Lahontan Cutthroat Trout
(Oncorhynchus clarkii henshawi)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Nevada Fish and Wildlife Office
Reno, Nevada

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5-YEAR REVIEW
Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*)

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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 Inter-mountain 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). Lahontan cutthroat trout (LCT) historically occupied large freshwater and alkaline lakes, small mountain streams and lakes, small tributary streams, and major rivers of the Lahontan Basin of northern Nevada, eastern California, and southern Oregon, including the Truckee, Carson, Walker, Susan, Humboldt, Quinn, Summit Lake/Black Rock Desert, and Coyote Lake watersheds (Service 1995, pp. 7-18). LCT evolved in a variety of habitats which resulted in resident, fluvial, and lacustrine life histories (Service 1995, pp. 19-20). Like most salmonids, LCT require relatively clear, cold waters to maintain viable populations. LCT reproduce in the spring and are obligatory stream spawners, sometimes migrating large distances to find adequate spawning areas. Unlike most freshwater fish species, LCT tolerate relatively high alkalinity and total dissolved solid levels found in some lake environments. LCT 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 Lahontan cutthroat trout Recovery Plan (Service 1995, pp. 1-147), 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. A standardized protocol was used to analyze the data collected from agency experts for consistency (May and Albeke 2008, pp. 1-31). This protocol format has been used in other cutthroat status reviews (Shepard *et al*. 2003, pp. 53-78; May and Albeke 2005, pp. 68-101; Hirsch *et al*. 2006, pp. 68-91; May *et al*. 2007, pp. 96-130).

The protocol developed by May and Albeke (2008, pp. 2-3) requires that each occupied LCT stream be treated as an individual mapping segment. Specific information relative to stocking records, presence of nonnative fish, LCT density, habitat quality, and relative stream width were collected for each mapping segment (May and Albeke 2008, pp. 6-12). For purposes of this review, summaries of these mapping segments will collectively be referred to as currently occupied streams.

As defined in May and Albeke (2008, p. 3), conservation populations represent a combination of mapping segments that when united together represent a conservation unit. For purposes of this review, summaries of these mapping segments will collectively be referred to as conservation populations. Conservation populations can exist in a genetically unaltered condition (*i.e.,* core conservation populations with genetic analysis indicating greater than 99 percent purity and/or there is reason to believe that the genetics are unaltered), and/or they can be based on unique ecological, genetic and behavioral attributes of significance even with some level of genetic introgression (hybridization). Conservation populations may exist as a network of subpopulations or streams, or they may exist as an independent stream or stream segment, but not all currently occupied habitat was categorized within each conservation population. Additional information was collected for identified conservation populations for this review (May and Albeke 2008, pp. 12-19).

We received no information from the public in response to our Federal Register Notice initiating this 5-year review. This 5-year review contains updated information on the species' biology and threats, and an assessment of that information compared to that known in the 1995 Recovery Plan. We focus on current threats to the species that are attributable to the ESA's five listing factors. The review synthesizes all this information to evaluate the listing status of the species and provide an indication of its progress towards recovery. Finally, based on this synthesis and the threats identified in the five-factor analysis, we recommend a prioritized list of conservation actions to be completed or initiated within the next 5 years.

Contact Information:

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Cooperating Regional Office(s): Region 1, Portland, Oregon.

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 February 14, 2007 (Service 2007a, pp. 7064-7068). We received no information from the public in response to our Federal Register Notice initiating this 5-year review.

Listing History:

<u>Original Listing</u>
FR Notice: Service (1970, pp. 16047-16048)
Date of Final Listing Rule: October 13, 1970
Entity Listed: *Salmo clarki* subsp. *henshawi*
Classification: Endangered

<u>Revised Listing</u>
FR Notice: Service (1975, pp. 29863-29864)
Date Listed: July 16, 1975
Entity Listed: *Salmo clarki* subsp. *henshawi*
Classification: Threatened

<u>State Listing</u>
Lahontan cutthroat trout (*Salmo clarki* subsp. *henshawi*) was listed as threatened by the State of Oregon on May 15, 1987 (Oregon Administrative Rules 635-100-0105).

Associated Rulemakings:

Lahontan cutthroat trout (*Salmo clarki* subsp. *henshawi*) 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 States and allow State-permitted sport harvest (Service 1975, p. 29864).

The Service recently completed a 90-day finding on a petition to delist LCT (Service 2008a, pp. 52257-52260). Our conclusion was that the petition did not present substantial information that recovery of LCT throughout their range had been met. The petitioner relied on the threats discussed in the 1975 downlisting rule to claim that recovery has been met, but did not provide any substantial supporting information.

Review History: Since its reclassification in 1975, there has been no official status review or 5-year review conducted for LCT to evaluate whether the current listing status is appropriate. Two rangewide status assessments have been conducted (Gerstung 1988, pp. 93-106; Service 1995, 1-147); however, they did not conduct a five-factor analysis nor did they address the listing status.

Species' Recovery Priority Number at Start of 5-Year Review: The recovery priority number for LCT is 9 according to the Service's 2008 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 or Outline

> **Name of Plan or Outline:** Recovery Plan for the Lahontan Cutthroat Trout
> **Date Issued:** January 30, 1995

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 plants, 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.

Prior to issuance of the Service's 1996 DPS policy, the range of LCT was divided into three "DPSs" in the species' Recovery Plan based on geographical, ecological, behavioral, and genetic factors, and has been managed as such since 1995 (Service 1995, pp. 1-2). The three DPSs as defined in the Recovery Plan include: (1) Western Lahontan Basin comprised of the Truckee, Carson, and Walker River watersheds; (2) Northwestern Lahontan Basin comprised of the Quinn River, Black Rock Desert, and Coyote Lake watersheds; and (3) Eastern Lahontan Basin comprised of the Humboldt River and tributaries (Service 1995, pp. 1-2). We note that, in current practice, it is inappropriate to discuss DPSs that are not listed through a formal rulemaking process, and that recovery plans do not designate DPSs. Since no DPSs of LCT are formally listed, we will not discuss the DPS delineations of the LCT Recovery Plan further in this 5-year review. Instead, we discuss watersheds within the three major basins identified above.

Information on the Species and its Status

Species Biology and Life History

Lahontan cutthroat trout inhabit lakes and streams, but are obligatory stream spawners. Distance traveled to spawning sites varies with stream size and strain of LCT (strain refers to locally adapted populations in a particular area or environment). Populations in Pyramid and Winnemucca Lakes migrated as far as 160 kilometers (km) (100 miles (mi)) up the Truckee River into Lake Tahoe and its tributary streams (Sumner 1940, p. 217; Peacock and Kirchoff 2007, pp. 74-75). Small, intermittent, tributary streams and headwater reaches are sometimes used as spawning sites (Coffin 1981, p. 31). Spawning generally occurs from April through July, depending upon stream flow, elevation, and water temperature (McAfee 1966, p. 227; Lea 1968, pp. 68-69; Moyle 2002, p. 291; Rissler *et al*. 2006, pp. 13-15). LCT in fluvial environments generally become sexually mature around year three (Ray *et al*. 2007, p. 40) while LCT in lacustrine environments become sexually mature between 3 and 4 years of age (Rissler *et al*. 2006, p. 35). The Pilot Peak broodstock, derived from the Pilot Peak range in Utah and now known to have originated from the Truckee River watershed, sexually matures between 3 and 4 years with less than 10 percent maturing at age 5 and above (Jay Bigelow 2009, personal communication).

Consecutive-year spawning by lacustrine individuals is variable. King (1982, p. 34) noted repeat rates of 3.2 and 1.6 percent for LCT spawners returning in subsequent migrations 1 and 2 years later, respectively. Rissler *et al.* (2006, p. 15) found that females in Independence Lake returned on consecutive years; however, repeat spawning of males was rare and usually only occurred once. Others (Calhoun 1942, p. 140; Lea 1968, p. 79; Sigler *et al*. 1983, pp. 14-15) observed that most repeat spawners return after 2 years or more. Cowan (1982, p. 17) noted post-spawning mortality of 60-70 percent for females and 85-90 percent for males, and spawner repeat rates of 50 and 25 percent for surviving females and male spawners, respectively. Rissler *et al*. (2006, p. 35) also found higher survival rates of females (68 percent) as compared to males (25 percent). No information on repeat spawning of fluvial individuals is available.

Spawning behavior of LCT is similar to other stream-spawning trout. They pair up, display courtship, lay eggs in redds (nests) dug by females, and chase intruders away from the nest (Rankel 1976, p. 15). Fecundity of 600-8,000 eggs per female has been reported for lacustrine populations (Calhoun 1942, p. 147; Lea 1968, p. 83; Cowan 1983, p. 34; Sigler *et al*. 1983, p. 17; Rissler *et al*. 2006, p. 17). By contrast, only 100-300 eggs were found in females collected from small Nevada streams (Coffin 1981, p. 43). Fecundity and egg size are positively correlated with length, weight, and age (Sigler *et al*. 1983, p. 17; Rissler *et al*. 2006, p. 17). Eggs are deposited in 6.4-12.7 millimeter (mm) (0.25-0.5 inch (in)) gravels within riffles, pocket water, or pool crests. Spawning beds must be well oxygenated and relatively silt-free for good egg survival. Fry (recently hatched) emerge from the gravel and remain in shallow shoreline areas with small gravel/cobble for hiding cover. By early fall the fry have developed into small (50.8-76.2 mm [2-3 in]) fingerlings which may school together in shallow pools.

LCT spawning migrations have been observed in water temperatures ranging from 5 to 16 degrees Celsius (C) (41 to 61 degrees Fahrenheit (F)) (Lea 1968, p. 78; Cowan 1983, p. 15;

Sigler *et al*. 1983, p. 13; Rissler *et al*. 2006, p. 15). LCT eggs generally hatch in 4-6 weeks, depending on water temperature, and fry emerge from the redd 13-23 days later (Lea 1968, p. 69; Rankel 1976, p. 22). Progeny of Summit Lake and Independence Lake LCT spawners generally begin moving out of spawning tributaries and into the lakes shortly after emergence (Rankel 1976, p. 24; Cowan 1991, pp. 20-21; Rissler *et al*. 2006, p. 18). Fry emigration has a distinct diel pattern with peak rates found in the early morning hours (Rissler *et al*. 2006, pp. 18, 21). Some fluvial-adapted fish remain for 1-2 years in nursery streams before emigrating in the spring (Rankel 1976, p. 24; Coffin 1983, p. 9; Johnson *et al*. 1983, p. 175; Umek 2007, p. 22).

Stream-resident LCT are opportunistic feeders, with diets consisting of drift organisms, typically terrestrial and aquatic insects (Moyle 2002, p. 290; Dunham *et al*. 2000, p. 308). Recent literature has documented the importance of terrestrial insects in the diet of stream salmonids (Baxter *et al*. 2005, pp. 201-214). In lakes, small LCT feed largely on insects and zooplankton (Calhoun 1942, pp. 197-199; McAfee 1966, p. 228; Lea 1968, pp. 59-63), and larger LCT become piscivorous. In Pyramid Lake, fish enter the diet when LCT reach 200 mm (7.9 in) in length, comprise over 50 percent of the diet at 300 mm (11.8 in), and represent almost 100 percent of the diet when LCT are over 500 mm (19.7 in) (Sigler *et al*. 1983, p. 16).

LCT growth rates are variable, with faster growth occurring in larger, warmer waters, and particularly where forage fish are utilized (*i.e.*, lake environments) (Table 1). In contrast, growth rates for stream-dwelling LCT are fairly slow (Table 1). LCT may live 5-9 years in lake environments (Lea 1968, p. 26; Rankel 1976, p. 29; Rissler *et al*. 2006, p. 22) while stream dwelling LCT are generally less than 6 years of age (Ray *et al*. 2007, pp. 39-60).

Table 1. LCT growth rates in mm (in) from five different studies.

Waterbody	Age						
	1	2	3	4	5	6	7
Pyramid Lake[a]	217 (8.5)	291 (11.5)	362 (14.3)	431 (17.0)	499 (19.6)	573 (22.6)	629 (24.8)
Blue Lake[b]	56-75 (2.2-3.0)	120-194 (4.7-7.6)	187-331 (7.4-13.0)	315-386 (12.4-15.2)			
Six Sierra Nevada streams[c]	89 (3.5)	114 (4.5)	203 (8.0)	267 (10.5)			
S.F. Little Humboldt River and tributaries[d]	80-94 (3.1-3.7)	113-125 (4.4-4.9)	133-142 (5.2-5.6)	161-171 (6.3-6.7)	181-197 (7.1-7.8)	206-216 (8.1-8.5)	242-251 (9.5-9.9)
Gance Creek[e]	96.1 (3.8)	123.9 (4.9)	162.7 (6.4)	198.7 (7.8)	237.6 (9.4)	282.5 (11.1)	

a = Sigler *et al*. 1983, p. 8 (mean fork lengths); b = Calhoun 1942, p. 133 (range of lengths calculated from scales); c = Gerstung 1986, p. 48 (mean fork lengths); d = Umek 2007, p. 22 (range of mean total lengths); e = Ray *et al*. 2007, p. 28 (mean total length).

Spatial Distribution

LCT historically occupied large freshwater and alkaline lakes, small mountain streams and lakes, small tributary streams, and major rivers of the Lahontan Basin of northern Nevada, eastern California, and southern Oregon, including the Truckee, Carson, Walker, Susan, Humboldt, Quinn, Summit Lake/Black Rock Desert, and Coyote Lake watersheds (Service 1995, pp. 4-7). Large lakes included Lake Tahoe, Fallen Leaf Lake, and Cascade Lake in the Tahoe watershed; Donner Lake, Independence Lake, Winnemucca Lake (now dry), and Pyramid Lake in the Truckee River watershed; Walker Lake in the Walker River watershed; and Summit Lake in the Black Rock Desert watershed (Gerstung 1988, p. 93). Other headwater lakes found in the Walker River watershed were also historically occupied (Gerstung 1988, p. 93). Prior to issuance of the Service's 1996 DPS policy, the range of LCT was divided into three DPSs in the species' recovery plan based on geographical, ecological, behavioral, and genetic factors, and has been managed as such since 1995 (Service 1995, pp. 1-2). The three DPSs include: (1) Western Lahontan Basin comprised of the Truckee, Carson, and Walker River watersheds; (2) Northwestern Lahontan Basin comprised of the Quinn River, Black Rock Desert, and Coyote Lake watersheds; and (3) Eastern Lahontan Basin comprised of the Humboldt River and tributaries (Service 1995, pp. 1-2).

It is not known with certainty every stream and lake that were historically occupied by LCT. For this status review, we assessed historically occupied habitat based on habitat believed to be occupied by LCT at the time of the first European exploration of the Great Basin (approximately 1800) (May and Albeke 2008, p. 2). We used historical fisheries data and reports, and published historical accounts, in our files to identify occupied habitats and produce a Geographic Information System (GIS)-based inventory of historical and currently occupied habitat. This information was augmented with professional and personal knowledge of the area, known anecdotal information, known habitat restrictions (*e.g.*, temperature), and known natural barriers of historical significance (May and Albeke 2008, p. 6). In general, current perennial streams (based on the National Hydrography Dataset (NHD; see *http://nhd.usgs.gov* for more information on NHD) were considered historically occupied if they were not above a barrier to fish movement (*e.g.*, waterfalls). In some instances, barriers were determined using only topographic maps and these should be verified in the future. Based on these criteria, we classified 11,046 km (6,864 mi) of stream habitat as potential historical LCT habitat (Tables 2 and A2.1). Headwater lakes were classified as historical habitat if they were not upstream of known barriers. An additional 127,274 surface hectares (ha) (314,502 surface acres (ac)) of lakes were known or had the potential of being occupied by LCT (Table 2). LCT historically occupied 23 different hydrologic units as defined in the NHD (Figure 1).

LCT currently occupy approximately 944.8 km (587.7 mi), or 8.6 percent of streams in 16 different hydrologic units within their historical range (Tables 2 and A2.1, Figures 1, 2, and A1.1-A1.17). LCT occupy an additional 84.8 km (52.7 mi) of habitat in 11 hydrologic units (Figures 1 and A1.18-A1.28) outside their historical range (Out-of-Basin) for a total of 1,030.1 km (640.1 mi) of occupied stream habitat. We identified 72 conservation populations based on the work of May and Albeke (2008, pp. 12-13), which represent 74 percent (764.3 km [475.0 mi]) of the currently occupied habitat (Table 3). The majority of conservation populations are in

Table 2. Historical and currently occupied stream and lake habitat (Nevada Fish and Wildlife Office (NFWO) analysis of data collected using the protocol developed by May and Albeke 2008).

