Aquatic Biota

Specialist Report

East Fork Boulder Creek Native Trout Restoration Project

USDA-Forest Service-Dixie National Forest

Submitted by: /s/ Mike Golden

Mike Golden, Forest Fisheries Biologist
Dixie National Forest

Date: June 30, 2011

This report analyzes the effects of the proposed East Fork Boulder Creek Native Trout Restoration project on aquatic biota. The alternatives analyzed, including actions that are not part of the Forest Service decision but connected to the project, are described in Appendix 1.

Description of Affected Environment and Analysis Methods

The aquatic biota of streams in two 6^{th} field Hydrologic Unit Codes (HUCs) would be potentially affected by the proposed project: Headwaters Boulder Creek (140700050206) and Bear Creek-Boulder Creek (140700050209). Streams within these HUCs potentially affected by the proposed project include: East Fork Boulder Creek, West Fork Boulder Creek, and Boulder Creek and all fish bearing springs, seeps and inflows flowing into these streams within the project area. Lakes and reservoirs affected by activities connected to the proposed project include King's Pasture Reservoir and the pond in King's Pasture.

Aquatic species selected for this analysis include: (a) species that are listed as Threatened, Endangered, or Proposed under the Endangered Species Act; (b) fish species, including species listed on the Regional Forester's Sensitive Species List and Management Indicator Species (MIS) in the Dixie National Forest Land and Resource Management Plan as amended (Forest Plan); (c) amphibian species; and (d) aquatic macroinvertebrates.

The MIS for fish habitat for the project would be non-native trout combined (specifically, brook trout (*Salvelinus fontinalis*), rainbow trout (*Oncorhynchus mykiss*), and brown trout (*Salmo trutta*)) for Boulder Creek and native cutthroat trout (specifically, Colorado River cutthroat trout, CRCT, *Oncorhynchus clarki pleuriticus*) for the East Fork and West Fork Boulder Creek. CRCT are on the Regional Forester's Sensitive Species List.

In addition the native, non-game mottled sculpin (*Cottus bairdi*) is also present adjacent to the project area.

Threatened, Endangered, or Proposed Species under the Endangered Species Act

There are no aquatic species listed as threatened, endangered, or proposed under the Endangered Species Act in the project area or cumulative effects area. There is no designated or proposed critical habitat for aquatic species in the project area or cumulative effects area. Therefore, this topic will not be analyzed further.

Fish

In the 1980s and 1990s remnant populations of CRCT were found in the East Fork and West Fork Boulder Creek (Hepworth et al. 2001a). CRCT are the native trout to the Colorado River system, and the East Fork Boulder Creek population was the first remnant population to be identified in the Escalante River system. CRCT were a Category 2 Candidate Species for listing under the Endangered Species Act until 1996. A Range-wide Conservation Agreement and Strategy for the Species was signed in 2001 and renewed in 2006, with Region 4 of the Forest Service as a signatory (CRCT 2006a, CRCT 2006b). CRCT are also an Intermountain Region Sensitive Species.

In the late 1990s CRCT were found throughout 3.8 miles (6.1 km) of the East Fork Boulder Creek, but the only significant abundance and standing crop of the species was found in a 0.5 mile (0.8 km) section of stream in the headwater meadow, above a series of natural waterfalls and cascades (Young et al. 1996, Hepworth et al. 2001a, Hadley et al. 2008). The cascades and waterfalls and/or cold temperatures appeared to have prevented nonnative brook trout from invading the headwater meadow area. Monitoring since the late 1990s has shown that CRCT can occasionally be found throughout East Fork Boulder Creek in low abundance, but only the headwater meadow and upstream areas maintain a self-sustaining population (Hadley et al. 2008, Hardy et al. 2009 a, Hardy et al. 2009b, Williams and Hardy 2010; Table 1). Throughout the remainder of East Fork Boulder Creek, brook trout are the dominant species with standing crops that would be considered high to very high for southern Utah trout streams (Hepworth and Beckstrom 2004). A large amount of spawning habitat for nonnative brook trout exists both above and below the East Fork (King's Pasture) Reservoir, as evidenced by the large number of young-of-year and juvenile brook trout found in fish surveys from these areas (Hadley et al. 2008, Hardy et al. 2009a, Hardy et al. 2009b).

When first identified the West Fork Boulder Creek CRCT population was restricted to the 2.1 miles (3.4 km) of stream above the West Fork Reservoir dam, where nonnative brook trout had been unable to colonize (Young et al. 1996, Hepworth et al. 2001a). In 2000 and 2001 the West Fork Boulder Creek CRCT population was expanded to encompass an additional 4.8 miles (7.7 km) of stream from the West Fork Reservoir downstream to a pair of fish barriers constructed 0.2 miles (0.3 km) upstream from the confluence with East Fork Boulder Creek (Hepworth et al. 2001b, Hadley et al. 2008). The expansion of the CRCT population in West Fork Boulder Creek was accomplished through nonnative trout removal using rotenone and reintroductions from CRCT brood stock populations (Hepworth et al. 2001b). At present the total CRCT occupied stream miles have been maintained at approximately 6.9 miles (11.1 km) in West Fork Boulder Creek (Hadley et al. 2008). Since the nonnative trout fishery was removed in 2001, CRCT biomass in the renovated portion of West Fork Boulder Creek has increased to levels similar to those seen in the original remnant population upstream from West Fork Reservoir (Table 2).

Table 1. Brook trout biomass/Colorado River cutthroat trout biomass (lbs/acre) at long-term monitoring stations in East Fork Boulder Creek. Data taken from Williams and Hardy (2010).

Year	Above West Fork confluence	Below King's Pasture Reservoir	Above King's Pasture Reservoir	Headwater meadow	Above headwater meadow
1996	24/0	na	na	na	na
1998	na	na	74/7	0/69	na
2006	151/6	89/0	133/8	0/92	na
2008	74/0	162/0	341/3	na	na
2009	257/1	181/15	203/2	na	0/65
2010	170/0	71/0	0/0	na	0/69

Table 2. Colorado River cutthroat trout biomass (lbs/acre) at long-term monitoring stations in West Fork Boulder Creek. Data taken from Williams and Hardy (2010).

Year	Above East Fork confluence	Above West Fork Reservoir	Headwaters
1998	na	89	na
2000	0	na	na
2006	46	112	na
2008	101	116	na
2009	117	55	313
2010	120	64	62

The Boulder Creek mainstem has a nonnative sport fishery comprised of rainbow trout, brook trout, and brown trout. Trout biomass has been consistently higher at the monitoring station downstream from the hydroplant return flows. Trout biomass upstream from the hydroplant return flow has been lower from 2008-2010 than it was in 2002 and 2007 (Table 3). Below the hydroplant return flow trout biomass has varied but was highest in 2008. With the exception of the 2009 sampling effort above the hydroplant inflow, trout biomass has been average or above average for southern Utah trout streams at both locations (Hepworth and Beckstrom 2004).

Table 3. Total resident trout biomass at long-term monitoring stations in Boulder Creek. Data taken from Williams and Hardy (2010).

Year	Above Power plant	Below power plant
2002	104	214
2007	122	201
2008	63	236
2009	48	166
2010	71	182

The native, non-game mottled sculpin is also present in Boulder Creek; however, their upstream distribution appears to end somewhere between the hydroplant return flow and the confluence of East Fork Boulder Creek and West Fork Boulder Creek.

Amphibians

While no recent amphibian observations have been recorded on the Forest portions of the two 6th level HUC watersheds overlapped by the project area, historical records show a single boreal toad (*Anaxyrus boreas*) observation within the Headwaters Boulder Creek HUC in 1960 (Fridell et al. 2000, UDWR Southern Region Native Aquatics database). Boreal toad was added to the Intermountain Region's Regional Forester's Sensitive Species List in 2010. UDWR surveys between 1994 and 1998 found boreal toads only in previously identified areas in the Fremont River drainage on Boulder Mountain. No boreal toads were found in the two watersheds affected by the proposed project. Additional boreal toad locations have been found in the Fremont drainage since those surveys, but no recent observations of boreal toad have been documented in the Escalante River drainage.

Historical observations of Great Basin spadefoot toad (*Spea intermontana*), red-spotted toad (*Bufo punctatus*), Woodhouse's toad (*Bufo woodhousii*), boreal chorus frog (*Pseudacris maculata*), and tiger salamanders (*Ambystoma tigrinum*) are recorded for adjacent drainages on and off the Forest (UDWR Southern Region Native Aquatics database). Forest Service employees have observed boreal chorus frog in the Lower Pine Creek Watershed (6th level HUC 140700050107) and Woodhouse's toad in the Oak Creek watershed (6th level HUC 140700030408) within the past 10 years. In 2010 Forest personnel conducted amphibian surveys at several locations within East Fork Boulder Creek drainage and did not find any evidence of amphibians (Golden and Mecham 2010a, Golden and Mecham 2010b). It is possible that some individual amphibians do occur in the vicinity of the project area and/or cumulative effects area, but currently there are no known breeding sites or breeding populations in the streams, springs, ponds and reservoirs potentially affected by the proposed project.

Aquatic macroinvertebrates

The aquatic macroinvertebrate community within the study area has been inventoried several times in the last 20 years (Table 4). No aquatic insect species that are classified as having special-status are known to be present in the proposed treatment area. No rare or endemic species are known to be present in the proposed treatment area. Total taxa richness and Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa richness are metrics commonly used to assess stream health and community diversity (Barbour et al. 1999). Macroinvertebrate sampling at two locations on Boulder Creek in May and October 1994 showed total taxa richness between 28 and 36 taxa and EPT taxa richness between 14 and 20 taxa (Mangum 1995; Table 4). Aquatic macroinvertebrate samples collected from the West Fork Boulder Creek just upstream from FR30166 by Forest personnel in 2003 and 2010 showed similar richness levels to the 1994 Boulder Creek samples (Vinson 2005, Judson and Miller 2011).

Forest personnel collected macroinvertebrate samples on East Fork Boulder Creek above King's Pasture Reservoir three times in 1996, and Utah Division of Water Quality repeated collections at that site in 2005 (Mangum 1997, STORET station 5989260). Total taxa richness and EPT taxa richness were lower than that seen in West Fork Boulder Creek and Boulder Creek samples, and the community would rank as "fair" based on the predictive model in development by the Utah Division of Water Quality (Holcomb 2010). An additional sample collected in East Fork Boulder creek just upstream from FR30166 in 2011 showed very similar levels of total taxa and EPT taxa richness to the sample collected in West Fork Boulder Creek in 2011 (Judson and Miller 2011).

Table 4. Average taxa richness and average taxa richness of Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) (EPT) taxa in macroinvertebrate inventories conducted in the potentially affected area since 1994.

Location	Time	Total taxa	EPT taxa
Boulder Creek, below power plant	May-94	28	14
Boulder Creek, above power plant	May-94	37	19
Boulder Creek, below power plant	October-94	36	19
Boulder Creek, above power plant	October-94	34	20
West Fork Boulder Creek upstream from FR30166	September-03	36	18
West Fork Boulder Creek upstream from FR30166	September-10	38	12
East Fork Boulder Creek, above King's Pasture Reservoir	July-96	23	13
East Fork Boulder Creek, above King's Pasture Reservoir	August-96	23	16
East Fork Boulder Creek, above King's Pasture Reservoir	September-96	26	15
East Fork Boulder Creek, above King's Pasture Reservoir	September-05	21	15
East Fork Boulder Creek upstream from FR30166	September-10	37	13

In addition to these historic samples, the Utah Water Research Laboratory at Utah State University collected benthic macroinvertebrate samples from four locations in East Fork Boulder Creek and two locations in West Fork Boulder Creek in August 2009 (Table 5). These samples are currently being processed, but data were not yet available at the time this document was prepared.

Table 5. Location and type of benthic macroinvertebrate samples collected by Utah Water Research Laboratory from East Fork Boulder Creek and West Fork Boulder Creek in August 2009.

Site	Drift net	D-net benthic	Date	UTM location
East Fork Above Reservoir	3	1	8/26/2009	459994E, 4212910N
East Fork Headwater Meadow	3	1	8/26/2009	459551E, 4214475N
West Fork Headwater	3	1	8/27/2009	456661E, 4212581N
East Fork Above Headwater Meadow	3	1	8/26/2009	459450E, 4214554N
East Fork Above Confluence	3	1	8/25/2009	461211E, 4208112N
West Fork Above Reservoir	3	1	8/27/2009	456941E, 4211909N

Cumulative Effects Area

The Cumulative Effects Area (CEA) for aquatic biota includes Bear Creek-Boulder Creek watershed (6th field HUC140700050210) and the Headwaters of Boulder Creek watershed (6th level HUC140700050209). This area encompasses a total of 62,794 acres, of which 49,440 acres are located on the Escalante Ranger District (Table 6).

Table 6. Aquatic Biota Cumulative Effects Area.

Watershed	6th field HUC	Acres	Acres on Escalante R.D.
Bear Creek-Boulder Creek	140700050210	28,822	15,468
Headwaters of Boulder Creek	140700050209	33,972	33,972

East Fork Boulder Creek is on an active grazing allotment, and historic timber sales and management have occurred in the watershed. The East Fork (King's Pasture) Reservoir diversion and a similar diversion on West Fork Boulder Creek at the West Fork Reservoir both combine to alter the flow regime in the mainstem of Boulder Creek. During most of the year all flows are diverted from the streams at these reservoirs and used for hydropower and irrigation downstream. The diversions have both formed small impoundments on the channel, reducing instream habitat. Both East Fork Boulder Creek and West Fork Boulder Creek are completely dewatered for approximately 0.5 miles (0.8 km) downstream from the diversion and the remainder of the Boulder Creek system has substantially reduced flows downstream to the hydroplant, where some flows go to irrigation and some are returned to the stream. A riparian inventory was conducted on Boulder Creek in August of 1994 (EnviroData Systems, Inc. 1995). This inventory noted that the riparian area was fragile because of existing soil and vegetation conditions but did not specify cause.

There are numerous authorized and unauthorized roads (roads) within the project area. A culvert where Forest Road 30166 crosses West Fork Boulder Creek within the project area is an impediment to fish passage and blocks approximately 5.7 miles (9.2 km) of fish habitat (Brazier 2008). A previous culvert on East Fork Boulder Creek that was an impediment to fish passage was replaced in summer 2009. Forest Roads (FR) 30165, 33290, 33289 all have sections that come within 100 m of East Fork Boulder Creek. FR 30165 leads up to FR 30165A, which is an administrative and private road leading from King's Pasture Reservoir to West Fork Reservoir. It crosses East Fork Boulder Creek at the bottom of the King's Pasture Reservoir. Another private road encircles the King's

Pasture Reservoir and several private roads have portions that cross springs and tributaries to East Fork Boulder Creek or are within 100m of the stream itself.

Direct and Indirect Effects

No action

Effects of No Action on Fish

Under the no action alternative fish would not be removed from or killed in the waters described in the treatment area. Nonnative brook trout would not be removed; therefore, they would remain the dominant fish throughout the majority of the East Fork Boulder Creek. CRCT would remain largely restricted to the small headwater meadow area of the stream, physically and genetically isolated from populations in the West Fork Boulder Creek.

Under the No Action alternative, brook trout would remain in East Fork Boulder Creek, which would not allow for any significant expansion of the range of CRCT. Brook trout have displaced and negatively impacted native salmonids throughout a good portion of their range in the western United States (Fuller et al. 1999, Dunham et al. 1999, Dunham et al. 2002, Dunham et al. 2004, Quist and Hubert 2004, Shepard 2004, Ficke et al. 2009). Brook trout are prolific breeders and can quickly increase their population size to relatively high densities (Ficke et al. 2009). Once brook trout have invaded an area with native cutthroat, they can reduce cutthroat numbers through a combination of depredation and competition. Brook trout are successful at invading native cutthroat trout habitat and displacing native cutthroat trout through direct impacts to native cutthroat trout recruitment and indirect impacts to adult native cutthroat trout growth and survival (Peterson et al. 2004). Brook trout are also prolific and have been shown to reach densities and exhibit production twice that of native cutthroat (Benjamin and Baxter 2010). High densities, combined with more aggressive behaviors can force adult native cutthroat trout from optimum habitats (Buys et al. 2009). By the late 1990s nonnative trout had displaced native CRCT throughout most of their historic range in Boulder Creek and the rest of the Lower Colorado Geographic Management Unit (Young et al. 1996, Hepworth et al. 2001a).

The West Fork Reservoir and the natural cascades and waterfalls below the headwater meadow in East Fork Boulder Creek appear to be the primary reason that nonnative brook trout did not completely displace CRCT in the Boulder Creek system. Some studies have shown that in addition to physical barriers, temperature can also play a role in the success of brook trout invasions (DeStaso and Rahel 1994, Dunham et al. 1999, Dunham et al. 2002, Shepard 2004). The results of these studies indicate that warmer water conveys a competitive advantage to brook trout; therefore, the lack of invasion success in the headwater meadow of East Fork Boulder Creek may be partially related to the cold water temperatures observed in this area. Without these physical/environmental barriers it is probable that brook trout would have completely eliminated CRCT in the Boulder Creek system. While CRCT populations persisted in the Boulder Creek system, they were small and isolated putting them at great risk of extirpation.

