

Paiute Cutthroat Trout
(Oncorhynchus clarkii seleniris)

**5-Year Review:
Summary and Evaluation**



Photo by Michael Graybrook

**U.S. Fish and Wildlife Service
Nevada Fish and Wildlife Office
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5-YEAR REVIEW

Paiute cutthroat trout (*Oncorhynchus clarkii seleniris*)

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I. GENERAL INFORMATION

Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (ESA) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing of a species as endangered or threatened is based on the existence of threats attributable to one or more of the five threat factors described in section 4(a)(1) of the ESA, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the ESA that includes public review and comment.

Species Overview:

Cutthroat trout (*Oncorhynchus clarkii*) have the most extensive range of any inland trout species of western North America, and occur in anadromous (migrating from salt to fresh water to spawn), non-anadromous, fluvial (river- or stream-dwelling), and lacustrine (lake-dwelling) populations (Behnke 1979, p. 27). Differentiation of the species into 14 recognized subspecies occurred during subsequent general desiccation and isolation of the Great Basin and Intermountain Regions since the end of the Pleistocene, and indicates presence of cutthroat trout in most of their historical range prior to the last major Pleistocene glacial advance (Loudenslager and Gall 1980, pp. 38–40; Behnke 1992, pp. 14–18). Paiute cutthroat trout (PCT) have the most restricted range of all cutthroat trout subspecies and historically occupied approximately 17.8 kilometers (km) (11.1 miles (mi)) of stream habitat within the Silver King Creek drainage, Alpine County, California. Paiute cutthroat trout now occupy approximately 37.8 km (23.5 mi) of stream habitat in five widely distributed drainages outside of their historical range. Like most salmonids, PCT require relatively clear, cold waters to maintain viable populations. Paiute cutthroat trout reproduce in the spring and are obligatory stream spawners. Paiute cutthroat trout evolved in the absence of other trout, and they are highly susceptible to hybridization and competition from introduced trout species.

Methodology Used to Complete This Review:

This review was prepared by the Nevada Fish and Wildlife Office (NFWO), following the Region 8 guidance issued in March 2008. We used information from the Paiute cutthroat trout Revised Recovery Plan (Service 2004, pp. 1–105) and the most recent 5-year review (Service 2008a, pp. 1–39), agency records, scientific literature, and survey information from experts who have been monitoring this species in various localities to update the species' status and threats.

Contact Information:

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Federal Register (FR) Notice Citation Announcing Initiation of This Review: A notice announcing initiation of the 5-year review of this taxon and the opening of a 60-day period to receive information from the public was published in the Federal Register on April 27, 2012 (Service 2012, pp. 25112–25116). We received no information from the public in response to our Federal Register Notice initiating this 5-year review. We received valuable information from the California Department of Fish and Wildlife (CDFW).

Listing History:

Original Listing

FR Notice: Service (1967, p. 4001)

Date of Final Listing Rule: March 11, 1967

Entity Listed: *Salmo clarki* subsp. *Seleniris*, a fish subspecies

Classification: Endangered

Revised Listing

FR Notice: Service (1975, pp. 29863–29864)

Date Listed: July 16, 1975

Entity Listed: *Salmo clarki* subsp. *Seleniris*, a fish subspecies

Classification: Threatened

Associated Rulemakings:

Paiute cutthroat trout (*Salmo clarki seleniris*) was reclassified from endangered to threatened in 1975 (see Revised Listing above). A special rule under ESA section 4(d) was published in conjunction with the downlisting rule to facilitate management by the State of California and allow State-permitted sport harvest (Service 1975, p. 29864).

Review History:

The original recovery plan was published on January 25, 1985 (Service 1985, pp. 1–68). Two rangewide status assessments have been conducted (Behnke 1992, pp. 116–118; Moyle 2002, pp. 287–293); however, they did not conduct a five-factor analysis nor did they address the listing status. A revised recovery plan was published on August 10, 2004 (Service 2004, pp. 1–105). The initial 5-year review was completed on July 10, 2008 (Service 2008a, pp. 1–39).

Species' Recovery Priority Number at Start of 5-Year Review:

The recovery priority number for PCT is 9 according to the Service's 2012 Recovery Data Call for the NFWO, based on a 1–18 ranking system where 1 is the highest-ranked recovery priority and 18 is the lowest (Service 1983a, pp. 43098–43105; 1983b, p. 51985). This number indicates that the taxon is a subspecies that faces a moderate degree of threats and has a high potential for recovery.

Recovery Plan

Name of Plan: Revised Recovery Plan for the Paiute Cutthroat Trout

Date Issued: August 10, 2004

Dates of Previous Revisions: January 25, 1985 (original recovery plan)

II. REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment (DPS) Policy

The ESA defines “species” as including any subspecies of fish or wildlife or plant, and any distinct population segment (DPS) of any species of vertebrate wildlife. This definition of species under the ESA limits listing as distinct population segments to species of vertebrate fish or wildlife. The 1996 Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the ESA (Service 1996, pp. 4722–4725) clarifies the interpretation of the phrase “distinct population segment” for the purposes of listing, delisting, and reclassifying species under the ESA. Paiute cutthroat trout was originally listed in its entirety, and there is no new information regarding the application of the DPS policy.

Information on the Species and its Status

Species Biology and Life History

Paiute cutthroat trout are obligatory stream spawners. Spawning generally occurs from May through July, depending upon stream flow, elevation, and water temperature (Wong 1975, pp. 117–118; Behnke 1987, p. 541). Spawning habitat is typical of stream-spawning salmonids with site selection being based on a variety of factors including gravel size, velocity, water depth, and water temperature (Bjornn and Reiser 1991, pp. 89–97; Beechie *et al.* 2008, pp. 84–85).

Spawning areas must be well oxygenated and relatively silt-free for good egg survival (Bjornn and Reiser 1991, p. 99). Redds are generally located in riffles and pool tails (Wong 1975, pp. 117–118; Behnke 1987, p. 540). Paiute cutthroat trout generally become sexually mature around year two; consecutive year spawning is unknown, and few individuals survive to spawn again (Behnke 1987, p. 541).

Spawning behavior of PCT is also similar to other stream-spawning trout. Females excavate a redd (*i.e.*, nest) and then deposit eggs in the redd while the male simultaneously fertilizes the eggs (Wong 1975, pp. 117–125). The female then covers the fertilized eggs with gravel. Paiute cutthroat trout generally deposit between 250 and 400 eggs during spawning (Wong 1975, p. 128; Behnke 1987, p. 541). Eggs hatch in 6–8 weeks and fry (recently hatched) emerge from the gravel 2–3 weeks later and remain in shallow shoreline areas with small gravel/cobble for hiding cover (Wong 1975, pp. 102–108, 151–152; Moyle 2002, p. 291). By early fall the fry have developed into small (35–40 millimeters (mm) (1.4–1.6 inches (in))) fingerlings which set up feeding territories during the day and may school together at night in hiding cover (Wong 1975, pp. 105–108, 151–155).

Migratory behavior in PCT is not known to exist (Behnke 1987, p. 540). Diana and Lane (1978, pp. 444–448) found limited movement of adult PCT in North Fork Cottonwood Creek. Most individuals were recaptured in their original capture locations; however, both upstream and downstream movement was detected and a few individuals moved over 1 km (0.6 mi) (Diana and Lane 1978, p. 446).

Paiute cutthroat trout are opportunistic feeders, with diets consisting of drift organisms, typically terrestrial and aquatic insects (Wong 1975, pp. 133–138; Behnke 1987, p. 540; Moyle 2002, p. 290). Recent literature has documented the importance of terrestrial insects in the diet of stream salmonids (Baxter *et al.* 2005, pp. 201–214; Saunders and Fausch 2012, p. 1524). Wong (1975, pp. 133–138) found that PCT less than 100 mm (3.9 in) in length fed exclusively on small aquatic organisms while individuals over 100 mm (3.9 in) in length incorporated terrestrial organisms as well as larger aquatic invertebrates.

Paiute cutthroat trout may live up to 6 years of age (Wong 1975, pp. 88–99; Titus and Calder 2009, pp. 8–11). Growth rates of PCT are variable, with faster and greater growth occurring in larger habitats (Wong 1975, pp. 99–108; Titus and Calder 2009, pp. 8–12). Total length at age was higher in the Upper Fish Valley section of Silver King Creek opposed to the comparatively smaller headwater habitats of Silver King Creek and Coyote Creek (Titus and Calder 2009, p. 11).

Spatial Distribution

Paiute cutthroat trout are known from a single drainage in the Sierra Nevada range in east-central California. The presumed historical distribution was limited to 17.8 km (11.1 mi) of habitat in Silver King Creek (Alpine County), from Llewellyn Falls downstream to barriers in Silver King Canyon, as well as the accessible reaches of three small, named tributaries: Tamarack Creek,

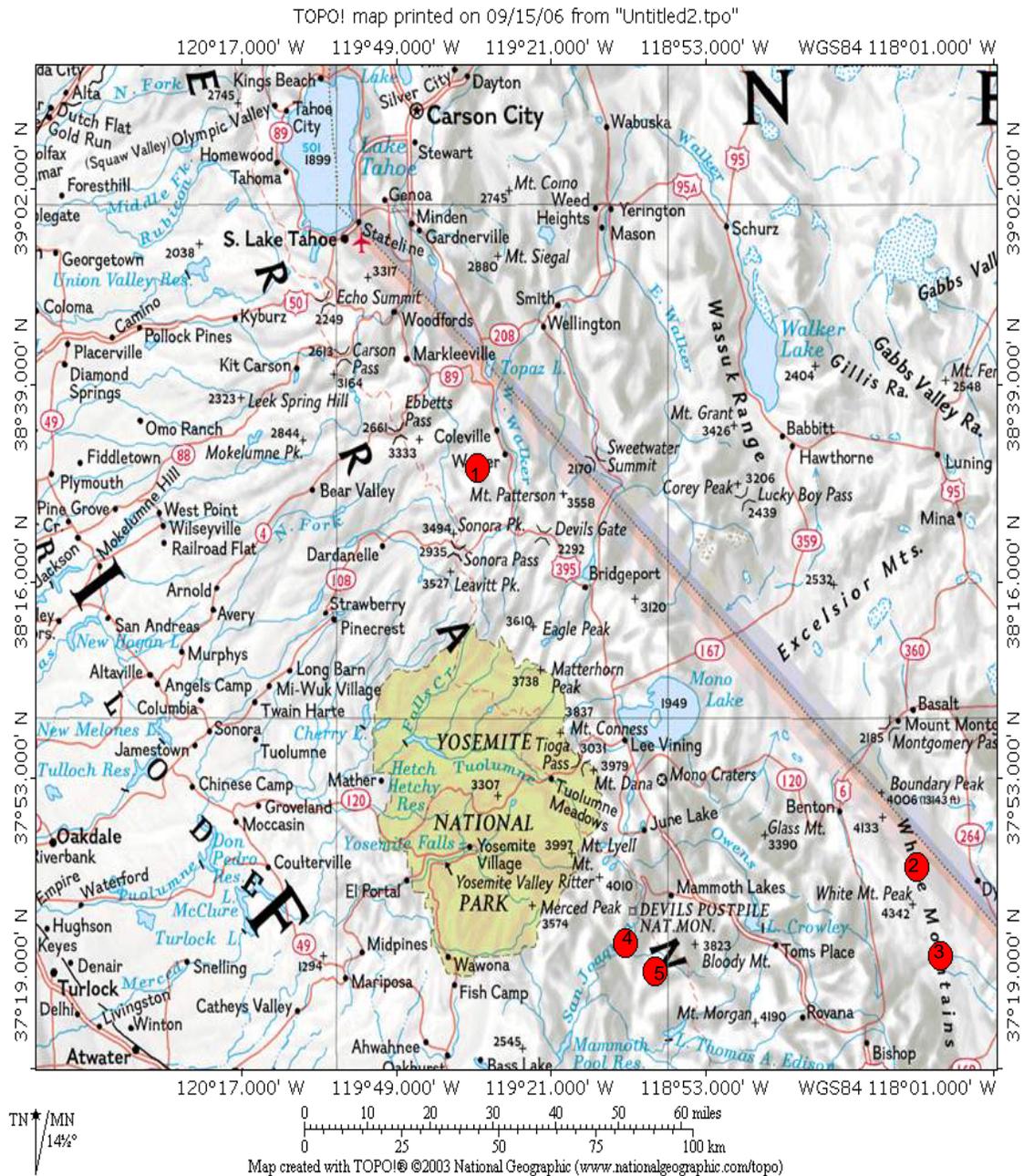


Figure 1. Location of existing Paiute cutthroat trout populations in the Sierra Nevada Mountain Range: 1) Silver King Creek, Humboldt-Toiyabe National Forest, Alpine County, California; 2) Cabin Creek, Inyo National Forest, Mono County, California; 3) North Fork Cottonwood Creek, Inyo National Forest, Mono County, California; 4) Stairway Creek, Sierra National Forest, Madera County, California; and 5) Sharktooth Creek, Sierra National Forest, Fresno County, California.

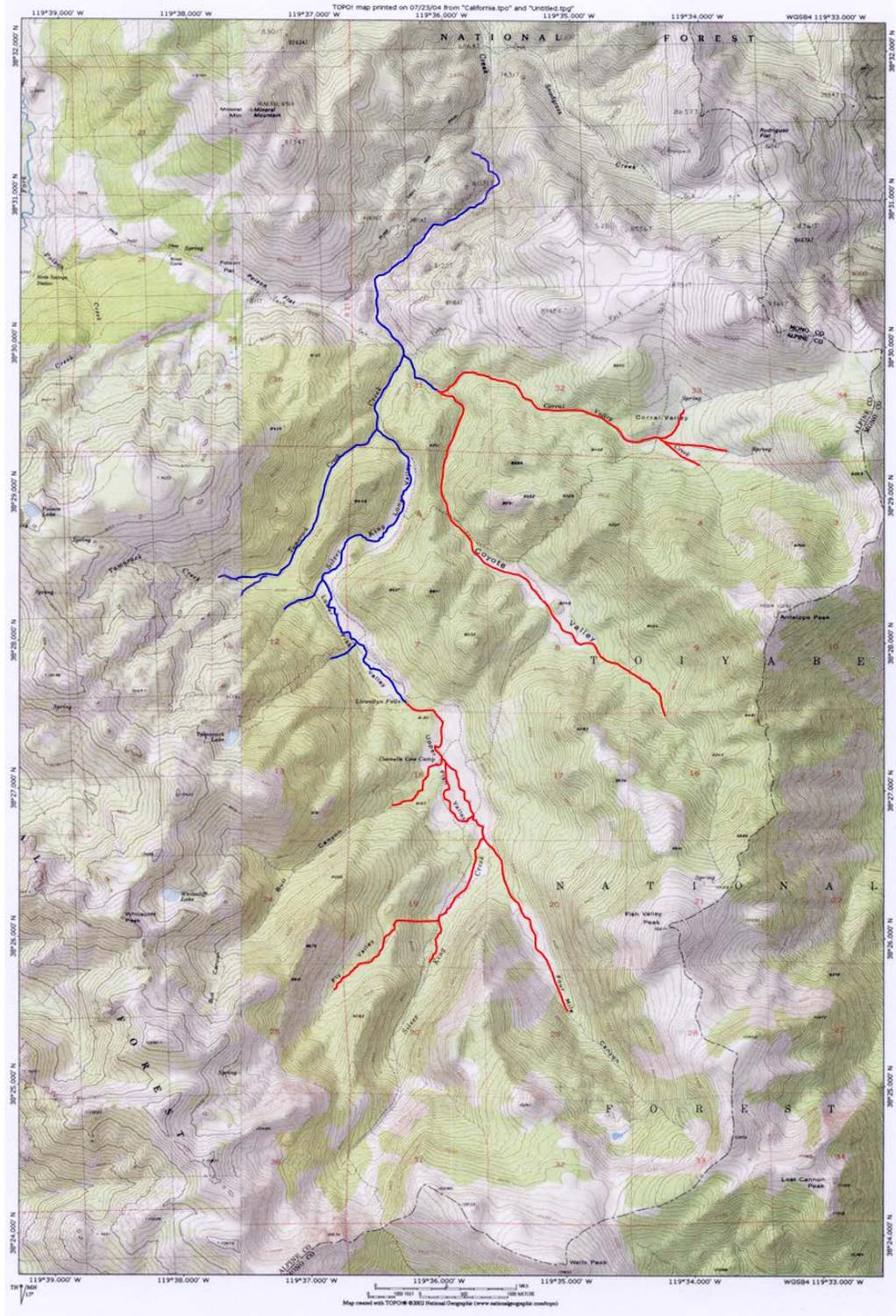


Figure 2. Historical (blue) and currently occupied (red) habitat for Paiute cutthroat trout in the Silver King Creek drainage (1), Humboldt-Toiyabe National Forest, Alpine County, California.

Tamarack Lake Creek, and the lower reaches of Coyote Valley Creek downstream of barrier falls (Figures 1 and 2; Service 2004, p. 12). Paiute cutthroat trout now occupy approximately 37.8 km (23.5 mi) of habitat in five widely distributed drainages (Figure 1). They were first established in the upper reaches of the Silver King Creek drainage (above natural barriers) in 1912, when local livestock operators transplanted fish above Llewellyn Falls (Figure 2; Service 2004, p. 13). The progeny of these early day transplants were then introduced into several other lakes and streams in California, many of which were not successful (Service 2004, p. 17). Four self-sustaining populations are now established outside their historical watershed (Figures 1, 3, and 4). Currently, no PCT occur within the historical range of the taxon. The current distribution of PCT has not changed since the 2008 5-year review (Service 2008a, pp. 4–5); however, estimates of both historically and currently-occupied habitat have increased due to more precise mapping resolution. Occupied habitat consists of the following locations:

Silver King Creek Drainage

This drainage is located in the Carson-Iceberg Wilderness, Humboldt-Toiyabe National Forest, Alpine County, California. Paiute cutthroat trout occupy approximately 11.9 km (7.4 mi) in the previously fishless upper reaches of Silver King Creek and its tributaries above Llewellyn Falls, including Four Mile Canyon Creek, Fly Valley Creek, and Bull Canyon Creek. The populations in Four Mile Canyon Creek (3.1 km, 1.9 mi) and Fly Valley Creek (1.8 km, 1.1 mi) are separated from Silver King Creek by impassable fish barriers. Two other occupied tributaries are located below Llewellyn Falls: Corral Valley (5.3 km, 3.3 mi) and Coyote Valley (6.1 km, 3.8 mi) Creeks. The middle portion of Silver King Creek proper (from below Llewellyn Falls to barriers in Silver King Canyon) and associated tributaries are the historical portion of PCT's range and currently occupied by nonnative rainbow trout (*O. mykiss*) (Figures 1 and 2; Service 2004, pp. 16, 20, 23; Finger *et al.* 2011, pp. 1378–1379).

North Fork Cottonwood Creek and Cabin Creek

Both of these drainages are located in the White Mountains Wilderness, Inyo National Forest, Mono County, California. Paiute cutthroat trout were first established in North Fork Cottonwood Creek in 1946 and currently occupy approximately 5.5 km (3.4 mi) of stream habitat. Cabin Creek was established in 1968 and 2.4 km (1.5 mi) of stream habitat are occupied (Figures 1 and 3; Service 2004, p. 23).