Watershed	Presumed Historical Stream Habitat km (mi)	Currently Occupied Stream Habitat km (mi [percentage of historical habitat])	Presumed Historical Lake Habitat ha (surface acres)	Currently Occupied Lake Habitat ha (surface acres [percentage of historical habitat])
Susan River, CA	599 (372)	0 (0 [0])	0	NA
Truckee River, CA and NV	1,056 (656)	156.1 (97 [14.8])	112,366.7 (277,664.2)	44,946.1 (111,064.2 [40])
Carson River, CA and NV	645 (401)	27.4 (17 [4.2])	0	NA
Walker River, CA and NV	917 (570)	49.4 (30.7 [5.4])	14,720.1 (36,376.1)	14,401.7 (35,587.5 [98])
Humboldt River, NV	6,040 (3,753)	478 (297 [7.9])	0	NA
Quinn River, OR and NV	1,598 (993)	116 (72 {7.3])	186.8 (461.6)	186.8 (461.6 [100])
Coyote Lake, OR	192 (119)	118 (73.5 [61.7])	0	NA
Total	11,046 (6,864)	945 (587.7 [8.6])	127,274.4 (314,501.9)	59,534.6 (147,113.3 [46.8])

Table 3. Number of conservation populations and associated stream length based on the degree of connectedness. The percentage of conservation populations and percentage of stream length is also presented (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

	Population Isolated	Weakly Connected 2-3 streams	Moderately Connected 3-4 streams	Strongly Connected > 5 streams	Total
Number of Conservation populations	52 (72.2%)	13 (18.1%)	4 (5.6%)	3 (4.2%)	72
Stream length km [mi (%)]	279.4 [173.6 (36.5%)]	242.4 [150.6 (31.7%)]	57.7 [35.8 (7.5%)]	185.0 [115.0 (24.2%)]	764.4 [475.0]

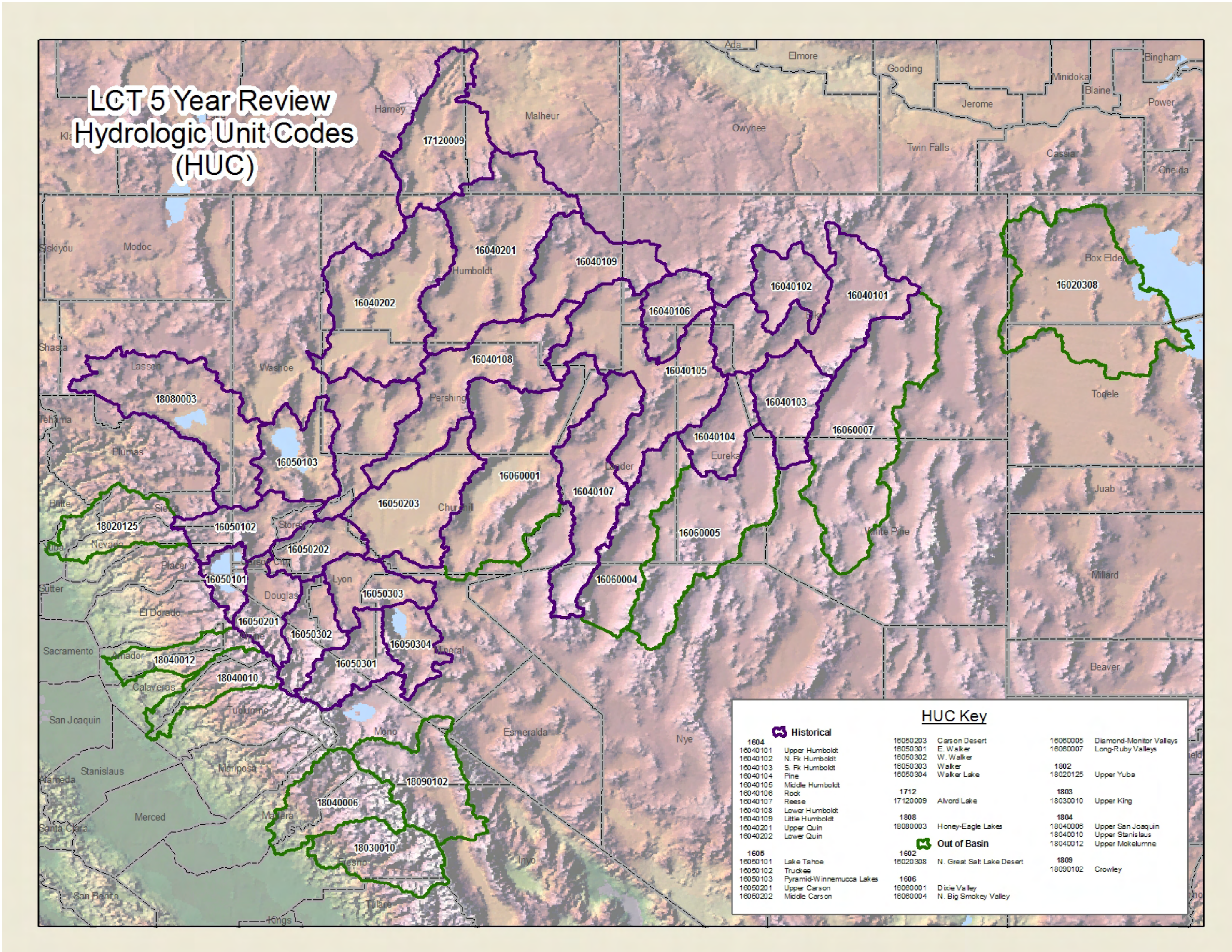

Figure 1. Historical Lahontan cutthroat trout watersheds (purple) and out-of-basin watersheds (green), prepared for 2009 5-year review.

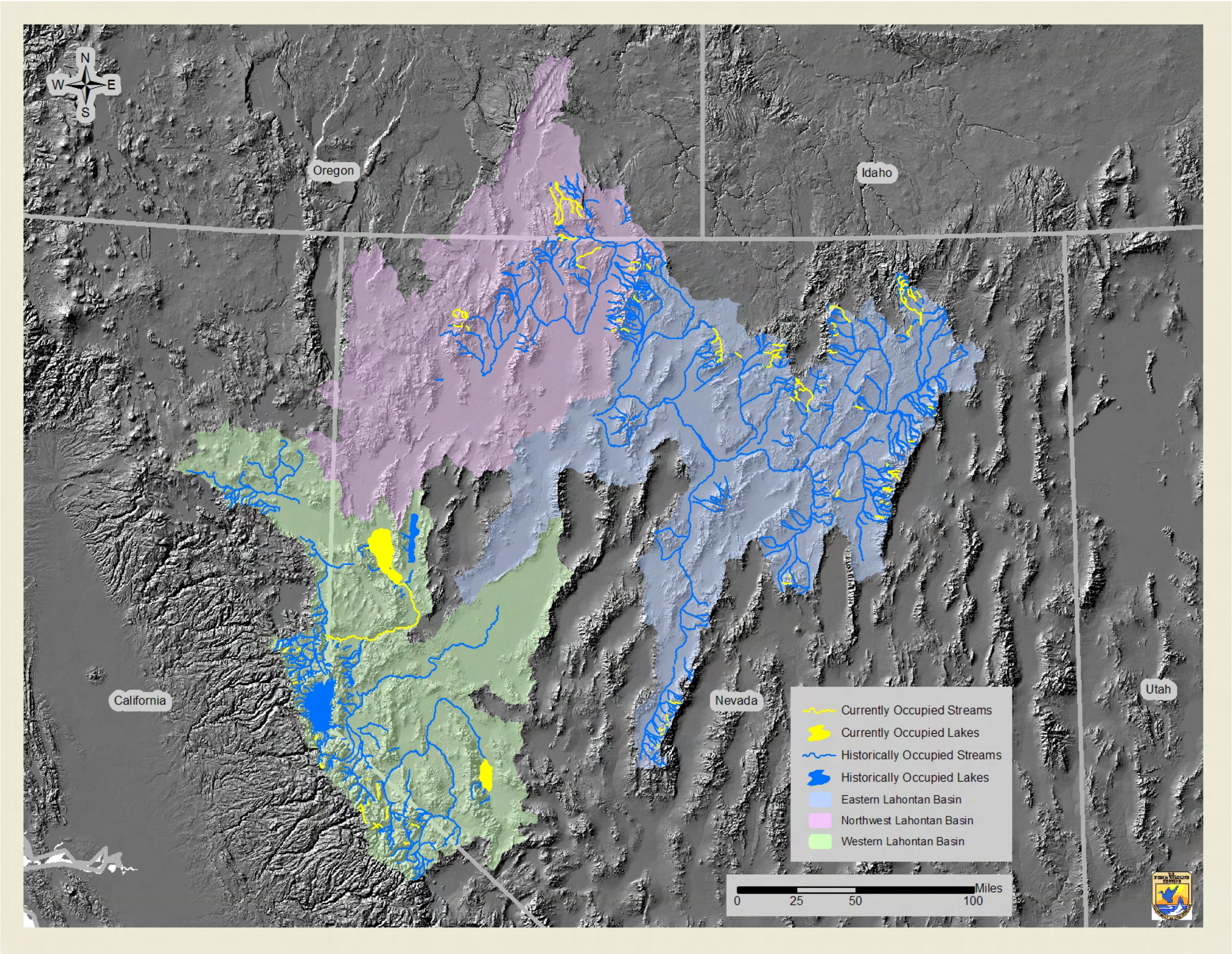

Figure 2. Probable historical (blue) and currently occupied (yellow) Lahontan cutthroat trout habitat separated into the Eastern, Northwest, and Western Lahontan Basins, prepared for 2009 5-year review. Out-of-Basin populations are not depicted on this map.

isolated stream reaches (52 populations, or 72.2 percent of the total number of conservation populations); however, the remaining 20 conservation populations have some level of connectivity and occupy 485.1 stream km (301.3 mi), or 63 percent of occupied stream habitat (Table 3).

LCT currently occupy five of their historical lakes (Summit, Independence, Pyramid, Fallen Leaf, and Walker Lakes) which constitute 46.8 percent of their historical lake habitat (Table 2). However, only two lakes (Summit and Independence Lakes) have self-sustaining populations, which comprises less than one percent of the historical lake habitat. All other lake populations within the Western Lahontan Basin are completely maintained by Federal, State, and Tribal hatchery stocking programs. LCT are also stocked into many other lakes (*e.g.*, Heenan Lake and Red Lake in the Carson River watershed) outside their historical range for recreational purposes.

Abundance

Comparisons of occupied stream miles reported in the 1995 Recovery Plan (Service 1995, pp. E1-E10) and in this status review are not applicable due to different methodologies and mapping resolutions. However, we can compare the list of occupied streams identified in 1995 to the list of occupied streams in this review. Since 1995, LCT have been introduced/established in 12 new waters, have remained present in 147 waters, and have been extirpated from 32 streams (Table A2.2). Note that some populations in streams listed as occupied in the 1995 Recovery Plan may have already been extirpated (see comments in Table A2.2). In addition, current populations in certain historical waters (Truckee River, Sagehen Creek, Hunter Creek, Dog Creek, Pyramid Lake, Fallen Leaf Lake, Walker Lake) in the Truckee River, Lake Tahoe, and Walker Lake watersheds were established and are maintained by hatcheries.

LCT populations fluctuate significantly because of highly variable environmental conditions in the Great Basin and life history attributes of the subspecies (Dunham 1996, pp. 22-24; Ray *et al*. 2007, pp. 70-82). Extensive demographic studies of LCT indicate extreme year-to-year variability in numbers of each age class (Neville and DeGraaf 2006, pp. 13-17; Ray *et al*. 2007, pp. 70-82). This variability in numbers reflects variability in recruitment and survival among years. Data from several populations indicate that recruitment is strongly associated with average stream flow from March through June and that survival is a strong function of population density (Ray *et al*. 2007, pp. 102-121). Seasonal and annual changes in climatic conditions and stream discharge can lead to dramatic population expansions or contractions (Dunham 1996, p. 64; Neville and DeGraaf 2006, pp. 4-6, 13-17; Ray *et al*. 2007, p. 77). Despite the high variability found in population size, Ray *et al*. (2007, p. 74) reported a general decline in population size in 13 different streams studied in the Eastern Lahontan Basin from 1996 to 2002.

Most stream densities of LCT are small due to the small extent of habitats they occupy. From our analysis of the available information, we estimate that over 83 percent (856.1 km [532.0 mi]) of the currently occupied habitat has 94 or fewer fish per km (150 fish/mi) (Table 4). Population density estimates between 94 and 250 fish/km (151 and 400 fish/mi) are found in approximately 11.4 percent (117.8 km [73.2 mi]) of currently occupied habitat, and densities greater than

Table 4. Stream length and percent occupied habitat for each fish density category (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

Fish Density Category fish/km (fish/mi)	Occupied Stream Length km (mi)	Percentage of Occupied Stream Length
0-31 (0-50)	432 (268.6)	42.0
32-94 (51-150)	423.9 (263.4)	41.1
94-250 (151-400)	117.8 (73.2)	11.4
>250 (> 400)	31.5 (19.6)	3.1
Unknown	24.7 (15.4)	2.4

250 fish/km (400 fish/mi) are found in approximately 3.1 percent (31.5 km [19.6 mi]) of currently occupied habitat (Table 4). Eight historical LCT watersheds (four in the Eastern Lahontan Basin [Upper Humboldt River, South Fork Humboldt River, Reese River, and Little Humboldt River], three in the Northwest Lahontan Basin [Upper Quinn River, Lower Quinn River, and Coyote Lake], and one Western Lahontan Basin [Pyramid Lake]) and six Out-of-Basin watersheds [Diamond-Monitor Valleys, Long-Ruby Valleys, Upper King, Upper San Joaquin, Upper Mokelumne, and Crowley Lake]) have over 90 percent of the currently occupied stream habitat with population densities of 94 or fewer fish per km (150 fish/mi) (Table A2.3). The most dense populations (greater than 250 fish/km [400 fish/mi]) are found in North Fork Humboldt, Rock Creek, West Fork Walker River, Dixie Valley, Big Smoky Valley, and Upper Yuba River watersheds (Table A2.3).

Habitat or Ecosystem

Specific habitat requirements for cutthroat trout are described in Hickman and Raleigh (1982, pp. 3-7) and summarized below. Optimal stream habitat is characterized by clear, cold water with silt-free substrate and a 1:1 pool-riffle ratio (see Factor E, Climate Change section, for a discussion of stream temperatures). Streams should have a variety of habitats including areas with slow deep water, abundant instream cover (*i.e.*, large woody debris, boulders, undercut banks), and relatively stable streamflow and temperature regimes. Streambanks should be well vegetated to provide cover, shade, and bank stabilization.

Our analysis of the available information indicates that most of the streams and stream reaches currently occupied by LCT are small with approximately 74 percent (763.3 km [474.3 mi]) being 3 meters (m) (10 feet (ft)) or less in width (Tables 5 and A2.4). Watersheds in which all currently occupied habitat is 3 m (10 ft) or less in width include the North Fork Humboldt River, Pine Creek, Rock Creek, and Reese River in the Eastern Lahontan Basin; Upper and Lower Quinn River in the Northwest Lahontan Basin; East Fork and West Fork Walker River in the Western Lahontan Basin; and all Out-of-Basin watersheds (Table A2.4). In addition, the majority of conservation populations (72.2 percent) occur in stream reaches 8 km (5 mi) long or less (Table 6).

Of the 1,031.3 stream km (640.8 mi) currently occupied by LCT, approximately 62 percent occur on public lands managed by Federal agencies (Tables 7 and A2.5), with 285.3 km (177.3 mi) on National Forest and 351.4 km (218.4 mi) on Bureau of Land Management (BLM) lands. Other

Table 5. Stream length and percent occupied habitat for each stream width category (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

Stream Width Category m (ft)	Occupied Stream Length km (mi)	Percentage of Occupied Stream Length
< 1.5 (< 5)	370.5 (230.2)	36.0
1.5-3.1 (5-10)	392.8 (244.1)	38.1
3.1-4.6 (10-15)	73.6 (45.7)	7.1
4.6-6.1 (15-20)	62.7 (38.9)	6.1
>7.6 (> 25)	129.2 (80.3)	12.5
unknown	1.2 (0.7)	0.1

Table 6. Number of conservation populations by occupied stream length (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

	Stream Length km (mi) Category			
	< 8 (< 5)	8-16.1 (5-10)	16.1-24.1 (10-15)	> 24.1 (> 15)
Number of Conservation Populations	53 (73.6%)	7 (9.7%)	4 (5.6%)	8 (11.1%)
Mean Length km (mi)	4.2 (2.6)	11.8 (7.3)	18.9 (11.7)	45.4 (28.2)
Median Length km (mi)	3.9 (2.4)	11.3 (7.0)	17.4 (10.8)	44.0 (27.4)
Range km (mi)	0.7–7.9 (0.4 – 4.9)	9.7–15.7 (6.0 – 9.8)	16.7–23.9 (10.4 – 14.8)	24.9–71.1 (15.5 – 44.2)

Table 7. Stream length and percent occupied habitat by land ownership (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

Land ownership	Occupied Stream Length km (mi)	Percentage of Occupied Stream Length
Bureau of Reclamation	3.1 (1.9)	0.3
Tribal	51.5 (32.0)	5.0
State	54.1 (33.6)	5.3
Private	284.4 (176.7)	27.6
US Forest Service	285.3 (177.3)	27.7
Bureau of Land Management	351.4 (218.4)	34.1

occupied habitat (38 percent) occurs on private (284.4 km [176.7 mi]), State (54.1 km [33.6 mi]), and Tribal (51.5 km [32.0 mi]) lands (Tables 7 and A2.5). Lacustrine LCT populations have adapted to a wide variety of lake habitats from oligotrophic (with low nutrient levels and primary productivity) alpine lakes (*e.g.*, Independence Lake) to large, productive desert terminal lakes (*e.g.*, Pyramid Lake). Unlike most freshwater fish species, LCT have been reported to tolerate alkalinity and total dissolved solid levels as high as 3,000 milligrams/liter (mg/L) (3,000 parts per million (ppm)) and 10,000 mg/L (10,000 ppm), respectively (Dickerson and Vinyard 1999a, pp. 510-514). Walker Lake is the most saline-alkaline water body with LCT; however, it is unknown how long stocked LCT can survive in Walker Lake due to the decreasing lake levels and increasing total dissolved solids which have recently exceeded 16,000 mg/L (16,000 ppm) (Lopes and Smith 2007, p. 3). LCT stocked into the lower Walker River may have better survival rates in Walker Lake through self-acclimation to alkaline water quality in the river before entering Walker Lake (J. Bigelow, 2009, personal communication).

Changes in Taxonomic Classification or Nomenclature

Lahontan cutthroat trout was first listed as *Salmo clarki henshawi*; 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

The 1995 Recovery Plan identified strategies for recovery that included population management that addressed genetic variation within and among LCT stocks, opportunities to maintain or develop large networked populations, and reintroduction programs. Principle among these issues is protecting the limited diversity of the remaining genetic stocks of LCT. Variable forms of lacustrine and fluvial LCT stocks occur within different Lahontan Basins and watersheds. The Recovery Plan states that isolated populations represent a potentially unique gene pool with characteristics that may differ from all other populations and that whenever possible, genetic stocks should be maintained within their historical basin source (Service 1995, p. 51). A wide range of taxonomists and conservation biologists recognize the uniqueness of locally-adapted LCT populations and their importance for restoration and recovery.

The Recovery Plan states that the lacustrine-adapted LCT are extremely vulnerable to extinction because only two small naturally reproducing populations exist within their historical range (Independence Lake and Summit Lake). Consequently, the Recovery Plan specifically addresses the potential importance of remnant populations of the lacustrine form of LCT from Lake Tahoe, Pyramid Lake, and Walker Lake that were transplanted to several areas outside their historical range. These populations are identified in the Recovery Plan as key to the recovery of the lacustrine-adapted form. Outplanted populations then hypothesized to be Truckee and Walker River watershed-related were Morrison and Bettridge Creeks in the Pilot Peak range in Utah (Pilot Peak strain), Macklin Creek in the Yuba River drainage of California, Edwards Creek in the Desatoya Mountains of central Nevada, and O'Harrel Creek in the eastern Sierra Nevada Mountains. The Service's Lahontan National Fish Hatchery Complex in Gardnerville, Nevada, began development of a broodstock of the Pilot Peak LCT in 1995 to secure that population strain for future potential recovery actions.

The Recovery Plan calls for genetic and ecological research to determine the role of lacustrine habitat and populations in future recovery efforts. The Service funded a comprehensive analysis of genetic variation and population genetic structure in part to determine the relatedness and appropriateness of these outplanted populations for recovery of lacustrine populations in Lake Tahoe, and Pyramid and Walker Lakes. The results of this effort are found in Peacock and Kirchoff (2007, pp. 70-74, 76) and clarifies the origins of some of these remnant Out-of-Basin populations (Appendix 3, Phylogentic Trees).

