Greenback Cutthroat Trout
(Oncorhynchus clarki stomias)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Colorado Field Office
Lakewood, Colorado

May 2009

5-YEAR REVIEW
Greenback cutthroat trout *(Oncorhynchus clarki stomias)*

1.0. GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office: Mountain-Prairie Regional Office
Bridget Fahey, Regional Endangered Species Chief, 303/236-4258
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Lead Field Office: Colorado Ecological Services Field Office
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1.2 Methodology Used To Complete The Review

This 5-year review was initiated on December 14, 2005 (70 FR 74030). The review was conducted primarily by the Colorado Field Office, although preliminary information was gathered by a student volunteer from Denver University. Materials used as the basis for information contained in this review included occurrence and stocking records, monitoring data, annual reports and maps provided by the Colorado Division of Wildlife (CDOW), Bureau of Land Management (BLM), National Park Service (NPS), and U.S. Forest Service (USFS). Published papers and reports also were provided by researchers representing Trout Unlimited, Colorado State University, the University of Colorado, New Mexico State University, Brigham Young University, the USFS Rocky Mountain Research Station, and Pisces Molecular, a private company. Information in U.S. Fish and Wildlife Service (Service/USFWS) files such as section 7 consultations also were used in the threats assessment. A public comment period and request for information extended from December 15, 2005, to February 14, 2006. Information received included updated reports from land management agencies, new regulations regarding management of cutthroat trout from CDOW, and a report on the effects of global warming on trout and salmon species. The Service solicited peer review of the science relevant to the Draft Greenback cutthroat trout 5-year review. Review packets were sent to four experts.

1.3 Background

1.3.1 Federal Register Notice Citation Announcing Initiation Of This Review

70 FR 74030, December 14, 2005

1.3.2 Listing History

<u>Original Listing</u>
FR notice: 32 FR 4001, March 11, 1967
Entity listed: Subspecies
Classification: Endangered rangewide

Revised Listings
FR notice: 39 FR 1175, January 4, 1974
Entity listed: Subspecies
Classification: Endangered rangewide
FR notice: 43 FR 16343, April 18, 1978
Entity listed: Subspecies
Classification: Threatened rangewide

1.3.3 Associated Rulemakings
43 FR 16343, April 18, 1978 -- 4(d) rule

1.3.4 Review History
Historic 5-year reviews for all species have been initiated by the Service's Washington, D.C., office (44 FR 29566, May 21, 1979; 50 FR 29901, July 22, 1985; 56 FR 56882, November 6, 1991). The subspecies' status also was considered in the 1977, 1983, and 1998 recovery plans (USFWS 1977, 1983, 1998).

1.3.5 Species' Recovery Priority Number At Start Of This 5-Year Review
At the start of the 5-year review, the Recovery Priority Number for the greenback cutthroat trout (greenback) was 15. This indicated: (1) populations face a low degree of threat; (2) recovery potential is high; and (3) the entity is listed at the subspecies level.

Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic Genus	1	1C
		Species	2	2C
		Subspecies/DPS	3	3C
	Low	Monotypic Genus	4	4C
		Species	5	5C
		Subspecies/DPS	6	6C
Moderate	High	Monotypic Genus	7	7C
		Species	8	8C
		Subspecies/DPS	9	9C
	Low	Monotypic Genus	10	10C
		Species	11	11C
		Subspecies/DPS	12	12C
Low	**High**	Monotypic Genus	13	13C
		Species	14	14C
		Subspecies/DPS	**15***	15C
	Low	Monotypic Genus	16	16C
		Species	17	17C
		Subspecies/DPS	18	18C

1.3.6 Current Recovery Plan
Name of Plan: Greenback Cutthroat Trout Recovery Plan
Date Issued: March 1998
Dates of previous revisions: November 11, 1977; September 30, 1983

2.0 REVIEW ANALYSIS

2.1 Application Of The 1996 Distinct Population Segment Policy

2.1.1 Is The Species Under Review A Vertebrate?
_X_ Yes
____ No

2.1.2 Is The Species Under Review Listed As A Distinct Population Segment?

____ Yes

_X_ No

2.1.3 Is There Relevant New Information For This Species Regarding The Application Of The DPS Policy?

____ Yes

_X_ No

2.2 Recovery Criteria

2.2.1 Does The Species Have A Final, Approved Recovery Plan Containing Objective, Measurable Criteria?

_X_ Yes

____ No

2.2.2 Adequacy Of Recovery Criteria

2.2.2.1 Do The Recovery Criteria Reflect The Best Available And Most Up-To-Date Information On The Biology Of The Species And Its Habitat?

___ Yes

_X_ No

2.2.2.2 Are All Of The 5 Listing Factors That Are Relevant To The Species Addressed In The Recovery Criteria?

___ Yes

_X_ No– At the time of Recovery Plan development, the main reasons cited for the subspecies' decline were hybridization, competition with nonnative salmonids, and overharvest (USFWS 1998). New threats have arisen, or have become more prevalent, which were not adequately addressed in the 1998 Recovery Plan. These include the effects of fire and firefighting with chemical retardants; increased human population growth within the range of the subspecies along with potential for new water depletions; new introductions of nonnative species; fragmentation and genetic isolation of small populations; and the effects of global climate change.

2.2.3 List The Recovery Criteria As They Appear In The Recovery Plan, And Discuss How Each Criterion Has Or Has Not Been Met, Citing Information

The following summary highlights the criterion, the specific tasks called for in the Recovery Plan, and the status of each task:

Note: Since 2006, a number of studies have been undertaken to try to determine the genetic relationships between greenback, Colorado River (*O. clarki pleuriticus*), and Rio Grande *(O. clarki virginalis)* cutthroat trout (Mitton et al. 2006, Metcalf et al. 2007, Metcalf 2007, Rogers 2008). The results of these studies are not conclusive in terms of the genetic identities of the greenback and the Colorado River cutthroat trout. Further information needs have been identified to help resolve this issue, and include: 1) an expanded analysis of cutthroat DNA from museum specimens collected in the 1800s; and 2) an analysis of physical differences (morphology and meristics) between the three DNA lineages of cutthroat trout occurring in Colorado. At this time, the recovery criteria and classification categories (Type A, B, C) identified in the Recovery Plan remain in place, but it is not possible to determine how many populations of each type currently occur in the wild due to the uncertainty of the new genetic information. Once the taxonomic issue is resolved these categories and the recovery criteria can be revisited.

Criterion 1. Maintain or enhance all known Type A greenback populations. The 1998 Recovery Plan defines Type A greenback populations as those that are considered to be genetically pure. The Recovery Plan states that all streams that contain Type A greenbacks should be censused at least once every 3 years, with an evaluation of numbers, age and condition of fish; and condition of the habitat. Since completion of the Recovery Plan, sampling has been conducted by standardized methods, including two-pass depletion sampling for streams, and mark-recapture and sonar for lakes. Frequency of sampling and reporting has varied by agency. However, habitat and population data was summarized for all populations in January 2007 using the Inland Cutthroat Trout range-wide protocol (Western Native Trout Initiative (WNTI) 2007). This summary documented 145 populations, considered to be Type A at the time, in 227.7 kilometers (km) of streams and 166.74 hectares (ha) of lakes, within greenback historic range on the eastern side of the Continental Divide (Albeke 2008). The data has been incorporated into this 5-year review (see Appendix 1 at the end of this document).

When necessary or appropriate, habitat that is below its potential is restored through physical manipulation. As an example, several dams built to increase the water storage of natural lakes within Rocky Mountain

National Park (RMNP) prior to 1915 have been removed. Restoration has included nonnative fish removal, greenback reintroduction, and monitoring of fish populations and habitat. The earthen dam on Lawn Lake failed in 1982. The remaining portion of the Lawn Lake dam and outlet structure was recently removed in order to improve fish passage between the lake and the stream. The stream below Lawn Lake has been allowed to recover on its own. It currently supports a self-sustaining population of greenbacks.

Stream barriers are essential to prevent invasions of undesirable fish into greenback habitat. Natural barriers are used where possible. These are inspected periodically to ensure effectiveness. Artificial barriers have been constructed when no natural barriers are available. Two natural barriers have been improved within RMNP since 1998. The 2007 database showed that 69% of habitat occupied by populations considered to be Type A greenbacks at that time was judged to be in either excellent (26%) or good (44%) condition (WNTI 2007). Only 12 of the identified populations occurred in the absence of a total barrier that would provide substantial protection from nonnative fish competition and disease.

Land use practices, including grazing, silviculture, mining, road construction, and recreational activities are reviewed regularly to ensure that they do not negatively impact greenbacks. Buffer strips along streams are encouraged to protect important riparian habitats. Coordination is facilitated through recovery team meetings; USFS, BLM, and NPS Management Plans; National Environmental Policy Act (NEPA) documents; and Endangered Species Act (ESA) section 7 consultations. While section 7 consultations are not considered recovery actions, they are a useful tool for implementing conservation measures to avoid or minimize take of the subspecies through habitat disturbance or actions that could cause direct take of individuals.

Although at this time we cannot determine with certainty which populations would meet a Type A definition, all populations previously deemed to be Type A continue to be monitored, and habitat enhancement is being accomplished as determined to be necessary.

Criterion 2. Establish or document the existence of 20 stable populations of pure (Type A) greenback within the subspecies' historic range. Recovery criteria call for 20 stable Type A greenback populations occupying at least 50 ha (124 acres (ac)) of lakes and 50 km (31 miles (mi)) of streams. At least 5 of these stable populations need to occur in the Arkansas River drainage. A greenback population is considered stable when there are a minimum of 22 kilograms (kg) of fish per hectare of habitat through natural reproduction. The populations should consist of a minimum of 500 adults greater than 120 millimeters (mm) in total length, and represent a minimum of 2-year classes within a 5-year period (USFWS 1998).

At the time the 1998 Recovery Plan was written, it was determined that there were Type A greenbacks present within 179 ha (442 ac) of lakes and 164 km (102 mi) of stream habitat. Although many of these areas included low density or non-reproducing populations, 17 stable Type A populations were located in the South Platte drainage and 3 stable Type A populations were present in the Arkansas drainage (USFWS 1998). In 2007, there were 167 ha of occupied lakes and 228 km of occupied streams containing what were considered to be Type A fish (Appendix 1). The drop in occupied hectares of lakes from 1998 to 2008 is due to renovation of two reservoirs (65 ha), which are anticipated to be restocked with pure greenbacks in the near future.

In order to achieve this criterion, the recovery partners (CDOW, BLM, NPS, USFS, USFWS) have continued to systematically search for historic populations of greenbacks that may still exist; have maintained a list of candidate aquatic habitats that could potentially support the subspecies; have prepared those habitats as appropriate, taking into account landowner or land manager goals; have reintroduced what were believed to be Type A greenbacks from wild populations or hatchery stocks; have monitored the success of these reintroductions; and have annually updated the greenback population status (See Appendix 1).

Translocation of fish believed to meet the Type A criteria has been one of the key methods for reintroducing greenbacks into the wild. Much research has been devoted to translocation success since the development of the 1998 Recovery Plan. Harig and Fausch (2002) claim that translocation is an important management strategy in the conservation of threatened and endangered species. However, translocations often fail for two main reasons: the reinvasion of nonnative salmonids, and the presence of unsuitable habitat (Harig et al. 2000b).

The establishment of new greenback populations by translocation can occur in “fishless” waters, but most often fish are introduced into waters above a permanent fish barrier where nonnative fish have been removed. When selecting habitats above barriers, it is important that sufficient habitat exists to support a minimum recovery population (a minimum of 500 adults greater than 120 millimeters (mm) in total length, and a minimum of 2-year classes represented within a 5-year period).

Stream barriers are essential to prevent invasions of nonnative fish, diseases, and nonnative invasive species into the habitat of greenback. Natural barriers are inspected periodically for their effectiveness and stability. Although natural barriers are strongly preferred, artificial barriers may be constructed when necessary and should be inspected regularly. To date, few artificial stream barriers have been used for greenback projects, and most appear to have been successful in preventing upstream movement by nonnatives.

This criterion was considered to have been met in the South Platte drainage, and was close to being met in the Arkansas River drainage, prior to questions arising regarding the genetic status of greenback populations (see section 2.3.1.3. below). The number of qualifying Type A populations and their distribution will need to be reassessed once a determination is made as to which populations qualify as greenbacks.

Criterion 3. Establish hatchery and wild populations of pure (Type A) greenback broodstock. Under the 1998 definition of what determined a Type A population, this criterion had been met. Given current genetic uncertainties (see section 2.3.1.3), we cannot make a determination of accomplishment at this time. Within the South Platte River drainage Bear Lake, Upper Hutcheson Lake, Zimmerman Lake, Como Creek, and Hunters Creek were identified as suitable wild broodstock sources. In the Arkansas River drainage, eggs were collected from South Apache Creek and Boehmer Reservoir.

