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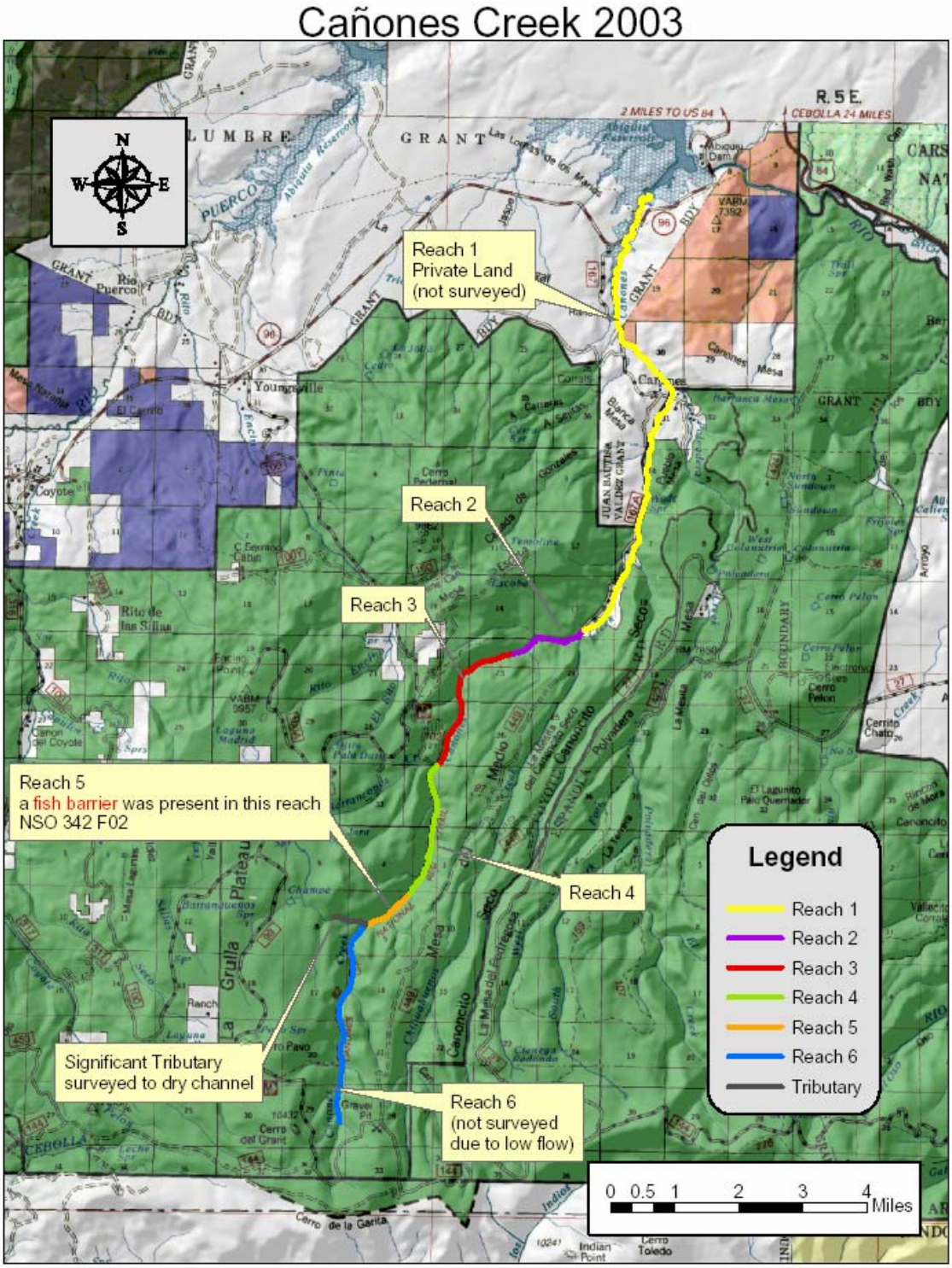

Cañones Creek 2003
N
W
E
S
Reach 1
Private Land
(not surveyed)
Reach 2
Reach 3
Reach 4
Reach 5
a fish barrier was present in this reach
NSO 342 F02
Reach 6
(not surveyed
due to low flow)
Significant Tributary
surveyed to dry channel
Legend
Reach 1
Reach 2
Reach 3
Reach 4
Reach 5
Reach 6
Tributary
0 0.5 1 2 3 4 Miles

Map 1.

This document is a specialist report. It is meant to assist managers in understanding current conditions of a stream corridor and possibly how those conditions have developed over a period of time. Recommendations are drawn up emphasizing the aquatic resource, although the accomplishment of multiple use is considered within those recommendations.

Readers should note that there is some amount of repetition in this document. The author assumes that readers may only read certain sections; therefore, points or observations may be repeated. A glossary is provided at the end of document to help the reader think like a fish biologist. In addition, appendices provide greater detail on certain data points.

INTRODUCTION
Cañones Creek 2002 and 2003 Stream Survey

Cañones Creek starts in the high subalpine meadows of Mesa del Medio on the Coyote Ranger District of the Santa Fe National Forest. From an altitude of 9,711 feet, Cañones flows northward through open meadows before entering a canyon. At the bottom of the canyon, it flows onto private land and continues on private land until it reaches the Abiquiu Reservoir. The Santa Fe National Forest Fisheries Program conducted a stream survey of Cañones Creek from October 24 to November 13, 2002, and from August 5 to August 6, 2003. A total of 7.8 miles of stream were surveyed, from the confluence with Chihuahueños Creek to a significant tributary after which the stream could no longer support fish.

The USDA Forest Service Region 3 stream survey protocol is a modified version of the Hankins/Reeves survey used in the Pacific Northwest Region. Under this protocol, streams are surveyed from the mouth upstream and separated into riffle, pool, side channel, dry channel, culvert, and falls habitat types by specific attributes (USFS 2002). Different habitat types require specific measurements relevant to evaluating the habitat (Appendix A, Table 1). In addition to the habitats located in the primary stream, tributary mouths are also surveyed and classified as a seep, spring, or stream (Appendix A, Table 3). All habitat types are assigned a Natural Sequence Order number (NSO) in the order that they are surveyed. The stream, as a collection of NSOs, is further organized by homogeneous sections and grouped into a sequence of reaches. Each reach is assigned a number in the order that it is surveyed and analyzed separately, as well as together for a holistic overview of the system.

A matrix of factors and indicators was developed to relate stream habitat information into an easily understood habitat condition classification of properly functioning, at risk, or not properly functioning. The matrix originally was developed in the Pacific Northwest by US Fish & Wildlife Service and National Marine Fisheries Service, but was modified for mountain streams in the intermountain west and relates to regulations determined by New Mexico Environment Department (NMED). The matrix was further refined to incorporate geology of streams historically occupied by Rio Grande cutthroat trout (see Table 1).

Table 1. Matrix of factors and indicators of habitat condition for historic and currently occupied Rio Grande cutthroat trout (RGCT) streams as related to R3 Stream Habitat Inventory.

FACTORS	INDICATORS	Properly Functioning	At Risk	Not Properly Functioning
Water Quality	***Temperature – State of New Mexico Standards***	<20°C (68°F) (3 day avg. max)	≥20°C (68°F) <23°C (73.4°F) (3 day avg. max)	≥23°C (73.4°F) (3 day avg. max)
	Temperature – Salmonid Development	≤17.8°C (64°F) (7 day avg. max)	>17.8º (64ºF) < 21.1º (70ºF) (7 day avg. max)	≥21.1ºC (70ºF) (7 day avg. max)
Habitat Characteristics	**Sediment**	<20% fines (sand, silt, clay) in riffle habitat. Fine sediment within range of expected natural streambed conditions		≥20% fines (sand, silt, clay) in riffle habitat. Fine sediment outside of expected natural streambed conditions.
	Large Woody Debris[1]	>30 pieces per mile, >12" diameter, >35 feet in length	20-30 pieces per mile, >12" diameter, >35 feet in length	<20 pieces per mile, >12" diameter, >35 feet in length
	Pool Development[2]	≥30% pool habitat by area[3]		<30% pool habitat by area[3]
	Pool Quality[4]	Average residual pool depth ≥1 foot		Average residual pool depth <1 foot
Channel Condition and Dynamics	**Width Depth Ratios by Channel Type** *(utilize Rosgen type and range given if applicable)*	Width/depth ratios and channel types within natural ranges and site potential		Width/depth ratios and channel types are well outside of historic ranges and/or site potential
		Expected range of bankfull width/depth ratios and channel type	**Rosgen Type** A, E, G B, C, F D	**W/D Ratio** <12 12-30 >40
	Streambank Condition[5]	<10% unstable banks (lineal streambank distance)	10-20% unstable banks (lineal streambank distance)	>20% unstable banks (lineal streambank distance)

[1] Large Woody Debris numeric are not applicable in meadow reaches. For this survey a meadow reach can be defined as an area where there is no natural local recruitment of LWD.
[2] Pool Development numeric are applicable to 3rd order or larger streams.
[3] Area is defined by habitat length.
[4] Due to surveyor error this parameter is excluded from analysis in reaches 2 and 4.
[5] Streambank Condition numeric are not applicable in reaches with > 4% gradient

Global positioning system (GPS) units are utilized for survey data collection. Trimble GeoExplorer 3 units are used to identify specific features throughout the survey (Appendix A, Table 2). The GPS feature locations are then transferred into a geographical information system (GIS) layer and used to provide graphical representations and spatial analysis of river attributes.

The primary objectives of the Region 3 Hankins/Reeves survey include the compilation of historical information and in-stream habitat data to assist in proper management decisions of the surveyed stream and its watershed. The historical information provides a background of land use and management techniques collected from the Forest Service and a variety of other sources. Previous land use and management practices reflect on the current condition of environmental systems. Historical information helps explain the current condition of the river and is incorporated into the survey. Understanding events that formed the habitat condition enhances decision-maker options. In-stream survey data is collected to provide an overview of the current condition of a stream. Survey data produces a "snapshot" in time of the stream's habitat condition and the factors affecting

it (see Photo 1). Survey information can be used to identify both degraded sections as well as ideal areas to be used as a reference or model for other similar sections of stream. By combining the historical and current information pertaining to a stream, management options can be more clearly identified, which is the goal of this document.

BASIN SUMMARY

Table 2. Stream Summary Table for Cañones Creek.

LOCATION:	
County:	Rio Arriba
Forest:	Santa Fe National Forest
District:	Coyote
Drainage:	Cañones
Tributary to:	Abiquiu Reservoir
Survey Began at:	T22N R4E Sec23 at 7200 feet
WATERSHED:	
HUC Code[1]:	1302010210
Watershed Area:	56,844.8 acres 88.82 square miles
Stream Order:	3 (at start of survey)
Stream Length:	84,163 feet[2] 15.94 miles[2]
AQUATIC BIOTA:	
Fish Species:	brown trout (Reaches 1-2); rainbow trout (Reaches 1-2); Rio Grande cutthroat trout[3] *(Oncorhynchus clarki virginalis)*(Reaches 2-5)

[1] Hydrologic Unit Code used to identify watersheds.
[2] Stream length includes both surveyed public land and un-surveyed private land.
[3] Listed as a Sensitive Species by USDA Forest Service, Southwest Region (1999)

Photo 1. Reach 4, NSO 288, R129. Typical stretch of Cañones Creek (5-Aug-03).

EXECUTIVE SUMMARY

Cañones Creek is a 3rd order stream originating from springs draining the north side of Mesa del Medio on the Coyote Ranger District of the Santa Fe National Forest. The stream survey covered 7.6 miles of the approximately 16 miles of flowing stream, just above the confluence with Chihuahueños and continuing until the creek no longer provided fish habitat. Cañones Creek Watershed encompasses 56,844.8 acres (88.82 square miles) owned by the Forest Service and private landowners (see Photo 2) and is drained by two large tributaries, Polvadera Creek and Chihuahueños Creek. Cañones Creek is divided into 6 reaches, each containing relatively homogeneous habitat characteristics. Reach divisions are based on stream and valley morphology, dramatic changes in stream flow, impoundments, or land ownership boundaries. Reaches are numbered sequentially as the survey progresses upstream (see Table 3).

Table 3. Description and length of reaches on Cañones Creek.

Reach	River Miles	Landmark at Beginning and End	Land Owner
1	0.0 to 8.3	Abiquiu Reservoir to just upstream of confluence with Chihuahueños Creek (T22N R4E S23)	Army Corps of Engineers and Private Land
2	8.3 to 9.8	Confluence with Chihuahueños to waterfall (T22N R4E S34)	Private Land and Santa Fe National Forest
3	9.8 to 12.6	Waterfall to dry tributary on right bank (T21N R4E S9)	Santa Fe National Forest
4	12.6 to 15.0	Dry tributary on right bank to active tributary on left bank (T21N R4E S9)	Santa Fe National Forest
5	15.0 to 15.9	Active tributary on left bank to significant tributary on right bank contributing over 90% of flow (T21N R4E Sec 9)	Santa Fe National Forest
6	15.9 to 18.9 (headwaters)	Confluence with significant tributary to headwaters (T21N R4E Sec 29); majority of length is dry (2003)	Santa Fe National Forest
Significant Tributary	0.0 to 0.7	Ends at a dry channel with steep gradient	Santa Fe National Forest

The average gradient of Cañones Creek is 3.2% or 169.0 feet of elevation gain per mile. When evaluated by reach divisions, the gradient ranges from 2.1% in Reach 5 to 5.8% in Reach 2 (see Table 9).

Sedimentary rocks (rocks deposited by water) form the colorful cliffs of the Piedra Lumbre. These rocks were deposited in the Mesozoic Era (the Age of Dinosaurs) when this area was the shoreline of a huge sea. These rocks are primarily cliff-forming sandstones and slope-forming shales. Some of the units erode (wash away) easily because they contain silt and gypsum. The rock that has washed away forms the gullies and benches around the bottoms of the cliffs (Dean 2004).

The southern part of the watershed is within the Jemez Volcanic province. These are Tertiary age (the Age of Mammals, newer than the Mesozoic Era) volcanic rocks related to the Valle Caldera and other, slightly older, volcanic activity (Dean 2004).

Some of the volcanic rocks have eroded and been deposited as sedimentary rocks in the lower areas. These sedimentary rocks are so new they haven't really cemented together (the rock pieces aren't stuck together), so they are easily washed away (Dean 2004).

Stream flow in Cañones Creek fluctuates between high flow events in the spring and lesser events in the late summer to low flow in mid-summer. Spring flow events originate from snow runoff and vary with the previous winter's snow pack. The late summer high flow events are related to monsoon weather patterns, which typically develop in July and August. The flow related to monsoon events is not as intense as the spring runoff. Low flow in Cañones Creek usually occurs in the mid-summer (June), fall and winter seasons, when flow is dependant on spring sources.

One water diversion is in the surveyed portion of Cañones Creek represented by several small irrigation pipes on private land in Reach 1. These pipes are along the right bank in NSO 7. They no longer appear to be functioning.

Photo 2. Upstream view of Cerro Pedernal along western boundary of watershed (25-Oct-02).

The 2003 survey was accompanied by temperature analysis at 3 thermograph (or temperature recording) sites. The thermographs were deployed at the beginning of the summer and retrieved in the fall. Analysis indicates elevated temperatures that need to be monitored over to assure that conditions do not worsen (noted as **at risk**).