The No Action alternative would not expand the self-sustaining CRCT population beyond its current 0.5 km (0.8 mile) headwaters meadow reach. In general, population viability of cutthroat trout is correlated with stream length or habitat size (Hilderbrand and Kershner 2000, Harig and Fausch 2002, Hildebrand 2003, Young et al. 2005). Stream length is important, because trout move throughout streams searching for necessary microhabitats for spawning, rearing, refuge, and migration (Baltz et al. 1991, Young 1996, Muhlfeld et al. 2001, Schmetterling 2001, Hilderbrand and Kershner 2004a, Schrank and Rahel 2004, Colyer et al. 2005, Neville et al. 2006). Longer stream reaches have more complexity and have a higher probability of supplying sufficient amounts of microhabitats than shorter reaches (Horan et al. 2000, Harig and Fausch 2002, Dunham et al. 2003). Larger, more connected habitat patches also decrease the likelihood that stochastic events (e.g., fire, flood, drought) will negatively impact a population.

Hilderbrand and Kershner (2000) estimated 8.2 km (5.1 mi) were required to maintain a population of 2,500 cutthroat trout when fish abundance was high (300 fish/km [484 fish/mi]). Adding a 10% loss rate of individuals, to account for emigration and mortality, increased the required length to 9.3 km (5.8 mi) to maintain 2,500 fish. For streams with smaller population sizes of 200 fish/km (320 fish/mi) and 100 fish/km (160 fish/mi), the corresponding length increased to 12.5 (7.8 mi) and 25 (15.5 mi) stream km, respectively (Hilderbrand and Kershner 2000). Young et al. (2005) found that to maintain a population of 2,500 cutthroat trout, 8.8 km (5.5 mi) of stream was needed. The CRCT population in East Fork Boulder Creek would not only be limited to 0.5 km (0.8 mi), but with the exception of stray individuals moving downstream it would also be isolated from the population in West Fork Boulder Creek by approximately 7 miles (11.3 km) of stream, including King's Pasture Reservoir, as well as the fish barriers at the lower end of West Fork Boulder Creek.

The No Action alternative would not eliminate the introduced nonnative fish, which often have negative impacts on non-game species. This has certainly been true for nonnative trout (Crowl et al. 1992, McDowall 2003). Dunham et al. (2000) found that brook trout consumed significantly larger prey than native Lahontan cutthroat trout. Nonnative trout have been shown to negatively affect sculpin growth and abundance (McDonald and Hershey 1992, Ruetz et al. 2003, Zimmerman and Vondracek 2006). Zimmerman and Vondracek (2007) demonstrated that while nonnative trout negatively impacted sculpin growth, native trout did not. Any negative impacts on native mottled sculpin by nonnative trout within the project area would continue under the No Action alternative.

Under the no action alternative current trends in fish distribution abundance and biomass would not be affected. The range of CRCT would not be expanded and the risk of local extirpation of the East Fork Boulder Creek population would remain high.

Effects of No Action on Aquatic invertebrates

No effects to the current aquatic invertebrate community would occur from treatment activities under the no action alternative, but any differential impacts from the continued proliferation of nonnative brook trout would remain. Nonnative trout have the capability to change food web dynamics, which could result in changes in benthic invertebrate diversity and abundance (McNaught et al. 1999, Vander Zanden et al. 1999, Parker et al. 2001, Simon and Townsend 2003, Vander Zanden et al. 2003, Baxter et al. 2004, Baxter et al. 2007, Pope et al. 2009). Studies have shown that brook trout and cutthroat trout can differ in the number and types of prey items they consume (Griffith 1974, Dunham et al. 2000, Hilderbrand and Kershner 2004b). As discussed under the potential impacts to fish, brook trout have also been shown to be more prolific than native cutthroat trout. Differential consumption and increased consumption by higher densities of fish may have caused changes to the abundance and /or diversity of the native, historic aquatic community of East Fork Boulder Creek when brook trout replaced CRCT as the top-level predator. These changes would persist under the no action alternative.

Effects of No Action on Amphibians

Under the no action alternative there would be no treatment activities that would affect individual amphibians that may be present in the project area; however, the potential for negative effects to native amphibians from nonnative trout would remain. Nonnative trout have been implicated in the decline of various amphibian species, particularly in alpine lakes (Fellers and Drost 1993, Hecnar and M'Closkey 1997, Tyler et al. 1998, Knapp and Matthews 2000, Maxell 2000, Pilloid and Peterson 2001, Welsh et al. 2006, Pope 2008). A recent study indicates that in addition to direct mortality via depredation by nonnative trout, amphibians can also suffer from competition for invertebrate food resources with nonnative trout (Joseph et al. 2011). As highlighted in the fish analysis, brook trout are more prolific than native cutthroat trout, allowing them to reach higher densities. The higher densities may result in higher consumption rates of amphibians. This increased consumption may have altered the abundance and/or diversity of the historic, native amphibian community. These changes would persist under the no action alternative.

Additionally, the potential change in historic prey base caused by nonnative trout outlined in the aquatic invertebrate analysis may also have had an effect on the prey base of any historic amphibian populations, and this change would also persist under the no action alternative.

Proposed action

Effects of the Proposed Action on Fish

Under the proposed action, the rotenone would eradicate all fish in the treatment area. Any brook trout, CRCT, brown trout, rainbow trout or mottled sculpin within a short distance downstream of the fish barriers in Boulder Creek may also be affected by the rotenone and potassium permanganate in the neutralization zone. Any fish species impacted downstream of the fish barriers would be able to repopulate this area from downstream sources, as there are no fish barriers present downstream from the recently constructed barriers.

Effects of the chemicals on fish

Rotenone is highly toxic to fish. In the aquatic environment, rotenone is readily transmitted across the permeable membranes of the gills. Fish are highly susceptible to low concentrations of rotenone. Potassium permanganate is toxic to gill-breathing organisms at the rate (2 to 6 mg/L) required for neutralization. Application of excess potassium permanganate could adversely affect downstream fish populations; however, as described in the proposed action, UDWR would avoid and minimize any effects of potassium permanganate on fish populations.

The short-term direct effects of the proposed action would be to eliminate all fish from the proposed project waters, as well as potentially eliminate fish a short-distance downstream from the neutralization stations. Fish would be killed as a result of the toxicity of rotenone, as described in the specialist report "Chemicals and Application of the Proposed Action." Fish may also be killed for 0.25-0.5 miles (0.4-0.8 km) below the neutralization station from the combined effects of the rotenone and potassium permanganate before mixing of the chemicals and neutralization can occur.

Effects of treatment on the fish species

Colorado River cutthroat trout. The proposed action would result in mortality of an unknown but likely low number of CRCT present in the treatment area. Sampling over the past 10 years has shown that few CRCT are present in the proposed project area. Within the project waters, native CRCT would be reintroduced once the waters were found to be free of nonnative trout, or they would be allowed to recolonize naturally from upstream populations. A similar project on West Fork Boulder Creek showed that CRCT biomass in the treated reach recovered to that of the untreated reach within 7 years (Hadley et al. 2008, Williams and Hardy 2010). The CRCT response in the treatment area is expected to be similar; therefore, while the proposed action would result in a short-term, non-significant loss of CRCT, overall the proposed action would result substantial benefit to the conservation of CRCT.

Recolonization and reintroduction of CRCT in the treated stream reach would expand the current range, restore the species to some of its historic range, and increase the size of the East Fork Boulder Creek population. The proposed action would reduce the risk of catastrophic loss of CRCT caused by stochastic events, such as flood or drought. Post-treatment recolonization or restocking has the potential to increase the CRCT occupied stream miles in the drainage by 13.7 km (8.5 miles).

Nonnative trout in the project area are a threat to the conservation and recovery of native CRCT; therefore, their eradication from the project area would be a benefit to CRCT, the MIS for the project area, and their habitat.

In areas below the neutralization station, CRCT may be killed in the mixing zone, although very few would be expected, and they could recolonize quickly from downstream areas, which would be unaffected by the proposed action, and upstream areas after CRCT are reestablished.

Nonnative trout. Nonnative trout would be eliminated from and not restored to the waters treated with rotenone. Nonnative trout, the MIS in Boulder Creek, may be killed in the mixing zone below the neutralization station. Downstream from the fish barriers, they could recolonize quickly from downstream areas, which would be unaffected by the proposed action. Nonnative trout populations across the Forest are stable, and the elimination of nonnative trout combined from the project area would not result in a significant impact to their populations Forest-wide (Rodriguez 2008).

Mottled sculpin. Mottled sculpin are currently thought to occur downstream from the project area; however any mottled sculpin that may exist within the project area would be eliminated under the proposed action. If mottled sculpin are observed within the project area during the proposed action, then fish from downstream would be reintroduced above the fish barriers once the proposed action is completed. Since nonnative trout have been shown to have negative impacts on the growth and abundance of sculpin, the proposed action would offer a long-term benefit to any mottled sculpin reintroduced into the project area. In areas below the neutralization station, mottled sculpin may be killed in the mixing zone; however, it is expected that this mortality would be minimal and that they could recolonize from downstream areas post-treatment.

Overall effects on fish

Based on the above, the proposed action would have a short-term (2-3 years) negative, but not significant, impact on fish populations; however, the impact would be temporary, since native CRCT, and potentially mottled sculpin, would reinhabit the area. The proposed action would have a permanent effect on brook trout and any rainbow or brown trout in the treatment area, because they would not be restocked. The proposed action would have a long term beneficial impact on CRCT through implementing conservation actions consistent with the Conservation Agreement.

Effects of the Proposed Action on Aquatic Invertebrates

The proposed action would directly affect aquatic biota in the project area, including macroinvertebrates. These impacts may include mortality and differential effects on species assemblages (composition). Macroinvertebrates play a key role in aquatic ecosystem function and are an important food source for trout and terrestrial fauna.

<u>Effects of the chemicals on aquatic invertebrates</u>

Rotenone can harm aquatic macroinvertebrates. In general, benthic macroinvertebrate communities tend to be more tolerant of rotenone than most fishes, but individual macroinvertebrate species have varying ranges of rotenone tolerance (Engstrom-Heg et al. 1978, Chandler and Marking 1982, Mangum and Madrigal 1999, Finlayson et al. 2010a, Vinson et al. 2010). Ling (2003) and Vinson et al. (2010) recently reviewed laboratory studies of rotenone toxicity to benthic macroinvertebrates and found LC50 values anywhere from 2 µg/l – 7,500 µg/l. Depending on exposure time, mortality was near 100% at rotenone formulation concentrations greater than 50-75 µg/l for lotic (stream) invertebrates and 150 µg/l for lentic (lake/pond) adult aquatic invertebrate taxa (e.g. Heteroptera, Coleoptera). Toxicity also varied widely both within and among taxonomic divisions. Many of the studies reviewed reported results of 24 -96 hr exposures, far exceeding the duration of the proposed action. Finlayson et al. (2010a) recently published findings from laboratory studies showing that aquatic invertebrate 8-hour LC50s ranged from 13 µg/l -174 µg/l for CFT Legumine and Nusyn Noxfish rotenone formulations. The lowest 8-hour LC50 concentration of active ingredient rotenone for the non-synergized CFT Legumine rotenone formulation was 34 µg/l. In comparison to the above studies, the planned treatment concentration for the proposed action would be 0.5 to 2.0 mg/L of Chemfish, Prentox Prenfish, or CFT Legimune rotenone formulations. Each of these products contains 5% active ingredient rotenone, meaning concentrations of active ingredient rotenone would be between 25 µg/l and 100 µg/l. The proposed application duration would be 6 to 8 hours.

The sensitivity of individual species and life stages to rotenone appears related to their oxygen uptake process (Engstrom-Heg et al. 1978). Smaller invertebrates appear more sensitive than larger invertebrates, and species that use gills to extract aqueous oxygen are more sensitive than species that obtain oxygen through other means (Vinson et al. 2010). The insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and some

Trichoptera (caddisflies) (EPT taxa) are all gill breathers. These EPT taxa are a major component in the trout diet. They are less tolerant to environmental stressors than other aquatic invertebrate groups and have not been found after some rotenone treatments (Mangum and Madrigal 1999). Finlayson et al. (2010a) found that mayflies appeared to be the most susceptible taxa to rotenone. Sensitivity to rotenone can also vary within the same taxonomic order. Whelan (2002) reported that while caddisflies (Trichoptera) had the highest number of species affected by rotenone, many caddisflies were tolerant.

Potassium permanganate is considered toxic to aquatic invertebrates and zooplankton, although there is likely to be a wide tolerance range among various freshwater invertebrates. For invertebrates, the 96 hr LC50 value is 5 mg/L. Like rotenone, toxicity differs between species but is often toxic in freshwater at concentrations between 1,000 and 2,000 µg/l (USEPA 2006). Therefore, the mixture of rotenone and potassium permanganate during the neutralization process could adversely affect benthic macroinvertebrates in the neutralization zone, extending approximately 0.25 to 0.5 mile (0.4-0.8 km) below the fish barriers. The macroinvertebrate resources within the neutralization zone would be expected to re-establish within a few months after the neutralization treatment ends. Areas below this point and tributary springs would serve as sources for recolonization. As a result, no taxa are expected to be lost, and re-establishment is expected to occur within a few months, thus resulting in no significant impact.

As described in the specialist report, "Chemicals and Application of the Proposed Action," rotenone formulations contain a variety of constituents other than rotenone. Since liquid rotenone formulations were used in all the lotic water studies discussed below, the effects of these constituents to macroinverebrate communities are represented. The one exception is the recent data indicating that formulations containing synergists, such as piperonyl butoxide, are more toxic to macroinvertebrates, and, therefore, would have a larger impact to macroinverebrates; however, the proposed action would not involve use of a rotenone formulation containing a synergist.

<u>Effects of the treatment on abundance and diversity</u>

Rotenone treatment results in short term decreases in macroinvertebrate abundance and diversity (Binns 1967, Cook and Moore 1969, Engstrom-Heg et al. 1978, Mangum and Madrigal 1999, Demong 2001, Whelan 2002, Ling 2003, Hamilton et al. 2009, Finlayson et al. 2010a, Vinson et al. 2010). Various studies have also evaluated recovery of the benthic community from rotenone treatments by tracking the return of individual taxa and taxonomic diversity (family, genus, and species) to approximate pre-treatment levels. While some studies have evaluated recovery of abundance and biomass, others have focused on community indices such as taxa richness or other diversity indices (e.g. Ephemeroptera, Plecoptera, Trichoptera [EPT] richness, Biotic

Condition Index [BCI]) (Binns 1967, Cook and Moore 1969, Engstrom-Heg et al. 1978, Whelan 2002, Demong 2001, Vinson and Vinson 2007, Hamilton et al. 2009, Finlayson et al. 2010a, Vinson et al. 2010).

The time needed for aquatic invertebrate assemblages to recover following rotenone treatment across studies have varied from a few months to 3 years or more depending on the measure of recovery and study length. Overall, aquatic invertebrate assemblage abundances generally return to pre-treatment levels more quickly than measures of biodiversity or community composition. Rapid recovery (< 1 year) to pre-treatment levels has been documented following some rotenone applications (Ling 2003, Hamilton et al., 2009). Assemblage abundances typically return to pre-treatment levels within a few months to a year (Binns 1967, Cook and Moore 1969, Beal and Anderson 1993, Mangum and Madrigal 1999, Melaas et al. 2001, Whelan 2002). Mangum and Madrigal (1999) found that the total abundance of invertebrates returned to pre-treatment levels in 1 to 36 months across their sampling sites. Hamilton et al. (2009) reported declines in invertebrate abundance immediately following treatment; however, no significant differences in abundance were detected 1-year following sampling.

The recovery times for biodiversity and community composition measures have been longer and have exceeded 2 years in some studies (Binns 1967, Whelan 2002) and more than 5 years for individual species (Mangum and Madrigal 1999). Vinson et al. (2010) reviewed field studies on the impacts of rotenone to aquatic invertebrate communities and found that longer-term (2 or more years of post-treatment sampling) studies are limited; however the results of some of the longer-term studies in lotic systems are reviewed below:

- In 1962, over 435 miles of the Green River were treated with rotenone prior to the closure of Fontenelle and Flaming Gorge Dams (Binns 1967). The target concentration was 5 mg/l of 5% rotenone formulation (250 µg/l active ingredient rotenone), but the concentration reached nearly 10 mg/l rotenone formulation (500 µg/l active ingredient rotenone) at some sites because of lower than expected flows. Binns (1967) reported that 2 years after treatment the patterns of dominant invertebrate groups were still different from pre-treatment assemblages and that two genera, *Pentagenia* and *Hexagenia* (Ephemeroptera: Ephemeridae), had not reappeared. The abundances of 3 taxonomic groups (Ephemeroptera, Trichoptera and Chironomidae) were found to increase with time after rotenone treatment. The abundance of each group increased more quickly upstream, perhaps reflecting colonization from upstream sources. Monitoring was not continued beyond 2 years. The observed patterns are confounded with the effects of dam closure soon after the treatment.

- In another example, the Strawberry River Watershed, Utah, the entire drainage received a double treatment within a single year. Mangum and Madrigal (1999) found that the total abundance of invertebrates returned to pre-application levels in 1 to 36 months across their sampling sites. The authors collected 46% of the pre-treatment taxa 1 year after treatments and 79% of the taxa after 5 years. This study provided evidence that macroinvertebrate community composition had significantly declined and had not fully recovered 5 years after treatment with rotenone. The comparability of macroinvertebrate impacts from both the Mangum and Madrigal (1999) and Binns (1967) studies to the proposed project is limited because the rotenone for these projects was applied at higher concentrations (150 µg/l - 500 µg/l) and for longer durations (up to 48 hours) than those planned under the proposed project.