Captive broodstocks from several wild populations have been established at several CDOW hatcheries, including Pitkin, Salida, and Bellview. All hatcheries involved in the program prepare annual reports. Progeny from these facilities have been used both to initiate new stocking efforts following habitat restoration and to supplement existing populations. Milt (the sperm-containing fluid of a male fish) from wild populations has been used for fertilization of hatchery ova to minimize genetic drift. Hatchery stocks are routinely replaced with wild fertilized eggs in order to maintain a wild stock, and prevent domestication of hatchery stocks.

As new genetic information has become available, greenback broodstocks have been adjusted to provide the best available source of pure fish for restoration purposes. It is anticipated that this trend will continue, with hatchery stocks used for restoration purposes representing the best available genetics and morphology.

Criterion 4. Document response to angler pressure, stocking rates, fish diseases, fishing regulations, and native non-salmonids. Research has been conducted on a mixed brook trout (*Salvelinus fontinalis*) greenback fishery to determine if special regulations requiring catch-and-kill of brook trout and catch-and-release for greenbacks would benefit greenbacks within stream habitats. Although the species co-existed, the special regulations did not appear to result in long term improvement for the stream population of greenbacks (Rosenlund et al. 2001). The WNTI (2007) data compilation identified only 11 greenback populations which were coexisting with nonnative salmonid species. It also showed that the majority of populations had a limited or minimal risk of being influenced by disease. Although not a formal study, greenbacks and Arkansas darters (*Etheostoma cragini)* coexisted in a small pond for over 10 years (Kennedy 2005), showing that greenbacks can co-exist with native non-salmonids.

Under the subspecies' 4(d) rule (50 CFR 17.44 (f)) numerous ponds, lakes, and creeks have been opened to catch-and-release greenback fishing. These include 12 areas in RMNP, 1 stream on the Arapaho-Roosevelt National Forest, 2 Fort Carson ponds not operated for sport fishing since 1998, and 6 lakes and streams on the Pike–San Isabel National Forest. Within RMNP, angler interviews conducted from 1998 to 2007 showed an average catch rate of 1.86 fish per hour over that 10-year period for all of the RMNP's greenback populations (Rosenlund pers. comm. 2008).

Multiple research stocking sites have been established in both the South Platte and Arkansas River drainages to evaluate stocking rates, and angling programs compared with other sport fish species. For research stockings of greenbacks, CDOW (Kehmeier pers. comm. 2008) reported no significant loss of fish per mile or biomass compared to other trout species, and a catch rate of approximately 10 fish per hour for areas where creel census (examination of fishers' catch to determine success per level of effort) was conducted. The CDOW and NPS enforce applicable regulations, and fishing closures on greenback water bodies within their jurisdictions.

This criterion has been achieved. Research and monitoring will continue as appropriate.

Criterion 5. Conduct an information and education program. The various recovery partner agencies have coordinated information and education efforts and promoted cooperation and cost-sharing in carrying out recovery plan tasks. The most visible of these efforts include the greenback brochure, greenback art work, and greenback bumper stickers. Funding for these efforts has been provided by individuals, agencies and Colorado Trout Unlimited. The recovery team meets at least once annually to bring all members up to speed on agency activities and to discuss new information and policy issues. Recovery activities are presented to other agency and interest groups as opportunities arise.

In 1994, the Colorado Legislature designated the greenback as Colorado's State fish. A display describing the history, biology and ecology of greenback was developed. At least two copies of the display remain, and it is available from the Service. It is suitable for both technical and non-technical meetings.

The RMNP provides interpretive signs at several sites throughout, and in partnership with the local Trout Unlimited Chapter, provides a variety of outreach opportunities for visitors. The RMNP also provides opportunities for the public to view greenbacks from observation areas at several alpine lakes during spawning season. Viewing opportunities include one roadside location (Lily Lake), and several back-country lakes (Odessa, Fern, Dream, Lawn). Public education also is important in preventing the introduction of non-desirable species into occupied greenback habitat.

While many educational and outreach efforts have been documented, these efforts will continue while the subspecies remains listed.

Criterion 6. Promote partnerships with conservation groups and explore alternative management and funding strategies. Effective partnerships have been developed with Colorado Trout Unlimited and the Rocky Mountain Nature Association. These partnerships have resulted in hundreds of volunteer hours each year in support of native fish work within RMNP. Volunteers at RMNP educate anglers about greenback, assist with fish surveys and make sure appropriate fishing regulations (catch-and-release, barbless hooks, etc.) are being followed to reduce damage to the fish. Almost 2,000 hours of greenback-related volunteer time has been donated at RMNP since 1998 (Watry pers. comm. 2008). In addition, Colorado Trout Unlimited Chapters have purchased chemicals for fish restoration projects.

These efforts remain ongoing. Funding opportunities will continue to be explored with groups such as Colorado Trout Unlimited, the Rocky Mountain Nature Association, and WNTI.

Criterion 7. Prepare a long-term management plan and cooperative management agreement for the greenback. An outline of a long-term agreement and plan was developed by the USFS in 2004, with the life history and ecology section of the long-term plan completed (Coleman 2007). This process has been put on hold until genetic and taxonomic issues are sorted out. When finalized, in compliance with Service planning guidance, the plan will serve as the post-delisting monitoring and management agreement. Conservation efforts needed to address new and likely future threats can be addressed during the development and implementation of the long term plan.

2.3 Updated Information And Current Species Status

2.3.1 Biology And Habitat

2.3.1.1 New Information On The Species' Biology And Life History

Since completion of the 1998 Recovery Plan, extensive study has been devoted to determining how habitat quality and translocation success are related. Harig and Fausch (2002) developed a model, based on a comparative field study, which predicted that cold summer water temperature, narrow stream width, and lack of deep pools limited translocation success of the greenback. Young and Guenther-Gloss (2004) evaluated the model developed by Harig and Fausch (2002), and found a positive correlation between the three model components and greenback abundance. Field studies conducted on factors limiting cutthroat trout recruitment success into translocation streams in RMNP, and several national forests, suggest that low water temperatures (averaging 7.8°C or below in July) may have an adverse effect on greenback fry (young fish) survival and recruitment (Coleman and Fausch 2007a, b). They also found that stream flows may influence recruitment and growth of cutthroat fry. Coleman and Fausch (2007a, b) found that streams that accumulate 900 to 1,200°C-days cumulatively during the growing season afforded the best opportunity for cutthroat trout recruitment and translocation success.

2.3.1.2 Abundance, Population Trends, Demographic Features, Or Demographic Trends

Prior to the acquisition of recent genetics data (discussed below in section 2.3.1.3), it was believed that existing populations exceeded the recovery goal, with approximately 166.7 ha of lakes and 227.7 km of stream habitat occupied (Appendix 1). The Recovery Plan (USFWS 1998) defines a recovery population as an occupied stream segment of greater than 2 km or containing 500 or more fish greater than 120 mm in total length. It is possible to have more than one population in a single stream if the populations are separated by barriers and individually meet the recovery population definition. Given the genetic uncertainty of greenback populations, we are unable to determine how many recovery populations currently exist.

2.3.1.3 Genetics, Genetic Variation, Or Trends In Genetic Variation

When the greenback was listed in the 1970s, morphology and meristic analysis was a prominent genetic determinant, based on phenotypic expression, which included spotting patterns, number of scales, coloration, number of basiobranchial teeth, etc. (Policky et al. 2003). Morphology and meristics were used to rank fish populations with a letter ranging from A (pure) to C (obvious hybrid) (USFWS 1998). The 1998 Recovery Plan mainly utilized morphology for determining the purity of greenback populations, but protein electrophoresis and mitochondrial transfer DNA (mtDNA) also were used to make recommendations on keeping the South Platte and Arkansas River drainages stocks separate.

Some of the first genetic analysis completed was University of Montana's electrophoresis work (Kanda and Leary 1999a, 1999b, 1999c, 2000). More recently, techniques for genetic analysis have focused on mtDNA and nuclear DNA (nDNA). The following paragraphs summarize the most recent mtDNA and nDNA genetic information.

Martin et al. (2005) described the extent of hybridization between natural populations of greenback and nonnative salmonids in RMNP. The RMNP has been cited as having the most native populations of the greenback, and a majority of the known South Platte populations are located there (Albeke 2008). Using mtDNA and nDNA analysis, Martin et al. (2005) found that the historic populations located within the RMNP had "significant genetic variation, implying the populations are genetically healthy." Overall, the greenback populations within RMNP appeared to be free of contamination (introgression) from nonnatives, such as rainbow trout (*Oncorhynchus mykiss*). Further study within 12 populations (3 in the South Platte and 9 in Arkansas River) indicated that 3 populations showed evidence of nonnative alleles from Yellowstone cutthroat trout (*O. clarki bouvieri*).

Martin (2005) also analyzed restoration populations of hatchery reared, hybrid, and historic populations of greenback within Como Creek (which had been identified as one of the best restoration populations). The major histocompatibility complex (MHC) gene family, involved with immune function, was utilized to determine if hatchery reared populations used for restoration had a genetic bottleneck due to lack of genetic diversity. The study was based on earlier findings that populations that have experienced severe bottlenecks sometimes harbor low levels of MHC diversity. Initial results on the Como Creek population indicated a "tremendous MHC diversity," while various restoration projects using Como Creek fish showed different levels of MHC diversity (Martin 2005). Additional work indicated that pure populations of RMNP greenbacks (some founded from Como Creek) had the lowest genetic variation, while populations with evidence of hybridization tended to exhibit higher levels of genetic variation (Martin 2008).

Mitton et al. (2006) performed research to clarify the taxonomic status of greenback. Mitton et al. (2006) used mtDNA analysis and phylogenetic relationships to determine if a subspecies status was warranted. Their study concluded that the Colorado River, Rio Grande, and greenback appeared to be very closely related. Specifically, they found that the three subspecies shared haplotypes and closely related haplotypes. Although their data was never published, Mitton et al. (2006) concluded that it did not support subspecific designations for Colorado River, greenback, and Rio Grande cutthroat. Their conclusion is consistent with previous assertions that Rio Grande and greenback recently evolved from Colorado River cutthroat trout through geographic isolation, and are in the process of diverging (Behnke 1992).

In a 2007 study, Metcalf et al. used molecular markers from the mitochondrial and nuclear genomes to analyze individuals from greenback and Colorado River cutthroat trout. Colorado River cutthroat trout are native to the Colorado River basin. See Map 1 for the historic distribution of the three cutthroat trout subspecies occurring in Colorado (from Behnke 1992). Phylogenetic analysis of the combined cytochrome oxidase I (COI) and nicotinamide adenine dinucleotide dehydrogenase 2 (ND2) mitochondrial gene sequences (n=1530 base pairs) revealed two divergent lineages within the ranges of greenback and Colorado River cutthroat trout consisting of 10 unique haplotypes. The average uncorrected sequence divergence between the two lineages was 1.7%, which is similar to divergence found among haplotypes of other cutthroat trout subspecies. Metcalf et al. (2007) determined that these two lineages corresponded with the two described subspecies.

However, the divergent evolutionary lineages defined by mitochondrial and nuclear DNA markers did not separate geographically on either side of the Continental Divide as expected (see Map 1). Results showed five populations with what the authors felt were Colorado River cutthroat trout genetic markers on the east side of the Continental Divide and one population with what they felt were greenback genetic markers occurring on the West slope of Colorado, in what should be Colorado River cutthroat habitat.

Subsequent sampling and analysis found that of 45 putative Colorado River cutthroat populations, 12 assigned to the greenback reference sample. In addition, of 12 putative greenback populations, 11 assigned to the Colorado River cutthroat trout (Rogers 2008). Additional sampling indicated that around 30 populations within the range of the Colorado River cutthroat trout assigned to the greenback sample. Metcalf et al. (2007) postulated that the reason for these unexpected results was the introduction of Colorado River cutthroats into the greenback range in the late 19th and early 20th centuries, and vise versa. However, we believe that assigning existing populations to specific subspecies based upon genetic markers found in a few existing reference populations may be subjective. The actual distribution of these markers per subspecies may possibly only be resolved by analyzing the few preserved cutthroat trout samples collected in the 1800s. Collection and analysis of these samples is ongoing. This project is technically difficult, complicated by few samples, poor storage/preservation and years of handling by museum staff. The Service is still looking for funding for this, and results of this project will likely not be available for at least 2 years.