Stream habitat conditions generally noted a lack of pool habitat with increased but functional fine deposition in riffle habitat. This could be a limiting factor to overall stream productivity and could be further complicated by the lack of large wood structure in the stream. Unstable banks measured over 1.6 miles in length, with the heaviest unnatural concentration of instability in Reach 4. This may have influenced an increase in width-to-depth ratios, further limiting the stream from developing adequate pool habitat.

Cañones Creek is occupied by a secure (uninhabited by non-natives) population of native Rio Grande cutthroat trout above the waterfall located at the terminus of Reach 2. This population is considered of great significance to the preservation of the species (see Fisheries write-up).

Habitat Characteristics

The 7.6 surveyed miles (40,392 feet) of Cañones Creek are divided into 366 Natural Sequence Order Habitat Units (NSOs). The 143 pool habitats comprise 9.4% of the stream habitat length. There are 165 NSOs that are riffle habitat, which comprises the majority of habitat (84.5%) in Cañones Creek (see Table 4). Other habitat types in Cañones Creek are tributaries, falls, and side channels.

Table 6. Summary of habitat and substrate composition in Cañones Creek.

Habitat Summary					
	# of Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth
Entire River	165	220	8.32	0.61	1.2

Substrate Summary						
	Sand (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)	Total (%)
Entire River	16.7	28.8	34.5	18.7	1.5	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Pool habitat is important over-wintering, resting, and foraging habitat for fish. Pool habitat is evaluated by both quality or residual depth and area of pool habitat (by length). Pool quality is **properly functioning** in Cañones Creek with 62% of the pool habitats with at least 1-foot residual depth. Residual depth is calculated by subtracting the maximum depth from the pool tail crest depth to determine the depth of water that would remain in the habitat if flow ceased. The pools observed in Cañones Creek have an average residual depth of 1.2 feet, just barely over the necessary depth to be considered properly functioning. These pools are shallow and at risk of filling. The sediment content in the pools is high at 30.5%. This number may be on the increase if flows remain low in the next few years. There is also a lack of large woody debris, which could also be leading to the shallow pools. The relative quantity of pool habitat (9.4%) is **not properly functioning** (see Table 7). Increasing pool habitat in Cañones Creek should be a priority in the stream's management.

Table 7. Summary of pool habitat and relative substrate in Cañones Creek.

Pool Habitat Summary											
Area	Number of Pool Habitats	Avg. Length	Avg. Width	Avg. Max Depth	Avg. PTC	Avg. Residual Depth	Pools per Mile	Number of Pools w/ Residual Depth >1'	Pools w/ Residual Depth >1'/Mile	Number of Pools w/ Max. Depth >3'	Number of Pools w/ Max. Depth >3'/Mile
Entire River	143	28.2	8.68	1.68	0.5	1.2	18.7	89	11.6	3	.4
Properly Functioning Indicators	-	-	-	-	-	≥1ft	-	-	-	-	-

Substrate Summary						
Area	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	% Total
Entire River	30.5	24.0	24.0	16.7	4.9	100.0

Large woody debris (LWD) is related to habitat complexity and the health of fish populations in stream habitats (Fausch and Northcote 1992). LWD density is **not properly functioning** in Cañones Creek. The LWD density is 9 pieces per mile, far below the standard (see Table 8). Cañones Creek had 74 pieces of wood classified as medium and large sizes (see Photo 3). Wood classified as medium LWD must be greater than 12 inches in diameter at a length of 35 feet from the large end (or two times bankfull width). Large pieces of LWD have a diameter of greater than 20 inches at a length of 35 feet from the large end (or two times bankfull width). Increasing LWD density should be a focus in the management of Cañones Creek. Increasing LWD may also improve other degraded factors in the stream habitat including pool development and stream temperature.

Photo 3. Reach 5, NSO 318, S32. Typical log jam (5-Aug-03).

Bank stability (10.7%) is **at risk** when analyzed by the length of the entire surveyed section of stream. When the length of the river was divided into reaches, Reaches 2, 3, and 6 had over 4% gradient and thus were not analyzed for bank stability. Reach 4 was the only reach **at risk** for bank stability.

Table 8. Selected habitat characteristics in Cañones Creek.

Area	Pool:Riffle Ratio	Avg. Riffle Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
Entire River	1:1.2	13.7:1	9.0	8,636	10.7
Properly Functioning Indicators	-	-	>30	-	<10

Tributaries

Twenty-one (21) tributaries contribute to the main channel flow for the surveyed length of Cañones Creek. These tributaries come in 3 primary forms: seeps, springs, and streams. There may be more tributaries that were contributing flow subsurface, especially in Reach 5. These tributaries were not included. A majority of the tributaries were found in the Reach 5. Of the 21 tributaries counted (see Appendix A, Table 3), only one was considered significant (see Table 10). This tributary marked the end of Reach 5. It contributes over 90% of the main channel flow. A survey of this tributary was conducted in 2003 and is included in this report.

Table 10. Summary of tributaries contributing more than 10% of the main flow of Cañones Creek during the 2002 and 2003 Stream Inventory.

Location		Bank	Habitat Type	Name	Percent Flow*	Time	Tributary Temp (°F)	Stream Temp (°F)	Comments
Reach	Tributary Number								
5	21	Right	Stream	-	>95%	17:27	57	57	surveyed

*Percent flow is a visual estimate by the surveyors and therefore should not be considered an exact measurement.

The surveyed length of the river included only two named tributaries: Barrancones Creek (Reach 3) and Chihuahueños Creek (Reach 1). Barrancones was not flowing at the time of the survey.

Stream Flow

Headwaters of Cañones Creek are a series of springs in an open meadow valley. From its headwaters to Abiquiu Reservoir, Cañones is joined by one significant unnamed tributary and many smaller unnamed tributaries. Named tributaries that flow into Cañones include Barrancones Creek, Chihuahueños Creek, Cañoncito Seco, Cañada de Gonzales, Polvadera Creek, and Arroyo Sejitas. Many of these named tributaries have only seasonal flow. Only two of these named tributaries enter Cañones Creek within the surveyed length of the river. Barrancones Creek enters in Reach 3 and the survey started just above the confluence with Chihuahueños.

The flow of Cañones Creek is governed by snowmelt, typically spiking in the spring usually late May to early June. Smaller peak flows occur after heavy precipitation events associated with the summer monsoons (July through September). These heavy flows typically flush sediment that has built up in the system downstream. However, over the last few years this region has experienced drought conditions, creating unusually low flows. The summers of 2002 and 2003 were atypically dry. In 2002 the last half-mile of the headwaters ran dry (Serrano 2002). In 2003, S. Eddy and C. Gatton walked the headwaters. They walked a mile down from what they believed to be the headwaters before they witnessed a steady flow of water. Above this section there would be short lengths of flowing water followed by long lengths of dry channel.

Flow was measured utilizing a Swoffer brand flow meter on October 24, 2002, in Reach 2, River Mile 8.3. The flow was measured at the beginning of the survey just above the confluence with Chihuahueños Creek. The flow measurement location was in a straight section of riffle with as few flow restricting obstacles (boulders, logs, etc.) as possible. A transect was created and divided into 26 equally spaced sections. At each section, flow was taken at 60% of the depth in twenty-second

intervals. The average flow is recorded from each section and related to area to calculate the stream flow. The flow in Cañones on October 24, 2002, was 1.89 cubic feet per second (cfs).

USGS quadrangle maps do not indicate that there are any irrigation ditches along Cañones Creek. However, near the confluence with Chihuahueños there are 1-inch diameter pipes, which were used to remove water from the creek. These pipes seem to be no longer in use. They are located on private land. There are no lakes within the watershed, but Cañones flows into the Abiquiu Reservoir.

Water Temperature

Water temperature is a key component of water quality in a stream environment. Combinations of multiple factors determine water temperature regimes in stream habitats. Solar radiation, air temperature, riparian vegetation cover, ground water, stream discharge, channel shape, stream orientation, and climate are some of the environmental factors that influence water temperature. Many chemical and biological processes depend on specific temperatures. Temperature can help determine the suitability of waters for aquatic species such as Rio Grande cutthroat trout (RGCT).

Fish growth, health, and reproduction are affected by water temperature. Fish are very sensitive to water temperature due to temperature specific enzymes. As water temperature increases, so does fish performance. Although fish have increased performance with temperature, they also approach a lethal limit. No lethal temperature information is currently available for RGCT. Another high elevation, arid cutthroat subspecies Lahontan cutthroat trout (*Oncorhynchus clarki henshawi)* indicated an upper limit for growth and long-term survival is somewhere between 71.6 and 73.4°F. These temperature limits were based on optimal conditions with high food availability and good water quality, not taking into account the other stressors that may exist in stream environments. It is possible that the actual lethal limits are lower due to water chemistry and other environmental factors (Dunham 1999).

Cutthroat trout reproduction is affected by temperature. Smith *et al.* (1983) compared egg quality of cutthroat trout in a variety of water temperatures. Eggs in cold water were expelled easily and were in good condition. In warm water the eggs were expelled with difficulty, were cloudy or opaque and often broken. Eggs spawned from two-year-old adults exhibited 74% viability in coldwater while in warm water only 6.9%.

Forest standards (noted as SFNF in Table 11) are based on seven-day average maximum temperatures and are stricter than the NMED standards. While it is stricter, the Forest standard is more in line with approaches taken by U.S. Fish and Wildlife Service and NOAA Fisheries across the western United States. It also allows the SFNF to be more pro-active in improving watershed conditions for native fish as well as ameliorating impairments to water quality before a stream is listed as impaired on the 303(d) list.

NMED standards are based on three-day average maximum temperatures (see Table 11). Forest temperature standards are derived from research done on inland cutthroat trout and salmonid development. NMED standards are based on the Clean Water Act and Total Maximum Daily Loads mandate for water quality standards but are defined by needs for a successful coldwater fishery (as

suggested in the Lahontan cutthroat trout study). Data between June 1st and September 30th is used for maximum water temperature standards analysis to identify high temperatures that occur in summer months.

Table 11. Santa Fe National Forest and New Mexico Environment Department Water Quality Temperature Standards 2002.

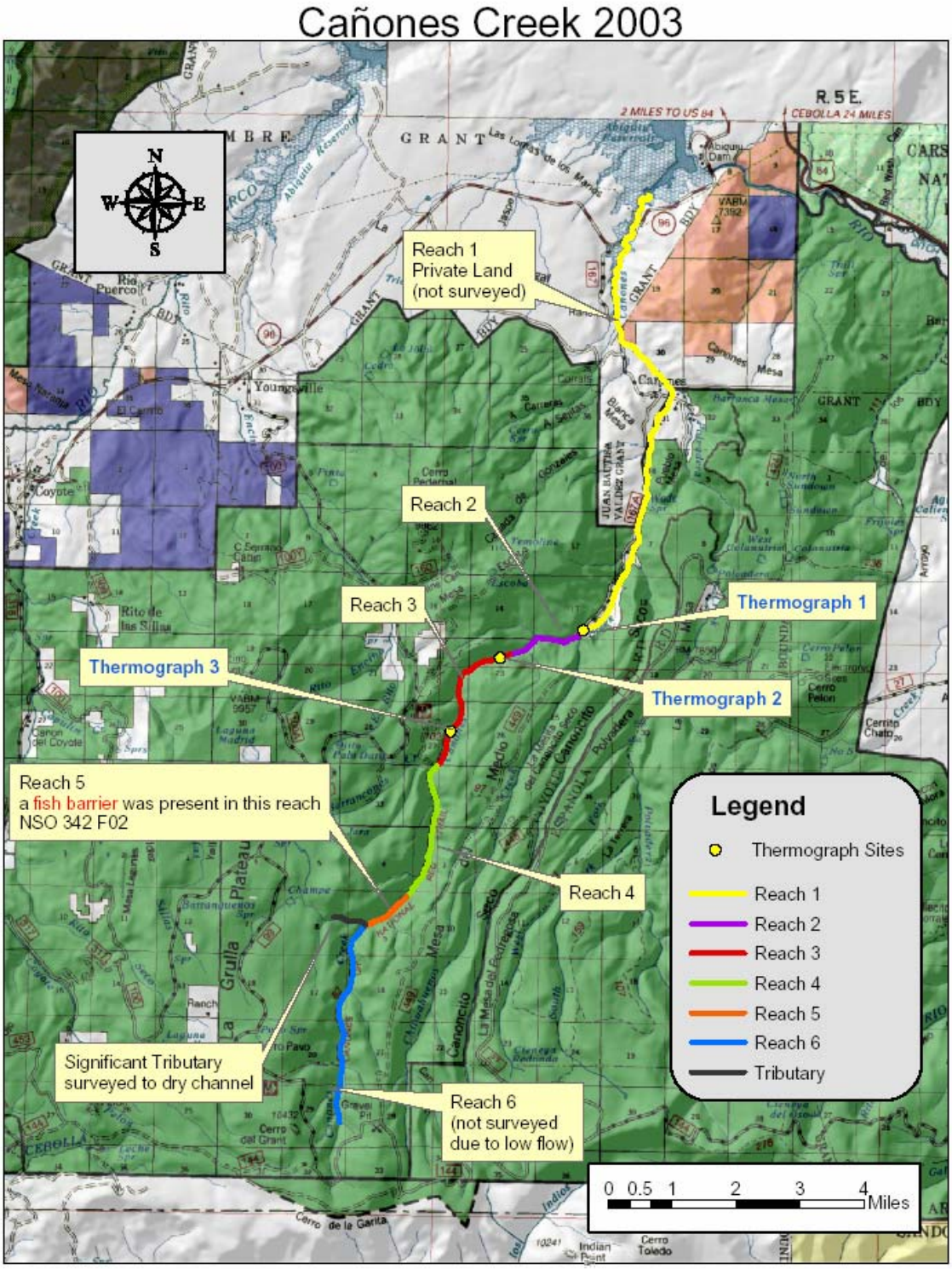
Water Temperature Standards	Properly Functioning	At Risk	Not Properly Functioning
SFNF 7-Day Average Max.	≤ 64°F	64 to 70°F	> 70°F
NMED 3-Day Average Max.	< 68°F	68 to < 73.4°F	≥ 73.4°F

Water temperature in Cañones Creek was monitored from June 16th to October 14th, 2003. Tidbit thermographs, small temperature recording devices, were strategically placed at 3 locations in Cañones Creek (see Photo 4). Thermographs recorded temperatures at 4-hour intervals for the duration of their time in the river, providing over 714 temperatures for each site. Data collected by thermographs was exported to Microsoft Excel 2000 for analysis and comparison to water quality standards and compared to Forest and NMED Water Quality Standards for temperature. Both standards classify water temperature as properly functioning (PF), at risk (AR), or not properly functioning (NPF), but with different requirements (see Table 11).

Photo 4. An example of the sedimentation found when thermographs were collected. This thermograph was placed on Chihuahueños Creek (30-Oct-03).