- Manning Creek, in southern Utah, was treated with rotenone in 1995 and 1996 (Whelan 2002). Rotenone was applied at a target concentration of 1.5 mg/L (75 µg/l active ingredient rotenone) in the stream channel for 12 to 18 hours. Utah Division of Wildlife Resources collected pre-treatment macroinvertebrate samples in 1988, 1990, and 1995, as well as post-treatment samples in 1997 and 1999. Whelan (2002) reported that about 50% of the taxa were found both pre-and post treatment, 21% taxa were collected only pre-treatment, and 30% were found only post-treatment. The author stated that the taxa found exclusively in post–treatment samples were to the result of sampling inefficiencies in detecting rare taxa. The most impacted order of aquatic insects was the Trichoptera (caddisflies), with about 10% of the taxa unaccounted for in post-treatment samples after 3 years. The study was confounded by land use changes and differences in sampling effort across years.

- Hamilton et al. (2009) applied Prentox PrenFish 5% rotenone formulation at concentrations of 5 mg/l (250 µg/l) for the first hour and 2 mg/l (100 µg/l) for the next 7 hours for each of two days in Strawberry Creek, Great Basin National Park, Nevada. Total and EPT taxa richness declined immediately (1month) following treatment (50% and 75% lower). After 1 year, differences in taxa richness between pre-treatment samples and post-treatment samples were not significant. Rotenone treatment resulted in an increase in the Hilsenhoff Biotic Index indicating that it differentially affected pollution sensitive species. Four taxa were found missing 1 to 3 years post-treatment. These four taxa had only been found in low abundance prior to the piscicide treatment. Conversely, three taxa were found in post-treatment samples that had not been found in pre-treatment samples. However, as pointed out by Finlayson et al. (2010b), Hamilton et al. (2009) applied rotenone at concentrations up to 5 times those suggested on the labeling for the Prentox PrenFish 5% rotenone formulation used in the study. Therefore, at the concentrations and duration described under the Proposed Action, which would be within the concentrations of the rotenone formulation labeling suggestions, invertebrate impacts may not be as severe as seen by Hamilton et al. (2009).

- Finlayson et al. (2010a) evaluated macroinvertebrate samples collected from rotenone treated and untreated portions of Silver King Creek between 1991 and 1996. Historical treatments had occurred in 1964 and 1976, and at the time of their study a portion of the stream was treated with Nusyn-Noxfish rotenone formulation from 1991-1993. These treatments lasted from 6-18 hours at concentrations of 16-23 µg/l active ingredient rotenone. Invertebrate samples collected at 5 locations in the treated area and one location in the untreated area between 1991 and 1996 showed no significant difference in taxa richness or number of rare taxa between treated and untreated sites. While three genera collected at the untreated site had not been collected at the treated site, 27 genera were collected at the five treatment sites that were not collected at the untreated site.

Data has also been collected adjacent to the project area. West Fork Boulder Creek was treated with an unspecified 5% active ingredient rotenone formulation in 2000 and 2001 to remove nonnative trout and reintroduce CRCT (Hepworth et al. 2001b). The rotenone formulation was applied at a concentration of 2 mg/l (100 µg/l active ingredient rotenone). A macroinvertebrate sample collected within the treated area in 2003 and 2010 showed similar average taxa richness and average EPT taxa richness to macroinvertebrate samples collected downstream in Boulder Creek in 1994 (see Table 4) indicating that macroinvertebrate diversity took less than two years to recover after a treatment very similar to the proposed action.

In lentic systems, field studies have focused on rotenone's impacts to lentic zooplankton communities, noting a substantial short-term negative effect on zooplankton abundance and taxa richness. Almquist (1959) observed that most zooplankton were killed with the addition of 0.5 to 0.6 mg/l rotenone formulation and that the toxicity of rotenone in lakes varied in response to light, oxygen, alkalinity, temperature, and turbidity. Kiser et al. (1963) observed 100% mortality of zooplankton within 2 days after applying 0.5 mg/l rotenone. Similarly, Beal and Anderson (1993) found no surviving zooplankton 2 days after treatment with 6µg/l of 2.5% rotenone. Reinertsen et al. (1990) found a substantial reduction in zooplankton species abundance after a 0.5 mg/l rotenone treatment.

However, recovery of the zooplankton community in lakes following rotenone treatment appears to be rapid and robust. After the 1997 rotenone treatment at Lake Davis, overall zooplankton abundance increased to roughly 300% of the pre-treatment abundance within 1 year after the treatment (CDFG 2006). Furthermore, all zooplankton taxa identified before the treatment were identified after treatment. In another evaluation, Kiser et al. (1963) reported that all 42 species collected before a treatment, killing all zooplankton, were subsequently present within 5 months. Melaas et al. (2001) reported complete recovery of prairie wetland zooplankton assemblages within 1 year of treatment. Blakely et al. (2005) reported that rotenone treatments of orchard ponds with measured concentrations in the ponds between 68 µg/l and 474 µg/l showed no significant differences in macroinvertebrate taxa richness among treatments but did show some more subtle differences in community structure (relative abundance, percent composition). Similarly, no significant differences in zooplankton richness were observed, but composition varied between fish-bearing, fish-less, and rotenone treated ponds. Composition changed in rotenone treated ponds between 6 months, 1-year, and 3-years post-rotenone treatments, but no major taxonomic groups were lost.

Effects of treatment on individual taxa

Determining the recovery of individual aquatic invertebrate taxa is more problematic. Within the Boulder Creek drainage, no pre-treatment data were collected in West Fork Boulder Creek and the presence of individual taxa varied widely among all known collections in the Boulder Creek drainage, so it is difficult to determine whether taxa were gained or lost following the 2001 West Fork Boulder Creek treatment. Presence of individual taxa even varied widely among samples taken at the same location at different times within the same year (Magnum 1995, Mangum 1997, Vinson 2005, USEPA 2010). Of 44 total taxa identified on Boulder Creek above the hydroplant inflow in May and June 1996, only 22 taxa (50%) occurred in both collections. Similarly, only 60% of the total number of taxa identified in both June and October 1994 collections on Boulder Creek below the power plant were present in both collections. Three collections were taken at a site on East Fork Boulder Creek in 1996 (July, August, and September) and only 42% of the total number of taxa identified were present in all three collections. This within site and year variability makes it difficult to know what kind of commonality in individual taxa presence should be expected among sites and between years.

The October 1994 macroinvertebrate sample collected on Boulder Creek above the hydroplant is probably the closest sample in geographic proximity and season to the September 2003 macroinvertebrate collection on West Fork Boulder Creek. A comparison of all taxa found in the three replicate samples at each location showed that a total of 63 taxa were collected. Fourteen of those taxa (22%) were found in both locations, 16 (25.5%) were found only in the October 1994 samples from Boulder Creek, and 33 (52.5%) were found only in the September 2003 samples from West Fork Boulder Creek. While it is impossible to ascertain the disposition of individual taxa in West Fork Boulder Creek pre-treatment, it does appear as though the macroinvertebrate community in 2003 recovered to a diversity exceeding that of the downstream station on Boulder Creek when it was sampled in 1994. Data interpretation may be confounded by land use changes over the 9-year period, as well as differences in taxonomic resolution between the two laboratories used to identify samples.

Similarly, data collected at the same location just upstream from FR30166 in West Fork Boulder Creek in 2010 along with data collected less than 0.4 miles to the east in East

Fork Boulder Creek just upstream from FR30166, are close in geographic proximity to the 2003 sample from West Fork Boulder Creek. Up to 68 taxa were collected when all three collections are viewed together. Sixteen (23%) were present in all three samples, 12 (18%) were present in the 2003 sample and one of the 2010 samples, 21 (31%) were only present in one, or both, of the 2010 collections, and 19 (28%) were present only in the 2003 collections. When just the data from the same location on West Fork Boulder Creek from 2003 and 2010 are examined only 21 of 47 (45%) total taxa collected were found in both 2003 and 2010.

In summary, the past field studies of rotenone impacts indicate that community recovery may occur within as little as 2 months but could take more than 5 years. Different studies have defined recovery differently, making comparison among estimated recovery times difficult. Comparison is also confounded by the specifics of the treatment (e.g. rotenone concentration), insufficient pre-treatment monitoring (typically limited to one or two sampling events), the highly variable temporal and spatial nature of macroinvertebrate communities, lack of adequate control and reference sites, and other confounding factors such as dams that altered hydrologic patterns (Binns 1967, Whelan 2002, Vinson et al. 2010). Variability in rotenone impacts on macroinvertebrate communities is probably caused by 1) concentration of rotenone used and duration of the treatment, 2) whether the rotenone formulation used contained a synergist, and 3) the variability in rotenone tolerance among different taxonomic groups.

Rotenone treatment can be considered akin to a severe pulse physical disturbance, such as a large, unpredictable flood (Vinson et al. 2010). Streams such as East Fork Boulder Creek are dynamic environments, and the organisms that inhabit them must be able to cope with disturbances. Flood, drought and fire are natural disturbances that affect streams. Understanding the recovery patterns of macroinvertebrate assemblages in response to natural disturbances provides additional context for interpreting and assessing the potential long-term effects of the proposed rotenone treatment. Disturbance can be any discrete physical event that disrupts community structure by changing the physical environment (Yount and Niemi 1990). Vinson and Vinson (2007) described disturbance as a discrete event that removes organisms and creates conditions for recolonization.

In a review of 150 case studies of aquatic ecosystem recovery from disturbance (15 of which were in response to rotenone treatments), Niemi et al. (1990) found that most recovery times were less than 3 years. Recovery of macroinvertebrate assemblages to 85% of pre-disturbance densities after pulse disturbances (including rotenone) occurred in less than 18 months. Recovery times were slightly quicker for low order (1st to 3rd order) streams than they were for larger rivers (4th to 5th order). They summarized that rates of recovery of aquatic invertebrate assemblages were influenced most by: 1) persistence of the impact, including changes in system productivity, habitat integrity, and persistence of the stressor; 2) life history of the organism, including generation time, and propensity to disperse; 3) time of year the disturbance occurs; 4) presence of refugia; and 5) distance to the recolonization source.

Niemi et al. (1990) found that assemblage densities recovered much more quickly than individual taxa. Times of recovery for common insect orders following pulse disturbances that did not affect physical habitat characteristics (mostly rotenone and DDT) varied among orders. Assemblage recovery times were near 80% for Diptera after 1 year, 70% for Ephemeroptera after 1 year and about 60% after 2 years for Trichoptera and Plecoptera. Coleoptera was not represented in enough studies for analysis, but Niemi et al. (1990) felt that Coleoptera likely recovered more slowly than Trichoptera and Plecoptera. They speculated that recovery time was primarily related to generation time, propensity to drift, and distance from colonization source. Downstream drift from unimpacted upstream areas was the critical factor in determining the recovery times for stream ecosystems following pulse disturbances that do not impact the physical characteristics of the habitat. Coincidentally, some of the species most sensitive to rotenone are also highly mobile with short life cycles; thus they may have the ability to repopulate depleted areas rapidly through dispersal and oviposition (Engstrom-Heg et al. 1978).

Overall effects on aquatic invertebrates

The proposed action would have an adverse short-term effect on benthic macroinvertebrate density and community composition through mortality of sensitive species. The rotenone treatment would have a stronger effect on the small, gilled EPT taxa species (stoneflies, caddisflies, mayflies) that are typical of cold-water, mountain streams. The impacts of the proposed rotenone treatment would not be significant, however, because recovery of the community composition would likely occur within 2 years. Several factors support this assessment. Other studies demonstrate that recovery can occur within as little as 2 months, extending to more than 5 years in some streams that received higher rotenone concentrations for longer durations than those under the proposed action. Furthermore, headwaters and tributaries upstream of the treatment area would remain untreated, thereby providing ample source populations to recolonize the treated area. Given the above, the proposed Action would have a temporary negative effect but not a significant impact on macroinvertebrate community composition. Although unlikely, the proposed action could result in loss of individual macroinvertebrate taxa.

Several features of the proposed action would help to mitigate impacts of applying rotenone formulations to remove nonnative trout on the aquatic invertebrate community. First, the treatment area is of limited geographic range. The proposed Action does not involve treating the headwater meadow or fishless portions of tributaries or springs; these areas would remain unimpacted by the proposed action and would act as important sources for recolonization. Second, liquid formulations proposed for use (Chemfish Regular, Prentox Prenfish, CFT Legumine) do not contain a synergist, which should help reduce impacts to aquatic invertebrates. Finally, the proposed Action would neutralize rotenone by applying potassium permanganate (2 to 6 mg/L) at the downstream end of the project area, which should limit the impacts of rotenone outside of the project area.

Effects of the Proposed Action on Amphibians
With the exception of one historical boreal toad observation in 1960 (Fridell et al. 2000), no amphibian detections have been documented within the 6th level HUC drainage where the project would occur, including in recent surveys of wetland areas in the East Fork Boulder Creek drainage (Golden and Mecham 2010a, Golden and Mecham 2010b). Boreal toad, boreal chorus frog, tiger salamander, Great Basin spadefoot toad, Woodhouse's toad, and red-spotted toads have been documented in adjacent drainages on or off the Forest.

Effects of the chemicals

Rotenone is toxic to amphibians but generally less toxic than to fish. Rotenone may be absorbed into both skin and respiratory membranes, but skin may present more of a barrier because it creates a greater distance for the chemical to diffuse across (Fontenot et al. 1994), and a smaller surface area relative to gill structures. Fontenot et al. (1994) reported that amphibian larvae with gills are most sensitive to rotenone. In early 1974, African clawed frogs (*Xenopus laevis*) were discovered in some ponds located in the Santa Clara River drainage in northern Los Angeles County, CA. An eradication program using rotenone to extirpate the exotic frogs was undertaken in the spring of 1974. Results indicated that all *X. laevis* tadpoles were killed but adults were unaffected and thus able to reproduce again later that spring (McCoid and Bettoli 1996).

In standard laboratory 24 hr and 96 hr aquatic rotenone toxicity tests, the LC50 values for tadpoles (*Rana sphenocephala*) and larval amphibians ranged between 5 µg/L and 580 µg/L in 24 hr tests and 25 µg/L to 500 µg/L in 96 hr tests (Chandler and Marking 1982, Fontenot et al. 1994). The adult northern leopard frog (*Rana pipiens*) demonstrated a much greater resistance with LC50 concentrations ranging from 240 µg/L to 1,580 µg/L (24 hr) and 240 µg/L to 920 µg/L (96 hr). This suggests that tadpoles and other larval forms of amphibians that utilize gills for respiration are just as sensitive to rotenone as fishes while adult forms, which no longer utilize gills, are much less susceptible to rotenone. Larval amphibians appear to have resistance roughly equivalent to those of the most tolerant fish species.

Potential direct impacts to amphibians include absorption of rotenone during implementation of the proposed Action. Amphibians in their terrestrial life stage should not be affected by the rotenone treatment; however, gill-breathing life stages, if present, would be susceptible. Most amphibians, such as toads, present during a late summer/early autumn treatment would have completed their metamorphosis and would not be affected. Additionally, breeding and rearing habitat for amphibians exists in off channel, fishless areas that would not be treated under the proposed action.

The EPA issued a "May Affect, Likely to Adversely Affect" finding in a Pesticide Effects Determination for rotenone use in waters containing the federally threatened California red-legged frog (*Rana aurora draytonii*), primarily because some individual mortality was probable (Jones and Steeger 2008). Similarly, Maxell (2000) concluded that all amphibian species in aquatic life stages would undergo mortality during rotenone treatments. While at least some mortality of aquatic stages of amphibians is probable from rotenone application, several studies have shown that population level affects do not occur to amphibian species during rotenone treatments. Hayes and Rombaugh (2008) found all six amphibian species that had been present in pre-treatment surveys were still present within two years after a rotenone treatment of a glacial lake in Oregon. They also indicated that amphibian distribution was approximating pre-treatment distribution by the end of the second year post-treatment. Similarly, Demong (2001) described a series of studies where individuals of various amphibian species were observed undergoing mortality during rotenone treatments, but still had live individuals present in post-treatment surveys. He noted that in many cases more species were encountered in post-treatment surveys than were seen undergoing mortality during the treatments.

Effects of the treatment

Potential indirect impacts on amphibians include loss of prey species from rotenone treatments. For example, reductions in emerging aquatic insects could occur over several years, particularly if multiple treatments are required. However, as described in above aquatic insect abundance is expected to recover quickly through drift from untreated upstream areas.

As highlighted in the no action alternative, current populations of non-native trout in the proposed project area could have adverse effects on amphibian populations through predation and competition for prey resources. Therefore, removal of non-native trout may benefit any amphibians using the project waters over the long term. Several studies have shown the removal of nonnative trout can result in an increase in abundance and diversity of amphibian populations (Hoffman et al. 2004, Vrendenberg 2004, Knapp et al. 2007, Pope 2008). In fact some projects have used rotenone treatments to remove nonnative fish in order to promote amphibian recovery. Piec (2006) documented a project in Great Britain that used a 2 mg/l – 3 mg/l concentration of CFT Legumine to remove nonnative fish in ponds containing the Great Crested Newt (*Triturus cristatus*), a priority species in the UK's Action Plan that has its own Species Action Plan. Few newts appeared to be killed during the treatments which were successful at removing nonnative fish with active ingredient rotenone concentrations between 10 µg/l and 200 µg/l. Piec (2006) concluded that rotenone was "an extremely effective conservation tool for Great Crested Newt conservation purposes." Similarly, Walston and Mullin (2007) found increased amphibian diversity after treating ponds with rotenone to remove nonnative fish. They also found that the life history characteristics and population dynamics of several species changed to more closely approximate those seen in fishless ponds.

Overall effects on amphibians

Based on the above factors and expected low occurrence of amphibians, the Proposed Action may impact individual amphibians but would not lead to significant, population level impacts. Removal of nonnative trout may also benefit any amphibians inhabiting the project area.