Stairway Creek and Sharktooth Creek

Both of these drainages are located on the Sierra National Forest. Stairway Creek is located in the Ansel Adams Wilderness, Madera County, California, and was established in 1972. Paiute cutthroat trout occupy approximately 3.5 km (2.2 mi) of stream habitat (Figures 1 and 4). Sharktooth Creek is located in the John Muir Wilderness, Fresno County, California, and was established in 1968. Paiute cutthroat trout occupy approximately 3.2 km (2 mi) of stream habitat (Figures 1 and 4; Service 2004, pp. 25–26).

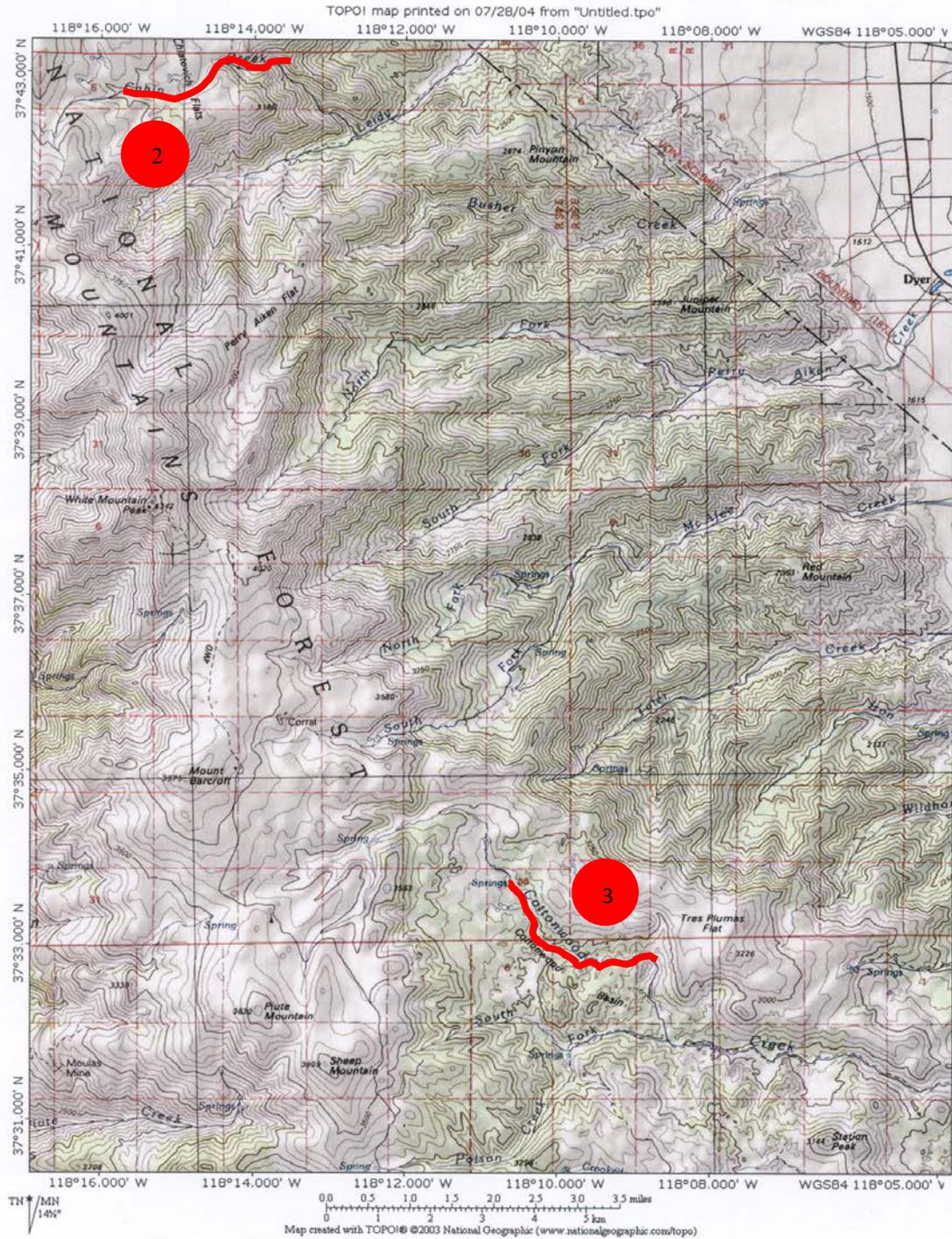


Figure 3. Refugial populations of Paiute cutthroat trout in Cabin Creek (2) and North Fork Cottonwood Creek (3), White Mountains, Inyo National Forest, Mono County, California.

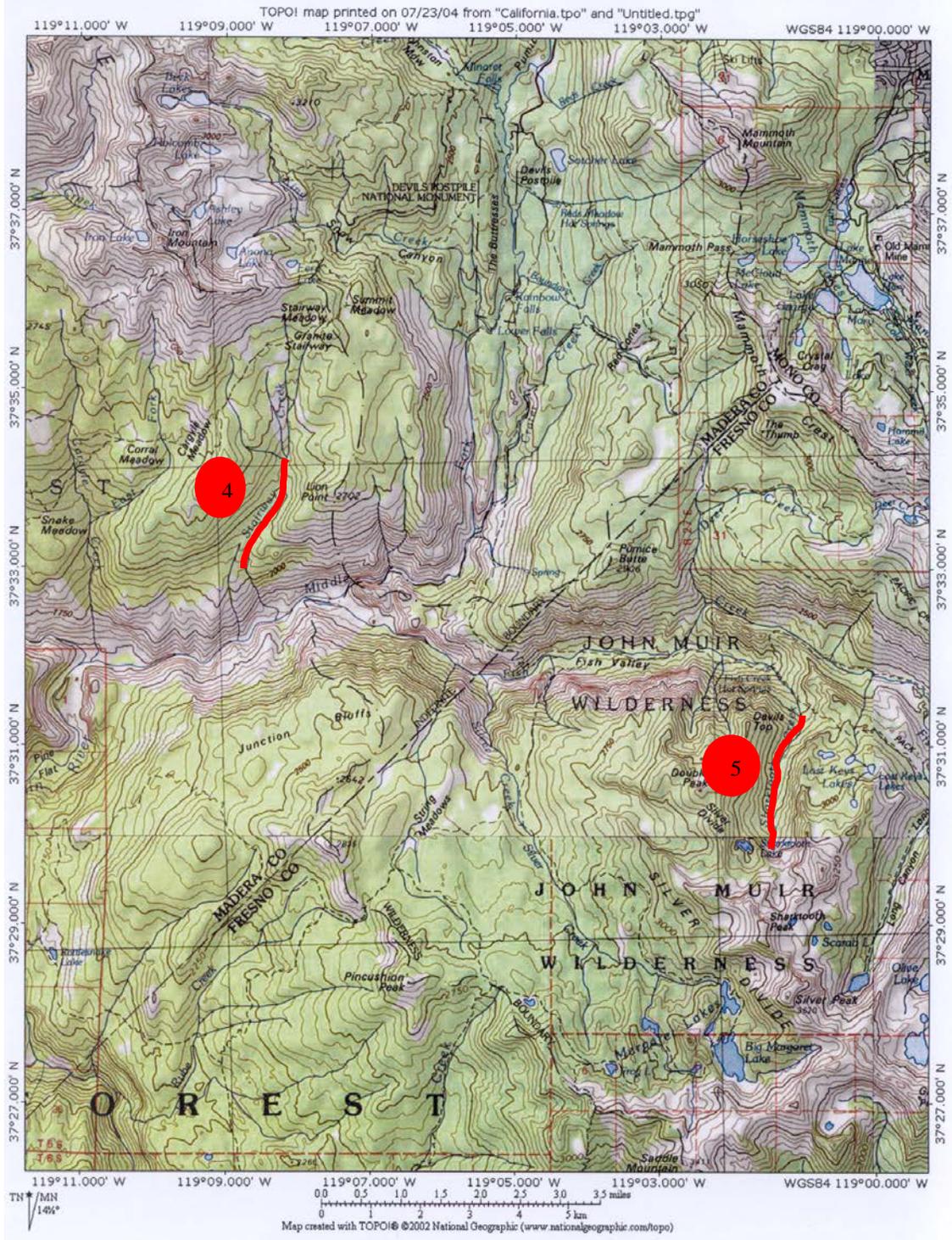


Figure 4. Refugial populations of Paiute cutthroat trout in Stairway Creek (4) and Sharktooth Creek (5), Sierra National Forest, Madera and Fresno Counties, California.

Abundance

It is difficult to fully characterize the abundance of PCT. Like most wildlife populations, numbers of PCT fluctuate annually due to biotic and abiotic factors. Further, population estimation methods have varied by location, which means only general comparisons among the populations can be made. Overall, population estimates suggest that PCT are stable. Abundance information for each drainage is discussed below.

Silver King Creek Drainage

Silver King Creek (Upper Fish Valley): Population estimates for Silver King Creek in Upper Fish Valley have been periodically conducted since 1964 using triple-pass depletion electrofishing and snorkeling. Four separate 150-m (500-ft) sections spaced throughout Upper Fish Valley are used to estimate the PCT population. The stream section in Upper Fish Valley is approximately 1.9 km (1.2 mi) long (W. Somer, CDFW, unpubl. data). Upper Silver King Creek and its tributaries were chemically treated from 1991 to 1993. Paiute cutthroat trout were reintroduced into Upper Fish Valley from 1994 to 1998 using populations in Fly Valley and Coyote Valley Creeks (Table 1). The population increased from 0 in 1993 to an estimated 608 adult fish in 2000. The population then declined to an estimated 63 adult fish in 2003. However, the population then increased to an estimated 500 adult fish in 2005. The adult population was lower again in 2012 with an estimated 111 adult fish (Figure 5). The mean for the entire population (adults and juveniles) over a 48-year period (1964–2012) is 798 individuals while the mean for the adult population is 392 individuals (Figure 5; W. Somer, CDFW, unpubl. data). As mentioned above, biotic and abiotic factors influence population sizes of PCT. For example, high run-off events occurred in 1969, 1982, 1986, 1995, 1997, 2005, 2006, and 2011; severe anchor ice was observed in 1989 and 2012; mechanical removal of hybrid fish occurred from 1973 to 1975; and chemical treatments occurred in 1964, 1976, and 1991–1993. Population estimates were not made in 1965, 1967, 1977, 1978, 1983, 2009, 2010, and 2011.

Table 1. Paiute cutthroat trout reintroductions to Upper Fish Valley, Silver King Creek, following the 1991–1993 chemical treatment.

Year	Number Stocked	Donor Stream
1994	139	Coyote Valley
1995	49	Fly Valley
1995	109	Coyote Valley
1996	134	Coyote Valley
1997	145	Coyote Valley
1998	30	Fly Valley
Total	606	

Source: W. Somer, CDFW, unpubl. data

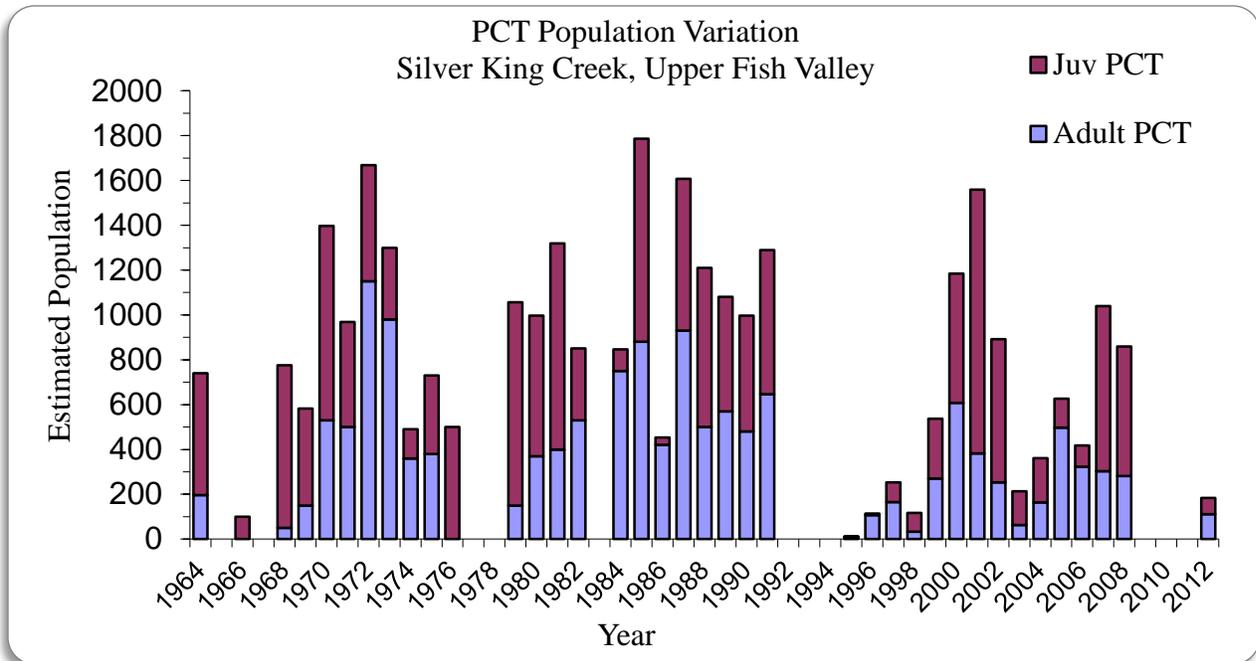


Figure 5. Population estimates for Upper Fish Valley, Silver King Creek from 1964 to 2012. Blue bars represent adults (over 150 millimeters (mm), 6 inches (in)); red bars represent juveniles (less than 150 mm (6 in)) (W. Somer, CDFW, unpubl. data).

Fly Valley Creek: Ten population density surveys have been conducted on Fly Valley Creek. The first survey was in 1984 and the last was in 2012. In 2012, CDFW surveyed 150 m (500 ft) of stream and estimated 98 adult fish/km (158 fish/mi) which is slightly higher than the mean of 92 adult fish/km (147 fish/mi). While juvenile numbers have historically fluctuated, adult numbers have stayed relatively constant (Figure 6; W. Somer, CDFW, unpubl. data).

Four Mile Canyon Creek: Twenty-three population density surveys have been conducted on Four Mile Canyon Creek. The first was in 1968 and the last was in 2012. In 2012, CDFW surveyed 255 m (835 ft) of stream and captured only 1 fish. This prompted crews to continue surveying all available habitat for 1,300 m (4,265 ft) upstream of the test section. An additional 12 individuals were captured, 4 of which were adults (Figure 7; 2012b). The mean estimated adult population in Four Mile Canyon Creek is 49 fish/km (79 fish/mi) (Figure 7; W. Somer, CDFW, unpubl. data).

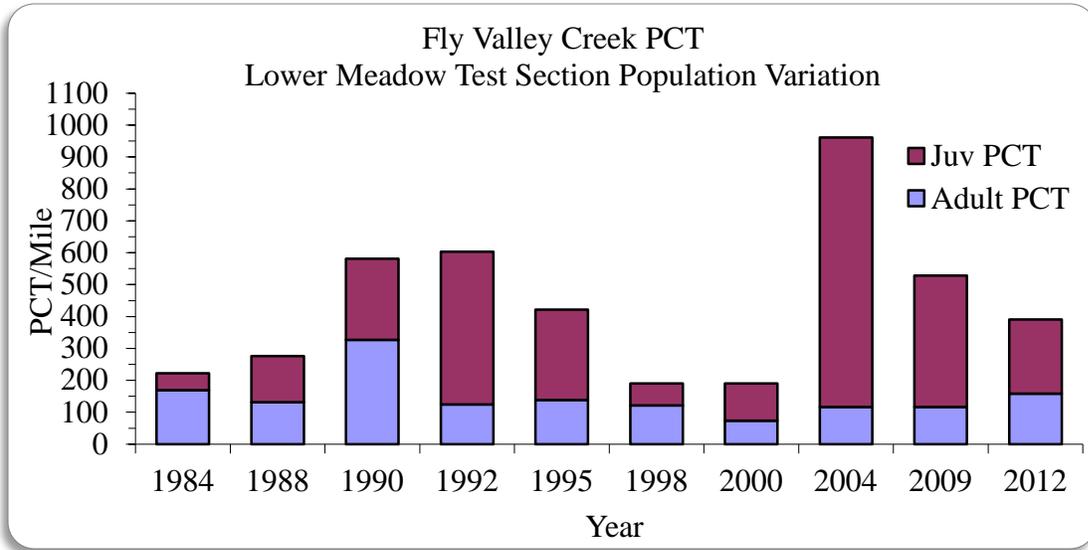


Figure 6. Population density estimates for Paiute cutthroat trout in Fly Valley Creek from 1984 to 2012. Blue bars represent adults (over 150 mm (6 in)); red bars represent juveniles (less than 150 mm (6 in)) (W. Somer, CDFW, unpubl. data).

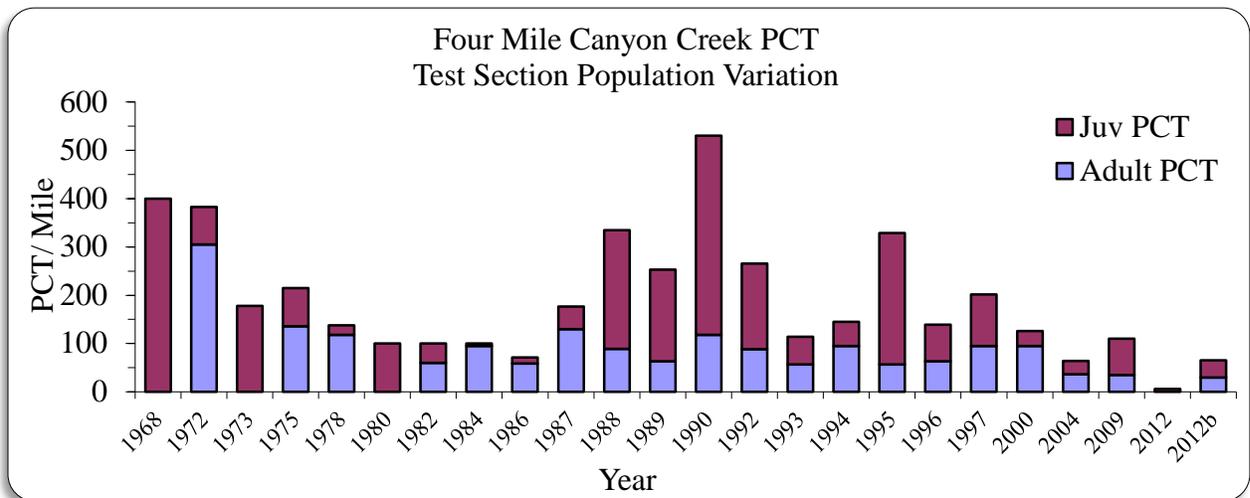


Figure 7. Population density estimates for Paiute cutthroat trout in Four Mile Canyon Creek from 1968 to 2012. Blue bars represent adults (over 150 mm (6 in)); red bars represent juveniles (less than 150 mm (6 in)) (W. Somer, CDFW, unpubl. data).

Corral Valley Creek: Population density surveys on Corral Valley Creek were conducted from 1974 to 2012. In 2012, CDFW surveyed a 150 m (500 ft) section and estimated 33 adult fish/km (53 fish/mi), which is lower than the average of 59 adult fish/km (95 fish/mi) (Figure 10; W. Somer, CDFW, unpubl. data). Like Coyote Valley Creek, Corral Valley Creek is very productive with the large majority of individuals being juveniles (Figure 10).