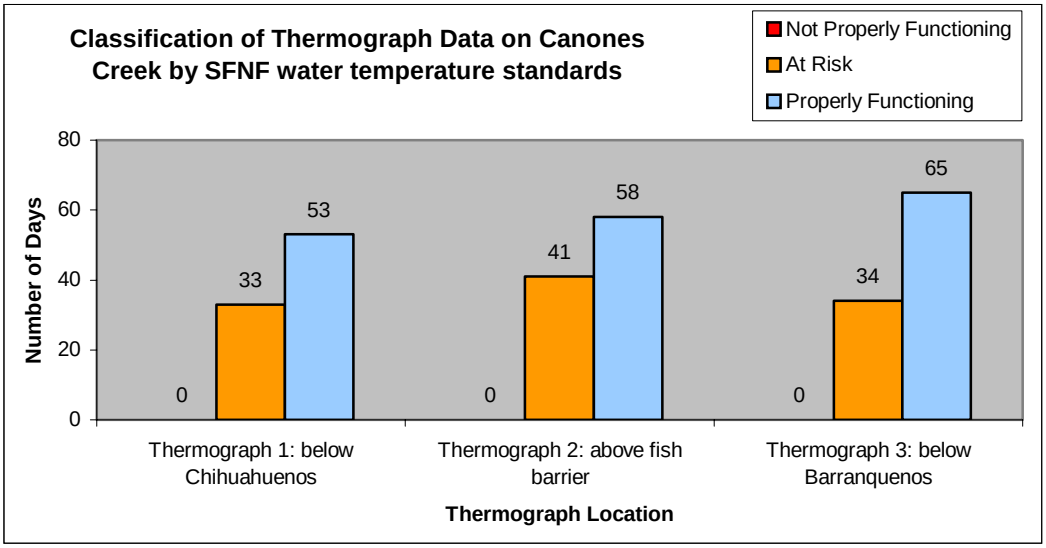
The first thermograph station was placed at the beginning of the 2002 stream inventory, just above the confluence with Chihuahueños (Reach 2, River mile 8.3; see Map 2). The next station was located immediately upstream from the human-made fish barrier (Reach 3 RM 9.8). The third station was located above the confluence with Barrancones Creek (Reach 4 RM 11.4).

Thermograph data collected between June 16th and September 30th was used to determine water quality. When SFNF standards are applied, all three stations are **at risk**. None of the sites were classified as not properly functioning and all of the sites had more properly functioning days than days at risk (see Figure 1).



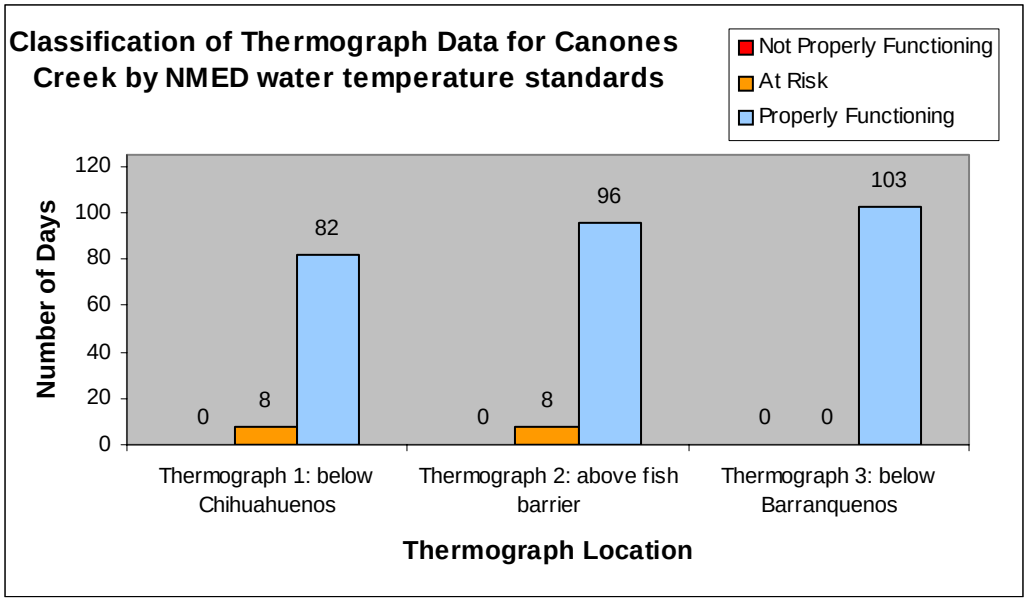
Map 2. Thermograph locations in Cañones Creek (2003)

Figure 1. Comparison of days not properly functioning, at risk, and properly functioning at three thermograph sites in Cañones Creek between June 16th and September 30th, 2003. Water temperature categories defined by SFNF Water Quality Temperature Standards are based on seven-day average maximum.



Two stations recorded **at risk** days when classified by NMED standards: above the confluence with Chihuahueños Creek and above the Fish Barrier (see Figure 2). Both sites had significantly fewer days at risk than properly functioning. No days were classified as not properly functioning during the monitoring period.

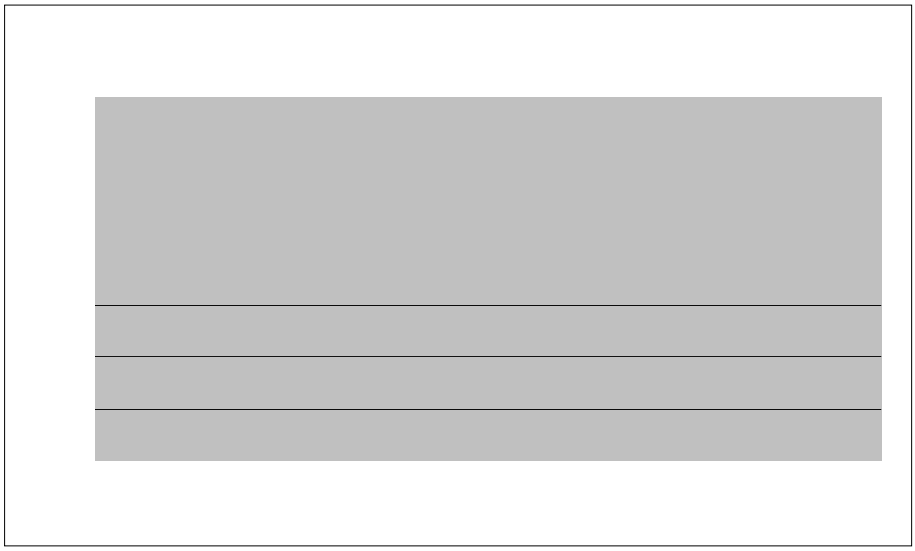
Figure 2. Comparison of days not properly functioning, at risk, and properly functioning in Cañones Creek between June 16th and September 30th, 2003. Water temperature categories defined by NMED Water Quality Temperature Standards are based on three-day average maximum.



Looking at stream temperatures across elevation can also distinguish areas in need of temperature mitigation. On July 31st, 2003, a maximum stream temperature of 66.2°F was recorded at Thermograph Station 3 (elevation 8,030'). This temperature was slightly higher than the 65.5°F recorded at Thermograph Station 1 (elevation 7,260', see Figure 3). The lowest maximum

temperature of 56.8°F on July 31st was recorded at Thermograph Station 2. This indicates a cooling effect that exists within Reach 3 which could be associated with the tightness of the canyon (shading; lack of solar influence) and/or upwellings. Temperature do increase 9°F in a span of 1.5 miles as the stream turns east. This could be increased solar radiation associated with geology but also there is a significant amount of unstable bank which may also limit thermal cover from riparian vegetation.

Figure 3. Maximum stream temperatures recorded on July 31st, 2003, across the three thermograph stations on Cañones Creek.



In addition, water quality in Cañones Creek was monitored by NMED in 2000. The creek was listed as impaired for use as High Quality Cold Water Fisheries. The assessment was done at the mouth of the creek near Abiquiqui Reservoir and downstream from private land influences. The threats to the integrity of the coldwater fishery were identified as agriculture, silviculture, removal of riparian vegetation, rangeland, streambank modification/destabilization, and onsite wastewater systems. Some of the specific pollutants include metals, turbidity, temperature, fecal coliform, and total organic carbon.

The **at risk** classification of multiple sites by both the Forest and NMED water quality standards implies that water temperature should be a management consideration for Cañones Creek. Temperature mitigating strategies should be applied to further protect the integrity of the coldwater fishery.

Riparian and Upland Vegetation

Riparian vegetation is located on both banks of streams. Riparian areas serve many important functions including water purification and storage, erosion reduction and more. Riparian vegetation removes toxins from the water column and improves water quality; stores water in the stream banks, increasing available water and stream flow duration; and improves stream bank stability, reducing erosion and its associated fine sediment inputs (Brodie 1996). Riparian vegetation is important in maintaining a healthy fish population in Cañones Creek.

Cañones Creek's woody riparian vegetation was dominated by alder. Willow and dogwood were also present in the lower reaches. Starting in Reach 3, woody vegetation began to overhang the stream, providing shade. Reach 5 vegetation was thick enough over the creek to block the passage of surveyors. Fir and spruce also began appearing in the riparian zone in the upper reaches. Herbaceous riparian vegetation includes water hemlock, sedges, equisetum, wild hops, and grasses.

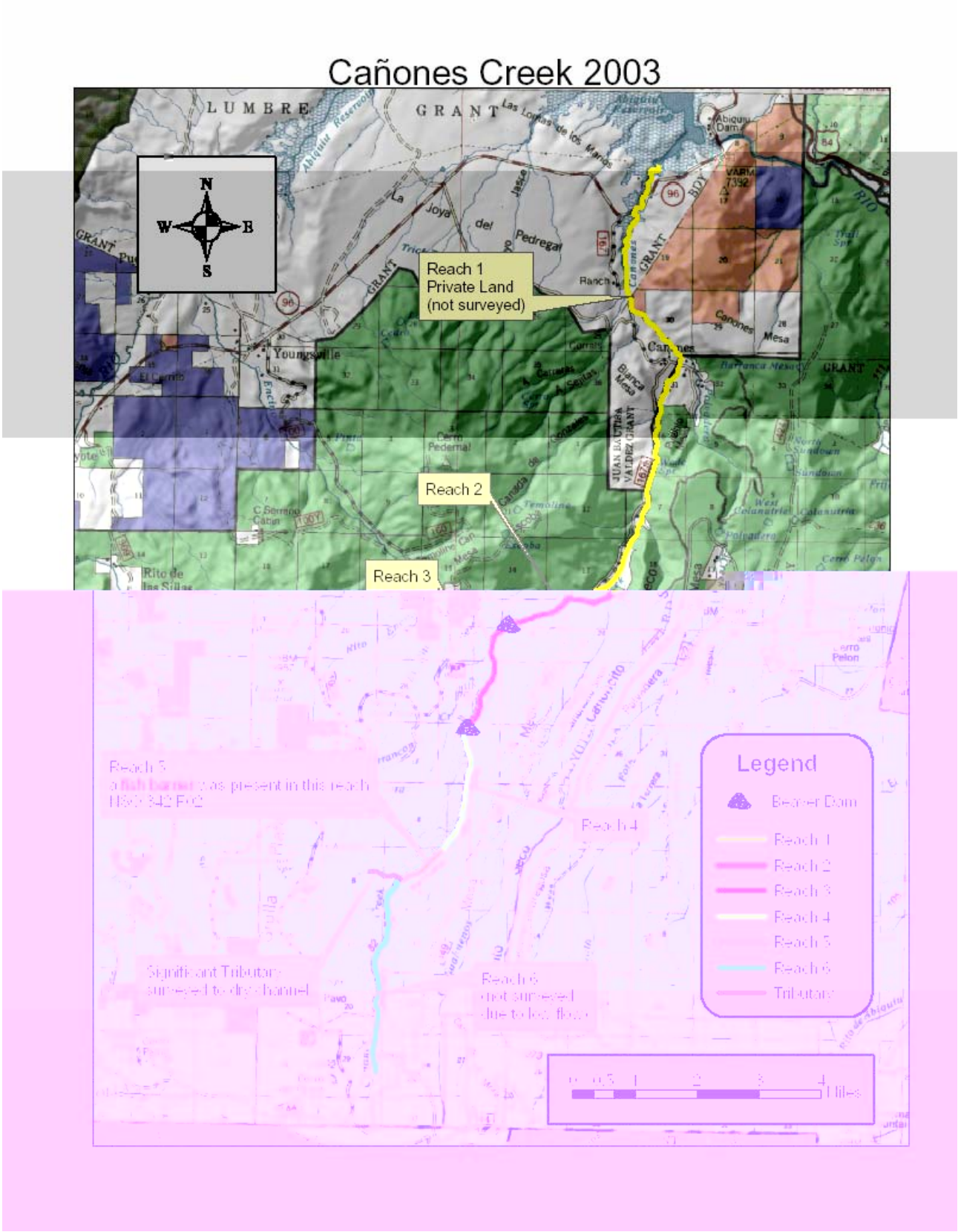
The upland vegetation in the lower reaches of Cañones is primarily ponderosa pine and piñon pine, Rocky Mountain juniper with some gambel oak and New Mexico locust. From Reach 3 on, Engelmann spruce, fir and aspen become more dominant species.

Beaver Activity

Beaver activity in Cañones Creek is located in all the surveyed reaches. Beaver activity in Reach 2 and 5 is limited to downed trees and lacks any sign of habitation (i.e. a dam). Four dams are present in Reach 3 and one dam is present in Reach 4 (see Photo 5 and Map 3).

While the beaver's role in a watershed has been generally misunderstood by the public, land managers and biologists, studies over the last few decades conclude that beavers are a critical component to increasing stream integrity as well as biotic productivity within the stream and floodplain. Beaver dams were methodically removed from streams on public land until recently (FS Files).

Beavers have many influences on stream systems, surrounding riparian vegetation, and fisheries populations. Beaver-caused stream impacts are considered to be generally beneficial to trout habitat and an asset to stream systems.



Map 3. Active beaver dams on Cañones Creek (2002)

Beaver activity and its associated ponds have many effects on stream water quality, most of which are considered beneficial to trout habitat. The decreased stream velocity that occurs in pool habitat, such as beaver ponds, decreases the water's ability to carry sediment suspended in the water column. Suspended sediment tends to settle into a pond's substrate, creating a sink for stream sediment and reducing turbidity. Sediment transport has been reduced by as much as 90% in studied streams (Olson and Wayne 1994).

Photo 5. Reach 3, NSO 212, P92. Beaver dam on a side channel (7-Nov-02).

Nitrogen- and phosphorus-contain(Nitrogen- and 2 242 Twtn% in studied stl520.0002 Tc -0.6 T88udie.66 studie

area allows for storage of water in the banks and floodplain. The storage of water in the soil and floodplain increases the water table and stores water for times of low flow. During late summer low flow conditions, water stored in the banks provides cool water to moderate flow and extreme temperatures (Parker *et al*. 1985).

Photo 6. Reach 4. Beaver chewed aspen (8-Nov-02).

While storing water, beaver dams also reduce extreme flows and related disturbance. The dams moderate flow during flood periods. This moderation reduces bank erosion related to flood events, improving bank stability in downstream areas (Olson and Wayne 1994).

Beavers consume large quantities of riparian vegetation or woody supplies in their diet, as well as for the construction and maintenance of their habitat (see Photo 5). Consumption rates for beaver populations are higher than the regeneration rates of riparian vegetation (Belovsky 1984). Beaver tend to occupy an area until the surrounding supplies are consumed and then move on to a new section of river within or outside of the watershed. Once a beaver leaves, high nutrient content in the area allows for fast regeneration of consumed riparian vegetation. Over time, the area will regenerate and be ready for a beaver to return in future years (deByle 1985).