The issue of DNA assignment to subspecies to either greenback or Colorado River cutthroats also appears to be further complicated by conflicting results between mtDNA and nDNA. Examples include Columbine Creek, within the Colorado River drainage and Como Creek within the South Platte drainage. In Columbine Creek, the University of Colorado reported that mtDNA (passed down exclusively from the mother) assigned the wild population to 95% greenback, while the nDNA (AFLP & microsatellites) assigned the population as 93% Colorado River cutthroat trout (Metcalf 2007). Metcalf et al. (2007) felt that Como Creek "appears to be greenback cutthroat trout" but subsequent AFLP analysis assigned Como Creek to Colorado River cutthroat trout (Rogers 2008). Additional work by the University of Colorado determined that the Fern Lake greenback restoration project that was founded from Como Creek fish, "meet the expectations of a pure *O.c. stomias* population" (Martin 2008). The reasons for the Columbine, Como, and Fern Lake results are not evident at this time.

Dr. Robert Behnke, a long-time expert on greenbacks and other inland cutthroat trout, has argued that the Metcalf et al. (2007) conclusion is premature and should not be the sole basis for decision-making for the greenback recovery program (Behnke 2007). His point is that before human impacts and widespread propagation and stocking of nonnative trout, both the Colorado River cutthroat and the greenback had broad and continuous distributions over vast areas. The original genetic diversity came from many trans-basin movements of various ancestors from the Snake River drainage (and perhaps the Bonneville basin) into the Green River drainage of the Colorado River basin, and eventually across the Continental Divide into the headwaters of the South

Platte and Arkansas drainages (greenback). In more recent times, the range of ancestral diversity was fragmented into tiny isolated populations. Some of these maintained bits and pieces of the ancestral diversity, but the complete range of ancestral diversity cannot be known because so much of the original distribution and abundance of Colorado River and greenback have been lost. Thus, Behnke (2007) raises doubts and uncertainties about the use of presently identified distinguishing Colorado River and greenback genetic markers in making taxonomic determinations.

With regard to taxonomy, Behnke (2004) also has argued that genetics should not be the sole factor in determining taxonomic distinctions, and that morphological traits may sometimes be distinguishing factors. An examination by Behnke (2004) indicated that while the greenback may contain Yellowstone cutthroat trout DNA markers, they do not appear to exhibit the same morphological characteristics as Yellowstone cutthroats. In the reconsidered finding for the westslope cutthroat trout (*O. clarki lewisi)* (USFWS 2003), the Service determined that for populations for which molecular genetic data may be the only data available, populations with less than 20% introgression will be considered westslope cutthroat trout under the ESA, whereas populations with more than 20% introgression will generally be excluded from the westslope cutthroat trout subspecies. The United States Court of Appeals (2008) affirmed that the Service engaged in "reasoned decision making based on the best available science" in relying on morphology as the "principal criterion," and in determining that fish that conformed morphologically to westslope cutthroat trout did not pose a threat of hybridization.

While Metcalf et al. (2007) raises concerns about the recovery status of the greenback, care must be taken when basing management decisions solely on genetically based data because a complete genetic profile is lacking. Policky et al. (2003) state that inconsistency in test results between different methodologies raises concerns about the validity or applicability of the various genetic testing methods. To safeguard the process of evolution in closely related but geographically separated organisms, it has been recommended by field managers and various researchers that the Greenback Recovery Team standardize the approach for genetics testing and validation for brood stocks used for reintroduction, and develop a genetic management directive (Policky et al. 2003).

MAP 1 – (Figure 12 from Behnke 1992)

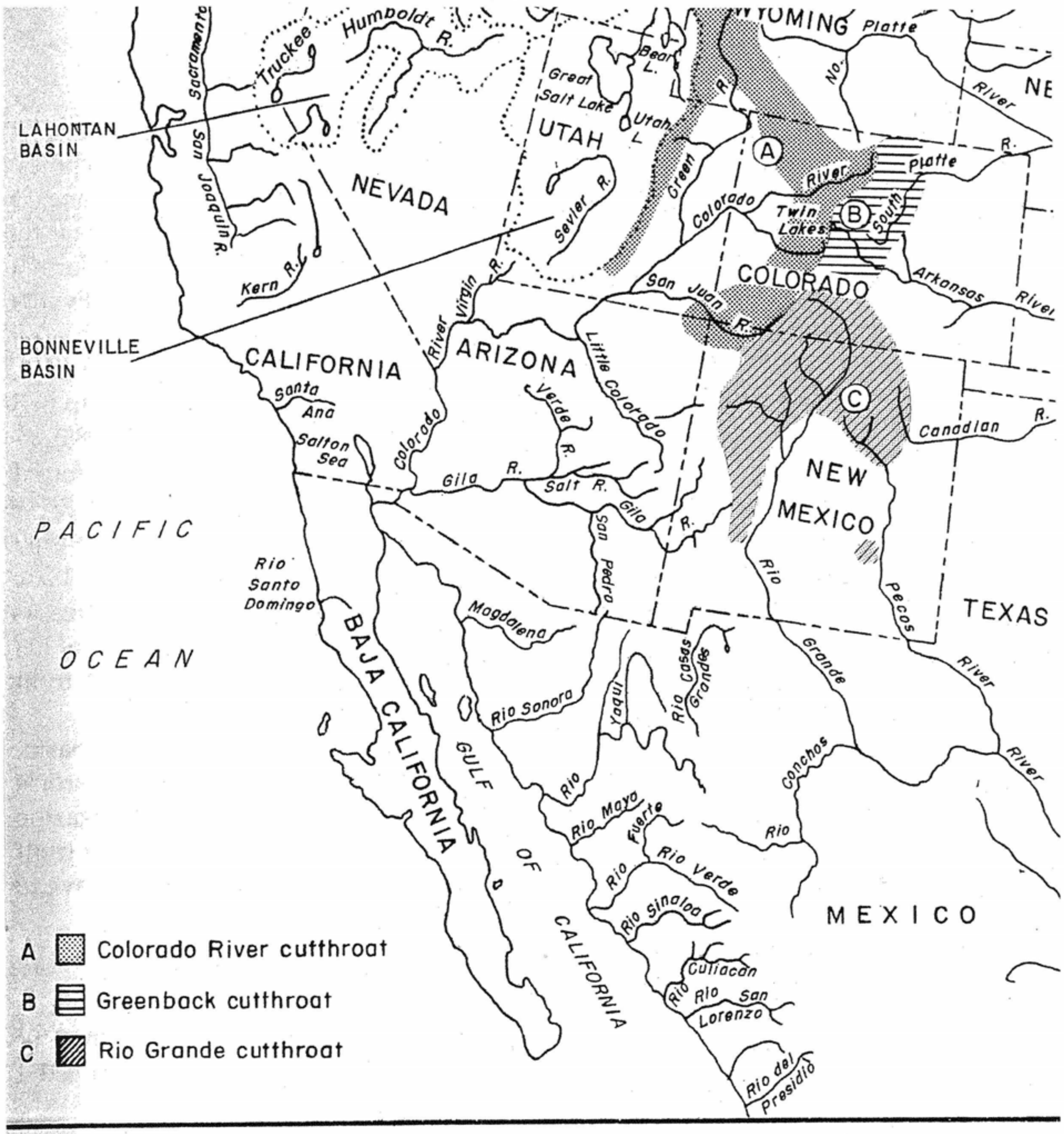

FIGURE 12.—Distributions of Colorado River cutthroat trout, greenback cutthroat trout, and Rio Grande cutthroat trout.

2.3.1.4 Taxonomic Classification Or Changes In Nomenclature

At this time, no changes in cutthroat trout taxonomy resulting from the new genetic information have been proposed. It is possible that in the future, continued and refined genetics analysis, in conjunction with morphometric and meristic characteristics, may lead to proposed taxonomic changes for all cutthroat subspecies. Any proposed changes will need to comply with legal and policy frameworks in effect at the time.

2.3.2 Five-Factor Analysis

2.3.2.1 Present Or Threatened Destruction, Modification Or Curtailment Of Its Habitat Or Range

Greenbacks are native to the headwaters of the South Platte and Arkansas River drainages in Colorado, and a few headwater tributaries of the South Platte in a small area of southeastern Wyoming (Behnke 1992). The original distribution of the subspecies is not precisely known due to its rapid decline in the 1800s. It is assumed that the original distribution included all mountain and foothill habitats of the two drainage systems, including drainages at lower elevations than it occupies today (Behnke and Zarn 1976). The subspecies may have extended as far east as present day Greeley, Colorado, during the mid-1800s (WNTI 2007).

The loss of high-quality trout stream habitat through logging, livestock over-grazing, water diversions, mining, and municipal and industrial pollution is considered a contributing factor to the historical decline of the range of greenback. In general, trout require different habitat types for different life stages: juvenile (protective cover and low velocity flow, as in side channels and small tributaries); spawning (riffles with clean gravels); over-winter (deep water with low velocity flow and protective cover); and adult (juxtaposition of slow water areas for resting and fast water areas for feeding, with protective cover from boulders, logs, overhanging vegetation or undercut banks) (Behnke 1992). Both water quality and quantity are important. Greenbacks, like other cutthroat trout, generally require clear, cold, well oxygenated water (McGrath 2004). High sediment loads, pollution, and diversion of streams for agricultural or municipal purposes can all adversely affect greenback habitat. Greenbacks are opportunistic feeders over a wide range of prey organisms, but a large percentage of the diet can be terrestrial insects (McGrath 2004).

Management efforts since the time of listing have assisted with the improvement of existing habitat. However, much of the historic greenback habitat in the transitional area between the mountains and the plains which was once suitable for the subspecies has been altered to the extent that it is no longer capable of supporting the subspecies. On the other hand, there is a wide-range of remaining montane and sub-alpine aquatic habitats within USFS, BLM, and NPS managed lands which are adequate to support a recovered, self-sustaining greenback population.

There is general concern within the scientific community that populations of greenback remain isolated or fragmented (Young and Guenther-Gloss 2004; Harig and Fausch 2002; McGrath 2004; Martin et al. 2005). Fragmentation is increasing because natural or artificial barriers are constructed or maintained to protect greenback populations from nonnative salmonids (USFWS 1998). Without barriers, new and historic populations would not exist because barriers protect the subspecies from invasion by nonnative species. However, isolated populations of fish are susceptible to genetic drift and more vulnerable to effects of environmental stochasticity (e.g., fire, drought) (Young and Harig 2001; McGrath 2004). Harig and Fausch (2002) recommend that isolated habitats should be enlarged by moving barriers downstream. Fragmentation and isolation effects were not considered in depth in the 1998 Recovery Plan.

During a multi-agency (USFWS, USFS, BLM, CDOW) workshop held the first week of January 2007, data representing the distribution of greenbacks were obtained. Using a process similar to that used to develop the Yellowstone cutthroat trout range-wide database (May 2006), each stream and lake occupied by greenback and found within the National Hydrography Dataset (USGS 2007) were identified and placed into the Geographic Information System (GIS) along with the corresponding attributes. Concurrently, a suite of broad-scale environmental parameters were derived for all streams within Colorado to help describe the relative habitat condition of occupied streams. The study found that most occupied greenback streams are at high elevation (average 9,327 ft) and relatively small in size. The average length of a contiguously operated stream segment is 2.37 km and the average occupied lake is 4.76 ha (Albeke 2008). The information will be used to track the status of existing populations and habitats into the future. The process is intended to be repeated every 3 to 4 years.

Mining. Many early settlers came to Colorado for the prospect of finding gold and other precious metals. However, early mining and ore processing activities produced waste piles and mine tailings that contained heavy metals and acid-generating compounds. These piles were, and in many cases continue to be, leached by flowing water, resulting in increased acidity, decreased pH, and heavy metal concentrations downstream. Water draining from historic mine tunnels and adits (horizontal passages leading into mines) also may contain high concentrations of heavy metals and be characterized by a low pH value (acidic). Larval greenbacks have been shown to be more sensitive to low pH than eggs and embryos, with a pH of 5 being a threshold for larvae in the absence of aluminum (WNTI 2007). Such pollution can negatively affect fishes through asphyxiation, ecological impacts due to destruction of food organisms, chronic toxicity resulting in reduced resistance to infection and other stresses, and interference with behavioral patterns. In addition, some waters within the range of greenbacks are impacted by naturally high levels of heavy metals.

Today, mining activities are not as prevalent and are under environmental permitting and reclamation restrictions that minimize polluted runoff from mine sites. Progress has been made at managing mine waste. The Surface Mining Control and Reclamation Act funds the closure and cleanup of abandoned mines. The Colorado Division of Reclamation, Mining & Safety (DRMS) gets about $2 million per year for cleanup of abandoned mines. The Colorado DRMS estimates that, Statewide, over 23,000 abandoned mines and 1,300 miles of streams impacted by past mining activities exist (Colorado DRMS 2009). While there may be some localized impacts to greenbacks due to past mining practices, there are ample areas available for restoration, and impacts of mining and natural heavy metals will not preclude population connectivity and have only a minimal effect on greenback recovery efforts.

