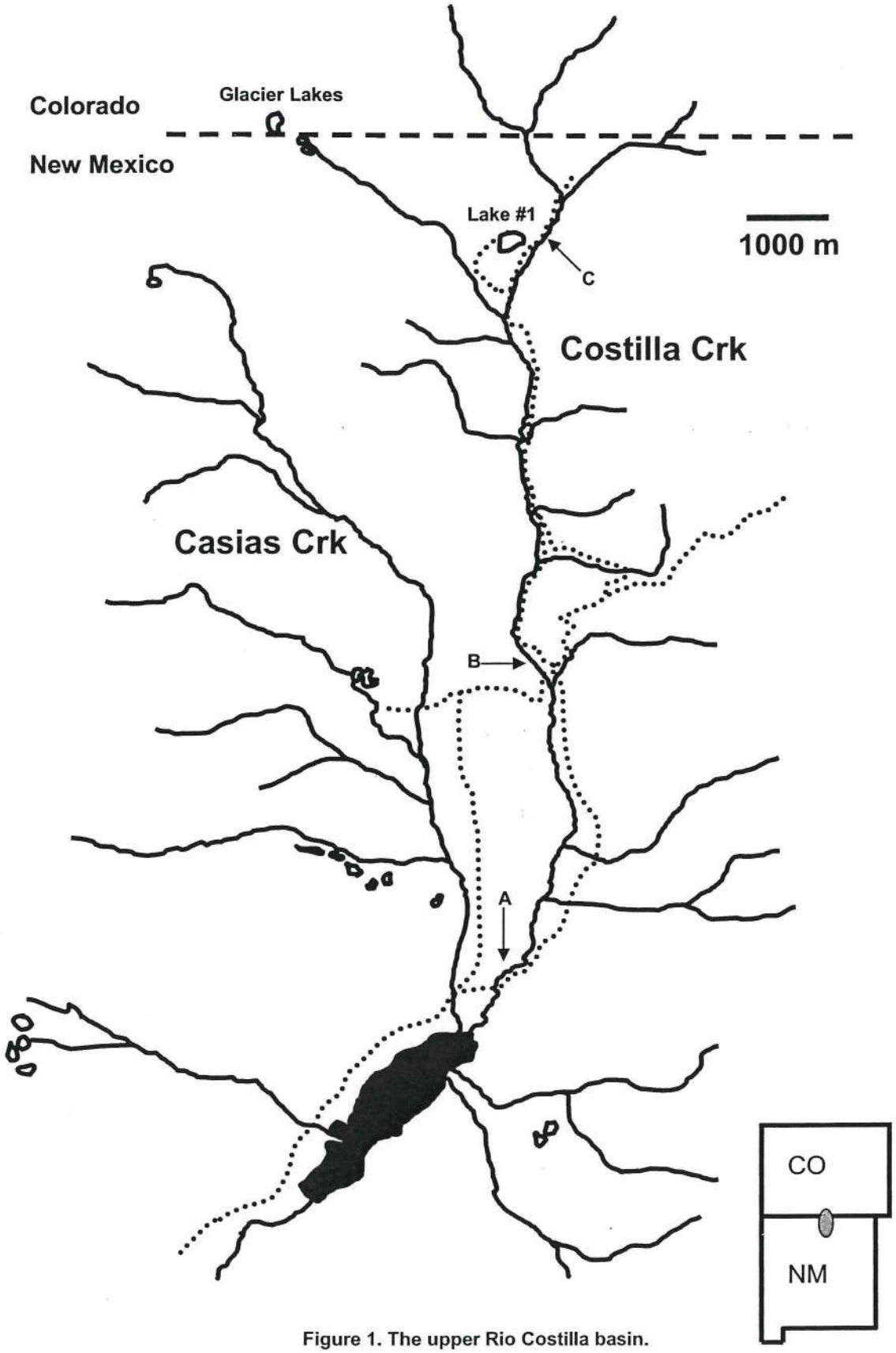

Figure 1. The upper Rio Costilla basin.

In fall 1976 an infiltration type (flow forced underground by passing through an artificial cobble screen into an outlet pipe) barrier to fish movement was installed on Costilla Creek above Costilla Reservoir (Site A, Figure 1). For the next 2 years from June to September, electrofishing and sodium cyanide applications were periodically used to collect and remove nonnative trout from the stream above the infiltration barrier. Fish visually appearing to be cutthroat trout were revived in fresh water and released back into the stream. Sodium cyanide was applied in tabular form at a rate of approximately 0.35 g/m3 (12.5 g/cfs) of flow every 150 m along the stream channel. Approximately 13,430 fish were captured over the 2 years and the percentage of fish visually appearing as native cutthroat increased from 14% in 1977 to 79% in 1979. However, with no further removal efforts after 1978, the percentage of putative cutthroat trout in the population decreased to 52% by 1982. The infiltration barrier ultimately plugged with fines and failed, and population monitoring and native fish conservation activity ceased in the early 1980s. Visually appearing cutthroat trout comprised only 15% of the population during pre-piscicide treatment surveys in 2002, and almost all of those individuals were partially hybridized (with rainbow trout) based on molecular genetic analyses.