Non-chemical Alternative

Effects of Non-chemical Alternative on Fish

All nonnative fish collected from the treatment area would be removed from the system and killed. They would not be replaced.

Direct impacts to CRCT in the form of injury of death could be caused by repeated electrofishing. Although the use of electrofishing to remove nonnative trout would allow more selectivity in the fish that would be removed and killed, electrofishing itself could kill or injure CRCT. Snyder (2003) reviewed the potential harmful effects of electrofishing. He found that spinal injuries and associated hemorrhages have sometimes been documented in over 50% of fish examined internally after electrofishing. Such injuries can occur anywhere in the electrofishing field at or above the intensity threshold for the twitch response. Other harmful effects, such as bleeding at the gills or vent and excessive physiological stress, are also of concern. Mortality, usually by asphyxiation, is a common result of excessive exposure to tetanizing intensities near electrodes or poor handling of captured specimens. Salmonids are especially susceptible. The use of low-frequency pulsed direct current and specially designed pulse trains helps prevent these types of injuries.

Indirect impacts to CRCT habitat through substrate and bank disturbance could be caused by repeated removal sampling.

Little information exists on the potential for repetitive electrofishing efforts to impact stream and riparian habitat through trampling by samplers, who will need to hike and/or wade up and down the treatment reaches multiple times for this method of removal. Roberts and White (1992) found that artificial stream channels containing trout redds that were waded in multiple times a day killed 83%-96% of the eggs present. Excessive recreation along the stream bank has been shown damage soils and riparian vegetation (Liddle and Scorgie 1980, Johnson and Carothers 1982). Loss of vegetation and damage to stream bank soils could increase erosion and cause sediment inputs to the stream. Increased sedimentation can result in the loss of habitat for both aquatic macroinvertebrates and fish, through the elimination of the interstitial spaces in the streambed and the filling of pools. Sappington (1992) found that larval fish density was inversely related to the amount of recreation in pools on the Virgin River in Zion National Park.

Suspended and deposited sediment directly impact fish and aquatic invertebrates through clogging of the gills or smothering and indirectly affect them by reducing spawning and resting habitat (Waters 1995). Sedimentation can also adversely affect the spawning success of salmonids, by impeding the process of excavating a redd, depleting oxygen flow to the eggs and sac fry, and blocking the passage of emerging sac fry (Waters 1995). These effects can lead to decreased abundance, diversity, and species composition within the aquatic community. If the project is successful in eradicating brook trout within a couple years, these impacts from the Non-chemical alternative should be small and short-lived; however, if the project continues for a long period of time, then trails could become established and more permanent soil compaction and vegetation impacts could occur. In order to have enough time to feasibly complete the Non-chemical treatment, instream activity would have to be conducted early in the year during CRCT spawning and egg development, which would probably cause egg mortality. Loss would be limited during the initial stages of the project, since CRCT abundance is low in the project area; however, more substantial losses could occur if the project takes many years to complete.

<u>Effects of the treatment</u>

The effects of removing nonnative trout on conservation of the CRCT are as described for the Proposed Action; however, the potential for not meeting the objective is higher. As described in the specialist report, "Effectiveness of Treatments," efforts to completely eradicate nonnative fish by non-chemical methods in streams, rivers, lakes, and reservoirs have generally been unsuccessful (Lentsch et al. 1996, Meronek et al. 1996, Thompson and Rahel 1996, Tyus and Saunders 2000, Golden and Holden 2002, Mueller 2005, Meyer et al. 2006, Birchell 2007). Specifically, electrofishing efforts to remove nonnative trout from streams have met with variable success. East Fork Boulder Creek is a relatively large, complex stream when compared to streams where electrofishing removal has been effective. Approximately 13.7 km of stream are slated for removal efforts under the proposed project. The project area on East Fork Boulder Creek is longer and generally wider than streams where successful electrofishing removal projects have occurred. Additionally, the habitat in a large portion of the project area is complex with deep riffles and cascades, as well as deep > 1 m pools, undercut banks, and abundant instream cover. Removing brook trout from King's Pasture Reservoir and the pond in King's Pasture also presents a challenge. Based on previous studies it would probably take at least two years to remove brook trout from the pond in King's pasture using non-chemical methods. Electrofishing removal in East

Fork Boulder Creek would not be able to be completed until this pond is free of brook trout.

Overall effects to fish

Brook trout would have to be eradicated from the stream prior to beginning removal efforts in the reservoir, in order for those efforts to be successful. Based on the above factors, the Non-chemical alternative would have a negative impact on fish populations during the removal time period, which would be at least 2 years and possibly considerably longer. The impact should be temporary since the area would be restocked with CRCT; however, it is unclear how long this alternative would take to achieve complete eradication of brook trout. The Non-chemical alternative could have a long term beneficial impact on CRCT through implementing conservation actions consistent with the Conservation Agreement; however, the effectiveness of this alternative for achieving the objective of the complete eradication of brook trout is suspect. Non-chemical removal has not been shown to be successful in a system with the size and complexity present in the proposed project area in the past. Temporary impacts to fish habitat through increased erosion and sedimentation caused by sampler bank trampling are also expected. The magnitude of these impacts would depend on the duration of the project.

Effects of Non-chemical Alternative on Aquatic invertebrates

As highlighted in the effects analysis for fish, the Non-chemical alternative would result in substantial disturbance to the stream bed, as the entire stream would be walked on approximately 16 times between June and October for at least two years. The stream bed disturbance would result in some direct mortality of aquatic macroinvertebrates through trampling and displacement of some aquatic macroinvertebrates through drift. As described in the effects analysis for fish stream bank trampling may result in increased levels of erosion and sedimentation. Additionally, application of electric current to the water would result in increased drift and displacement of aquatic macroinvertebrates.

The Non-chemical alternative would involve 5-6 people walking in and along the stream bed approximately 16 times during at least two consecutive summers. Continued walking in streams has been shown to displace invertebrates. Shakarjan and Stanford (1998) observed a strong inverse relationship between the number of hikers passing through an area and the density and biomass of aquatic invertebrates in the Narrows section of the Virgin River in Zion National Park. Similarly, Caires (2007) found that the density of drifting of aquatic invertebrates increased with increased hiker use until hiker numbers exceeded 40 hikers per half hour. Direct sampling of the impacted areas showed no difference in total benthic invertebrate abundances among sites of different use levels. This suggests that concentrated use reaches in the North Fork of the Virgin River were quickly recolonized by most taxa. Mayflies in the genus *Baetis* did show a significantly lower density at high use sites. Caires (2007) found that hiker impacts were overshadowed and ameliorated by a flash flood, indicating that natural disturbance could have a much greater effect on invertebrate communities than recreational use of the river. Muller et al. (2003) found a lower diversity of dragonfly species in sites where vegetation disturbance had been caused by sport fishermen on the floodplain of the Tisza River in Hungary.

Aquatic invertebrates can be susceptible to being stunned during electrofishing activities (Penczak and Rodriguez 1990, Rabeni et al. 1997, Taylor et al. 2001). Elliot and Bagenal (1972) found that the combination of electrofishing and trampling increased the total number of invertebrates in the drift by 5%, but that overall macroinvertebrate densities in the study area were reduced up to 30% after electrofishing. In laboratory tests 8 of 9 taxa tested were induced to drift by applying an electric field similar to that from a backpack shocking unit (Mesick and Tash 1980). The authors concluded that impacts to aquatic invertebrate communities could occur in places that are electrofished so frequently that the rate of drift exceeds the rate of recolonization. Other studies have shown that macroinvertebrate populations subject to electrofishing have been reduced through drift by more than 90% when macroinvertebrates are the target organism (Taylor et al. 2001), and as much as 80% with commonly used methods (Fowles 1975). The combined impact of walking in the stream and electrofishing appears to elevate drift more than electrofishing alone (Elliot and Bagenal 1972, Kruzic et al. 2005).

Kruzic et al. (2005) recommended that electrofishing later in the season, when most invertebrates have hatched, would likely minimize effects on macroinvertebrates; however, in order to achieve the objective of the purpose and need of the proposed project treatment would most likely have to occur throughout the entire summer. As outlined in the effects analysis for fish, increased bank trampling could have a negative impact on aquatic invertebrate populations during the removal time period, which would be at least 2 years and possibly considerably longer. The impact would be temporary and short-lived if the alternative only takes 2-3 years to be successful; however, it is unclear how long this alternative would take to achieve complete eradication of brook trout. It may take up to 10 years. The Non-chemical alternative could have a long term beneficial impact on aquatic invertebrates through restoring the native top-level predator and eliminating a nonnative trout capable of altering food web dynamics, as discussed in the effects analysis for the proposed action. The impacts of the Non-chemical alternative to aquatic invertebrates are dependent on the duration of activities and their effectiveness at eradicating brook trout.

Effects of Non-chemical Alternative on Amphibians

Little published information exists on potential electrofishing impacts to amphibians; however, amphibians are affected by the electric field during electroshocking activities (Whittier et al. 2007). Therefore, impacts to amphibians from electrofishing are probably similar to those described for fish. All life stages could be directly affected by accidental trampling mortality or injury during sampling efforts (Maxell 2000, Bradford 2002, Keinath and Mcgee 2005). Direct injury and mortality can also result from amphibians collected as bycatch during gill netting efforts (Mike Golden, Dixie National Forest, personal observation). Amphibian densities have been shown to be significantly lower in streams with higher sediment loads (Welsh and Oliver 1998, Gillespie 2002). As highlighted in the proposed action, removal of nonnative trout could have beneficial impacts to amphibians through restoring the natural food web and removing a nonnative predator.

Since no breeding areas for amphibians are known to occur in the project area, impacts should be restricted to individual amphibians. As with fish and aquatic invertebrates, the positive and negative impacts of the Non-chemical alternative are dependent on its duration and effectiveness.

Cumulative Effects

The potential cumulative effects on fish and aquatic resources from past, present, and reasonably foreseeable actions, including the proposed action or alternatives, are effects to the likelihood of successful conservation of CRCT and effects on fish habitat. The CEA for conservation of CRCT is the Lower Colorado Geographic Management Unit. The CEA for effects on aquatic habitat is listed in Table 6.

Cumulative Effects of No Action

<u>Effects on conservation of CRCT</u>

As highlighted under the indirect effects of the no action alternative, allowing brook trout to remain in East Fork Boulder Creek restricts the self-sustaining CRCT population to 0.5 miles of East Fork Boulder Creek. This population would be considered at high risk of local extinction under this scenario during future evaluations of the species status. The West Fork Boulder Creek population would continue to occupy 11.1 km (6.9 miles); however, the West Fork Reservoir splits the population into two segments of 3.4 km (2.1 miles, upstream) and 7.7 km (4.8 miles, downstream). While gene flow and immigration can proceed downstream when the reservoir spills, no upstream transfer can occur without active management.

In addition to nonnative species, the CRCT populations of both the East and West Forks of Boulder Creek have been negatively impacted by Garkane's hydropower operations de-watering the lower portions of both streams for over 50 years. Anywhere from 0.25-0.5 miles (0.4-0.8 km) of stream can be completely dewatered during base flow periods and the remaining stream contains considerably less water than under the natural flow regime. The low water conditions limit the potential density and biomass of trout populations in the lower portions of these streams.

The future planned continuous release of 2 cfs from King's Pasture Reservoir as a condition of Garkane's operating license (FERC 2007) will increase the potential for trout populations in the lower 3.9 miles (6.3 km) of East Fork Boulder Creek; however, this will not benefit CRCT conservation without the associated removal of nonnative fish. Marks et al. (2009) found that both removal of nonnative fish and flow restoration resulted in positive impacts to native fish populations in Arizona, but that flow restoration in the absence of nonnative fish removal would have paid minimal dividends for native fish restoration. In the absence of CRCT restoration, flow restoration would still benefit the nonnative resident trout population below East Fork Reservoir, as well as stream ecosystem function.

Since the initial identification of CRCT populations in the Escalante River drainage, considerable effort has gone toward expanding their populations in the Escalante drainage and throughout the Lower Colorado GMU. These renovation projects are highlighted in the Specialist Report for Effectiveness and cost comparison of treatment options. Currently the Lower Colorado GMU only has two populations (combined Right Fork UM and UM Creek population in the Fremont River drainage and the combined West Branch Pine Creek and Pine Creek population in the Escalante River drainage) that are completely connected and fit both the length of occupied stream and density criteria laid out for persistent CRCT populations (Hilderbrand and Kershner 2000, Hadley et al. 2008). Without the West Fork Reservoir present, the West Fork Boulder Creek population would satisfy both criteria.

A separate condition of the Garkane Boulder Hydroplant FERC license indicates that if CRCT objectives are not met in the Boulder Creek drainage then renovation projects may move forward in one or more of three other creeks: North Creek, Pleasant Creek, and Carcass Creek. Two of these streams have the have the potential to meet the criteria set forth by Hilderbrand and Kershner (2000) on National Forest property; however, it is difficult to determine what the CRCT density will be once restoration efforts are complete. A cumulative effect of the no action alternative would be that the CRCT Conservation may not progress at developing another connected population that satisfied the persistence criteria set forth in Hilderbrand and Kershner (2000). This would leave all but two of the current populations more vulnerable to local extinction.

<u>Effects on aquatic habitat</u>

The No Action alternative would result in no additional disturbance to aquatic habitat; therefore, there is no cumulative effect on aquatic habitat.

Cumulative Effects of the Proposed Action

<u>Effects on conservation of CRCT</u>

The cumulative effects of the proposed action and subsequent expansion and stocking of native CRCT would increase the persistence ability of both the East Fork Boulder Creek and West Fork Boulder Creek CRCT populations and expand the occupied habitat of CRCT in the Lower Colorado GMU. Expanding the populations in the Lower Colorado GMU promotes persistence of the species.

The 2000-2001 expansion of the West Fork Boulder Creek population has produced relatively high densities of CRCT in the expansion area (Hadley et al. 2008, Hardy et al. 2009a, Hardy et al. 2009b). This would indicate that similar densities could be achieved in the East Fork Boulder Creek. The future planned continuous release of 2 cfs from King's Pasture Reservoir as a condition of Garkane's operating license (FERC 2007) would also increase the potential density of CRCT that could develop in East Fork Boulder Creek. The 2009 removal of the FR 30166 road culvert across East Fork Boulder Creek, along with the planned removal of the fish barriers in West Fork Boulder Creek and the FR 30166 road culvert across West Fork Boulder Creek would create the potential to connect approximately 13.5 km (8.4 miles) of CRCT habitat in the lower East and West Forks Boulder Creek and upper portion of Boulder Creek.

The proposed action would not only increase occupied stream mileage, but would create a new connected population below both reservoirs that could provide a persistent population according to the criteria outlined in Hilderbrand and Kershner (2000). In addition the two connected tributaries would create a metapopulation which should significantly decrease the potential for local extinction caused by a stochastic event (Young et al. 1996, Hilderbrand and Kershner 2000). Therefore, the proposed action would make a significant contribution to CRCT conservation in the Lower Colorado GMU.

<u>Effects on aquatic habitat</u>

In 2008 the Bear Creek Fire burned a total of 1,450 acres within the CEA. The severity of Bear Creek Fire varied widely within the burn perimeter (USFS 2008). The fire burned approximately 1,068 acres within the Bear Creek drainage and approximately 0.5 miles (0.8km) of Bear Creek were located within a moderate to high severity area. The portions of Bear Creek impacted by the fire have undergone accelerated erosion, which has increased the amount of sediment moving downstream in Bear Creek and eventually into Boulder Creek.

Grazing and recreation use will continue to affect the condition of aquatic biota populations and habitat in the future. The Boulder allotment will continue to be grazed at or below current stocking rates. Road related impacts to aquatic systems in the project area would be reduced with implementation The Dixie National Forest motorized travel plan, which changes the designation of most of the roads in the project area. A reduction in traffic volume or elimination of traffic and any subsequent vegetation recovery will reduce the amount of sediment entering streams within the project area. A reduction in sediment would reduce sediment related impacts to aquatic organisms.

An additional timber harvest is planned within the Bear Creek drainage for private land near Haw's Pasture. This area was not impacted by the Bear Creek Fire and has sufficient wet meadow and other riparian vegetation to ameliorate timber harvest impacts. Additionally, several projects have been proposed to salvage and reforest areas within the Bear Creek fire. Skidding and yarding of logs will result in a loss of ground cover, displacement of soil, and compaction of soils (Chamberlain et al. 1991). This will increase upland erosion rates and fine sediment influx into adjacent stream channels within the project area. Reviews of the available information on the impacts of postfire logging indicate that the synergistic effect of a fire and subsequent logging on the burned landscape can be greater than either individual action (McIver and Starr 2000, McIver and Starr 2001, Beschta et al. 2004, Karr et al. 2004, Lindenmayer and Noss 2006, Peterson et al. 2009). Studies and literature reviews suggest that timber harvest, especially ground-based skidding, on a burned landscape will create higher rates of soil compaction and disturbance resulting in increased overland flow, erosion, and sediment generation (McIver and Starr 2000, McIver and Starr 2001, Peterson et al. 2009).These impacts should be short-term and wane parallel to vegetation recovery.

Fire, livestock grazing, timber harvest, and roads all have the potential to increase erosion and thereby sediment transport and deposition (Platts 1991, Furniss et al. 1991, Trombulak and Frissell 2000). Impacts from past, present and foreseeable future projects is limited; however, the potential for fire and post-fire debris flows remains.

The Proposed Action alternative would result in no long-term disturbance to aquatic habitat. It would not add to the existing level of disturbance from other activities; therefore, there are no cumulative effects on aquatic habitat.