In summary, the Pilot Peak broodstock and Bettridge Creek populations were derived from the Morrision Creek population and are definitively of Truckee River watershed ancestry (Peacock and Kirchoff 2007, pp. 71-72). Phylogentic analyses place these LCT populations as the most closely related populations to known Lake Tahoe-Truckee River watershed historical samples obtained from museum specimen collections made prior to extirpation in the 1940's (Peacock and Kirchoff 2007, pp. 71-72). LCT found in Macklin Creek, which was believed to be the original Lake Tahoe strain, is more closely related to the Willow-Whitehorse populations in Oregon (Coyote Lake watershed); more study is needed to determine the reason for this strong association (Peacock and Kirchoff 2007, pp. 71-72). LCT found in Edwards Creek are more closely aligned with Reese River LCT than the Truckee River watershed historical samples and may provide a good donor source for Reese River reintroductions in the future (Peacock and Kirchoff 2007, pp. 73, 76). LCT in O'Harrel Creek aligned with the Carson River populations (Peacock and Kirchoff 2007, pp. 71-73, 76). Thus, the Pilot Peak strain represents the only known outplanted LCT population with Truckee River watershed ancestry.

The status of native LCT in the Western Lahontan Basin (Truckee, Carson, Walker River watersheds) is the most tenuous. There are no extant fluvial populations of LCT native to the Truckee River watershed. A population was founded with Independence Lake LCT in the upper Truckee River, but nonnative brook trout (*Salvelinus fontinalis*) threaten the long-term persistence of this population (see Factor A, Recovery Actions section below). Independence Lake and the Out-of-Basin Pilot Peak strain are the only extant native Truckee River watershed LCT. While Pilot Peak LCT have the strongest phylogenetic relationship to LCT of known Lake Tahoe-Truckee watershed origin, the Independence Lake LCT do not show a strong phylogenetic relationship with either Pilot Peak or Truckee River watershed historical samples or any other Western Lahontan Basin populations (Peacock and Kirchoff 2007, pp. 71-72). The population-level phylogenetic tree of Western Lahontan Basin populations is largely unresolved due to a combination of factors including historical genetic differentiation within basins, contemporary loss of most populations in these watersheds, isolation of existing populations, and the concomitant loss of genetic diversity through small population size and genetic bottleneck events (Peacock and Kirchoff 2007, p. 86).

Extant Walker River watershed populations were founded from LCT in By-Day Creek, a small, isolated population of unknown origin. It is unknown if By-Day Creek is a remnant LCT population from when the watershed was largely occupied or if LCT were planted in these waters sometime in the 20th century. The current fluvial LCT populations in the Walker River watershed are genetically very depauperate (Peacock and Kirchoff 2007, pp. 68-70). Loss of genetic diversity through repeated founder events (a limited number of colonizers at a particular site) and/or genetic bottlenecks (a sudden decrease in population size) has resulted in an inability to reconstruct the evolutionary history of these populations, not only with regard to other LCT populations in the Western Lahontan Basin but throughout the extant range (Peacock and Kirchoff 2007, pp. 68-70). Low levels of genetic diversity and the unknown evolutionary origin of these fish precludes their use to create a broodstock from these populations for recovery activities in the Walker River watershed.

The Pilot Peak strain of LCT has a high level of heterozygosity and allelic richness (measures of genetic diversity) and retains the genetic signature of its source population, as indicated by genetic microsatellites (Peacock and Kirchoff 2007, p. 73). As such, this strain likely retains any adaptations specific to lacustrine life history and represents the best chance for recreating native networked populations within the Lake Tahoe-Truckee and Walker River watersheds.

In this same genetic study, the authors explored the population genetic diversity and genetic structure of 40 extant populations within and among watersheds and within each basin (Peacock and Kirchoff 2007, pp. 11-13, 21-25, 46-70). Genetic diversity was greatest in the Eastern Lahontan Basin (sample size 13 streams) (Peacock and Kirchoff 2007, pp. 12-13, 21). This was attributed to the number of occupied streams, the size of extant populations, and availability of connected habitat. Genetic diversity was also high in the Coyote Lake Basin (sample size 2 streams), followed by the Northwest Lahontan Basin (sample size 5 streams) and the Western Lahontan Basin (sample size 11 streams) (Peacock and Kirchoff 2007, pp. 21, 23-24). Five Out-of-Basin streams sampled had moderate to very low genetic diversity (Peacock and Kirchoff 2007, p. 24). Additionally, the four lake populations sampled all had high levels of genetic diversity (Independence Lake, Heenan Lake, Pyramid Lake, and Summit Lake) (Peacock and Kirchoff 2007, p. 24).

Genetic structure is the frequency of genes and alleles (different forms of a gene), or genotypes, in a population. Genetic differentiation is the accumulation of differences in allelic frequencies among isolated populations. Genetic structure (*i.e.,* several genotypes) and differentiation in LCT were evident within a population, among populations within a watershed, and among watersheds. If sufficient habitat within an isolated stream was available or a stream network existed, genetic structure consisting of several genotypes was present (Neville *et al*. 2006, pp. 908-911; Peacock and Kirchoff 2007, pp. 82-83). In contrast, small isolated populations showed little genetic structure (*i.e.*, few genotypes) (Peacock and Kirchoff 2007, p. 24). In general, small isolated populations exhibited stronger evidence for bottlenecks (*i.e.*, differentiation expressed as reduced genotype frequencies) than populations in larger connected habitats (Peacock and Kirchoff 2007, pp. 46-68). Evidence of genetic bottlenecks was found in all streams used in this study (Peacock and Kirchoff 2007, p. 31). Genetic differentiation was found among populations within the same watershed. Stream populations which were closer to each other were more similar (*i.e.*, less differentiated) than stream populations which were farther apart (Peacock and Kirchoff 2007, pp. 33-34, 82-83). This same pattern of differentiation was found at the watershed level. For example, watersheds in the upper portion of the Eastern Lahontan Basin (*e.g.,* Marys River and North Fork Humboldt River) were more similar than watersheds found in the lower portion of the Eastern Lahontan Basin (*e.g.,* Little Humboldt River and Reese River) (Peacock and Kirchoff 2007, pp. 33-34, 82-83). Finally, genetic differentiation was also evident between basins. A phylogenetic analysis demonstrated support for geographical designations between the Eastern, Northwest, and Western Lahontan Basins (Peacock and Kirchoff 2007, p. 27), as identified in the Recovery Plan.

Species-specific Research and/or Grant-supported Activities

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

Independence Lake-United States Geological Survey, Biological Resources Division (USGS): This project continues prior Service and USGS joint efforts in recovery of LCT in Independence Lake. To prevent the extirpation of the Independence Lake strain of LCT and restore the population to some semblance of its historical abundance, nonnative salmonids need to be extirpated or controlled and reestablishment of the downstream spawning migration may be required. The project represents a 5-year study integrated with management to determine means of controlling or eliminating nonnative salmonids from the Independence Lake system, and quantifying effects to the LCT population by using the Independence Lake LCT Population Viability Model (Rissler *et al*. 2006, pp. 1-68). In addition, the project will assess the benefit of restoring a lake outlet LCT spawning migration. Project Status: Ongoing.

Population Viability Analysis-University of Nevada Reno (Ray et al. 2007, pp. 1-205): In 1993, the University of Nevada Reno (UNR) began collecting demographic and genetic data on LCT stream populations. Population viability analyses (PVA) were initiated in 1996 on streams found throughout the extant range of LCT. This research was designed to explore persistence and extinction probabilities and their environmental correlates in LCT stream populations. UNR now has 9 consecutive years of data on seven streams and 6-7 consecutive years of data on the remaining eight streams. Eight additional years of demographic data are also available for the Gance Creek population (from 1975 to 1985) (Platts and Nelson 1988, pp. 333-345). Project Status: Complete.

Genetics-University of Nevada Reno (Peacock and Kirchoff 2007, pp. 1-109): Ten highly variable nuclear microsatellite markers developed specifically for LCT (Peacock *et al.* 2004) were used to resolve evolutionary and contemporary relationships among populations within and among watersheds identified in the Recovery Plan, that were not resolved with morphological or other genetic data (Loudenslager and Gall 1980, pp. 27-42; Gall and Loudenslager 1981, pp. 1-53; Williams *et al*. 1992, pp. 1-26; Williams *et al.* 1998, pp. 1-29; Nielsen and Sage 2002, pp. 376-388). This project addressed a series of questions with these data regarding population dynamics and hierarchical phylogenetic relationships: (1) Are the Recovery Plan basin ("DPS") designations that were determined with morphological, meristic, allozyme, and mitochondrial genetic data consistent with data from microsatellite markers and more extensive and systematic sampling of extant LCT populations; (2) Is there evidence for a metapopulation dynamic within the few remaining interconnected stream habitats within the Lahontan Basin across habitat types; (3) What is the population genetic structure of extant populations within and among watersheds within each basin; (4) What is the likely origin of Out-of-Basin transplanted LCT populations putatively from the Lake Tahoe-Truckee River watershed (pre-extirpation), based upon genetic comparison with extant LCT populations and museum-preserved samples of LCT collected from 1872 to 1911 from the lower Truckee River and multiple locations in Lake Tahoe; (5) Is there historical evidence for population genetic structure of the now extinct LCT populations from within the Lake Tahoe-Truckee River watershed based upon genetic analyses of museum-preserved samples collected from multiple locations within Lake Tahoe and the lower Truckee River; and (6) How can the level and pattern of genetic diversity within extant populations inform priority ranking for recovery activities? Project Status: Complete.

Design Implementation for Ecosystem Restoration Along the Truckee River-The Nature Conservancy: The Nature Conservancy will create designs to determine the project extent, construction scope, and restoration budget to enable it to seek stakeholder financing, detailed design and engineering, and active implementation of ecosystem restoration at three restoration sites (Lockwood, Mustang Ranch, and 102 Ranch) along the lower Truckee River. Project Status: Ongoing.

Habitat Improvements due to Improved Water Management on the Truckee River-Otis Bay Consultants: This project is to conduct research and collect data to determine the results of a decade of managed flows in the Truckee River for promoting the recruitment of cottonwoods along the lower Truckee River riparian corridor from Vista downstream to Pyramid Lake. Project Status: Ongoing.

Walker River Watershed Instream Flow Study-Otis Bay Consultants: The scope of work for this project is to continue a Walker River watershed instream flow study which includes continuation of: (1) flow study as a basis for development of flow prescription for the East Fork Walker River and mainstem Walker River below to the confluence with the West Fork Walker River; (2) flood frequency analysis for appropriate gauges on the East Fork and mainstem Walker River below to the confluence with the West Fork Walker River; (3) review of flood peak modifications; (4) review of base flow modifications; (5) evaluation of flow characteristics, timing, frequency, magnitude, duration, and rate of change; (6) formulation of recommended flow regimes for wet, average, below average, and drought conditions to form a matrix similar in concept to the Truckee River; and (7) work with the Service to develop a final instream flow recommendation report. Project Status: Ongoing.

Mahogany Creek Fish Passage-Otis Bay Consultants: This project included the removal of an irrigation diversion structure on Mahogany Creek, the main spawning tributary to Summit Lake, to improve upstream fish passage for this important lacustrine LCT population. After removal of the diversion, boulders and rock were strategically placed in the stream to provide stability of the restored site and to prevent future erosion resulting from high flow events. Project Status: Complete.

McDermitt Creek Restoration-Oregon Department of Fish and Wildlife: This project involves working cooperatively with State and other Federal agencies to establish a LCT metapopulation throughout the McDermitt Creek watershed located in the Northwest Lahontan Basin along the Nevada-Oregon border. This project is being implemented in phases by building temporary and permanent barriers to isolate sections of stream to facilitate nonnative fish removal. Once nonnative fish are removed from the watershed, and the temporary barriers are removed, approximately 88.5 km (55 mi) of connected habitat will be available for LCT. 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 1970, pp. 16047-16048). The Recovery Plan (Service 1995, p. 7) identified threats from: (1) degraded and/or limited habitat; (2) displacement and/or hybridization with nonnative trout; (3) competition with nonnative fishes; and (4) decreased viability.

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

Nonnative Fish

Nonnative fish, especially salmonid species, are currently the greatest threat to LCT rangewide, resulting in loss of available habitat and range constrictions primarily through competition and 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). 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 (17 percent of all nonnative vertebrates present), brown trout (*Salmo trutta*) (16 percent), and rainbow trout (*Oncorhynchus mykiss*) (14 percent) (Lomnicky *et al*. 2007, p. 1086). Of the 6,600 km (4,100 mi) of streams sampled in Nevada, 70 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 77.2 percent of the waters sampled in Nevada were occupied by nonnatives. This indicates that there is a greater likelihood of finding nonnative vertebrates in larger streams (Whittier and Peck 2008, p. 1890).

Since the late 1800’s, fishery managers introduced nonnative salmonids and warm-water species into lake and stream habitats throughout the historical habitat of LCT (Miller and Alcorn 1945, pp. 174-191; Dill and Cordone 1997, pp. 84-112). Introduced salmonid species include rainbow trout, brook trout, brown trout, lake trout (*Salvelinus namaycush*), kokanee salmon (*Oncorhynchus nerka*), and Yellowstone cutthroat trout. Other important nonnative fish species introduced into LCT historical habitat include bass (*Micropterus* sp.), carp (*Cyprinus carpio*). and although Lahontan redside shiners (*Richardsonius egregius*) are native to most of the Lahontan basin, they have been introduced to Summit Lake and may be impacting LCT in that watershed. The majority of LCT population extirpations since the mid 1990’s have been caused by nonnative trout (Table A2.2).

Our analysis of the available information indicates that nonnative fish co-occur with LCT in approximately 36.3 percent of currently occupied stream habitat and all historical lake habitat except for Walker Lake. Most LCT populations which co-occur with nonnative species are decreasing in both range and abundance. The most common nonnative trout sympatric with (occurring in the same geographic area) LCT is brook trout (196.6 km [122.2 mi]) followed by brown (103.4 km [64.2 mi]) and rainbow trout (110.1 km [68.4 mi]) (Tables 8 and A2.6). The Western Lahontan Basin has the most currently occupied LCT habitat with nonnatives (67 percent of occupied habitat within the basin), followed by the Eastern Lahontan Basin (35.4 percent), Out-of-Basin watersheds (18.8 percent), and Northwest Lahontan Basin (14.3 percent) (Table A2.6). Six historical watersheds have over 50 percent of the currently occupied habitat co-occurring with nonnatives (2 in the Eastern Lahontan Basin [North Fork Humboldt River and South Fork Humboldt River], 1 in the Northwest [Lower Quinn River], 3 in the Western [Lake Tahoe, Truckee River, Pyramid Lake], and 3 in Out-of-Basin watersheds [Big Smoky Valley, Diamond-Monitor Valley, and Long-Ruby Valley]) (Table A2.6). In contrast, 4 historical watersheds have no nonnatives co-occurring with LCT (1 in the Eastern [Pine Creek], 1 northwest [Coyote Lake], and 2 in the Western [East Fork Carson River and East Fork Walker River], and 7 in Out-of-Basin watersheds [North Great Salt Lake Desert, Coyote Lake, Dixie Valley, Upper Yuba River, Upper King River, Upper San Joaquin, Upper Stanislaus, Upper Mokelumne, and Crowley Lake]) (Table A2.6).

Many of the Out-of-Basin streams were selected because of the lack of nonnative trout and the presence of natural barriers protecting these LCT populations from nonnative trout. Most of these streams are also in small headwater reaches. It should be noted that two important sub-watersheds found in the Upper Humboldt (Maggie Creek) and Little Humboldt River (South Fork Little Humboldt River) watersheds also do not contain nonnatives and the LCT populations in these watersheds are some of the strongest rangewide.

Competition

Competition from nonnative trout has been identified as one of the most detrimental threats to native inland cutthroat trout (Griffith 1988, pp. 136-137; Behnke 1992, pp. 53-55; Young 1995b, pp. 55-56). Some recent studies indicate that both abiotic and biotic processes can influence competitive advantages for nonnative trout over native trout (Dunham *et al*. 2002, pp. 378-383; Peterson *et al*. 2004, pp. 766-770; Shepard 2004, pp. 1092-1096; de la Hoz Franco and Budy

Table 8. Stream length and percent occupied LCT habitat which are sympatric with non-native fish (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

Species	Occupied Stream Length km (mi)	Percentage of Occupied Stream Length
Brook Trout	196.6 (122.2)	19.1
Brown Trout	103.4 (64.2)	10.0
Rainbow Trout	110.1 (68.4)	10.7
Other non-native species	167.9 (104.3)	16.3
None	656.0 (407.6)	63.7
Unknown	1.9 (1.2)	0.2

2005, pp. 387-389; Quist and Hubert 2005, pp. 681-684; Korsu *et al*. 2007, pp. 9725-9727; McGrath and Lewis 2007, pp. 1384-1388; Hasegawa and Maekawa 2008, pp. 390-392). Competition from nonnative trout, especially brook trout, is recognized as a threat to LCT (Service 1995, pp. 25-26).

Brook trout occur in five of seven occupied watersheds in the Eastern Lahontan Basin, one of three occupied watersheds in the Northwest Lahontan Basin, and three of six occupied watersheds in the Western Lahontan Basin (Table A2.6). In the Eastern Lahontan Basin, brook trout co-occur with LCT in 33.1 percent of occupied habitat in the Upper Humboldt, 34.6 percent in the Reese River, 57.6 percent in the North Fork Humboldt River, and 75.9 percent in the South Fork Humboldt River watersheds (Table A2.6). When brook trout invade streams occupied by cutthroat trout, the native cutthroat trout decline or are displaced (Griffith 1988, pp. 136-137; Behnke 1992, pp. 53-55; Young 1995b, pp. 55-56). Competition with brook trout reduces recruitment of cutthroat trout and reduces inter-annual survival of juveniles, leading to a reduction of population size (Peterson *et al*. 2004, pp. 766-769; McGrath and Lewis 2007, pp. 1389-1390). When LCT occur in the same stream as brook trout, LCT typically occupy the colder, headwater reaches and the nonnative trout occupy areas downstream (Dunham *et al*. 1999, p. 885; Dunham *et al*. 2002, p. 380). Several authors have reported high diet overlap between brook trout and native cutthroat trout (Dunham *et al*. 2000, p. 307; Hilderbrand and Kershner 2004b, p. 37; McGrath and Lewis 2007, p. 1389); however, these studies indicated that interspecific competition for food alone could not explain why brook trout out-compete cutthroat trout. In a study performed on Abel Creek (Quinn River watershed) where brook trout and LCT co-occur, 55 percent of the brook trout gained weight over the study period while 75 percent of the LCT lost weight (Osborne-Gowey *et al*. 2006, p. 9). Additionally, brook trout gained 2.5 percent of their body mass while LCT lost 6 percent of their body mass (Osborne-Gowey *et al*. 2006, p. 9).