In 1997 initial overtures were made by Vermejo Park Ranch to NMDGF and CDOW regarding a piscicide-based stream renovation project for restoration of native Rio Grande cutthroat trout in the upper Rio Costilla basin. In 2000 the ranch constructed a wire-gabion falls barrier (Site C, Figure 1) that isolated a small portion of Costilla Creek; however, upon further discussion concerning the potential long term effects of isolating a small population above a movement barrier (e.g., Novinger and Rahel 2003), the Costilla Watershed Working Group agreed that the proposed project area should be enlarged if possible. In July 2002, a second wire-gabion barrier was constructed (Site B, Figure 1) that isolated approximately 22 km of stream and 4 small lakes from the remainder of the upper Rio Costilla basin. The site chosen for the terminal barrier was as low in the drainage as possible given the low stream gradient and wide valley downstream. Following product label directions (Aquabiotics 2002) and protocols similar to those described in Gresswell (1991), Stefferud et al. (1992) and now Moore et al. (2005), a single, 10-ppb application of Fintrol®, an antimycin-based piscicide, was administered across the project area in late July 2002. Chemical was applied to the lakes by dispersing into the propeller wash and pumping to depth to ensure complete mixing of the chemical in the water body. Flowing water was treated for 8 h using constant flow drip stations (described by Stefferud and Propst 1996) spaced every 305 m along the stream channel. Slack and side channel waters were sprayed with backpack sprayers containing a diluted solution of antimycin. Residual antimycin was detoxified below the terminal barrier using a 1-ppm potassium permanganate drip. Flows in the treatment area during application were well below the long term average, with mainstem Costilla Creek flowing approximately 42 L/s (1.5 cfs) during treatment at the terminal barrier. One small side tributary required two consecutive treatments to fully eradicate all nonnative fish. Posttreatment gill netting and electrofishing surveys were unable to capture any fish within the treatment area.

Reestablishing Native Rio Grande Cutthroat Trout

The Costilla Watershed Working Group determined that the upper barrier (Site C, Figure 1) would remain in place as insurance to protect at least a portion of the treatment area until it was determined with high confidence that no nonnative fish remained in the treatment area and no fish could pass upstream over the terminal barrier (Site B, Figure 1). Consequently, a decision was made to segregate the fish stocked above and below the upper barrier into less and more genetically diverse groups to facilitate potential research regarding genetic fitness of future generations. In other words, the Working Group choose to stock Rio Grande cutthroat trout from CDOW hatchery sources across the entire project area, but supplement only that portion of the treatment area below the upper barrier with additional Rio Grande cutthroat trout from New Mexico

hatchery sources, likely providing a genetically more diverse founding population in the lower portion of the restored area. A hypothesis was that the smaller, potentially less genetically diverse population introduced above the upper barrier might manifest a significantly different population genetic structure after multiple generations than the more robust population below the upper barrier; ultimately beginning to elucidate genetic questions associated with choosing a founding population source and the isolation of small populations (see discussions in Hildebrand and Kershner 2000; Kruse et al. 2001; Novinger and Rahel 2003 for example).

For three consecutive years starting in the fall of 2002, CDOW annually stocked approximately 10,000, 25- to 50-mm long fingerling Rio Grande cutthroat trout into the main stem and lower sections of tributaries throughout the treatment area (1 fish per 2 m of stream or 4 m^2 surface area). The NMDGF stocked an additional 4,700 one year and older Rio Grande cutthroat trout into the main stem between the two barriers over the 3-year period from 2002 to 2004. Fin clips were collected from at least 60 fish during each stocking event, preserved in ethanol, and held in cold storage to document the baseline or founding genetic characteristics of the newly introduced population.

Because of their value to the guest fishing program, the two largest renovated lakes, Lake #1 (5.7 ha) and upper Glacier Lake (2.6 ha; Figure 1) were stocked with larger brood fish as well as fingerlings in attempt to immediately provide angling opportunity. Glacier Lake received an initial stocking of 750 fingerlings per hectare in the fall of 2002 with subsequent introductions of several hundred large (> 350 mm) brood fish from the NMDGF hatchery system the following summer and additional fingerling (1,000) and age-2 (800) fish in 2004. Lake #1 was initially stocked with 1,500 brood fish during the summer of 2003; however, less than one-half of these fish survived due to transportation stress and warm water temperatures. At the request of Vermejo Park Ranch, an additional 4,200 fish ranging in size from 150 to 375 mm long were stocked by NMDGF in June of 2004 to support guest angling. Both lakes were stocked with fingerling fish from CDOW in August 2006 at a rate of 250 fish per hectare. Throughout the stocking cycle in the streams and lakes all fingerling fish came from CDOW and all age-1 or older (larger) fish came from NMDGF.

