Colorado River Cutthroat Trout (*Oncorhynchus clarki pleuriticus*) Species and Conservation Assessment

Prepared for the Grand Mesa, Uncompahgre, and Gunnison National Forests

September 2005

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INTRODUCTION

This report assesses the biology and conservation status of the Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) in the Grand Mesa, Uncompahgre, and Gunnison National Forests (Forest). The goal of this assessment is to summarize historical and current literature, and Forest-level resource data related to Colorado River cutthroat trout (CRCT) to provide land managers and the general public an objective overview of this species within the Forest. Peer-reviewed scientific literature and summarized data are the primary information sources used in this report. Interpretation and extrapolation of studies conducted on other sub-species of cutthroat trout in the intermountain west has been used where relevant. Data from unpublished federal and state sources have been used to provide local information on the distribution, localized abundance, and habitat condition on the Forest.

Areas of Uncertainty

There is difficulty in identifying the exact distribution and abundance of CRCT Conservation Populations due to introgression between other non-native trout species. Many streams on the Forest may contain individual fish that meet Conservation Populations guidelines (CRCT Task Force 2001), but are part of a longer section of stream in which the majority of populations do not. Seasonal dispersal patterns in some streams may further complicate the identification of Conservation Populations.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

- USDA Forest Service, Rocky Mountain Region Sensitive Species List (April 2003)
- State of Colorado, Species of Concern
- Colorado Bureau of Land Management, Sensitive Species
- Petitioned for Federal Listing, Endangered Species Act (December 1999)
- Fish and Wildlife determination that species is not warranted for listing at this time (2004)
- Natural Heritage Rankings: G4 (Globally Ranked Apparently Secure) T3 (Intra-specific Taxon Vulnerable to Extirpation), S3 (State Ranked Vulnerable to Extirpation)

Existing Regulatory Mechanisms, Management Plans, and Conservation Agreements

- Conservation Agreement and Strategy for the Colorado River Cutthroat Trout (*Oncorhynchus clarki pleuriticus*) in the States of Colorado, Utah, and Wyoming, April 2001
- Grand Mesa, Uncompahgre, and Gunnison National Forests Amended Land and Resource Management Plan, 1991

An assessment of CRCT populations is provided in ***The Conservation Agreement for Colorado River Cutthroat Trout in the States of Colorado, Utah, and Wyoming (CAS, 2001)***. This recovery plan has been developed by various state and Federal agencies and provides a comprehensive and strategic plan for maintaining the viability of CRCT across the species natural range. The Plan identifies population and habitat objectives for 15 Geographic Management Units (GMU) across the historic distribution of CRCT (Figure 1).

The CAS was developed to expedite implementation of conservation measures for Colorado River cutthroat trout in Colorado, Utah, and Wyoming as a collaborative and cooperative effort among resource agencies. Threats that warrant Colorado River cutthroat trout listing as a special status species by state and federal agencies and might lead to listing under the Endangered Species Act of 1973, as amended, are expected to be eliminated or reduced through implementation of the CAS. Specific goals and objectives in the CAS include:

Goals:

To assure the long-term prosperity of Colorado River cutthroat trout throughout their historic range by establishing two self-sustaining meta-populations, each consisting of 5 separate, but viable interconnected sub-populations, in each Geographic Management Unit (GMU) within the historic range.

To maintain areas which currently support abundant Colorado River cutthroat trout and manage other areas for increased abundance,

To maintain the genetic diversity of the species, and

To increase the distribution of Colorado River cutthroat trout where ecologically, sociologically, and economically feasible.

Objectives:

To maintain and restore 383 conservation populations in 1754 stream miles and 18 populations in 652 lake acres in 14 GMUs within the historic range in Utah, Wyoming and Utah. The Forest provides habitat-supporting CRCT in the Colorado, Dolores and Gunnison GMU (Figure 1). The GMU include private, state and federal lands (BLM and Forest Service). Objectives for the number and miles of streams and acres of lakes identified in the CAS are:

GMU	Streams (number)	Streams (miles)	Lakes (number)	Lakes (acres)
Colorado	50	122	13	222
Dolores	9	23	0	Na
Gunnison	15	60	0	Na

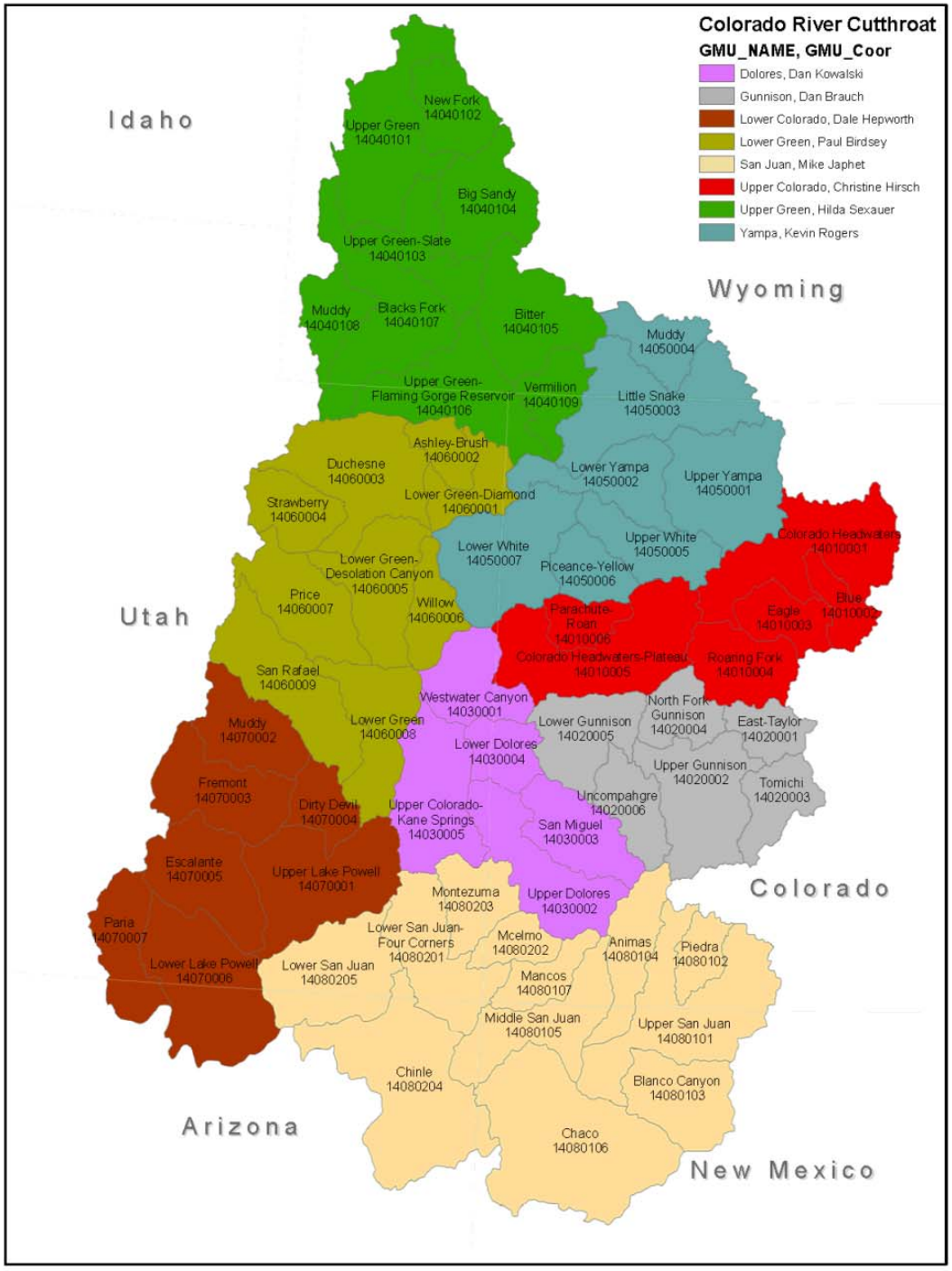

Figure 1. Geographic Management Units (GMU) identified in the Conservation Agreement and Strategy for Colorado River cutthroat trout.

The Grand Mesa, Uncompahgre, and Gunnison National Forests 1991 Revised Forest Plan (LRMP) provide additional land management direction. The LRMP includes standards and guidelines for managing habitat for the CRCT (Table 1).