Cumulative Effects of the Non-chemical Alternative

Effects on conservation of CRCT

The cumulative effects for conservation of CRCT are the same as the proposed action; however, because of the questionable effectiveness of the non-chemical treatment in removing the non-native trout, there is possibility that the establishment of CRCT in the project area may not occur. The cumulative effect, then, would be the same as the No Action alternative.

Effects on aquatic habitat

The major impact to aquatic habitat from the Non-Chemical alternative is increased erosion and sedimentation which would be additive to sources of sediment from other activities or disturbances in the CEA. The effects of an increase in suspended and deposited sediments are discussed under the direct and indirect effects of the Non-chemical alternative.

The implementation of the Non-chemical alternative may result in increased erosion and sedimentation; however, additive effects associated with the non-chemical alternative are expected to be limited in scope and not result in long-term detrimental effects to aquatic biota.

Summary

The No Action alternative would have no direct, indirect, or cumulative effects to aquatic habitat; however, maintaining a brook trout fishery in East Fork Boulder Creek does have impacts to CRCT conservation, as well as to the ecosystem function. In the absence of an action to remove nonnative brook trout, CRCT conservation may not advance in the Lower Colorado GMU and the opportunity to create a persistent metapopulation of the species in the Lower Colorado GMU may not be feasible. In addition any ecosystem level effects from the presence of nonnative brook trout would remain.

The Proposed Action would have short-term negative impacts to fish populations in the project area. In the short-term, all fish would be eliminated within the area above the neutralization stations. Non-native trout would be completely eliminated from East Fork Boulder Creek, but their persistence Forest-wide would not be affected by the Proposed Action. The remnant population of CRCT, a Conservation Agreement and Intermountain Region Sensitive species, as well as the MIS for East Fork Boulder Creek, would be expanded from the headwaters of East Fork Boulder Creek, creating a persistent metapopulation between King's Pasture Reservoir and the West Fork Reservoir; thereby, significantly contributing to CRCT conservation in the Lower Colorado GMU. Mottled sculpin may be reintroduced to the treatment area, although they are not known to be present currently. Any fish species, including nonnative trout, the MIS for Boulder Creek, that may be impacted in the mixing zone below the neutralization site would be able to recolonize that area.

The Proposed Action would have short-term negative impacts to both the density and diversity of aquatic macroinvertebrates within the project area. Based on similar past projects, macroinvertebrate density is expected to recover within 1-2 years and macroinvertebrate diversity within 2-5 years. There is the potential for individual taxa to be lost for longer than that time; however, it would be difficult to determine if individual taxa are lost due to the propensity for macroinvertebrate sampling to pick up and lose taxa even in the absence of a chemical treatment. The proposed action may have negative impacts to individual amphibians within the project area during the treatment but is not expected to have population level effects.

The Non-chemical alternative would result in riparian and bank damage, which would increase erosion and sedimentation. The negative effects of erosion and sedimentation from implementation of the Non-chemical alternative are expected to be short-lived; however, their duration is dependent on the effectiveness of the alternative. The Non-chemical removal alternative may have short-term negative impacts to macroinvertebrate density and diversity. These impacts are not expected to be as severe as the Proposed action, but their severity is dependent on the effectiveness of the Non-chemical alternative. During the Non-chemical alternative individual amphibians may be negatively impacted by electrofishing, gill netting, and/or trampling by workers; however, no population level impacts are expected.

As with the Proposed action nonnative resident trout would be removed from the project area under the Non-chemical alternative, but their persistence would not be affected by the Forest-wide. Any native mottled sculpin and CRCT present would be returned to the stream but could experience lethal or sublethal effects from repeated electrofishing. The negative impacts from repeated electrofishing on CRCT and mottled sculpin are not expected to produce population level effects. Similar to the proposed action, the Non-chemical alternative has the potential to expand the remnant CRCT population in the East Fork Boulder Creek and create a persistent metapopulation; however, the effectiveness of the alternative is questionable.

Compliance with Other Laws and Regulations

National Forest Management Act

The National Forest Management Act requires compliance as outlined in the Code of Federal Regulations (CFR) 219.27 through 219.27 (g). Relevant points for this report include CFR 219.27 (a)(5) "provide for and maintain diversity of plant and animal communities to meet overall multiple-use objectives…" and CFR 219.27 (g) "management prescriptions…shall preserve and enhance the diversity of plant and animal communities…". Diversity of aquatic biota communities would be maintained with the implementation of the proposed action or no action alternative.

Endangered Species Act

The project area does not contain aquatic species or provide critical habitat for aquatic species that would be protected by the Endangered Species Act of 1973.

Forest-plan Consistency Determination

The proposed action is consistent with the Forest Plan goal to "Manage classified species...habitat to maintain and enhance their status through direct habitat improvement and agency cooperation" (LMRP p IV-6). CRCT are specifically mentioned as one of the classified species. Removing nonnative fish and restoring CRCT within their historic range would also move the Forest towards meeting two of the objectives of the interagency Conservation Agreement for the species (CRCT 2006a). This is consistent with Wildlife habitat Improvement and Maintenance, prescription 04A, management direction 1, "Provide habitat to meet or exceed the needs of estimated existing populations for all aquatic MIS" (Forest Plan IV-138).

CRCT is the MIS in East Fork Boulder Creek. The proposed project would move the Forest towards achieving the estimated maximum suitable habitat (Forest Plan II-16a). The purpose of the project is to provide habitat for self-sustaining CRCT populations, which would be consistent with Forest Plan Wildlife and Fish Resource Management General Direction 7, "Maintain aquatic habitat capable of supporting self-sustaining trout populations to provide for those populations" (Forest Plan IV-33,34).

Use and/or Consideration of Best Available Science

The techniques and methodologies used in this analysis consider the best available science. The analysis includes a summary of the credible scientific evidence which is relevant to evaluating reasonably foreseeable impacts. The analysis also identifies methods used and references scientific sources relied on.

The conclusions stated within this report are based on the scientific analysis that utilized a thorough review of relevant scientific information, a consideration of responsible opposing views, and site specific data collected using regionally accepted protocols. It is acknowledged that there may be incomplete or unavailable information, scientific uncertainty, and risk associated with the analysis included in this report.

The best available science is a composite of several key elements. The elements of the science used are:

- Site-specific data and history: Aquatic habitats within the project area were surveyed for the presence of aquatic species and suitable habitat. Historical and recent population data on MIS species were available for the streams within the project area. Surveys on East Fork Boulder Creek, Boulder Creek and West Fork of Boulder Creek were conducted by the Utah Division of Wildlife Resources and the Utah Water Research Laboratory Water Laboratory using backpack electrofishing equipment and regionally accepted protocols (Hadley et al. 2008, Hardy et al. 2009a, Hardy et al. 2009b, Williams and Hardy 2010). Relevant site-specific aquatic biota data collected prior to this project proposal were utilized during this analysis. These data were evaluated and interpreted by Mike Golden, the Dixie National Forest Fish Biologist.

- Scientific Literature: Literature reviewed and cited as part of this analysis is clearly identified within the body of the report, and is listed within the literature cited sections of this report.

- Professional knowledge, judgment, and experience: The primary specialist who conducted the Aquatic Biota resource analysis was Mike Golden (Forest Fisheries Biologist). Professional knowledge of the project area and cumulative effects area, professional judgment of how to integrate relevant science with local conditions, and past experience with similar projects have been incorporated into this analysis.

Literature Cited

Almquist, E. 1959. Observations on the effect of rotenone emulsives on fish food organisms. Institute of Freshwater Research, Drottingholm. 40:146-160.

Baltz, D.M., B. Vondracek, L.R. Brown, and P.B. Moyle. 1991. Seasonal changes in microhabitat selection by rainbow trout in a small stream. Transactions of the American Fisheries Society. 120:166-176.

Barbour, M. T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington D. C.

Baxter, C.V., K.D. Fausch, M. Murakami, P.L. Chapman. 2007. Invading rainbow trout usurp a terrestrial prey subsidy from native charr and reduce their growth and abundance. Oecologia 153:461–470.

Baxter, C.V., K.D. Fausch, M. Murakami, P.L. Chapman. 2004. Fish invasion restructures stream and forest food webs by interrupting reciprocal prey subsidies. Ecology 85: 2656-2663.

Beal, D.L. and R.V. Anderson. 1993. Response of zooplankton to rotenone in a small pond. Bulletin Environmental Contaminants and Toxicology. 51:551-556.

Benjamin, J.R. and C.V. Baxter. 2010. Do nonnative salmonines exhibit greater density and production than the natives they replace? A comparison of nonnative brook trout to native cutthroat trout. Transactions of the American Fisheries Society 139:641–651.

Beschta, R.L., J.J. Rhodes, J.B. Kauffman, R.E. Gresswell, G.W. Minshall, J.R. Karr, D.A. Perry, F.R. Hauer, and C.A. Frissell. 2004. Postfire management on forested public lands of the western United States. Conservation Biology 18(4): 957-967.

Binns, N. A. 1967. Effects of Rotenone Treatment on the Fauna of the Green River, Wyoming. Fish. Res. Bull. 1, Wyoming Fish and Game Commission. 114 pp.

Birchell, G.J. 2007. The effects of invasive brook trout removal on native Colorado River cutthroat trout on a small headwater stream in northeastern Utah. Master's Thesis. Utah State University, Logan, UT. 75 pp.

Blakely, T.J., W.L, Chadderton, and J.S. Harding. 2005. The effect of rotenone on orchard-pond invertebrate communities in the Mteuka area, South Island, New Zealand. DOC Research and Development Series 220, Department of Conservation, Wellington, New Zealand. 26pp.

Bradford, D.F. 2002. Amphibian Declines and Environmental Change in the Eastern Mojave Desert. Conference Proceedings. Spring-fed Wetlands: Important Scientific and Cultural Resources of the Intermountain Region, 2002. (http://www.wetlands.dri.edu)

Brazier, S. 2008. Fish Passage and Road Crossings Assessment: Dixie National Forest FY 2007. Dixie National Forest, Cedar City, UT. 12pp.

Buys, D.J., R.H. Hilderbrand, and J.L. Kershener. 2009. The effects of varied densities on growth and emigration of adult cutthroat trout and brook trout in fenced stream exclosures. Western North American Naturalist 69: 371–381.

Caires, A.M. 2007. Hiker impacts to aquatic invertebrate assemblages in the North Fork of the Virgin River, Zion National Park, UT. Master's Thesis. Utah State University, Logan, UT. 76pp.

California Department of Fish and Game (CDFG). 2006. Result of a monitoring study of the littoral and planktonic assemblages of aquatic invertebrates in Lake Davis, Plumas County, California, following a rotenone treatment.

Chamberlain, T. W., R. D. Harr, and F. H. Everest. 1991. Timber Harvesting, Silviculture, and Watershed Processes. American Fisheries Society Special Publication 19:181-205.

Chandler, J.H.J. and L.L. Marking. 1982. Toxicity of Rotenone to Selected Aquatic Invertebrates and Frog Larvae. Progressive Fish Culturist. Vol. 44:78-80.

Colyer, W.T., J.L. Kershner, and R.H. Hilderbrand. 2005. Movements of fluvial Bonneville cutthroat trout in the Thomas Fork of the Bear River, Idaho-Wyoming. North American Journal of Fisheries Management. 25:954-963.

Cook, S. F. Jr. and R. L. Moore. 1969. The Effects of Rotenone Treatment on the Insect Fauna of a California Stream. Trans. Amer. Fish. Soc., No. 3: 539-544.

CRCT Conservation Team. 2006a. Conservation agreement for Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) in the States of Colorado, Utah, and Wyoming.

Colorado Division of Wildlife, Fort Collins. 10p.

CRCT Coordination Team. 2006b. Conservation strategy for Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) in the States of Colorado, Utah, and Wyoming. Colorado Division of Wildlife, Fort Collins. 24p.

Crowl, T.A., C.R. Townsend, and A.R. McIntosh. 1992. The impact of introduced brown and rainbow trout on native fish: the case of Australasia. Reviews in Fish Biology and Fisheries 2: 217-241.

Demong, L. 2001. The Use of Rotenone to Restore Native Brook Trout in the Adirondack Mountains of New York—An Overview. Pages 29-35 in R. L. Cailteux, L. DeMong, B. J. Finlayson, W. Horton, W. McClay, R. A. Schnick, and C. Thompson, editors. Rotenone in fisheries: are the rewards worth the risks? American Fisheries Society, Trends in Fisheries Science and Management 1, Bethesda, Maryland.

DeStaso, J., III, and F. J. Rahel. 1994. Influence of water temperature on interactions between juvenile Colorado River cutthroat trout and brook trout in a laboratory stream. Transactions of the American Fisheries Society 123:289–297.

Dunham, J.B., M.M. Peacock, B.E. Rieman, R.E. Schroeter, and G.L. Vinyard. 1999. Local and Geographic Variability in the Distribution of Stream-Living Lahontan Cutthroat Trout. Transactions of the American Fisheries Society 128:875–889.

Dunham, J.B., M. E. Rahn, R. E. Schroeter, and S. W. Breck. 2000. Diets of sympatric Lahontan cutthroat trout and nonnative brook trout: Implications for species interactions. Western North American Naturalist 60: 304–310.

Dunham, J.B., S.B. Adams, R.E. Schroeter, and D.C. Novinger. 2002. Alien invasions in aquatic ecosystems: Toward an understanding of brook trout invasions and potential impacts on inland cutthroat trout in western North America. Reviews in Fish Biology and Fisheries 12: 373-390.

Dunham, J.B., D.S. Pilloid, and M.K. Young. 2004. Assessing the consequences of nonnative trout in headwater streams of western North America. Fisheries 29: 18-26.

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 (2003) 183-196.

Elliott, J.M. and T.B. Bagenal. 1972. The Effects of Electrofishing on the Invertebrates of a Lake District Stream. Oecologia 9: 1-11.

Engstrom-Heg, R., R.T. Colesante and E. Silco. 1978. Rotenone Tolerances of Stream-Bottom Insects. New York Fish and Game Journal. Vol. 25, No. 1: 31-41.

EnviroData Systems, Inc. 1995. Dixie National Forest Level II Riparian Inventory, Boulder Creek: Summary report and recommendations. Prepared for the Dixie National Forest under Contract Number 53-8462-4-01013.

Fellers, G.M. and C.A. Drost. 1993. Disappearance of the cascades frog Rana cascadae at the southern end of its range, California, USA. Biological Conservation 65: 177-181.

Federal Energy Regulatory Commission (FERC). 2007. Final Environmental Assessment for Hydropower License: Boulder Creek Hydroelectric Project. FERC Project No. 2219-020. Federal Energy Regulatory Commission, Office of Energy Projects, Division of Hydropower Licensing, Washington, D.C. 95pp. + Appendices.

Ficke, A.D., D.P. Peterson, and W.A. Janowsky (2009, June 26). Brook Trout (Salvelinus fontinalis): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/brooktrout.pdf [8 April 2010].

Finlayson, B., W.L. Somer, and M.R. Vinson. 2010a. Rotenone toxicity to rainbow trout and several stream mountain insects. North American journal of Fisheries Management 30: 102-111.

Finlayson, B.J., R. Schnick, D. Skaar, W.D. Horton, J.D. Anderson, L. Demong, and J. Steinkjer. 2010b. Comment: Comparative Effects of Rotenone and Antimycin on Macroinvertebrate Diversity in Two Streams in Great Basin National Park, Nevada. North American Journal of Fisheries Management 30:.1126-1128.

Fontenot, L.W., G.P. Noblet, and S.G. Platt. 1994. Rotenone hazards to amphibians and reptiles. Herpetological Review, 25:150-156.

Fowles, C.R. 1975. Effects of Electric Fishing on the Invertebrate Fauna of a New Zealand Stream. N.Z. J. Mar. Freshwater Res. 9:35-43.

Fridell, R.A., K.M. Comella, G.N. Garnett, B.A. Zettle, T.K. Smith, and D.L. Harstad. 2000. Boreal toad distribution surveys in southwestern Utah: 1994-1998. Publication Number 00-10, Utah Division of Wildlife Resources, Salt Lake City, UT. 21pp.

Fuller, P. L., L. G. Nico, and J. D. Williams. 1999. Nonindigenous fishes introduced into inland waters of the United States. Am. Fish. Soc. Spec. Publ. 27.

Furniss, M. J., T. D. Roelofs, and C. S. Yee. 1991. Road Construction and Maintenance. American Fisheries Society Special Publication 19: 297-323.

Golden, M.E. and P.B. Holden. 2002. Nonnative fish impacts and control options between Washington Fields Diversion and Pah Tempe Springs on the Virgin River. Prepared for the Virgin River Resource Management and Recovery Program, Utah Department of Natural Resources. BIO-WEST Report PR 821-1.

Golden, M., and J. Mecham. 2010a. East Fork Boulder Creek amphibian monitoring, Escalante Ranger District, 16 June 2010. Dixie National Forest unpublished field report.

Golden, M., and J. Mecham. 2010b. East Fork Boulder Creek amphibian monitoring, Escalante Ranger District, 24 June 2010. Dixie National Forest unpublished field report.

Gillepsie, G.R. 2002. Impacts of sediment loads, tadpole density, and food type on the growth and development of tadpoles of the spotted tree frog *Litoria spenceri*: an in-stream experiment. Biological Conservation 106: 141–150.

Griffith, J.S. 1974. Utilization of Invertebrate Drift by Brook Trout (Salvelinus fontinalis) and Cutthroat Trout (Salmo clarki) in Small Streams in Idaho. Transactions of the American Fisheries Society 103: 440-447.