Coyote Valley Creek: Population density surveys on Coyote Valley Creek were sporadically conducted from 1964 to 2012. Two separate 150 m (500 ft) sections, Upper Meadow and Lower Meadow, were surveyed. In 2012, CDFW estimated 69 adult fish/km (110 fish/mile) for the Lower Meadow section which is lower than the average of 88 adult fish/km (141 fish/mi). The Upper Meadow section had an estimated 39 adult fish/km (63 fish/mi), which is well below the average of 112 adult fish/km (180 fish/mi) (Figures 8 and 9; W. Somer, CDFW, unpubl. data). Coyote Valley Creek is very productive with high levels of juvenile fish nearly every year; particularly in the Lower Meadow section (Figures 8 and 9; W. Somer, CDFW, unpubl. data).

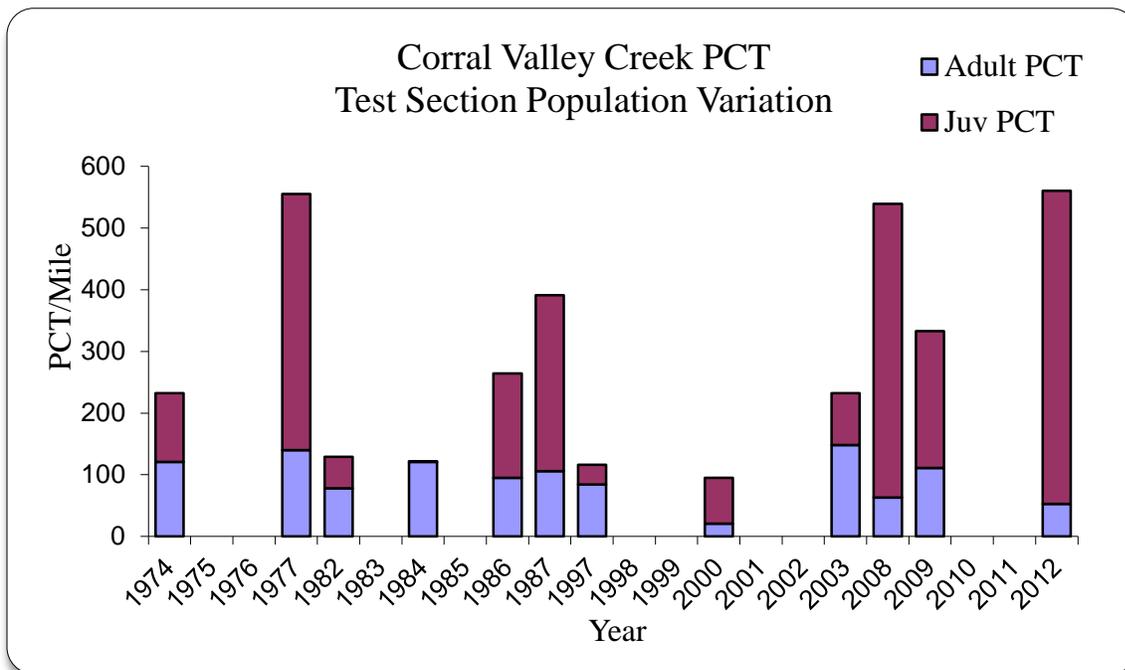


Figure 10. Population density estimates for Paiute cutthroat trout in Corral Valley Creek from 1974 to 2012. Blue bars represent adults (over 150 mm (6 in)); red bars represent juveniles (less than 150 mm (6 in)) (W. Somer, CDFW, unpubl. data).

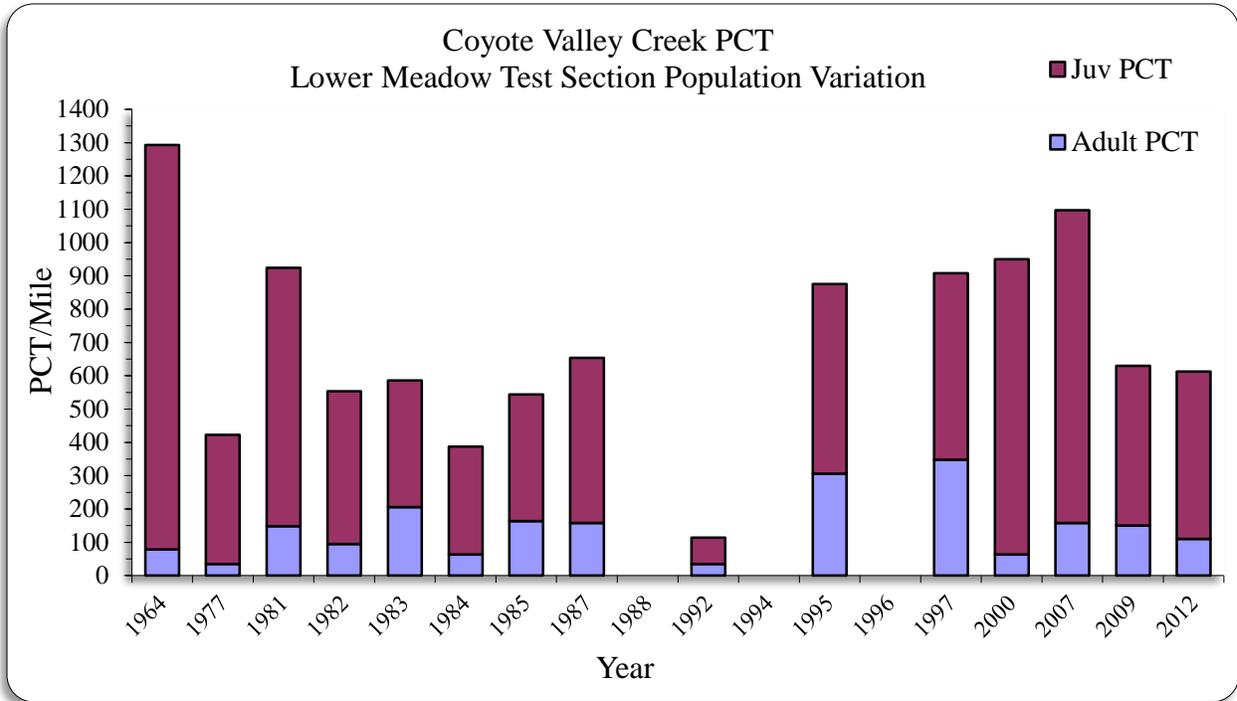


Figure 8. Population density estimates for Paiute cutthroat trout in the Lower Meadow section of Coyote Valley Creek from 1964 to 2012. Blue bars represent adults (over 150 mm (6 in)); red bars represent juveniles (less than 150 mm (6 in)) (W. Somer, CDFW, unpubl. data).

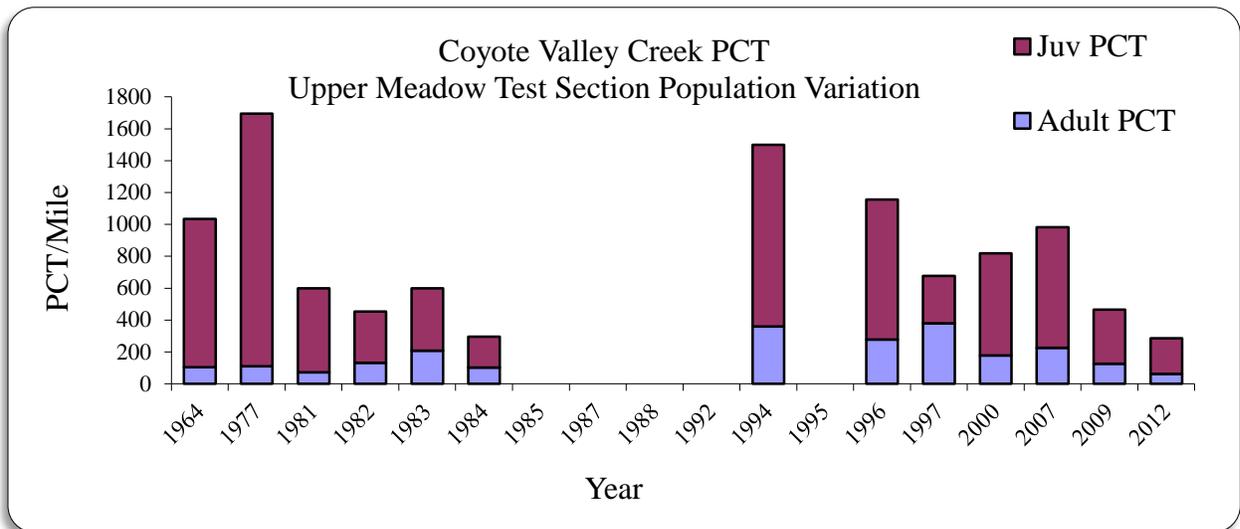


Figure 9. Population density estimates for Paiute cutthroat trout in the Upper Meadow section of Coyote Valley Creek from 1964 to 2012. Blue bars represent adults (over 150 mm (6 in)), while red bars represent juveniles (less than 150 mm (6 in)) (W. Somer, CDFW, unpubl. data).

Sharktooth and Stairway Creeks

The Sierra National Forest has used a fly rod depletion method (Stephens and Christenson 1980, p. 1) on an approximate 5-year rotation for sampling PCT on Sharktooth and Stairway Creeks. Sharktooth Creek was sampled in 1999, 2004, 2009, and 2012 (Figure 11) while Stairway Creek was sampled in 2000, 2005, and 2012 (Figure 12). This method of sampling is not intended to be a good estimator of population size and is biased towards larger fish; however, other information can be collected such as size distribution. The size distribution indicates that there are multiple age classes present, and while numbers fluctuate between years, the populations in Sharktooth and Stairway Creeks seem stable (Figures 11 and 12; P. Strand, Sierra National Forest and K. Johnson, CDFW, unpubl. data).

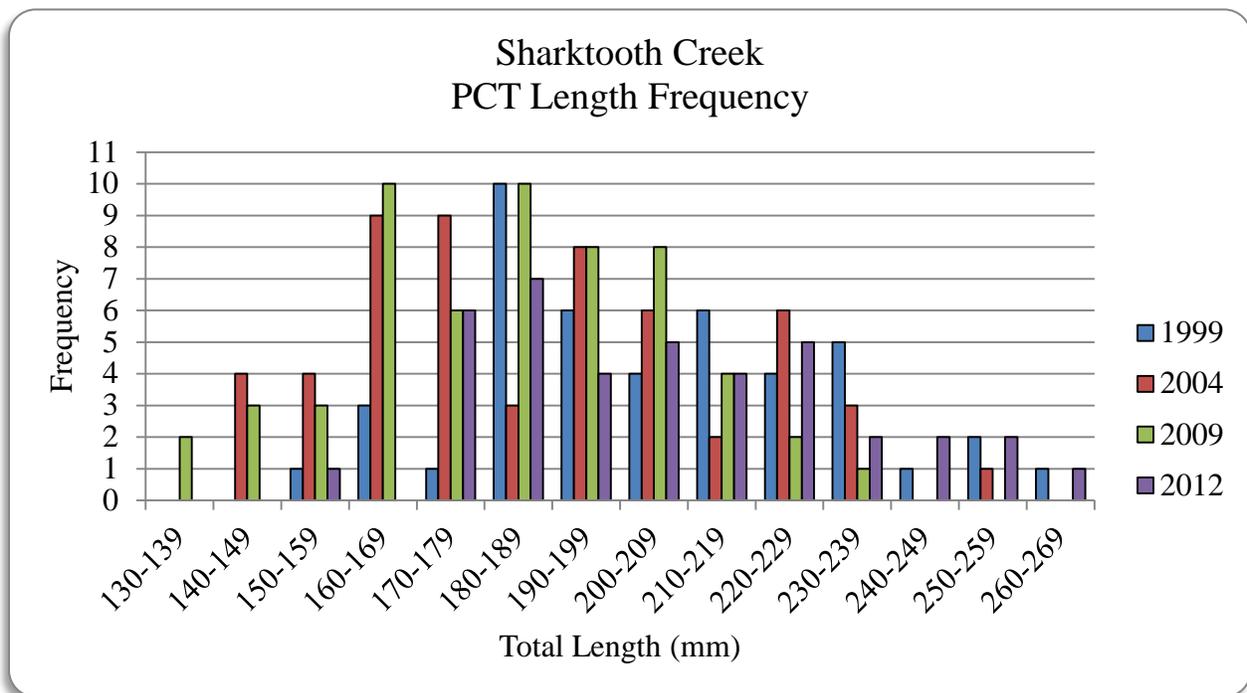


Figure 11. Length frequency data for Paiute cutthroat trout in Sharktooth Creek, Sierra National Forest (P. Strand, Sierra National Forest and K. Johnson, CDFW, unpubl. data).

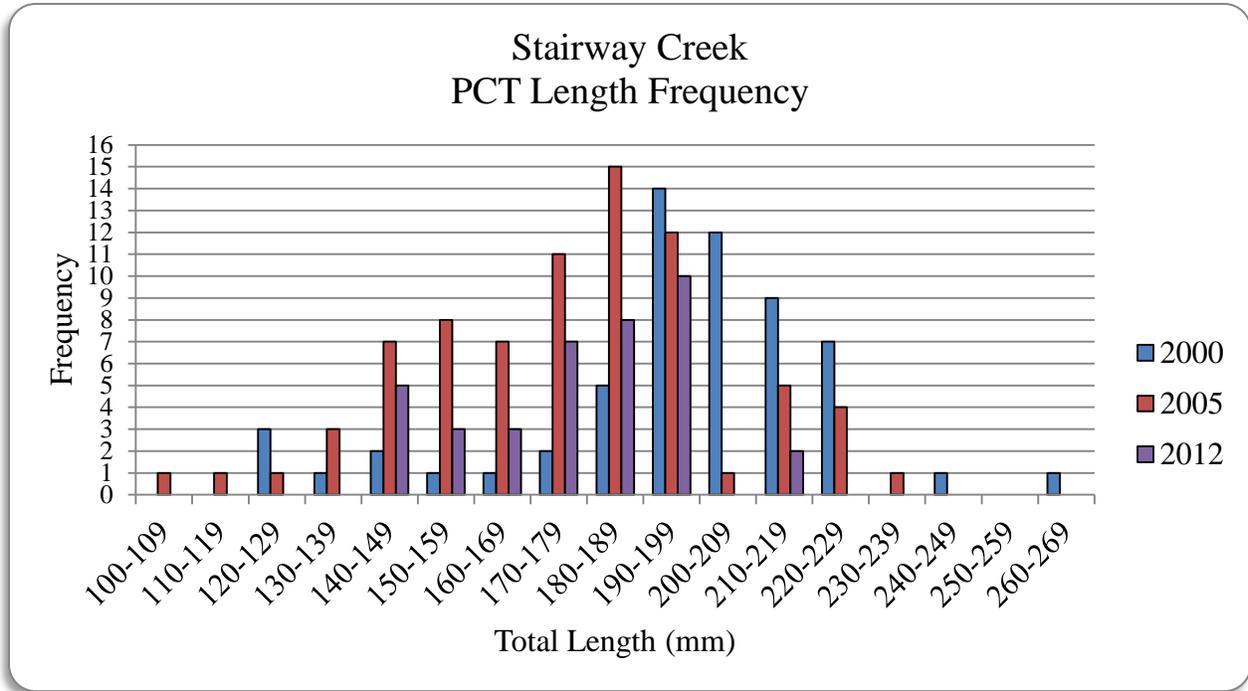


Figure 12. Length frequency data for Paiute cutthroat trout in Stairway Creek, Sierra National Forest (P. Strand, Sierra National Forest and K. Johnson, CDFW, unpubl. data).

North Fork Cottonwood and Cabin Creeks

A standard section of North Fork Cottonwood Creek from Granite Meadows downstream to just above the Tres Plumas barrier has been surveyed visually since 1989 by CDFW (D. Emery, CDFW, unpubl. data). Visual surveys conducted since 1999 indicates a stable population with multiple age classes present (Figure 13; D. Emery, CDFW, unpubl. data). Visual encounter surveys underestimate population sizes and may be biased towards larger size classes because smaller fish are more difficult to see (Bozek and Rahel 1991, p. 40). Visual surveys were conducted on Cabin Creek in 1995, 2000, and 2009 (D. Emery, CDFW, unpublished data). In 1995, 139 fish were observed and were broken down into size classes. Thirty-eight fish were between 100 and 200 mm (4 and 8 in). The remaining 101 fish were between 200 and 254 mm (8 and 10 in). In 2000, 186 fish were observed. The 2000 survey did not break down individual sizes, although multiple size classes were present. The 2009 survey was incomplete due to time constraints and heavy willow (*Salix* sp.) growth which made observations difficult; however, all age classes were observed (D. Emery, CDFW, unpubl. Data).

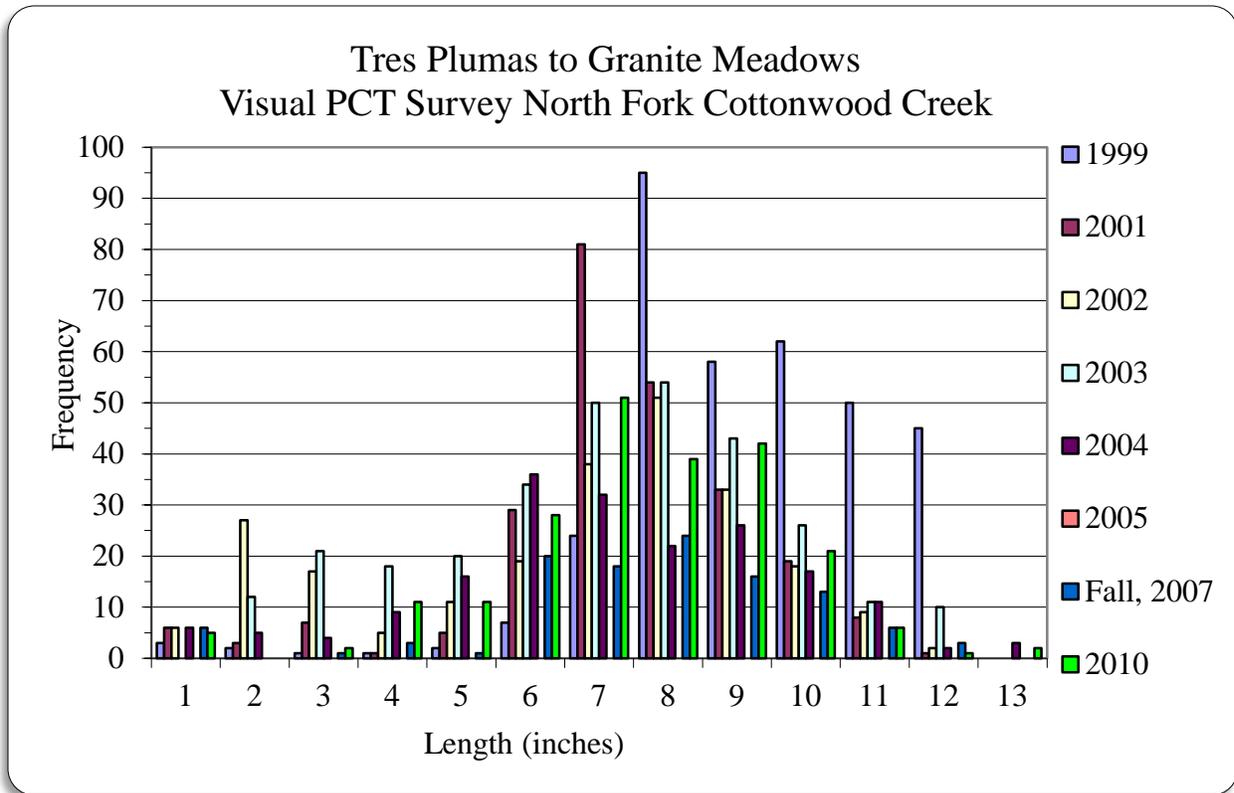


Figure 13. Length frequency distribution of Paiute cutthroat trout in North Fork Cottonwood Creek, Inyo National Forest. This section of stream is from Granite Meadows downstream to just above the Tres Plumas barrier (D. Emery, CDFW, unpubl. data).