Table 1. Forest Plan direction related to Colorado River cutthroat trout, LRMP 1991.

Management Activities	**General Direction**	**Standards and Guidelines**
Aquatic and Terrestrial Habitat Management	03 Inventory aquatic habitats associated with perennial streams on the Forest. Maintain this aquatic habitat in at least its current condition with stable or improving trends. Improve aquatic systems to an over-all upward trend. 04 Manage habitat for needs of macroinvertebrate and fish indicator species on all perennial streams, which provide potential fisheries. Manage waters capable of supporting self-sustaining trout populations to provide for these populations. 05 Prioritize streams for intensive management based on their current condition and ability to support self-sustaining trout populations and manage these streams to provide optimal habitat for trout populations.	f. Maintain fisheries habitat at a level, which reflects an improving trend. c. Manage stream habitat to improve habitat conditions. If alternatives to management activities, which cause unfavorable conditions, cannot be developed, then mitigation measures will be included in project proposals.
Wildlife and Fisheries Threatened, Endangered and Sensitive Species	Manage for and provide habitat for threatened, endangered and sensitive species as specified in the Regional Forester's 1920 letter dated June 25, 1982.	c. Delineate and manage habitat for Colorado River cutthroat trout (Oncorhynchus clarki pleuriticus) as part of the State's recovery plan for de-listing the species.

Management Status of Colorado River cutthroat trout in the Colorado, Dolores and Gunnison GMU

In 2004, a management and accomplishment report was prepared summarizing work in the years 1999-2003 by members of CAS (CAS 2004). The number and miles of streams occupied by CRCT increased substantially in the Colorado and Gunnison Geographic Management Unit (GMU) from 1998 to 2003 (Table 2). This increase was largely due to the discovery of new CRCT populations through extensive inventory work conducted by State and Forest Service biologists during this period. Only one chemical restoration project to remove non-native fish species in occupied CRCT habitat occurred during the 5-year period. Approximately .25 miles was treated in the Colorado River GMU. While significant progress has been made, objectives identified in the CAS for the number and miles/acres of occupied streams have not been attained.

Table 2. Comparison of the number and miles/acres of streams or lakes and miles/acres supporting CRCT Conservation populations by GMU on the GMUG – 1998 versus 2003.

	1998				2003			
GMU	Stream (#)	Stream (mi)	Lake (#)	Lake (ac.)	Stream (#)	Stream (mi.)	Lake (#)	Lake (ac.)
Colorado	47	107	7	171	75	184	19	234
Dolores	3	2.5	0	Na	4	9	0	Na
Gunnison	3	10	0	Na	21	84	2	75

Most CRCT conservation populations in the Colorado, Dolores and Gunnison GMU are small (< 500 adult fish), restricted to headwater reaches, and are isolated (Table 3). Only two meta-populations are suspected to exist, one each in the Colorado and Gunnison GMU. Of these two, only one occurs on the GMUG NF in the Upper Muddy Creek watershed on the Paonia Ranger District. However, more recent data indicates the upper Muddy Creek populations may not meet the meta-population definition in the CAS (five subpopulations that are connected). Further evaluation should be conducted to determine the status of these populations.

Table 3. Frequency of CRCT Conservation populations with adult abundance (>150mm) and the number of identified meta-populations in GMU in which GMUG has ownership (2003).

	Abundance of CRCT populations				Number of meta-populations (5 or more connected streams)	Number of meta-populations (2-4 connected streams)
GMU	0-100	101-499	500-999	>1000		
Colorado	18	32	16	8	1	3
Dolores	2	1	0	0	0	0
Gunnison	2	5	3	1	1	2

Biology and Ecology

Systematics/Taxonomy

Behnke (1992) provides a thorough discussion of the description and taxonomy of CRCT and other cutthroat trout of the Southern Rocky Mountain Basins. Behnke (1992) states that CRCT are commonly identified through bright crimson colors along the ventral region, with golden yellow along the lower sides of the body (Figure 2). Scale counts and coloration have been used most often to characterize CRCT (Behnke 1992), however, variations in color, spotting patterns, and body size can vary between local watersheds (C. James pers. obs.). Introgression with rainbow and other non-native cutthroat trout have made identification of pure-strain CRCT more difficult. Recent developments in DNA analysis appear to be the most reliable method for determining the purity of CRCT.

Figure 2. Illustration of "typical" Colorado River cutthroat trout found on the Grand Mesa, Uncompahgre, and Gunnison National Forests (Fish illustration by Joseph R. Tomelleri).

Genetic status has been determined on 27 of the 32 known populations on the Forest (Table 4). All genetic analysis was completed by the genetic lab at Brigham Young University using a variety of genetic techniques. Twenty-three of these populations are considered native Colorado River cutthroat trout with less than 5% genetic influence from other cutthroat subspecies (i.e. Yellowstone) or rainbow trout. Four populations are slightly hybridized with other salmonids and 5 populations are unknown. Under the CAS, all populations with less than 1% hybridization (A purity) are considered "core" populations (N=27). Conservation Populations are considered only slightly hybridized (< 10% of the characters indicate hybridization), and retain all the phenotypic attributes associated with the subspecies.

Table 4. Distribution, estimated population of adult fish (>150mm) in fish/mile, and genetic purity rating for Conservation populations of Colorado River cutthroat trout on or adjacent to the GMUG NF as of 2004 (Colorado Division of Wildlife, 2002-2004 and Forest Service data 2001-2004).

Stream Name	Conservation population I.D.	Geographical Management Unit	Geographic Planning Area	Miles of Stream or Acres of Lake	Adult Pop'l estimate per mile (high)	Total adult pop'l estimate	Purity Rating*
Antelope Creek, West	14020002cp002	Gunnison River	Gunnison	5	10	50	A
Anthracite Creek, North	14020004cp001	Gunnison River	North Fork	3	86	258	B
Beaver Creek	14020002cp003	Gunnison River	Gunnison	15	72	1080	A
Beaver Creek, West	14020002cp001 14020002cp003	Gunnison River	Gunnison	5	70	350	A
South Beaver, East Fork	14020002cp010	Gunnison River	Gunnison	3.5	72	253	U
Beaver dams Creek	14020006cp001	Gunnison River	Uncompahgre	2.0	30	60	A
Big Creek, East Fork	14010005cp008	Colorado River	Grand Mesa	2	U	U	A
Brush Creek	14010005cp007	Gunnison River	Gunnison	2.5	U	U	U
Chair Creek		Gunnison River	North Fork	2.0	U	U	U

Stream Name	Conservation population I.D.	Geographical Management Unit	Geographic Planning Area	Miles of Stream or Acres of Lake	Adult Pop'l estimate per mile (high)	Total adult pop'l estimate	Purity Rating*
Cunningham Creek	14020004cp003	Gunnison River	North Fork	2.0	245	490	A
Deep Creek	14030003cp001	Dolores River	San Jaun	3	33	100	A-
Deep Creek	14020004cp002	Gunnison River	North Fork	3	U	U	A
Deer Beaver Creek	14020002cp004	Gunnison River	Gunnison	3	111	334	B
Doug Creek (BLM)	14020002cp008 14020002cp009	Gunnison River	North Fork	3	33	100	A
Dry Creek, East Fork	14020006cp001	Gunnison River	Uncompahgre	2	16	32	A
Dyke Creek	14020004cp004	Gunnison River	North Fork	4	123	492	A
Elk Creek	14030003cp002	Dolores River	San Juan	1.5		50	B+
Henderson Creek	14020004cp005	Gunnison River	North Fork	4	U	U	A-
Hubbard Creek, Main	14020004cp007	Gunnison River	North Fork	2	78	156	A-
Hubbard Creek, Middle	14020004cp008	Gunnison River	North Fork	2	102	204	A-
Lake Fork Gunnison (BLM)	14020002cp011		Gunnison			103	U
Nate Creek	14020006cp002	Gunnison River	San Juan	3	65	195	B
Pryor Creek	14020006cp001	Gunnison River	Uncompahgre	2	32	64	A
Roberts Creek	14020004cp006	Gunnison River	North Fork	2.5	138	345	U
Rock Creek	14020004cp009	Gunnison River	North Fork	1	17	17	A
Road Beaver Creek (BLM)	14020002cp005	Gunnison River	Gunnison	4	50	200	A
Second Creek	14020002cp007	Gunnison River	North Fork	3	17	50	A-
Smith Fork Gunnison, North	14020002cp006	Gunnison River	North Fork	9	U	U	B
Terror Creek, West Fork	14020004cp003	Gunnison River	North Fork	3	166	498	A
Trail Gulch	14020004cp010	Gunnison River	North Fork	2	U	U	A
Youngs Creek Resv. 2	14020005cp002	Gunnison River	Grand Mesa	52.1 (ac)		U	A
Youngs Creek Resv. 3	14020005cp001	Gunnison River	Grand Mesa	23.0 (ac)		U	A