Hadley, M.J., M.J. Ottenbacher, C. B. Chamberlain, J.E. Whelan, and S.J. Brazier. 2008. Survey of Colorado River cutthroat trout in southern Utah streams 2006-2007. Utah Division of Wildlife Resources, Salt Lake City, UT. Publication Number 08-41. 45pp.

Hamilton, B.T., S.E. Moore, T.B. Williams, and N. Darby. 2009. Comparative effects on rotenone and antimycin on macroinvertebrate diversity in two streams in Great Basin National Park, NV. North American Journal of Fisheries Management 29: 1620-1635.

Hardy, T.B., N. Bouwes, C. Williams, and C. Thomas. 2009a. Trout population monitoring in Boulder Creek: 2008 results. Utah Water Research Laboratory, Utah State University, Logan, UT. 11pp.

Hardy, T.B., C.S. Williams, C.W. Thomas. 2009b. Trout population monitoring in Boulder Creek: 2009 results. Utah Water Research Laboratory, Utah State University, Logan, UT. 13pp.

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

Hayes, M.P., and C.J. Rombough. 2008. Aquatic Amphibian and Reptile Surveys during the second year after the Fall 2006 Rotenone Treatment of Diamond Lake. Final 2008 report. Submitted to Oregon Department of Fish and Wildlife, Southwest Region, Roseburg, OR. 20pp.

Hecnar, S.J. and R.T. M'Closkey. 1997. The effects of predatory fish on amphibian species richness and distribution. Biological Conservation 79 : 123 131.

Hepworth, D.K. and S. Beckstrom. 2004. A simple 4 step method to manage for quality fishing: Implementing Utah's Blue Ribbon Fishery Program. Publication Number 04-24, Utah Division of Wildlife Resources, Salt Lake City, UT. 13 pp.

Hepworth, D.K., M.J. Ottenbacher, and C.B. Chamberlain. 2001a. Occurrence of native Colorado River cutthroat trout (Oncorhynchus clarki pleuriticus) in the Escalante River drainage, Utah. Western North American Naturalist 61: 129–138.

Hepworth, D.K, C.B. Chamberlain, and J.E. Whelan. 2001b. West Boulder Creek rotenone treatment 2001. Utah Division of Wildlife Resources, Southern Region, Cedar City, UT. 9 pp. + appendices.

Hilderbrand, R.H. 2003. The roles of carrying capacity, immigration, and population synchrony on persistence of stream-resident cutthroat trout. Biological Conservation. 110:257-266.

Hilderbrand, R.H. and J.L. Kershner. 2000. Conserving inland cutthroat trout in small streams: how much is enough? North American Journal of Fisheries Management. 20:513-520.

Hilderbrand, R.H., and J.L. Kershner. 2004a. Are there differences in growth and condition between mobile and resident cutthroat trout? Transactions of the American Fisheries Society. 133:1042-1046.

Hilderbrand, R.H., and J.L. Kershner. 2004b. Influence of Habitat Type on Food Supply, Selectivity, and Diet Overlap of Bonneville Cutthroat Trout and Nonnative Brook Trout in Beaver Creek, Idaho. North American Journal of Fisheries Management 24:33–40.

Holcomb, B. 2010. Biological Assessment Program Coordinator, Utah Department of Environmental Quality, Division of Water Quality. Personal communication with Mike Golden regarding macroinvertebrate communities on the East Fork Boulder Creek. 4/19/2010.

Hoffman, R. L., G. L. Larson, and B. Samora. 2004. Responses of Ambystoma gracile to the removal of introduced nonnative fish from a mountain lake. Journal of Herpetology, 38:578–585.

Horan, D.L., J.L. Kershner, C.P. Hawkins, and T.A. Crowl. 2000. Effects of habitat area and complexity on Colorado River cutthroat trout density in Uinta Mountain Streams. Transactions of the American Fisheries Society. 129:1250–1263.

Johnson, R.R., and S.W. Carothers. 1982. Riparian habitats and recreation: Interrelationships and impacts in the Southwest and Rock Mountain region. Eisenhower Consortium Bulletin 12. Rocky Mountain Forest and Range Experiment Station, USDA Forest Service, Fort Collins CO. 31p.

Jones, R.D. and T. Steeger. 2008. Risks of Rotenone Use to Federally Threatened California Red-legged Frog (Rana aurora draytonii): Pesticide Effects Determination. Environmental Fate and Effects Division, Office of Pesticide Programs, Washington, D.C. 88 pp.

Joseph, M.B., J. Piovia-Scott, S.P. Lawler, and K.L. Pope. 2011. Indirect effects of introduced trout on Cascades frogs (*Rana cascadae*) via shared aquatic prey. Freshwater Biology 56: 828–838.

Judson, S., and S. Miller. 2011. Aquatic Invertebrate Report For Samples Collected By USFS - R6 - Dixie National Forest. Prepared for the Dixie National Forest by the National Aquatic Monitoring Center, Utah State University, Logan, UT. 44pp.

Karr, J.R., J.J. Rhodes, G.W. Minshall, F.R. Hauer, R.L. Beschta, C.A. Frissell, and D.A. Perry. 2004. The effects of postfire salvage logging on aquatic systems in the American West. Bioscience 54 (11): 1029-1033.

Keinath, D. and M. McGee. 2005. Boreal Toad (Bufo boreas boreas): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/borealtoad.pdf

Kiser, R.W., J.R. Donaldson, and P.R. Olson. 1963. The effect of rotenone on zooplankton populations in freshwater lakes. Transactions of the American Fisheries Society. 92:17-24.

Knapp, R. A., D. M. Boiano, and V. T. Vredenburg. 2007. Removal of nonnative fish results in population expansion of a declining amphibian (mountain yellow-legged frog, Rana muscosa). Biological Conservation 135:11–20.

Knapp, R.A., and K.R. Matthews. 2000. Non-Native Fish Introductions and the Decline of the Mountain Yellow-Legged Frog from within Protected Areas. Conservation Biology 14: 428–438.

Kruzic, L.M., D.L. Scarnecchia and B.B. Roper. 2005. Effects of electroshocking on macroinvertebrate drift in three cold water streams. Hydrobiologia 539: 57-67.

Lentsch, L. D., R. T. Muth, P. D. Thompson, B. G. Hoskins, and T. A. Crowl. 1996. Options for selective control of non-native fishes in the Upper Colorado River Basin. Publication 96-14. Utah Division of Wildlife Resources Salt Lake City.

Liddle, M.J., and H.R.A. Scorgie. 1980. The effects of recreation on freshwater plants and animals: a review. Biological Conservation 17: 183-206.

Lindenmayer, D.B., and R.F. Noss. 2006. Salvage Logging, Ecosystem Processes, and Biodiversity Conservation. Conservation Biology 20(4): 949-958.

Ling, N. 2003. Rotenone - a review of its toxicity and use for fisheries management. Science for Conservation 211. January 2003, New Zealand Department of Conservation. 40 pp.

Mangum, F.A. 1995. Aquatic Ecosystem Inventory Macroinvertebrate Analysis: Dixie National Forest, Escalante, Teasdale, Cedar City, and Powell Ranger Districts 1994. National Aquatic Ecosystem Monitoring Center Laboratory, Brigham Young University, Provo, UT.

Mangum, F.A. 1997. Aquatic Ecosystem Inventory Macroinvertebrate Analysis: Dixie National Forest, Escalante and Teasdale Ranger Districts 1996. National Aquatic Ecosystem Monitoring Center Laboratory, Brigham Young University, Provo, UT.

Mangum, F.A., and J.A. Madrigal. 1999. Rotenone effects on aquatic macroinvertebrates of the Strawberry River, Utah: A five-year summary. Journal of Freshwater Ecology 14: 125-135.

Marks, J.C., G.A. Haden, M. O'Neill, and C. Pace. 2009. Effects of Flow Restoration and Exotic Species Removal on Recovery of Native Fish: Lessons from a Dam Decommissioning. Article first published online: 25 SEP 2009 DOI: 10.1111/j.1526-100X.2009.00574.x.

Maxell, B.A. 2000. Management of Montana's Amphibians: A Review of Factors that may Present a Risk to Population Viability and Accounts on the Identification, Distribution, Taxonomy, Habitat Use, Natural History and the Status and Conservation of Individual Species. Report Order Number 43-0343-0-0224, University of Montana Missoula, Montana. 161pp.

McCoid, M.J. and P.W. Bettoli. 1996. Additional Evidence for Rotenone Hazards to Turtles and Amphibians. Hepetological Review. 27: 70-71.

McDonald, M.E., and A.E. Hershey. 1992. Shifts in abundance and growth of slimy sculpin in response to changes in the predator population in an arctic Alaskan lake. Hydrobiologia 240: 219-223.

McDowall, R.M. 2003. Impacts of Introduced Salmonids on Native Galaxiids in New Zealand Upland Streams: A New Look at an Old Problem. Transactions of the American Fisheries Society 132:229–238.

McIver, J.D., and L. Starr. 2000. Environmental effects of postfire logging; literature review and annotated bibliography. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. General Technical Report PNW-GTR-486. 72pp.

McIver, J.D., and L. Starr. 2001. A literature review on the environmental effects of postfire logging. Western Journal of Applied Forestry 16(4): 159-168.

McNaught, A. S., D. W. Schindler, B. R. Parker, A. J. Paul, R. S. Anderson, D. B. Donald, M. Agbeti. 1999. Restoration of the Food Web of an Alpine Lake Following Fish Stocking. Limnology and Oceanography 44: 127-136.

Melaas, C.L., K.D. Zimmer, M.G. Butler, and M.A. Hanson. 2001. Effects of rotenone on aquatic invertebrate communities in prairie wetlands. Hydrobiologia 459: 177-186.

Meronek, T.G., P.M. Bouchard, E.R. Bukner, T.M. Burri, K.K. Demmerly, D.C. Hatleli, R.A. Klumb, S.H. Schmidt, and D.W. Coble. 1996. A review of fish control projects. North American Journal of Fisheries Management 16: 63-74.

Mesick, C.F., and J.C. Tash. 1980. Effects of Electricity on Some Benthic Stream Insects. Transactions of the American Fisheries Society

Meyer, K.A., J.A. Lamansky, Jr., and D.J. Schill. 2006. Evaluation of an unsuccessful brook trout electrofishing removal project in a small Rocky Mountain stream. North American Journal of Fisheries management 26: 849-860.

Mueller, G.A. 2005. Predatory fish removal and native fish recovery in the Colorado River mainstem: What have we learned? Fisheries 30: 10-19.

Muhlfeld, C.C., D.H. Bennett, and B. Marotz. 2001. Fall and winter habitat use and movement by Columbia River redband trout in small streams in Montana. North American Journal of Fisheries Management 21:170-177.

Müller, Z., T. Jakab, A. Tóth, G. Dévai, N. Szállassy, B. Kiss, and R. Horváth. 2003. Effect of sports fisherman activities on dragonfly assemblages on a Hungarian river floodplain. Biodiversity and Conservation 12:167-179.

Neville, H.M., J.B. Dunham, and M.M. Peacock. 2006. Landscape attributes and life history variability shape genetic structure of trout populations in a stream network. Landscape Ecology 21:901-916.

Niemi, G.J., P. DeVore, N. Detenbeck, D. Taylor, K. Lima, J. Pastor, J.D. Yount, and R.J. Naiman. 1990. Overview of case studies on recovery of aquatic systems from disturbance. Environmental Management 14:571-587.

Parker, B.R., D.W. Schindler, D.B. Donald, and R.S. Anderson. 2001. The effects of stocking and removal of a nonnative salmonid on the plankton of an alpine lake. Ecosystems 4: 334-345.

Penczak T, Rodriguez G. 1990. The use of electrofishing to estimate population densities of freshwater shrimp s(Decapoda, Natantia) in a small tropical river, Venezuela. Archiv fur Hydrobiologie 118: 501–509.

Peterson, D. L., J.K. Agee, G.H. Aplet, D.P. Dykstra, R.T. Graham, J.F. Lehmkuhl, D.S. Pilloid, D.F. Potts, R.F. Powers, and J.D. Stuart. 2009. Effects of timber harvest following wildfire in western North America. Gen. Tech. Rep. PNW-GTR-776. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 51 p.

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.

Piec, D.L. 2006. Rotenone as a conservation tool in amphibian conservation: A case study of fish control operation undertaken at Orton Pit SSSI, Peterborough, UK. The Froglife Trust. 28pp.

Pilloid, D.S. and C.R. Peterson. 2001. Local and Landscape Effects of Introduced Trout on Amphibians in Historically Fishless Watersheds. Ecosystems 4: 322-333.

Platts, W.S. 1991. Livestock grazing. American Fisheries Society Special Publication 19: 389-423.

Pope, K.L. 2008. Assessing Changes in Amphibian Population Dynamics Following Experimental Manipulations of Introduced Fish. Conservation Biology 22: 1572–1581.

Pope, K.L., J. Piovia-Scott, and S.P. Lawler. 2009. Changes in aquatic insect emergence in response to whole-lake experimental manipulations of introduced trout Freshwater Biology 54: 982–993.

Quist, M.C. and W.A. Hubert. 2004. Bioinvasive species and the preservation of cutthroat trout in the western United States: ecological, social, and economic issues. Environmental Science & Policy 7: 303–313.

Rabeni, C.F., K.J. Collier, S.M. Parkyn, B.J. Hicks. 1997. Evaluating techniques for sampling stream crayfish (Paranephrops planifrons). New Zealand Journal of Marine and Freshwater Research, 31: 693 — 700.

Reinertsen, H., A. Jensen, and K.I. Koksvik, A. Langeland, and Y. Olsen. 1990. Effects of fish removal on the limnetic ecosystem of a eutrophic lake. Canadian Journal of Fisheries and Aquatic Sciences 47:166-173.

Roberts, B.C., and R.G. White. 1992. Effects of Angler Wading on Survival of Trout Eggs and Pre-emergent Fry. North American Journal of Fisheries Management 12:450-459.

Rodriguez, R.L. 2008. Life History and Analysis of Endangered, Threatened, Candidate, Sensitive, and Management Indicator Species on the Dixie National Forest. Version 5.0, July. Dixie National Forest, Cedar City, Utah.

Ruetz, C.R. III, A.L. Hurford, and B. Vondracek. 2003. Interspecific interactions between brown trout and slimy sculpin in stream enclosures. Transactions of the American Fisheries Society 132:611-618.

Sappington, J.M. 1992. Recreation disturbance of a desert stream fish community: detecting ecological effects of environmental impact. Master's Thesis, University of Nevada Las Vegas, Las Vegas, Nevada. 47pp.

Shakarjian, M. J., and J. A. Stanford. 1998. Effects of trampling by hikers on zoobenthos of the North Fork of the Virgin River, Zion National Park, Utah. Flathead Lake Biological Station Open File Report 145-97: 18 p.

Schmetterling, D.A. 2001. Seasonal movement of fluvial westslope cutthroat trout in the Blackfoot River Drainage, Montana. North American Journal of Fisheries Management 21:507-520.

Schrank, A.J., and F.J. Rahel. 2004. Movement patterns in inland cutthroat trout (Oncorhynchus clarki utah): management and conservation implications. Canadian Journal of Fisheries and Aquatic Science 61:1528-1537.

Shepard, B. B. 2004. Factors that may be influencing nonnative brook trout invasion and their displacement of native westslope cutthroat trout in three adjacent southwestern Montana streams. North American Journal of Fisheries Management 24:1088-1100.

Simon, K.S., and C.R. Townsend. 2003. Impacts of freshwater invaders at different levels of ecological organisation, with emphasis on salmonids and ecosystem consequences. Freshwater Biology 48: 982–994.

Snyder, D.E. 2003. Electrofishing and its harmful effects on fish. Information and Technology Report USGS/BRD/ITR--2003-0002: U.S. Government Printing Office, Denver, CO: 149 p.

Taylor, B.W., A.R. McIntosh, and B.L. Peckarsky. 2001. Sampling stream invertebrates using electroshocking techniques: implications for basic and applied research. Can. J. Aquat. Sci. 58:437-445.

Thompson, P.D. and F.J. Rahel. 1996. Evaluation of depletion-removal electrofishing of brook trout in small rocky Mountain streams. North American Journal of Fisheries Management 16: 332-339.

Trombulak, S. C., and C. A. Frissell. 2000. Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. Conservation Biology. Vol. 14, No. 1. pp 18-30.

Tyler, T., W.J. Liss, L.M. Ganio, G.L. Larson, R. Hoffman, E. Deimling, and G. Lomnicky. 1998. Interaction between Introduced Trout and Larval Salamanders (Ambystoma macrodactylum) in High-Elevation Lakes. Conservation Biology 12: 94–105.

Tyus, H.M., and J.F. Saunders. 2000. Nonnative fish control and endangered fish recovery: lessons from the Colorado River. Fisheries 25: 17-24.

USDA Forest Service. 2008. Bear Creek Burned Area Response (BAER) Report. FSH 2509.13. 7pp.

U.S. Environmental Protection Agency (USEPA). 2010. STORET/WQX. http://www.epa.gov/storet/. Accessed 4/12/2010.

U.S. Environmental Protection Agency (USEPA). 2006. Environmental fate and ecological risk assessment for the re-registration of rotenone. Office of Prevention, Pesticides, and Toxic Substances (www.epa.gov/pbt/pubs/cheminfo.htm).

Vander Zanden, M.J., J.M. Casselman, and J.B. Rasmussen. 1999. Stable isotope evidence for the food web consequences of species invasions in lakes. Nature 40:464-467.

Vander Zanden, M.J., S. Chandra, B.C. Allen, J.C. Reuter, and C.R. Goodman. 2003. Historical Food Web Structure and Restoration of Native Aquatic Communities in the Lake Tahoe (California–Nevada) Basin. Ecosystems (2003) 6: 274–288.