Beavers generally improve trout habitat. Cutthroat trout in Rocky Mountain streams tend to be most abundant in streams with beaver ponds. Beavers do several things for fisheries habitat: provide a food source, moderate stream temperatures, as well as increase habitat volume and over-wintering habitat. Trout biomass and individual size increases with the presence of beaver dams. One possible explanation is high density of macroinvertebrates involved in the decomposition of organic matter and consumption of bacteria (Olson and Wayne 1994).

Macroinvertebrates are a key food source for many trout, including RGCT. Increased pool volume, a vital habitat feature for trout, could also contribute to the correlation of healthy fish populations and beaver ponds. Over-wintering habitat is also provided by the deep pools created by some ponds. The deeper pools become a refuge for fish when riffle habitat is frozen and can determine the carrying capacity of a stream. Flow and water temperature moderating effects that are caused by increased water tables provide cool water to the stream during low flow conditions. This could further increase the fish population carrying capacity of the stream (Olson and Wayne 1994).

The RGCT population above the barrier has been identified as a "core population" by the U.S. Fish and Wildlife Service in their recent candidate status review. There are only 13 known core populations that remain in the world. A core population is considered pure (not hybridized), secure (protected by a barrier and not invaded by non-native salmonids), and stable (strong fish health and large sustaining population) and is critical to the long-term persistence of the species. This population was a key factor in not listing the species for protection under the Endangered Species Act (USFWS 2002).

Another outside threat facing RGCT is the introduction of whirling disease. In a 2000 study by New Mexico Game and Fish, whirling disease was found in Cañones Creek just above the town of Cañones. It is not known if whirling disease is present above the barrier.

Changing habitat conditions have also been recorded throughout the Cañones Watershed (see Photo 8). A 1974 survey by Propst and McInnis described a lack of riparian vegetation, bank erosion, and siltation resulting from overgrazing by livestock in the upper sections (Propst and McInnis 1975). The report indicated the stream's limited ability to produce a viable native trout population due to habitat degradation in the upper watershed. This survey found no fish above the canyon and even in the canyon fish were infrequently observed. Their recommendations were to plant riparian vegetation in the upper portion of Cañones Creek and remove cattle from this section.

Photo 8. Reach 6. Lack of riparian vegetation and over grazing on Cañones Creek in 1982.

Previous Surveys

A stream inventory of Cañones Creek was conducted in 1993 by the Santa Fe National Forest. This survey also utilized Hankin and Reeves survey methods. The 1993 survey began at the Forest Boundary (T22N R4E Sec 13) and ended 7.6 miles upstream in the meadow headwaters (T22N R4E Sec 16). The stream was divided into 4 reaches, which roughly correspond with the 6 reaches recognized in the 2002/2003 survey (see Table 14). The complete reach summaries from the 1993 survey are available in Appendix C.

The 1993 survey had 297 pool and 296 riffles (see Table 13). In the 2002/2003 survey 143 riffles and 165 pools were identified. The average length of pool habitat was 27.2 feet in 1993, which corresponds with the 28.2 feet average found in 2002/2003. The average riffle length in 1993 was 105 feet, which is about half the length of the average riffle in 2002/2003 (220'). Evidence of these shorter riffles can be seen in the difference in percent stream length each habitat represents from 1993 to 2002/2003. In 1993 pools make up 20.7% of the stream length, but in 2002/2003 they represent only 10%. This coupled with high sediment load found in pools would indicate that pools are filling in and becoming riffles. This loss of pool volume over 10 years is a concern. There are several possible causes of this event. It could be that sediment is not getting washed downstream during high flow events because of the drought conditions New Mexico has been in for several years. Sediment could also accumulate from unstable banks. Most bank instability within Cañones Creek is natural but several reaches are experiencing impacts from cattle (Reaches 4 and 6).

Table 13. Stream summary information for the Cañones Creek Survey 1993.

Habitat Type	Number of Habitats	Total Stream Length (ft)	Stream Length* (%)	Properly Functioning Indicators
Pool	297	8,077	20.7	>30%
Riffle	296	31,006	79.3	-
Culvert	0	-	-	-
Tributary	Not counted	-	-	-
Falls	1	10	0	-
Side Channel	Not counted	-	-	-
Total	594	39,093	100.0	-

This reduction in pool volume can also be seen in a reach-by-reach comparison (Table 14). The most significant change can be seen between Reach 3 of the 1994 survey and Reach 5 of the 2003 survey. Although these two reaches do not line up perfectly, they overlap enough to make the differences significant. In 1993 almost 30% of the stream length was pool habitat, but in 2002/2003 only 9% of the length was pools. Reach 2, which corresponds with Reach 4 of the 2002/2003 survey, lost 9% of its pool habitat over 10 years, and Reach 1 (Reaches 2 &3 in 2002/2003) lost 8%.

Table 14. Comparative look at 2002/03 survey and 1993 survey

Reach		Total Length	Pool Habitat		Riffle Habitat		Dominant Riffle Substrate		Large LWD per mile	
1993	2002/2003	(mi)	1993	2002/03	1993	2002/03	1993	2002/03	1993	2002/03
1	2 & 3	3.2	19.5	11.3	80.2	88.7	Cobble/ Gravel	Boulder & Cobble	6.5	2.9
2	4	1.9	17.6	8.2	82.4	91.8	Gravel/ Cobble	Cobble	4.2	4 8
3	5	1.4	8.4	8.9	71.6	91	Cobble	Cobble	37.1	2.2
4	6	1.1	18.8	Not surveyed	81.2	Not surveyed	Sand	Not surveyed	0.6	Not surveyed

Large woody debris (LWD) concentration has also changed over ten years; in some areas the change has been drastic (Table 14). The 1993 survey only took into account woody debris in the large category of the 2002/2003 survey. The greatest difference could be seen again in Reach 3 (Reach 5 in 2002/2003). In473.19 0 0 7.e9T3had 37.1 pieces of large LWD per mile, but in 2002/2003 it only had 2.2 pieces per mile. Reach 1 also saw a significant decrease in large LWD (from 6.5 pieces per mile to 2.9). Reach 2 remained roughly the same. The protocol used to identify woody debris in the

1993 survey may have included counting standing trees that looked like potential LWD (leaners) as well as downed wood in the floodplain. If this was the case, it could explain the elevated numbers (the 1993 survey summary notes that wood does not have an influence of pool formation which alludes to the theory that wood outside of bankfull was counted). The 2002/2003 survey did not include leaners or downed wood outside of bankfull.

Stream depth is another variable comparable across the two surveys (Table 15). The general trend indicates no change in pool maximum depth or residual depth. There does seem to be a slight increase in riffle maximum depth across the two surveys. The most significant change can be seen in Reach 1. In 1993 the average maximum depth in riffles was 0.9 feet; in

the rock at 2.5-foot intervals and these holes were stuffed with explosives. Three rounds of blasting were used to create an 8-foot vertical falls (see Photos 9-11). This barrier was deemed necessary to protect a remnant population of Rio Grande cutthroat trout from hybridization and competition with stocked rainbow trout (FS Files).

Photo 9. Before barrier constructed (1980).

Photo 10. After barrier constructed (1980).

Photo 11. Reach 2, NSO 75, F1. Barrier in 2002 (26-Oct-02).

from embryos to emergent fry has been inversely related to the proportion of fine sediment in spawning gravels (USDA Forest Service 2000).

Roads have very little impact on the surveyed length of Cañones Creek. Within the watershed are 43.30 miles of road. This leads to a road density of 0.73 miles/square mile. Only one of these roads comes close to Cañones Creek. FS Road 144 crosses Cañones Creek near the headwaters. However, both in 2002 and 2003 this upper section of the creek was dry. Additional roads, including the maintained FS Road 99, run along the edge of the canyon that Cañones flows through. These roads are at quite a distance from the creek and probably have negligible impacts. In the unsurveyed Reach 1, FS Road 167A parallels the creek above the town of Cañones. Below the town, FS Road 167 parallels the creek (crossing it once) until Highway 96.

Recreation

Cañones Creek experiences infrequent recreational use, especially along its surveyed length. There are no developed recreation sites within the canyon, and only a few dispersed sites were observed during the survey. These sites saw only moderate use and were not affecting the creek. National Scenic Trail 82 runs along the streamside throughout the Forest Service section of the stream, providing recreational access. This trail does not appear to be heavily used or regularly maintained. There is some amount of illegal ATV use on the non-motorized trail (Garcia 2005). User-created trails (generally closer to the creek than the established trail) were found all along the length of the trail, but mostly in areas where trees had blown down across the trail. These user trails are much less stable than the established trail.

Trail 82 is theoretically accessible from 4 different points of entry: from the village of Cañones (near the Chihuahueños confluence, T22N R4E Sec 13), from FS Road 173 (T22N R4E Sec 27), from FS Road 449 (T21N R4E Sec 16), or from FS Road 99 (T21N R4E Sec 20). In 2003, the survey crew (C. Gatton and S. Eddy) attempted to use the last two points of access but could never locate them. They are no longer be maintained (Garcia 2005). Access from FS Road 173 seems to be the most regularly used. There is a developed trailhead area and trail leading down the canyon to the creek.

Timber

Forest in the Cañones Creek Watershed consists primarily of ponderosa pine (*Pinus ponderosa*), and spruce. Douglas-fir (*Pseudotsuga menziessii*), quaking aspen (*Populus tremuloides*), piñon pine (*Pinus cembroides*), and white fir (*Abies concolor*) are also found in the watershed. Timber harvests have gone on for as long as people have inhabited the region. There is no record of when the first timber harvest occurred.

In recent history there have been five documented timber harvests. Two of these were clear cuts prescribed to eradicate spruce beetle infestations. One of these clear cuttings occurred in the 1970's. It covered approximately two square miles of forest near the headwaters of Cañones Creek, including Cerro Pavo, Cerro del Grant, and all the land in between (Barela 2002).

Mesa del Medio Timber Sale occurred from 1966 to 1974. Clear-cutting occurred in 30 small sections comprising a total of 2 square miles in the southwest portion of the watershed. In addition, thinning occurred over 25 miles, including all land east of Cañones Creek from the confluence with Chihuahueños to its headwaters. Most of Cañoncito Seco and Polvadera Creek areas were not logged. This thinning was intended to reduce fuel loading in the forest (Barela 2002).

RECOMMENDATION SUMMARY

Riparian

Objective:
Restore a natural riparian vegetation community, promoting watershed integrity and function.

Concerns:
Currently, the riparian vegetation is degraded in the headwaters of Cañones Creek. Grazing has had significant impact on the riparian zone in this area. Reduction of riparian zone species diversity and decreased vegetation density are examples of the current degradation. The integrity of the riparian zone is crucial to stream function and coldwater fish habitat. The current riparian vegetation and management practices should be altered to stimulate and promote a healthy vegetation community.

Scenic Trail 82 parallels Cañones Creek through most of the surveyed length. This trail is in poor repair. Multiple user-created trails have been created to go around downed trees and other trail blocks. These user-created trails are not stable and generally run closer to the creek than the main trail. The primary users of these trails are permittees (Garcia 2005).

Implementation methods:

1) Augment current riparian area density by planting native species.
2) Grazing practices should be managed to protect the riparian area. Riparian grazing should be eliminated or highly reduced during the vegetation's growing season. This can be accomplished through seasonal use, rest rotation, range riding and riparian exclosure fencing. The greatest impacts occur in Reach 4 and 6.
3) Assess trail condition and alignment in association with creek when it is in the floodplain; determine maintenance needs and possible re-alignment if there are sections that impact floodplain and streambank integrity.

Large Woody Debris (LWD)

Objective:
Increase L

Concerns:
Below the man-made barrier in Reach 2, RGCT have hybridized with rainbow trout. These rainbows should be removed so the population can extend downstream and connect with the populations in Chihuahueños and Polvadera Creeks. Also, populations above the barrier need to be assessed for risk of introgression. Barriers created by acequias do exist in Cañones Creek on private land.

Implementation methods:

1. Conduct snorkeling surveys to determine whether the human-made barrier is functioning in Reach 2.
2. Work in partnership with New Mexico Game and Fish and the communities to methodically expand the range of RGCT to downstream reaches and tie together with other streams such as Polvadera and Chihuahueños Creeks. There could be an opportunity at the very least to tie Chihuahueños and Cañones together on the Montoya property.
3. Perform genetic testing of RGCT above the barrier to determine current genetic purity. This will further support snorkeling survey work.

REACH SUMMARIES

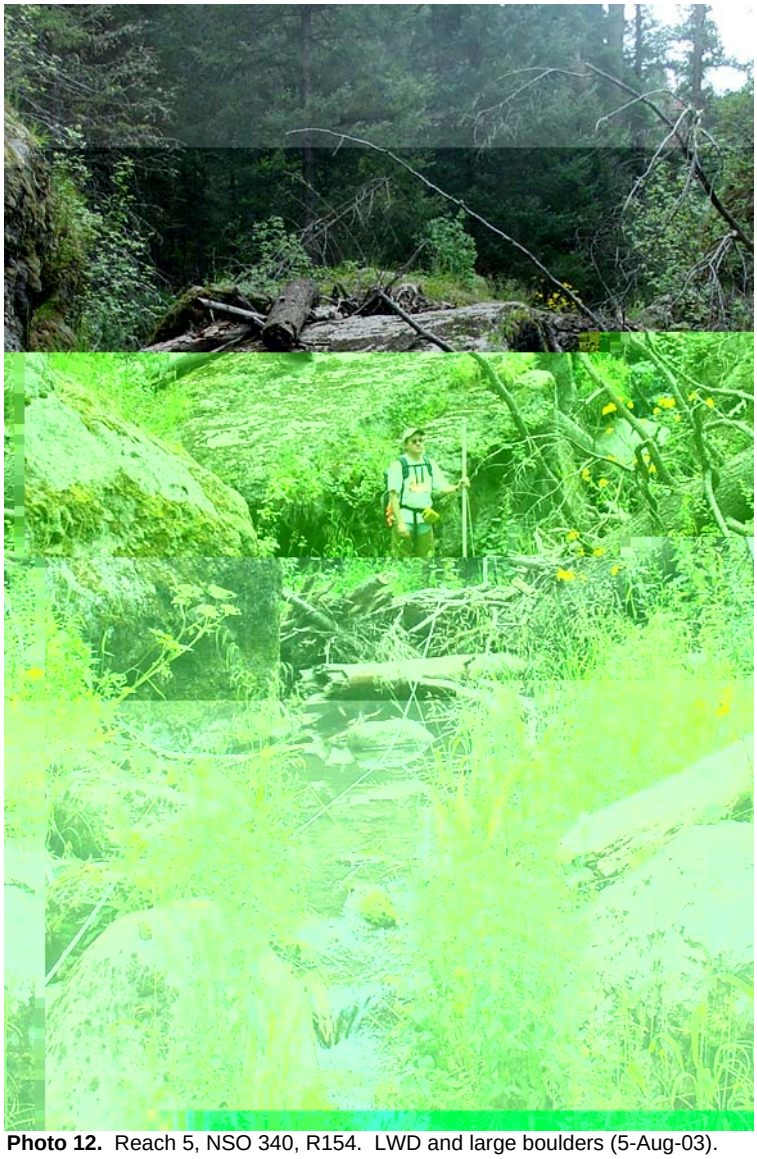


Photo 12. Reach 5, NSO 340, R154. LWD and large boulders (5-Aug-03).