Several studies have documented cutthroat trout populations increasing after brook trout removal (Shepard *et al.* 2002, pp. 198-200; Peterson *et al.* 2004, pp. 763-765). A population viability analysis performed on the Independence Lake LCT population predicted the population would go extinct in the next 25 years, primarily due to co-occurring nonnative brook trout and kokanee salmon (Rissler *et al*. 2006, pp. 36-37). This analysis predicted an increase in LCT persistence and population size if brook trout and kokanee salmon were removed (Rissler *et al*. 2006, p. 37). Experimental removal of brook trout from Independence Creek (the only LCT spawning tributary) has already resulted in an increase in LCT recruitment and survival, and changes in certain life history traits (*i.e.*, juvenile LCT are spending more time in Independence Creek prior to migrating to the lake) (G. Scoppettone 2008, USGS, unpublished data).

Brown trout have also been shown to displace native cutthroat trout populations through competitive advantages (Wang and White 1994, pp. 479-482; de la Hoz Franco and Budy 2005, pp. 387-389; McHugh and Budy 2005, pp. 2788-2790; McHugh and Budy 2006, pp. 1446-1449; Budy *et al.* 2007, pp. 597-602; Shemai *et al.* 2007, pp. 320-321). Brown trout occupy the best habitat, have higher growth rates, are associated with reduced survival of cutthroat trout, and have a distinct allopatric (in different geographic areas) distribution within a watershed when they co-occur with native cutthroat trout (Wang and White 1994, pp. 479-482; de la Hoz Franco and Budy 2005, p. 387; McHugh and Budy 2005, pp. 2790-2793; McHugh and Budy 2006, pp. 1449-1452; Budy *et al*. 2007, p. 597; Shemai *et al.* 2007, pp. 320-321). Brown trout co-occur with LCT in approximately 10.3 percent of LCT total currently occupied stream habitat, most of which is in the Truckee River watershed (Tables 8 and A2.6); however, they are also found in non-occupied historical LCT habitat within the Humboldt, Quinn, Little Humboldt, Reese, Truckee, Walker, and Carson River watersheds. Brown trout also occupy historical lake habitat in the Lake Tahoe watershed and Donner Lake in the Truckee River watershed.

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), LCT (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 (*O. mykiss aguabonita*) (Service 2002, p. 59242), Westslope cutthroat trout (*O. c. lewisi*) (Service 2003a, p. 47004), Gila trout (*O. gilae*) (Service 2003b, pp. 30-31), Paiute cutthroat trout (*O. c. seleniris*) (Service 2004, pp. 43-44), Yellowstone cutthroat trout (*O. c. bouvieri*) (Service 2006, pp. 8828-8829), Colorado River cutthroat trout (*O. c. pleuriticus*) (Service 2007b, pp. 32597-32599), Apache trout (*O. gilae apache*) (Service 2007c, p. 22), and Rio Grande cutthroat trout (*O. c. virginalis*) (Service 2008b, pp. 27908-27909). Nonnative rainbow trout readily hybridize with native cutthroat trout and produce fertile offspring. 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 (Rhymer and Simberloff 1996, pp. 96-100).

Our analysis of the available information indicates that rainbow trout co-occur with LCT in approximately 10.7 percent (110.1 km [68.4 mi]) of currently occupied habitat (Table 8). Similar to brown trout, rainbow trout mostly co-occur with LCT in the Truckee River watershed (Table A2.6). Currently, there are few known hybridized LCT populations; 87.5 percent of conservation populations have been tested as unaltered and another 9.4 percent are presumed unaltered because of barriers or no records of stocking nonnatives (Table 9). Moreover, several hybridized populations have recently been eradicated (see Factor A, Recovery Actions section below). However, where LCT and rainbow trout co-occur, hybridization is a substantial threat. Recent hybridization events (last 10-15 years) have occurred in streams within the Quinn River

Table 9. Stream length and percent occupied habitat by genetic status (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

Genetic Status Category	Occupied Stream Length km (mi)	Percentage of Occupied Stream Length
Unaltered (<1%)	901.8 (560.4)	87.5
>1% and <=10%	18.4 (11.4)	1.8
>30%	2.1 (1.3)	0.2
Not tested- suspected unaltered	96.4 (59.9)	9.4
Not tested- suspected hybridized	11.1 (6.9)	1.1

watershed and North Fork Little Humboldt River sub-watershed which have led to the extirpation of LCT within these watersheds (Sevon *et al*. 1999, p. 12; Peacock and Kirchoff 2004, p. 318) (Table A2.2). Rainbow trout are a larger threat to LCT in the Western Lahontan Basin, the Quinn River watershed, North Fork Little Humboldt River sub-watershed, and mainstem Humboldt River due to their continued stocking, establishment of self-sustaining populations, and presence in most historical LCT habitat within these watersheds (Peacock 2003, p. 9; Nevada Department of Wildlife 2008, pp. 1-13). The Nevada Department of Wildlife (NDOW) has recently started stocking triploid rainbow trout (sterile) in the Truckee River to reduce the threat of hybridization (NDOW 2008, pp. 7-8); however, there is a well-established, naturally reproducing population of rainbow trout throughout the entire Truckee River watershed (see Factor A, Recovery Actions section below).

To minimize contact between nonnative trout and LCT, artificial barriers have been constructed on streams to prevent nonnatives from invading LCT occupied habitat. Planned or recently constructed barriers and subsequent nonnative trout eradication projects are occurring in several different watersheds throughout the range of LCT (see Factor A, Recovery Actions section below). Where nonnatives already exist, series of temporary and permanent barriers are being constructed to facilitate eradication efforts and LCT are then reintroduced. However, isolating populations of native salmonids with barriers can restrict life history traits (such as metapopulation dynamics), isolate populations in small habitats which reduces long-term survival, and prevent recolonization if the population is extirpated (Fausch *et al*. 2006, pp. 5-9).

Invasive Species

Aquatic invasive species including *Mysis* shrimp, New Zealand mud snails (*Potamopyrgus antipodarum*), and Quagga mussels (*Dreissena rostriformis bugensis*) also potentially threaten LCT recovery. *Mysis* shrimp have been implicated in disrupting the entire food web of lakes in the Lake Tahoe watershed (Goldman *et al*. 1979, pp. 295-296; Richards *et al*. 1991, pp. 32-37; Vander Zanden *et al*. 2003, p. 276). Neither New Zealand mud snails nor Quagga mussels have been found in the historical range of LCT; however, they have been found in waters nearby. If introduced, these species could cause numerous negative impacts on existing LCT populations and their habitat or potential recovery waters (Stokstad 2007 p. 453; Davidson *et al*. 2008, p. 350). New Zealand mud snails have been found at California Department of Fish and Game's (CDFG) Hot Creek Hatchery near Mammoth Lakes, California, which is where LCT from Heenan Lake are reared. This has limited LCT stocking for recreational fisheries from this hatchery to waters outside the historical range of LCT that already contain New Zealand mud snails. We conclude that *Mysis* shrimp are currently a substantial threat to recovery actions for the lacustrine form LCT in the Lake Tahoe watershed since they are found throughout historical lake environments. New Zealand mud snails and Quagga mussels are not currently a major threat to LCT, but they are likely to be an increasing threat and may impede future recovery actions involving LCT stocking.

Summary of Nonnative Fish Impacts

We conclude that nonnative fish are the primary threat to LCT rangewide because: (1) approximately 36.3 percent of currently occupied habitat has nonnative trout present; (2)

nonnative fish have had documented negative effects on LCT populations, including extirpations; (3) efforts required to reduce or eliminate nonnative fish populations are not currently being conducted on a rangewide basis; (4) nonnative fish occur throughout the majority of historical habitat; (5) nonnative salmonids continue to be stocked and managed for within historical LCT habitat; and (6) the number of streams and lakes that need treatment to control or eradicate nonnative species exceeds the capabilities of resource managers at their current staffing and funding levels.

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). Fragmentation accelerates extinction, especially when movement of fish among stream segments is not possible, which is the case with the majority of LCT 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). 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). Evidence of loss of genetic diversity has been found in small isolated LCT populations while large connected populations have higher genetic diversity (Peacock and Kirchoff 2007, pp. 103-109).

Historically, most of the watersheds supporting LCT contained streams, rivers, and lakes that were connected allowing for movement of individuals from one population to another, increasing genetic diversity and facilitating recolonization of populations if they became extirpated (Service 1995, pp. 34-35; Dunham *et al*. 1997, p. 1131; Hilderbrand 2003, p. 264; Neville *et al*. 2006, pp. 911-914; Peacock and Kirchoff 2007, pp. 81-82; Umek 2007, pp. 13-28). For example, in the Western Lahontan Basin, lacustrine life forms of LCT migrated out of Pyramid and Walker Lakes into the Truckee and Walker Rivers to spawn, while resident fluvial forms migrated throughout these watersheds. In the Eastern Lahontan Basin, large fluvial LCT could migrate from the mainstem Humboldt River into any of its tributaries such as the Marys River, Maggie Creek, or the Reese River. As a consequence of habitat loss (due to various land use practices, water management, and nonnative fish), most of the historical LCT habitat is now fragmented and/or isolated at the stream, watershed, and basin scales.

Our analysis of the available information indicates that the majority of watersheds containing LCT conservation populations have at least one isolated population, with the most severe degree of isolation being found in the Western Lahontan Basin (81 percent of watersheds in the basin containing at least one isolated conservation population); introduced Out-of-Basin populations share a similar high degree of isolation (90 percent of watersheds containing at least one isolated conservation population) (Tables A2.7 and A2.8). Watersheds which contain completely isolated conservation populations include the Reese River, Upper Carson, East Fork Walker River, West Fork Walker River, and all of the Out-of-Basin populations (Tables A2.7 and A2.8). The only three strongly connected conservation populations (occupying more than five streams) occur in the Upper Humboldt River watershed (Marys River and Maggie Creek) and Little Humboldt River watershed (South Fork Little Humboldt River) which together represent 24.2 percent (185.0 km [115.0 mi]) of stream habitat occupied by conservation populations (Tables A2.7 and A2.8).

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 LCT. 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 2004a, 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). The shorter the stream reach the more likely it is that one or more of LCT'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*. 2003b, 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 were needed. Ray *et al*. (2007, pp. 73-76) found a general positive relationship between stream length and population size for 13 different LCT streams in the Eastern Lahontan Basin.

Our analysis of the available information indicates that, the majority (73.6 percent) of LCT conservation populations occur in short stream segments of 8 km (5 mi) or less, with a mean stream length of 4.2 km (2.6 mi) (range 0.7–7.9 km [0.4 – 4.9 mi]) and a median stream length of

3.9 km (2.4 mi) (Tables 6 and A2.9). The majority of watersheds containing LCT conservation populations have at least one population occupying less than 8 km (5 mi) of stream, with the Western Lahontan Basin (80.0 percent) and Out-of-Basin (100 percent) areas having the most populations occupying stream habitat 8 km (5 mi) or less (Table A2.9) (recall that the Out-of-Basin populations were intentionally isolated to protect them from nonnative fish). The Eastern Lahontan Basin (5 populations) and Northwest Lahontan Basin (3 populations) are the only areas which have conservation populations occupying stream habitat greater than 24.1 km (15 mi) in length (Table A2.9).

In summary, 72.2 percent (52 populations) of LCT conservation populations are completely isolated and they occur in short (less then 8 km [5 mi]) stream reaches (Tables 4 and 6). Relatively few conservation populations (seven) are found in networked streams (moderately or strongly networked), which represents nearly 32 percent of habitat occupied by conservation populations. These data indicate that habitat fragmentation and isolation pose a substantial threat to the majority of LCT conservation populations and LCT rangewide.

<u>Land Use Activities</u>

Land use activities can negatively impact aquatic systems through sedimentation, nutrient enrichment, contaminants, altered hydrology, loss of large woody debris, and loss of riparian and stream habitat (Allan 2004, pp. 263-267). Land uses associated with each LCT conservation population were identified for this review. Recreation (non-angling), grazing, angling, and roads were the top four activities occurring within watersheds occupied by conservation populations in terms of both stream length and number of conservation populations (Tables 10 and A2.10). Other notable land use activities include stream de-watering, mining, hydroelectric facilities, and timber harvest (Tables 10 and A2.10). Non-angling recreation covers various outdoor activities

Table 10. Stream lengths km (mi) of land use activities occurring with LCT conservation populations (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

Land Use Activity	Occupied Stream Length km (mi)	Percentage of Occupied Stream Length	Number of Conservation Populations (%)
Timber Harvest	14.4 (9.0)	1.9	4 (5.6%)
Other	19.8 (12.3)	2.6	3 (4.2%)
Hydroelectric, water storage, and/or flood control	71.1 (44.2)	9.3	1 (1.4%)
Mining	124.4 (77.3)	16.3	7 (9.9%)
De-watering	133.3 (82.8)	17.4	7 (9.9%)
Roads	496.4 (308.5)	64.9	37 (52.1%)
Angling	560.3 (348.2)	73.3	36 (50.7%)
Range (livestock grazing)[a]	727.0 (451.7)	95.1	64 (88.9%)
Recreation (non-angling)	748.6 (465.2)	97.9	66 (91.7%)

a = Streams which have riparian exclosures were included since livestock still graze in upland areas within the watershed.

including, but not limited to, hiking, hunting, and camping. There may be negative impacts to LCT from these activities; however, we do not have information on specific threats to LCT from non-angling recreation. Angling is discussed under Factor B and water management (*i.e.*, stream de-watering, hydroelectricity) is discussed below in Factor A. Timber harvest occurs in a very small portion of LCT occupied habitat and was a much larger threat in the late 1800's and early 1900's during the Comstock mining period (Townley 1980, pp. 3-7). Impacts from grazing, roads, mining, and fine sediment are discussed below.

Grazing

Impacts of improper 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 (undercut banks, spawning beds, etc.) or localized reductions in habitat quality (sedimentation, loss of riparian vegetation, etc.). 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.

According to Minshall *et al.* (1989, p. 118), riparian/stream ecosystems are the most threatened ecosystems in the Great Basin. 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 (Kie and Boroski 1996, pp. 485-487; Parsons *et al*. 2003, pp. 337-340). Livestock grazing can affect riparian areas by changing, reducing, or eliminating vegetation (Schulz and Leininger 1990, pp. 297-299; Green and Kauffman 1995, pp. 308-313), and by the actual loss of riparian areas through channel widening (Overton *et al*. 1994, pp. 5-7), channel degradation, or lowering of the water table (Chaney *et al.* 1990, p. 10). Effects to 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 (Belsky *et al*. 1999, pp. 425-428). Behnke and Zarn (1976, p. 5) identified livestock grazing as the greatest threat to the integrity of stream habitat in the western United States.

Recent literature has documented improved habitat conditions in the Marys River watershed due to changes in land management. Changes in grazing management along with restoration efforts significantly improved habitat conditions throughout the Marys River watershed between 1979 and the early 1990's (Gutzwiller *et al*. 1997, pp. 365-375). More recently, Newman and Swanson (2008, pp. 5-10) report continued improvements along the Marys River in most riparian and habitat conditions measured between 1997-2000 compared to conditions between 1992-1993. Changes in grazing management in the Maggie Creek sub-watershed (Upper Humboldt watershed) and Rock Creek watershed have shown improved riparian condition and continue to be monitored to document the effects to LCT (C. Evans 2009, Bureau of Land Management, unpublished data).

Our analysis of the available information indicates that some level of livestock grazing occurs in 95 percent of stream lengths containing LCT conservation populations (64 conservation populations) (Table 10). All conservation populations located in the Eastern Lahontan and Northwest Lahontan Basins, 72 percent in the Western Lahontan Basin, and 77 percent of the Out-of-Basin watersheds have some level of grazing occurring (Table A2.10). We did not compile and analyze data concerning livestock stocking rates, season of use, or utilization levels. However, only about one-third of conservation populations are protected by riparian fencing, which presumably protects streams and riparian habitat from grazing impacts (Table A2.11). We conclude that improper grazing is a threat to LCT and their habitat because grazing occurs in nearly all LCT conservation populations; however, there is uncertainty to the level of threat that we were not able to ascertain in this analysis.

Roads

The ecological effects of roads on aquatic systems and fish are well documented (Forman and Alexander 1998, pp. 216-221; Spellerberg 1998, p. 321; Trombulak and Frissell 2000, pp. 18-30; Gucinski *et al*. 2001, pp. 12-20, 24-33; Forman *et al*. 2003, pp. 171-252; Wheeler *et al*. 2005, pp. 141-164). Road crossings can create barriers to fish migration (*e.g.*, culverts), effectively isolating populations in headwater reaches (Furniss *et al*. 1991, pp. 301-302; Warren and Pardew 1998, pp. 640-643). Roads can affect the hydrology, geomorphology, and disturbance regimes in stream networks (Jones *et al*. 2000, pp. 76-85). Increases in the frequency and magnitude of flood events have been attributed to roads (Jones *et al*. 2000, pp. 79-80), which reduce a stream's ability to cope with other large disturbances, and it may not be as resilient as it once was under a normal flow regime. Water, through precipitation or shallow groundwater transport, may be intercepted by roads and rerouted into the stream at road crossings (Wemple *et al*. 1996, p. 1204), which can add to the flood peak and increase sediment delivery to streams (Sugden and Woods 2007, pp. 201-204). Several studies have found that increasing road densities were clearly associated with declining salmonid populations (Lee *et al*. 1997, pp. 1256-1258; Dunham and Rieman 1999, p. 649). Roads also facilitate movement of vectors for invasive species of plants (Tyser and Worley 1992, pp. 256-257; Forman *et al*. 2003, pp. 103-104) and animals (Rahel 2004, pp. 431-443). Increases in illegal fishing and illegal introductions of nonnative fish and other aquatic organisms are facilitated by public road access to different water bodies (Rahel 2004, p. 433).