* A = Pure (Core Conservation Population=CCP)
A- = Pure, but slightly different from norm (CCP or Conservation Population=CP)
B+ = Essentially pure (<5% of characters indicate hybridization) (CP)
B = Slight hybridization (5-10% of characters indicate hybridization) (CP)
U = Unknown

Range, Distribution and Abundance

The Colorado River cutthroat trout historically occupied portions of the Colorado River drainage in Wyoming, Colorado, Utah, Arizona, and New Mexico (Behnke 1992). Its original distribution probably included portions of larger streams, such as the Green (Simon 1935), Yampa, White, Colorado, and San Juan Rivers. Behnke and Zarn (1976) suggested this subspecies was absent from the lower reaches of many large rivers because of summer thermal barriers. However, other subspecies of cutthroat trout have demonstrated seasonal migrations over 100 km, usually upstream in spring and downstream in autumn (Bjornn and Mallet 1964). It is feasible to speculate that the lower reaches of the rivers within the Colorado River cutthroat trout range may have become acceptable habitat in winter as water temperatures moderated and this may partially explain the disjunct historical distribution apparent for this subspecies.

Conservation populations are known to occur in 22 7th field watersheds on the GMUG (Figure 3). Two additional populations exist on BLM lands adjacent to the Forest. Conservation Populations are restricted to approximately 96 miles of stream, with most populations occurring in tributaries of the North Fork of the Gunnison River. Streams on the Forest, support 27% of the known CRCT Conservation Populations in the Colorado, Dolores and Gunnison GMUs. Two CRCT Conservation Populations have been established in lakes totaling approximately 75 surface acres on the Grand Mesa; however, severe drought and dam reconstruction have likely resulted in the loss of these populations. The miles of stream occupied by CRCT on the Forest has increased 29% since 2001. This increase was largely due to the discovery of new CRCT Conservation Populations, not from increases in abundance or dispersal of individual populations.

Quantitative population monitoring has been conducted on 23 of the 32 streams containing conservation populations occurring on the Forest (Table 4). The number of adult fish (>150mm) ranges from a low of 32 fish in East Fork Dry Creek to a high of over 1000 fish in Beaver Creek. Nine populations (29%) have 100 or fewer adult fish, 13 (42%) have 100-499 adult fish, zero populations have 500-1000 fish and only one population (3%) has an estimated adult population greater that 1000. The data indicate that the majority of conservation populations have fewer than 500 adults (71%) and largely occur in small headwater streams, ranging from 2-4 miles in length.

Generally cutthroat trout populations are composed of four to five age classes and generally range from 40-200 mm in length (Wang and Lambert unpubl. report; James, unpubl. data). Fish larger than 200 mm were observed in only 7% of the fish sampled, with most fish ranging between 55 and 165 mm.

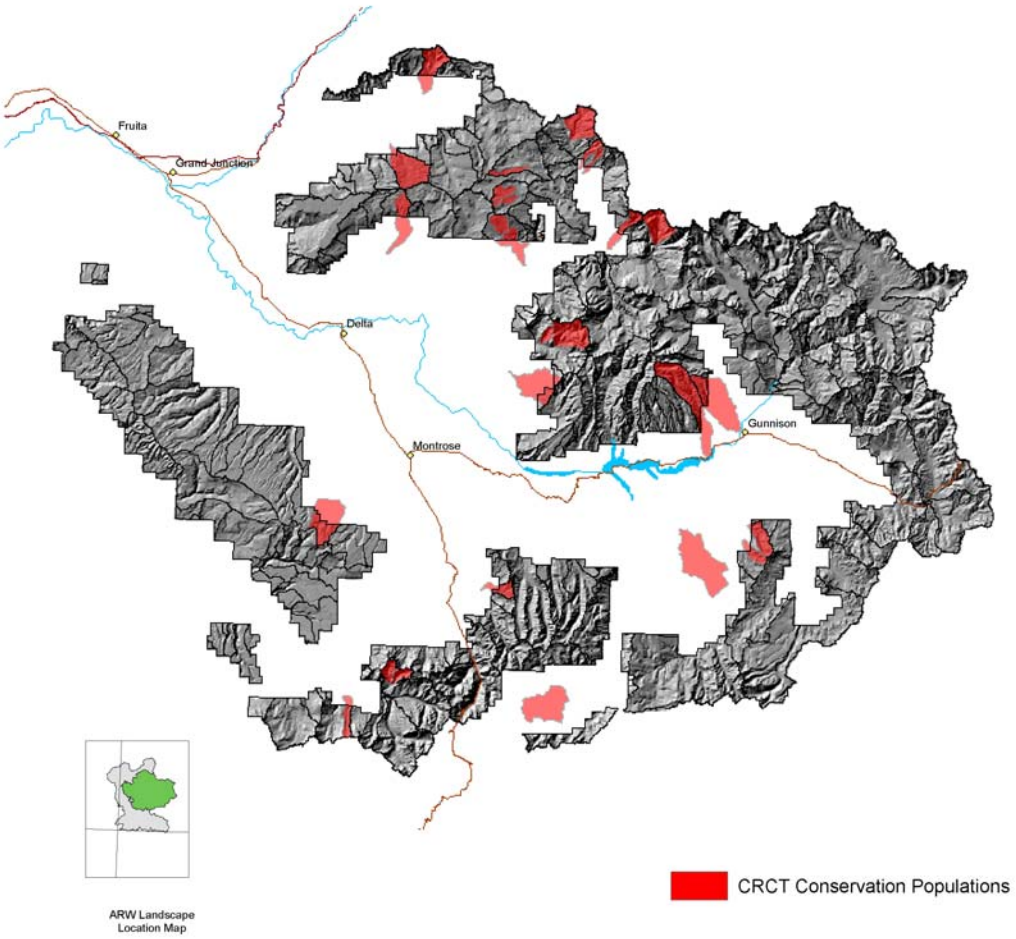

Figure 3. Seventh-level subwatersheds currently supporting Conservation populations of CRCT.

Population Trend

Since 2001, the Colorado Division of Wildlife and Forest biologists have obtained population data from 74% of the known conservation populations residing on the Forest. These data will serve as a baseline in which to judge success of future conservation efforts and to determine changes in distribution or population numbers. Recent drought conditions in 2002-2004 have likely affected the abundance and distribution of CRCT throughout the Forest. A cursory assessment of drought effects indicated that at least five CRCT Conservation Populations experienced significant declines in the numbers of fish (C. James pers. obs.). Population estimates made for West Antelope Creek prior to 2000 were nearly 40 times higher than the number of individuals captured in August 2002. Subsequent population sampling should provide information related to populations trends on the Forest (CDOW data 2002).

Activity Patterns and Movements

Since CRCT Conservation Populations on the Forest occur in isolated headwater streams movement within and between streams is probably limited. Young (unpubl. data) noted home ranges of over 1,000 m in the North Fork Little Snake River drainage from June to August, but weekly movements declined to just 14 m by late August. Distribution patterns of existing CRCT Conservation Populations suggest that larger migration patterns and dispersal capability could occur between some Forest streams, in particular, Clear Fork Muddy Creek, East Fork Dry Creek, and Beaver Creek.

Habitat

Intensive habitat inventories were completed during the 2001-04 field seasons on nearly 10 miles of CRCT streams on 61 reaches. This data represent the best available information to date on fish habitat conditions, and likely provides the Forest with a good "cross-section" of current habitat conditions for CRCT. Several important fish habitat parameters were sampled to determine overall habitat conditions and requirements for CRCT.