Habitat or Ecosystem

Paiute cutthroat trout habitat requirements appear to be similar to those reported for other western stream-dwelling salmonids (Hickman and Raleigh 1982, pp. 3–7). All life stages require cool, well oxygenated waters. Adult fish prefer stream pool habitat in low gradient meadows with undercut or overhanging banks and abundant riparian vegetation (Ashley 1970, pp. 5, 22). Pools are important rearing habitat for juveniles and act as refuge areas for all life stages during winter (Brown *et al.* 2011, pp. 19–21). During the winter months, trout move into pools to avoid physical damage from ice scouring and to conserve energy (Cunjak 1996, p. 268; Brown *et al.* 2011, pp. 12–13). As with other salmonids, suitable winter habitat may be more restrictive than summer habitat (Jakober *et al.* 1998, pp. 229, 233; Brown *et al.* 2011, p. 14). Paiute cutthroat trout survive in lakes, but there is no evidence that they ever occurred naturally in any lakes within the Silver King basin (Behnke and Zarn 1976, p. 34).

Silver King Creek Drainage

This description of habitat is based on the account presented by Ryan and Nicola (1976, pp. 12–18; Figure 2). Silver King Creek is a tributary of the East Fork Carson River, which drains into the Lahontan Basin. Silver King Creek originates at 2,926 m (9,600 ft) elevation in the southernmost portion of the drainage, and flows north through three distinct valleys (Upper Fish Valley, Lower Fish Valley, and Long Valley) for approximately 22.5 km (14 mi) where it meets the East Fork Carson River. Between the headwaters and the confluence of Silver King Creek with the East Fork Carson River, eight tributaries, three above and five below Llewellyn Falls, join Silver King Creek. Llewellyn Falls, at an elevation of 2,438 m (8,000 ft), is located at the head of Lower Fish Valley, some 16.2 km (10 mi) above the confluence with the East Fork Carson River.

From its source, Silver King Creek flows precipitously down gradient for 3.2 km (2.0 mi) before beginning a gradual descent to Upper Fish Valley in an area of washed-out beaver ponds just above the mouth of Fly Valley Creek. For 2.4 km (1.5 mi) through Upper Fish Valley, it is a typical meandering meadow creek, averaging 3.7 m (12 ft) wide and 0.3 m (1 ft) deep in the summer. Several soda springs occur in the valley, with some seeping directly into the stream. From the southeast, Four Mile Canyon Creek enters 2.0 km (1.2 mi) above Llewellyn Falls, while Bull Canyon Creek joins the mainstem from the west 0.8 km (0.5 mi) above Llewellyn Falls. In 1984, an abandoned stream channel (side channel) was reconnected with the mainstem, providing approximately 0.5 km (0.3 mi) of spawning and juvenile rearing habitat. The upstream portion of the side channel begins approximately 0.2 km (0.1 mi) below the confluence of Silver King Creek and Four Mile Canyon Creek. The lower portion of the side channel rejoins the mainstem immediately above the confluence of Silver King Creek and Bull Canyon Creek.

At the lower end of Upper Fish Valley, the stream gradient increases through a sparsely forested section before reaching Llewellyn Falls. The vertical drop of Llewellyn Falls is approximately 6.1 m (20 ft). Within the 2.8 km (1.7 mi) length of Lower Fish Valley, two small tributaries enter the mainstem from the west: Tamarack Lake Creek, located 1.2 km (0.7 mi) below Llewellyn Falls, and a short, unnamed tributary downstream another 1.2 km (0.7 mi). Long Valley, only 1.5 km (0.9 mi) in length, is the shortest of the three valleys. No tributaries enter this section of Silver King Creek. Between Lower Fish Valley and Long Valley the gradient increases, but no barriers similar to Llewellyn Falls are known to exist in this section. Approximately 0.6 km (0.4 mi) downstream of Long Valley, Tamarack Creek enters Silver King Creek from the west, and Coyote Valley Creek enters from the east 1 km (0.6 mi) farther downstream.

Approximately 2.8 km (1.7 mi) below the mouth of Coyote Valley Creek, Silver King Creek descends through Silver King Canyon and emerges from the canyon in the vicinity of Snodgrass Creek. Upstream from Snodgrass Creek, in the canyon, a series of falls present a fish barrier to nonnative trout and other native fish species that occur downstream. No tributary of significance enters Silver King Creek from Snodgrass Creek downstream for 5.4 km (3.4 mi) until its

confluence with the East Fork Carson River. Three small lakes occur in the drainage: Tamarack Lake, Whitecliff Lake, and an unnamed lake in the headwaters of Four Mile Canyon Creek. The average gradient of Silver King Creek is 4.1 percent, which is less than any of its tributaries. However, the portion of Silver King Creek between Fly Valley and Coyote Valley Creeks has an average gradient of 1.6 percent.

North Fork Cottonwood Creek

The occupied reach in North Fork Cottonwood Creek ranges from 2,784 to 3,096 m (9,141 to 10,155 ft) in elevation. Wong (1975, pp. 32–35) described the stream in three sections. The upper section flows through relatively flat stringer meadows with sections of heavy willow growth. The second section flows through a narrow canyon with increasing gradient, creating a series of cascades that form barrier falls 3–4 m (10–13 ft) high. This section of stream is characterized by large boulders that create plunge pools, and it is heavily overgrown with a tree canopy of aspen (*Populus tremuloides*) and understory of willow. The third section again flows through more meadows with low gradient, and willow dominates as stream cover. A 2.3 m (7 ft) natural barrier is located 100 m (330 ft) above the confluence with Tres Plumas Creek. The occupied reach has an average gradient of 5.6 percent.

Cabin Creek

The occupied reach of Cabin Creek ranges from 3,048 to 3,353 m (10,000 to 11,000 ft) in elevation. The Inyo National Forest (U.S. Forest Service (USFS) 2009, pp. 7–8) describes Cabin Creek as relatively steep compared to the other occupied streams with an average gradient of 8 percent through the 2.4 km (1.5 mi) occupied reach. Shallow riffles and scattered small pools dominate the habitat. The occupied reach can be split into two distinct segments based on gradient and riparian vegetation. The upper segment is approximately 1.6 km (1 mi) in length and has a gradient of 9 percent, has heavy willow cover, and is well armored with rocky substrate. The middle section is approximately 0.8 km (0.5 mi), has an average gradient of 6 percent, and has scattered willows and sedges (*Carex* sp.) that dominate the riparian plant community. A 0.4 km (0.25 mi) segment below the middle reach increases in gradient to 14 percent with willow dominating the riparian area and may be occupied by PCT but probably in low numbers due to poor habitat. Beyond this segment the stream gradient increases to 20 percent until its confluence with Leidy Creek.

Stairway Creek

Stairway Creek originates in two forks at 2,743 m (9,000 ft) elevation and flows south into the Middle Fork San Joaquin River. Strand and Eddinger (1999, pp. 9–12, 15) described Stairway Creek based on a survey conducted in 1996. The survey focused on a 2.5 km (1.6 mi) low gradient section of stream, just upstream of a 500 m (1,640 ft) long section of stream with a greater than 40 percent gradient, above the confluence with the Middle Fork San Joaquin River. This section serves as a natural barrier to fish from downstream. A combination of A2 (greater than 4 percent gradient, confined channel, boulder substrate) and B3 (1–4 percent gradient,

moderately confined channel, boulder/cobble substrate) Rosgen types (Rosgen 1996, pp. 5-40–5-43, 5-68–5-71) describe this 2.5 km (1.6 mi) reach. Using USFS Region 5 habitat typing methods (USFS 1996, pp. 1–15), 6 percent of the stream length was characterized as fast water while 94 percent was slow water. Channel stability was rated “good” for all reaches sampled. Canopy cover was approximately 40 percent in the riparian zone, accounting for the low quantity of large woody debris, 3.3 pieces per 100 m (328 ft), found in the stream (Strand and Eddinger 1999, pp. 9–12).

Sharktooth Creek

Sharktooth Creek exits Sharktooth Lake at 2,999 m (9,836 ft). It is a headwater tributary to Fish Creek that flows northwest into the Middle Fork San Joaquin River. Sharktooth Creek is described by Strand and Eddinger (1999, pp. 6–8, 15) as having high gradient sections that provide natural migration barriers. A 250-m (820-ft) section of stream near the confluence with the Lost Keys Lake outflow is described as a cascade/falls that has a gradient of 35 percent with large cobble and boulders as substrate. Upstream of this point a step-pool sequence develops as the gradient reduces to less than 15 percent. Then comes a low gradient (less than 2 percent) section, approximately 1,565 m (5,133 ft) in length, that is described in greater detail below. Above this section, the stream again increases in gradient to the outflow of Sharktooth Lake.

A Stream Condition Inventory reach was established in 1999 by Sierra National Forest personnel on the lower gradient middle section (approximately 1.6 km (1 mi)) of Sharktooth Creek, in order to monitor long-term habitat trends within Sharktooth Creek (Strand and Eddinger 1999, pp. 6–8, 15). This section of stream is a Rosgen type C3 (less than 2 percent gradient, well developed floodplain, mostly cobble with lesser amounts of gravel and sand) (Rosgen 1996, pp. 5-92–5-95), and included 205 pieces of large woody debris with 7 aggregations, and stream shading was 71 percent, which indicates that the riparian area is dominated by large woody species of trees. Sixty percent of the stream length was characterized as fast water (riffles, cascades, and step-pools) while 40 percent was slow water (pools, glides and runs). Bank stability was 75 percent or greater for all 50 transect points, which are considered good ratings (Strand and Eddinger 1999, pp. 6–8, 15).

More recent habitat data have been collected on Stairway (2005) and Sharktooth (2004) Creeks (P. Strand, 2005, USFS, pers. comm.). Analysis indicates that both streams continue to recover from a 1997 rain-on-snow event, which caused severe flooding. This event simplified the habitat by reducing riparian vegetation, reducing large woody debris, and changing pool habitat to runs and riffles (P. Strand, 2005, USFS, pers. comm.). Now, riparian vegetation is recolonizing eroded areas, and large woody debris is being deposited into the stream channels which is forming more pools and creating more complex and diverse habitat (P. Strand, 2005, USFS, pers. comm.).

Changes in Taxonomic Classification or Nomenclature

Paiute cutthroat trout was first listed as *Salmo clarki seleniris*; however, all western North American trout have been reclassified from the genus *Salmo* to the genus *Oncorhynchus*, as summarized by Smith and Stearly (1989, pp. 4–10) and adopted by the American Fisheries Society's Committee on Names of Fishes, the accepted authority on North American fish taxonomy (Robins *et al.* 1991, pp. 28, 79). More recently, the species name for all cutthroat trout changed from *clarki* to *clarkii* to reflect the original spelling (Nelson *et al.* 2004, pp. 98, 209).

Genetics

Paiute cutthroat trout are genetically and meristically (physically) similar to Lahontan cutthroat trout (*O. c. henshawi*) from which they recently diverged (Behnke and Zarn 1976, p. 32). Behnke and Zarn (1976, p. 32) concluded that the separation of PCT from Lahontan cutthroat trout occurred relatively recently (no more than 10,000 years ago), following the desiccation of Lake Lahontan. Investigations of population genetic structure of the Lahontan group of cutthroat trout detected no unique alleles in PCT; however, microsatellite allelic frequency data indicated considerable genetic differentiation from Lahontan cutthroat trout which had not been previously documented (Nielsen and Sage 2002, pp. 381, 383). Paiute cutthroat trout have limited genetic variability, due in part to bottleneck and founder effects when PCT were originally isolated from a common ancestor with Lahontan cutthroat trout and/or more recent bottlenecks resulting from the past history of stocking and management of PCT (Nielsen and Sage 2002, pp. 381, 383; Cordes *et al.* 2004, pp. 112–116). Additionally, there is no population that currently possesses all of the alleles known to PCT, so further transfers to maintain what is left of genetic diversity may be required (Cordes *et al.* 2004, p. 110). Cordes *et al.* (2004, p. 116) concluded that all extant populations of PCT should be considered part of a single management unit with regard to restoration, and recommended that restocking should ideally consist of large numbers of fish from multiple donor populations with as much genetic variation as possible in order to minimize loss of diversity and the effects of inbreeding.

Busack and Gall (1981, p. 948) conducted an allozyme analysis of PCT populations within the Silver King and North Fork Cottonwood drainages and determined that these populations had been introgressed with nonnative rainbow trout. A more recent genetic study using nuclear microsatellite and singular copy nuclear DNA markers evaluated the efficacy of past nonnative trout eradication efforts for the conservation of PCT by determining levels of rainbow trout hybridization and relationships among nine populations of PCT (Cordes *et al.* 2004, pp. 105–106). This study indicates that past efforts to remove trout hybrids in several creeks in the Silver King Creek drainage and the North Fork Cottonwood Creek have been successful as no evidence of rainbow trout introgression was observed in any of the nine populations sampled (Cordes *et al.* 2004, pp. 109, 111–112). These include PCT populations in the Silver King Creek drainage (Fly Valley Creek, Upper Silver King Creek, Four Mile Canyon Creek, Bull Canyon Creek, Coyote Valley Creek, and Corral Valley Creek) and the four out-of-basin populations (North Fork Cottonwood Creek, Cabin Creek, Stairway Creek, and Sharktooth Creek). In contrast, the

fish residing in Silver King Creek downstream of Llewellyn Falls (including Tamarack Creek) are nonnative hybrids of rainbow trout and California golden trout (*O. aguabonita*), comprised mostly of rainbow trout with very little cutthroat trout genetic influence in the trout population within the historical range of PCT (Finger *et al.* 2011, pp. 1378–1379).

Species-specific Research and/or Grant-supported Activities

Listed below are examples of research and restoration projects which the Service has recently funded for PCT recovery efforts.

Six Diagnostic Single Nucleotide Polymorphism Markers for Detecting Introgression Between Cutthroat and Rainbow Trout-University of California, Davis (Finger *et al.* 2009, pp. 759–763): Six diagnostic single nucleotide polymorphisms (SNP) were found which distinguish California golden trout and rainbow trout from PCT and Lahontan cutthroat trout. These SNPs will be useful in monitoring hybridization between these two groups of trout. Project Status: Complete.

Determining Age and Growth Rates of Paiute Cutthroat Trout in Silver King Creek-California Department of Fish and Game (Titus and Calder 2009, pp. 1–15): This study provided valuable demographic information on PCT within the Silver King Creek drainage, specifically age and growth of the various populations. Paiute cutthroat trout were found to live up to 6 years and growth of individuals varied depending on the size of habitat. Project Status: Complete.

Rotenone Toxicity to Rainbow Trout and Several Mountain Stream Insects-California Department of Fish and Game (Finlayson *et al.* 2010, pp. 102-111): Due to concerns about the impacts of rotenone to non-target macroinvertebrates during native trout restoration projects, this study evaluated the toxicity of two formulations of rotenone to rainbow trout and six species of aquatic insects. Results indicate rotenone is more toxic to rainbow trout than macroinvertebrates used in the study. Additionally, formulations of rotenone which use the synergist piperonyl butoxide increase the toxicity of rotenone only to macroinvertebrates but not to rainbow trout; therefore, the authors recommend using rotenone formulations without the synergist. Project Status: Complete.

National Environmental Policy Act and California Environmental Quality Act Analysis of Implementing the Paiute Cutthroat Trout Restoration Project-ENTRIX, (U.S. Fish and Wildlife Service and California Department of Fish and Game 2010, pp. 1-284): The Service and California Department of Fish and Game analyzed the environmental impacts of implementing the Paiute Cutthroat Trout Restoration Project under the National Environmental Policy Act and California Environmental Quality Act. Our joint analysis was upheld in court; however, the project has been enjoined since 2010 due to Wilderness Act compliance (U.S. District Court 2011, pp. 1–63). Project Status: Complete.

Application of a Method for Estimating Effective Population Size and Admixture Using Diagnostic Single Nucleotide Polymorphisms (SNPs)-University of California, Davis (Finger *et al.* 2011, pp. 1369–1386): Using the six diagnostic single nucleotide polymorphisms (SNP)

found in Finger *et al.* (2009, pp. 759–763), the authors were able to estimate the amount of hybridization between California golden trout and rainbow trout with PCT in the historical range of Silver King Creek. In addition the effective population size of the hybridized population was estimated. Project Status: Complete.

Paiute Cutthroat Trout Habitat Restoration Project-California Department of Fish and Wildlife: On September 24, 2009, California Department of Fish and Game received a Section 6 grant from the Service to implement the Paiute Cutthroat Trout Restoration Project. Implementation has been stalled due to legal issues. An extension was granted until 2015. Project Status: Ongoing.

FIVE-FACTOR ANALYSIS

The following five-factor analysis describes and evaluates the threats attributable to one or more of the five listing factors outlined in section 4(a)(1) of the ESA. The final listing rule did not include a five-factor analysis (Service 1967, p. 4001). The final downlisting rule described the destruction, drastic modification, or severe curtailment of their habitat and hybridization with other trout species as threats to PCT (Service 1975, p. 29863). The Revised Recovery Plan identified threats from: (1) displacement and/or hybridization with nonnative trout; (2) degraded and/or limited habitat; and (3) overutilization for recreational purposes (Service 2004, pp. 41–45).

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

Nonnative Fish

Nonnative salmonid species are currently the greatest threat to PCT, resulting in loss of available habitat and range constrictions primarily through hybridization. The introduction of nonnative fish has been documented as a global threat to native fish species (Townsend 1996, pp. 15–16; Cambray 2003, pp. 61–64; Morita *et al.* 2004, pp. 969–970; Jug *et al.* 2005, pp. 386–387; Spens *et al.* 2007, p. 659; Crawford and Muir 2008, pp. 313–337; Cucherousset and Olden 2011, pp. 215–223). In the western United States, Lomnicky *et al.* (2007, p. 1086) found that over half of stream lengths surveyed contained nonnative vertebrates and that increased stream order (larger streams) had higher occupancy of nonnative vertebrates. They also found that the most common nonnative vertebrates were brook trout (*Salvelinus fontinalis*) (17 percent of all nonnative vertebrates present), brown trout (*Salmo trutta*) (16 percent), and rainbow trout (14 percent) (Lomnicky *et al.* 2007, p. 1086). Of the 30,400 km (18,890 mi) of streams sampled in California, 34 percent of stream miles contained nonnative vertebrates (Lomnicky *et al.* 2007, p. 1086). Using the same dataset, Whittier and Peck (2008, p. 1889) analyzed the surface area occupied by nonnative vertebrates and found that 64.8 percent of the waters sampled in California were occupied by nonnatives. The authors also found a greater likelihood of finding nonnative vertebrates in larger streams (Whittier and Peck 2008, p. 1890).