Reach 1: Abiquiu Reservoir to Confluence with Chihuahueños

Reach 1 begins at the mouth of Cañones Creek at Abiquiu Reservoir and ends at the confluence with Chihuahueños Creek. The mapped channel length of this reach is 8.3 miles. This section of stream has a low gradient (2.5%) and low sinuosity (1.2). This reach was not surveyed because it lies almost entirely on private land. Much of the land along the creek is used for cattle grazing or developed by homeowners. The creek also runs through the village of Cañones in this reach. There are no recorded NSOs for Reach 1.

Thermograph Station 1 was placed at the very end of Reach 1 just below the confluence with Chihuahueños. The tidbit monitored 1.4 stream miles. This section of Cañones Creek is a fairly open canyon and is the beginning of contiguous Forest Service management of the creek. The thermograph data collected in 2003 determined Cañones Creek below the confluence with Chihuahueños was **at risk**, exceeding the NMED standards 8 out of 90 days recorded (8.8% of days). The site was also **at risk** for SFNF standards 33 out of 86 days recorded (38.4% of days).

Photo 13. Reach 1. Small falls forming plunge pool at Thermograph Station 1 (30-Jun-03).

Maximum stream temperatures were recorded in July, 2003, reaching 69.6°F on July 18th. After July, temperatures decreased steadily until the thermograph was pulled in October (see Figure 5).

Reach 2: Chihuahueños Confluence to Barrier

Reach 2 begins at the confluence with Chihuahueños Creek. This reach was surveyed from October 24th to Oct 26th, 2002. Beginning at an elevation of 7,280 feet on a section of private land (T22N, R4E, Sec. 13), the reach ends 1.5 miles upstream at a barrier to fish migration (T22N, R4E, Sec. 23, elev. 7,740'). The reach was broken due to a dramatic increase in canyon wall height and steepness, as well as a slight widening of the valley floor. The average gradient is 5.8% with a sinuosity of 1.25. The Rosgen channel type is A2, dominated by boulders, cobble and sand.

Reach 2 starts on a small section of private land. The confluence with Chihuahueños is on this property. The creek flows for 0.14 miles before entering Forest Service land. At the beginning of the reach, the stream is marginally confined with a slight down-cut channel. As the stream continues, the valley tightens and the channel becomes increasingly confined. In this section of the reach, the substrate increases in size and bedrock becomes more common (see Photo 14). Because of the gradient, step pools also become an increasingly common feature. The valley opens again briefly near a dry tributary in NSO 59.

Within this reach the riparian zone is composed of willow, alder, and some dogwood. The herbaceous streamside vegetation included water hemlock, sedges, and grasses. No fish were observed within this reach, but there was evidence of beaver chewings in the second half of the reach. The chewings may have drifted down from further upstream.

Human i

Photo 15. Reach 2, NSO 1, R1. Non-functioning bridge on private land (25-Oct-02).

A human-made barrier to fish migration is located at the end of the Reach (see Photos 9-11, page 22). This barrier was constructed in 1980 to protect a remnant population of Rio Grande cutthroat trout (RGCT) from hybridizing with stocked rainbow trout (FS Files). Holes were drilled into the rock at 2.5-foot intervals and these holes were stuffed with explosives. Three rounds of blasting were used to create an 8-foot vertical falls.

Water temperatures were measured at random intervals during the survey using a handheld thermometer. Main channel temperature readings were taken in the water column. The maximum temperature observed was 59ºF and the minimum was 38ºF. The average of all the samples was 41ºF. This reach was surveyed in the fall, so temperatures collected are not a measure of maximum temperatures reached during the summer months.

Habitat Characteristics

Reach 2 is divided into 91 NSOs, measuring 1.5 miles (7,987 feet). Forty-one (41) NSOs are pool habitats, and comprise 13.2% of the stream habitat. Forty-two (42) riffle habitats make up 83.5% of the stream habitat in Reach 2 (see Table 16).

Table 16. Summary of Reach 2 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	41	1,086	13.6	13.2	>30%
Riffle	42	6,894	86.3	83.5	-
Culvert	0	0	0	0	-
Tributary	1	0	0	0	-
Falls	1	7	0.1	0.1	-
Side Channel	6	265	NA	3.2	-
Total	91	8,252	100.0	100.0	-

*Percent Stream Length calculated with only riffle, pool, culvert, and falls habitat types.
**Percent Stream Habitat calculated using all stream habitat types except tributary.

Table 18. Summary of pool habitat and substrate percentages in Reach 2.

Pool Habitat Summary											
Reach	# Of Pools	Avg. Length	Avg. Width	Avg. Max Depth	Avg. PTC	Avg. Residual Depth	Pools/Mile	# of Pools w/ Residual Depth >1'	Pools w/ Residual Depth >1'/Mile	# of Pools w/ Max. Depth >3'	# of Pools w/ Max. Depth >3'/Mile
2	41	26.5	10.1	1.9	.6	1.3	27.2	28	18.5	1	.7
Properly Functioning Indicators	-	-	-	-	-	≥1ft	-	-	-	-	-

Substrate Summary								
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total	
	2	41.1	13.9	11.8	22.9	10.3	100.0	

Large woody debris density in Reach 2 is **not properly functioning**. A total of 8 pieces of LWD are in the reach, resulting in only 5.3 pieces per mile (see Table 19). Large woody debris is a key factor in pool development and is related to the substandard pool development in the reach.

Streambank condition within this reach was not analyzed due to steep grade. Most of the reach had a large amount of natural instability due to the steep gradient within the reach and the steep canyon walls. In lower gradient areas cattle grazing may have caused some instability increase.

Bankfull width-to-depth ratio, 11:1, is outside the expected range for the related Rosgen stream type classification and is therefore **not properly functioning** (see Table 19). This is possibly due to surveyor error and should be investigated further.

Table 19. Habitat Characteristics for Reach 2 of Cañones Creek.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
2	1:1	14:1	5.3	2,909	18.2
Properly Functioning Indicators	-	<12	>30	-	<10*

*- due to >4% gradient, this reach is not analyzed for bank stability.

Recommendations

Loss of pool habitat since 1993 is a concern. The loss may be natural. Low flows over the last few years have not flushed sediment downstream and so it may be building up in pools, which are evolving into riffles. The natural instability of the terrain in this area probably contributes most of this sediment (see Photo 17), but cattle grazing within the riparian zone is also contributing. Exclosure fencing in the lower gradient sections along the stream would keep cows out of the riparian and prevent increased instability and sediment loading.

Snorkeling transects should be established above and below the fish barrier to determine how functional the barrier is.

In 1993 a rock dam located about 500 feet above the Forest Service boundary was observed diverting nearly 100% of the creek flow into an acequia. However, about 75% of the flow seeped back into the stream channel after a short distance. This structure was not observed in 2003, but its removal needs to be verified. A few more structures were observed on private land. In addition, an old non-functioning bridge and water pipes could be removed (the private landowner would be in support of their removal).

Photo 17. Reach 2, NSO 53, R24. Typical naturally unstable bank associated with soil conditions and high gradient system (25 Oct 02).

Reach 3: Fish Barrier to Dry Tributary (right bank)

Reach 3 begins above the man-made fish barrier. This reach was surveyed from October 26th to November 7th, 2002. Beginning at an elevation of 7,740 feet (T22N, R4E, Sec. 23), Reach 3 ends 2.74 miles upstream at a dry tributary along the right bank (T22N, R4E, Sec. 34, elev. 8,340'). The average gradient is 4.4% with a mapped sinuosity of 1.25. Rosgen channel type is A3 with a cobble-dominated substrate.

Photo 18. Beaver dam in Reach 3 (27-Oct-02).

The first mile of this reach is highly confined with rock cliffs over 1,000 feet high. At the first dry arroyo on the right bank (T22, R4E, Sec. 22), the canyon walls fall to about 400 feet. At the confluence with Barrancones Creek, the canyon walls rise again to about 800 feet. Within this reach the width of the valley varies from 25 to 100 feet.

The plants within the riparian zone include alder, willow, wild rose, and dogwood. Throughout the reach, sections of riparian vegetation overhang the creek and provide shade. The herbaceous vegetation includes equisetum, nettles, geranium, mullen, wild hops, and grasses. There is evidence of active beavers within this reach. Beaver chewings were present along the stream and in debris jams. Four beaver dams were present in the first tightly confined section of the stream (see Photo 18). These dams are creating shallow pools. Trout of several different age classes were observed throughout the reach. All the observed fish were less than 8 inches. Some of the observed fish were identified as RGCT. Some of these fish were heavily spotted, a sign of possible genetic impurity.

Reach 3 is fairly inaccessible due to the steep bedrock canyon walls, so human impacts throughout this reach are minimal. National Scenic Trail 82 runs streamside for the entire length of this reach. This trail receives minimal use and does not contribute significantly to bank instability. Another

trail descends the right canyon wall from Forest Road 173 to Trail 82 within this reach. Where this trail meets Trail 82, there is a human-made rock weir within the creek. This weir does not successfully create a pool but may have been created as a stream crossing.

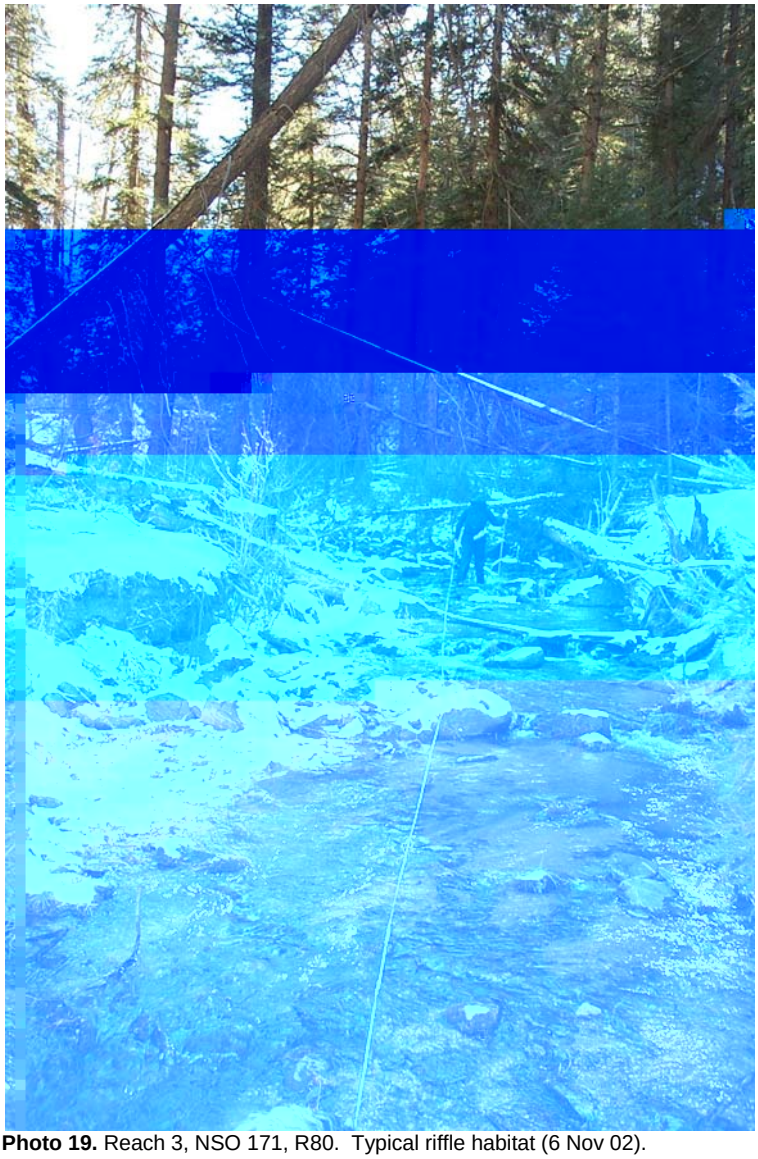


Photo 19. Reach 3, NSO 171, R80. Typical riffle habitat (6 Nov 02).

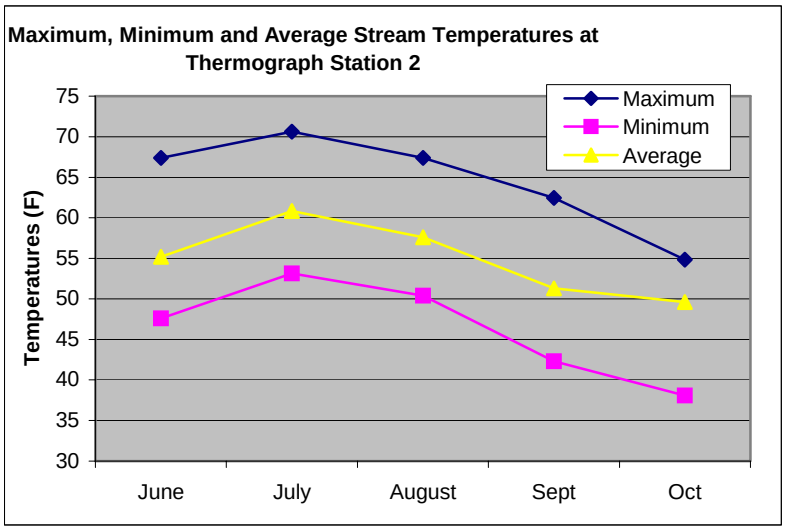
Water temperatures were measured at random intervals during the survey using a handheld thermometer. Main channel temperature readings were taken in the water column. Twenty-one (21) temperatures were taken during the survey of Reach 3. The highest temperature was 54ºF and the lowest 32º F. This reach was surveyed in the fall, so temperatures collected are not a measure of maximum temperatures reached during the summer months.

Thermograph Station 2 was placed in Reach 3 just above the man-made barrier (see Photo 20). This station monitored 1.6 stream miles. The data collected in 2003 determined Cañones Creek above the man-made barrier was **at risk** for 8 of the 104 days recorded by NMED standards (7.8% of days). The site was considered **at risk** for SFNF standards 41 out of 99 days recorded (45.1% of days).

Photo 20. Reach 3. Riffle above which Thermograph 2 was deployed (16-Jun-03).

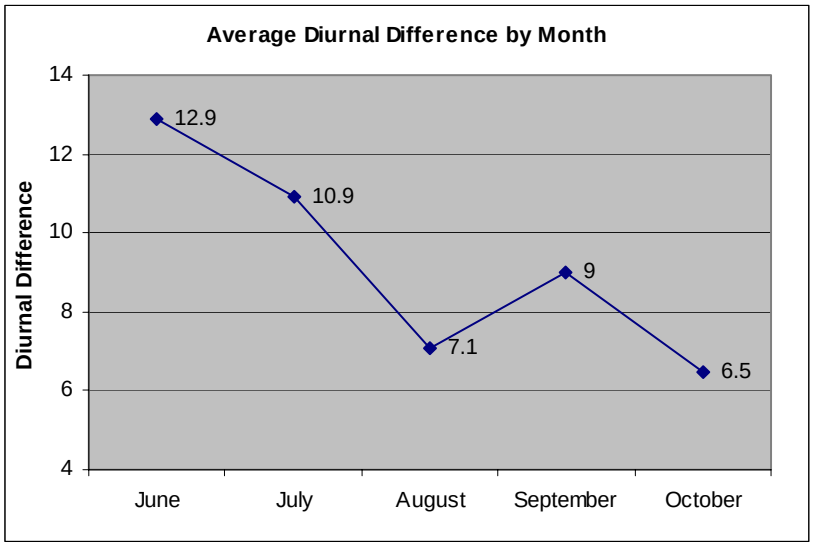
Maximum stream temperatures were recorded in July. On July 18th, 2003, temperatures peaked at 70.6°F. After July, stream temperatures decreased steadily until the thermograph was pulled in October (see Figure 7).