Other Land Use Activities. Several types of activities may negatively impact greenback habitat through removal of riparian habitat which shades streams and lowers water temperatures, and through vegetation removal and trampling of streambanks, which cause bank erosion, producing stream sedimentation. Logging, grazing, road and trail construction and use, and recreational vehicle use near streams have the potential to cause a negative chain reaction by contributing to bank destabilization, which causes an increase in erosion, sediment deposition, and in turn a threat of elevated water temperatures and higher turbidity in lower elevation habitats. In addition to the direct effects of vegetation removal and trampling, these types of land management activities also can reduce the input of terrestrial insects, which comprise about half of the diet of trout populations, into the aquatic environment (Saunders and Fausch 2007).

Erosion materials may form a new substratum inconsistent with that required for spawning by greenback, and may smother redds (the nests of salmonid species) after the eggs are laid, cutting off oxygen needed for the eggs to hatch. Additionally, erosion of material into streams can fill in deep water areas, thereby reducing the available over-winter habitat. Because sediment loads are greatest during spring runoff and thus have their greatest negative effect on reproduction of spring-spawning native trout, accelerated erosion can favor populations of fall-spawning nonnative brook and brown trout *(Salmo trutta)* (Behnke 1992). Greenbacks inhabit coldwater streams and lakes and spawn in the spring (from May to mid-July) in waters with temperatures ranging from 5 to 8°C (USFWS 1998). High quality riparian habitat may allow them to spawn at lower elevation sites that would otherwise be too warm. During the drought of 2002, most of the high elevation populations did very well, due to increased temperatures. As noted above, protective cover also is important for almost all life stages of greenback.

Generally, activities that could negatively impact greenback habitat, such as grazing, logging, and trail construction on federally managed lands are subject to section 7 consultation to minimize those effects. Land management agencies participating in the recovery program use their authorities to improve habitat conditions and often move activities out of the riparian habitat zone. Should the subspecies be delisted, these agencies will continue to manage the subspecies under an approved long-term management plan, so these types of activities should have minimal impacts on the subspecies' ability to survive and recover.

Fire Management Activities. Fire is a natural component of the ecological region occupied by the greenback; however, fire suppression over the past 80 to 100 years in North America has resulted in many forest types with substantial fuel accumulations that are at risk of wildfires that burn at a greater intensity and severity than historically occurred. The added effects of drought, climate change, and large acreages of recently beetle-killed timber add to the potential fire risk (Thompson pers. comm. 2008; Watry pers. comm. 2008). The potential negative impacts of fire were not addressed in the 1998 Recovery Plan, other than encouragement of sound land and silvicultural practices.

While managers do their best to control and or prevent fire, unplanned fires, such as the 2002 Hayman fire, do occur and can have negative impacts on aquatic species and their habitat. The direct effects of fire can be severe to fish both from the increases in stream temperature, and from smoke and ash (both immediate ashfall and later erosional deposition) that can cause an increase in ammonia and respiratory distress, respectively. Indirect adverse effects can result from the loss of streamside and forest vegetation and include erosion and loss of bank stabilization from burned vegetation cover and bankside vegetation, which increases sediment, causing increased turbidity, and increasing stream temperature. Minshall and Brock (1991) believe that increased temperatures, which can range from 4 to 10°C (Gresswell 1999), can kill fish in small (first and second order) streams but doubt that larger streams get hot enough to kill organisms. Mortality in second and third order streams could be caused by smoke and ash (Minshall et al. 1989). Some of the greenback streams in dense forests are susceptible to adverse impacts from fire and would likely benefit from forest thinning treatments that would reduce the impacts of a high severity fire, although some short-term localized impacts could still result from increased sedimentation in streams. Although individual greenback populations could be extirpated by a severe fire, it is extremely unlikely that fire would impact the subspecies significantly enough on a range-wide basis to impact recovery.

Chemical fire-fighting retardants are known to be toxic to aquatic wildlife and lethal levels have been documented in studies on rainbow trout (Buhl and Hamilton 2000). Depending on the size of the retardant drop and the stream characteristics, ammonia concentrations from the retardant can remain lethal for at least 1 km downstream of the retardant drop (Norris and Webb 1989). Larger, better connected fish populations are more resilient (Rieman et al. 1995; Dunham et al. 2003). In these cases, individuals from downstream may migrate back into the headwater system to spawn, helping fish re-establish in that area. No known drops of fire retardant have occurred on greenback streams. However, given the smaller-sized streams that greenbacks typically occupy and their reduced potential for dilution of fire retardant, combined with the general inability to be naturally repopulated due to isolated populations and downstream barriers, the effects of a retardant drop on an individual greenback stream could be severe.

Lakes represent a substantial amount of the current recovery effort, and lake populations may be less impacted by retardants due to the volume of water in the lakes, and multiple water sources for some lakes.

An additional threat to greenback populations from fire management is the potential to introduce whirling disease into greenback streams by the aerial application of water during fire fighting activities (see section 2.3.2.3, disease and predation). Contamination could occur in this manner if the water was drafted from a stream or lake containing whirling disease. This threat can be greatly reduced by avoiding whirling disease positive streams when drafting water and by treating water in the helicopter bucket prior to release. Interim guidelines have been developed for fire personnel to help them avoid the spread of aquatic invasive species, including whirling disease (USFS 2007). The guidelines include measures to locate and map (in a GIS database) the known sites containing whirling disease and other aquatic invasive species. The guidelines also include measures to prevent the spread of aquatic invasive species, including measures to clean and sanitize equipment, such as water tankers, that have been in contact with untreated water.

Since recovery efforts began in the 1970s (which includes both cold and record dry years), no greenback population has been negatively impacted by fire activities. Many of the reintroduction sites are at high elevation, with low fuel loads and minimal fire threats. One restoration project, Ouzel Lake and Creek, was completed immediately after a wildland fire. Since fire is natural, it is often patchy within existing greenback habitats, and allows for early and productive successional stages. The addition of nutrients and additional sun light can result in increased fish production at higher elevations. Although no pre-fire fish data are available, Ouzel Creek currently supports a range of 100 to 137 kg/ha of trout from below Ouzel Lake to Ouzel Falls (Kennedy pers. comm. 2008). Since almost the entire subspecies' habitat is located within federally managed land, proactive fire management activities are analyzed under NEPA and section 7 of the ESA, which require minimization of adverse impacts to the greenback as a result of any planned activities. Should the subspecies be delisted, these agencies will continue to manage the subspecies under an approved long-term management plan, so these types of activities should have minimal impacts on the subspecies' ability to survive and recover.

Water Depletions and Water Storage Facilities. Water management, movement and storage have occurred within the range of the greenback since the 1880s, and continue to the present day. Even within RMNP, water is diverted from the Colorado River drainage into the South Platte drainage (Poudre River), and dams were constructed prior to the creation of the RMNP in 1915. The 1982 failure of the Lawn Lake Dam within RMNP resulted in impacts to over 10 km of stream habitat. As a result of the flood, all the old dams within RMNP have been removed, and many of the former dam sites are now greenback restoration sites – including Lawn Lake and the Roaring River. The early successional habitat within the Roaring River currently supports over 70 kg/ha of greenbacks, with both the Roaring River and Lawn Lake open to catch-and-release sport fishing since 1988.

Continued rapid development is expected along Colorado’s East slope as the human population continues to grow. The State of Colorado expects the population of Front Range counties including Boulder, Douglas, El Paso, Jefferson, Larimer, and Weld to increase by an additional 1.5 million people by 2035 (Colorado Demography Office 2008). The Arkansas and South Platte River drainages are the main sources of water for the East slope. In theory, demand for water within the range of greenback habitat is expected to increase commensurate with population growth. Potential water diversions or depletions can reduce stream flow, fragment stream habitat, restrict greenback movement along stream corridors, and adversely impact water quality, aquatic food chains, and watershed conditions.

However, we are not currently aware of any plans for water development projects in greenback habitat. As noted above, most greenback populations occur in smaller tributaries at high elevation, which are likely not attractive for water development. Most requests for water diversions or depletions within the range of greenbacks would require ESA section 7 consultation, which would require measures to minimize impacts. Should the subspecies be delisted, it is still likely that NEPA analysis would occur on large water development projects, and that greenback needs could be addressed.

Although many of the streams with greenback habitat do not have instream flow water rights or protections, waters within RMNP have instream flow protections or Federal reserved rights. The BLM also has established instream flow rights on some of its greenback streams, including those containing restored populations of greenbacks. Instream flow protections also are in place on several West Slope streams which have been found to contain cutthroat trout of greenback lineage (Smith pers. comm. 2008). While this is currently a low level threat, it could become a greater threat in the future under expanded drought cycles, climate change, and water withdrawals.

2.3.2.2 Overutilization For Commercial, Recreational, Scientific, Or Educational Purposes

Unregulated fishing was a major cause in the historic reduction of greenback (USFWS 1998). Since the subspecies was reclassified as a threatened species in 1978, sport angling for the greenback has been regulated under section 4(d) of the ESA. The 4(d) rule allows sport angling under applicable State law as described in the paragraphs below. However, angling for greenbacks is limited since most streams and lakes containing greenbacks are in remote, high elevation locations that often have difficult angler access.

The CDOW regulates the taking of greenback for commercial, recreational, scientific, or educational purposes as long as it is consistent with State law and the 4(d) rule. The CDOW regulations in Chapter 10 specifically regulate 'taking' of the greenback (CDOW 2008b). The greenback is managed under a 'catch and release' regulation, which requires that any fish caught be immediately returned to the water. Chapter 1, Article II, #108 of the CDOW regulations (2008a), identifies which drainages are open for greenback 'catch and release' fishing. These include certain drainages within RMNP and in the Cache la Poudre drainage. All anglers fishing in these drainages must have a valid Colorado fishing license and adhere to the special regulations. Managing the cutthroat under a 'catch and release' regulation is consistent with the 1998 Recovery Plan, Part 2 Section 4, which indicates that prior to delisting of the subspecies, at least one population of greenbacks will be available for angling in order to determine and document the subspecies response to angling pressure. The current 'catch and release' approach has been successful and does not appear to have been abused, to have resulted in any population declines of the greenback, or to be precluding recovery.

In addition, all collection of specimens, or management actions, such as population estimates, are regulated by collection permits from the Service or CDOW. The CDOW also has stocking regulations in Chapter 0 (revised 2009a), Appendix C, that require approval prior to stocking any fish in restricted cutthroat trout waters, including those occupied by Type A greenbacks.

The current regulations appear to be adequately protecting existing greenback populations from overutilization. It is anticipated that, as part of the long-term management plan to be prepared prior to subspecies delisting, CDOW would continue to control catch and collection of the subspecies through its regulations and permitting processes.

2.3.2.3 Disease Or Predation

Whirling disease is a parasitic infection caused by *Myxobolus cerebralis* that impacts young trout, and can infect the greenback. The disease was introduced to the United States in the 1950s, and has been present in Colorado since the 1990s. Parasites enter through the nerve endings on the skin, and feed upon cartilage in the head and spinal area of young fish, resulting in pressure on the nerves and equilibrium loss (Whirling Disease Foundation 2009). The nerve pressure causes the fish to 'whirl' making them susceptible to predators and starvation.

Young greenbacks are highly susceptible to whirling disease. Greenbacks less than 1 year of age had a mortality of greater than 25% when lightly exposed to the disease (Markiw 1990). However, to date, no known wild greenback populations have been infected with whirling disease.

The disease can be spread through hatcheries use and/or release of contaminated water, stocking of infected fish, by mud on angler equipment, and by birds eating infected fish. Controlling or managing the disease has proven to be a challenge for fishery managers. However, live infected fish appear to be the main vector for the spread of the disease. Each time an infected fish dies, millions of the spores can be released, with these spores able to survive in the mud for at least 20 years and over extremes in temperatures, making the spores difficult to eradicate (Whirling Disease Foundation 2009). Barriers can serve to protect native cutthroat populations from immigration by nonnative trout that are whirling disease positive.

The 1998 Recovery Plan identified whirling disease as a threat to the greenback, and called for more research on the disease and implementation of appropriate regulations. While elimination of whirling disease has not been possible, Federal and State agencies have successfully implemented regulations that prevent the spread of exotic diseases, such as whirling disease. Hatchery operations also have been improved to prevent the spread of whirling disease. Leadville National Fish Hatchery has recently completed a clean up of the hatchery and its water sources, which included construction of concrete raceways for fish rearing and construction of a new water treatment plant housing two drum filters, two disc filters, and four UV radiators. The hatchery was certified whirling disease free in 2007 and may raise greenback in the future.