Most CRCT streams on the Forest lack suitable fish habitat to sustain large populations of trout species. Abundance and size of CRCT are generally limited by steep gradients, lack of spawning habitat, cold-water temperatures, pool depth and frequency, and lack of cover (Behnke 1992, Young 1995). Recent stream surveys suggest that most fish-bearing streams on the Forest have gradients ranging between 1 and 7%. Generally, most of the CRCT streams are small with an average Bankfull Width (BFW) of 5.2m. Ninety-one percent of the sampled reaches have a BFW between 1 and 10m.

Spawning habitat is very limited in these headwater systems causing trout to spawn in marginal spawning areas. This has likely resulted in poor egg-to-fry survival for trout. Laboratory studies indicate that geometric mean particle sizes from 13.8 to 15.9 mm or larger yielded the best chance of survival for cutthroat trout (Young et al. 1991). Spawning substrate size criteria for CRCT and other inland cutthroat trout has been

described as ranging from 2-100 mm, and varies with body size (Young 1995; Kershner 1995; McIntyre and Reiman 1995). Pebble count samples indicate that these size classes make up about 30% of the substrate composition of CRCT streams. However, few areas greater than 1 meter^2 or larger were observed in most streams. Measurements of percent fines less than 2 mm indicate that fine sediment may comprise a high percentage of typical spawning sites, particularly in lower gradient stream reaches (James, unpubl. data). Pebble count data suggests substrates such as small boulders and larger comprise approximately 17% of the total substrate composition.

Literature suggests that optimum water temperatures for cutthroat trout is between 12-15°C, and mortality may occur when temperatures exceed 22°C (Dwyer and Kramer 1975, Hickman and Raleigh 1982). Based on existing temperature data, optimum water temperature requirements for cutthroat trout are generally met from June-September, however, water temperatures begin to drop dramatically after September, and remain near 0°C during the months of November-March (James, unpubl. data). This temperature profile likely limits growth and activity during most of the season, and may result in poor embryo survival following spawning.

Pool density and pool depth play an important role in the survival of all cutthroat trout species, particularly during low flow periods (Young 1995, Meehan 1991). Herger (1993) found that Colorado River cutthroat trout larger than 152 mm were located primarily in pools, and that pool depth influenced trout density. Herger (1993) also found that the density of fish in pools increased as the flows declined over the summer. Behnke (1992) has observed that adult trout generally live at depths of 0.3 m or greater in areas of slow water (0.1 m/s) are juxtaposed with fast waters that carry food and where protective cover is provided by boulders or logs. Additionally, Harig and Fausch (2002) showed that pool depth is an important consideration when determining sites for translocations of Rio Grande and greenback cutthroat trout.

Pools comprised 41% of the area, and 58% of the total volume during summer low flow conditions on inventoried streams. Residual pool depths greater than 0.3 meters occurred in 37% of the pools surveyed, with the majority of these occurring in larger streams. Eighty-five percent of pools have a residual pool depth of between .2 and .5m. These data indicate pools comprise the majority of fish habitat in most small streams, but the lack of depth may limit cutthroat trout survival during low flow conditions in late summer and during the winter. Beaver dams play a critical role in the survival of many of these small populations of cutthroat trout, providing good summer and winter rearing habitat. Beaver dams comprised 73% of the total volume of fish habitat during summer low flow conditions.

Cover is an important feature for the survival of CRCT, and appears to be abundant in most streams. Large woody debris (LWD), boulders, and undercut banks have been described as key cover components for cutthroat trout (Giger 1972; Horan et al. 2000; Young unpubl. data;). Large woody debris is abundant in most reaches of stream providing good cover for cutthroat trout. In forested stream reaches, LWD densities range from 3 to 76 pieces per 100 meters of stream. The average was 23 pieces per

100m. Median LWD density per pool unit was 3 pieces, suggesting that most pools offer suitable cover for CRCT.

The amount of stable bank directly relates to the amount of cover provided by undercut banks. Bank stability averages 84% on all sampled streams. On streams having a gradient less than 2% (response reaches) bank stability drops to 82%, which is not statistically different than the mean. Approximately 56% of all CRCT streams have greater than 90% stable bank. Undercut banks were not frequently observed, comprising only 10% of the total streambanks sampled.

Food Habits

Though the diet of CRCT has not been comprehensively studied, data suggests that invertebrates comprise the majority of their diet (Colborn 1966, Bozek et al. 1994). Given the low productivity of most CRCT streams, fish are most likely opportunistic feeders, selecting a combination of aquatic and terrestrial invertebrates. Consumption of CRCT fry and other small fish does not appear to occur very often, but is more likely to occur in large fish.

Breeding Biology

A thorough assessment of the reproductive behavior of cutthroat and other western trout has been characterized in Behnke (1992). Locally, spawning occurs between June and mid July on most Forest CRCT streams, depending primarily on water temperatures and the hydrograph. During the spawning season males aggressively compete with each other in close proximity to ripe females. Females dig nests known as *redds* from gravel, and eggs are deposited, fertilized, and then covered with gravel. Redds tend to be located where velocity, depth, and bottom configuration induce water flow though stream substrate (Young 1989). Incubation periods for CRCT range from 28-49 days, or longer depending on water temperatures (Cope 1957, Scott and Crossman 1973).

Literature suggests that colder water temperature regimes and high streambed gradients can greatly inhibit spawning and incubation success for CRCT (Behnke 1992; Harig and Fausch 2002). Cold-water temperature can reduce embryo survival, causing young CRCT to never fully develop. Accumulation of fine sediments can also effect embryo development and survival. Embryo survival has been shown to decline in trout and salmon species as the percentage of fine sediment < 6.35 mm increases (Bjornn and Reiser 1991). Additionally, most CRCT that reside in headwater streams do not migrate substantial distances to seek suitable spawning areas. Therefore, localized disturbances can greatly affect reproduction success where suitable spawning grounds are limited.

Demography

Like most inland cutthroat trout species, CRCT evolved in isolation from rainbow trout and other trout species. This evolutionary history left the Colorado River cutthroat trout vulnerable to hybridization with rainbow trout and other sub-species of cutthroat trout. CRCT can easily hybridize with rainbow trout and other non-native cutthroat trout and produce fertile offspring. Hybridization and subsequent loss of existing CRCT populations have been well documented within its range (Snyder and Tanner 1960; Wiltzius 1985; Martinez 1988). Behnke and Zarn (1986) believe that more populations of CRCT had been lost by hybridization than through any other cause.

The CRCT has four major life history stages (Table 5). Spawning occurs in late spring to mid summer and depends primarily on water temperatures and the hydrograph. Length and age at maturity are related food abundance and the length of the growing season. Data from fish sampling suggests that CRCT on the Forest likely mature at age 3 at approximately 125-150 mm in length.

Table 5. The timing of four major life history stages for Colorado River cutthroat trout. Variation and overlap in timing is accountable to variations in habitats occupied by this species.

	Autumn			**Winter**			**Spring**			**Summer**		
Life History Stage	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**
Spawning Period										X	X	
Egg Incubation Period	X										X	X
Summer Rearing	X	X							X	X	X	X
Winter Rearing		X	X	X	X	X	X	X				

Rearing life history stages have been divided into summer and winter rearing because CRCT exhibit much different behavioral patterns. During the late spring and early summer CRCT are generally widely dispersed and mainly interested in feeding (Lewensky 1986). As water levels recede CRCT spend increasingly more time in pool habitats (Herger 1993). During the winter months CRCT tend to hide in the interstices of substrate or under banks in slow moving pools. Much of this change in behavior is the result of cold-water temperatures that alter the fish's metabolism and available energy. Lack of available winter rearing habitat can reduce the fish's ability to survive into the following summer.

Community Ecology

Young (1995) suggested that the introductions of non-native salmonids might have had the greatest effect on CRCT. Brook trout appear to have easily displaced CRCT within much of its range. Displacement or replacement of native CRCT populations can occur in less than 6-8 year in some cases (Eiserman 1958; Behnke and Zarn 1976; Oberholtzer 1990). Competition is likely the mechanism, and appears to effect juvenile fish resulting in loss of adult recruitment to localized populations (Peterson and Fausch, in press).