Population Recovery in the Renovated Section of Costilla Creek

In 2001, eight 100-m sampling sections were established for pre- and posttreatment population monitoring with standard three-pass electrofishing techniques (e.g. Peterson and Cederholm 1984; Riley and Fausch 1992). With the exception of 2003, the same four sections have been monitored every year in July or August since 2002, including sites above and below the upper barrier. Inferences regarding population abundance over a longer period can also be made from data collected during population sampling from 1977 to 1981.

The strategy of stocking fingerling fish for three consecutive years allowed the population to recover (as measured by individual mean size and abundance) to pretreatment levels within 3 years (Table 1). The average size fish sampled during the two years prior to piscicide treatment (2001-2002) were similar and not significantly different (ANOVA $P > 0.05$) from the size of fish captured in posttreatment sampling from 2005 through 2007. In fact, the averages were startlingly similar. Actual numbers of fish (> 80 mm long) captured at each 100-m sampling site and their overall size range were also very similar when comparing the pretreatment (2001-2002) and post-recovery (2005-2007) periods. Population data collected during the sodium cyanide treatments and monitoring in the late 1970s and early 1980s suggest that Costilla Creek within the treatment area has supported a consistent trout population over time.

Reproduction by restored Rio Grande cutthroat trout was documented for the first time in the spring of 2005 and was probably the result of the 2002 age class reaching maturity. Spawning by some of the larger fish stocked by NMDGF may

Table 1. Average numbers and sizes of salmonid fishes captured prior to and after a 2002 piscicide treatment and subsequent restocking in Costilla Creek. Species present prior to treatment included brook trout, rainbow trout, Rio Grande cutthroat trout, and hybrids in the 1977-1981 samples; the addition of brown trout Salmo trutta in the 2001-2002 samples; and only Rio Grande cutthroat after 2002. Annual average fish sizes with the same numbered superscript are not significantly different (P > 0.05)

Year	Number of 100-m sites sampled	Number of fish > 80 mm per site[b]	Average size (mm) of fish > 80 mm	Size range (mm)
1977	-	-	144.5	-
1978	-	-	152.0	-
1979	-	-	175.5 [4]	80-261
1980	-	-	152.2 [2,3]	80-261
1981	-	-	147.6 [2]	81-295
2001	2	52.5	164.8 [3,4]	95-293
2002	8	48.3	166.9 [3,4]	80-306
2002[a]	4	61.3	168.6 [4]	80-306
2003	3	20.0	102.1 [1]	82-130
2004	4	20.3	147.2 [2]	104-196
2005	4	52.0	165.1 [3,4]	93-260
2006	4	56.0	166.3 [3,4]	85-246
2007	4	64.3	164.5 [3,4]	82-270

[a] *these four sites are a subset of the eight sampled in 2002, but match the sites sample from 2003-2007.*
[b] *the 1977-1981 samples were not conducted over a standard length, thus number per 100-m reach could not be calculated; these numbers represent actual fish captured.*

have occurred at an earlier date; however, it was not detected (but see discussion in the following section). Further, although NMDGF stocked over 4,000 larger fish into the lower section over the 3 years, few of these fish were seen during posttreatment electrofishing surveys, especially in 2003 and 2004 when these fish should have been noticeably larger than the younger year classes stocked by CDOW. It is suspected that many of these fish may have moved downstream after stocking, resulting in densities in the treatment area low enough to avoid detection.

Inadvertent Rainbow Trout Stocking

In early 2004, due to limited survival of larger fish stocked in 2003, Vermejo Park Ranch requested that any larger Rio Grande cutthroat trout available in the NMDGF hatchery system be stocked into Lake #1 to increase densities and provide a limited catch-and-release fishery for anglers. In June of 2004, NMDGF provided several thousand age-1 and older fish (see stocking discussion above), the largest of which went into Lake #1, with a portion of the age-1 individuals (approximately 1,500) stocked into the restored section of Costilla Creek between the barriers. Near the end of the stocking event, staff collected a morphologically irregular fish – a fish visually identified as a suspected rainbow trout. Locations where fish had been stocked into the stream were immediately electroshocked and two additional suspect fish were collected. All three were later genetically confirmed as pure rainbow trout.