The NPS, CDOW, and USFWS have all engaged in outreach efforts with the public, particularly recreational anglers, to prevent the spread of whirling disease. The NPS has created *Guidelines for Prevention of Introduction and Spread of Aquatic Threats by Cleaning and Disinfecting Fishing and Field Equipment*. The recommended guidelines include:

- dedicating fishing equipment to one site
- conducting surveys from upgradient to downgradient
- washing and disinfecting equipment that has had contact with soil and water.

Chapter 0, Article VII of the CDOW revised regulations (2009a) is specific to aquatic wildlife transportation, importation, possession and release, and discusses required licenses and permits for the transportation of live aquatic species within the State of Colorado. Article VII also addresses aquatic wildlife health management issues, and requires the inspection and certification of all in-State fish production or holding facilities, which sell, stock, or import live salmonids into Colorado. Those facilities identified with the presence of whirling disease must be treated, and fish from a positive hatchery can only be stocked into waters that are already contaminated. The CDOW believes that the revised regulations will prevent whirling disease from being introduced into streams and lakes where greenbacks are present.

Since greenback populations exist in relatively unaltered habitats, and many of the higher/colder elevation streams have low numbers of the required intermediate host, whirling disease does not appear to be a high threat to current populations. However, the presence of the disease may limit future reproduction and reintroduction of all salmonids in lower elevation lakes and streams. Currently, there are not any contingency plans in place to identify measures to be taken in the event of whirling disease becoming established in greenback habitat. If climate change causes high elevation stream temperatures to warm, whirling disease could be a more significant threat in the future (see section 2.3.2.5).

2.3.2.4 Inadequacy Of Existing Regulatory Mechanisms

During the greenback's decline and prior to listing in 1974, very few laws were in place that could protect the greenback or its habitat, and the inadequacy of regulatory mechanisms was considered a threat of moderate magnitude. Due to listing, numerous Federal regulations that protect the subspecies have resulted in additional protection for greenbacks and their habitat. Besides the ESA, other regulatory mechanisms that provide some protection for the subspecies include the Clean Water Act, Federal Power Act, Fish and Wildlife Coordination Act, and NEPA. Since all or most of greenback habitat is located on federally managed lands, land management practices and regulations, such as the ESA, Clean Water Act, and NEPA, ensure that actions implemented by Federal agencies are analyzed to minimize and mitigate their potential negative impacts on greenback populations and habitat. These laws and regulations have proved effective in protecting the subspecies and its habitat.

As discussed above in section 2.3.2.3, CDOW also has implemented laws and stocking regulations to aid in the recovery of the greenback. These laws and regulations have been effective in minimizing direct take of the subspecies, in decreasing the introduction of nonnative species such as brook trout, and in preventing the spread of invasive species like whirling disease.

To ensure continued survival of the subspecies after delisting, the Recovery Plan requires development of a long-term management plan and cooperative management agreement for the greenback. This plan would be approved and adopted by all participating recovery and management agencies, "to ensure that adequate regulatory mechanisms and management programs remain in existence after delisting to ensure that adequate populations of greenback cutthroat trout are maintained" (USFWS 1998). An outline of a long-term agreement and plan was developed by the USFS in 2004, with the life history and ecology section of the long-term plan completed (Coleman 2007). Finalization of this plan is on hold until a taxonomy determination is made.

2.3.2.5 Other Natural Or Manmade Factors Affecting Its Continued Existence

Nonnative Salmonid Species. The number one reason for the historic decline of the greenback was the introduction of nonnative salmonid fish species (Behnke 1992). Nonnative trout, most commonly brook trout, occurred within approximately 25% of greenback population sites examined by McGrath (2004). The 2007 database identified only 12 populations occurring in the absence of a total barrier that would provide protection from nonnative fish competition (WNTI 2007). Other nonnative salmonids considered a threat include: rainbow trout, brown trout, and Yellowstone cutthroat trout. Harig et al. (2000a) also state that, "Native subspecies of cutthroat trout (*Oncorhynchus clarki)* have declined drastically because of the introduction of nonnative salmonids."

Nonnative fish species pose a threat to the greenback for several reasons. The greenback hybridizes with several introduced fish species, such as the rainbow trout, while other species like the brook trout are competitors. Both of these species also prey on young greenbacks. Brown trout prey on all sizes of greenback. The 1998 Recovery Plan states that, ". . . no action had more long-term impacts on the endemic trout subspecies than the introduction of non-native salmonids, which hybridized and competed with native fishes" (USFWS 1998).

Brook trout (a fall-spawning, cold hardy char) apparently outcompete the greenback for common food sources early in life in most stream habitats. Brook trout spawn in the fall, while greenbacks spawn in the late spring or early summer (McGrath 2004). Because brook trout spawn in the fall, they hatch earlier in the year than greenbacks, and so the young are larger and better able to compete for resources than the greenbacks that hatch later in the summer (USFWS 1998). Peterson et al. (2004) found that age-0 Colorado River cutthroat trout survival was 13 times greater, and age-1 survival 1.5 times greater, when brook trout were removed. However, McGrath and Lewis (2007) found that prey consumed by greenbacks and brook trout differed significantly at five of six sites where the species were sympatric.

Adult brook trout also have been observed attacking and showing aggression toward greenbacks (McGrath 2004), but adult greenbacks and brook trout do coexist in some stream habitats where immigration of adult greenbacks occurs. McGrath and Lewis (2007) only found 1 greenback while investigating the stomach contents of 323 brook trout. Peterson et al. (2004) found no difference in adult Colorado River cutthroat survival when brook trout were removed. Observational data suggest the competition dynamic appears to be different in lake habitats, and greenbacks can compete successfully with brook trout in some lake habitats under restricted harvest regulations.

Although nonnative salmonid species continue to present a threat to greenback populations, management activities have ensured that very few populations co-exist with such species. Construction and maintenance of barriers will continue to be used, as necessary, to ensure that nonnatives do not preclude recovery of the subspecies.

New Zealand Mud Snail. The New Zealand mud snail (NZMS) is a recently introduced species that has the potential to negatively impact the greenback. It was introduced after publication of the 1998 Recovery Plan, and so is not addressed. The NZMS are about 0.25-inch long and were first observed in the United States in Idaho's Snake River in 1987 (Western Regional Panel on Aquatic Nuisance Species 2001). Within the last 10 years, the snails have been detected in the South Platte River.

The NZMS have great potential for wide-spread colonization because they have a broad environmental tolerance. Since the mid-1980s, North American population densities in some infested streams have reached up to 0.75 million individuals per square meter. The NZMS could displace native invertebrates which provide food for cutthroat trout. Studies have shown that few fish species eat NZMS, and those that do derive little to no energy value from the snails, as they are able to pass through the fishes' digestive systems alive and intact (Aquatic Nuisance Species Task Force 2008).

Five species of mollusks (all native to the Snake River) have recently been listed as "endangered" in part due to the establishment of the NZMS and its potential impacts. Establishment is expected to have negative impacts on native fauna (e.g., decrease in densities of herbivorous invertebrates, decrease in attached filter-feeding organisms). This species may have the potential to impact the food chain of native trout and other fish species and have the potential to disrupt the physical characteristics of invaded ecosystems (e.g., reduction in the biomass of periphyton and the resulting interactions can have wide-ranging affects on stream ecosystem processes) (Aquatic Nuisance Species Task Force 2008).

The New Zealand Mudsnail Management and Control Plan Working Group (2007) recommends cleaning all mud and debris that might harbor NZMS from boot, waders, and gear with a stiff brush; putting fishing gear in a freezer for 6 to 8 hours; putting fishing gear in water maintained at 120°F for a few minutes; or drying fishing gear at 84 to 86°F for at least 24 hours or at 104°F for at least 2 hours. Gear should be thoroughly brushed with a stiff bristled brush prior to drying. Effective alternative methods may include exposing NZMS to solutions of benzethonium chloride, chlorine bleach, Commercial Solutions Formula 409® Cleaner Degreaser Disinfectant, Pine-Sol®, ammonia, and copper sulfate.

There are currently no NZMS in water bodies occupied by greenbacks, but it is possible that they could be transferred to greenback streams in the future. The extent of their potential impact on greenback populations is unknown. Currently, there are not any contingency plans in place to identify measures to be taken in the event NZMS become established in greenback habitat.

Zebra and Quagga Mussels. Quagga and zebra mussels spread from Eurasia to the Northeast and Great Lakes in contaminated ballast water of boats, on anchors and anchor lines. They quickly spread to the Mississippi River, its tributaries and inland lakes and have now established a presence in the Western States. Quagga and zebra mussels are small barnacle-like mollusks with dark and light colored stripes. They smother aquatic organisms, such as crayfish and native clams and outcompete other aquatic organisms for food and aquatic habitat. They damage equipment by attaching to boat motors or hard surfaces and clog water treatment facilities (CDOW 2009b). In Colorado, zebra mussels are only known from Pueblo Reservoir in the Arkansas River drainage. Quagga mussels were discovered in 2008 in Lake Granby in the Colorado River drainage, and have spread to Grand Lake, Shadow Mountain, and Willow Creek Reservoirs, which are connected to Grand Lake. They also have been located in Jumbo Reservoir and Tarryall Reservoir in the South Platte drainage. Careless actions by boaters and fishermen could result in more widespread occupation in the future. The extent of their potential impacts on greenback populations, should they spread into inhabited streams, is unknown. Currently, there are not any contingency plans in place to identify measures to be taken in the event zebra or quagga mussels become established in greenback habitat.

Contaminants. The Western Airborne Contaminants Assessment Project was completed by the NPS in 2008 (Landers et al. 2008). From 2002 to 2007, researchers conducted analysis of the concentrations and biological effects of airborne contaminants in air, snow, water, sediments, lichens, pine needles, and fish in eight national parks, including RMNP. The study found high levels of endosulfans and dacthal in snowpack depositions and also in fish samples in RMNP. Mercury levels in fish samples were fairly low, although mercury level increased with increasing age of fish. Poorly developed testes and or intersex trout were found in five of the nine lakes tested in RMNP, indicating that endocrine and reproductive disruption is occurring (Landers et al. 2008). As part of this study, a sample from a male greenback collected in Twin Lakes in the 1800s also was examined and found to be an intersex fish, showing that this is not a new phenomenon, and likely does not pose a significant threat to greenback recovery.

Global Climate Change. According to the Intergovernmental Panel on Climate Change (IPCC 2007) "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." Average Northern Hemisphere temperatures during the second half of the 20th century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1,300 years (IPCC 2007). It is very likely that over the past 50 years cold days, cold nights, and frosts have become less frequent over most land areas, and hot days and hot nights have become more frequent (IPCC 2007). It is likely that heat waves have become more frequent over most land areas, and the frequency of heavy precipitation events has increased over most areas (IPCC 2007). To date, these changes do not appear to have had a negative impact on greenback.

The IPCC (2007) predicts that changes in the global climate system during the 21st century are very likely to be larger than those observed during the 20th century. For the next two decades, a warming of about 0.2°C per decade is projected (IPCC 2007). Afterwards, temperature projections increasingly depend on specific emission scenarios (IPCC 2007). Various emissions scenarios suggest that by the end of the 21st century, average global temperatures are expected to increase 0.6 to 4.0°C with the greatest warming expected over land (IPCC 2007). Localized projections suggest the southwest may experience the greatest temperature increase of any area in the lower 48 States (IPCC 2007). The IPCC predicts that it is very likely hot extremes, heat waves, and heavy precipitation will increase in frequency (IPCC 2007). There also is high confidence that many semi-arid areas like the western United States will suffer a decrease in water resources due to climate change (IPCC 2007). Milly et al. (2005) project a 10 to 30% decrease in precipitation in mid-latitude western North America by the year 2050 based on an ensemble of 12 climate models.

As a recently emerging issue, warming temperatures associated with current climate change theories were not specifically discussed in the 1998 Recovery Plan. Although few documents produced in the 1990s discussed the threats of warming temperatures, the task of monitoring populations is generally outlined in Recovery Plan tasks 1.1 and 2.6. As part of the monitoring protocol, one of eight study sites in the Service's Fishery Resources Status and Trends, Global Climate Change Component (1993) was in greenback habitat. The goal of this program was to determine the effects of global climate change on fishes in selected regions of the United States. As such, water temperatures and spawning dates for high elevation greenback populations were collected at eight sites as baseline data for this study (USFWS 1993). Temperature monitoring has continued, and has been expanded to most greenback populations within RMNP.

Coleman and Fausch (2007a) monitored 6 headwater streams containing greenback populations in RMNP and the Arapaho-Roosevelt National Forest. Their results showed that recruitment of native cutthroat trout in Colorado is limited by cold water temperatures that reduce growth and recruitment. Based on these results, we can hypothesize that, at least for the short-term, an increase in water temperature could be beneficial for greenback reproduction and recruitment. The recovery program has a good baseline data set for water temperature, and the potential to identify population changes within sub-alpine habitats in the future, which will allow evaluation of the effects of changing water temperatures on greenback populations.