Silver King Creek has a long and complicated history of trout management (Table 2; Cordes *et al.* 2004, pp. 103–105). Five different trout species have been moved into and around the Silver King drainage, including PCT, Lahontan cutthroat trout, California golden trout, rainbow trout, and brook trout (Finger *et al.* 2011, p. 1372). Paiute cutthroat trout are now extirpated from their historical habitat due to introduced trout, but exist in formerly fishless areas of the Silver King Creek drainage and four out-of-basin watersheds above fish passage barriers.

Sometime in the 1860s or 1870s, PCT were transplanted from Silver King Creek into Corral Valley and Coyote Valley Creeks by loggers. In 1890, Virgil Connell (sheepherder) observed that there were no fish present above Llewellyn Falls. In 1912, a Basque sheepherder, Joe Jaunsaras, transported fish by bucket from Lower Fish Valley to Upper Fish Valley upstream of Llewellyn Falls. In 1914, California golden trout were reportedly planted downstream of Llewellyn Falls in Silver King Creek; however, there are no records of this stocking. By 1924, PCT that had been planted upstream of Llewellyn Falls had established a robust population and the fishery downstream had become “mixed with other kinds, probably due to stocking” (Letter from Virgil Connell in Ryan and Nicola (1976)). A summary of fish stocking records from the CDFW are in Table 2.

Hybridization

Hybridization from nonnative salmonids is a common threat to all native western salmonid species, including the Little Kern golden trout (*O. mykiss whitei*) (Service 1978, p. 15428), Lahontan cutthroat trout (Service 1995, pp. 25–26), greenback cutthroat trout (*O. c. stomias*) (Service 1998, pp. 7–8), Great Basin redband trout (*O. mykiss*) (Service 2000, p. 14933), Bonneville cutthroat trout (*O. c. utah*) (Service 2001, p. 51365), California golden trout (Service 2002, p. 59242), westslope cutthroat trout (*O. c. lewisi*) (Service 2003a, p. 47004), Gila trout (*O. gilae*) (Service 2003b, pp. 30–31), PCT (Service 2004, pp. 43–44), Yellowstone cutthroat trout (*O. c. bouvieri*) (Service 2006, pp. 8828–8829), Colorado River cutthroat trout (*O. c. pleuriticus*) (Service 2007, pp. 32597–32599), Rio Grande cutthroat trout (*O. c. virginalis*) (Service 2008b, pp. 27908–27909), and Apache trout (*O. apache*) (Service 2009, p. 21). Nonnative rainbow trout and golden trout readily hybridize with native cutthroat trout and produce fertile offspring; however, fitness and survival rates decreases as the proportion of rainbow trout admixture increases (Muhlfeld *et al.* 2009, pp. 329–331; Rasmussen *et al.* 2010, pp. 362–364). Even with reduced fitness, hybridization spreads rapidly because the initial F₁ (first generation) hybrids have high fitness, hybrids tend to stray more frequently, and all offspring of hybrids are hybrids (Boyer *et al.* 2008, p. 666; Muhlfeld *et al.* 2009, pp. 329–331). Extensive genetic mixing of natives, nonnatives, and hybrids contribute to the loss of locally-adapted genotypes and can lead to the extinction of a population or an entire species (Leary *et al.* 1995, p. 97; Rhymer and Simberloff 1996, pp. 96–100; Finger *et al.* 2011, pp. 1378–1379). As indicated by a recent genetic analysis, hybridization by nonnative species has eliminated PCT from their entire historical habitat (Finger *et al.* 2011, pp. 1378–1379). All populations of PCT have rainbow trout in stream reaches downstream of occupied habitat. Natural fish barriers separate the two species on all occupied streams.

Table 2. California Department of Fish and Wildlife fish stocking records for the Silver King Creek drainage (1930–1991).

Date	Trout Species	Number	Hatchery Source	Stocking Location
Silver King Creek				
8/15/1930	Rainbow	5,000	Mt. Whitney	
8/18/1930	Steelhead ¹	5,000	Mt. Whitney	
8/27/1931	Rainbow	10,000	Alpine	
9/15/1932	Rainbow	10,000	Alpine	
8/13/1933	Rainbow	10,000	Alpine	
7/20/1935	Brook	5,000	Alpine	
9/12/1935	Lahontan cutthroat	10,000	Alpine	
8/21/1946	Lahontan cutthroat	8,700	Hot Creek	near Poison Valley
9/5/1947	Lahontan cutthroat	19,600	Hot Creek	Long Valley-Forks
9/6/1947	Lahontan cutthroat	19,600	Hot Creek	Forks-mouth
9/7/1947	Lahontan cutthroat	9,800	Hot Creek	Long Valley-Forks
9/29/1949	Rainbow	8,400	Hot Creek	below Llewellyn Falls
9/30/1949	Rainbow	5,040	Hot Creek	above Llewellyn Falls
8/8/1951	Rainbow	6,010	Markleeville	Snodgrass Canyon above Corral Valley Creek
8/13/1952	Rainbow	5,017	Markleeville	Upper Bagley Valley to Llewellyn Falls
8/7/1953	Rainbow	4,960	Markleeville	2 mi above Vaquero Camp
9/23/1976	Rainbow	960	American	Lower Fish Valley
9/23/1976	Rainbow	2,900	American	Lower Fish Valley
1991*	Rainbow-Paiute cutthroat hybrids	unknown	wild	Lower Fish Valley
Whitecliff Lake				
1955	Lahontan cutthroat	unknown	unknown	Whitecliff Lake
1956	Lahontan cutthroat	unknown	unknown	Whitecliff Lake
Coyote Creek				
8/21/1946	Lahontan cutthroat	1,740	Hot Creek	Lower stream
9/7/1947	Lahontan cutthroat	4,200	Hot Creek	Mouth to barrier

¹ Steelhead (*Oncorhynchus mykiss*) is the anadromous form of rainbow trout.

Table 2 continued. California Department of Fish and Wildlife fish stocking records for the Silver King Creek drainage (1930–1991).

Date	Trout Species	Number	Hatchery Source	Stocking Location
Tamarack Lake				
1955	Lahontan cutthroat	1,005	unknown	Tamarack Lake
1957	Lahontan cutthroat	1,000	unknown	Tamarack Lake
1959	Lahontan cutthroat	1,035	unknown	Tamarack Lake
1962	Lahontan cutthroat	1,020	unknown	Tamarack Lake
1967	Lahontan cutthroat	4,000	unknown	Tamarack Lake
1968	Brook	500	unknown	Tamarack Lake
1968	Lahontan cutthroat	5,000	unknown	Tamarack Lake
1969	California Golden	1,018	unknown	Tamarack Lake
1971	Lahontan cutthroat	4,000	unknown	Tamarack Lake
1972	California Golden	1,000	unknown	Tamarack Lake
1973	California Golden	1,141	unknown	Tamarack Lake
1973	Lahontan cutthroat	3,600	unknown	Tamarack Lake
1974	California Golden	2,250	unknown	Tamarack Lake
1975	Lahontan cutthroat	3,600	unknown	Tamarack Lake
1976	California Golden	2,272	unknown	Tamarack Lake
1976	Lahontan cutthroat	4,000	unknown	Tamarack Lake
1980	Lahontan cutthroat	4,000	unknown	Tamarack Lake
1982	Lahontan cutthroat	4,000	unknown	Tamarack Lake
1985	Paiute cutthroat	173	wild	Tamarack Lake
1987	Lahontan cutthroat	3,000	unknown	Tamarack Lake
1987	Paiute cutthroat	100	wild	Tamarack Lake
1991*	Rainbow-Paiute cutthroat hybrids	unknown	wild	Tamarack Lake
Source: W. Somer, CDFW, unpubl. data				
*In 1991, prior to chemical treatment of Upper Silver King Creek, multiple age classes of hybrid rainbow-Paiute cutthroat were transported to Lower Fish Valley and Tamarack Lake.				

Summary of Nonnative Fish Impacts

In summary, nonnative species, particularly hybridizing salmonids, pose the greatest threat to the continued existence of PCT. Nonnative salmonids were historically stocked in Silver King Creek which caused the eradication of PCT in its historical habitat. Nonnative rainbow trout currently occupy the entire historical range of PCT and are present downstream of all currently-occupied habitat.

Population Isolation and Habitat Fragmentation

Habitat fragmentation is one of the leading causes of cutthroat trout population declines in the western United States (Dunham *et al.* 1997, pp. 1130–1131; Peterson *et al.* 2008, p. 558). Habitat fragmentation reduces the total habitat available, reduces habitat complexity, and prevents gene flow (Rieman and McIntyre 1995, pp. 293–294; Dunham *et al.* 1997, pp. 1130–1131; Wenburg and Bentzen 2001, pp. 1063–1065; Frankham 2005, pp. 133–134; Wofford *et al.* 2005, pp. 631–633; Pritchard *et al.* 2007, pp. 614–617; Guy *et al.* 2008, pp. 1754–1755; Cook *et al.* 2010, pp. 1505–1508). Fragmentation accelerates extinction, especially when movement of fish among stream segments is not possible, which is the case with all PCT populations (Fagan 2002, pp. 3244–3248; Fahrig 2002, p. 349; Hilderbrand 2003, p. 263; Frankham 2005, pp. 133–134). Isolated populations are vulnerable to extinction through demographic stochasticity (random fluctuations in birth and death rates); environmental stochasticity (random variation in environmental attributes) and catastrophes; loss of genetic heterozygosity (genetic diversity) and rare alleles (inherited forms of a genetic trait); and human disturbance (Hedrick and Kalinowski 2000, pp. 140–142; Lande 2002, pp. 18–35; Reed and Frankham 2003, pp. 233–234; Noss *et al.* 2006, pp. 213–240; Pringle 2006, pp. 243–246; Whiteley *et al.* 2010, pp. 1937–1939). Completely isolated populations are the most severe form of fragmentation because gene flow among populations does not occur, thereby inflicting inbreeding depression dynamics on the population and reducing fitness (Hedrick and Kalinowski 2000, pp. 140–142; Reed and Frankham 2003, pp. 232–233; Frankham 2005, pp. 135–136; Scribner *et al.* 2006, pp. 390–392; Pritchard *et al.* 2007, pp. 614–617; Guy *et al.* 2008, p. 1758). Moyle *et al.* (2011, pp. 2414–2422) consider PCT as one of the most imperiled native fish in California due to loss of genetic diversity and habitat fragmentation. Evidence of loss of genetic diversity has been found in all PCT populations (Cordes *et al.* 2004, pp. 112–113). All current PCT populations are completely isolated from each other which does not allow for genetic exchange or recolonization after a disturbance.

Apart from the isolation that habitat fragmentation causes, the short length of stream segments and small population sizes that they support are of concern for PCT. Several studies found that population viability of cutthroat trout is correlated with stream length or habitat size (Hilderbrand and Kershner 2000, pp. 515–518; Harig and Fausch 2002, pp. 542–548; Young *et al.* 2005, pp. 2403–2405). Stream length is important because trout move throughout stream networks searching for a variety of habitats necessary to complete their life cycle (*i.e.*, spawning, rearing, migration corridors, refugium) (Baltz *et al.* 1991, pp. 173–175; Fausch and Young 1995, pp. 364–365; Young 1996, pp. 1405–1407; Muhlfeld *et al.* 2001, pp. 174–175; Schmetterling 2001, pp. 511–519; Hilderbrand and Kershner 2004, pp. 1043–1045; Schrank and Rahel 2004, pp. 1531–1536; Colyer *et al.* 2005, pp. 957–961; Neville *et al.* 2006, pp. 908–914; Umek 2007, pp. 13–28; Sanderson and Hubert 2009, pp. 332–335; Young 2011, pp. 945–949). The shorter the stream reach the more likely it is that one or more of PCT's required habitats is either missing or inadequate for completion of the species' life cycle. In contrast, longer stream reaches have more complexity and have a higher probability that no particular habitat type limits the population (Horan *et al.* 2000, pp. 1254–1261; Harig and Fausch 2002, p. 546; Dunham *et al.* 2003, pp. 185–187; Huusko *et al.* 2007, pp. 478–479).

To ensure long-term persistence, Hilderbrand and Kershner (2000, p. 515) estimated that a population should consist of at least 2,500 cutthroat trout, and that at least 8.2 km (5.1 mi) of habitat is required to maintain a population of that size when fish density was high (300 fish/km; 484 fish/mi). Adding a 10 percent loss rate of individuals, to account for emigration and mortality, increased the required length up to 9.3 km (5.8 mi) in order to maintain 2,500 fish. For streams with smaller population densities of 200 fish/km (320 fish/mi) and 100 fish/km (160 fish/mi), the corresponding stream length increased to 12.5 km (7.8 mi) and 25 km (15.5 mi), respectively, to maintain a population of 2,500 (Hilderbrand and Kershner 2000, p. 515). In a similar study, Young *et al.* (2005, p. 2405) found that to maintain a population of 2,500 cutthroat trout, 8.8 km (5.5 mi) of stream habitat were needed.

The PCT population in Silver King Creek was a naturally isolated population consisting of 17.8 km (11.1 mi) of habitat. The size of the drainage, the size of the population, and the quality and distribution of habitat allowed a viable population of PCT to persist and evolve for thousands of years.

While there is approximately 23.5 km (14.5 mi) of occupied habitat within the Silver King Creek drainage, populations of PCT are fragmented and isolated into five separate areas: (1) Four Mile Canyon Creek, (2) Fly Valley Creek, (3) Upper Silver King Creek and associated tributaries, (4) Coyote Valley Creek, and (5) Corral Valley Creek. Standard three-pass electrofishing surveys have been conducted in the Silver King drainage since the 1960s. Fish densities are typically in the high range (300 fish/km; 484 fish/mi) in all locations except for Four Mile Canyon Creek which has low densities (100 fish/km, 160 fish/mi). It should be noted that monitoring locations for population estimates are conducted in the best habitat available (low gradient meadow stream segments) in that particular stream and fish densities decline sharply outside of the sampled areas (typically higher gradient stream segments). The PCT population in Four Mile Canyon Creek is isolated from Silver King Creek by a fish barrier. Occupied habitat is approximately 3.1 km (1.9 mi). Fly Valley Creek is also isolated from Silver King Creek by a fish barrier and has 1.8 km (1.1 mi) of occupied habitat. Paiute cutthroat trout populations in Corral Valley Creek and Coyote Valley Creek are separated by a fish barrier which is located on Coyote Valley Creek just upstream from the confluence of the two streams. Corral Valley Creek has 5.3 km (3.3 mi) of occupied habitat, and Coyote Valley Creek has 6.1 km (3.8 mi) of occupied habitat. Upper Silver King Creek, an associated side channel in Upper Fish Valley, and lower Bull Canyon Creek are connected and represent approximately 7.2 km (4.5 mi) of combined habitat which is below the minimum amount of habitat predicted (9.3 km; 5.8 mi) for long-term persistence.

Standardized population estimates are not used for the four out-of-basin populations; therefore, the population density component of the persistence requirements cannot be used. Regardless of population density, the PCT populations in these streams currently do not meet long-term persistence criteria based on the minimum amount of stream habitat (9.3 km; 5.8 mi) described above (Hilderbrand and Kershner 2000, p. 515). On the Inyo National Forest, occupied habitat in North Fork Cottonwood Creek is approximately 5.5 km (3.4 mi) and Cabin Creek is 2.4 km (1.5 mi). The same situation exists for streams on the Sierra National Forest where occupied

habitat on Stairway Creek (3.5 km; 2.2 mi) and Sharktooth Creek (3.3 km; 2.0 mi) are less than half of what is needed for long-term persistence.

In summary, all populations of PCT do not meet minimum habitat requirements for long-term persistence. These data indicate that habitat fragmentation and isolation pose a substantial threat to all PCT populations.

Land Use Activities

Grazing

Impacts of livestock grazing to stream habitat and fish populations can be separated into acute and chronic effects. Acute effects are those which contribute to the immediate loss of individuals, loss of specific habitat features (*e.g.*, undercut banks, spawning beds) or localized reductions in habitat quality (*e.g.*, sedimentation, loss of riparian vegetation). Chronic effects are those which, over a period of time, result in loss or reduction of entire populations of fish, or widespread reduction in habitat quantity and/or quality.

Behnke and Zarn (1976, p. 5) identified livestock grazing as the greatest threat to the integrity of stream habitat in the western United States. Native and domestic grazers, especially cattle, are attracted to these narrow green strips of vegetation due to the presence of water, shade, succulent vegetation, and gentle topography (Platts 1979, p. 42; 1991; p. 393; Marlow and Pogacnik 1986, pp. 213–215; Smith *et al.* 1992, pp. 387–389; Kie and Boroski 1996, pp. 485–487; Parsons *et al.* 2003, pp. 337–340). Riparian areas are most vulnerable to the effects of overgrazing because cattle tend to concentrate in them (Platts 1979, p. 42; 1991; p. 393). Hot season grazing (July 1 through September 15) focuses livestock use on riparian areas because of the availability of water, green vegetation, trees and shrubs for cover and food, and the cooler microclimate associated with areas near water and shade (Platts 1979, p. 42; 1991, pp. 407–408).

Livestock grazing can affect riparian areas by changing, reducing, or eliminating vegetation, and by the actual loss of riparian areas through channel widening, channel degradation, or lowering of the water table (Government Accounting Office 1988, pp. 20–25; Schulz and Leininger 1990, pp. 297–299; Overton *et al.* 1994, pp. 5–7; Dobkin *et al.* 1998, pp. 213–218). Effects on fish habitat include reduction of shade and cover and resultant increases in water temperature, changes in stream morphology, and the addition of sediment due to bank degradation and off-site soil erosion (Knapp and Matthews 1996, pp. 811–818; Belsky *et al.* 1999, pp. 425–428; Isaak and Hubert 2001, pp. 359–363). Direct adverse effects of livestock grazing on salmonids include wallowing and wading in streams. Wading in streams by livestock can be assumed to induce mortality on trout eggs and pre-emergent fry (Gregory and Gamett 2009, pp. 364–366; Peterson *et al.* 2010, pp. 958–964).

Silver King Cattle and Horse Allotment (Silver King Allotment) is composed of 4,812 hectares (11,891 acres) which encompasses Silver King Creek and its tributaries. Sheep grazing was authorized from the early 1900's until about the 1930's when cattle predominantly grazed the

area. From 1977 to 1987 the Term Grazing Permit was for 525 cow/calf pairs from July 14 to September 30. The permit was transferred to a new permittee in 1987 and included the same occupancy rates and season of use dates. However, the actual authorized use for most years was 225 cow/calf pairs from July 16 to September 7 (USFS 2012b, pp. 5–6).