Vinson, M.R. 2005. Aquatic invertebrate report for samples collected from the Dixie national Forest summer and fall 2003. Report prepared by U.S. Department of the Interior, Bureau of Land Management, National Aquatic Monitoring Center, Utah State University, Logan, UT.

Vinson, M.R. and D. Vinson. 2007. An analysis of the effects of rotenone on aquatic invertebrate assemblages in the Silver King Creek Basin, California. June 2007. Prepared for U.S. Forest Service Humboldt-Toiyabe National Forest, Carson City, Nevada. 255 pp.

Vinson, M.R., E.C. Dinger, and D. Vinson. 2010. Piscicides and invertebrates: After 70 years, does anyone really know. Fisheries 35(2): 61-71.

Vrendenberg, V.T. 2004. Reversing introduced species effects: Experimental removal of introduced fish leads to rapid recovery of a declining frog. Proceedings of the National Academy of Sciences, USA 2004;101:7646–7650.

Walston, L. J., and S. J. Mullin. 2007. Responses of a pond-breeding amphibian community to the experimental removal of predatory fish. American Midland Naturalist 157:63–73.

Waters, T. F. 1995. Sediment in streams: sources, biological effects, and control. American Fisheries Society Monograph 7.

Welsh, H.H. and L.M. Olliver. 1998. Stream amphibians as indicators of ecosystem stress: a case study from California's redwoods. Ecological Applications 8: 1118-1132.

Welsh, H.H., Jr., K.L. Pope, and D. Boiano. 2006. Sub-alpine amphibian distributions related to species palatability to non-native salmonids in the Klamath mountains of northern California. Diversity and Distributions 12: 298–309.

Whelan, J.E. 2002. Aquatic Macroinvertebrate Monitoring Results of the 1995 and 1996 Rotenone Treatments of Manning Creek, Utah. Publication Number 02-04, Utah Division of Wildlife Resources, Salt Lake City, UT. 34pp.

Whittier, T.R., R.M. Hughes, G.A. Lomnicky, and D.V. Peck. 2007. Fish and Amphibian Tolerance Values and an Assemblage Tolerance Index for Streams and Rivers in the Western USA. Transactions of the American Fisheries Society 136:254–271.

Williams, C.S., and T.B. Hardy. 2010. Trout population monitoring in Boulder Creek: 2010 results. Utah Water Research Laboratory, Utah State University, Logan, UT. 16pp.

Young, Michael K., R. Nick Schmal, Thomas W. Kohley, and Victoria G. Leonard. 1996. Conservation status of Colorado River cutthroat trout. General Technical Report RM-GTR-282. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 32 p.

Young, M.K. 1996. Summer movements and habitat use by Colorado River cutthroat trout in small, montane streams. Canadian Journal of Fisheries and Aquatic Sciences. 53:1403-1408.

Young, M.K., P.M. Guenther-Gloss, and A.D. Ficke. 2005. Predicting cutthroat trout (Oncorhynchus clarkii) abundance in high-elevation streams: revisiting a model of translocation success. Canadian Journal of Fisheries and Aquatic Science 62:2399-2408.

Yount, J.D. and J.G. Niemi. 1990. Recovery of lotic communities and ecosystems from disturbance – A narrative review of case studies. Journal of Environmental Management 14: 547-569.

Zimmerman, J.K.H., and B. Vondracek. 2007. Interactions between Slimy Sculpin and Trout: Slimy Sculpin Growth and Diet in Relation to Native and Nonnative Trout. Transactions of the American Fisheries Society 136:1791–1800.

Zimmerman, J.K.H., and B. Vondracek. 2006. Interactions of slimy sculpin (*Cottus cognatus*) with native and nonnative trout: consequences for growth. Canadian Journal of Fisheries and Aquatic Science 63: 1526–1535.

Appendix A. Project Area and Analyzed Alternatives

The following describes and compares the Forest Service alternatives analyzed.   It includes a description of the UDWR's proposed project and considers UDWR's treatment alternative in detail. This section also presents the alternatives and the UDWR activities that would be authorized or connected actions to the alternatives in comparative form.

Project Area

The proposed East Fork Boulder Creek Native Trout Restoration Project (project) is located approximately 7 miles northwest of Boulder, Utah (see Figure 1). The total treatment area is as follows:

- approximately 7.8 miles (12.6 km) of East Fork Boulder Creek from the natural barrier (below headwater meadow) on East Fork Boulder Creek to its confluence with West Fork Boulder Creek;
- approximately 0.2 miles (0.4 km) of lower West Fork Boulder Creek, from a previously constructed barrier to its confluence with East Fork Boulder Creek;
- approximately 0.5 miles (0.8 km) of Boulder Creek from the confluence of East Fork Boulder Creek and West Fork Boulder Creek downstream to a previously constructed fish barrier;
- all seeps and springs flowing into those sections of streams proposed for fish removal; and
- the Garkane Energy water transfer pipeline between the West Fork Reservoir and King's Pasture Reservoir; King's Pasture (East Fork) Reservoir; a pond on private property in King's Pasture, and the Garkane Energy penstock, between King's Pasture Reservoir and the Garkane Energy Boulder Creek Hydroelectric Power Plant (main power plant).

The treatment stream reaches flow through portions of Sections 27, 28, 33, and 34 of T31S, R4E, and Sections 3, 10, 15, 21, 22, and 28 of T32S, R4E, Salt Lake Baseline Meridian. Treatment would include connecting waters, including relatively large inflows or tributaries with permanent fish habitat and smaller springs and seeps that are capable of at least temporarily holding small fish. Known tributaries and inflows vary in length from 10 meters to over 750 meters.

The reaches on NFS-lands are all on the Escalante Ranger District of the Forest in Garfield County, Utah. The inflow of the water transfer pipeline is at the West Fork Reservoir in Section 8, T32S, R4E, and the outflow is at King's Pasture Reservoir in Section 10 of T32S, R4E. The inflow of the penstock is at King's Pasture Reservoir, and the outflow is at the main power plant in Section 35 of T32S, R4E.

No Action- No Further Treatment Scenario

Under the No Action alternative, the Forest would not approve the pesticide use permit to UDWR, would not authorize UDWR to use motorized vehicles off of designated routes for the application of rotenone to waters of the treatment area on NFS lands, and would not approve a special use authorization for UDWR to bury removed fish.

The No Action alternative would not preclude UDWR from implementing actions on NFS lands that would meet the purpose and need for UDWR's project but do not require Forest Service authorization. This includes UDWR activities described under the Non-chemical Treatment alternative (Section 2.1.3) except for the use motorized vehicles off of designated routes or burial of removed fish on NFS lands. The No Action alternative would also not preclude UDWR from implementing actions on non-NFS lands that are related to the purpose and need for UDWR's project but not under Forest Service jurisdiction or authorization.

One possible option for UDWR is to take no further action to meet the purpose and need of the proposed project. This possible option is identified in this analysis as the "No Action - No Further Treatment Scenario" and is the basis for the effects analysis for the No Action alternative to provide the base line for comparison of expected future conditions if neither the Proposed Action nor Non-chemical Treatment alternative were implemented by the Forest and UDWR were to take no further action to meet the purpose and need.

Proposed Action

The Proposed Action is to approve the pesticide use permit that the Forest Service requires the UDWR to have to apply the fish toxicant rotenone to waters that flow on NFS lands and to authorize motorized vehicle use off of designated routes. The pesticide use permit would authorize the UDWR to implement a maximum of three treatments on NFS land, one treatment per year for three consecutive years. Waters on NFS land that would be treated by UDWR under the Forest Service pesticide use permit are as follows:

- approximately 7.8 miles (12.6 km) of East Fork Boulder Creek from the natural barrier (below headwater meadow) on East Fork Boulder Creek to its confluence with West Fork Boulder Creek;

- approximately 0.2 miles (0.4 km) of lower West Fork Boulder Creek, from a previously constructed barrier to its confluence with East Fork Boulder Creek;

- approximately 0.5 miles (0.8 km) of Boulder Creek from the confluence of East Fork Boulder Creek and West Fork Boulder Creek downstream to a previously constructed fish barrier; and

- all seeps and springs flowing into those sections of the stream reaches specified in the permit.

The UDWR activities that would be authorized by the Forest under the Proposed Action would completely eradicate non-native trout from East Fork Boulder Creek, a short segment of Boulder Creek, and a very short segment of West Fork Boulder Creek. All fish would be temporarily eliminated by UDWR from target waters. Use of motorized vehicles by UDWR off of designated routes may be needed to facilitate placement of equipment, especially neutralization equipment, in effective locations.

Several actions that are not part of the Forest Service decision are connected to the UDWR project, as follows. UDWR is proposing chemical treatment of connected waters on private property to meet the purpose of the UDWR project. Following fish removal, UDWR would introduce the CRCT into the treated stream segments to establish self-sustaining populations. Sterile hybrids of species of non-native trout may also be stocked by UDWR at some locations following the treatments to provide sport fishing opportunities while native trout become established. The following describes the UDWR project in detail, including identification of those actions that do not require Forest Service authorization.

Chemicals. Liquid emulsifiable rotenone (Liquid Rotenone, 5% Active Ingredient, EPA Registration No. 432-172) would be used by UDWR to treat target waters. Rotenone was selected as the chemical to use because of its effectiveness in controlling fish populations and its lack of long-term effects on the environment (Sousa et al 1987). When used at the concentrations planned for the UDWR project, rotenone is a naturally occurring fish toxicant that is toxic to only fish, some aquatic invertebrates, and some juvenile amphibians. EPA found it to be not toxic to humans, other mammals, and birds at the concentrations used to remove fish (EPA 2007). It has been widely used in the United States since the 1950's. UDWR has used rotenone successfully in many similar projects and has refined application techniques to minimize adverse side effects to the environment (Hepworth et al. 2001a, Hepworth et al. 2001b, Hepworth et al. 2001c, Ottenbacher and Hepworth 2001, Chamberlain and Hepworth 2002a, Chamberlain and Hepworth 2002b, Chamberlain and Hepworth 2002c, Fridell et al. 2004, Fridell et al. 2005, Fridell and Rehm 2006).

Potassium permanganate would be used by UDWR to neutralize the rotenone at suitable locations to prevent the movement of rotenone into non-target waters. Potassium permanganate was selected, because it is a strong oxidizer that breaks down into potassium, manganese, and water. All are common in nature and have no deleterious environmental effects at the concentrations that would be used for the UDWR project activities, including those that would be authorized by the Forest under the Proposed Action (Finlayson et al. 2000). Potassium permanganate is used as an oxidizing agent in treatment plants to purify drinking water (EPA 1999). Although the oxidation process is not immediate, neutralization should occur within an estimated 0.25 to 0.5 miles of the neutralization site.

A more detailed description of the chemicals that would be used for the UDWR project activities, including those that would be authorized by the Forest under the Proposed Action, can be found in specialist report on Chemicals and Application of the Proposed Action.

Application. Liquid rotenone would be applied by UDWR at a rate of 0.5 to 2.0 ppm. In the pond and reservoir, liquid rotenone would be dispersed from personnel on small water-craft using pressurized backpack spray units. For flowing waters, seeps, and springs, liquid rotenone would be applied using a combination of 30 gallon and 5 gallon dispensers with constant flow drip-heads at approximately 50 to 60 stations throughout the UDWR project area over a 3 to 24 hour period (Finlayson et. al 2000, Ottenbacher et al. 2009). One 30 gallon drip station would be used by UDWR at each at the following:

- lower end of the headwater meadow at the upstream end of the UDWR project area,
- approximately halfway between the headwater meadow and King's Pasture Reservoir,
- immediately below King's Pasture Reservoir, and
- at the intake for the water flow pipeline between the West Fork Reservoir and King's Pasture Reservoir.

Five-gallon drip stations would be located by UDWR at approximately 1 mile intervals, beginning one mile below King's Pasture Reservoir and ending 1 mile upstream from the fish barriers on the main stem of East Fork Boulder Creek, and at all major springs and seeps within the UDWR project area. The interval placement of drip stations on the main stem of East Fork Boulder Creek would be to facilitate efficient travel time of chemicals. Depending on flow volume, a single 30 gallon or 5 gallon drip would be placed by UDWR on the lower fish barrier on West Fork Boulder Creek. Pressurized backpack sprayers would be used by UDWR to apply a diluted solution of the chemical to springs and backwater areas containing fish that were not effectively treated by boat or drip station.

Rotenone would be neutralized by UDWR with potassium permanganate downstream from target waters. Three sites are planned: where the penstock water is released at the upper power plant, where water is released at the main power plant, and at the fish barrier at the lower end of the treatment area. Each site would have a main neutralization station and at least one contingency neutralization station to ensure effectiveness. The neutralization stations would prevent rotenone from escaping the target area, except for the estimated 0.25 to 0.5 miles downstream in which the neutralization or natural degradation of rotenone would be occurring.

Post-treatment activity. Following confirmation of complete non-native trout removal, UDWR would reintroduce CRCT into project stream reaches from "core" CRCT populations or from fish produced by UDWR CRCT brood stocks. Sterile hybrids of species of non-native trout may also be stocked by UDWR at some locations following the treatments to provide sport fishing opportunities while native trout become established. All UDWR transfers or stocking of fish would comply with Utah Department of Agriculture and Food rules and UDWR policies.

Design Criteria. The following design criteria would be implemented and included in the Forest Service authorizations:

1. Stream sections will be treated in the fall to minimize impacts on non-target wildlife species (amphibians, insectivorous birds and bats). The fall treatment period will also minimize the impacts on sport fishing recreation.

2. Each treatment will be preceded by internal and external notifications and media releases to notify the public of treatment sites and dates and will include the following: notification of the Boulder Town Council, notification of private landowners in the treatment area, and news releases in local papers.

3. The treatment area will be placarded to prohibit public access during treatment and for at least 3 days following treatment.

4. Application of the chemical will be conducted by licensed pesticide applicators in accordance with all applicable regulations and policies.

5. Access by motorized vehicles will be on National Forest System roads designated for motorized vehicle use to the extent possible. Any use of motorized vehicles off of designated routes will be minimal and will require written Forest Service approval.

6. Neutralization sites will be placed to maximize their effectiveness at preventing downstream escapement of rotenone.

7. Treated waters will remain open to fishing.

8. Transport to the site and storage of chemicals on the site will comply with FSH 2109.14.40 (Pesticide-Use Management and Coordination Handbook, Chapter 40 - Storage, Transportation, and Disposal).

9. Sentinel fish ("in situ bioassay") will be used for pesticide residues monitoring to determine the presence or absence of unacceptable environmental effects.

10. Treatments will be discontinued if the objective of complete removal of non-native trout from the project area has been met.

Actions connected to but not included in the decision. The following parts of the UDWR project, as described above, are not subject to Forest Service permit requirements, and therefore are not included in the Forest Service decision. Selection of the Proposed Action is for issuance of the pesticide use permit for the application of rotenone on NFS lands only. The following, however, are considered connected actions and thus included in the environmental analysis:

1. The proposed UDWR treatment area includes private property, including property owned by Garkane Energy; thus, this area is not under Forest Service jurisdiction. This includes approximately 1.4 miles of East Fork Boulder Creek, Kings Pasture Reservoir, and the pond in Kings Pasture. To meet the purpose and need of the UDWR project, these areas as well as the water in the transmission pipeline and penstock must be treated by UDWR. Forest Service approval of the pesticide use permit for UDWR to apply rotenone to waters on NFS land is not approval of UDWR activities on non-NFS lands; however, the Forest Service would not approve the pesticide use permit unless UDWR is able to complete its project by treating waters off of NFS land.

   The expectation is that the entire UDWR project treatment area would receive chemical treatment as described below, although the UDWR may decide to use another method or methods to achieve the treatment objective. FERC license order Section 4(e), item 16, condition 4, requires Garkane Energy to use its reasonable efforts to cooperate in the work of UDWR and other agencies to remove non-native fish and re-establish CRCT in the above stream sections. This cooperation has already been demonstrated through construction of the fish barriers and through the first chemical treatment of Kings Pasture Reservoir in 2009.

2. Stocking of fish is under the jurisdiction of UDWR; thus, the CRCT stocking is not under Forest Service jurisdiction. To meet the purpose and need of the UDWR project, the stream would need to be stocked by UDWR with CRCT from core populations or UDWR brood stock post-treatment.

   The expectation is that the post-treatment recolonization/stocking of CRCT would occur as described. The purpose and need for the UDWR project, including stocking with CRCT, is to implement conservation actions under the CRCT Conservation Agreement and Strategy, to which UDWR is a signatory. In addition, the Forest Service conditions regarding the non-native fish eradication and fish restocking were included in a 2006 settlement agreement relating to the FERC license conditions and signed by Garkane Energy, Forest Service, and UDWR.

3. Fishing regulations, including whether or not treated waters would remain open to fishing, is under the jurisdiction of UDWR.

   The expectation is that UDWR would manage the fishing regulations to meet the conservation actions under the CRCT Conservation Agreement and Strategy. UDWR recognizes the importance of the area to recreation users. Because of this, UDWR may also stock sterile hybrids of species of non-native trout at some locations following the treatments while native trout become established.

Non-chemical Treatment Alternative

Under the Non-chemical Treatment alternative, the Forest Service would authorize UDWR to use motorized vehicles off of designated routes and approve a special use authorization for UDWR to bury fish that are removed as necessary to implement a non-chemical treatment to remove non-native trout from waters on NFS land.