Recent studies have indicated that global warming has the potential to adversely affect river systems that support greenback (Defenders of Wildlife 2002; Ficke et al. 2007). In general, threats from climate change could affect fish populations through reduction of precipitation, increase in fire, and increase in stream temperature. Higher temperatures in lentic systems (lakes) also could increase evaporation and result in lowered lake levels (Ficke et al. 2007).

Defenders of Wildlife and The Natural Resources Defense Council performed a 2002 study that modeled the effects of increased air and water temperatures in trout habitat. The report suggests that species of trout and salmon could lose 5 to 17% of their existing habitat by the year 2030, 14 to 34% by 2060, and 21 to 42% by 2090 (Defenders of Wildlife 2002). Although relative impacts to the greenback are unknown, these studies suggest that native cutthroat trout may experience a significant decline in habitat within the next 25 years due to climate change, with highest concern for trout populations in southern and southwestern States. Subspecies such as the greenback, that already occur at high elevations in small tributaries, and are at the eastern edge of cutthroat trout range, may be less able to disperse into new habitats.

However, a slight increase in water temperature also could be beneficial in extending the growing season and increasing fish production in high elevation greenback streams, where spawning and incubation are delayed due to current cold temperatures, as described by Coleman and Fausch (2005). A general temperature increase also could decrease fish production at lower elevations due to decreased levels of dissolved oxygen and may allow invasion of nonnative species and pathogens, such as whirling disease, into higher elevation habitats. While it appears reasonable to assume that greenbacks may be affected, we lack sufficient certainty to know how climate change will affect the subspecies. In general, climate change would likely put the most pressure on the subspecies at the lower elevation and easternmost extent of its range, due to a combination of less moisture and higher temperatures.

Fragmentation. Section 2.42 of the 1998 Recovery Plan recommended construction and improvement of artificial barriers as a management strategy. Artificial fish migration barriers have been constructed in Bear Creek, Graneros Creek, and Boehmer Creek in the Arkansas drainage (Policky et al. 2003); and in Clear Creek in the Platte River basin and have had positive results for maintaining greenback populations by excluding nonnative fish.

However, as previously discussed, barriers contribute to isolation, restricting gene flow, and have the potential of genetic bottlenecking unless managers move small numbers of fish between the populations. More than 90% of the stream segments occupied by greenback are less than 5 km in length, with an average length of 2.37 km (Albeke 2008). Small, isolated populations also are vulnerable to stochastic events, such as drought, flooding, and fires. But many of the small stream lengths are tied to lake populations, and as such, they are not as vulnerable to stochastic events.

The opposite effect may be occurring in Pacific salmonids; that is, that outbreeding depression (when offspring from crosses between individuals from different populations have lower fitness than progeny from crosses between individuals from the same population) may be more likely to occur and reduce survival after a population is supplemented (Utter 2004). Utter (2004) hypothesizes that this may be because fish populations develop specific adaptations to local conditions through natural selection, and these can be disrupted by hybridization with hatchery fish or wild fish that are stocked from elsewhere.

The Recovery Team has authorized the translocation of greenbacks from Roaring Creek to the South Fork of the Poudre River to simulate gene flow and genetic connectivity not possible with current population isolation. In the future, these translocations may need to occur with more frequency to prevent genetic bottlenecking and to re-establish small populations destroyed by stochastic events.

2.4 Synthesis

Although new genetics information has called into question the status of the greenback populations previously thought to have met recovery goals, this issue should not have an effect on the long-term conservation of the subspecies. Until we have a scientific determination as to the taxonomic distinctions between greenback and Colorado River cutthroat trout, based on genetic information, morphology, and meristics, greenbacks should continue to be classified according to the categories (A, B, C) in the Recovery Plan. Greenbacks have high recovery potential because of the demonstrated ability to successfully reintroduce them into the wild in habitats where nonnative fish have been removed. Implementation of recovery activities over the last 25 years has shown that greenback habitats can be restored and enhanced, and that stable populations of fish can be successfully established in these habitats. Since initial listing, we also have had great success in developing hatchery broodstocks, and thus should be able to incorporate new genetics material into hatchery populations as is determined necessary.

Due to the listing of the subspecies and implementation of recovery activities by the State and Federal recovery partners, threats from Overutilization and Inadequate Regulatory Mechanisms are virtually nonexistent. Since the majority of greenback populations occur on federally managed lands, and the State of Colorado is able to control and manage fishing and fish stocking activities, there is little chance that these threats will increase in the future. Even after the subspecies is recovered and delisted, it will be managed by the cooperating recovery agencies under an approved long-term management plan which will ensure the subspecies and its habitat are maintained.

Some of the threats identified in the 1998 Recovery Plan continue at a low level, and for the most part their impacts are limited to specific populations and do not occur at a range-wide level. Low level threats include the ongoing negative effects of past mining operations on water quality; the impacts of grazing, logging, and road and trail construction and use on riparian habitat and streambanks, causing increased erosion, sediment deposition, and in turn elevated water temperatures and higher turbidity; and the co-occurrence of nonnative salmonids with greenback populations. Regulatory and land management agencies have the ability to improve habitat conditions and eliminate or minimize these threats by cleanup and remediation of old mine sites; by implementing conservation measures to avoid streamside habitat degradation while approving new grazing, logging, and road and trail construction proposals; by moving existing roads and trails away from streamside habitats and rehabilitating disturbed riparian habitats; and by creating barriers to protect greenbacks from nonnative salmonid populations, and removing nonnatives from protected areas above such barriers. All of these positive activities are ongoing throughout the subspecies' range and are implemented based on agency priorities and funding levels on an annual basis. The potential risk of catastrophic wildfire to destroy habitat, or the potential for fish to be killed by fire retardants used to fight wildfires, has increased since 1998. Although the effects of a wildfire could be catastrophic on an individual stream, potentially causing extirpation of greenbacks within it, it is unlikely that one, or even several, large fires would have adverse effects on the subspecies as a whole given the dispersed nature of populations. Habitat destroyed by fire could be rehabilitated and greenbacks could be restocked over time. However, of greatest concern is the potential for a catastrophic event, such as a high severity fire or an accidental drop of fire retardant, to extirpate one of the few remaining historic native populations, especially if that population's genetic material has not been replicated elsewhere in a stream or fish hatchery.

Other threats identified in the Recovery Plan, or newly emerging since 1998, may prove to have a more moderate or higher degree of impact than initially described, or have broader impacts on the subspecies rangewide in the foreseeable future. These include the potential effects of global climate change. Modeling to predict effects of climate change, particularly at a localized level, is still developing, but there is already some evidence that lower elevation trout populations could be adversely affected by warmer temperatures and lower precipitation levels. However, high elevation populations may benefit from increased temperatures, at least for the short term. Human population growth along the Front Range of Colorado, in combination with a drier climate, may result in significantly increased water demands from streams and lakes occupied by greenbacks. Most greenback populations are located upstream of water diversions, and occur within USFS and NPS lands. Although greenbacks appear to have some protection from whirling disease at present due to their locations above barriers and colder water temperatures, the disease may become more widespread with warming temperatures. However, silt substrate also is necessary to support tubeficid worms, which could take a long time to develop in these watersheds that are currently granitic in nature, with low levels of organic materials. Other aquatic invasive species, such as NZMS, also may become more widely distributed. For subspecies such as greenback, which already occurs in high-elevation tributary streams and lakes, the ability to shift their range in response to climate change and invasive species may be limited. As discussed above, fragmentation and isolation of small populations is already a concern, and this may become more pronounced under the effects of climate change.

Our overall conclusion is that the subspecies' classification as threatened and recovery priority number of 15 should remain the same. Many beneficial actions have been undertaken under the 1998 Recovery Plan, including habitat improvements, stocking of wild and hatchery-raised fish, placement of barriers, removal of nonnative salmonids, and implementation of protective regulations. Although new hatchery stocks may need to be developed and recovery populations restocked based on use of new genetic and taxonomic information, these beneficial actions will allow the newly stocked populations to grow and persist.

3.0 RESULTS

3.1 Recommended Classification

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change is needed

3.2 New Recovery Priority Number

No change from 15 (see section 1.3.5. above)

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Recovery Team Actions

4.1 The Recovery Team, in coordination with the Service, should make a determination of the taxonomic distinctions between greenback and Colorado River cutthroat trout. This "subspecies" definition should take into account morphometric and meristic characteristics, genetics, and current Service policy and legal decisions. Recommendations of an expert panel or additional peer review of available genetic information should be used to help with this determination, and the results should be published in a peer-reviewed journal.

4.2 The Recovery Team, in coordination with the Service, should continue to promote and fund research that will help to delineate the genetic make-up of populations of both (presumed) greenback and Colorado River cutthroat trout, to aid in the taxonomic review.

4.3 Given the significant amount of new information that has been acquired on both threats and genetics since 1998, the Recovery Team should update and revise the Recovery Plan, including the identification of measurable recovery goals for all Objectives. Principles of Strategic Habitat Conservation, such as identification of limiting factors and development of population-habitat relationship models, should be used to formulate habitat objectives and design a conservation plan for the subspecies.

4.4 Development of a long-term management plan for a recovered population should be initiated upon completion of the revised plan. This plan should address the requirements of section 4(g) of the ESA and comply with our 2008 post-delisting monitoring guidance (USFWS 2008).

4.5 The Recovery Team should identify those historic native populations whose genetic material is currently not replicated, either in a stream or fish hatchery, and should replicate the population.

4.6 The Recovery Team should work collectively to establish and implement standardized population and habitat monitoring protocols for the subspecies.

4.7 The Recovery Team should explore feasible ways to connect isolated populations (develop metapopulations) wherever possible, while still preserving viable small populations that are dispersed throughout the range of the subspecies, to buffer against catastrophic loss of large, interconnected populations. As a contingency, the Recovery Team also should develop a plan for supplementing isolated populations to ensure genetic robustness, or to re-populate areas that become extirpated due to stochastic events.

4.8 The Recovery Team, and the agencies and organizations involved, should continue to use creative funding mechanisms for implementing recovery actions, such as the Western Native Trout Initiative.

Management Actions

4.9 The regulatory and land management agencies involved with greenback recovery should continue their efforts to improve habitat conditions, to establish new populations as appropriate, and minimize the negative effects of ongoing and proposed actions on the subspecies.

4.10 Needs of the greenback must continue to be considered when planning fire management activities, through the development of contingency plans and conservation measures to proactively prepare for the threat of fire.

4.11 Data and information about climate change should continue to be obtained and analyzed to determine how greenback might be affected.

4.12 Land management agencies and hatchery operators must continue to implement preventative mechanisms in hatcheries and in fish stocking operations to prevent the spread of whirling disease.

4.13 Populations used for broodstocks should continue to be monitored for fish diseases, and greenback populations should be sampled as part of the Service's wild fish health monitoring.

4.14 Plans should be developed and implemented to preclude the spread of non-desirable organisms into greenback habitat. Contingency plans also should be developed for use in the event that occupied greenback habitat is colonized by a new disease, competitor, or predatory species.

4.15 Current management strategies, including the eradication of nonnatives at relocation and translocation sites, need to be continued to prevent competition from nonnative species. Measures to eradicate nonnative species, such as mechanical barriers and/or lethal chemicals, should be evaluated for the 25% of the range where greenbacks co-occur with nonnative salmonids. Other innovative ways to protect the greenback from nonnative species should be considered to prevent population isolation caused by natural and non-natural barriers.

5.0 REFERENCES

Albeke, S. 2008. Greenback cutthroat trout spatial habitat analysis. Unpublished report provided to Bruce Rosenlund, May 28, 2008. 6 pp.

Aquatic Nuisance Species Task Force. 2008. New Zealand Mudsnail (*Potamopyrgus antipodarum*). Available online at: http://www.anstaskforce.gov/spoc/nzms.php. Accessed on September 23, 2008.

Behnke, R.J. 1992. Greenback cutthroat trout. pp. 146-148 *in* Native trout of western North America. American Fisheries Society Monograph 6, Bethesda, Maryland. 275 pp.

Behnke, R. 2004. Genetics: A double-edged sword. Trout, Winter 2004, pp. 59-61.

Behnke, R. 2007. Science and the Endangered Species Act. Trout, Winter 2008, pp. 56-58.

Behnke, R.J., and M. Zarn. 1976. Biology and management of threatened and endangered western trout. U.S. Forest Service General Technical Report RM-28. 45 pp.