Our analysis of the available information indicates that roads are associated with 65 percent of stream lengths containing LCT conservation populations (37 conservation populations) (Tables 10 and A2.10). Some level of road impacts occur on 90 percent of the conservation populations found in the Northwest Lahontan Basin, 67 percent in the Western Lahontan Basin, 51 percent in the Eastern Lahontan Basin, and 39 percent in the Out-of-Basin watersheds (Table A2.10). Six historical watersheds have greater than 90 percent of the stream miles occupied by conservation populations with some level of road impacts (2 in the Eastern [North Fork Humboldt River and Rock Creek], 1 in the Northwest [Upper Quinn River], 3 in the Western [Pyramid Lake, East Fork Walker River, and West Fork Walker River], and 1 Out-of-Basin watershed [Upper Yuba River]) (Table A2.10). We conclude that roads are a threat to LCT and their habitat because roads occur in the majority of LCT conservation populations; however, there is uncertainty to the level of threat that we were not able to ascertain in this analysis. Future data collection should include the number of road crossings, types of road crossings, road densities, or lengths of roads adjacent to occupied streams.

Mining

The effects of mining on receiving water systems can be a severe threat to all aquatic organisms in localized situations (Nelson *et al*. 1991, pp. 429-446). Mining can contribute toxic substances into waterways, alter stream morphology, and dewater streams completely (Nelson *et al*. 1991, pp. 429-446; Service 2008c, pp. 30-33). Up until 2001, Nevada had the second-highest level of atmospheric mercury releases in the nation (Miller 2004, p. 1). According to Toxic Release Inventory data from the Environmental Protection Agency (USEPA), major precious metal mining facilities in Nevada released between 5,443.1 and 5,896.7 kilograms (12,000 and 13,000 pounds) of mercury directly into the atmosphere from 1998 to 2001 (Higgins *et al*. 2007, p. 3), the majority of which came from the gold mining industry (USEPA 2006, pp. 1-4). Additionally, a recent advisory was issued by the Nevada State Health Division (NSHD) that recommends limiting human consumption of fish from six northern Nevada waters due to elevated methylmercury levels (NSHD 2007, pp. 1-2). A recent study found that mercury levels in the Walker River watershed are high enough that adverse effects on aquatic species may be found (Seiler *et al*. 2004, pp. 19-21). In 2008, the Service published an assessment of trace-metal exposure to aquatic biota from historical mine sites in the western Great Basin (Service 2008c, pp. 1-59). The study looked at five different streams across the western Great Basin with various levels of mining impacts (Service 2008c, p. 11). The authors found low pH and increased concentrations of certain trace-metals in some streams which pose a significant threat to aquatic biota, increased concentrations of trace-metals in stream sediment, and bioaccumulation of trace-metals in macroinvertebrates and fish (Service 2008c, pp. 30-33).

In November 2006, a perched aquifer in the headwaters of the North Fork Humboldt River began to drain due to deep core drilling at the Big Springs Mine (HydroGeo 2008, p. 62). Water levels continued to drop until spring 2008, at which time loss of groundwater stopped and some recharge of the aquifer occurred throughout the summer of 2008; however, groundwater levels still remain over 45.7 m (150 ft) below the original levels (HydroGeo 2008, p. 43). Additionally, Sammy Creek, a tributary to the North Fork Humboldt River, and portions of the North Fork have gone dry in both 2007 and 2008 due to the drained aquifer (HydroGeo 2008, p. 50).

Our analysis of the available information indicates that mining is associated with 16.3 percent of stream lengths containing LCT conservation populations (7 conservation populations) in the Eastern and Northwest Lahontan Basins (Tables 10 and A2.10). In the Eastern and Northwest Lahontan Basins, the North Fork Humboldt River watershed is the most impacted watershed with 100 percent of the conservation populations being impacted by mining, followed by the Upper Humboldt River watershed (38.6 percent), Rock Creek watershed (16.7 percent), Reese River watershed (15.4 percent), and Upper Quinn River watershed (7 percent) (Table A2.10). We did not compile data concerning the type of mining (*i.e.*, gold, silver, copper, open pit, below ground), whether mining was active or historic, or the occurrence of other mining-associated activities. We also did not compile data concerning mining impacts on historical waters which may preclude reintroduction of LCT into these streams. Mining is an overall low threat to LCT on a rangewide basis; however, it is locally important in several watersheds as mentioned above. Due to the current high price in gold, we expect this threat to expand into other areas.

Fine Sediment

Effects of suspended sediment, either as turbidity or suspended solids, on fish are well documented (Newcombe and MacDonald 1991, pp. 72-82; Bash *et al*. 2001, pp. 1-74). Suspended sediments can affect fish behavior, physiology, and embryo survival, and produce habitat alterations which may result in physiological stress and reduced growth and survival (Suttle *et al*. 2004, p. 971). Additionally, temperature acts synergistically to increase the effects of suspended sediment (Newcombe and Jensen 1996, p. 713). The severity of effects of suspended sediment increases as a function of the sediment concentration and exposure time, or dose (Newcombe and Jensen 1996, pp. 700-702).

Effects on fish behavior include avoidance of turbid water (Bisson and Bilby 1982, p. 372), altered territoriality (Berg and Northcote 1985, pp. 1412-1414), changes in foraging and predation (Gregory 1993, pp. 243-244; Gregory and Northcote 1993, pp. 236-238), and homing and migration (Whitman *et al*. 1982, p. 67). Physiological effects associated with increased levels of suspended sediment or turbidity include gill trauma (Berg and Northcote 1985, p. 1416) and increased plasma cortisol levels indicating stress (Redding *et al*. 1987, pp. 741-742). Survival of salmonid embryos is reduced dramatically as fine sediment increases (Bjornn and Reiser 1991, p. 99). Common alterations of salmonid habitat from fine sediment deposition are increased embeddedness (the degree to which gravel, cobble and boulders are covered or sunken into the silt, sand or mud of the stream bottom) (Chapman 1988, pp. 4-6), reduction of habitat complexity and abundance (McIntosh *et al*. 2000, pp. 1483-1486), decreased areas for refugia (Poole and Berman 2001, p. 796), reduced spawning and rearing habitat (Platts *et al*. 1989, pp. 280-282), and alterations to hyporheic (zone of stream where mixing of shallow groundwater and surface water occurs) inputs (Baxter and Hauer 2000, p. 1478).

Excess fine sediment can be caused by many different factors including, but not limited to roads, grazing, and mining activities. Our analysis of the available information indicates that excess fine sediments were present in over 61 percent of LCT occupied habitat that was categorized in fair or poor condition, as defined below (258.1 km [160.4 mi]) (Table A2.12). In addition, no data were compiled on turbidity or suspended solid levels. We conclude that fine sediment is a threat to LCT and their habitat because it occurs in the majority of LCT populations categorized as fair or poor; however, there is uncertainty to the level of threat that we were not able to ascertain in this analysis. Future data collection should determine the cause of excessive fine sediment in these streams on a rangewide basis.

Habitat Condition

The impacts of land use activities were not individually evaluated in relation to the LCT conservation populations. Instead, we evaluated overall habitat quality for currently occupied LCT streams. The evaluation considered both natural habitat features and human disturbances, including land use activities described above. A stream is ranked excellent if it has ample pool habitat, low sediment levels, optimal stream temperatures, and quality riparian habitat (May and Albeke 2008, pp. 10-11, 27-29). Good habitat quality has some attributes that are slightly less than ideal, fair habitat has a greater number of attributes that are less than ideal, and poor habitat quality has most habitat attributes in inferior conditions (May and Albeke 2008, pp. 10-11, 27-29).

Our analysis of the available information indicates that approximately 57.6 percent of currently occupied LCT habitat is in excellent (49.1 km [30.5 mi]) or good (545.1 km [338.7 mi]) condition, while 40.5 percent of currently occupied LCT habitat is in fair (397.3 km [246.9 mi]) or poor (20.3 km [12.6 mi]) condition (Table 11). The remaining two percent [18.7 km (11.6 mi)] is in an unknown condition (Table 11). The majority of occupied habitat in the Eastern Lahontan Basin (57.5 percent) is in poor or fair condition (Table A2.13) while only 5.9 percent in the Northwest Lahontan Basin is in fair or poor condition. Five historical watersheds (2 in the Eastern Lahontan Basin [Pine Creek and Rock Creek] and 3 in the Western Lahontan Basin [Lake Tahoe, Pyramid Lake, and East Walker River], and 2 Out-of-Basin watersheds [Northern Great Salt Lake Desert and Upper Mokelumne]) have over 90 percent of the currently occupied stream habitat characterized in poor or fair condition (Table A2.13). In contrast, 4 historical watersheds (2 in the Northwest Lahontan Basin [Lower Quinn River and Coyote Lake Basin] and 2 in the Western Lahontan Basin [Truckee River and West Fork Walker River]), and 6 Out-of-Basin watersheds (Dixie Valley, Long-Ruby Valley, Upper King River, Upper San Joaquin River, Upper Stanislaus River, and Crowley Lake) have greater than 90 percent of the currently occupied stream habitat characterized in good or excellent condition (Table A2.13).

Habitat condition varies by land management agency (Table 12). The Bureau of Land Management manages 34.1 percent of all occupied LCT stream habitat, of which 28.0 percent is in fair or poor condition. The Forest Service manages 27.7 percent of occupied LCT stream habitat, of which nearly 40 percent is in fair or poor condition. Private, State, and Tribal entities manage 37.9 percent of occupied LCT stream habitat, of which nearly 45 percent of private, 66 percent of State, and 82.8 percent of Tribal LCT habitat are in fair or poor condition (Table 12). When currently occupied habitat condition data were collected, biologists were asked to choose the top three habitat attributes which categorized each stream segment (May and Albeke 2008, pp. 10-11). When streams were categorized as excellent or good, the top three attributes were: (1) pool habitat contributes 35-60 percent of the total stream habitat area; (2) streambank stability is greater than 90 percent; and (3) streambank cover is greater than 25 percent (Table A2.12). When streams were categorized as fair or poor, the top three attributes were: (1) streambank stability is less than 75 percent; (2) substrate fine sediments (less than 0.25 in [6.3 mm]) exceed 25 percent; and (3) amount of pool habitat is below 35 percent of the total stream habitat area (Table A2.12).

Table 11. Stream length km (mi) and percent occupied habitat within each habitat category (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

Habitat Category	Occupied Stream Length km (mi)	Percentage of Occupied Stream Length
Excellent	49.1 (30.5)	4.8
Good	545.1 (338.7)	52.9
Fair	397.3 (247.0)	38.6
Poor	20.3 (12.5)	2.0
Unknown	18.7 (11.4)	1.8

Table 12. Stream length km (mi) of currently occupied LCT habitat in each habitat category separated by land ownership (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

Land Ownership	Habitat Quality Category					
	Unknown	Poor	Fair	Good	Excellent	Total
Bureau of Land Management	5.1 (3.2)	1.6 (1.0)	97.0 (60.3)	240.6 (149.5)	7.2 (4.5)	351.6 (218.5)
Forest Service	10.0 (6.2)	8.2 (5.1)	104.9 (65.2)	126.3 (78.5)	35.9 (22.3)	285.3 (177.3)
Private	1.6 (0.9)	10.5 (6.5)	116.8 (72.6)	153.7 (95.5)	1.9 (1.2)	284.5 (176.9)
State	0.5 (0.3)		35.9 (22.3)	14.0 (8.7)	4.0 (2.5)	54.4 (33.8)
Tribal	1.4 (0.9)		42.6 (26.5)	7.4 (4.6)		51.5 (32.0)
Bureau of Reclamation				3.1 (1.9)		3.1 (1.9)

Many different types of land uses occur within occupied LCT habitat and the impacts from these land uses are variable. Over 40 percent of the habitat occupied by conservation populations was characterized in fair to poor condition; however, the cause of this condition was difficult to decipher from the protocol used. Hilderbrand (2003, p. 263) found that increasing carrying capacity of a stream increased persistence of that population. Since the majority of LCT populations are isolated, improving habitat conditions may be the only option to increase carrying capacity and subsequently increase long-term persistence. In summary, due to the fact that over 40 percent of the stream habitat occupied by LCT rangewide is in only fair or poor condition, we conclude that land use activities overall remain a threat to LCT throughout its range.

<u>Drought</u>

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 historic drought conditions likely negatively impacted LCT. For example, Benson *et al*. (2002, p. 680) reported that drought conditions 3,800-6,500 years before present caused Lake Tahoe to fall below its natural rim and stop contributing flows to the Truckee River, which ultimately reduced water levels in Pyramid Lake and most likely isolated LCT populations in various parts of the watershed. Due to dispersal abilities, metapopulation dynamics, and unimpaired connected habitat in which they evolved, LCT were able to persist and repopulate areas when conditions became favorable, despite these severe recurring drought conditions (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). Drought related decreases in several LCT populations have recently been documented (Sevon *et al.* 1999, p. 13; Neville and DeGraaf 2006, pp. 7, 13-15; Ray *et al*. 2007, p. 77).

Small streams (width of 1.5 m [5 ft] or less) are more susceptible than larger streams to drying, increased stream temperatures during the summer, and freezing during the winter, and stream width is an indicator of these risks (Lake 2003, pp. 1163-1164). Approximately 35 percent of currently occupied LCT habitats are in streams that are 1.5 m (5 ft) or less in width (Table 5). 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 (White and Rahel 2008, p. 891). Since most LCT conservation 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).

LCT populations have been severely reduced or even extirpated due to drought-related effects (Service 1995, p. 37; Dunham 1996, p. 20; Neville and DeGraaf 2006, p. 7, 13-15; Ray *et al*. 2007, p. 77). Since most populations are isolated, recolonization after extirpation or input of genetic material from other populations cannot occur naturally. The reduction of flow into important terminal lakes is decreasing water quality and affecting LCT survival (see Water Quality section below). With more frequent and severe droughts likely accompanying climate change (see Factor E, Climate Change section below), we conclude that drought is a threat to LCT throughout its range.

<u>Water Quality (Pyramid and Walker Lakes)</u>

Pyramid Lake and Walker Lake are terminal lakes in the Truckee and Walker River watersheds, respectively. Pyramid and Walker Lakes are two of only eight large hyposaline (less than 20,000 mg/L [20,000 ppm]) lakes in the world (Beutel *et al*. 2001, p. 91). Terminal lakes are sensitive to changes in stream inflows, and lake levels have fluctuated greatly over time due to natural and anthropogenic influences (Lebo *et al*. 1994, p. 88; Beutel *et al*. 2001, p. 101; Mensing *et al*. 2004, pp. 32-36; Yuan *et al*. 2004, pp. 5-9). Lower lake levels have caused a suite of water quality issues which have negatively affected LCT in these lakes, including lowered dissolved oxygen, increased nutrient concentrations, increased temperatures, increased concentrations of pollutants from upstream urban areas, and increased total dissolved solids (TDS) (Service 2003c, pp. 16-17; 2003d, pp. 15-16).

Beutel *et al*. (2001, p. 95) reported that TDS levels in Walker Lake increased from 2,600 mg/L (2,600 ppm) in 1882 to between 14,000 and 15,000 mg/L (14,000 and 15,000 ppm) in 1995. Additionally, Beutal *et al*. (2001, p. 101) predicted that if historical desiccation rates continued, salinity levels would reach critical levels (15,000-16,000 mg/L [15,000-16,000 ppm]) for fish persistence by 2020. More recently, TDS levels have exceeded 16,000 mg/L (16,000 ppm) (Lopes and Smith 2007, p. 3). Increasing TDS has had a profound influence on the biota of Walker Lake with three of the five endemic fishes and several zooplankton species having gone extinct in the last century (Beutel *et al*. 2001, p. 100). Only tui chub (*Gila bicolor*) and LCT persist in Walker Lake; however, LCT are maintained by hatcheries as there is no natural reproduction. Walker Lake is the most saline-alkaline water maintaining a LCT recreational fishery; however, stocked LCT have to be acclimated prior to being released into Walker Lake to improve survivorship when TDS levels are above 10,000 mg/l (10,000 ppm).

The elevation of Pyramid Lake has also declined over the last century, increasing TDS levels; however, due to its larger volume and inflows, TDS levels have not increased at the same rate as in Walker Lake. TDS levels were approximately 3,500 mg/L (3,500 ppm) in 1882 and now fluctuate between 5,000 and 6,000 mg/L (5,000 and 6,000 ppm) (Stockton *et al*. 2003, p. 4). The native fish assemblage is still present in Pyramid Lake; however, LCT do not reproduce naturally and the population is maintained by hatcheries.

Pyramid and Walker Lakes have fluctuated in elevation naturally over time; however, anthropogenic impacts in the past century have caused measurable affects to water quality which have negatively impacted the lacustrine form of LCT. We conclude that decreases in water quality are a substantial threat to LCT in these lake populations, with the threat imminent in Walker Lake.

<u>Water Management</u>

Truckee River

In California, dams on tributaries of the Truckee River have significant impacts on Truckee River discharge. Prominent dams include Lake Tahoe, Donner Creek, Martis Creek, Prosser Creek, Stampede, Boca, and Independence Lake Dams. Although a number of flood storage facilities exist in the Truckee River watershed’s upper reaches, their actual influence on flood magnitude is unclear (Service 2003c, p. 12).

Our analysis of historical flood records at the USGS Farad gage indicate that there is no difference in the magnitude of Truckee River watershed flooding prior to and following the year 1962, despite the construction of Prosser Creek (1962), Stampede (1970), and Martis Creek

(1971) Dams. Human modifications of the river channel (including channelization and channel incision) have significantly increased flood magnitude in the river's downstream reaches. Although the presence of dams and reservoirs alters the magnitude, duration, and frequency of flow events, management of Stampede Reservoir and Prosser Creek Reservoir will provide the opportunity to implement instream flows that resemble the natural flow regimes, once the Truckee River Operating Agreement is implemented (Service 2003c, pp. 12-13).

The Service funded research that led to the development of variable instream flow recommendations for the Truckee River. Flow management that varies across seasons and across years appears to be the only solution for meeting all ecosystem needs in a naturally variable riverine system with variable availability of water for environmental flows. Four flow management regimes recommended by The Nature Conservancy for the lower Truckee River in 1995 were designed for variable flow management based on water availability and existing knowledge about biological flow requirements and physical processes that sustain the system (Service 2003c, pp. 13-14). We managed for these flows from 1995 through 1999 using reservoir releases, which resulted in substantial improvement in the riparian forest below Derby Dam and in other sites throughout the mainstem Truckee River, where appropriate substrate and bank slope occurred (Rood *et al*. 2003, pp. 650-654).

Water availability in the Truckee River is determined by four principle factors, amount of water in the Sierra snowpack, reservoir storage levels, expected river flows below Derby Dam without environmental supplements, and expected reservoir flood surcharge. Once water availability for the year in question is determined (high, fair, moderate, or poor), decisions regarding the priorities in ecosystem management need to be made. For this, we currently recognize six basic issues, LCT recruitment, riparian woodland recruitment and maintenance, cui-ui (*Chasmistes cujus*) recruitment and population maintenance, invertebrate community maintenance, and maintenance of the riverine environment (temperature, oxbow wetland maintenance, sediment transport). Other priorities for ecosystem management may arise as more scientific knowledge is acquired about the system (Service 2003c, p. 14).