Investigation at the Seven Springs Hatchery where the New Mexico Rio Grande cutthroat trout broodstock was held confirmed that rainbow trout eggs had been previously brought into the hatchery and through administrative error or escapement had contaminated a group of similar age Rio Grande cutthroat trout. Further genetic evaluation of the entire New Mexico Rio Grande cutthroat trout broodstock program also confirmed the presence of as much as 20% Yellowstone cutthroat trout *O. c. bouvieri* hybridization in the broodstock (Pritchard and Cowley 2005). It was confirmed that both rainbow trout and hybrid Yellowstone cutthroat trout had been introduced into the Costilla Creek restoration area below the upper barrier.

Based on the percentage of rainbow trout remaining at the Seven Springs Hatchery, NMDGF estimated that at least 30, and probably closer to 50, rainbow trout had been introduced into Costilla Creek. Political opposition to the continued use of piscicides in New Mexico in 2004 precluded an immediate re-treatment of the affected area; thus, an extensive electrofishing removal effort was undertaken. On July 8 and 9, the entire 8.5-km section of Costilla Creek between the barriers was electrofished at least once and 21 rainbow trout (including the two captured immediately after stocking) were removed. Subsequent passes through the section on September 8 and 10 yielded 19 and 4 rainbow trout, respectively. Acknowledging that using these passes to estimate a population size violates several assumptions of the three-pass depletion model, we nevertheless used these numbers (21, 19, and 4) to estimate a potential rainbow trout population in the restored area of 50 individuals (95% confidence intervals 44-61) – similar to what NMDGF originally estimated. Further electrofishing on September 27 and 28 captured another 7 rainbow trout – for a total of 51.

The Costilla Watershed Working Group understood it was probable that a few rainbow trout remained in the system, but was cautiously optimistic that overwinter mortality, out-migration (from the project area), and additional electrofishing in 2005 might eliminate any remaining rainbow trout prior to significant reproduction occurring as expected in the spring of 2006 (as 3-year olds). We also agreed that if future electrofishing failed to recover any additional rainbow trout or hybrids, periodic genetic sampling would be conducted in attempt to detect both future rainbow trout and Yellowstone cutthroat trout genetic influence. In 2005, in addition to sampling the four standard population monitoring sites, a single electrofishing pass was completed through the entire affected reach. No rainbows were observed in 2005 or during population monitoring in 2006. In 2005, a random sample of 90 adult fin clips was analyzed for presence of Yellowstone cutthroat trout – none was detected (Douglas and Douglas 2006). In 2007, anglers began reporting suspected hybrid fish within the restoration area, and fall population monitoring surveys also captured suspected hybrid fish that were 140 to180 mm in length. These are 2-year old fish that would have been spawned in the spring of 2005. Fin clips from suspected hybrids are currently under analyses at a genetic laboratory, and if the results confirm rainbow presence, it would strongly suggest that: our rainbow trout suppression efforts failed and the larger (for age) hatchery rainbow trout spawned as 2-year olds (most likely); rainbow trout are successfully passing over the terminal barrier (less likely); or anglers are inadvertently moving rainbow trout over the terminal barrier (possible). No hybrids were angled or captured in any sampling above the upper barrier.

Future

The Costilla Watershed Working Group remains strongly committed to Rio Grande cutthroat trout restoration in the upper Rio Costilla basin. Although disappointed, we are currently assessing options for removing or containing the possible hybridization in the restored area of Costilla Creek and believe that a highly genetically pure population of Rio Grande cutthroat trout in that area is still an obtainable goal. In 2003, the Working Group expanded to include the Carson National Forest and the Rio Costilla Cooperative Livestock Association, the next two downstream (from Costilla Dam) land managers or owners, as well as other interested parties including Trout Unlimited, New Mexico Interstate Stream Commission, and the U.S. Fish and Wildlife Service, among others. The Working Group has initiated a bold effort, formalized in a 2003 Memorandum of Understanding and 2007 Environmental Assessment, to expand the initial restoration effort in Costilla Creek to over 100 km and 20 lakes including connected waters on Vermejo Park Ranch, Carson National Forest, and the Rio Costilla Cooperative Livestock Association - if fully implemented. The first phase of this expanded effort was initiated in 2007 with a piscicide (rotenone) treatment in the Comanche Creek drainage, a large Costilla Creek tributary downstream from Costilla Reservoir. The Working Group has also developed a draft Candidate Conservation Agreement with Assurances to protect private land activities, if successful restoration of

Rio Grande cutthroat trout occurs and the subspecies becomes nationally listed under the Endangered Species Act. That document should be finalized and signed in 2008. This larger effort is expected to require a decade or more to complete; however, the Costilla Watershed Working Group is excited by the conservation gain for Rio Grande cutthroat that this, and other similar projects, represent if successfully completed.

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