Buhl, K.J., and S.J. Hamilton. 2000. Acute toxicity of fire-control chemicals, nitrogenous chemicals, and surfactants to rainbow trout. Transactions of the American Fisheries Society 129:408-418.

Coleman, M.A. 2007. Life-history and ecology of the greenback cutthroat trout. Unpublished report, Colorado Natural Heritage Program. 15 pp.

Coleman, M.A., and K.D. Fausch. 2005. Causes of recruitment bottlenecks in translocated cutthroat trout populations: investigation of low temperature effects. Third Annual Report, Colorado State University, Ft. Collins. 53 pp.

Coleman, M.A., and K.D. Fausch. 2007a. Cold summer temperature limits recruitment of Age-0 cutthroat trout in high-elevation Colorado Streams. Transactions of the American Fisheries Society 136:1231-1244, 2007.

Coleman, M.A., and K.D. Fausch. 2007b. Cold summer temperature regimes cause a recruitment bottleneck in age-0 Colorado River cutthroat trout reared in laboratory streams. Transactions of the American Fisheries Society 136:639-654.

Colorado Demography Office, Division of local governments. 2008. Population totals for Colorado counties. Available online at: http://www.dola.state.co.us/dlg/demog/pop_cnty_forecasts.html. Accessed on July 22, 2008.

Colorado Division of Reclamation Mining & Safety. 2009. Abandoned mines. Available online at: http://mining.state.co.us/AMLReclamationProgram.htm. Accessed on February 26, 2009.

Colorado Division of Wildlife. 2008a. State of Colorado Division of Wildlife regulations, Chapter 1, Article II. 43 pp.

Colorado Division of Wildlife. 2008b. State of Colorado Division of Wildlife regulations, Chapter 10. 23 pp.

Colorado Division of Wildlife. 2009a. State of Colorado Division of Wildlife regulations, Chapter 0, Article VII, pp. 20-35, and Appendix C, pp. 69-77.

Colorado Division of Wildlife. 2009b. Zebra and Quagga mussels. Available online at: http://wildlife.state.co.us/WildlifeSpecies/Profiles/InvasiveSpecies/ZebraandQuaggaMussels.htm. Accessed on February 27, 2009.

Defenders of Wildlife. 2002. Effects of global warming on trout and salmon in U.S. streams. Washington, D.C. 44 p. report.

Dunham, J.B., M.K. Young, R.E. Gresswell, and B.E. Rieman. 2003. Effects of fire on fish populations: landscape perspectives on persistence of native fishes and nonnative fish invasions. Forest Ecology and Management 178:183-196.

Ficke, A.D., C.A. Myrick, and L.J. Hansen. 2007. Potential impacts of global climate change on freshwater fisheries. Rev Fish Biol Fisheries. 33 pp.

Gresswell, R.E. 1999. Fire and aquatic ecosystems in forested biomes of North America. Transactions of the American Fisheries Society 128(2):193-221.

Harig, A.L., and K.D. Fausch. 2002. Minimum habitat requirements for establishing translocated cutthroat trout populations. Ecological Society of America 12(2):535-551.

Harig, A.L., K.D. Fausch, and P.M. Guenther-Gloss. 2000a. Application of a model to predict success of cutthroat trout translocation in central and southern Rocky Mountain streams. From Proceedings of Wild Trout VII: Management in the new millennium-Are we ready? Yellowstone National Park, October 1-4, 2000. 10 pp.

Harig, A.L., K.D. Fausch, and M.K. Young. 2000b. Factors influencing success of greenback cutthroat trout translocations. North American Journal of Fisheries Management 20:994-1004.

Intergovernmental Panel on Climate Change. 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp. Available online at: http://www.ipcc.ch/ipccreports/ar4-syr.htm.

Kanda, N., and R. Leary. 1999a. Unpublished report to Gary Dowler (CDOW) concerning eletrophoretic analysis of trout samples. 7 pp.

Kanda, N., and R. Leary. 1999b. Unpublished report to Jim Melby (CDOW) concerning eletrophoretic analysis of trout samples. 5 pp.

Kanda, N., and R. Leary. 1999c. Unpublished report to Greg Polizky (sic) (CDOW) concerning eletrophoretic analysis of trout samples. 4 pp.

Kanda, N., and R. Leary. 2000. Unpublished report to Gary Dowler (CDOW) concerning eletrophoretic analysis of trout samples. 8 pp.

Kehmeier, K. 2008. E-mail to Bruce Rosenlund and others dated March 09, 2008.

Kennedy, C.M. 2005. Summary of aquatic resource surveys on Fort Carson military reservation, Colorado. 82 pp.

Kennedy, C.M. 2008. Personal communication to Bruce Rosenlund.

Landers, D.H., S.L. Simonich, D.A. Jaffe, L.H. Geiser, D.H. Campbell, A.R. Schwindt, C.B. Schreck, M.L. Kent, W.D. Hafner, H.E. Taylor, K.J. Hagemen, S. Usenko, L.K. Ackerman, J.E. Schrlau, N.L. Rose, T.F. Blett, and M.M. Erway. 2008. Chapter 2. Park Summaries, Rocky Mountain National Park. pp. 2-24 – 2-27 *in* The Fate, Transport, and Ecological Impacts of Airborne Contaminants in Western National Parks (USA). EPA/600/R-07/138. Environmental Protection Agency, Office of Research and Development, NHEERL, Western Ecology Division, Corvallis, Oregon.

Markiw, M.E. 1990. Unpublished letter to the Colorado Division of Wildlife. USFWS, National Fish Health Research Laboratory, Kearneysville, WV. 1 p.

Martin, A. 2005. Comparison of sequence variation in the major histocompatibility complex between Como Creek and restoration populations originating from Como Creek stock. Unpublished report. 16 pp.

Martin, A. 2008. Final Report: Genetic identification of cutthroat trout in Rocky Mountain National Park based on mtdna and microsatellite analysis. Unpublished report. 18 pp.

Martin, A., J. Mitton, and J. Metcalf. 2005. Final Report: Describe existing populations and determine appropriate source populations for restoration of native trout subspecies in RMNP utilizing mitochondrial and nuclear DNA analysis. Unpublished report. 21 pp.

May, B. 2006. Assessment Protocol and Data Tables. Appendix C in Yellowstone cutthroat trout status update. pp. 96-130.

McGrath, C.C. 2004. Trophic roles of native greenback cutthroat trout and nonnative Brook trout in montane streams of Colorado. Unpublished PhD Thesis, University of Colorado, Boulder. 135 pp.

McGrath, C.C., and W.M. Lewis, Jr. 2007. Competition and predation as mechanisms for displacement of greenback cutthroat trout by brook trout. Transactions of the American Fisheries Society 136:1381-1392.

Metcalf, J.L. 2007. Estimates of introgression for Columbine Creek, Rocky Mountain Park from microsatellite, aflp, and mitochondrial dna data. 12 pp.

Metcalf, J.L, V. Pritchard, S. Silvestri, J. Jenkins, J. Wood, D. Cowley, R. Evans, D. Shiozawa, and A. Martin. 2007. Across the great divide: genetic forensics reveals misidentification of endangered cutthroat trout populations. Molecular Ecology (2007). 10 pp.

Milly, P.C.D., K.A. Dunne, and A.V. Vecchia. 2005. Global pattern of trends in streamflow and water availability in a changing climate. Nature 438:347-350.

Minshall, G.W., and J.T. Brock. 1991. Observed and anticipated effects of forest fire on Yellowstone stream ecosystems. In R.B. Keiter and M.S. Boyce, eds., Greater Yellowstone Ecosystem: Redefining America's Wilderness Heritage. Yale University Press, New Haven, CT. pp 123-135.

Minshall, G.W., J.T. Brock, and J.D. Varley. 1989. Wildfires and Yellowstone's Stream Ecosystems. BioScience 39:707-715.

Mitton, J.B., J.L. Metcalf, A. Martin, B.R. Kreiser, K.L Durand, and J. Woodling. 2006. MtDNA phylogeny of the subspecies of Cutthroat Trout, *Oncorhynchus clarki*. Unpublished report. 16 pp.

New Zealand Mudsnail Management and Control Plan Working Group. 2007. National Management and Control Plan for the New Zealand Mudsnail (*Potamopyrgus antipodarum*). Prepared for the Aquatic Nuisance Species Task Force. 52 pp. + Appendices.

Norris, L.A., and W.L. Webb. 1989. Effects of fire retardant on water quality. USDA, Forest Service General Technical Report PSW-109. pp. 79-86.

Peterson, D.P., K.D. Fausch, and G.C. White. 2004. Population ecology of an invasion: effects of brook trout on native cutthroat trout. Ecological Applications 14:754-772.

Policky, G.A., J.L. Melby, G.S. Dowler, and D.A. Krieger. 2003. Greenback cutthroat trout recovery efforts, 2003 progress report, Southeast region, Colorado Division of Wildlife. Unpublished report. 37 pp.

Rieman, B.E., D.C. Lee, G. Chandler, and D. Myers. 1995. Does wildfire threaten extinction for salmonids: responses of redband trout and bull trout following recent large fires on the Boise National Forest. Pages 47-57 in: Greenlee, J. (ed.) Proceedings of the Conference on Wildfire and Threatened and Endangered Species and Habitats, Coeur D'Alene, Idaho. International Association of Wildland Fire, Fairfield, Washington, November 13-15, 1995.

Rogers, K.B. 2008. Using amplified fragment length polymorphisms to characterize purity of cutthroat trout in Colorado: results from 2007. 74 pp.

Rosenlund, B.D. 2008. Personal communication to Susan Linner.

Rosenlund, B.D, C. Kennedy, and K Czarnowski. 2001. Fisheries and aquatic management, Rocky Mountain National Park, 2001. Unpublished report. 201 pp. + Appendices.

Saunders, W.C., and K.D. Fausch. 2007. Improved grazing management increases terrestrial invertebrate inputs that feed trout in Wyoming rangelands. Transactions of the American Fisheries Society 136:1216-1230.

Smith, R. 2008. E-mail to Doug Krieger and others dated May 23, 2008.

Thompson, J. E-mail to Bruce Rosenlund and others dated March 27, 2008.

U.S. Court of Appeals. 2008. American Wildlands, et al., appellents v. Dirk Kempthorne, Secretary, U.S. Department of the Interior and Dale Hall, Director, U.S. Fish and Wildlife Service, appellees. Opinion for the Court filed by Circuit Judge Griffith. July 18, 2008. 19 pp.

U.S. Fish and Wildlife Service. 1967. Native Fish and Wildlife, Endangered Species, 32 FR 4001, March 11, 1967.

U.S. Fish and Wildlife Service. 1974. Endangered Native Wildlife. 39 FR1175-1176, January 4, 1974.

U.S. Fish and Wildlife Service. 1977. Greenback cutthroat trout recovery plan. 20 pp. + Attachment.

U.S. Fish and Wildlife Service. 1978. Endangered and Threatened Wildlife and Plants; Final Rule Listing the Greenback Cutthroat Trout as a Threatened Species. 43 FR 16343-16345, April 18, 1978.

U.S. Fish and Wildlife Service. 1979. Endangered and Threatened Wildlife and Plants; Review of all species listed prior to 1975. 44 FR 29566-29567, May 21, 1979.

U.S. Fish and Wildlife Service. 1983. Greenback cutthroat trout recovery plan. 45 pp.

U.S. Fish and Wildlife Service. 1985. Endangered and Threatened Wildlife and Plants; Review of all species listed prior to 1976. 50 FR 29901-29009, July 22, 1985.

U.S. Fish and Wildlife Service. 1991. Endangered and Threatened Wildlife and Plants; Review of all species listed prior to 1991. 56 FR 56882-56892, November 6, 1991.

U.S. Fish and Wildlife Service. 1993. Fishery Resources and Trends, Global Climate Change Component. Annual Report to Research and Development for FY 1992. 21 pp. + Appendices.

U.S. Fish and Wildlife Service. 1998. Greenback Cutthroat Trout Recovery Plan. 62 pp.

U.S. Fish and Wildlife Service. 2003. Endangered and Threatened Wildlife and Plants; Reconsidered finding for an amended petition to list the westslope cutthroat trout as threatened throughout its range. 68 FR 46989-47009, August 7, 2003.

U.S. Fish and Wildlife Service. 2005. Endangered and Threatened Wildlife and Plants; Initiation of a 5-year review of greenback cutthroat trout (*Oncorhynchus clarki stomias*). 70 FR 74030-74031, December 14, 2005.

U.S. Fish and Wildlife Service. 2008. Post-delisting monitoring plan guidance under the Endangered Species Act. August 2008. 18 pp. + Appendices.

U.S. Forest Service. 2007. Preventing spread of aquatic invasive organisms common to the Intermountain Region. Interim Guidance for 2007 fire operations. 11 pp.