The influence of predators on CRCT populations is not well documented. Young (1995) briefly discussed predatory fish, birds, and other mammals that can potentially effect CRCT populations. Young-of-the-year CRCT are likely most vulnerable to predation

from fish, snakes, and other birds particularly in edge-water habitat. Low-flow conditions likely make adult CRCT more vulnerable to mink and other mammals.

Cutthroat trout are susceptible to common salmonid diseases, including whirling disease, which is caused by the myxosporen *Myxobolus cerebralis* (Markiw 1992). Whirling disease is a parasitic infection that attacks the nerves, and cartilage of small trout, reducing their ability to feed and avoid predators. The disease was discovered in Colorado in 1987 and is now found in 9 state hatcheries and numerous private facilities. It is found in the wild in all coldwater drainages except the Animas and North Republican Rivers; populations are impacted in the following rivers: Cache la Poudre, Colorado, Dolores, Fryingpan, Gunnison, Middle Fork of South Platte, South Platte, Rio Grande, Roaring Fork Rivers, as well as some smaller streams. CRCT trout exposed to *M. cerebralis* (MC) in sentinel fish experiments suffered significantly greater mortality from the infection than most other non-native salmonids (Nehring 1998). Very little is known about other diseases and parasites of CRCT. Transmission of disease to wild cutthroat trout populations through hatchery-based fish stocking is recognized as a significant threat to local CRCT populations. Stocking practices in Colorado, Utah, and Wyoming have been developed strict stocking practices to reduce future transmission of whirling disease to existing populations.

CONSERVATION OF COLORADO RIVER CUTTHROAT TROUT

Threats

The greatest threats to the viability of CRCT on the Forest include competition with non-native species, drought, water development and depletion, disease, poor road design, and improper livestock management. Non-native species impacts have been well documented in many native inland cutthroat trout assessments (CRCT Task Force 2001; Gresswell 1995; Kershner 1995; McIntyre and Reiman 1995; Rinne 1995; Young 1995;), greatly affecting distribution, abundance, and genetic integrity.

Severe drought conditions can have significant impacts to localized populations, potentially causing populations of CRCT and other trout species to become locally extinct in headwater areas. Many small streams may have natural or man-made barriers to fish migration, which could limit the ability of trout to re-colonize headwater streams. Local water depletions could magnify this problem when key flows needed for dispersal are removed from the hydrograph for domestic or agricultural use.

The number of streams infected with whirling disease on the Forest is not completely known. Transmission of disease to wild cutthroat trout populations through hatchery-based fish stocking is recognized as the most significant threat to local CRCT populations. Stocking practices in Colorado, Utah, and Wyoming have developed strict stocking practices to reduce future transmission of whirling disease to existing populations.

Impacts from poor road design to salmonid species have been well documented in the Pacific Northwest (Furniss et al 1991). Primary factors that can potentially affect fish habitat in the assessment area are surface erosion and increased runoff during storm events. Sediment delivery to a number of streams has been observed on many native surface roads and at stream crossings throughout the Forest. Excessive sediment loads can impact the survival of fish following spawning activities, and effect macro-invertebrate densities that are the primary food sources for trout species. Areas where the road system parallels the stream in close proximity have the greatest risk of impacting fish habitat, and causing downstream impacts.

Historic livestock use has had dramatic impacts on riparian and vegetation on the Forest over the last 100 years (Platts 1991). However, by comparing recent photographs to historic photographs, rangeland and riparian conditions on the Forest have dramatically improved since the turn of the century (Bradford, et.al. 2003).

In 2005, the GMUG completed a rangeland condition and trend assessment (GMUG Comprehensive Assessment, in preparation). The assessment evaluated ecological status of suitable rangelands as mapped in the Forests Common Vegetation Units database. Since the Forest currently lacks an accurate spatial riparian vegetation coverage, riparian vegetation conditions and trends were only evaluated as inclusions in broader vegetation polygons. Complete discussions of the methods used in the Assessment are available in the Forests Comprehensive Evaluation Assessment (U.S. Forest Service-GMUG, in draft).

Seventh-field HUCs supporting CRCT populations have approximately 64,000 acres of suitable rangeland. Of these acres, 35,825 (56%) are considered to be in good ecological condition, 25,817 (41%) acres in fair ecological condition and 2,101 acres (3%) are in poor ecological condition. The majority of the suitable rangeland in CRCT watersheds is either in a static or upward trend. Less than 1% was classified as being in a downward trend.

Despite significant changes in the timing, use, and duration of livestock grazing, improvements in some streams channels continue to show impacts from historic use. Low gradient, meadow streams are most susceptible to livestock use, and are locations where livestock practices may pose the greatest risk for conflict with fisheries and other aquatic species.

The Forest recently completed an Assessment that evaluated watershed sensitivity and the level of past and current management activities occurring in 6th level watersheds on the Forest. A detailed description of the process can be found in the Aquatic, Riparian and Wetland Assessment currently being completed for Revision of the Forest Plan (U.S, Forest Service-GMUG, in draft). Watershed sensitivity is defined as the physical environmental factors that determine inherent response to disturbance (natural or management related). Activities include the variety of management activities or impacts that have or continue to occurred on Forest. To determine overall watershed integrity, watershed sensitivity and additive activities were combined into a numeric rating. These

ratings provide a relative characterization of watershed integrity. Ratings are relative ratings between watersheds on the Forest and should not be interpreted that the entire watershed is impaired or unstable.

Watershed was divided into four integrity classes ranging from class I- highest integrity to class IV – lowest integrity (Figure 4). Class I are watersheds believed to reflect a range of on-the-ground conditions that indicate natural functions predominate and show little influence from past or current land management. Class IV are watersheds having the greatest likelihood for specific areas or stream segments that have become degraded and could be affecting stream function and biotic integrity.

Table 6 provides a summary of watershed sensitivity, activity level, and watershed integrity for 6th-level HUCs containing Conservation Populations of CRCT. Twenty-seven of 31 (87%) known conservation populations occur in integrity class I (15 populations) or II (12 populations) watersheds. Three populations are in integrity class III and one population in integrity class IV. The presences of the vast majority of the known conservation populations in high integrity watersheds is not surprising since CRCT are known to be sensitive to habitat induced changes due to land management activities (Binns 1977, Oberholtzer 1987, Jesperson 1981, and Quinlan 1980).

All of the populations with 100 or more adults occur in Integrity Class I or II watersheds. Two (West Fork Antelope Creek and Deep Creek - Dolores River basin) of the 4 populations in Class III and IV watersheds have population estimates available. Both populations contain 100 or less adults. In addition, 61 miles (64%) of occupied habitat occur in Class I watersheds, 21 miles (22%) in Class II, 10 miles (10%) in Class III, and 4 miles (4%) in Class IV.