Total diversions at Derby Dam represent about 32 percent of the average annual flow of the Truckee River watershed measured at the USGS Farad gauging station near the California-Nevada state line. The average amount of flow diverted at Derby Dam has declined over time, primarily due to the development of Operating Criteria and Procedures (OCAP) for the Newlands Project, and further refinement of OCAP in 1998 under the Adjusted OCAP (U.S. Department of Interior 2004, pp. 3-10 – 3-11). The effects of flow depletion at Derby Dam are apparent in virtually every type of hydrologic analysis. Based on its historical record of operation, Derby Dam probably imposes the single largest hydrologic disruption of the Truckee River in Nevada. Dams and diversions have been a key cause of habitat degradation because they affect seasonal flow variability and flood magnitude. Lower lake levels in Pyramid Lake have also reduced the ability of LCT to access the Truckee River for spawning (Service 2003c, p. 11).

The Truckee River watershed has in excess of 40 potential barriers to fish migration (Table 13). Barriers have impeded LCT migration to historical spawning and rearing habitats. Certain structures are complete obstructions to upstream migration, while others are only partial barriers.

Table 13. A list of of the primary Truckee River diversions from the California-Nevada state line downstream to Pyramid Lake, Nevada. Most diversions supply water for irrigation and municipal needs, except three diversions which supply water for hydroelectric or power generation (Service 2003c, p. 15).

Diversion Name	Use	Return Flow
Steamboat Ditch	Irrigation	Through Steamboat Creek
Verdi Power Diversion and Coldron Ditch	Power generation, irrigation	Through Verdi Powerhouse
Washoe Power Diversion and Highland Ditch	Power generation, municipal	Washoe Power through Mogul Powerhouse. None through Highland Ditch
Last Chance Ditch	Irrigation and municipal	Through Steamboat Creek
Lake Ditch	Irrigation and municipal	Through Steamboat Creek
Orr Ditch	Irrigation	Through North Truckee Drain
Cochrane Ditch	Municipal	None
Glendale Treatment Plant	Municipal	None
Pioneer Ditch	Irrigation	Through Steamboat Creek
Largomarsino-Murphy Ditch	Irrigation	To Truckee River
McCarran Ditch	Irrigation	None
Tracy Power Plant	Power generation	To Truckee River via cooling ponds
Derby Dam/Truckee Canal	Interbasin transfer Lahontan Reservoir	Partial to Truckee River
Numana Dam	Irrigation	None

When access is limited, fish may be forced to utilize sub-optimal habitats, which exposes them to potential predation and competition from nonnative fish. All life stages may be entrained in diversion canals, impinged on screens, or delayed in migration. The combined effects of disrupted migration have reduced productivity for LCT (Service 2003c, p. 11).

Truckee River Operating Agreement (TROA)

Public Law 101-618 requires the Secretary of Interior to negotiate an agreement with Nevada, California, and others for the coordinated operation of Truckee River reservoirs. A U.S. Department of Interior Coordinator, with the aid of the Service, Bureau of Reclamation, Geological Survey, and Bureau of Indian Affairs has been negotiating on behalf of the Secretary since 1991. Among other things, TROA would implement a 1989 Preliminary Settlement Agreement between the Pyramid Lake Paiute Tribe and Sierra Pacific Power Company (now NV Energy), subsequently modified by Congress to include the United States. The negotiated agreement was completed August 2007. On September 15, 2008, the Bureau of Reclamation published a proposed rule to govern the implementation of TROA (BLM 2008, pp. 53180-53187).

Implementation of TROA is expected to provide further overall benefits to inflow to Pyramid Lake over existing conditions, and benefits to LCT through improved river operations. It will lead to an anticipated annual average increased inflow to Pyramid Lake of approximately 5,200 acre-feet, which will add to the already improving conditions of the Pyramid Lake ecosystem (U.S. Bureau of Indian Affairs 2002, p. 4-88; U.S. Department of Interior 2004, p. 3-235). TROA benefits to LCT include more effective use of available storage space in Federal reservoirs and the creation of new categories of water for additional beneficial uses, including LCT (U.S. Bureau of Indian Affairs 2002, p. 4-88; U.S. Department of Interior 2004, pp. 3-229 – 3-245).

For TROA to be fully implemented, the Bureau of Reclamation, Truckee Meadows Water Authority, and the Washoe County Water Conservation District filed water right change petitions and applications with California State Water Resources Control Board. The change petitions were filed to add points of diversion, rediversion, and redistribution. Purposes and places of use for rights for Prosser Creek, Boca, and Stampede Reservoirs and Independence Lake and will be conditioned on TROA becoming effective. Currently the change petitions and applications are pending, and approval by the California State Water Resources Control Board is a necessary step to full implementation of TROA. Although TROA is not yet effective, the Truckee River reservoirs will continue to be operated under current conditions in the interim. The U.S. Department of Interior is committed to seeing TROA become effective and anticipates its full implementation.

Walker River

Irrigation diversions, dams, berms, and levees have been constructed throughout the Walker River watershed. Regulated flow in the Walker River watershed has disrupted the channel-forming processes that create and maintain river and stream habitats. Portions of the Walker River seasonally dry due to agricultural diversions. Other areas in the river seasonally become braided and shallow due to alterations of the channel-forming processes and reduction or elimination of the riparian vegetation. Channelization and bank armoring further degrade riverine habitats by modifying and simplifying many reaches of the Walker River.

Limited data exist on water quality and hydrologic relationships in the Walker River watershed. As human development increased, the management of the Walker River changed. Today there are increased demands for water resources in the Walker River watershed. Prior to the development of the diversions and storage facilities in the watershed, the natural hydrologic regime of the watershed reflected regional climate and runoff patterns. Typically summer and fall periods are dry with occasional summer thunderstorms impacting local areas. Winter high-flow conditions occur with rain or snow events and may result in localized and sometimes watershed-wide flooding. Spring flows are typically high due to snowmelt run-off. Water quality issues of concern are temperature, dissolved oxygen, and TDS. Water diversions and irrigation return flows have contributed to water quality deterioration, specifically, warm summer temperatures, low dissolved oxygen related to high biological oxygen demand, and high TDS. Today the complexity of water management and infrastructure in the Walker River watershed poses substantial challenges to recovery of LCT.

Desert Terminal Lakes Program (DTLP) funding under Public Law 109-103 section 208 (c) provides funds for riparian and channel restoration and for fishery improvements in the Walker

River watershed, while Section 208 (a) provides funds for a water acquisition program in the Walker River watershed to benefit Walker Lake. Using DTLP funds, the Service is leading efforts to restore riparian areas, address issues related to altered channel structure, and improve overall habitat connectivity throughout the watershed. The Service is working with a wide diversity of private, local, State, and Federal partners to develop restoration projects that provide key habitat linkage, restore channel function, and improve, enhance, or restore riparian and aquatic habitat. Efforts include modifying irrigation ditches to allow for fish passage, restoring channel structure to promote natural flows in the river system, eradicating noxious weeds, and addressing issues related to accelerated aggradation and degradation in the watershed. In addition, future water acquisitions under the DTLP and changes in flow management will provide additional improvements that would promote LCT recovery within the Walker River watershed. Managing acquired water to mimic natural flows will promote natural ecological processes and positively impact LCT recovery in the Walker River watershed. Funds provided through the DTLP have provided a unique opportunity to preserve current habitat that is intact while advancing opportunities to restore and enhance impacted habitat to further promote future recovery of LCT in the Walker River watershed. The continued support for research and management of the Walker River watershed substantially improves the recovery potential for LCT throughout the Walker River watershed.

Northwest and Eastern Basins

Little is known on the number and location of water diversion structures in the Northwest and Eastern Lahontan Basins. However, the Bureau of Land Management identified 34 irrigation diversions/stabilization structures as fish barriers along the Marys River in 2008. Fifteen of these structures were determined to be complete fish barriers, three were undeterminable, and the remaining 16 were functionally non-barriers (P. Coffin 2009, pers. comm.). Agriculture is the dominant land use in the valley bottoms of the Eastern and Northwest Lahontan Basins, where the mainstem rivers occur. Diversions limit LCT access to these mainstem rivers, reduce water quantity, and further isolate LCT populations.

The combined effects of water management described above result in a loss of habitat diversity required by native aquatic species (Allan 2004, pp. 262-266; Anderson *et al*. 2006, pp. 310-311). Degradation of native riparian communities associated with altered hydrology and land use practices has added to the loss of channel diversity and habitat complexity (Nilsson and Berggren 2000, pp. 784-789; Allan 2004, pp. 262-266). Healthy, intact riparian zones provide hydraulic diversity, add structural complexity, buffer the energy of runoff events and erosive forces, moderate temperatures, and provide a source of nutrients (Naiman and Décamps 1997, pp. 632-638). Riparian zones are especially important as a source of organic matter in the form of woody debris (Naiman and Décamps 1997, pp. 630-631). Woody debris helps control the amount and quality of pool habitat and adds complexity to the habitat (Montgomery *et al*. 2003, pp. 27-28).

Where water diversions lead to lower instream flows, LCT habitat is affected by increased water temperature, limited access to aquatic habitats, and increased opportunity for competition between fish species (Spence *et al.* 1996, pp. 143-145, 210; Harvey *et al*. 2006, p. 1002). Natural low flows caused by droughts have occurred historically in the Northwest and Eastern Lahontan Basins, and are now exacerbated by flow diversions. Dewatering of stream channels during the irrigation season may result in stranding of fish, exposure and desiccation of spawning redds and nursery habitat, and disruption of LCT migratory patterns (Spence *et al.* 1996, pp. 143-145).

Many of these diversion structures fragment watersheds and act as barriers to fish migration, limiting the ability of migrating adults, juveniles and fry to migrate to required life history habitats (Fausch *et al*. 2002, pp. 484-487; Ovidio and Philippart 2002, pp. 61-64; Compton *et al*. 2008, pp. 1736-1741). Certain barriers are complete obstructions to upstream immigration, while others may be partial barriers. When access is limited, fish may spawn in and utilize sub-optimal habitats. Out-migrating fry and juveniles may be injured or killed during downstream migration through entrainment into irrigation canals or passage over obstructions (Carlson and Rahel 2007, pp. 1338-1341; Roberts and Rahel 2008, pp. 955-959).

Summary of Water Management Impacts

Water management throughout the historical range of LCT continues to negatively impact LCT through reduced water quality and quantity, fish entrainment into irrigation systems, fish barriers, and the loss of habitat diversity. We conclude that water management is a substantial threat to LCT throughout its range, with the most substantial impacts occurring in the Western Lahontan Basin.

<u>Fire</u>

Fire has been one of the dominant factors shaping ecosystems for millennia (Skinner and Chang 1996, p. 1041; Miller and Rose 1999, pp. 555-558; Van Wagtendonk and Fites-Kaufman 2006, p. 270). Median fire return intervals in eastside Sierra Nevada forests are believed to be 8-16 years with a range of 5-47 years, although data are very limited (Skinner and Chang 1996, p. 1056; Van Wagtendonk and Fites-Kaufman 2006, pp. 288-289). 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).

Fire regimes in the Great Basin differ in the three main vegetation types: sagebrush shrublands, desert shrublands, and pinyon-juniper woodlands. Prior to European settlement, fire regimes in sagebrush shrublands of the Great Basin have been characterized as a combination of mixed-severity and stand-replacing fires with return intervals ranging anywhere from 10 to 70 years (Rice *et al*. 2008; p. 154). Desert shrubland vegetation types are characterized by infrequent, stand-replacement fires with fire return intervals between 35 years to several centuries (Rice *et al*. 2008, p. 155). Pinyon-juniper woodlands are characterized as a mixed fire regime; however, fire histories in pinyon-juniper woodlands are difficult to reconstruct (Paysen *et al*. 2000, p. 130). Return intervals in pinyon-juniper woodlands range from 10 to over 300 years depending on site productivity and plant community structure (Rice *et al*. 2008, p. 162).

Riparian areas are also subject to fires; however, return intervals and fire regimes may be different than the adjacent uplands. The scant information available on fire in riparian areas indicates that return intervals and fire regime type depend on the width of the riparian area and the fuel type adjacent to the riparian area (Dwire and Kauffman 2003, pp. 62-63). Smaller riparian areas are more similar to the adjacent upland areas while larger riparian areas tend to have longer return intervals and lower fire intensity (Dwire and Kauffman 2003, pp. 62-63). Riparian plant species have adapted to disturbances such as fire which, coupled with being in a moist environment, facilitates rapid recovery (Dwire and Kauffman 2003, pp. 67-70).

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; Paysen *et al*. 2000, pp. 153-154; Stephens and Sugihara 2006, pp. 431-441; Richardson *et al*. 2007, pp. 277-278; Brooks 2008, pp. 33-45). 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; Paysen *et al*. 2000, pp. 153-154; 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).

In contrast, fire regimes in the Great Basin have become more frequent due to wildfire exclusion, historical grazing practices, and the introduction of invasive nonnative plant species (Rice *et al*. 2008, p. 141). More frequent fires favor the establishment of nonnative plants (e.g., cheatgrass [*Bromus tectorum*]), which results in the loss of sagebrush and other native plant species (Rice *et al*. 2008, p. 154). Northern Nevada has experienced very large fires in the past decade alone (Table 14) which have impacted occupied LCT streams in the Little Humboldt River, Rock

Table 14. Large fires in Northern Nevada between 1999 and 2007 (Data source: National Interagency Fire Center).

Year	Fire Name	Location	Fire Size ha (ac)
2007	Murphy Complex	BLM Twin Falls District-ID, Humboldt-Toiyabe NF-NV	263,862 (652,016)
1999	Dunn Glen Complex	BLM Winnemucca District-NV	116,638 (288,220)
2006	Winters	BLM Winnemucca and Elko Districts-NV	96,500 (238,458)
1999	Sadler Complex	BLM Elko District-NV	90,856 (224,509)
2006	Charleston Complex	BLM Elko District-NV	77,061 (190,421)
1999	Battle Mountain Complex	BLM Battle Mountain District-NV	68,638 (169,608)
1999	Jungo Complex	BLM Winnemucca District-NV	68,481 (169,220)
2006	Sheep	BLM Elko District-NV	60,812 (150,270)

Creek, Maggie Creek, Marys River, Quinn River, Walker River, and Truckee River watersheds (Figures A4.1-A4.18; Tables A2.14 and A2.15). Over 63 percent of the Rock Creek watershed has burned between 1999 and 2008 (Table A2.14) which has impacted 27 percent of the occupied LCT habitat within the watershed (Figure A4.6; Tables A2.14 and A2.15).

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). 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 (see Factor E, Climate Change section below).

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). 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*. 2003b, pp. 185-186; Howell 2006, pp. 990-993). 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). Additionally, effects on small headwater streams are more severe because entire drainages are burned at these smaller spatial scales, in contrast to larger stream orders where relatively small proportions of the drainage burn. Numerous LCT streams have been burned in the last decade alone (Table A2.15), and while no extirpations have been recorded, mortalities, reduction in population size, and poor recruitment have been documented (Humboldt-Toiyabe National Forest 2004, pp. 2-4; Neville and DeGraaf 2006, pp. 7, 13).

Dunham *et al.* (2007, p. 342) found significantly elevated stream temperature for at least a decade following fire because of a lack of stream shading. Additionally, they suggest that post-fire temperatures may take longer to recover if streams encounter debris flows and flooding which reorganize the stream channel and riparian vegetation. Elevated post-fire stream temperatures were recorded in Mill Creek (West Fork Walker River watershed) after it burned in 2002 during the Cannon Fire; however, post-fire stream temperatures never reached lethal levels for LCT and the minimum, maximum, and mean stream temperatures were nearing pre-fire levels 3 years after the burn (Mellison *et al*. 2006, p. 2). Several authors suggest that habitat degradation favors nonnative fish and that species with narrow habitat requirements are expected to be more sensitive to habitat alteration caused by fire than generalist species such as rainbow trout (Moyle and Light 1996, p. 157; Dunham *et al.* 2002, p. 382; Dunham *et al.* 2003b, p. 189).

Fire suppression methods include the construction of fire lines, back burning, application of water from pumps or aerial drops, use of fire retardants and suppressant foams, and construction and use of helicopter landings, material storage and refueling areas, and fire camps. Some effects to aquatic species and their habitat include increased erosion and overland flow, increased risk of mass failure from mechanical fire line construction on landslide-prone terrain, and temporary reduction or cessation of flows in small streams when drafting or dipping water (Backer *et al*. 2004, pp. 939-944). Fire camps, helibases, and other operational facilities and equipment have the potential to disturb aquatic species, unintentionally introduce fuel and other chemicals to waterways, and facilitate transport of propagules of noxious weeds and invasive aquatic plant and animal species (Backer *et al*. 2004, p. 943).

Fire retardants and suppressant foams are toxic to aquatic species (Gaikowski *et al*. 1996, p. 1370; Buhl and Hamilton 2000, pp. 413-416; Little and Calfee 2002, p. 2). The surfactant portion of foam suppressants is detrimental to aquatic life because it decreases water tension, thereby decreasing an aquatic organism's ability to obtain oxygen (McDonald *et al*. 1997, p. 1373). The toxic component of retardant chemicals in aquatic systems is ammonia (McDonald *et al*. 1996, p. 68), which is highly soluble and typically becomes available when retardants are added to water. In 2002, the Cannon Fire burned 5.9 km (3.7 mi) of occupied habitat in Mill Creek (West Walker River watershed). A retardant drop crossed the stream and all LCT downstream from the drop were extirpated (Mellison 2002, p. 8). While the population rebounded by 2004 from upstream sources (Humboldt-Toiyabe National Forest 2004, pp. 2-4), it is unknown what the effects of genetic loss will be on the population.

Although LCT 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 (see Factor E, Climate Change section below). Current wildfires are a larger threat to LCT because of existing habitat loss and the current fragmented and isolated state of occupied habitat. LCT populations in the South Fork Little Humboldt River, Rock Creek, Maggie Creek, Quinn River, Truckee River and Walker River have recently been impacted by wildfires and/or fire suppression tactics (Figures A3.1-A3.18; Tables A2.14 and A2.15). We conclude that wildfire is a significant threat to LCT throughout its range.

<u>Recovery Actions</u>

There are numerous projects that have been implemented recently or are being planned in the near future to eliminate the threats of nonnative salmonids to LCT or are aimed at increasing connectivity of fragmented habitat. These projects include: (1) permanent and temporary fish barriers, followed by nonnative trout eradication and then repatriation of LCT; (2) construction of permanent barriers to protect LCT occupied upstream habitat; (3) eradication/control of nonnative salmonids through electrofishing; and (4) barrier removal projects to reconnect habitat.