U.S. Geological Survey. 2007. National Hydrography Dataset. Available from: http://nhd.usgs.gov/. Accessed July 22, 2008.

Utter, F. 2004. Population genetics, conservation and evolution of salmonids and other widely cultured fishes: some perspectives over six decades. Reviews in Fish Biology and Fisheries 14:125-144.

Watry, M.K. E-mail to Susan Linner and Bruce Rosenlund dated March 31, 2008.

Western Native Trout Initiative. 2007. Greenback cutthroat trout assessment. 6 pp.

Western Regional Panel on Aquatic Nuisance Species. 2001. The invasion of western waters by nonnative species: Threats to the West. 8 p. brochure.

Whirling Disease Foundation. 2009. About whirling disease. Available from: http://www.whirling-disease.org/. Retrieved February 26, 2009.

Young, M.K., and P.M. Guenther-Gloss. 2004. Population characteristics of greenback cutthroat trout in streams: their relation to model predictions and recovery criteria. North American Journal of Fisheries Management 24:184-197.

Young, M.K., and A.L. Harig. 2001. A critique of the recovery of greenback cutthroat trout. Conservation Biology 15(6):1575-1584.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW
of Greenback cutthroat trout (*Oncorhynchus clarki stomias*)

Current Classification: Threatened range-wide

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change is needed

Review Conducted By: Susan Linner, Field Supervisor, Colorado Ecological Services Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve____________________ Date 2/27/09
Field Supervisor, Colorado Ecological Services Office

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Approve____________________ Date 5/27/09
Regional Director, Region 6
Acting

APPENDIX 1

Current list of greenback populations that conform to the morphology[i] of historic greenback populations (Albeke 2008).

WATER NAME	BASIN	GENETIC STATUS	KM	HA
Bear Creek	AR	>10% and <=20%	4.22	
Bear Creek	AR	Unaltered (< 1%)	2.89	
Boss Lake Reservoir	AR	Unaltered (< 1%)		8.76
Cascade Creek	AR	>10% and <=20%	0.27	
Cascade Creek	AR	>10% and <=20%	1.42	
Cascade Creek	AR	>20% and <=30%	2.91	
Cottonwood Creek	AR	>1% and <=10%	5.73	
Elk Creek	AR	>10% and <=20%	0.28	
Elk Creek	AR	>10% and <=20%	1.42	
Graneros Creek	AR	Unaltered (< 1%)	7.98	
Greenhorn Creek	AR	>1% and <=10%	3.77	
Greenhorn Creek	AR	>1% and <=10%	1.36	
Hayden Creek	AR	Unaltered (< 1%)	0.22	
Hunt Lake	AR	Unaltered (< 1%)		1.74
Inlet to Boss Lake Reservoir	AR	Unaltered (< 1%)	0.27	
Inlet to Boss Lake Reservoir	AR	Unaltered (< 1%)	1.27	
Lake Fork	AR	Unaltered (< 1%)	2.07	
Lake Fork	AR	Unaltered (< 1%)	1.01	
Lake Fork	AR	Unaltered (< 1%)	0.52	
Maxwell Creek	AR	Unaltered (< 1%)	3.8	
Maxwell Creek	AR	Unaltered (< 1%)	2.15	
McReynolds Reservoir	AR	Not Tested - Suspected Unaltered		40.51
Middle Prong Hayden Creek	AR	Unaltered (< 1%)	5.29	
N Unnamed Trib to Rock Creek	AR	>10% and <=20%	1.53	
Native Lake	AR	>10% and <=20%		4.1
Newlin Creek	AR	>1% and <=10%	1.27	
Newlin Creek	AR	Unaltered (< 1%)	0.4	
North Apache Creek	AR	>10% and <=20%	2.77	
North Cheyenne Creek	AR	Unaltered (< 1%)	3.45	
North Taylor Creek	AR	Unaltered (< 1%)	6.78	
Rock Creek	AR	>1% and <=10%	2.95	
Rock Creek	AR	>10% and <=20%	2.1	
Rock Creek	AR	>10% and <=20%	0.35	
Rock Creek	AR	>10% and <=20%	0.79	
Rock Creek	AR	>10% and <=20%	0.47	
S Unnamed Trib to Maxwell Creek	AR	Unaltered (< 1%)	1.41	
S Unnamed Trib to Rock Creek	AR	>10% and <=20%	1.55	
Severy Creek	AR	Unaltered (< 1%)	1.11	
Severy Creek	AR	Unaltered (< 1%)	0.98	
Severy Creek	AR	Unaltered (< 1%)	1.8	
South Apache Creek	AR	Unaltered (< 1%)	10.4	
South Prong	AR	Unaltered (< 1%)	3.65	
South Prong	AR	Unaltered (< 1%)	2.37	
Swamp Lakes	AR	>10% and <=20%		1.58
Swamp Lakes Outlet	AR	>10% and <=20%	0.78	
Timberline Lake	AR	Unaltered (< 1%)		11.05
Unnamed Trib to Cascade Creek	AR	>10% and <=20%	0.21	
Unnamed Trib to Lake Fork Arkansas	AR	Unaltered (< 1%)	2.58	
Unnamed Trib to Unnamed Trib to Lake Fork Arkansas	AR	Unaltered (< 1%)	1.7	
Virginia Lake	AR	Unaltered (< 1%)		0.98
W Unnamed Trib to Lake Fork Arkansas River	AR	Unaltered (< 1%)	0.63	
Arrowhead Lake	SP	Unaltered (< 1%)		13.82
Bard Creek	SP	Unaltered (< 1%)	4.97	
Bear Lake	SP	Unaltered (< 1%)		3.87
Bear Lake Outlet	SP	Not Tested - Suspected Unaltered	0.5	

WATER NAME	BASIN	GENETIC STATUS	KM	HA
Big Thompson River	SP	Unaltered (< 1%)	8.9	
Caddis Lake	SP	Unaltered (< 1%)		0.54
Caddis Lake Outlet	SP	Not Tested - Suspected Unaltered	0.26	
Caddis Lake Outlet	SP	Not Tested - Suspected Unaltered	0.4	
Caddis Lake Outlet	SP	Not Tested - Suspected Unaltered	0.96	
Clear Creek	SP	>20% and <=30%	1.91	
Clear Creek	SP	Unaltered (< 1%)	0.94	
Cony Creek	SP	>30%	4.15	
Cony Creek	SP	>1% and <=10%	1.22	
Cony Creek	SP	Not Tested - Suspected Hybridized	0.47	
Cony Creek	SP	Not Tested - Suspected Hybridized	0.79	
Cony Creek	SP	Not Tested - Suspected Unaltered	0.04	
Cony Creek	SP	Not Tested - Suspected Hybridized	0.41	
Cornelius Creek	SP	Not Tested - Suspected Unaltered	4.01	
Crystal Lake	SP	Not Tested - Suspected Unaltered		10.25
Dream Lake	SP	>30%		1.39
Dry Gulch	SP	Unaltered (< 1%)	0.91	
Dry Gulch	SP	Unaltered (< 1%)	1.45	
East Fork Sheep Creek	SP	Not Tested - Suspected Unaltered	5.2	
Fern Creek	SP	Not Tested - Suspected Unaltered	0.98	
Fern Creek	SP	Not Tested - Suspected Unaltered	0.72	
Fern Creek	SP	Not Tested - Suspected Unaltered	0.57	
Fern Lake	SP	Unaltered (< 1%)		2.85
George Creek	SP	Unaltered (< 1%)	8.96	
George Creek	SP	Not Tested - Suspected Unaltered	2.61	
Hague Creek	SP	Unaltered (< 1%)	0.84	
Hazeline Lake	SP	>10% and <=20%	0.33	
Hazeline Lake	SP	>10% and <=20%	0.37	
Hidden Valley Creek	SP	Unaltered (< 1%)	5.79	
Hunters Creek	SP	Unaltered (< 1%)	2.93	
Hutcheson Lakes	SP	>20% and <=30%		2.64
Icy Brook	SP	Not Tested - Suspected Hybridized	1.23	
Icy Brook	SP	Not Tested - Suspected Unaltered	0.63	
Icy Brook	SP	Not Tested - Suspected Unaltered	0.16	
Icy Brook	SP	Not Tested - Suspected Unaltered	0.61	
Icy Brook	SP	Not Tested - Suspected Hybridized	0.36	
Lake Husted	SP	Unaltered (< 1%)		4.35
Lake Louise	SP	Unaltered (< 1%)		2.43
Lake of Glass	SP	Not Tested - Suspected Hybridized		1.27
Lawn Lake	SP	Unaltered (< 1%)		7.45
Little Rock Lake	SP	Unaltered (< 1%)		0.14
Loomis Lake	SP	Not Tested - Suspected Unaltered		1.18
Lost Lake	SP	Not Tested - Suspected Unaltered		2.95
Lost Lake Outlet	SP	Unaltered (< 1%)	0.74	
Louise Lake Outlet	SP	Not Tested - Suspected Unaltered	0.36	
Lower Hutcheson Lake	SP	>1% and <=10%		1.8
Lower Triple Lakes	SP	Unaltered (< 1%)		1.16
May Creek	SP	Not Tested - Suspected Unaltered	3.68	
Middle Hutcheson Lake	SP	>1% and <=10%		0.59
Middle Triple Lakes	SP	Unaltered (< 1%)		0.91
N Unnamed Trib to W. Unnamed Trib to Roaring Creek	SP	Unaltered (< 1%)	1.33	
North Fork Big Thompson River	SP	Unaltered (< 1%)	3.21	
North Fork Big Thompson River	SP	Not Tested - Suspected Unaltered	1.8	
Odessa Lake	SP	Not Tested - Suspected Unaltered		3.24
Ouzel Creek	SP	Not Tested - Suspected Unaltered	3.36	
Ouzel Creek	SP	Unaltered (< 1%)	1.19	
Ouzel Lake	SP	Unaltered (< 1%)		2.03
Pear Reservoir	SP	Unaltered (< 1%)		6.47

WATER NAME	BASIN	GENETIC STATUS	KM	HA
Pennock Creek	SP	Not Tested - Suspected Unaltered	3.01	
Roaring Creek	SP	Unaltered (< 1%)	7.35	
Roaring River	SP	>1% and <=10%	4.43	
Roaring River	SP	Not Tested - Suspected Unaltered	2.81	
Roaring River	SP	Not Tested - Suspected Unaltered	0.88	
Roaring River	SP	Not Tested - Suspected Unaltered	0.49	
Rock Lake	SP	Unaltered (< 1%)		1.23
S Unnamed Trib to Poudre River	SP	Not Tested - Suspected Unaltered	2.42	
Sandbeach Creek	SP	>10% and <=20%	0.65	
Sandbeach Creek	SP	>1% and <=10%	2.46	
Sandbeach Creek	SP	Not Tested - Suspected Unaltered	0.29	
Sandbeach Lake	SP	Not Tested - Suspected Unaltered		4.85
South Fork Cache la Poudre River	SP	Unaltered (< 1%)	1.47	
Spruce Lake	SP	Unaltered (< 1%)		1.57
The Loch	SP	>10% and <=20%		5.27
Triple Lakes	SP	Unaltered (< 1%)		6.48
Tyndall Creek	SP	Not Tested - Suspected Hybridized	0.26	
Unnamed Trib To Big Thompson River	SP	Unaltered (< 1%)	1.62	
Unnamed Trib To Big Thompson River	SP	Not Tested - Suspected Unaltered	0.36	
Unnamed Trib To Big Thompson River	SP	Not Tested - Suspected Unaltered	0.62	
Unnamed Trib To Ouzel Creek	SP	Unaltered (< 1%)	0.24	
Unnamed Trib to Pennock Creek	SP	Not Tested - Suspected Unaltered	1.52	
Unnamed Trib to Roaring River	SP	>1% and <=10%	0.5	
Unnamed Trib to Roaring River	SP	Not Tested - Suspected Unaltered	1.1	
W Unnamed Trib to Roaring Creek	SP	Unaltered (< 1%)	3.6	
West Creek	SP	Unaltered (< 1%)	1.6	
West Fork Sheep Creek	SP	Not Tested - Suspected Unaltered	5.16	
Williams Gulch	SP	Not Tested - Suspected Unaltered	2.67	
Ypsilon Lake	SP	Unaltered (< 1%)		3.07
Ypsilon Lake Outlet	SP	Not Tested - Suspected Unaltered	0.64	
Ypsilon Lake Outlet	SP	Not Tested - Suspected Unaltered	0.4	
Zimmerman Lake	SP	Unaltered (< 1%)		4.22
		TOTAL HECTARES		**166.74**
		TOTAL KILOMETERS	**227.7**	

[i] This table is strictly based on morphometric data and does not reflect new genetic information acquired on various populations from 2007 to the present time.