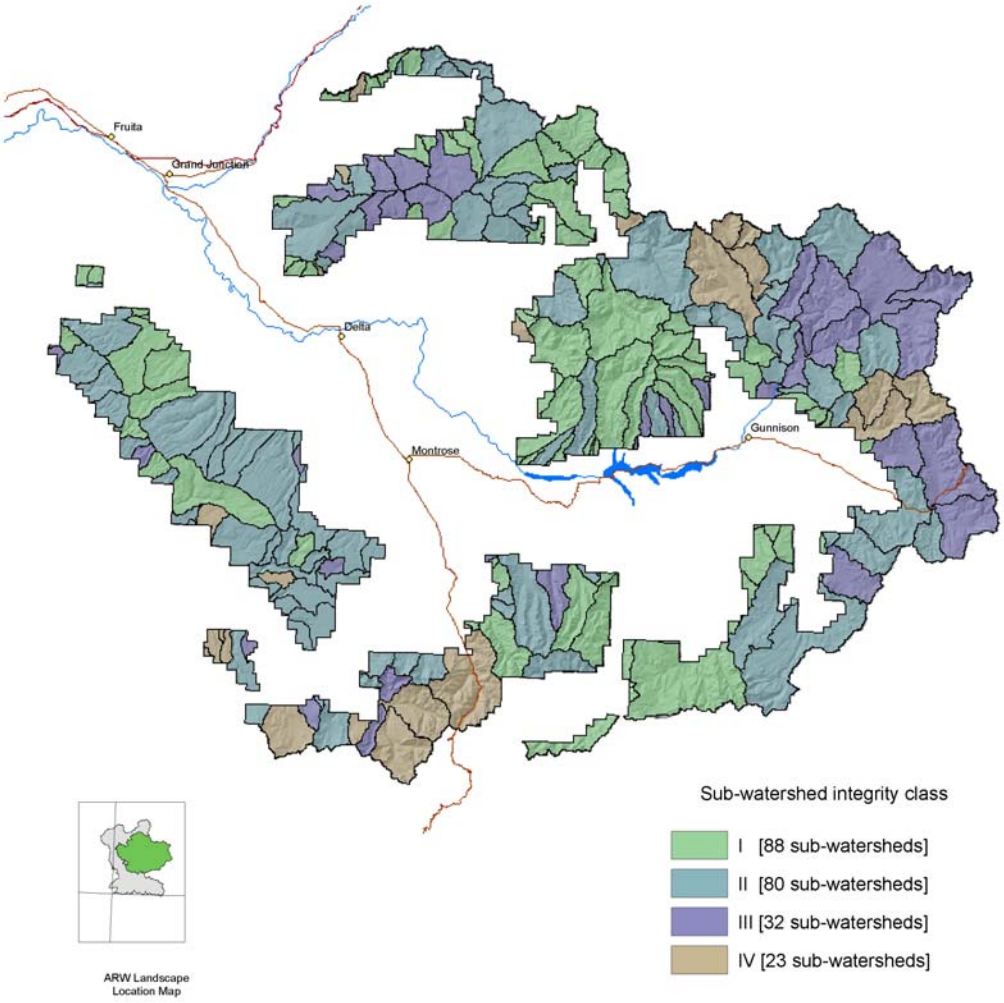

Figure 4. Sub-watershed integrity classes on the Forest.

Table 6. Colorado River cutthroat trout subwatersheds by overall integrity class, sensitivity class and activity class.

HUC6_NAME	HUC6	CRCT Streams	Integ Class	Sens Class	Act Class
Upper South Beaver	140200025001	East Beaver Creek Deer-Beaver Creek	1	1	1
Muddy Ck	140200020502	Doug Creek (BLM)	1	2	2
Upper West Muddy Ck	140200045502	Dyke Creek	1	2	2
Smith Fk	140200020501	Smith Fork Gunnison River, North Second Creek	1	3	1
Lower East Muddy Ck C	140200040901	Henderson Creek Roberts Creek Chair Creek	1	3	1
Clear Fk East Muddy Ck	140200040903	Trail Gulch Rock Creek	1	3	1
Lower Hubbard Ck C	140200045601	Main Hubbard Creek Middle Hubbard Creek	1	3	2
Beaver Ck	140200020310	Beaver Creek West Beaver Creek	1	4	1
East Fk Dry Ck	140200065001	East Fork Dry Creek Beaver Dams Creek Pryor Creek	2	1	4
Terror Ck	140200041103	West Fork Terror Cunningham Creek	2	2	3
Anthracite Ck	140200040701	North Anthracite Creek	2	3	2
Upper Hubbard Ck	140200045602	Main Hubbard Creek Middle Hubbard Creek	2	3	2
Brush Ck	140100051904	Brush Creek	2	3	3
Leroux Ck	140200045801	Young's Creek Reservoir #1 and #2	2	3	3
Nate Ck	140200064803	Nate Creek	2	3	3
Fall Ck	140300036308	Elk Creek	2	3	3
Antelope Ck	140200020311	West Antelope Creek	3	2	3
Deep Ck	140300036305	Deep Creek (Dolores)	3	3	3
Big Ck	140100051710	Big Creek, East Fork	3	3	4
Paonia Reservoir C	140200041104	Deep Creek	4	3	4

Recommended Actions to Address Threats

Aquatic ecosystem health

Conservations populations of CRCT primarily occur in watersheds with high ecological integrity. Eighty-seven percent of the known CRCT Conservation populations and 86% of the total miles of occupied habitat occur in integrity Class I or II watersheds. Therefore, future land management activities in these watersheds, particularly Class I should be carefully assessed to determine long-term impacts to the sustainability of CRCT. Only those activities, through project level evaluation, determined to be compatible with the goals and objectives of the CAS and maintain high quality habitat or improve degraded habitat or watershed function, should be allowed. Areas of potential management induced degradation should be evaluated and corrected to provide high quality aquatic habitat and properly functioning watersheds.

In Class III and IV watersheds management should focus on maintenance and/or improvement of stream flows, riparian vegetation, and stream morphology needed to rebuild CRCT populations. Standards and criteria identified in the Region 2 Watershed Conservation Handbook (FSH 2509.25) provide scientifically based direction for designing projects and managing riparian areas to protect, soil, aquatic, and riparian ecosystems. It is important to note that due to the presence of non-native trout, improvements in fish habitat conditions may not necessarily facilitate increases in CRCT populations or abundance.

The Forest also recently prepared an analysis of environmental factors (ecological drivers) that exert an influence on aquatic, riparian and wetland ecosystems that ultimately may affect the fitness of individuals and population size. The ecological drivers can be considered as comprising the physio-chemical "template" of an ecosystem. Two ecological driver analyses have been completed on watersheds comprising the Forest – one for the San Juan Mountains and the second is the rest of the Forest including the Upper Gunnison Basin above Blue Mesa, the North Fork of the Gunnison, the Grand Mesa and the northern 2/3's of the Uncompahgre Plateau (U.S Forest Service-GMUG, Ecological Driver Analysis, in draft). Factors assessed on the San Juan Mtns. portion of the analysis include percent of the watershed composed of igneous versus non-igneous rock types; calcareous versus non-calcareous rock types; the percent of the watershed in rain and snow, snowfall and rainfall precipitation regimes; and the percent low, moderate and high gradient streams present in the watershed. The same driver combination was used for the rest of the Forest but the amount of metal versus non-metal bearing geology was included. Each watershed cluster group was evaluated and interpretations provided related to hydrology and sediment transport, fisheries potential, riparian potential, and aquatic productivity and benthic macroinvertebrates potential.

Colorado River cutthroat trout watersheds fall into four ecological driver cluster (Table 7). A complete description of each of the clusters related to hydrology and sediment transport, fisheries potential, riparian potential and aquatic productivity and benthic

macroinvertebrates is available in the GMUG Comprehensive Assessment (U.S Forest Serice-GMUG, in draft).

Most of the CRCT populations are in GMUG watershed cluster group 4 or 5. Cluster 4 watersheds are characterized by predominately moderate to high gradient streams, underlain by non-metal bearing geology that is of sedimentary origin. These watersheds tend to produce high levels of fine sediment. Low gradient response reaches are therefore vulnerable to impact from increased management induced sediment. Fish production is limited due to cold-water temperature, lack of low gradient streams, moderate to high sediment production, and the lack of calcareous geology that could enhance aquatic production. Cluster 5 watersheds are mostly high elevation, snowmelt driven systems. Streams are generally high gradient, underlain by non-metal bearing geology of sedimentary origin. The watersheds produce abundant fine sediment and because streams are high gradient, they readily transport sediment. Low gradient response reaches are therefore vulnerable to impact from increased management induced sediment. Fisheries potential is limited in these watersheds due to cold-water temperatures, the potential for high sediment production and the lack of calcareous geology that could enhance aquatic production.

Table 7. Sixth-level HUC watersheds containing CRCT by watershed integrity class and Ecological Cluster group for stream and riparian resources.