In 1984, 1987, and 1990, physical habitat and biological field surveys were conducted within the Silver King Creek drainage. The objectives of this effort were to provide the USFS with a general assessment of habitat and to provide recommendations for future management. Habitat surveys were performed using the General Aquatic Wildlife System (GAWS) procedures (Duff 1989, pp. 1–26). A Habitat Condition Index (HCI) is obtained using the GAWS methodology which can then be used to provide habitat trend data. Nine stations were monitored on Silver King Creek above Llewellyn Falls, two stations on Bull Canyon Creek, one station on Fly Valley Creek, two stations on Four Mile Canyon Creek, four stations on Coyote Valley Creek, and two stations on Corral Valley Creek. The HCI over this 6-year period improved in nearly all of the stations monitored, which was primarily due to a change in grazing management including riparian enclosure fencing (Duff 1991, pp. 2–5, 7–8). However, even though most stations increased their HCI rating, 12 of the 21 stations still rated as fair to poor (Duff 1991, pp. 2–5, 7–8).

In 1991, another habitat assessment was conducted to describe and compare stream reaches in Upper Fish Valley and Coyote Creek in grazed and ungrazed sections (Overton *et al.* 1994, pp. 3–27). This study used the USFS's Region 1/Region 4 (Northern Region/Intermountain Region) Fish Habitat Procedures Protocol (Overton 1994, pp. 16–27). Significant differences between grazed and ungrazed stream sections were found in several stream habitat measurements (Overton *et al.* 1994, pp. 5–11). The ungrazed stream segments had greater bank stability, deeper bank undercuts, deeper and narrower stream channels with lower width to depth ratios (Overton *et al.* 1994, pp. 5–11).

California Department of Fish and Wildlife conducted stream channel morphology measurements at a number of locations in both Upper Fish and Lower Fish Valleys in 1999–2002 (Flint 2004, pp. 3–4). Flint (2004, pp. 5–7) concluded that both valleys are recovering from grazing impacts, stream banks are stable, and willows and sedges are rapidly recolonizing the riparian area.

Due to the status of PCT, between 1987 and 1994 the Silver King Allotment was rested several times for resource protection, and in 1995, the term grazing permit was cancelled due to permittee noncompliance, and the Allotment has remained vacant since that time. The Paiute cutthroat trout Revised Recovery Plan recommended the closure of the Silver King Allotment (Service 2004, p. 54) and, in 2012, the Humboldt-Toiyabe National Forest officially closed the Allotment to all livestock grazing for the protection of PCT (USFS 2012c, p. 5).

The Cottonwood Creek and Tres Plumas Allotments on North Fork Cottonwood Creek also have the potential to affect PCT habitat (Wong 1991, p. 184; Kondolf 1994, pp. 506–507). Grazing was suspended for both these Allotments in 2000, and they have been in non-use status since that

time (USFS 2000, pp. 1–10). Cabin Creek is within an active grazing allotment (Indian Creek Allotment), and historical grazing management resulted in some degradation of habitat due to bank failure and increased sediment input (USFS 2009, p. 10). A new 10-year grazing permit was issued for the Indian Creek Allotment which set conservative utilization and streambank disturbance levels aimed to minimize impacts from livestock grazing (Service 2010, pp. 20–23). To date the Indian Creek Allotment has been vacant. Stairway Creek is within the 77 Corral Allotment which is currently closed to grazing (Strand and Eddinger 1999, p. 17). Sharktooth Creek is within the Cassidy Allotment; however, the Sharktooth Unit of the Allotment, which encompasses Sharktooth Creek, is closed to grazing for the protection of PCT (USFS 2010, p. 17). Therefore, grazing does not currently affect occupied habitat in Stairway and Sharktooth Creeks.

Recovery Actions

Recovery actions since the 2008 5-year review have focused on habitat improvement projects and implementing the Paiute Cutthroat Trout Restoration Project. The purpose of the Paiute Cutthroat Trout Restoration Project is to remove nonnative salmonids from the historical range of PCT and repatriate PCT from existing populations (Service and California Department of Fish and Game 2010, pp. 1-284). However, due to legal challenges regarding the use of rotenone, the project has not been implemented. In 2009, the Inyo National Forest completed a gravel augmentation project to improve spawning habitat in North Fork Cottonwood Creek. As mentioned above, the Humboldt-Toiyabe National Forest officially closed the Silver King Allotment to all livestock grazing for the conservation of PCT

Summary for Factor A

Paiute cutthroat trout populations continue to be threatened by interactions with nonnative species, and habitat fragmentation and isolation. Paiute cutthroat trout have been extirpated from their entire historical habitat by nonnative salmonids. Additionally, hybridizing salmonids are present downstream of all currently occupied habitat. Paiute cutthroat trout occupy stream habitat in five widely separated drainages and are primarily confined to isolated, short headwater stream reaches. These factors work to reduce gene flow between populations and reduce the ability of populations to recover from catastrophic events, thus threatening their long-term viability. The literature suggests that to ensure long-term viability, populations should consist of more than 2,500 individuals, occupy at least 9.3 km (5.8 mi) of stream habitat, and have no nonnative species present. Currently, no population meets the minimum requirements. The purpose of the Paiute Cutthroat Trout Restoration Project is to eliminating threats from nonnative fish and repatriate PCT into its historical habitat which will meet the minimum habitat requirements for long-term persistence. Livestock grazing has been a past threat (Service 1985, pp. 20–21; 2004, pp. 41–42; Service 2008a, pp. 9–10); however, grazing has either been eliminated from occupied habitat or conservative grazing management objectives are in place for active grazing allotments. Nonnative salmonids were identified as threats in the reclassification rule (Service 1975, pp. 29863–29864), both recovery plans (Service 1985, pp. 17–22; 2004, p. 43), and the 2008 5-year review (Service 2008a, p. 13). Based on the best scientific and

commercial information available, we conclude that the present or threatened destruction, modification, or curtailment of its habitat or range is still a significant threat to the continued existence of PCT.

FACTOR B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Recreational

No threats from overutilization were identified under this factor at the time of reclassification (Service 1975, p. 29863). The final reclassification rule states the PCT would benefit from regulated taking by sportfishing and finalized regulations that permitted sportfishing of PCT in accordance with applicable State law, and that violation of State law will also be a violation of the ESA (50 CFR 17.44(a)).

Contrary to the 1975 reclassification rule (Service 1975, p. 29863), PCT are susceptible to unregulated angling. Both the 1985 recovery plan (Service 1985, p. 19) and the revised recovery plan (Service 2004, pp. 42–43) address the issue of unregulated angling. Connell (letter in Ryan and Nicola 1976, pp. 54–55) reported that in 1890 he and a companion took 1,500 fish from Silver King Creek in only 3 days of fishing. He noted that “...they fished only a very small part of the time” and that their angling success was enhanced when his fishing companion “...conceived the idea of putting two hooks on his line and succeeded in bringing out two fish in the majority of his casts.” From 1952 to 1965, Silver King Creek was open to angling to reduce the number of hybrid fish and the PCT population above Llewellyn Falls was severely depleted. Angling has been closed in Silver King Creek above Llewellyn Falls since 1965. In the early 1970s, the population above the Llewellyn Falls was again significantly reduced following a brief period of unauthorized angling by military personnel (Ryan and Nicola 1976, p. 31).

Fishing in Silver King Creek from Llewellyn Falls downstream to the confluence of Tamarack Lake Creek has recently (2006) been closed to reduce the threat of intentional movement of nonnative salmonids above Llewellyn Falls into occupied habitat (Section 7.50(b)(178), Title 14, California Code of Regulations). Additionally, North Fork Cottonwood Creek, an out-of-basin population, is closed to fishing. The other occupied streams are open to fishing; however, due to their remote locations, fishing has not been documented to be a threat. Currently, there are no data to indicate that overutilization from recreation is occurring.

Scientific and Educational

Annual sampling of PCT populations is an important aspect of fisheries management and scientific research. Federal and State biologists sample various PCT populations in the Silver King Creek drainage on an annual basis. Most other populations are variably sampled using visual or fly rod depletion methods (Strand and Eddinger 1999, p. 6). Sampling stream populations of PCT in the Silver King Creek drainage is usually performed with electrofishing equipment. Electrofishing is a process by which an electrical current is passed through water

containing fish in order to stun them—thus making them easy to capture. It can cause a suite of effects ranging from simple harassment to actual mortality (all life stages) (Snyder 2003, pp. 42–55).

The amount of unintentional harassment and harm attributable to electrofishing may vary widely depending on the equipment used, the settings on the equipment, and the expertise of the technician. Reported effects of electrofishing on salmonids range from mortality (Hudy 1985, p. 476; Dwyer *et al.* 1993, pp. 841–843; McMichael 1993, pp. 230–231; Dwyer and Erdahl 1995, pp. 648–650; Habera *et al.* 1996, pp. 195–197; Ainslie *et al.* 1998, p. 908; Roach 1999, pp. 925–926; Cho *et al.* 2002, pp. 226–227; Walsh *et al.* 2004, pp. 318–319), spinal injuries (Sharber and Carothers 1988, pp. 118–119; McMichael 1993, pp. 230–231; Hollender and Carline 1994, pp. 645–646; Dalby *et al.* 1996, pp. 563–564; Habera *et al.* 1996, pp. 195–197; Kocovsky *et al.* 1997, pp. 310–311; Thompson *et al.* 1997a, pp. 146–147; Ainslie *et al.* 1998, pp. 908–910; Habera *et al.* 1999, pp. 122–123; Carline 2001, pp. 574–575; Walsh *et al.* 2004, pp. 318–319), hemorrhaging (McMichael 1993, pp. 230–231; Hollender and Carline 1994, pp. 645–646; Habera *et al.* 1996, pp. 195–197; Thompson *et al.* 1997a, p. 147; Habera *et al.* 1999, pp. 122–123; Walsh *et al.* 2004, pp. 318–319), behavioral changes (Mesa and Schreck 1989, pp. 648–652; Sorensen 1994, pp. 863–864), and changes in growth (Gatz *et al.* 1986, pp. 177–178; Dwyer and White 1995, pp. 149–150; Dalby *et al.* 1996, pp. 565–566; Thompson *et al.* 1997b, pp. 156–157; Ainslie *et al.* 1998, pp. 910–911; Carline 2001, p. 578).

The severity of the effects to fish reported in these studies depended on many factors including type of electrical current (alternate current or direct current), waveform (pulsed or continuous), the frequency (Hz) and voltage used, type of electrofishing unit used (backpack versus boat mounted), frequency of sampling through time (number of times an individual or population is sampled), species of fish, life stage of species (egg, juvenile, adult), size of the individual fish, and the conductivity of the water. Only a few studies have examined the long-term effects of electrofishing on salmonid survival and growth (Dalby *et al.* 1996, pp. 564–566; Thompson *et al.* 1997b, p. 158; Ainslie *et al.* 1998, pp. 911–912; Schill and Elle 2000, pp. 732–733). These studies indicate that although some fish suffer hemorrhage and spinal injury, few die as a result. However, severely injured fish grow at slower rates and sometimes show no growth at all (Dalby *et al.* 1996, pp. 565–566; Ainslie *et al.* 1998, pp. 910–911). Most biologists have many years of experience with electrofishing and a large number of State and Federal biologists who work with PCT have taken the Principles and Techniques of Electrofishing course offered by the Service through the National Conservation Training Center in Shepherdstown, West Virginia (Alan Temple, Service, pers. comm. 2009). Snyder (2003, p. 98) concluded that population effects were unlikely except for intensively sampled populations.

The special rule for PCT under ESA section 4(d) facilitates management by the State and allows regulated angling (Service 1975, p. 29864; 50 CFR 17.44(a)). Collection of PCT for scientific and educational purposes is controlled through State permitting processes that prevent excessive sampling. In addition, advancements in molecular technology have resulted in non-lethal techniques to perform genetic analyses. Scientific and educational overutilization are not believed to be significant threats to PCT at this time.

Summary of Factor B

In summary, recreational fishing was a historical threat to PCT within the Silver King Creek drainage. Because small streams are vulnerable to overharvest, recreational fishing has been closed for populations of PCT in the Silver King Creek drainage and North Fork Cottonwood Creek. The other populations are open to fishing; however, due to their remote locations recreational fishing is not a significant effect at this time. Scientific sampling of PCT populations within the Silver King Creek drainage with electrofishing equipment occurs on an annual basis, but most populations are not sampled every year and biologists are trained in the proper use of electrofishing equipment. Scientific and educational sampling is also regulated by State permitting processes and new, non-lethal techniques have been developed for genetic analyses. Overutilization was not identified as a threat in the 2008 5-year review (Service 2008a, p. 12). Consistent with our previous determination, we conclude that the best scientific and commercial information available indicate that PCT are not threatened by overutilization for commercial, recreational, scientific, or educational purposes.

FACTOR C: Disease or Predation

Predation

There are several natural predators to PCT eggs and fry including water shrews (*Sorex palustris*), dippers (*Cinclus mexicanus*), and trichopteron larvae, but few prey on adult fish (Wong 1975, pp. 110–115). Predation does not seem to be a significant threat at this time.

Disease

Disease is apparently a significant cause of adult PCT mortality in North Fork Cottonwood Creek, particularly in the post-spawning period. Wong (1975, pp. 115–116) observed extensive fungal infections on the dorsal and caudal fins of several spawned-out fish in North Fork Cottonwood Creek. Many of these fish were so weakened by spawning they were unable to recover. It is unknown how this infection affects PCT at the population level; however, it should be noted the population has persisted in North Fork Cottonwood Creek since the fungus was first observed in the early 1970's. Due to this fungus, CDFW altered their sampling techniques from electrofishing to visual encounter surveys. This disease has not been observed outside of North Fork Cottonwood Creek (Service 2004, p. 43); therefore, disease does not seem to be a significant threat to the species throughout its current range.

Summary of Factor C

Disease and predation were not identified as threats in the reclassification rule (Service 1975, pp. 29863–29864), either recovery plan (Service 1985, pp. 17–22; 2004, p. 43), nor the 2008 5-year review (Service 2008a, p. 13). Disease and predation are not believed to be significant threats to PCT at this time.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

State Protections in California

There are several State and Federal laws and regulations that are pertinent to federally-listed species, each of which may contribute in varying degrees to the conservation of listed and non-listed species. These laws, most of which have been enacted in the past 30–40 years, have reduced or eliminated the threat of habitat destruction. These laws are discussed below.

State Protections in California

California Endangered Species Act (CESA): The CESA (California Fish and Game Code (CFGF) section 2080 *et seq.*) prohibits the unauthorized take of State-listed threatened or endangered species. Paiute cutthroat trout are not State-listed in California.

California Environmental Quality Act (CEQA): The CEQA requires review of any project that is undertaken, funded, or permitted by the State or a local governmental agency. If significant effects are identified, the lead agency has the option of requiring mitigation through changes in the project or to decide that overriding considerations make mitigation infeasible (CEQA section 21002). Protection of listed species through CEQA is, therefore, dependent upon the discretion of the lead agency involved.

California Lake and Streambed Alteration Program: The Lake and Streambed Alteration Program (CFGF sections 1600–1616) may promote the recovery of listed species in some cases. This program provides a permitting process to reduce impacts to fish and wildlife from projects affecting important water resources of the State, including lakes, streams, and rivers. This program also recognizes the importance of riparian habitats to sustaining California’s fish and wildlife resources, including listed species, and helps prevent the loss and degradation of riparian habitats.

State Bill SB 1573: This bill was signed into law in 2002 and established an Interagency Aquatic Invasive Species Council to provide for the development of a State Aquatic Invasive Species Plan. The plan, prepared by CDFW’s Habitat Conservation Planning Branch, will follow Federal guidance and fall under the direction of the State invasive species coordinator.

Federal Protections

National Environmental Policy Act (NEPA): NEPA (42 U.S.C. 4371 *et seq.*) provides some protection for listed species that may be affected by activities undertaken, authorized, or funded by Federal agencies. Prior to implementation of such projects with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. In cases where that analysis reveals significant environmental effects, the Federal agency must propose mitigation alternatives that would offset those effects (40 C.F.R. 1502.16). These mitigations usually provide some protection for listed species.

However, NEPA does not require that adverse impacts be fully mitigated, only that impacts be assessed and the analysis disclosed to the public.

Clean Water Act: Under section 404, the U.S. Army Corps of Engineers (USACE) regulates the discharge of fill material into waters of the United States, which include navigable and isolated waters, headwaters, and adjacent wetlands (33 U.S.C. 1344). In general, the term “wetland” refers to areas meeting the USACE’s criteria of hydric soils, hydrology (either sufficient annual flooding or water on the soil surface), and hydrophytic vegetation (plants specifically adapted for growing in wetlands). Any action with the potential to impact waters of the United States must be reviewed under the Clean Water Act, NEPA, and ESA. These reviews require consideration of impacts to listed species and their habitats, and recommendations for mitigation of significant impacts.

Wilderness Act: The Wilderness Act of 1964 established a National Wilderness Preservation System made up of federally-owned areas designated by Congress as “wilderness” for the purpose of preserving and protecting designated areas in their natural condition. Commercial enterprise, road construction, use of motorized vehicles or other equipment, and structural developments are generally prohibited within designated wilderness. Livestock grazing is permitted within designated wilderness, subject to other applicable laws, if it was established prior to the passage of the Wilderness Act. All historical and currently occupied PCT habitat occurs in designated wilderness areas including the Carson-Iceberg Wilderness, John Muir Wilderness, Ansel Adams Wilderness, and the White Mountains Wilderness. The Wilderness Act has likely helped to protect PCT habitat from development or other types of habitat conversions and disturbances.

National Forest Management Act: Under the National Forest Management Act of 1976, as amended (NFMA) (16 U.S.C. 1600 *et seq.*), the USFS is tasked to manage National Forest lands based on multiple-use, sustained-yield principles, and implement land and resource management plans (LRMP) on each National Forest to provide for a diversity of plant and animal communities. The purpose of an LRMP is to guide and set standards for all natural resource management activities for the life of the plan (10–15 years). NFMA requires the USFS to incorporate standards and guidelines into LRMPs. The 1982 planning regulations for implementing NFMA (USFS 1982, pp. 43026–43058), under which all existing forest plans in the Sierra Nevada were prepared until recently, guided management of National Forests and required that fish and wildlife habitat on National Forest system lands be managed to maintain viable populations of existing native and desired nonnative vertebrate species in the planning area. A viable population is defined as a population of a species that continues to persist over the long term with sufficient distribution to be resilient and adaptable to stressors and likely future environments. In order to insure that viable populations will be maintained, habitat must be provided to support, at least, a minimum number of reproductive individuals and that habitat must be well distributed so that those individuals can interact with others in the planning area.

On April 9, 2012, the USFS published a final rule (USFS 2012, pp. 21162–21276) amending 36 CFR 219 to adopt new National Forest System land management regulations to guide the

development, amendment, and revision of LRMPs for all Forest System lands. These revised regulations, which became effective on May 9, 2012, replace the 1982 planning rule. The 2012 planning rule requires that the USFS maintain viable populations of species of conservation concern at the discretion of regional foresters. This rule could thereby result in removal of the limited protections that are currently in place for PCT under the Sierra Nevada Forest Plan Amendment (SNFPA), as described below. Thus, the impact of the 2012 rule to listed species is unknown at this time.