Eastern Lahontan Basin

In 2002, a temporary barrier was built below the confluence of the North Fork and South Fork of Green Mountain Creek (South Fork Humboldt River watershed), and both forks were subsequently treated with rotenone to eradicate brook trout in 2003. This treatment created approximately 17.7 km (11 mi) of habitat within the two forks of Green Mountain Creek. This project was the first phase of a larger restoration project. The second phase involves treating and connecting another tributary (Toyn Creek), which will add an additional 12.1 km (7.5 mi), forming a connected LCT population with approximately 29.8 km (18.5 mi) of habitat. In 2004, a project was initiated to eradicate hybridized LCT in Cottonwood and San Juan Creeks (Reese River watershed). In 2004, a temporary barrier was built on Cottonwood Creek just upstream of the confluence with San Juan Creek, and Cottonwood Creek was treated with rotenone. In 2005, a permanent barrier was built below the confluence of the two creeks and a treatment followed in 2006 on San Juan Creek. The temporary barrier will slowly be dismantled over a few years to limit disturbance to the site. Repatriation of LCT from a suitable source is expected in 2009 creating approximately 32.2 km (20 mi) of connected habitat. In 2007, a permanent barrier was built on Marysville Creek (Reese River watershed) and the stream was treated in 2008. Once eradication of nonnative brook trout is confirmed, LCT will be reintroduced to occupy approximately 12.9 km (8 mi) of habitat in this isolated stream.

Several major tributaries to the Humboldt River have large permanent barriers constructed or planned near their confluences with the Humboldt River to keep nonnative fishes from invading. These include the Dixie Creek barrier (completed in 2008) which protects approximately 40.2 km (25 mi) of potential and currently occupied habitat, the Maggie Creek barrier (2009) which will protect approximately 80.5 km (50 mi) of occupied habitat, and the Susie Creek barrier (2010) which will protect 53.1 km (33 mi) of potential habitat.

Two barrier removal projects have been implemented to allow for movement of LCT. Three occupied tributaries to Maggie Creek had impassable culverts. The Bureau of Land Management and partners replaced the culverts with bridges which allowed for approximately 80.5 km (50 mi) of seasonal connectivity between these tributaries and the mainstem of Maggie Creek. A barrier removal project on Gance Creek (North Fork Humboldt River watershed) was implemented by the U.S. Forest Service in 2007. An undersized culvert was replaced with a bottomless arch culvert which allowed LCT access to another 4.5 km (2.8 mi) of habitat.

Northwest Lahontan Basin

McDermitt Creek (Quinn River watershed) is a large watershed that straddles the Nevada-Oregon boarder. A series of temporary barriers have been built on tributaries to McDermitt Creek and one permanent barrier is being planned for the bottom of the watershed. Treatments have occurred and others are being planned to eradicate nonnatives throughout the entire watershed. Once the project is complete, approximately 88.5 km (55 mi) of connected habitat will be available for LCT. Pole Creek (Quinn River watershed) was treated in 2004 to eradicate hybridized LCT creating 5.3 km (3.3 mi) of habitat. Pole Creek is connected seasonally to Crowley Creek which has 7.6 km (4.7 mi) of occupied habitat. Happy Creek (Quinn River watershed) was treated in 1999 and 2000, which has created approximately 9.6 km (6 mi) of habitat in this isolated stream. As mentioned previously, drought-related effects have delayed LCT repatriation into Happy Creek.

Western Lahontan Basin

Truckee River

The Truckee River Basin Recovery Implementation Team was organized to develop a strategy for LCT restoration and recovery efforts in the Truckee River watershed. A Short-Term Action Plan for LCT in the Truckee River watershed was developed in 2003 and implementation of these actions has been underway since (Service 2003c, pp. 1-71). Restoration of watershed connectivity through barrier removal or provision of fish passage is critical to connecting the

Pyramid Lake population of LCT to historical spawning habitat in the Truckee River watershed. Fish passage was installed at Derby Dam (2003) for the first time in its 100-year history. This opens up the barrier that caused the original extirpation of LCT from Pyramid Lake. Other barrier issues and fish passage are being addressed through a variety of programs including the U.S. Army Corps of Engineers Community Based Flood Control Alternative. Connectivity of the watershed for LCT has also been improved through establishment of a natural flow regime that mimics the historical hydrograph and provides year-round flow in the mainstem Truckee River, enhancing passage, instream water chemistry, and potential rearing conditions for LCT. Propagation of Pilot Peak strain LCT for recreational fishing and evaluation has been ongoing to varying degrees for the past 4 years in collaboration with the Nevada Department of Wildlife and the Pyramid Lake Paiute Tribe. Nevada Department of Wildlife now stocks triploid rainbow trout (sterile) in the mainstem Truckee River and only as supplemental stocking in the late summer months (NDOW 2008, pp. 7-8). Expansion of opportunities to provide regular stocking of Pilot Peak LCT in the mainstem river, in concert with the development of streamside incubation and imprinting programs, will increase the likelihood for establishment of a self-sustaining lacustrine population in the watershed. This has to be coupled with increased efforts to address the threats posed by rainbow and brown trout populations in the mainstem Truckee River.

Brook trout have been removed with electrofishing equipment in Independence Creek, a tributary to Independence Lake, annually since 2005. Suppression of the brook trout population has increased LCT recruitment and survival, altered expression of certain life-history traits (*e.g.*, resulting in more stream-resident fish), and altered the timing of LCT migration (G. Scoppettone 2008, USGS, unpublished data). In concert with the brook trout removal, a barrier is being planned for Independence Creek near its confluence with the lake. Fish passage will be allowed during the spring when spawning LCT are entering the stream. During the fall, fish passage will be prohibited and brook trout will not be able to enter the stream to spawn. This barrier will protect 2.3 km (1.4 mi) of spawning habitat.

Walker River

The Walker River Basin Recovery Implementation Team approved its Short-Term Action Plan in 2003 and has recently completed the following tasks: (1) identification and evaluation of fish passage barriers in the Walker River watershed; (2) development of a watershed analysis of the physical components of the Walker River watershed; (3) identification of historical distribution of LCT within the basin; (4) monitoring of present LCT population abundance and distribution; and (5) initiation of habitat surveys to evaluate potential LCT introduction streams and validate against existing LCT inhabited streams. With completion of these tasks, the Short-Term Action Plan is being updated to include the information and data compiled in 2008. On-the-ground restoration activities in 2007 included the recontouring of an old irrigation diversion to allow for upstream migration of LCT in Mill Creek (West Fork Walker River watershed). The upstream reaches of Mill Creek are occupied; however, the irrigation diversion did not allow LCT downstream of the diversion to access the upper 6.4 km (4 mi) of the watershed. Road crossings in both Mill and By-Day Creeks were also improved by building low stream-crossing bridges to prevent vehicles from crossing in the streams and allowing fish to move freely upstream and downstream. Finally, Silver Creek (West Fork Walker River watershed) was treated with rotenone from 1994 to 1996 to remove nonnative fish and LCT were stocked in 1997. Brook trout were found in 2004 and electrofishing efforts to eradicate them have occurred annually since 2004.

Lake Tahoe

The Tahoe Basin Recovery Implementation Team, comprised of representatives from the Service, U.S. Forest Service-Lake Tahoe Basin Management Unit, Tahoe Regional Planning Agency, California Tahoe Conservancy, Nevada Department of Wildlife, Washoe Tribe, and California Department of Fish and Game, is developing an action plan based on the most complete biological, geographical, and hydrological information available for the Lake Tahoe watershed to restore and recover LCT. The action plan will outline the strategy for successful reintroduction management of LCT in the Lake Tahoe watershed. Long-term reintroduction and management strategies will include LCT production targets sufficient to support conservation and recreational fishing, streamside incubation programs in high priority stream habitats to establish natural reproduction, habitat connectivity between stream and lake environments to meet all life history requirements, management of nonnative species, and monitoring and research that will inform adaptive management strategies over time to achieve LCT recovery and conservation. An integral component of the plan is the important preliminary information gathered from 4 years of research on Fallen Leaf Lake. Lahontan National Fish Hatchery Complex has developed methods for targeting invasive lake trout using hydroacoustics. The fishery management strategies learned in Fallen Leaf Lake will eventually be employed in Lake Tahoe.

The Upper Truckee River was initially treated with rotenone between 1988 and 1990 to eradicate brook trout; however, in 1995, brook trout were found near the Pacific Crest Trail crossing. Between 1996 and 2008 crews have been eradicating brook trout using electrofishing. In both 2007 and 2008, no brook trout were found. Nonnative eradication efforts on the Upper Truckee River will continue downstream from the currently occupied LCT habitat approximately 16.1 km (10 mi) and will include tributaries and four small lakes which contain brook trout. It is estimated the project will take 10-15 years to complete. Once completed, LCT will be able to occupy approximately 24.9 km (15.5 mi) of streams and 38.4 ha (95 surface acres) of lakes.

<u>Summary for Factor A</u>

LCT populations have been and continue to be impacted by interactions with nonnative species, habitat fragmentation and isolation, poor habitat condition due to various land use practices, drought, water quality, water management, and fire. LCT occupy nearly half their historical lake habitat; however, only two lacustrine populations are self-sustaining. Nonnative fish co-occur with LCT in 36.3 percent of currently occupied stream habitat and the majority of currently occupied historical lake habitat. Additionally, nonnative fish occupy nearly all unoccupied LCT historical habitat, making repatriation of LCT extremely difficult. Nonnative fish have documented negative impacts on cutthroat trout through competitive displacement and predation, and are an ongoing threat to the long-term persistence of LCT. LCT occupy a small portion of their historical stream habitat 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 8 km (5 mi) of habitat, and have no nonnative species present. Currently, only 28.2 percent of conservation populations occupy habitat greater than 8 km (5 mi) and 83.1 percent of currently occupied streams have fewer than 93.8 fish/km (150 fish/mi). Negative impacts due to drought and fire are expected to increase in response to climate change. Pyramid and Walker Lakes are important habitat for the lacustrine form of LCT. Water quality conditions in these lakes have deteriorated over the past 100 years and continue to decline. Permitted water diversions and diversion structures will continue to affect LCT migration, baseline water quantities, and thereby water quality. Many of the recovery actions listed above were aimed at eliminating threats from nonnative fish and expanding LCT populations into larger, more connected habitat. 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 LCT.

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

Commercial

Overutilization from commercial interests was a significant threat to LCT from the late 1800's to the mid 1940's, which aided in the demise of LCT in the Truckee River watershed (Service 1995, p. 8). Between 1873 and 1922 approximately 45,359-90,718 kilograms (kg) [100,000-200,000 pounds (lbs)] of LCT were harvested annually from Pyramid Lake and the Truckee River for commercial purposes (Townley 1980, p. 39). By 1939, the commercial fishery for LCT on Lake Tahoe had disappeared, and by 1944 the original Pyramid Lake strain of LCT was extinct in its historical habitat (Gerstung 1988, p. 94). There is no longer any commercial fishery for LCT, and commercial overutilization was not a factor in listing LCT as endangered in 1970.

Recreational

When LCT was reclassified from endangered to threatened, an ESA section 4(d) rule was published to facilitate management by the States and allow State-permitted sport harvest (Service 1975, p. 29864; 50 CFR 17.44(a)). At that time, there was evidence that LCT would benefit from regulated taking by sport-fishing (angling) as an acceptable method of preventing overpopulation, especially in restocked streams.

Cutthroat trout are vulnerable to recreational angling (Gresswell 1995, p. 47; Kershner 1995, p. 32; McIntyre and Rieman 1995, pp. 9-10; Rinne 1995, p. 25; Young 1995a, pp. 20-21). Local populations in small streams can be negatively impacted by the loss of even a few individuals (Rieman and Apperson 1989, p. 70). Fishing regulations vary by State, Tribe, and waterbody. Most occupied streams within the historical range of LCT in California are either closed to fishing or have catch-and-release regulations. A few Out-of-Basin populations and lakes which are regularly stocked with LCT for recreational purposes have general fishing regulations of 5 fish per day and 10 fish in possession. Occupied LCT streams in Oregon are either closed to fishing or have catch-and-release regulations. Oregon fishing regulations have been implemented to protect natural populations of LCT. Streams in the "Out of Basin" category have been closed to angling. Willow and Whitehorse Creeks were closed to angling until 2000, when the Oregon Department of Fish and Wildlife determined that the population was large enough to withstand catch-and-release fishing. Because of the remoteness of the basin, the open streams do not likely receive much angling pressure.

The two Out-of-Basin streams in Utah are closed to fishing. Regulations in Nevada include several closed waters and catch-and-release streams in the Quinn River watershed and a 10-trout limit in most historical and currently occupied streams in the Quinn and Humboldt River watersheds, except for the Marys River which has a 5-trout limit. The Truckee River has either a 5-trout limit or a limit of 2 trout greater than 35.6 cm (14 in), and fishing gear restrictions. Most LCT occupied streams in Nevada are remote and see little fishing pressure (NDOW 2004, pp. 7, 9-11, 13-18), the Truckee River and Pyramid and Walker Lakes being notable exceptions. Heavily fished waters are supplemented by Federal, State, and Tribal hatcheries (see Factor E, Fisheries Management section below). Pyramid Lake on the Pyramid Lake Paiute Reservation has a 2-fish limit and a slot limit of 40.6-48.3 centimeters (cm) (16-19 in) or greater than 61 cm (24 in). Summit Lake on the Summit Lake Paiute Reservation is closed to fishing for non-tribal members. Regulations for tribal members change on an annual basis based on data collected by Tribal fisheries staff and recommendations given to the Tribal Council. The 2008 season had a 5-fish limit for adults and a 2-fish limit for children. Because fishing pressure is generally light, numerous waters are either closed to fishing or have special regulations, and heavily fished areas are supplemented by stocking, recreational fishing for LCT outside the Western Lahontan Basin does not pose a significant threat to LCT at this time.

Harvest poses a more substantial threat to LCT within the Western Lahontan Basin. The general fishing regulation for Walker Lake in Nevada is 5 trout per day (NDOW 2009, p. 19). Walker Lake is being stocked for a recreational fishery as well as for refining strategies for establishing a self-sustaining LCT population in the Walker Lake system. Fishing regulations on the Truckee River make no distinctions between catching LCT and the various nonnative trout that are stocked annually (NDOW 2009, p. 21). Both of these habitats are important for recovery of the lacustrine strain of LCT, and harvest is impacting research to understand its life history needs and identify the necessary actions for achieving self-sustaining populations. A reduction in the harvest number or specific protection for LCT would allow for meeting both recovery needs and providing a recreational fishery. Another impact from harvest occurs in Lake Tahoe where the fishing regulations for both California and Nevada allow for 5 game fish to be taken but no more than 2 lake trout (CDFG 2008, p. 55; NDOW 2009, p. 20). The regulations provide harvest protection for a nonnative trout, identified as a significant threat to the recovery of LCT due to its predation of all life history stages of LCT (See Factor C, Disease or Predation below). Current fishing regulations in Fallen Leaf Lake allow for similar harvest of LCT and nonnative fishes (*i.e.*, lake trout) (CDFG 2008, p. 27). After stocking catchable-sized LCT in Fallen Leaf Lake in 2005, creel surveys indicated that LCT comprised 42.1 percent of angler harvest overall, representing nearly 100 percent of the catch by shore fishermen (Al-Chokhachy 2008, UNR, unpublished data). The angler harvest in Fallen Leaf Lake is especially damaging because it removes the larger size classes of LCT, eliminating a critical component of the food web. Fishing regulations need to be modified to reduce angling losses while still supporting the LCT-based shoreline sport fishery.

To summarize, recreational fishing for LCT outside the Western Lahontan Basin does not pose a significant threat to LCT at this time. However, harvest from recreational fishing in the Western Lahontan Basin does appear to pose a threat to LCT recovery because it impedes our ability to establish recovery populations, to understand the life history needs of lacustrine LCT, and to identify the actions needed to achieve recovery.

Scientific and Educational

Annual sampling of LCT populations is an important aspect of fisheries management and scientific research. Federal, State, and Tribal biologists, as well as universities and Trout Unlimited (a private conservation organization), sample various populations on an annual basis. Most populations are sampled on a 5-year rotating basis; however, some populations are sampled annually for research or nonnative fish eradication. Sampling stream populations of LCT 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 mortality 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), to 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 recent 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 LCT 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 2009, Service, personal communication). Snyder (2003, p. 98) concluded that population effects were unlikely except for intensively sampled populations.

The special rule for LCT under ESA section 4(d) facilitates management by the States and allows regulated angling (Service 1975, p. 29864; 50 CFR 17.44(a)). Collection of LCT for scientific and educational purposes is controlled through State and Tribal permitting processes that prevents 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 LCT at this time.

<u>Summary of Factor B</u>

In summary, commercial fishing was a historical threat to LCT but no longer occurs. Recreational fishing in popular fishing waters is regulated and these heavily-fished populations are augmented by hatcheries; however, harvest from recreational fishing in the Western Lahontan Basin poses a threat to LCT recovery because it impedes our ability to establish recovery populations, to understand the life history needs of lacustrine LCT, and to identify the actions needed to achieve recovery. While small streams may be vulnerable to overharvest, most such occupied habitats are in remote areas and receive little fishing pressure. Scientific sampling of LCT populations 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 are also regulated by State and Tribal permitting processes and new, non-lethal techniques have been developed for genetic analyses. Therefore, we conclude that the best scientific and commercial information available indicate that LCT are not threatened by overutilization for commercial, recreational, scientific, or educational purposes, except for over harvest of LCT populations in certain Western Lahontan Basin.

FACTOR C: Disease or Predation

<u>Disease</u>

Whirling disease caused by the nonnative myxosporean parasite, *Myxobolus cerebralis*, is found worldwide and is the most common disease threatening native cutthroat trout (Hoffman 1990, p. 31), including greenback cutthroat trout (Service 1998, p. 12), Colorado River cutthroat trout (Service 2007b, p. 32594), and Rio Grande cutthroat trout (Service 2008b, p. 27911). Despite being present in nonnative salmonid (rainbow and brown trout) populations within the Lahontan Basin, including the Truckee, Carson, and Walker River watersheds, whirling disease has not been found to have impacts on salmonids in this area (Modin 1998, p. 141). Other diseases impacting LCT have been associated with hatcheries. Disease screening is conducted on LCT produced at Lahontan National Fish Hatchery prior to importation into California for stocking. Intermittently, a positive test for bacterial kidney disease (*Renibacterium salmoninarum*) (BKD) occurs. However, a positive test does not indicate that fish are expressing the disease. BKD affects wild and hatchery produced salmonids, and is commonly found throughout the waters of North America and is considered biologically insignificant (Warren 1991, pp. 28-29). When expressed, BKD produces a chronic, systemic infection in the kidney, and in advanced cases, the kidney becomes enlarged and necrotic (Fryer and Sanders 1981, p. 274). BKD causes direct and indirect mortality of infected fish; however, no precise quantitative measurements of mortality rates have been formulated because of the slow growth of the bacterium and chronic nature of the disease (Fryer and Sanders 1981, pp. 282-283).