HUC6_NAME	HUC6	CRCT Streams	Integ Class	Riparian/stream channel cluster group
Upper South Beaver	140200025001	East Beaver Creek Deer-Beaver Creek	1	8
Muddy Ck	140200020502	Doug Creek (BLM)	1	Na
Upper West Muddy Ck	140200045502	Dyke Creek	1	5
Smith Fk	140200020501	Smith Fork Gunnison River, North Second Creek	1	5
Lower East Muddy Ck C	140200040901	Henderson Creek Roberts Creek Chair Creek	1	5
Clear Fk East Muddy Ck	140200040903	Trail Gulch Rock Creek	1	4
Lower Hubbard Ck C	140200045601	Main Hubbard Creek Middle Hubbard Creek	1	5
Beaver Ck	140200020310	Beaver Creek West Beaver Creek	1	8
East Fk Dry Ck	140200065001	East Fork Dry Creek Beaver Dams Creek Pryor Creek	2	4
Terror Ck	140200041103	West Fork Terror Cunningham Creek	2	4
Anthracite Ck	140200040701	North Anthracite Creek	2	5

Upper Hubbard Ck	140200045602	Main Hubbard Creek Middle Hubbard Creek	2	5
Brush Ck	140100051904	Brush Creek	2	4
Leroux Ck	140200045801	Young's Creek Reservoir #1 and #2	2	NA
Nate Ck	140200064803	Nate Creek	2	1
Fall Ck	140300036308	Elk Creek	2	1
Antelope Ck	140200020311	West Antelope Creek	3	8
Deep Ck	140300036305	Deep Creek (Dolores)	3	2
Big Ck	140100051710	Big Creek, East Fork	3	4
Paonia Reservoir C	140200041104	Deep Creek	4	4

Expansion of CRCT populations

Population and distribution goals and objectives described in the CAS have not been attained in the Colorado, Dolores or Gunnison GMUs. The Forest is a key player in attainment of these goals, particularly in providing high quality habitat and in re-establishment of meta-populations in cooperation with CDOW. Several streams have been identified by CDOW and Forest Service biologists as having the greatest potential for expansion of CRCT populations (Table 8). This list is not intended to be an exhaustive list of potential expansion sites and is subject to change, as additional information is made available. Watersheds included are a combination of 7th and 6th level HUCs where expansion of existing populations to connect them to other existing populations is technically feasible (Figure 8). Five of the proposed expansion watersheds are in the Gunnison GMU and one (Fall and Elk Creeks) watershed occur in the Delores GMU. All six potential expansion areas are in watershed integrity Class I or II. Land management activities in these watersheds should be compatible with direction provided in the CAS to ensure high quality habitat for future CRCT populations.

Table 8. Sixth-level HUCs determined potentially suitable for establishment of CRCT meta-populations on the GMUG.

Stream Name	HUC Code	Watershed Integrity Class	Comments
Fall Creek, Elk Creek, and Woods Lake.	14030003630802 14030003630803	II	Several miles of Elk Creek currently support a CRCT population. Reclamation of upper Fall Creek and Woods Lake is considered technically feasible.
Clear Fork Muddy Creek including Trail Gulch and Rock Creeks	14020004090301 14020004090302 140200040903003	I	Has one of the highest potentials for expansion by combining existing populations in Trail Gulch and Rock Creeks. Other

			tributaries in the watershed are believed to contain CRCT of unknown genetic purity.
Razor Creek and tributaries.	140200035101	II	Razor Creek and tributaries are currently unoccupied by CRCT but provides suitable habitat and is technically feasible to restore CRCT.
Beaver Creeks including Deer Beaver and South Beaver Creeks.	140200025001	I	High potential for link existing CRCT populations in 2 7th field watersheds to create a meta-population.
Beaver Creek including North and West Beaver Creeks.	140200020310	I	Because of the miles of currently occupied habitat in the watershed, this HUC is a high priority for establishment of a meta-population. Issues complicating establishment of a meta-population include large numbers of brook trout in lower Beaver Creek and a barrier that prevents access to most of West Beaver Creek.
Upper West Muddy Creek and tributaries including Dyke Creek.	14020004550201 14020004550202	I	Strong population of CRCT currently exists in Dyke Creek, which provides an opportunity to expand the population into West Muddy Creek. Brook and CRCT have been observed in West Muddy Creek but the number of fish and purity are unknown.
Tribs to North Anthrocycte including Gold, Sardine, Silver and Middle Anthrocycte Creeks		II	Strong populations in Anthrocycte Creek which provides opportunites to expand populations into numerous tributaries in the watershed.
Deep Ck including	140300036305	III	

South Fork Deep – tributaries to San Miguel River			

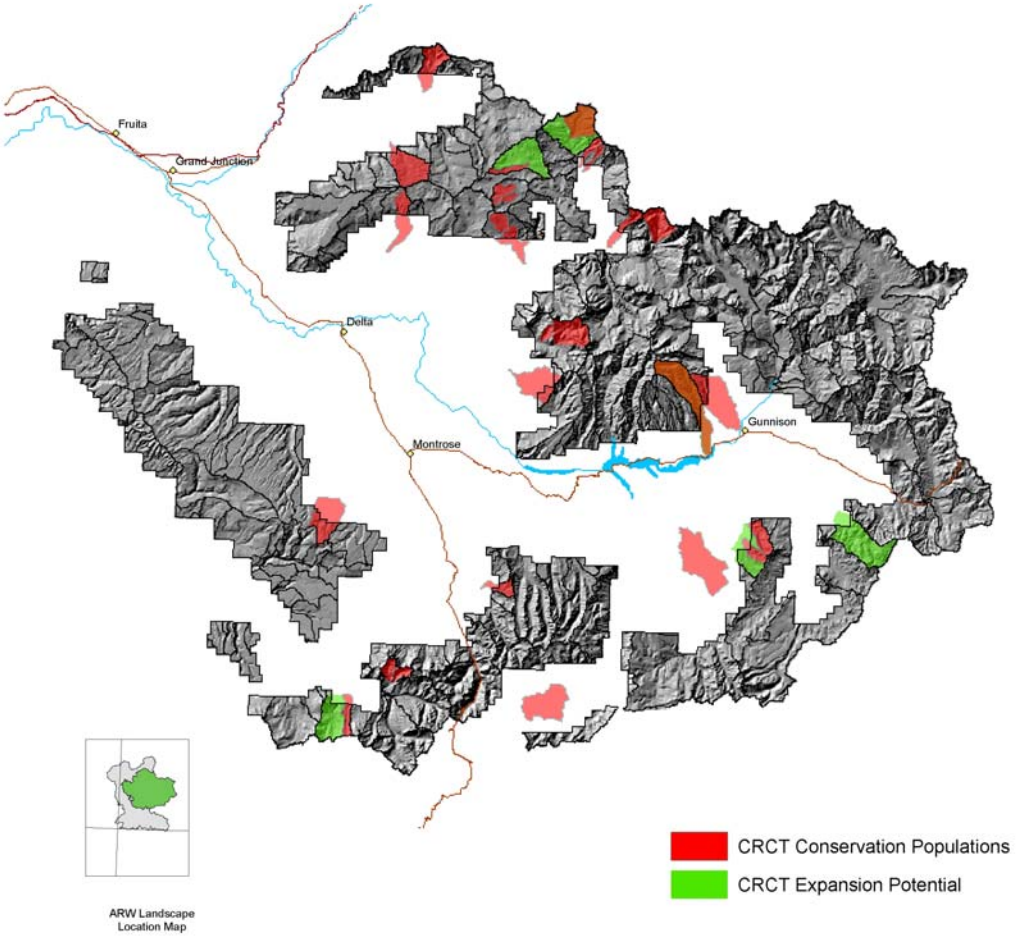

Figure 8. Subwatersheds currently supporting Conservation populations of CRCT and watersheds where expansion of CRCT may be feasible to establish metapopulations.

Information Needs

A thorough assessment of research needs for improving the understanding of CRCT life-history stages and habitat requirements has been identified in Young (1995). In summary, research needs include: Life history variation between populations and how has this variation been affected by land management activities; Information on migration, seasonal dispersal, and risk of extinction; What environmental factors affect abundance; and Historical information on how the species has responded to natural disturbances.

Locally, the Forest needs to continue to inventory current habitat conditions in CRCT Conservation Population streams, monitor abundance and distribution during the course of the revised Forest Plan, and work in cooperation with CDOW to validate suitability of proposed expansion sites. Additional work should focus on remediation of immediate threats to existing Conservation Populations, and expanding current populations.

Literature Cited

Behnke, R.J. 1992. Native trout of western North America. American Fisheries Society Monograph 6.

Behnke, R.J. and M. Zarn. 1976. Biological management of threatened and endangered trouts. USDS Forest Service, Rocky Mountain Forest and Range Experimental Station, Fort Collins, CO. General Technical Report RM-28.

Bjornn T.C. and J. Mallet 1964. Movements of planted and wild trout in an Idaho River system. Transactions of the American Fisheries Society 93:70-76.

Bjornn T.C. and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. *In* Meehan 1991.