Sierra Nevada Forest Plan Amendment: In 2001, a record of decision was signed by the USFS for the Sierra Nevada Forest Plan Amendment (SNFPA), based on the final environmental impact statement for the SNFPA effort and prepared under the 1982 NFMA planning regulations. The Record of Decision amends the USFS Pacific Southwest Regional Guide, the Intermountain Regional Guide, and the LRMPs for National Forests in the Sierra Nevada and Modoc Plateau. This document affects land management on all National Forests throughout the range of PCT. The SNFPA addresses and gives management direction on issues pertaining to old forest ecosystems; aquatic, riparian, and meadow ecosystems; fire and fuels; noxious weeds; and lower west-side hardwood ecosystems of the Sierra Nevada. In January 2004, the USFS amended the SNFPA, based on the final supplemental environmental impact statement, following a review of fire and fuels treatments, compatibility with the National Fire Plan, compatibility with the Herger-Feinstein Quincy Library Group Forest Recovery Pilot Project, and effects of the SNFPA on grazing, recreation, and local communities (USFS 2004, pp. 26–30).

Relevant to PCT, the Record of Decision for SNFPA aims to protect and restore aquatic, riparian, and meadow ecosystems, and to provide for the viability of associated native species through implementation of an aquatic management strategy. The aquatic management strategy is a general framework with broad policy direction. Implementation of this strategy is intended to take place at the landscape and project levels. There are nine goals associated with the aquatic management strategy: (1) the maintenance and restoration of water quality to comply with the Clean Water Act; (2) the maintenance and restoration of habitat to support viable populations of native and desired nonnative riparian-dependent species, and to reduce negative impacts of nonnative species on native populations; (3) the maintenance and restoration of species diversity in riparian areas, wetlands, and meadows to provide desired habitats and ecological functions; (4) the maintenance and restoration of the distribution and function of biotic communities and biological diversity in special aquatic habitats (such as springs, seeps, vernal pools, fens, bogs, and marshes); (5) the maintenance and restoration of spatial and temporal connectivity for aquatic and riparian species within and between watersheds to provide physically, chemically, and biologically unobstructed movement for their survival, migration, and reproduction; (6) the maintenance and restoration of hydrologic connectivity between floodplains, channels, and water tables to distribute flood flows and to sustain diverse habitats; (7) the maintenance and restoration of watershed conditions as measured by favorable infiltration characteristics of soils and diverse vegetation cover to absorb and filter precipitation, and to sustain favorable conditions of streamflows; (8) the maintenance and restoration of instream flows sufficient to sustain desired conditions of riparian, aquatic, wetland, and meadow habitats, and to keep

sediment regimes within the natural range of variability; and (9) the maintenance and restoration of the physical structure and condition of streambanks and shorelines to minimize erosion and sustain desired habitat diversity.

If these goals of the aquatic management strategy are pursued and met, threats to PCT resulting from habitat alterations could be reduced. However, the aquatic management strategy is a generalized approach that does not contain specific implementation timeframes or objectives, and it does not provide direct protections for PCT. Additionally, as described above, the April 9, 2012, final rule (USFS 2012, pp. 21162–21276) that amended 36 CFR 219 to adopt new National Forest System land management planning regulations could result in removal of the limited protections that are currently in place for PCT under the SNFPA.

Endangered Species Act of 1973, as amended (ESA): The ESA is the primary Federal law providing protection for PCT. The Service’s responsibilities include administering the ESA, including sections 7, 9, and 10 that address take. Since listing, the Service has analyzed the potential effects of Federal projects under section 7(a)(2), which requires Federal agencies to consult with the Service prior to authorizing, funding, or carrying out activities that may affect listed species. A jeopardy determination is made for a project that is reasonably expected, either directly or indirectly, to appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution (50 CFR 402.02). A non-jeopardy biological opinion may include reasonable and prudent measures that minimize the amount or extent of incidental take of listed species associated with a project. Since 2003, four non-jeopardy biological opinions have been completed for PCT.

Section 9 prohibits the taking of any federally-listed endangered or threatened species. Section 3(18) defines “take” to mean “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.” Service regulations (50 CFR 17.3) define “harm” to include significant habitat modification or degradation which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering. Harassment is defined by the Service as an intentional or negligent action that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. The ESA provides for civil and criminal penalties for the unlawful taking of listed species. Incidental take refers to taking of listed species that result from, but is not the purpose of, carrying out an otherwise lawful activity by a Federal agency or applicant (50 CFR 402.02).

Section 4(d) of the ESA provides for special rules for species listed as threatened, through regulations deemed necessary and advisable to provide for the conservation of the species. Under specified circumstances, 4(d) rules may include exemptions from section 9 take prohibitions. A 4(d) rule was published on July 16, 1975, in conjunction with reclassifying PCT from endangered to threatened, to facilitate management by the State and allow State-permitted sport harvest (Service 1975, p. 29864; 50 CFR 17.44(a)).

Summary of Factor D

In summary, the ESA is the primary Federal law that provides protection for PCT since its reclassification from endangered to threatened in 1975 (Service 1975, pp. 29863–29864). Other Federal and State regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under the ESA. Inadequacy of existing regulatory mechanisms was not identified as a threat in the reclassification rule (Service 1975, pp. 29863–29864), either recovery plan (Service 1985, pp. 17–22; 2004, p. 43), nor the 2008 5-year review (Service 2008a, pp. 13–15). Consistent with our previous determination, we continue to believe the inadequacy of other laws and regulations are not a threat to PCT at this time.

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence

Climate Change

In this section, we discuss the aspects of climate change that will most likely affect PCT and their habitat. We present information that indicates climate change is occurring on a global scale and information regarding local effects from the Sierra Nevada, and discuss how climate change will likely exacerbate the threats to PCT discussed previously in this review.

Our analyses under the ESA include consideration of ongoing and projected changes in climate. The terms “climate” and “climate change” are defined by the Intergovernmental Panel on Climate Change (IPCC). The term “climate” refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007, p. 78). The term “climate change” thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007, p. 78).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has been faster since the 1950s. Warming trends documented over the past 50 years in the United States are predicted to continue to increase (Field *et al.* 2007, pp. 626–627); however, the magnitude varies spatially across the continent, is most pronounced during spring and winter months, and has affected daily minimum temperatures more than daily maximum temperatures (Field *et al.* 2007, p. 620). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate, and is “very likely” (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (IPCC 2007, pp. 5–6; Solomon *et al.* 2007, pp. 21–35; Serreze 2010, pp. 11–13). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011, p. 4), who concluded it is extremely

likely that approximately 75 percent of global warming since 1950 has been caused by human activities.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (Meehl *et al.* 2007, pp. 747–845; Ganguly *et al.* 2009, pp. 11555, 15558; Prinn *et al.* 2011, pp. 527, 529). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (IPCC 2007, pp. 44–45; Meehl *et al.* 2007, pp. 760–764, 797–811; Ganguly *et al.* 2009, pp. 15555–15558; Prinn *et al.* 2011, pp. 527, 529).

Climate change is predicted to have several effects on cold water habitat including: (1) Increased water temperature; (2) decreased stream flow; (3) change in the hydrograph; and (4) increased frequency and severity of extreme events such as drought and fire (Stewart *et al.* 2005, pp. 1140–1154; Ficke *et al.* 2007, pp. 583–593; Bates *et al.* 2008, pp. 102–106; Webb *et al.* 2008, pp. 909–911; Williams *et al.* 2009, pp. 538–546; Kaushal *et al.* 2010, pp. 462–464; Wenger *et al.* 2011, pp. 14176–14178; Isaak *et al.* 2012, pp. 513–515). These effects are discussed below.

Increased Water Temperature

Recent literature has documented increases in stream temperatures across the globe (Bates *et al.* 2008, p. 36; Webb *et al.* 2008, pp. 909–911); however, the magnitude varies considerably due to the very complex and site-specific processes influencing water temperature (Poole and Berman 2001, pp. 789–792; Brown and Hannah 2008, pp. 960–965; Chu *et al.* 2008, pp. 301–307). It should be noted that all waterbodies will not be influenced by increasing air temperatures in the same way and a 1°C (1.8°F) increase in air temperature does not equate to a 1°C (1.8°F) increase in water temperature (Stefan and Preud'homme 1993, pp. 27–29; Poole and Berman 2001, pp. 789–792; van Vliet *et al.* 2011, pp. 12–14).

Several studies have modeled the effects of increased water temperatures due to climate change on North American salmonids (Keleher and Rahel 1996, pp. 4–5; Jager *et al.* 1999, pp. 232–236; Rahel 2002, pp. 100–103; Mohseni *et al.* 2003, pp. 398–405; Flebbe *et al.* 2006, pp. 1376–1378; Preston 2006, pp. 101–110; Rieman *et al.* 2007, pp. 1556–1558; Kennedy *et al.* 2009, pp. 508–511; Isaak *et al.* 2012, pp. 513–515). The extent of habitat predicted to become unsuitable for salmonids ranges from 17 to 97 percent, depending on various factors such as the magnitude of the temperature increase, which climate model is used, and the region of North America in which

the species exists (Rahel 2002, pp. 100–103; Flebbe *et al.* 2006, pp. 1376–1378; Preston 2006, pp. 101–110; Rieman *et al.* 2007, pp. 1556–1558; Wenger *et al.* 2011, p. 14176). Additionally, these studies predict the loss of suitable habitat for salmonids, mainly at the southern extent of their range and at lower elevations.

Water temperature influences the survival and distribution of salmonids and all aquatic life (Allan 1995, p. 74). Alterations in the temperature regime from natural background levels can negatively affect population viability, when considered at the scale of the watershed or individual stream (McCullough 1999, p. 160). High temperatures can suppress appetite and growth (Meeuwig *et al.* 2004, pp. 211–212), influence behavioral interactions with other fish (De Staso and Rahel 1994, pp. 292–293), increase susceptibility to disease (McCullough 1999, pp. 104–116; Schisler *et al.* 2000, pp. 861–862), or be lethal (Dickerson and Vinyard 1999, p. 518). Salmonids inhabiting warm stream segments have higher probabilities of mortality due to stress (McCullough 1999, p. 156; Meeuwig *et al.* 2004, p. 214). All current PCT populations occur between 2,438 and 3,353 m (8,000 and 11,000 ft) in elevation, and thus, stream temperatures are not likely to exceed PCT's thermal tolerance levels.

Winter conditions can strongly influence survival of salmonids (Huusko *et al.* 2007, pp. 469–470; Brown *et al.* 2011, pp. 12–21). Impacts from stream freezing, anchor ice (submerged ice attached to the stream bottom), and frazil ice (ice crystals in the water column) have been shown to cause overwinter mortality in salmonids at all life stages; however, the egg and juvenile stages are most susceptible (Huusko *et al.* 2007, pp. 470–476; Brown *et al.* 2011, pp. 12–21). An important function in small streams is the insulating properties of snow when it completely covers the stream. Gard (1963, p. 196) found that diurnal air temperatures above the snow varied by nearly 35.4°C (64°F); however, below 483 mm (19 in) of snow, air temperatures varied only 1.2°C (2.25°F) and water temperatures varied 0.3°C (0.55°F). Berg (1994, p. 381) found extensive ice formation on streams in the Sierra Nevada during a particularly cold fall prior to any snowfall. Extensive ice formations were observed in Silver King Creek during January 2012 as there was no snow in the Sierra Nevada until mid-January (Natural Resources Conservation Service 2012, p. 1).

While disease is not currently a major threat to PCT (see Factor C above), increasing temperatures may cause higher stress levels which may increase their susceptibility to disease (McCullough 1999, pp. 104–105; Rahel *et al.* 2008, p. 555). Schisler *et al.* (2000, p. 861) performed laboratory experiments and found that mortality of rainbow trout due to whirling disease increased at higher temperatures. The authors also looked at the effects of adding multiple stressors in the presence of *Myxobolus cerebralis*, the parasite that causes whirling disease. As the number of stressors increased, mortality also increased (Schisler *et al.* 2000, p. 862). Other studies have found increased prevalence of *M. cerebralis* in wild salmonids as stream temperatures increased (Thompson *et al.* 1999, p. 318; de la Hoz Franco and Budy 2004, p. 1183).

Decreased Streamflow

Climate models are predicting an overall increase in precipitation over most of North America except for the southwestern United States (Christensen *et al.* 2007, p. 890). In western North America, the predicted increase in precipitation has a strong north-south orientation with higher predicted precipitation in northern latitudes and lower predicted precipitation at southern latitudes (Christensen *et al.* 2007, p. 890). For the Sierra Nevada there is much uncertainty on the effects of climate change on total precipitation (PRBO 2011, p. 18). Despite this uncertainty, there is greater predictability in terms of winter and spring warming which will cause an increased fraction of winter precipitation to come as rain, resulting in a reduced snowpack, an earlier snowmelt, decreased spring runoff, and reduced summer streamflows (Hayhoe *et al.* 2004, pp. 12425–12426; Stewart *et al.* 2005, pp. 1140–1144; Knowles *et al.* 2006, pp. 4548–4550, Bates *et al.* 2008, p. 102; PRBO 2011, pp. 19–24). Dettinger *et al.* (2004, p. 307) predict that by the last quarter of the century, the amount of average snowwater content in the Carson River drainage may be reduced by 67 percent. A reduction in streamflow will reduce the amount of PCT occupied habitat, particularly in high elevation headwater streams.

For salmonids and other aquatic organisms, flow regimes in streams and rivers determine the amount and availability of water, the types of micro- and macrohabitats, and the seasonal patterns of disturbance to aquatic communities (Swanston 1991, pp. 148–152; Spence *et al.* 1996, p. 92; Marchetti and Moyle 2001, pp. 537–538; Kiernan and Moyle 2012, p. 1158). Low flow conditions can reduce the amount of habitat available for juvenile refugia from predators, limit refugia suitable for avoidance of elevated water temperatures, reduce the availability of food which may affect growth (Harvey *et al.* 2006, p. 1002), and increase competition for space and food sources (Spence *et al.* 1996, p. 210). Reduced flows can strand fish in isolated pools, which increases their susceptibility to predation, disease, and extreme environmental conditions such as high temperatures and low dissolved oxygen (Spence *et al.* 1996, pp. 143–145). In addition, desiccation of recently spawned eggs or newly-hatched fry will occur if redds are no longer covered with water. During the summer of 2012, flows were so low in Upper Fish Valley, a fish rescue was performed in the side channel as it had been reduced to a few isolated pools (C. Mellison, Service, unpub. data).

Lower streamflows can alter the biotic composition, structure, and function of aquatic and riparian ecosystems (Richter *et al.* 1996, p. 1164; Poff *et al.* 1997, p. 769). Decreased flows can negatively affect intra- and inter-annual flows which are necessary for maintenance of many riparian plant species (Poff *et al.* 1997, p. 775), stream channel maintenance and development (Chavez 1996, p. 148; Ryan 1997, pp. 847–851), and the sustainability of the native biodiversity (Bain *et al.* 1988, pp. 389–390; Kiernan and Moyle 2012, p. 1158). Reduced flows during the summer months can increase water temperature (Gu and Li 2002, p. 54; van Vliet *et al.* 2011, pp. 6–18), reduce available habitat for aquatic species (Bjornn and Reiser 1991, p. 123), and stress riparian vegetation (Smith *et al.* 1991, pp. 95–96).

Change in Hydrograph

Changes in air temperature and precipitation will likely lead to changes in the magnitude, timing, and duration of runoff (Bates *et al.* 2008, p. 102). Stewart *et al.* (2005, pp. 1140–1144) report that spring streamflow during the last five decades has shifted so that the major peak now arrives 1–4 weeks earlier, resulting in declining fractions of flow in the spring and summer (see Decreased Streamflow above). Additionally, flooding events, particularly during the winter, are expected to increase (Hamlet and Lettenmaier 2007, pp. 14–17; Coats *et al.* 2013, pp. 64–65). The life history of salmonids is closely associated with flow regimes (Bjornn and Reiser 1991, pp. 87–90). Changes in the flow regime can have differential effects on species due to differences in their life history (Wenger *et al.* 2011, pp. 14176–14178 ; Kiernan and Moyle 2012, pp. 1150–1159). A change in timing or magnitude of floods can scour the streambed, destroy eggs, or displace recently emerged fry downstream (Erman *et al.* 1988, pp. 2197–2199; Kondolf *et al.* 1991, pp. 181–182; Wenger *et al.* 2011, p. 14176). Seegrist and Gard (1972, pp. 478–480) found decreased abundance of fall spawning brook trout during winter flood events and decreased abundance of spring spawning rainbow trout during spring flood events which were attributed to a reduction in recruitment success. Wenger *et al.* (2011, p. 14176) predict that fall spawning salmonids (*e.g.*, brook trout and brown trout) will be significantly more impacted by an increased frequency and magnitude of winter flood events as compared to spring spawning salmonids (*e.g.*, rainbow and cutthroat). Since PCT spawn in the spring, any change in the timing, or magnitude of spring runoff could disrupt recruitment and survival.

Extreme Events

Natural disturbances have been and will continue to be important processes shaping aquatic habitat (Benson *et al.* 2002, p. 680; Benda *et al.* 2003, pp. 107–112; Germanoski and Miller 2004, pp. 110–117; Miller *et al.* 2004, pp. 49–83). Recovery of aquatic systems from disturbance varies with the severity, magnitude, frequency and type (*i.e.*, pulse or chronic), and availability of refugia (Niemi *et al.* 1990, pp. 573–585; Sedell *et al.* 1990, pp. 714–719; Magoulick and Kobza 2003, pp. 1186–1195). The frequency, severity, and magnitude of disturbances such as drought and fire are expected to increase with climate change (Westerling *et al.* 2006, pp. 941–942; Field *et al.* 2007, p. 627; Wehner *et al.* 2011, p. 1374).

Drought

Drought has been an important natural disturbance in the western United States since the early Holocene (Cook *et al.* 2004, p. 1017; Mensing *et al.* 2004, pp. 31–37; Yuan *et al.* 2004, pp. 7–9). Cook *et al.* (2004, p. 1016) report the percentage of the western United States in drought conditions has gradually increased over the last century and that the current drought rivals the drought conditions in the 1930's; however, these more recent droughts (*i.e.*, in the last century) pale in comparison to conditions found 700–1,100 years before present in terms of duration and severity. Century-long drought conditions have been determined with pollen records throughout the western portion of the Great Basin with drought termination dates at approximately 1,800, 1,200, 800, and 550 years before present (Mensing *et al.* 2008, p. 85). These historical drought

conditions likely negatively impacted PCT. However, despite these severe recurring drought conditions, the PCT population in Silver King Creek was able to persist due to the size of the Silver King Creek drainage, the size of the population, and the quality and distribution of habitat (Lake 2003, pp. 1166–1167; Wilcox *et al.* 2006, p. 859).

Drought-related effects can impact many different scales of organizational complexity, including effects to individuals, local populations, local fish assemblages, metapopulations, watershed or regional faunas, ecosystems, and evolutionary impacts (Labbe and Fausch 2000, pp. 1784–1788; Lake 2003, pp. 1164–1166; Matthews and Marsh-Matthews 2003, p. 1234). In a review of 50 different studies on drought-related impacts to fish, Matthews and Marsh-Matthews (2003, p. 1237) reported the most common impacts were decreases in numbers at the population and community level, loss of habitat, poor water quality (*i.e.*, hypoxia and temperature), decreased ability for movement, crowding, and desiccation. The authors also noted that studies of the effects of drought have occurred on a local scale but that large spatial studies incorporating metapopulations dynamics were lacking (Matthews and Marsh-Matthews 2003, p. 1236).