Figure 7. Maximum, minimum and average temperatures for each month for the thermograph station above the Barrier on Cañones Creek.



Average monthly diurnal difference also peaked in July (see Figure 8). The maximum daily variation in stream temperature recorded was 16.6°F on July 9th, 2003. The minimum daily change in stream temperature was 2.9°F on August 28th, 2003.

Figure 8. Average diurnal difference by month.



Habitat Characteristics

The 2.7 miles (14,454') of Reach 3 is divided into 120 NSOs (see Table 20). Fifty (50) NSOs are pool habitat and comprise 9.6% of the stream habitat. Riffles comprise 86.5% of stream habitat (50 NSOs). The remaining 3.9% of habitat is side channel. Of the 10 side channels within this reach, 9 were deep enough to provide fish habitat. Six (6) tributaries within this reach originated from springs that were on average 100 feet away from the stream.

Table 20. Summary of Reach 3 stream habitat.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	50	1,447	10	9.6	>30%
Riffle	54	13,007	90	86.5	-
Culvert	0	0	0	0	-
Tributary	6	0	0	0	-
Falls	0	0	0	0	-
Side Channel	10	590	0	3.9	-
Total	120	15,044	100.0	100.0	-

*Percent Stream Length calculated with only riffle, pool, culvert, and falls habitat types.
**Percent Stream Habitat calculated using all stream habitat types except tributary.

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 2 contains characteristics that are both not properly functioning and properly functioning. The parameters that are **not properly functioning** include pool development, LWD density, and bankfull width-to-depth ratio. **Properly functioning** factors include pool quality and sediment content. Bank stability was not analyzed due to high gradient in this reach.

Riffles, the dominant habitat type, are properly functioning for relative sediment content (see Table 21).

Table 21. Summary of habitat and substrate percentages for riffles in Reach 3.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
3	54	240.9	9.1	.6	1.2	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
3	11.7	31.1	37.2	18.3	1.9	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Pool development calculated by habitat leng

Table 23. Habitat characteristics of Reach 3.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
4	1:1.1	19.7:1	13.9	2,841	9.8
Properly Functioning Indicators	-	<12	>30	-	<10

Streambank condition was not analyzed due to gradient. Reach 3 had 9.8% unstable banks (see Table 23). A majority of the instability within this reach comes from natural causes (see Photo 21). The steep canyon walls in this reach are highly unstable in many areas.

Bankfull width-to-depth ratio, 20:1, is outside the expected range for the related Rosgen stream type classification and is therefore **not properly functioning** (see Table 23). Further analysis needs to be conducted to determine if this is surveyor error or related to actual conditions.

Photo 21. NSO 171, R80. Bank instability in Reach 3 (26-Oct-02).

Recommendations

Loss of pool habitat since 1993 is a concern. The loss may be natural. Low flows over the last few years have not flushed sediment downstream and so it may be building up in pools that have evolved into riffles. The natural instability of the terrain in this area probably contributes most of this sediment, but cattle grazing within Reach 4 (upstream) is likely another contributor. Exclosure fencing along Reach 4 would keep cows out of the riparian and prevent increased instability and sediment loading. Another area of concern is the lack of LWD. Riparian and lower slope thinning would increase LWD and improve habitat conditions for fish. In addition, snorkeling this section of stream is important to identify what species of fish are present. This reach is just above the human-made fish barrier, so the population should be pure RGCT if the barrier is functioning.

Reach 4: Dry Tributary (right bank) to Active Tributary (left bank)

Reach 4 begins at a dry tributary on the right bank (T22N, R4E, Sec. 34) where the valley gradient decreases dramatically. This reach was surveyed from November 7th to November 26th, 2002. Beginning at an elevation of 8,340 feet, Reach 4 ends 2.5 miles upstream at an active tributary on the left bank (T21N, R4E, Sec 9, elev. 8,600'). The average gradient is 2.2% with a sinuosity of 1.18. The Rosgen channel type is B3 with a cobble-dominated substrate.

Canyon walls along this reach range from 100 to 300 feet in height. Though confined, the river valley remains wide, ranging from 50 to 200 feet in width. This open space allows the stream to be dynamic. Six (6) abandoned side channels, or possible old main channels, were identified within the reach (see Photo 20). Ten (10) active side channels were also observed.

Photo 22. Reach 4, NSO 252, S22. Stable island and LWD on side channel (8-Nov-02).

Riparian vegetation within this reach was consistent with previous reaches. Alder, willow, and grasses were the primary plants. Beaver activity was also observed within the reach. Most of the beaver chewings observed were on willow and alders. There was one functioning beaver dam at the beginning of the reach. RGCT were observed throughout the reach.

Human impacts within this reach were more evident than in previous reaches. In NSO 276, five logged stumps were observed, and the old growth present in the uplands in previous reaches was no longer present in the second half of Reach 4. National Scenic Trail 82 runs along the right bank for the entire length of the reach. Again, this trail does not seem to significantly impact stream function. However, the first evidence of dispersed camping was found in NSO 213. This campsite included

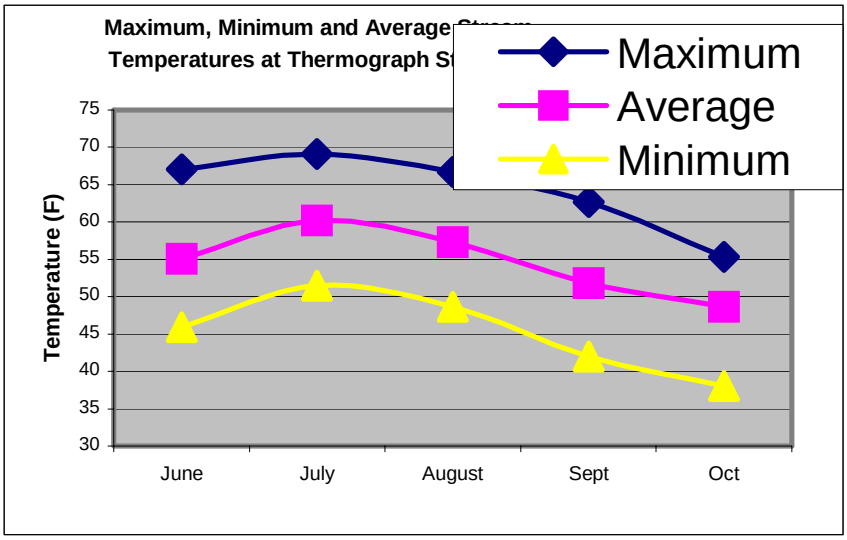
two fire rings and a large open clearing on the right bank of the stream. Evidence of cattle grazing also increased within this reach. Much of the open meadow areas along this reach were heavily grazed. Slumped and impacted banks, grazed grass stubble, and trampled marsh areas were all present within the reach. Because the canyon walls are steep, the cattle are confined to grazing within the riparian zone.

Thermograph Station 3 was placed in Reach 4 (see Photo 23). This station monitored 8.2 miles of Cañones Creek. Data collected in 2003 determined Cañones Creek above the confluence with Barrancones was **properly functioning** by NMED standards all 103 days recorded. The site was considered **at risk** by SFNF standards 34 out of 99 days recorded (34.3% of days).

Photo 23. Shallow pool in which Thermograph 3 was deployed (16-Jun-03).

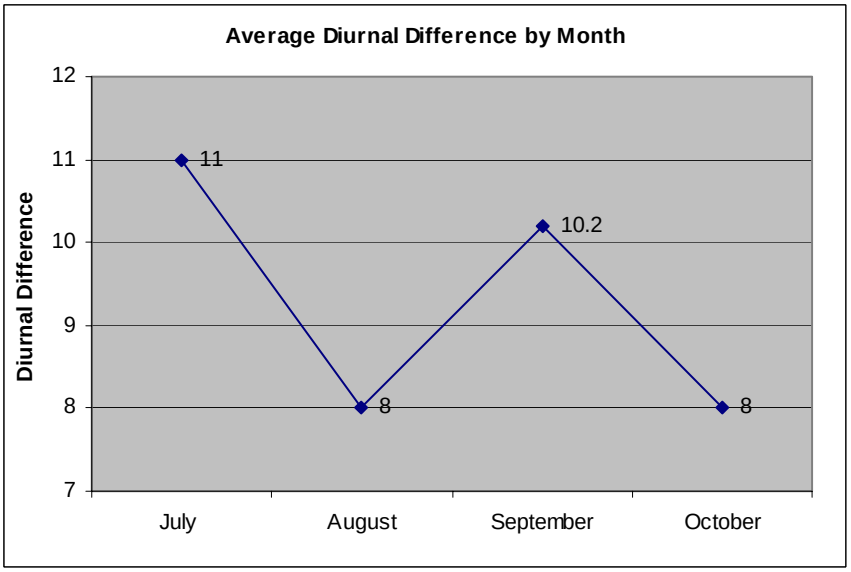
Maximum stream temperatures were recorded in July (see Figure 9). On July 18th, 2003, stream temperature peaked at 69.1°F. After July, stream temperatures decreased steadily until the thermograph was pulled in October.

Figure 9. Maximum, minimum and average temperatures for each month for thermograph station below the confluence with Barrancones Creek.



Average monthly diurnal difference also peaked in July at 11°F. A second peak occurred in September when the average diurnal difference rose back up to 10.2°F (see Figure 10). The maximum daily diurnal difference of 18°F occurred on June 26th, 2003. The minimum daily diurnal difference of 3.4°F was observed on October 2nd, 2003.

Figure 10. Average diurnal difference by month.



Habitat Characteristics

The 2.5 miles (13,097') of Reach 4 is divided into 78 NSOs (see Table 26). Pools comprise only 7.4% of the existing stream habitat. A majority of the stream habitat is riffle (82.7%) and the remaining 9.9% are side channels. Of the 10 side channels observed, 8 were deep enough to support fish.

Table 26. Summary of Reach 4 stream habitat.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	31	1,072	8.2	7.4	>30%
Riffle	33	12,025	91.8	82.7	-
Culvert	0	0	0	0	-
Tributary	3	0	0	0	-
Falls	0	0	0	0	-
Side Channel	11	1,444	0	9.9	-
Total	78	15,044	100.0	100.0	-

*Percent Stream Length calculated with only riffle, pool, culvert, and falls habitat types.
**Percent Stream Habitat calculated using all stream habitat types except tributary.

When compared to the matrix of factors and indicators of stream condition for historic and occupied Rio Grande cutthroat trout streams, Reach 4 contains characteristics that are both not properly functioning and properly functioning. The parameters that are **not properly functioning** include pool development and LWD density. **Properly functioning** factors include pool quality, bankfull width-to-depth ratio and sediment content. Streambank condition is **at risk**.

Riffles, the dominant habitat type, are properly functioning for relative sediment content (see Table 27).

Table 27. Summary of habitat and substrate percentages for riffles in Reach 4.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
4	33	364.4	8.6	0.5	1.1	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
4	8.2	40.3	43.6	7.9	1.9	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Pool development calculated by habitat length is **not properly functioning** in Reach 4 (see Table 28). The 31 pools comprise only 7.4% of the stream habitat, which is well below the matrix standard. These pools are **properly functioning** for pool quality with an average residual depth of 1.1 feet, although they are at risk of filling in. Sediment within these pools was primarily cobble and gravel. The **properly functioning** classification is marginal in this reach. Of the 31 pools present, only 18 have a residual depth greater than 1 foot (58% of pool habitat) with no pools having a maximum depth greater than 3 feeet. Forty-two percent (42%) of the pools in this reach are **not properly functioning** for pool quality.

Table 28. Summary of pool habitat and substrate percentages in Reach 4.

Pool Habitat Summary											
Reach	# Of Pools	Avg. Length	Avg. Width	Avg. Max Depth	Avg. PTC	Avg. Residual Depth	Pools/Mile	# of Pools w/ Residual Depth >1'	Pools w/ Residual Depth >1'/Mile	# of Pools w/ Max. Depth >3'	# of Pools w/ Max. Depth >3'/Mile
4	31	34.6	7.5	1.5	0.4	1.1	12.5	18	7.3	0	0
Properly Functioning Indicators	-	-	-	-	-	≥1ft	-	-	-	-	-

Substrate Summary							
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
	4	17.4	36.1	36.1	9.7	0.7	100.0

LWD density in Reach 3 is **not properly functioning**. Twenty (20) pieces of LWD were identified in the reach, creating a density of 8.1 pieces per mile (see Table 29). LWD density is far below the matrix standard of greater than 30 pieces per mile. Recent studies have found that LWD is an essential part of pool formation and critical in providing complex fish habitat (Fausch and Northcote 1992).

Photo 24. Reach 4, NSO 262, P113. LWD creating complex pool habitat (8 Nov 02)

Table 29. Habitat characteristics of Reach 4.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces	atio

Reach 5: Active Tributary (left bank) to Significant Tributary (right bank)

Reach 5 begins at an active tributary on the left bank where there is an increase in gradient and substrate size from the previous reach. This reach was surveyed on August 5th, 2003 by a different survey team. Reach 5 starts at 8,600 feet (T21N, R4E, Sec. 9), and runs 0.9 miles to Tributary 21 (T21N, R4E, Sec. 9, elev. 8,750'). The average gradient is 2.1% with a sinuosity of 1.13. The Rosgen channel type is B3 with a cobble-dominated substrate.

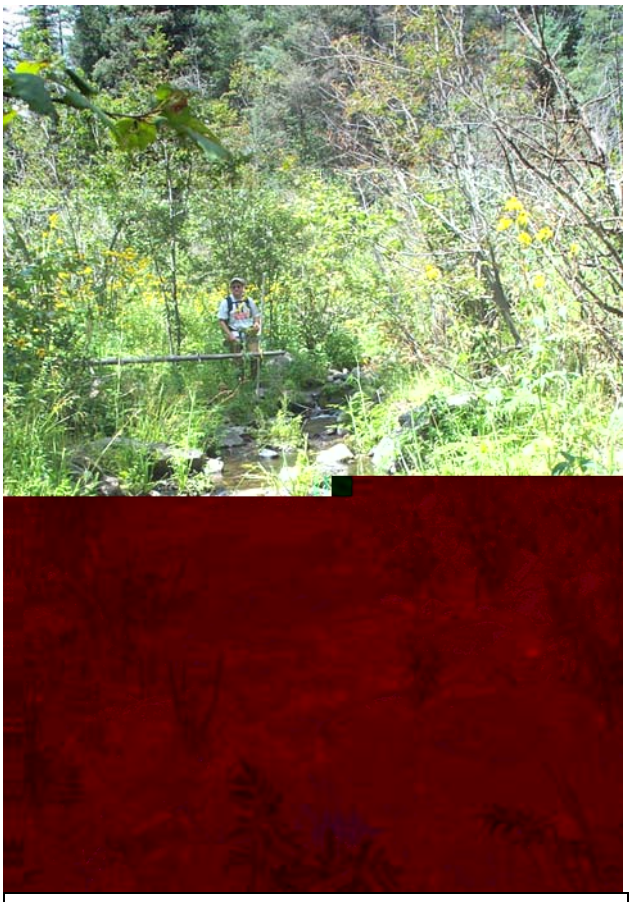


Photo 26. NSO 314, R142. Typical riffle in Reach 5 (5-Aug-03).