Bozek M.A., L.D. Debrey, and J.A Lockwood. 1994. Diet overlap among size classes of Colorado River cutthroat trout in a high elevation mountain stream. Hydrobiologia 273:9-17.

Bradford Dave. Range Conservationist, U.S. Department of Agriculture, Forest Service, Paonia Ranger District, Paonia, CO.

Colborn L.G. 1966. The limnology and cutthroat trout fishery of Trappers Lake. Colorado Department of Game, Fish, and Parks, Denver, CO. Fisheries Research Division Special Report 9.

Colorado Division of Wildlife. 2003. Colorado River cutthroat trout management in western Colorado during 1999-2002. D.Brauch and S. Hebein editors. Colorado Department of Natural Resources Colorado Division of Wildlife Denver, CO.

CRCT Task Force. 2001. Conservation Agreement and Strategy for Colorado River cutthroat trout (Oncorhynchus clarki pleuriticus) in the states of Colorado, Utah, and Wyoming, 2001.

Cope, O. B. 1957. The choice of spawning sites by cutthroat trout. Proc. Utah Acad. Sci. Arts, and Letters 34:73-79.

Dwyer, P. D. and R. H. Kramer. 1975. The influence of temperature on scope for activity in cutthroat trout, Salmo clarki. Transactions of American Fisheries Society 104(3):552-554.

Eiserman, F. 1958. A fisheries survey of the Little Snake River drainage, Wyoming Game and Fish Commission, Cheyenne. Fisheries Technical Report 6.

Furniss, M. J. T.D. Roelofs, and C. S. Yee. 1991. Road Construction and Maintenance. *In Meehan 1991*.

Giger, R. D. 1972. Ecology and mangement of coastal cutthroat trout in Oregon. Oregon Game Comission., Corvallis, OR. Fish Res. Report 6. 61pp.

Gresswell, R.E. 1995. Yellowstone cutthroat trout. In Conservation Assessment for Inland Cutthroat Trout. General Tech. Report RM-GTR-256. USDA Forest Service. February 1995.

Harig, A.L. and K.D. Fausch. 2002. Minimum habitat requirements for establishing Translocated cutthroat trout populations. Ecological Applications 12(2) 2002 535-551.

Herger, L. G. 1993. Assessment of the basin-wide inventory technique relative to Colorado River cutthroat trout. Master's Thesis, University of Wyoming, Larimie.

Hickman, T. and R. F. Raleigh. 1982. Habitat suitability index models: Cutthroat trout. USDIFish and Wildlife Service. FWS/OBS-82/10.5.

Horan, D.L, and 3 others. 2000. Effects of habitat area and complexity on Colorado River cutthroat trout density in Uinta Mountain Streams. Trans. Am. Fish Soc. 129:1250-1263.

James, Christopher. 2003. An assessment of fish habitat, distribution, and abundance of Colorado River cutthroat trout on the Grand Mesa, Uncompahgre, and Gunnison National Forests, 2001-02. Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Ouray Ranger District, Montrose, CO.

Kershner, J.L. Bonneville cutthroat trout. In Conservation Assessment for Inland Cutthroat Trout. General Tech. Report RM-GTR-256. USDA Forest Service. February 1995.

Lewynsky, V.A. 1986. Evaluation of special angling regulations in he Coeur d'Alene River trout fishery. Master's thesis. University of Idaho, Moscow.

Markiw, M.E. 1992. Salmonid whirling disease. Washington D.C.: U.S. Department of Interior, U.S. Fish and Wildlife Service, Fish and Wildlife Leaflet 17.

Martinez, A.M. 1988. Identification and status of Colorado River cutthroat trout in Colorado. American Fisheries Society Symposium 4:81-89.

McIntyre J.D. and B.E. Rieman. Westslope cutthroat trout. In Conservation Assessment for Inland Cutthroat Trout. General Tech. Report RM-GTR-256. USDA Forest Service. February 1995.

Meehan, W.R. 1991. Influences of Forest and Rangeland Management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19.

Myers, L.S., T.F. Thuelmer, and G.W. Kornely. 1992. Seasonal movements of brown trout in northeast Wisconsin. North American Journal of Fisheries Management 12:433-441.

Nehring B. 1998. Stream fisheries investigations. Special regulations evaluations. Colorado Division of Wildlife Job 2 Final Report, Fed. Aid Proj. F-237. 138 pp.

Oberholtzer, M. 1990. Current status of Colorado River cutthroat trout in the Little Snake River drainage, Carbon County, Wyoming. Fish Division, Wyoming Game and Fish Department, Cheyenne. Project 5086-01-8501.

Platts, W.S. 1991. Livestock grazing. *In* Meehan 1991.

Rinne, J.R. 1995. Rio Grande cutthroat trout. In Conservation Assessment for Inland Cutthroat Trout. General Tech. Report RM-GTR-256. USDA Forest Service. February 1995.

Scott W.B. and E.J. Crossman 1973. Freshwater fishes of Canada. Fish. Res. Board Can. Bull. 184. 966 pp.

Simon, J.R. 1935. A survey of waters of the Wyoming National Forest. U.S. Department of Commerce, Bureau of Fishes, Washington D.C.

Snyder G.R. and H.A Tanner. 1960. Cutthroat trout reproduction in the inlets to Trappers Lake. Colorado Department of Game, Fish, and Parks, Denver, CO Fisheries Research Division Special Report 7.

U.S. Department of Agriculture 2001. Management Indicator Species Assessment. Grand Mesa, Uncompahgre, and Gunnison National Forests, Version 1.0. Delta, CO. Pages 115-129.

U.S. Forest Service, Rocky Mountain Region 2001. Watershed Conservation Handbook (FSH 2509.25-2001-1), Rocky Mountain Region, Denver, CO.

U.S. Forest Service, Grand Mesa, Uncompahgre and Gunnision National Forests, in draft. Comprehensive Evaluation Report for Aquatic Resources.

U.S. Forest Service, Grand Mesa, Uncompahgre and Gunnision National Forests, in draft. Ecological Driver Analysis for the GMUG and San Juan National Forests.

Wang, Andrea and Annette Lambert. 1999. Surveys and sampling for Colorado River cutthroat trout on the Grand Mesa, Uncompahgre, and Gunnison National Forests 1999. Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Paonia Ranger District, Paonia, CO.

Wiltzius, W.J. 1985. Fish culture and stocking in Colorado, 1872-1978. Colorado Division of Wildlife, Fort Collins, Division Report 12.

Young, M.K. 1989. Effects of substrate composition on the survival to emergence of Colorado River cutthroat trout and brown trout. Doctoral dissertation, University of Wyoming, Laramie.

Young, M.K. 1995. Colorado River cutthroat trout. In Conservation Assessment for Inland Cutthroat Trout. General Tech. Report RM-GTR-256. USDA Forest Service. February 1995.

Young, M.K., W.A. Hubert, and T.A. Wesche. 1991. Selection of measures of substrate composition to estimate survival to emergence of salmonids and to detect changes in stream substrates. North American Journal of Fisheries Management 11:339-346.

Definitions

Conservation Populations: The CRCT Task Force (2001) has defined conservation populations as those CRCT populations with less than 10 percent introgression (90% genetically pure Colorado River cutthroat trout genes). Reducing threats and increasing the distribution and abundance of self-sustaining conservation populations is the primary objective of the recovery plan.

Hybrid: an individual fish, not a population, that has cross-bred with other salmonids, commonly rainbow trout or other cutthroat trout species.

Hydrograph: chart that depicts stream discharge rate versus time.

Introgression: reproduction between a native cutthroat trout subspecies and other cutthroat trout subspecies (intra-specific) or other salmonid species (inter-specific), and occurs in varying degrees among populations.

Life history: the series of living phenomena exhibited by a fish in the course of its development from conception to death.

Reach: section of a stream between two specified points that has a consistent slope and complement of habitat units.

Redd: nest made in gravel, consisting of a depression hydraulically dug by a fish for egg deposition (and then filled) and associated gravel mound.

Residual Pool Depth: depth of pool independent of flow. Obtained by subtracting the depth of the pool tail crest from the maximum pool depth.

Salmonid: fish of the family Salmonidae, including salmon, trout, chars, whitefish, ciscoes, and grayling. In general usage, the term most often refers to salmon, trout, and chars.

Sympatric: co-occurring in the same area.