The non-chemical treatment methods would not involve the use of rotenone or other pesticides on NFS lands and, therefore, would not require Forest Service approval. The effects of the non-chemical treatment are being analyzed, because this option may be exercised by UDWR in the event that the Forest Service were to choose not to authorize pesticide use, and the approach would be a connected action to the authorization of the use of motorized vehicles off of designated routes and approval of a special use authorization for burial of removed fish. The other connected actions that would also not require new Forest Service action are described below. UDWR's non-chemical treatment and other connected actions may or may not occur under the No Action alternative if the UDWR were to use motorized vehicles only on designated routes. These UDWR actions also may or may not occur under the Proposed Action.

Under the Non-chemical Treatment alternative, UDWR would use electrofishing to remove non-native trout from the treatment waters on NFS lands. Except for possible motorized vehicle use off of designated routes and burial of removed fish, this alternative would not require Forest Service authorization.

Treatment area. The treatment area would remain the same as described in the Proposed Action.

Methodology and Equipment. Electrofishing would be used by UDWR to remove non-native trout from the treatment area on NFS lands. Electrofishing introduces an electric current into the water and is commonly used as a fish removal method. The electricity causes an involuntary muscle contraction in the fish, attracting them toward the source of the electricity (electrode). Workers with long-handled nets then collect the stunned fish. Voltage, amperage, pulse frequency, and waveform are manipulated to maximize effectiveness, which can be influenced by water flow and velocity, temperature, clarity, conductivity (dissolved mineral content), and substrate. Other factors influencing effectiveness include the fish size, species and behavior, presence of aquatic vegetation, time of year, and time of day. It is most effective in shallow water and is, therefore, most commonly used in rivers and streams and occasionally in the shallow water zones of lakes.

Electrofishing removal would be accomplished by UDWR using multiple Smith-Root LR24 backpack electrofishing units or their equivalent from another manufacturer. Block nets of sufficient width would be set up to prevent fish emigration during removal activities. Dip nets, buckets, and live wells would also be necessary for capture and removal of brook trout (*Salvenlinus fontinalis*) and capture and safe holding of CRCT.

Removal activities. Mechanical removal of non-native trout species using backpack electrofishing has been attempted in several other projects (Moore et al. 1986, Meronek et al. 1996, Thompson and Rahel 1996, Buktenica et al. 2000, Kulp and Moore 2000, Shepard et al. 2002, Peterson et al. 2004, Moore et al. 2005, Meyer et al. 2006, Earle et al. 2007). The results of these prior mechanical removal projects indicate: 1) achieving complete mechanical removal of trout in streams with the width, complexity, and number of small, heavily vegetated springs/tributaries found in East Fork Boulder Creek would be difficult; 2) success would be enhanced by implementing multiple-pass depletion removal efforts 3 to 4 times within the same year, and 3) success would be enhanced by treatment over multiple years (minimum of 2). For this UDWR project, the multi-year removal effort would involve a minimum of 5 to 6 people conducting multiple-pass removal efforts for the majority of summer and early autumn (late June to September) over a period of several years. While such removal efforts would undoubtedly cause major reductions in brook trout density and biomass, they may or may not result in complete eradication. UDWR would begin CRCT reintroduction efforts only when no brook trout are found within the project area.

The electrofishing removal by UDWR would follow the population monitoring methods used by Utah State University's Institute for Natural Systems Engineering, Utah Water Research Lab (INSE) during their Garkane-funded fish population monitoring on the Boulder Creek system (Hardy et al. 2009a, Hardy et al. 2009b). Personnel would electrofish approximately 100-meter reaches in 8.5 miles of the mainstem of East Fork Boulder Creek, West Fork Boulder Creek, and Boulder Creek along with all spring inflows and tributary streams. A block net would be placed across the upstream and downstream end of each reach to increase capture efficiency by preventing emigration. Up to 4 passes, or until no fish were collected, would be completed through each reach. Each pass would involve all personnel walking in the stream channel and on the banks while applying constant electric current to the water from at least two backpack electrofishers. All organisms within the stream would be subjected to the electric field. All non-native brook trout would be removed from the system, killed and buried. Any CRCT collected would be held in buckets/live wells and returned to the stream after completion of the 4 pass removal.

Effort. One crew would consist of at least 2 personnel using backpack electrofishers, 2 netters retrieving stunned fish, and 1 person with a bucket receiving and disposing of fish. Electrofishing batteries would be recharged using small gasoline powered generators. Based on their previous monitoring efforts, INSE estimated that in a 40 hour work week, 9 sites that were each 100 m long could be completed by a 5 to 6 person crew using the four pass methodology (C. Williams, Institute for Natural Systems Engineering, personal communication with M. Golden, Dixie National Forest, 3/12/2010). Based on this INSE estimate, for UDWR fish removal activities under the Non-chemical Treatment alternative, one removal effort on the 11.5 km mainstem stream (12.8 reaches, 900 m long) on NFS land would require approximately 512 hours (12.8 reaches times 40 hours) or 63 days (8 hours per day) to be completed by a 5 to 6 person crew using the four pass method. An additional effort of approximately 13 days would be needed to treat the 2.3 km mainstem on private property.

Because UDWR's removal activities would need to occur between late-June or early July and September to minimize access, weather, and high stream flow issues, each removal effort would be limited to approximately 20 days to be able to conduct 4 removal efforts in a single year. To be able to treat the entire mainstem stream, on NFS lands and private lands, during any one removal effort, 20 people (four

5-person crews) would be needed. For four removal efforts, this would total up to 80 days per year. As described below, UDWR may need up to 10 years of removal effort under this method.

During the UDWR's 2009 chemical treatment of East Fork Boulder Creek above King's Pasture Reservoir, 23 relatively large inflows or tributaries with permanent fish habitat were identified, along with many smaller springs and seeps capable of at least temporarily holding small fish. These tributaries and inflows varied in length from 10 m to over 750 meters. Additional inflows and tributaries that contain fish habitat are probably present in the reach below Kings Pasture and could add another 30 days or more to the estimated treatment time.

Efficiency of fish removal by electrofishing is substantially lower in certain types of habitats found in the treatment area, especially those with heavy aquatic vegetation, root wads, woody debris, and boulder fields. The time for one removal effort in these types of areas could be higher, and effectiveness could be lower. Also, in order to eliminate the possibility of fish moving between treated and untreated reaches, crews would need to operate simultaneously, which may negatively impact fish-removal efficiency, as stream bed disturbance from upstream crews would impact water clarity and visibility for downstream crews. Because of reduced removal efficiency with electrofishing as the fish removal method, the UDWR project may extend to 10 years.

Post-Fish Removal activities. Post-fish-removal activities by UDWR would be the same as those described for the Proposed Action.

Design Criteria. The following design criteria would be included in the written authorization for use of motorized vehicles off of designated routes and the special use authorization for the burial of removed fish:

1. State of Utah decontamination protocols for prevention of the spread of Aquatic Nuisance Species will be followed for all gear and personnel involved with the removal project.

2. The Forest Archaeologist will be consulted about potential locations to bury fish to avoid impacts to cultural resources.

3. Dead fish collected will be buried no closer than 300 feet from the stream and away from known camping areas to minimize bear/human interactions.

4. Access by motorized vehicles will be on National Forest System roads designated for motorized vehicle use to the extent possible. Any use of motorized vehicles off of designated routes will be minimal, and will require written Forest Service approval.

5. Trails will be used whenever possible to move from one location to another to minimize soil and vegetation disturbance and to prevent establishing new trails.

6. Sensitive plant habitat will be avoided during action implementation.

7. Personnel will ensure reach being treated is void of livestock and people not involved with the operation. Treated waters will remain open to fishing.

Actions connected to fish removal actions on NFS lands. The following parts of the UDWR project, as discussed above, are not subject to Forest Service permit requirements, and therefore are not included in the Forest Service decision. They are considered connected actions to UDWR's fish removal activities on NFS lands and thus included in the environmental analysis:

1. As described for the Proposed Action, the UDWR treatment area includes private property, including that owned by Garkane Energy; thus, this area is not under Forest Service jurisdiction.

   The expectation is that under the Non-Chemical Treatment alternative, the UDWR would implement non-chemical treatment methods on non-NFS lands, as described below, although the UDWR may decide to use another method or methods to achieve the treatment objective on the private lands or not pursue treatment on the private lands. The flowing portions of the project area on private lands would undergo similar electrofishing removal by UDWR, as described for NFS lands above.

   For the non-flowing portions of the project area on private lands, electrofishing would not be effective in removing brook trout from King's Pasture Reservoir or the pond in Kings Pasture. To remove brook trout from these areas without use of chemicals, UDWR would deploy experimental gill nets with many different mesh sizes at several locations and depths throughout each water body. Other studies where this method has been successful at eradicating brook trout suggest that it would take at least two and up to four seasons of semi-continuous netting to eliminate all size classes of trout from small lakes with relatively low trout densities (Knapp and Matthews 1998, Parker et al. 2001).

2. Potential recolonization from East Fork Boulder Creek would severely reduce the efficacy of removing brook trout from King's Pasture Reservoir; therefore, UDWR would need to construct a fish migration barrier in East Fork Boulder Creek on private property above King's Pasture Reservoir.

   The barrier would generally consist of a small check dam constructed of boulders and large rocks, creating a vertical drop of approximately 5 ft on the downstream side. The location for the barrier would be selected by UDWR to utilize any naturally occurring drops which can be enhanced and where the stream channel and floodplain are confined to minimize the size of the structure and the amount of water impounded behind it. Barrier construction would comply with laws, regulations, and permitting requirements of the State Engineer for stream channel alteration. Barrier materials would be taken from the ground surface, near the stream. The collection of these materials would not require excavation, stream alteration, or vegetation disturbance. If sufficient material is not available on site, additional materials would be hauled to the barrier site from an approved source.

   The barrier location would be selected by UDWR to minimize changes in stream gradient, hydraulic function, and water pooling. In addition, the barrier would be constructed by UDWR adjacent to existing roads where equipment access is acceptable, thus requiring little disturbance to surrounding areas. Riparian vegetation would be disturbed as little as possible during the construction of the barrier, while areas where surface disturbance would occur would be restored to pre-project conditions. The barrier would not be placed in areas of cultural or historic significance or in areas where sensitive, threatened or endangered plants occur. It would be designed to operate under the natural fluctuations of a stream flow without routine maintenance. The barrier would be designed to pose little, if any, threat to the natural stream system or its associated riparian area so that if it were to fail, no damage would result to the stream environment. UDWR's maintenance could include the adjustment or replacement of individual rock materials, but such work would be minor. The barrier could be removed but only after treatment is determined to be fully successful.

Neither netting nor electrofishing are options for UDWR for removing any non-native trout that may be using the upper portion of the penstock inflow or the lower portion of the pipeline from the West Fork Reservoir during treatment efforts. Shutting off water to these areas until they were completely dry would be the only way to ensure complete eradication; however, this is not feasible (M. Avant, Garkane Energy, personal communication with M. Golden, Dixie National Forest, 4/1/2010). Because of this, the effectiveness of the rest of the treatment would be reduced, contributing to the likelihood of the longer period of treatment.

3. Stocking of fish by UDWR would be as described for the Proposed Action.

4. As described for the Proposed Action, fishing regulations, including whether or not treated waters would remain open to fishing, is under the jurisdiction of UDWR. The expectation is as described for the Proposed Action.

Literature Cited

Buktenica, M. W., B. D. Mahoney, S. F. Girdner, and G. L. Larson. 2000. Response of a resident bull trout population to nine years of brook trout removal, Crater Lake National Park, Oregon. Pages 127-132 in D. Schill, S. Moore, P. Byorth, and B. Hamre, editors. *Wild Trout VII: Management in the New Millennium, Are We Ready?* Yellowstone National Park, WY. 284 pp.

Chamberlain, C.B., and D.K. Hepworth. 2002a. Pine Creek rotenone treatment, 2002. A native cutthroat trout restoration project. Utah Division of Wildlife Resources, Southern Region, Cedar City, UT. 9 pp. + attachments.

Chamberlain, C.B., and D.K. Hepworth. 2002b. The treatment of Pine Creek, Fremont River drainage, and Pine Creek Reservoir, 2002. A native cutthroat trout and sport fish enhancement project. Utah Division of Wildlife Resources, Southern Region, Cedar City, UT. 9 pp. + attachments.

Chamberlain, C.B., and D.K. Hepworth. 2002c Twitchell Creek and Round Willow Bottoms, 2002: A sport fish and native cutthroat trout restoration project. Utah Division of Wildlife Resources, Southern Region, Cedar City, UT. 8 pp. + attachments.

Earle, J.E., J.D. Stelfox, and B. Meagher. 2007. Quirk Creek brook trout suppression project 2004-2006. Alberta Sustainable Resource Development, Fish and Wildlife Division, Calgary, Alberta, Canada. 36pp.

Finlayson, B. J., R. A. Schnick, R. L. Cailteaux, L. DeMong, W. D. Horton, W. McClay, C. W. Thompson, and G. J. Tichacek. 2000. Rotenone use in fisheries management; administrative and technical quidelines manual.

Fridell, R.A., M.K. Morvilius, M.A. Schijf, and K.K. Wheeler. 2004. Virgin River Basin 2003 treatment projects. Utah Division of Wildlife Resources, Salt Lake City, UT. Publication No. 04-03. 33 pp.

Fridell, R.A., M.K. Morvilius, and C.B. Rognan. 2005. Virgin River Basin 2004 treatment projects. Publication No. 05-05. Utah Division of Wildlife Resources Publication Number 05-05. 38 pp.

Fridell, R.A., and A.H. Rehm. 2006. Virgin River Basin 2005 Treatment Projects Utah Division of Wildlife Resources Publication Number 06-05. 30 pp.

Hardy, T. B., N. Bouwes, C. Williams, and C. Thomas. 2009a. *Trout Population Monitoring in Boulder Creek: 2008 Results*. Utah Water Research Laboratory, Utah State University, Logan, UT. 11 pp.

Hardy, T. B., C. S. Williams, C. W. Thomas. 2009b. *Trout Population Monitoring in Boulder Creek: 2009 Results*. Utah Water Research Laboratory, Utah State University, Logan, UT. 13pp.

Hepworth, D.K., C.B. Chamberlain, and J.E. Whelan. 2001a. Pine Creek rotenone treatment, 2001: A native cutthroat trout restoration project. Utah Division of Wildlife Resources, Southern Region, Cedar City, UT. 4 pp. + attachments.

Hepworth, D.K., C.B. Chamberlain, and J.E. Whelan. 2001b. Twitchell Creek, Long Willow Bottoms and Round Willow Bottoms, 2001: A native cutthroat trout restoration project. Utah Division of Wildlife Resources, Southern Region, Cedar City, UT. 4 pp. + attachments.

Hepworth, D.K., C.B. Chamberlain, and J.E. Whelan. 2001c. West Fork Boulder Creek rotenone treatment, 2001: A native cutthroat trout restoration project. Utah Division of Wildlife Resources, Southern Region, Cedar City, UT. 9 pp. + attachments.

Knapp, R. A., and K. R. Matthews. 1998. Eradication of nonnative fish by gill netting from a small mountain lake in California. Restoration Ecology 6: 207-213.

Kulp, M. A., and S. A. Moore. 2000. Multiple electrofishing removals for elimination rainbow trout in a small southern Appalachian stream. North American Journal of Fisheries Management 20: 259-266.

Meronek, T. G., P. M. Bouchard, E. R. Bukner, T. M. Burri, K. K. Demmerly, D. C. Hatleli, R. A. Klumb, S. H. Schmidt, and D. W. Coble. 1996. A review of fish control projects. North American Journal of Fisheries Management 16:63-74.

Meyer, K. A., J. A. Lamansky, Jr., and D. J. Schill. 2006. Evaluation of an unsuccessful brook trout electrofishing removal project in a small Rocky Mountain stream. North American Journal of Fisheries Management 26:849-860.

Moore, S. E., M. A. Kulp, J. Hammonds, and B. Rosenlund. 2005. *Restoration of Sam's Creek and an Assessment of Brook Trout Restoration Methods, Great Smoky Mountains National Park*. Technical Report/NPA/NRWRD/NRTR-2005/342 U.S. Department of the Interior National Park Service, Water Resources Division, Fort Collins, CO. 36 pp.

Moore, S. E., G. L. Larson, and B. Ridley. 1986. Population control of exotic rainbow trout in streams of a natural area park. Environmental Management 10: 215-219.

Ottenbacher, M.J., and D.K. Hepworth. 2001. White Creek rotenone treatment project, August 2001. Utah Division of Wildlife Resources, Southern Region, Cedar City, UT. 6 pp. + attachments.

Parker, B. R., D. W. Schindler, D. B. Donald, and R. S. Anderson. 2001. The effects of stocking and removal of a nonnative salmonid on the plankton of an alpine lake. Ecosystems 4: 334-345.

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.

Shepard, B. B., R. Spoon, and L. Nelson. 2002. A native westslope cutthroat population responds positively after brook trout removal. Intermountain Journal of Science 8:191-211.

Sousa, R.J., F.P. Meyer, and R.A. Schnick. 1987. Better Fishing through Management. U. S. Fish and Wildlife Service, Washington, D. C.

Thompson, P. D. and F. J. Rahel. 1996. Evaluation of depletion-removal electrofishing of brook trout in small Rocky Mountain streams. North American Journal of Fisheries Management 16: 332-339.

US Environmental Protection Agency (EPA). 2007. Registration Eligibility Decision for Rotenone. EPA 738-R-07-005. 44 pp.

US Environmental Protection Agency (EPA). 1999. Alternative Disinfectants and Oxidants Guidance Manual. EPA 815-R-99-014. 346 pp.

Figure 1. Project area location