Reach 5 is an approximately 200' wide valley with steep canyon walls (400 feet or higher). Although the valley was wide, there were no open meadows along the stream channel.

Alder is the dominant riparian species within the reach, often thick enough to obstruct surveyor passage through the stream. Banks were well vegetated with grasses (see Photo 26). Sedges and rushes were not observed during the survey. Upland woody species included fir and spruce. These trees were also found growing within the riparian zone.

Some signs of historic and recent beaver activity were observed, but no active structures were found in the stream channel. Reach 5 also supports a healthy population of RGCT (see Photo 27). Fish of all age classes were observed. No other fish species were identified during the survey. Fish were captured by surveyors using a fly rod (adults) and a mess-kit pan (juveniles).

Photo 27. Reach 5, NSO 341, P135. Large RGCT adult caught below falls, F2 (5 Aug 03).

National Scenic Trail 82 runs parallel to Cañones Creek throughout the reach on the right bank. Heavy impacts to the stream by the trail were not observed. Game trails and user-created trails down to the creek were not frequently observed. Dispersed campsites were found between the trail and the stream near the upper end of the reach. Cattle were also present in the upper end of the reach along Trail 82, but seemed to largely stay out of the riparian zone. Impacts on the stream by cattle were minimal.

Water temperatures were measured at random intervals during the survey using a handheld thermometer. Main channel temperature readings were taken in the water column. The highest temperature was 64°F and the lowest temperature, 56°F. On average the stream was around 59°F.

Habitat Characteristics

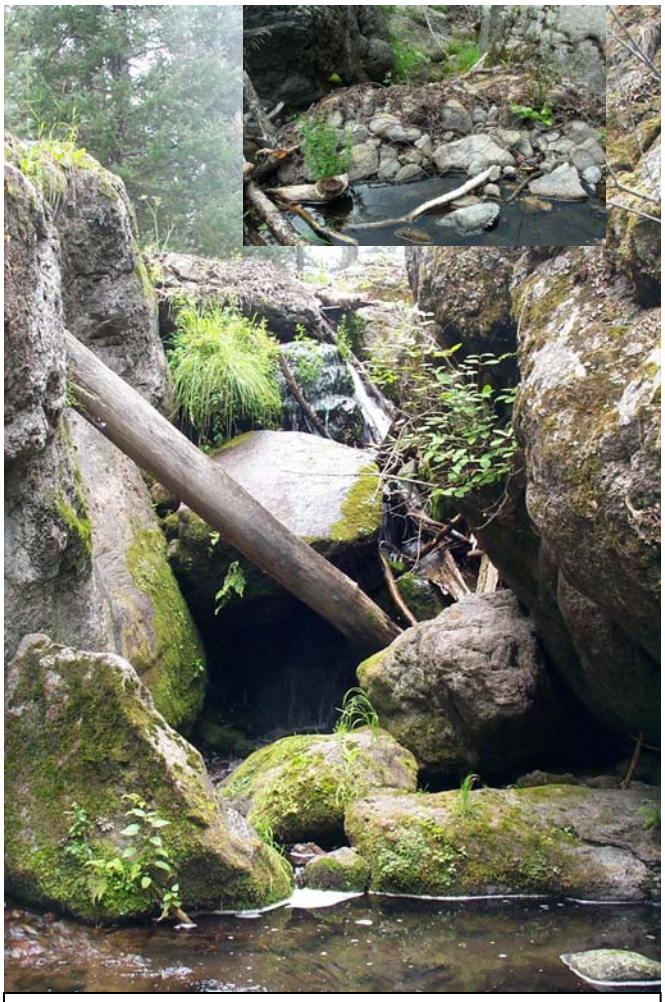


Photo 28. Reach 5, NSO 342, F2. Potential fish migration barrier (5-Aug-03). **Insert:** Rip-rap structure at top of waterfall (5-Aug-03).

The 0.9 stream miles (4,854 ft) of Reach 5 is divided into 77 NSOs (see Table 30). Thirty-six (36) NSOs in this reach are riffle habitat, comprising 85.8% of the stream length. Pools make up a meager 8.4% of the stream habitat. Eight (8) side channels make up 5.9% of the habitat length. One (1) falls was present in this reach. At over 10 feet high, it was considered a barrier to fish migration. At the base of the falls was a sheet of bedrock, so the depth at splash was only 0.1 feet. There was a man-made gabion structure at the top of the falls confining the flow to a tight channel through bedrock (see Photo 28).

When compared to the matrix of factors and indicators of stream condition for historic and occupied RGCT streams, Reach 5 contains both not properly functioning and properly functioning characteristics. Parameters that are **not properly functioning** include large woody debris density, pool development, and sediment content. **Properly functioning** characteristics include bank stability, pool quality, and bankfull width-to-depth ratio.

Table 30. Summary of Reach 5 habitat types.

Habitat Type	Number of Habitats	Total Stream Habitat (ft)	Stream Length* (%)	Stream Habitat** (%)	Properly Functioning Indicators
Pool	21	432	8.9	8.4	>30%
Riffle	36	4,418	91	85.8	-
Culvert	0	0	0	0	-
Tributary	11	0	0	0	-
Falls	1	4	0.1	0.1	-
Side Channel	8	304	NA	5.9	-
Total	77	5,518	100.0	100.0	-

*Percent Stream Length calculated with only riffle, pool, culvert, and falls habitat types.
**Percent Stream Habitat calculated using all stream habitat types except tributary.

Riffle habitat is **not properly functioning** for sediment content. Sediment content in riffles, 22.3%, exceeds the standard (see Table 31).

Table 31. Summary of habitat and substrate percentages for riffles in Reach 5.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
5	36	121.7	7.8	0.5	1.1	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
5	22.3	29.7	30.3	17.7	0.0	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Pool habitat in Reach 5 is **not properly functioning** for pool development, but is **functioning** for pool quality (see Table 32). The average residual depth within this reach is 1.3 feet. Though pool quality is functioning, only one (1) pool out of 21 had a maximum depth of 3 feet or more.

Table 32. Summary of pool habitat and substrate percentages in Reach 5.

Pool Habitat Summary											
Reach	# Of Pools	Avg. Length	Avg. Width	Avg. Max Depth	Avg. PTC	Avg. Residual Depth	Pools/Mile	# of Pools w/ Residual Depth >1'	Pools w/ Residual Depth >1'/Mile	# of Pools w/ Max. Depth >3'	# of Pools w/ Max. Depth >3'/Mile
5	21	20.6	8.3	1.6	0.3	1.3	23.1	16	17.6	1	1
Properly Functioning Indicators	-	-	-	-	-	≥1ft	-	-	-	-	-

Substrate Summary							
	Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
	5	39.0	21.0	22.4	13.8	3.8	100.0

Large woody debris density is **not properly functioning**, with only 8 pieces found in the reach (8.8 pieces per mile; see Table 33). The desirable LWD density is greater than 30 pieces per mile. Large

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
5	1:1.7	20	8.8		

Reach 6: Significant Tributary (right bank) to Dry Channel

Tributary 21 contributes over 95% of the flow to the main channel of Cañones Creek. From this point onward, Cañones Creek is too shallow to support fish habitat and so was not fully surveyed. Only bankfull measurements were taken. The stream continues through the canyon and then into an open meadow system with low gradient. Bankfull width-to-depth ratio, 17:1, is within the expected range for the related Rosgen stream classification and is therefore **properly functioning**.

In the summer of 2003, the flow was intermittent throughout this reach. Multiple springs contribute to flow. It is below each of these springs that the stream flows for a short time and then goes dry again. Cattle impacts within this reach were significant. Several containment fences span the valley, breaking up pastures. At least 20 cattle were observed the day the reach was walked (August 12, 2003). Because of grazing cattle, there was little to no riparian cover and marshy areas around several springs were trampled. There were severe collapsed banks and many browned out areas.

In 1993, a little over one (1) mile of this reach was surveyed (see Table 34). It was determined that fish could not be supported above this mile, so the survey was ended. Surveyors determined that of all the reaches surveyed, this reach showed the most damage from ungulates. Like the 2003 surveyors, they saw "raw-exposed/ slumping streambanks…[and] turbid water conditions" (USDA Forest Service 1993). Thirty-one (31) head of cattle were also observed within this reach. The 1993 survey was terminated due to "an apparent degradation in water quality" (USDA Forest Service 1993). The complete reach summary is available in Appendix C.

Table 34. Analysis of data from 1993 survey for the 2002/2003 survey's Reach 6.

Reach 3 (1993 survey)	Total Stream Habitat (ft)	% Stream Length	Average Length	Max Depth	Pool Tail Crest	Residual Depth
Pools	1049.1	18.8	28.4	1.1	0.2	0.9
Riffles	4524	81.2	125.7	0.6	-	-
Properly Functioning Indicators		30%				≥1

Recommendations

Due to documented degraded riparian and in-stream conditions, Reach 6 should be managed to improve these conditions. Consideration in the upcoming Mesa del Medio AMP (2005) should be given to establishing a limited grazing season in the meadows that line Reach 6. Grazing should be limited to allow maximum riparian vegetation vigor, streambank recovery and a return to natural floodplain conditions. Exclusion fences could be another option which would further promote riparian recovery and limit downstream effects to occupied RGCT habitat. As stated in the statewide RGCT Conservation Agreement which the SFNF is party to, the Forest shall "protect, maintain and improve existing and potential Rio Grande cutthroat trout habitat and manage these watersheds and stream-riparian habitats to ensure long-term conservation and persistence of the subspecies" (USDA Forest Service 2002).

Photo point and bankfull monitoring stations should be established, monumented, and revisited annually to assure management of the reach is successful.

Significant Tributary

During the survey of 2003, surveyors followed the source of highest flow near were Trail 82 crosses Cañones Creek. During an office review, it was determined that the source contributing highest flow was not Cañones Creek, but rather an unnamed tributary (Tributary 21). Above this tributary, Cañones Creek can no longer support fish, as it is less than 0.5 feet deep in most places and flow was intermittent. The tributary, on the other hand, is deep enough to provide fish habitat, and fish were observed within the reach. Because it provides fish habitat, the tributary was surveyed.

Photo 30. NSO 13, at likely fish barrier (6 Aug 03).

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ominated by large boulders (see
er end of the tributary,
stream flow decreases dramatically. Infrequent
p trib s b ry chan

Table 36. Summary of habitat and substrate percentages for riffles in Significant Tributary to Cañones Creek.

Riffle Habitat Summary						
Reach	# Riffles	Avg. Length	Avg. Width	Avg. Depth	Avg. Max. Depth	
Significant Tributary	20	122.1	3.6	.4	1.0	
Substrate Summary						
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
6	19.5	20.0	24.0	30.0	6.5	100.0
Properly Functioning Indicators	<20.0	-	-	-	-	-

Pool habitat is related to both properly and not properly functioning matrix parameters (see Table 37). Pool quality (see Photo 32) is **properly functioning** as determined by residual depth. Average residual depth is 1.8 feet, well above the standard. The residual depth observed in this tributary is deeper than any observed for Cañones Creek by 0.5 feet. Pool development is **not properly functioning**. Pool development by area of pool is determined by the length of pool habitat relative to the other habitat types. The tributary has less than half of the properly functioning indicator standard for pool development.

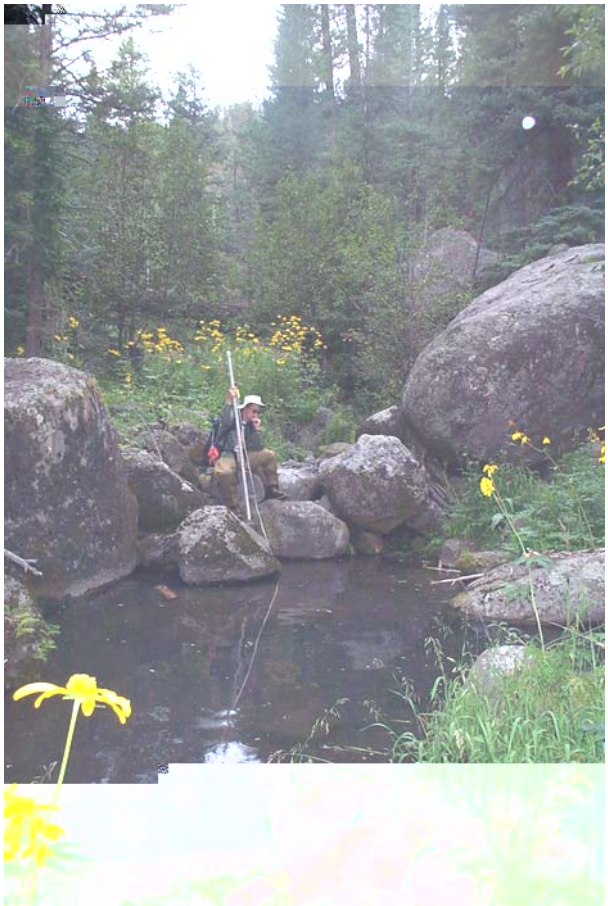


Photo 32. **NSO 36, P10. Typical boulder-lined habitat**

upstream from upper limits of RGCT (6 Aug 03).

Table 37. Summary of pool habitat and substrate percentages in the significant tributary to Cañones Creek.

Pool Habitat Summary											
Reach	# Of Pools	Avg. Length	Avg. Width	Avg. Max Depth	Avg. PTC	Avg. Residual Depth	Pools/Mile	# of Pools w/ Residual Depth >1'	Pools w/ Residual Depth >1'/Mile	# of Pools w/ Max. Depth >3'	# of Pools w/ Max. Depth >3'/Mile
Significant Tributary	12	16.8	8.7	2.0	0.2	1.8	18.1	12	18.1	0	0
Properly Functioning Indicators	-	-	-	-	-	≥1ft	-	-	-	-	-

Substrate Summary							
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total	
Significant Tributary	30.0	19.2	15.8	9.2	25.8	100.0	

Bankfull width-to-depth ratio was determined but was not analyzied. The measurement was taken across the alluvial fan near the mouth of the tributary. Alluvial fans are naturally wide and are not representative of exemplary bankfull conditions.

Large woody debris is **not properly functioning** in the tributary. Eight (8) pieces of LWD in the tributary create a density of 15.1 pieces per mile. The LWD density is about half of the properly functioning indicator (see Table 38).

While bank instability was not analyzed due to its high gradient, no unstable banks were observed in the significant tributary (see Table 38).

Table 38. Habitat characteristics for the significant tributary to Cañones Creek.