Small streams are more susceptible than larger streams to drying, increased stream temperatures during the summer, and freezing during the winter (Lake 2003, pp. 1163–1164). Although not all small streams have equal risk from drought (*i.e.*, spring-dominated flow has less risk than snowmelt-dominated flow), small headwater streams, especially those with an inadequate number of deep pools, are most likely to lose suitable habitat (Lake 2003, pp. 1163–1164). However, functioning small streams with good quality habitat (*e.g.*, deep pools) and limited anthropogenic influences can sustain salmonids during drought conditions (Magoulick and Kobza 2003, pp. 1186–1195; White and Rahel 2008, p. 891). Since PCT populations are small and isolated, any reduction in population size due to drought can also reduce genetic diversity and fitness (Rutledge *et al.* 1990, pp. 215–216; Faber *et al.* 2000, pp. 1470–1471).

Fire

Fire has been one of the dominant factors shaping ecosystems for millennia (Skinner and Chang 1996, p. 1041; Van Wagtenonk and Fites-Kaufman 2006, p. 270). Median fire return intervals in eastside Sierra Nevada forests where PCT reside are believed to be 8–16 years with a range of 5–47 years (Skinner and Chang 1996, p. 1056; Van Wagtenonk and Fites-Kaufman 2006, pp. 288–289; North *et al.* 2009, pp. 25–30; Van de Water and North 2010, pp. 388–391). In this fire regime type the following effects occur: (1) Fire controls plant species composition by favoring species that require sunlight (*e.g.*, Jeffrey pine (*Pinus jeffreyi*) over shade-tolerant forms such as white fir (*Abies concolor*)), and by favoring fire-resistant and fire-dependent species over non-fire dependent species; (2) fire consumes understory vegetation without damaging the overstory; (3) crown fires are rare and patchy; and (4) small patches of intense surface burning often result in openings (Chang 1996, pp. 1071–1072).

Changes in historical fire regimes are well documented in the western United States (McKelvey *et al.* 1996, pp. 1033–1039; Arno 2000, pp. 100–105; Stephens and Sugihara 2006, pp. 431–441; Richardson *et al.* 2007, pp. 277–278; Brooks 2008, pp. 33–45; Van de Water and North 2011,

pp. 222–226). Around the late 1800's, high-frequency, low-intensity fire regimes associated with dry forest types, as found in the eastern Sierra Nevada, began having longer fire return intervals due to: (1) Relocation of Native Americans which disrupted their historical burning practices; (2) loss of fine fuels, which carried low-intensity ground fires, due to extensive overgrazing; (3) disruption of fuel continuity on the landscape due to irrigation, agriculture, and development; and (4) fire exclusion management policies (Arno 2000, pp. 100–101; Keane *et al.* 2002, pp. 1–2). Effects from the post-Euroamerican settlement influence on fire regimes include longer fire return intervals which allow fuel loads to increase. In return, relatively small, low-intensity ground fires have become uncharacteristically large, stand-replacing fires (Arno 2000, p. 101; Miller *et al.* 2009, pp. 22–30; Miller and Safford 2012, pp. 45–54).

Changing climate has affected summer temperatures and the timing of spring snowmelt, which have contributed to increasing the length of the wildfire season, wildfire frequency, and the size of wildfires (McKenzie *et al.* 2004, pp. 893–897; Westerling *et al.* 2006, p. 941; Miller *et al.* 2009, pp. 22–30). Westerling *et al.* (2006, p. 942) conclude that there are robust statistical associations between wildfire and climate in the western United States and that increased fire activity over recent decades reflects responses to climate change. Miller *et al.* (2009, pp. 22–30) studied the frequency, severity, and size of fires in the Sierra Nevada forests and found that all three parameters are increasing. Although PCT evolved in a fire-prone environment, increases in wildfire frequency, size, and severity due to increased fuel loads and effects from climate change (Westerling *et al.* 2006, p. 942; Miller *et al.* 2009, p. 26) have increased the threats due to wildfire. Wildfires are a larger threat to PCT because of the current fragmented and isolated state of occupied habitat (Haak *et al.* 2010, p. 47)

Fish mortalities can occur from increases in water temperatures which exceed lethal levels, fire induced changes in pH, increased ammonia levels from smoke gases absorbed into surface waters, and increased phosphate levels leached from ash (Brown 1989, pp. 107–108; Spencer and Hauer 1991, pp. 26–29; Rinne 1996, pp. 654–657; Rieman and Clayton 1997, pp. 51–53; Gresswell 1999, pp. 194–199; Earl and Blinn 2003, pp. 1020–1028; Ranalli 2004, pp. 1–21; Neary *et al.* 2005, pp. 119–134). Studies have shown that post-fire hydrologic events can severely reduce or extirpate local fish populations (Novak and White 1990, pp. 122–123; Propst *et al.* 1992, p. 120; Bozek and Young 1994, p. 92; Rinne 1996, p. 654; Rieman *et al.* 1997, pp. 50–53; Burton 2005, pp. 142–148; Sestrich *et al.* 2011, pp. 139–140). Recolonization rates depend on the proximity and relative location of refugia, access from refugia to disturbed areas (*i.e.*, no fish barriers), presence of nonnative fish, and interactions with complex life history traits and overlapping generations (Gresswell 1999, p. 210; Dunham *et al.* 2003, pp. 185–186; Howell 2006, pp. 990–993; Dunham *et al.* 2007, pp. 340–344; Neville *et al.* 2009, pp. 1321–1324; Sestrich *et al.* 2011, pp. 143–144). Isolated fish populations are at a much higher risk of extinction because they cannot recolonize after a large disturbance (Rinne 1996, p. 656; Dunham *et al.* 1997, p. 1131; Dunham *et al.* 2003, pp. 187–189; Burton 2005, pp. 142–148; Dunham *et al.* 2007, pp. 340–344; Williams *et al.* 2009, pp. 543–546). Additionally, effects on small headwater streams are more severe because larger proportions of the drainage are burned at these smaller spatial scales, in contrast to larger stream orders, where relatively small proportions of the drainage burn (Romme *et al.* 2011, pp. 1204–1205; Sestrich *et al.* 2011, p. 143). All

occupied PCT habitat is located in the headwaters of each watershed.

Haak *et al.* (2010, pp. 1–67) analyzed the potential cumulative impacts of increased stream temperatures, winter flooding, wildfire, and drought on the persistence of 10 native salmonids in the western United States, including Lahontan cutthroat trout, a closely-related subspecies to PCT. While PCT were not included in the study, we have used the results for Lahontan cutthroat trout from the Sierra Nevada portion of its range as a surrogate for PCT since similar Lahontan cutthroat trout occupied habitat surrounds the Silver King Creek drainage. The primary climate risk factors for Lahontan cutthroat trout populations in the Sierra Nevada are from winter flooding and wildfires while drought and increased stream temperatures were low to moderate risk (Haak *et al.* 2010, pp. 44–48).

Climate Change Summary

The impacts to PCT from climate change are not known with certainty. Predicted outcomes of climate change imply that negative impacts will occur through increased stream temperatures, decreased stream flow, changes in the hydrograph, and increased frequency of extreme events. Water temperatures are expected to increase in the future; however, all occupied PCT habitat is located above 2,438 m (8,000 ft) and thus, stream temperatures are not likely to rise above critical thresholds. Rising stream temperatures may increase their susceptibility to various diseases which are not current threats. Reductions in streamflow through changes in the hydrograph and drought are predicted to have a negative impact on PCT populations because of the fragmented nature of PCT populations, the small size of occupied stream habitats, and the close association of recruitment and survival to stream flow. Although PCT evolved in a fire-prone environment, increases in wildfire frequency and severity due to increased fuel loads and effects from climate change (Westerling *et al.* 2006, p. 941) have increased the threats due to wildfire. Current wildfires are a larger threat to PCT because of the current fragmented and isolated state of occupied habitat (Haak *et al.* 2010, p. 47). These impacts associated with climate change will likely intensify the threats to PCT previously described under Factor A. Climate change impacts were not evaluated in our 2008 5-year review; however in light of the above considerations, we now conclude climate change is likely a threat to PCT.

III. RECOVERY CRITERIA

Recovery plans provide guidance to the Service, States, other partners and interested parties on ways to minimize threats to listed species, and on criteria that may be used to determine when recovery goals are achieved. There are many paths to accomplishing the recovery of a species and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded while other criteria may not have been accomplished. In that instance, we may determine that over all, the threats have been minimized sufficiently and the species is robust enough to downlist or delist the species. In other cases, new recovery approaches and/or opportunities unknown at the time the recovery plan was finalized may be more appropriate ways to achieve recovery. Likewise, new information may change the extent that criteria need to be met for recognizing recovery of the species. Overall, recovery is a

dynamic process requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not, fully follow the guidance provided in a recovery plan. We focus our evaluation of species status in this 5-year review on progress that has been made toward recovery since the species was listed (or since the most recent 5-year review) by eliminating or reducing the threats discussed in the five-factor analysis. In that context, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated.

The 2004 PCT Revised Recovery Plan identifies criteria that must be met before the subspecies can be delisted (Service 2004, pp. 49–52). The Service is currently using these criteria to guide recovery activities. The recovery criteria, as presented in the 2004 PCT Revised Recovery Plan, are summarized below.

The objective of this recovery plan is to recover PCT by improving its status and habitat and eliminating nonnative salmonids so it can be delisted. Criteria for accomplishing the goal of delisting are:

1. All nonnative salmonids are removed from Silver King Creek and its tributaries downstream of Llewellyn Falls to fish barriers in Silver King Canyon;
2. A viable population occupies all historical habitat in Silver King Creek and its tributaries downstream of Llewellyn Falls to fish barriers in Silver King Canyon;
3. PCT is maintained in all occupied streams;
4. The refuge populations in Corral and Coyote Creeks, Silver King Creek, and tributaries above Llewellyn Falls as well as out-of-basin populations are maintained as refugia and are secured from the introduction of other salmonid species; and
5. A long-term conservation plan and conservation agreement are developed, which will be the guiding management documents once PCT are delisted.

The primary threat to PCT is hybridization with nonnative trout, compounded by its extremely limited distribution (making it vulnerable to catastrophic events). Consequently, it is critical to remove nonnative trout from the historical range downstream of Llewellyn Falls and reestablish PCT populations there, monitoring population abundance and genetics to evaluate success. Reinvasion of PCT habitat by nonnative trout should be prevented by monitoring or establishing instream barriers and discouraging deliberate introductions. Because PCT are vulnerable to angling pressure, appropriate fishing regulations and closures should be maintained and enforced by a stream guard and signage. Potential habitat degradation should be addressed by appropriate fish habitat improvement actions, including management of recreational

access and grazing, and control of beaver populations as necessary. The recovery criteria above should be met by addressing these threats, as detailed below.

Meeting the first and second recovery criteria will secure long-term protection and population viability of PCT by their expansion within their native range. This range expansion will be accomplished by removing nonnative trout from the Silver King Creek drainage from Llewellyn Falls downstream to the Silver King Canyon, including tributaries, followed by reintroduction with PCT from donor tributaries best suited as determined by genetic testing (Israel *et al.* 2002, p. 13). A viable population will be achieved when the population is secure and comprises three or more age classes for 5 years, and consists of a minimum of 2,500 fish greater than 75 millimeters (3 inches) (Hilderbrand and Kershner 2000, p. 515). This figure is a preliminary estimate and may need to be revised as additional information becomes available. Population estimates will be made during the nonnative fish eradication. This estimate will be used as a surrogate to help us understand the population size of PCT that will be expected within the historical range and aid in validating the minimum number needed for recovery. Once this estimate is made, population data from above Llewellyn Falls will be used to estimate a range in the population size that can be expected due to inherent natural fluctuations.

Since the last 5-year review in 2008, nonnative salmonids still occupy all historical PCT habitat. Management agencies have been trying to implement the Paiute Cutthroat Trout Restoration Project, which would implement Recovery Criteria 1 and 2; however, legal challenges have stalled the project. A joint Environmental Impact Statement/Environmental Impact Report (Service and California Department of Fish and Game 2010, pp. 1–284) has been published and upheld in court; however, the project has been enjoined since 2010 due to Wilderness Act compliance (U.S. District Court 2011, pp. 1–63). The USFS submitted a revised Minimum Requirements Decision Guide to comply with the Court and on May 13, 2013, U.S. District Court for the Eastern District of California dissolved the injunction allowing the agencies to move forward with project implementation (U.S. District Court 2013, pp. 1–2).

The third recovery criterion is to maintain suitable habitat for PCT. Historical and occupied PCT stream and riparian habitat should have no degradation from existing conditions due to anthropogenic effects. The condition of existing habitat will be identified using established stream habitat monitoring protocols which use measurable and repeatable methods. Beaver control will need to be conducted in the event that they repopulate the drainage. To secure the protection of the North Fork Cottonwood population, a second barrier will be needed to protect the population from the introduction of nonnative trout species from downstream. Cabin Creek is within an active grazing allotment where continued management will be necessary to ensure degradation of PCT habitat does not occur. Stairway and Sharktooth Creeks are subject to limited human disturbance since they are in designated wilderness areas, are inaccessible to livestock, and get limited recreational use. Therefore, habitat monitoring

should be done periodically to document stochastic events such as a rain on snow event which occurred in 1997.

Since 2008 several projects have been implemented for Recovery Criteria 3. To protect PCT habitat, the Humboldt-Toiyabe National Forest closed the Silver King Allotment to all livestock grazing and the Inyo National Forest implemented strict grazing levels for the Indian Creek Allotment which encompasses Cabin Creek. The Inyo National Forest also conducted a gravel augmentation project to improve spawning habitat in North Fork Cottonwood Creek. All populations have been visited at least once since 2008 and no habitat related concerns have been documented.

The fourth recovery criterion is to protect and enhance PCT that do not occupy historic habitat. To protect against a catastrophic event that could affect the entire Silver King Creek gene pool, populations in Corral Valley and Coyote Valley Creeks, Silver King Creek and tributaries (Four Mile Canyon, Fly Valley, and Bull Canyon Creeks) above Llewellyn Falls, and the four out-of-basin populations must be maintained as Paiute cutthroat trout refugia. Monitoring these populations will aid in management decisions aimed to maintain and improve the abundance of PCT and collection of long-term trend data. Continued genetic monitoring of all populations of PCT will be used to: (1) monitor population genetic diversity, (2) evaluate effective population size and reproductive isolation, (3) examine populations for evidence of hybridization, and (4) identify appropriate donor sources.

Since 2008, all populations have been monitored at least once (Figures 5–13). Genetic material has also been collected from all populations for hybridization analysis and conservation genetic analyses. See Species-specific Research and/or Grant-supported Activities above.

The fifth and final criterion is to develop a long-term conservation plan and conservation agreement that will guide the agencies responsible for the management of PCT after it is delisted. The purpose of the conservation plan is to ensure that adequate regulatory mechanisms and management programs remain in existence after delisting to ensure that all populations of PCT and their habitat are maintained. The conservation plan will be consistent with other existing cutthroat trout subspecies conservation plans. The purpose of the conservation agreement is to define the role of the management agencies and to document their commitment to implementing the conservation plan. The conservation plan and conservation agreement will need to be approved and signed by all responsible agencies before delisting occurs.

No work has occurred on Recovery Criteria 5 since 2008.

Recovery efforts as outlined in the Revised Recovery Plan continue to be implemented. Legal challenges continue to slow our progress in conducting Recovery Criteria 1 and 2; however, management agencies continue to seek approval from the courts. Anthropogenic impacts to PCT habitat are negligible at this time; conditions seem to be stable or improving. Populations are

monitored at adequate frequencies and intensities for management decisions. We continue to support and implement the recovery criteria outlined in the Revised Recovery Plan.

IV. SYNTHESIS

All PCT populations are isolated and confined to small habitat patches. These factors reduce gene flow between populations, and reduce the ability of populations to recover from extreme events thus threatening their long-term persistence and viability. The literature suggests that to ensure long-term persistence, populations should consist of more than 2,500 individuals, occupy at least 9.3 km (5.8 mi) of habitat, and have no nonnative species present. Currently no population meets the minimum population size or minimum habitat size, and all populations have hybridizing species immediately downstream of occupied habitat.

Overutilization, disease, and predation are not believed to be significant threats at this time.

The ESA is the primary Federal law that provides protection for PCT since its listing as threatened in 1975. Other Federal and State regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under the ESA. The ESA provides adequate protection for PCT at this time.

The impacts to PCT from climate change are not known with certainty. Predicted outcomes of climate change imply that negative impacts will occur through increased stream temperatures, decreased streamflow, changes in the hydrograph, and increased frequency of extreme events such as drought and fire. These impacts will likely increase the magnitude and severity of other existing threats to PCT. Adding stressors predicted by climate change may exacerbate the current threats to PCT populations throughout its range, many of which already have multiple stressors affecting their persistence.

We conclude that PCT still meets the definition of threatened throughout its range. Paiute cutthroat trout populations are small and isolated which increases their risk of extinction. All currently occupied habitats have hybridizing species found downstream from fish migration barriers, and no population meets long-term persistence criteria. The only habitat patch which meets minimum stream length criteria for long-term persistence is the historical range in Silver King Creek which is currently occupied by nonnative rainbow trout.

V. RESULTS

Recommended Listing Action:

- Downlist to Threatened
 Uplist to Endangered
 Delist (indicate reason for delisting according to 50 CFR 424.11):
 Extinction
 Recovery
 Original data for classification in error
 No Change

VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

1. Implement the Paiute Cutthroat Trout Restoration Project.

Recent legal challenges to project implementation have been dismissed; therefore, project implementation is moving forward in 2013. Implementation will fulfill Recovery Criteria 1 and 2 in the Revised Recovery Plan (Service 2004, pp. 49–50).

2. Develop a genetics management plan.

A genetics management plan will help the agencies make decisions regarding the management of PCT. Conservation genetics plays a vital role in the management of PCT, in particular, testing for hybridization, evaluating donor populations, and maintaining genetic diversity of extant populations. A genetics management plan will help fulfill Recovery Criteria 1, 2, 3, 4, and 5.

3. Reevaluate habitat conditions in Silver King Creek.

Habitat monitoring was conducted in the late 1980's, 1990's, and early 2000's by agency researchers (Duff 1991, pp. 1–11; Overton *et al.* 1994, pp. 1–27; Flint 2004, pp. 1–14). Valuable baseline habitat information was collected at this time. Changes in habitat have been occurring since cessation of livestock grazing in 1995. Documenting changes in habitat will help fulfill Recovery Criteria 3 in the Revised Recovery Plan (Service 2004, pp. 49, 51).

4. Improve population estimates in Silver King Creek drainage.

Population estimates for PCT are routinely conducted in low stream gradient meadow habitat. Fish densities are known to decrease in higher gradient portions of occupied streams but the extent of this decrease is unknown. To better understand population dynamics in all habitat types of Silver King Creek and its tributaries, population monitoring should also include higher gradient sections. A better understanding of population dynamics will help fulfill Recovery Criteria 2.

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U.S. FISH AND WILDLIFE SERVICE 5-YEAR REVIEW

Paiute cutthroat trout (*Oncorhynchus clarkii seleniris*)

Current Classification: Threatened

Recommendation Resulting from the 5-Year Review:

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

Review Conducted By: Nevada Fish and Wildlife Office, Reno, Nevada

Date Submitted to Region 8: June 6, 2013

FIELD OFFICE APPROVAL:

Lead State Supervisor, U.S. Fish and Wildlife Service

Approve  Date 6/6/13