Reach	Pool:Riffle Ratio	Bankfull Width:Depth	Pieces of LWD per Mile	Total Unstable Banks (ft)	% Unstable Banks
Significant Tributary	1:1.7	20	15.1	0	0
Properly Functioning Indicators	-	<12	>30	-	<10

Recommendations

The only recommendation is to return to the tributary and determine the actual bankfull width-to-depth ratio in order to monitor change over time.

APPENDIX A:
Supporting Information

Table 1. Summary of measurements and estimations used in the Region 3 Hankins/Reeves stream survey protocol (Stream Inventory Handbook April 2002).

Measurements	Estimations
Maximum depth of pools, riffles, and side channels	Average depth of riffles
Depth of pool tail crest	Substrate percentages in bankfull width
One bankfull width depth transect per reach	Average wetted width of riffles and pools*
Number of large woody debris within bankfull	Length of bank instability
Surveyor collected main channel and tributary water temperature and time	Total length, wetted width, and maximum depth of side channels
Thermograph collected water temperature (Recorded every four hours)	Length of first habitat unit of tributaries and percent stream flow contribution

*Width estimations were corrected by the comparison of a minimum of 10% measured habitats in each reach to the related estimates. This technique was used to produce correction factor for each reach, which was then applied to analysis of the widths of that reach and the entire stream analysis.

Table 2. Feature types collected by Trimble Geo Explorer 3 GPS units.

Reach Breaks	Tributary Mouth
Woody Debris Jams (of 3 or More Pieces)	Barriers to Fish Passage
Areas of Concern (Major Erosion, Road Crossings, Etc…)	Side Channels (only longer than 10 times the wetted width of the main channel)
Beaver Dams (If Active and over 1' in Height)	Thermograph Stations
Snorkel Survey Transect Locations	Culverts
Flow Stations	Water Temperature Monitoring Stations

Tributaries

Table 3. Information summary of the tributaries to Cañones Creek.

Reach Number	NSO Number	Habitat Number	Bank	Type	Name	% Flow*	Date	Time	Trib Temp (°F)	Stream Temp (°F)	Comments
2	28	T1	Left	Stream			26-Oct-02	1540	59	44	
3	172	T2	Right	Stream		<5	6-Nov-02	1328	39	32	
3	177	T3	Right	Spring		<5	6-Nov-02	1430	48	38	
3	181	T4	Right	Spring		<5	7-Nov-02	1020	49	33	
3	182	T5	Right	Spring		<5	7-Nov-02	1040	54	33	Enters stream in two locations
3	185	T6	Right	Seep		<5	7-Nov-02	1130	49	35	
3	187	T7	Right	Spring		<5	7-Nov-02	1220	43	35	
4	272	T8	Left	Spring		5	13-Nov-02	1410	50	40	
4	280	T9	Left	Spring		<5	26-Nov-02	1030	33	38	
4	289	T10	Left	Stream		5	26-Nov-02	1140	35	35	
5	291	T11	Left	Stream		5	5-Aug-03	0928	58	56	

APPENDIX B:
Pool Volume Proof

$$f(x,y) := \left(\frac{x}{a}\right)^2 + \left(\frac{y}{b}\right)^2$$

Area of an Ellipe

$$\int_{-a}^{a} \int_{-b\cdot\frac{\left(a^2-x^2\right)^{.5}}{a}}^{b\cdot\frac{\left(a^2-x^2\right)^{.5}}{a}} 1\,dy\,dx \rightarrow$$

$$3.1415926535897932385\cdot b\cdot a$$

or π*b*a

Volume of a parabolic ellipsoid with h=height a=from ctr to b is from center to edge 1

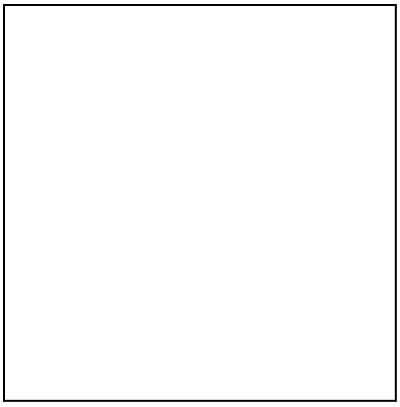
$$\int_{-a}^{a} \int_{-b\cdot\frac{\left(a^2-x^2\right)^{.5}}{a}}^{b\cdot\frac{\left(a^2-x^2\right)^{.5}}{a}} \int_{0}^{h\cdot\left[\left(\frac{x^2}{a^2}\right)+\left(\frac{y^2}{b^2}\right)\right]} 1\,dz\,dy\,dx \rightarrow$$

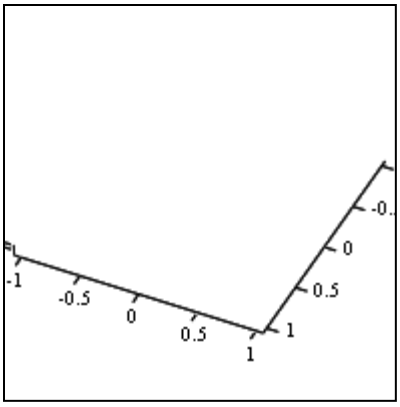
$$\frac{\pi}{2}\cdot h\cdot b\cdot a$$ I believe this is your volume

$a := 4 \qquad b := 5$

$$f(x,y) := \left(\frac{x}{a}\right)^2 + \left(\frac{y}{b}\right)^2$$

Surface Plot **Contour Plot**

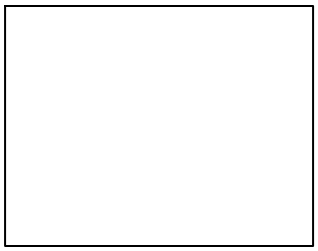




f x = 0 f y = 0

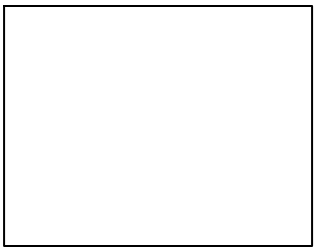
Cross Sections (2-D)

$f(0,y)$



y

$f(x,0)$



x

For pool volume calculations the corrected average width, average max depth and average length is applied to the formula and multiplied by the number of habitats. Pool volume proof was derived and submitted by Matthew Goodman.

Riffle volume is estimated by the volume of a prism. Measurements used are average length (L), corrected average width (W) and average depth (D) multiplied by the number of riffle habitats (N).

$$\mathbf{L_{ave}*w_{ave}*d_{ave}*N = \text{Riffle Volume}}$$

APPENDIX C:

Reach Summaries from 1993 Cañones Stream Inventory

Reach 1 (equivalent to Reaches 2 and 3 in 2002/2003):

Reach #1 begins at the forest boundary T.22N. R.4E. Section 13 and ends approx 16.883 ft (+/- 7%) upstream in Section 34 (approx. elev. 8260 ft.). Cañones flows through a deep canyon for most if its entire length. This fact is most apparent in Reach 1 where steep bare-rock cliff walls (as high as 300 ft and void of most vegetation) line the canyon. Between the lower edges of these cliffs and extending down to the riparian zone is an upland community varying in width between 300-600 ft and consisting of Piñon, juniper and ponderosa pine. The riparian zone is limited to a narrower band and is between 30-50 ft wide. Water width averages approximately 9.4 ft and average maximum water depth is 1.4 ft. The pool to riffle ratio is 1.3:.75/

The riparian vegetative community can be typed as *Populus angustifolia* but this designation does not adequately describe the floral diversity in this area. The riparian zone supports an abundance of trees, shrubs and forbs including: *Alnus tenuifolia* (mountain alder), *Salix* (two species- *bebbiana*, *exigua* or *scouleriana*), *Robinia neomexicana* (New Mexico locust), *Cornus stolonifera* (red osier dogwood), *Populus angustifolia* (narrow leaf cottonwood), *Populus tremuloides* (quaking aspen), *Sambucus* (elder), *Quercus gambelii* (gambel oak), *Betula occidentalis* (water birch), *Prunus virens* (southwestern choke cherry), *Aconitum* (monkshood), and *Urtica dioica* (stinging nettle). Many other forbs and grasses were noted but not positively identified. This diverse array of plants creates a dense impenetrable barrier, which parallels the stream for a good part of Reach 1. The vegetation also creates a thick canopy, which provides great amounts of stream shade. It was noted that at mid-day, ambient air tem

located within the riparian vegetative zone. There is a potential for sediment to be introduced into the stream from the trail during precipitation events and/or during spring runoff. Frequent side trails (cow paths) are also present between Trail 82 and the stream bank. There could also introduce particulates into the system. Although recent grazing activity is evident, it does not appear to cause an immediate threat to stream bank stability or riparian vegetative vigor.

Reach 3 (equivalent to Reach 5 in 2002/2003)

Reach 3 begins where Reach 2 left off in Section p NE1/4 and continues upstream for approximately 7300 ft (+/-6%) to Section 16, approximate elevation 9120 ft. The average stream gradient is >4%, defining this section as a Type "A" channel. Some stretches of high-grade "B" channel are also present but these are dominated by the steeper lengths. Upland vegetative communities are mainly composed of *Picea pungens* (Colorado Blue Spruce), *Abies concolor* (White Fir), *Populus tremuloides* (Quaking Aspen), *Pinus flexilis* (Limber Pine) and *Picea engelmannii* (Engelmann Spruce).

The riparian vegetative community type is *Alnus teuifolia*-mixed deciduous. Riparian vegetation growth is strong and shows few if any signs of reduced vigor or stress. Numerous 'cow paths' do exist between the stream and Trail 82, but these do appear to greatly affect the vegetation or stream bank. Average water width narrows from a high of 10.22 ft (average width for the first one mile of Reach 1), to a width of 6.4 ft in this one. Average maximum water depth is 1.1 ft. The pool to riffle ratio is 1:2.6.

Streambed substrates consist mainly of cobbles and gravels but also include frequent small boulders. Visual observations made during this survey indicate that, of all the reaches, this one (Reach 3), contains the highest percentage of mature (large) fish. Ordinarily one would expect to find the highest concentration of large fish in Type "B" and Type "C" channels, but it does not appear to be so in this case. At least one mature fish (>7" in length) was seen in each of the many pools present in Reach 3. (Admittedly, fish presence was highest in those stretches of Type "B" channel which are a subdominant feature of this reach. Intensive population inventory would need to be conducted in order to confirm this hypothesis.

Fish cover is provided mainly by substrate and undercut banks, with approximately 42% of the stream being affected. Woody material, though present, does not greatly enhance habitat.

A third manmade structure was noted in Section 9. When asked about the origins of this structure, Robert Martinez, Coyote RD, stated that it "is probably a fish barrier" but he is not certain of its exact function due to the fact that it was constructed before he arrived at Coyote, RD.

Two tributaries are present in this reach, both in Section 9. The first enters from the west at an approximate elevation of 8750 ft. This tributary cortributes approximately 40% of the total flow below the confluence. The second trib. enters Cañones in the SW ¼ of Section 9 and contributes approximately 1.5 cfs. Both tribs appear to persist year-round.

Reach 4 (equivalent to Reach 6 in 2002/2003):

Reach 4 begins in the SW ¼ of Section 16, just as the stream flows out of Section 17 and continues upstream to the headwaters. The total length of this reach is approximately 9120 ft (+/-7%). Of this total length, approximately 5827 ft were surveyed. The remaining 3293 ft. were not surveyed because water quality, specifically the stream's ability to support fish populations, was questionable.

Reach 4 is characteristic of a Rosgen Type "C" channel but also contains some Type "B" in the lower ½ mile. Gradient is low (<1.5%) and sinuosity is moderate. Substrate is predominately fine gravels, sands, and silts.

The riparian vegetative community type for the first length of Reach 4 is *Picea pungens*. This short stretch of riparian is adjacent to the Type "B" channel previously mentioned and is transitional between the steep, Alnus tenuifolia condition found in Reach 3, and the meadow community of Reach 4. The meadow varies in width between 40-500 ft and for the most part occupies the entire valley bottom. Meadow vegetation is composed mainly of grasses and forbs. Few woody species are present in the riparian zone, but *Populous tremuloides* is a common component along outer edges and encroaching into the meadow. Upland vegetation is mainly composed of *Picea pungens*, *Picea engelmannii* and *Populus tremuloides*. The meadow in the upper end of this reach becomes marshy and this meadow-marsh is a principle source of Cañones Creek.

Of all reaches surveyed, Reach 4 exhibits the most ungulate damage. Raw-exposed/slumping streambanks were noted in Section 17 as were 31 head of cattle in and around the riparian are in Section 20. Other observations included: turbid water conditions, and abundance of algae, embeddedness high (not unusual for Type "C" channel), and an abundance of biting flies-deer flies and black flies. Because of low flow conditions (<1 cfs) and an apparent degradation in water quality, this survey was terminated in Section 20.

GLOSSARY

Eutrophication: Having waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae, which reduces dissolved oxygen content and often causes the extinction of other organisms.

Gabion Structures: Wire boxes filled with cobble or larger sized substrate to create "walls" and used for bank stability. Much like riprap, these structures have equally adverse effects as streams adjust to this hardening.

Hybridization: The result of a genetic cross between different species. In the fish populations of New Mexico, Rio Grande cutthroat trout when in contact with rainbow trout will cross breed to produce cut-bows. Hybridization destroys the genetic purity of Rio Grande cutthroat trout populations.

HUC Code: Hydrologic Unit Code used to identify watersheds.

Large Woody Debris (LWD): Wood that is within the bankfull channel for a habitat unit and is above the minimum size requirement. Woody debris is classified into categories with relation to length and diameter. The smallest wood classified in this survey must be greater than 6 inches in diameter at a length of 20 feet from the largest end. For analysis only wood with a diameter of greater than 12 inches at a length of 35 feet from the large end are used (designated as medium and large pieces).

Large Woody Debris Jams: A minimum of 3 pieces of LWD interacting within the bankfull channel.

Meadow Reach: Predominance of valley formation has meadow characteristics, which includes lacking trees in the active floodplain. No LWD recruitment within the reach.

Natural Sequence Order (NSO): A division system used to classify stream habitats. Each habitat is assigned a unique NSO number in consecutive order from the mouth upstream.

Response Reach: Low-gradient and/or constricted reaches typically located downstream from high gradient transportation reaches. Response reaches are noted for their channel and habitat formation caused by upstream factors.

Riparian Vegetation: Streambank or streamside vegetation; influenced by wet conditions associated to a high water table or live water.

Riprap: A loose assemblage of broken stones erected in water or on soft ground as a foundation. Riprap is used to improve bank stability in streams, but has other and occasionally adverse effects.

Seep: A tributary with very slow flow, often associated with draining wet meadows

Spring: A flowing tributary with a source within 100 feet from the stream channel.

Stream: All tributaries that are not classified as a seep or spring. Usually streams are associated with a distinct drainage and have a more significant flow than the other tributary types.

Stream Habitat (%): A calculation of relative habitat types, which includes culverts, falls, pools, riffles and secondary channels. Tributary habitats are not included in the calculation.

Stream Length (%): A calculation of relative main channel habitat types, which includes culverts, falls, pools, and riffles. Tributary and secondary channel habitats are not included in the calculation.

Transport Reach: High gradient and non-constricted reaches that act as a conveyor belt of source materials, such as large wood, substrate and fine materials.

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