LCT spawned from Heenan Lake and raised in California Department of Fish and Game's Hot Creek Hatchery have been found with *Nucleospora salmonis*. *Nucleospora salmonis* is a fish parasite with symptoms characterized by anemia and a chronic and severe lymphoblastosis (Hedrick *et al*. 1991, p. 103). The exact cause of death is not known; however, it is presumed that lymphoblasts (immature cells that proliferate uncontrollably in the bloodstream in certain types of leukemia) spread from the kidney and spleen, resulting in a leukemic-like condition which impairs organ (*i.e.*, kidney, liver, intestine) function causing death (Hedrick *et al*. 1991, pp. 107-108).

A significant disease influence ranking was made for each LCT conservation population using a ranking index to indicate low to progressively higher levels of risk associated with the possible or potential influence of significant diseases (May and Albeke 2008, pp. 16-17). Limited disease risk is characterized by May and Albeke (2008, p. 17) as significant diseases and the pathogens that cause these diseases have very limited opportunity to interact with an existing LCT population, significant diseases and pathogens not known to exist in the stream or watershed associated with an LCT population, barriers provide complete blockage to upstream fish movement, and/or stocking of fish from other sources does not occur. All LCT conservation populations were categorized as having limited disease risk. While disease is not currently a major threat to LCT, increasing temperatures may cause higher stress levels which may increase their susceptibility to disease (se Factor E, Climate Change below).

<u>Predation</u>

Piscivory

Piscivorous nonnative salmonids (brown, brook trout, and lake trout) are likely the most common predators of LCT. Introduced brown trout have been shown to have a negative effect on native fishes due to predation (Townsend 1996, p. 16; 2003, pp. 44-46; Vander Zanden *et al*. 2003, p. 281). In lacustrine environments, nonnative brown trout overlap with LCT in Lake Tahoe, Cascade Lake, and Fallen Leaf Lake. Hyvärinen and Huusko (2006, pp. 91-95) found that brown trout between 17 and 30 cm (6.7 and 11.8 in) eat prey up to 40 percent of their body length and that brown trout greater than 30.5 cm (12 in) were completely piscivorous in a lake environment. However, Al-Chokhachy and Peacock (2008, pp. 17-18) examined nine stomachs of brown trout from Fallen Leaf Lake and found no evidence of predation on recently stocked LCT. Study of brown trout diet at Fallen Leaf Lake is ongoing.

In stream and riverine environments, brown trout overlap LCT populations most prominently in the Western Lahontan Basin, being found in all three major rivers (Truckee, Carson, Walker Rivers); however, they are also found in the Eastern Lahontan Basin (mainstem Humboldt River) and Northwest Lahontan Basin (Quinn and Little Humboldt River watersheds) (Table A2.6). Little research has been conducted on brown trout predation on LCT in stream and riverine environments; therefore, brown trout predation rates on LCT in fluvial systems are unknown at this time. However, Johnson *et al*. (1983, pp. 144-148) reported that 25 percent of the brown trout between 191 and 300 mm (7.5 and 11.8 in) in length consumed recently stocked LCT fry in Cold Creek (Truckee River watershed) and they estimated that the nonnative fish assemblage (81 percent brown trout) consumed 23,000 LCT fry between July and November. There is also anecdotal evidence of angler harvested brown trout on the Truckee River with LCT found in their stomachs (M. Maples 2009, NDOW, unpublished data).

Brook trout are also a known predator on native cutthroat trout (Dunham et al. 2002, pp. 378-379); however, predation is a less well studied mechanism than competition, as described previously. Predation by brook trout on LCT has been documented in two studies. Johnson *et al*. (1983, pp. 144-148) sampled 25 brook trout from Cold Creek and found newly released LCT fry in three brook trout stomachs. Rissler *et al*. (2006, p. 37) have also documented brook trout consuming LCT fry from Independence Creek as they migrate downstream to Independence Lake.

Lake trout have been shown to have detrimental effects on native cutthroat trout populations (Ruzycki *et al*. 2001, p. 1186; Ruzycki *et al*. 2003, p. 34; Koel *et al*. 2005, pp. 12-13). Lake trout were introduced into Lake Tahoe and surrounding lakes (including Fallen Leaf Lake and Donner Lake) in 1889 (Miller and Alcorn 1945, p. 180). Lake trout have replaced LCT as the top piscivore in these lake systems and have contributed to the disruption of the entire food web (Vander Zanden *et al*. 2003, pp. 281-282).

Non-native lake trout currently inhabit Fallen Leaf Lake and Lake Tahoe. Predation by lake trout on LCT in Fallen Leaf Lake has been shown to be a significant threat (Allen *et al*. 2006, pp. 1-57; Al-Chokhachy and Peacock 2008, pp. 1-43; D. Bloomquist, USFWS, unpublished data). Al-Chokhachy and Peacock (2008, pp. 1-43) studied population size, predation rates and diet of lake trout. Through mark recapture, the population of lake trout was estimated at 8,799 fish (95 percent confidence interval between 4,990 and 16,530) (Al-Chokhachy and Peacock 2008, p. 13). Stomach contents of lake trout collected after stocking tagged LCT determined that 12 percent of lake trout less than 425 mm (16.7 in) and 27 percent of lake trout greater than 425 mm (16.7 in) contained anchor tags (Al-Chokhachy and Peacock 2008, p. 17). This result corresponds with the overall diet of lake trout. Lake trout less than 425 mm (16.7 in) primarily consumed mysid shrimp while lake trout greater than 425 mm (16.7 in) consumed a combination of crayfish, mysids, and salmonids (Al-Chokhachy and Peacock 2008, p. 17). D. Bloomquist (USFWS, unpublished data) demonstrated the ability to target specific sizes of lake trout with hydroacoustics, increasing gill netting accuracy and efficiency. Given the estimated population range of lake trout and the newly developed methods for management, lake trout numbers can be effectively reduced with little incidental catch of native species. Lake trout management, combined with routine and comprehensive stocking of Pilot Peak LCT will minimize the effect of lake trout predation in Fallen Leaf Lake and Lake Tahoe.

To summarize, the impact of brown and brook trout predation on LCT in stream and riverine environments is unknown at this time; however, where the two nonnative species overlap with the current LCT distribution, they can have a substantial affect on the LCT population, given their known piscivory. Documented negative impacts from lake trout on LCT pose a substantial threat to lacustrine LCT populations where the two species overlap.

Avian Predation

The most prominent avian predators on LCT include American white pelicans (*Pelecanus erythrorhynchos*), double-crested cormorants (*Phalacrocorax auritus*), bald eagles (*Haliaeetus leucocephalus*), and osprey (*Pandion haliaetus*). Anaho Island in Pyramid Lake supports one of North America's largest American white pelican nesting colonies (Scoppettone *et al*. 2006, p. 6). Between 2001 and 2005, Scoppettone *et al*. (2006, pp. 7-8) looked at fish species composition in the diet of American white pelicans based on the recovery of fish tags on Anaho Island. The authors found that the majority of tags recovered (90.7 percent) were from cui-ui and LCT (8.5 percent) (Scoppettone *et al*. 2006, pp. 7-8). Rissler *et al*. (2006, p. 28) documented frequent osprey and bald eagle predation on LCT in Independence Creek during the spawning run when LCT are congregated in the stream.

<u>Summary of Factor C</u>

Although LCT produced at hatcheries have tested positive for diseases such as BKD there has been no documentation of these fish expressing the disease. Stocking of BKD-positive fish within Nevada by Nevada based hatcheries is allowed. However, stocking in California waters can be intermittent due to importation policies. *Nucleospora salmonis* has been found in hatchery-produced LCT as well as LCT spawned from the broodstock found in the wild at Heenan Lake. Whirling disease is currently not a threat to LCT; however, it has the potential to become more widespread due to warmer waters that could result from climate change (see Factor E, Climate Change section below). Brown and brook trout are known piscivores; however, the extent to which brown trout prey on LCT is unknown. Given the potential for impact from piscivory, studies of brown and brook trout predation on LCT in both stream and lake environments are warranted. Most historical LCT waters in the western portion of their range, including lakes and to a more limited extent streams in the mainstem Humboldt River, Quinn, and Little Humboldt River watersheds, are occupied by brown trout. Brook trout are the most common nonnative salmonid which co-occur with LCT and are found in nearly every major historical LCT watershed. Lake trout co-occur with LCT in one historical lake, and occur in several others within the Western Lahontan Basin, making LCT repatriation into these lakes difficult. Avian predation on LCT may be an important local factor on populations in Pyramid Lake and Independence Lake. Based on the best scientific and commercial information available, we conclude that disease is not currently a major threat to LCT but may become a larger threat in the future. Predation from nonnative fish is a threat to LCT populations where they co-occur and where recovery actions will involve stocking of LCT into waters occupied by these species.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

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 to 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 section 2080 *et seq.*) prohibits the unauthorized take of State-listed threatened or endangered species. LCT 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 (CFGC 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 California Department of Fish and Game's Habitat Conservation Planning Branch, will follow Federal guidance and fall under the direction of the State invasive species coordinator.

State Protections in Nevada

Under Nevada Administrative Code (NAC) 503.050, 503.065, 503.067, 503.075, 503.080, 503.090, 503.103, and 503.104 (Nevada Revised Statutes (NRS) 501.105, 501.110, 501.181, and 503.650), a species may be designated as protected, threatened, endangered, or sensitive. LCT are not designated in any of these categories and are classified as game fish in Nevada (NAC 503.060).

State Protections in Oregon

Protection for State-listed Threatened or Endangered Wildlife: According to Oregon Revised Statute (ORS) 496.004(19), the term "wildlife" means "fish, shellfish, wild birds, amphibians and reptiles, federal swine as defined by State Department of Agriculture rule and other wild mammals." The term is further defined in Oregon Administrative Rules (OAR) 635-100-0001(5) as "fish and wildlife species, subspecies and populations." State-listed threatened and endangered wildlife species are addressed in ORS 496.171 to 496.192 and ORS 498.026, and these statutes are implemented, interpreted or prescribed in OAR Chapter 635, Division 100. Upon listing of a species in the State, the State Fish and Wildlife Commission establishes guidelines that it considers necessary to ensure the survival of individual members of the species. These guidelines may include take avoidance and protecting resources sites such as spawning beds, nest sites, nesting colonies or other sites critical to the survival of individual members of the species (ORS 496.182(2)). ORS 498.026(1) states that "no person shall take, import, export, transport, purchase or sell, or attempt to take, import, export, transport, purchase or sell any threatened or endangered species, or the skin, hides or other parts thereof, any article made in whole or part from the skin, hide or other parts of any threatened or endangered species." A permit system for the scientific taking of State-listed threatened and endangered wildlife species is managed by the Oregon Department of Fish and Wildlife. An incidental taking permit or statement issued by a Federal agency for a species listed under the ESA "shall be recognized by the State as a waiver for any state protection measures or requirements otherwise applicable to the actions allowed under the federal permit" (ORS 496.172(4)). LCT is State-listed as threatened according to OAR 635-100-0125.

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.

The USACE interprets "the waters of the United States" expansively to include not only traditional navigable waters and wetlands, but also other defined waters that are adjacent or hydrologically connected to traditional navigable waters. However, recent Supreme Court rulings have called into question this definition. On June 19, 2006, the U.S. Supreme Court vacated two district court judgments that upheld this interpretation as it applied to two cases involving "isolated" wetlands. Currently, USACE regulatory oversight of such wetlands (*i.e.*, vernal pools) is in doubt because of their "isolated" nature. In response to the Supreme Court decision, the USACE and the USEPA have recently released a memorandum providing guidelines for determining jurisdiction under the Clean Water Act. The guidelines provide for a case-by-case determination of a "significant nexus" standard that may protect some, but not all, isolated wetland habitat (USEPA and USACE 2007, pp. 4-11). The overall effect of the new permit guidelines on loss of isolated wetlands, such as vernal pool habitat, is not known at this time.

<u>Endangered Species Act of 1973, as amended (ESA)</u>: The ESA is the primary Federal law providing protection for LCT. 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 opinion may include reasonable and prudent measures that minimize the amount or extent of incidental take of listed species associated with a project. Since 1995, 48 non-jeopardy biological opinions have been completed for LCT, the majority (42 percent) of which are grazing consultations (Table 15).

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 results from, but is not the purpose of, carrying out an otherwise lawful activity by a Federal agency or applicant (50 CFR 402.02). For projects without a Federal nexus that would likely result in incidental take of listed species, the Service may issue incidental take permits to non-Federal applicants pursuant to section 10(a)(1)(B). To qualify for an incidental take permit, applicants must develop, fund, and implement a Service-approved HCP that details measures to minimize and mitigate the project's adverse impacts to listed species. Regional HCPs in some areas now provide an additional layer of regulatory protection for covered species, and many of these HCPs are coordinated with California's related NCCP program.

Table 15. The number and type of non-jeopardy consultations completed for LCT since 1995.

Project Type	Number of Consultations	Percentage
Development	1	2.0
Transportation	1	2.0
Land	2	4.0
Fire	4	8.0
Water	8	15.0
Management	10	19.0
Grazing	22	42.0
Total	48	

Safe Harbor Agreements are voluntary arrangements between the Service and cooperating non-Federal landowners provided for by ESA section 10(a)(1)(a). This policy's main purpose is to promote voluntary management for listed species on non-Federal property while giving assurances to participating landowners that no additional future ESA regulatory restrictions will be imposed. The agreements must provide a net conservation benefit to covered species while giving landowners assurances from additional restrictions. Of the 1,031.3 km (640.8 mi) of LCT currently occupied streams, nearly 28 percent (284.7 km [176.9 mi]) occurs on private lands (Table 7). Two programmatic Safe Harbor Agreements were recently signed between the Nevada Department of Wildlife and the Service for the Northwest (2005) and Eastern Lahontan Basins (2006) to aid in LCT recovery efforts on non-Federal property in these areas. We expect the Nevada Department of Wildlife to sign the first cooperative agreement with a participating private landowner in 2009.

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 LCT from endangered to threatened, to facilitate management by the States and allow State-permitted sport harvest (Service 1975, p. 29864; 50 CFR 17.44(a)).

<u>Sikes Act</u>: The Sikes Act (16 U.S.C. 670) authorizes the Secretary of Defense to develop cooperative plans with the Secretaries of Agriculture and the Interior for natural resources on public lands. The Sikes Act Improvement Act of 1997 requires Department of Defense installations to prepare Integrated Natural Resource Management Plans (INRMPs) that provide for the conservation and rehabilitation of natural resources on military lands consistent with the use of military installations to ensure the readiness of the Armed Forces. INRMPs incorporate, to the maximum extent practicable, ecosystem management principles and provide the landscape necessary to sustain military land uses. While INRMPs are not technically regulatory mechanisms because their implementation is subject to funding availability, they can be an added conservation tool in promoting the recovery of endangered and threatened species on military lands. The Mountain Warfare Training Center is located on 18,615 ha (46,000 ac) within the Bridgeport Ranger District, Humboldt-Toiyabe National Forest. Three occupied LCT streams (Silver, Wolf, and Mill Creeks) are found within the MWTC boundaries. To date, no INRMP has been developed for the MWTC.

National Forest Management Act (NFMA): The NFMA (36 C.F.R. 219.20(b)(i)) has required the USDA Forest Service to incorporate standards and guidelines into Land and Resource Management Plans, including provisions to support and manage plant and animal communities for diversity and for the long-term, range-wide viability of native species. Recent changes to NFMA may affect future management of listed species, particularly rare plant occurrences, on National Forests. On January 5, 2005, the Forest Service revised National Forest land management planning under NFMA (U.S. Forest Service 2005, pp. 1023-1061). The 2005 planning rule changed the nature of Land Management Plans so that plans generally would be strategic in nature and could be categorically excluded from NEPA analysis, and thus not subject to public review. Under the 2005 planning rule, the primary means of sustaining ecological systems, including listed species, would be through guidance for ecosystem diversity. If needed, additional provisions for threatened and endangered species could be provided within the overall multiple-use objectives required by NFMA. The 2005 planning rule did not include a requirement to provide for viable populations of plant and animal species, which had previously been included in both the 1982 and 2000 planning rules. On March 30, 2007, however, the United States District Court in *Citizens for Better Forestry et al. v. USDA* (N.D. Calif.) enjoined (prohibited) the USDA from implementing and using the 2005 rule until the Forest Service provided for public comment and conducted an assessment of the rule's effects on the environment, including listed species.

On April 21, 2008, the Forest Service published a final 2008 planning rule and a record of decision for a final environmental impact statement examining the potential environmental impacts associated with promulgating the new rule (U.S. Forest Service 2008, pp. 46242-46244). The 2008 planning rule also does not include a requirement to provide for viable populations of plant and animal species on Forest Service lands. As part of the environmental analysis, a biological assessment was prepared to address the 2008 planning rule's impact to threatened, endangered, and proposed species and designated and proposed critical habitat. The assessment concluded that the rule does not affect, modify, mitigate, or reduce the requirement for the Forest Service to consult or conference on projects or activities that it funds, permits, or carries out that may affect listed or proposed species or their designated or proposed critical habitat. On August 8, 2008, the Forest Service published an interim directive and requested public comment on its section 7 consultation policy for developing, amending, or revising Land Management Plans under the 2008 planning rule. Thus, the impact of the 2008 rule to listed species is unknown at this time. Of the 1,030.1 km (640.1 mi) of streams currently occupied by LCT, approximately 27.7 percent (285.3 km, 177.3 mi) occur on public lands managed by the Forest Service (Tables 7 and A2.5) and 103.5 km (64.2 mi) are in designated wilderness areas.

Federal Land Policy and Management Act of 1976 (FLPMA): The BLM is required to incorporate Federal, State, and local input into their management decisions through Federal law. The FLPMA (Public Law 94-579, 43 U.S.C. 1701) was written "to establish public land policy; to establish guidelines for its administration; to provide for the management, protection, development and enhancement of the public lands; and for other purposes." Section 102(f) of the FLPMA states that "the Secretary [of the Interior] shall allow an opportunity for public involvement and by regulation shall establish procedures … to give Federal, State, and local governments and the public, adequate notice and opportunity to comment upon and participate in the formulation of plans and programs relating to the management of the public lands." Therefore, through management plans, the BLM is responsible for including input from Federal, State, and local governments and the public. Additionally, Section 102(c) of the FLPMA states that the Secretary shall "give priority to the designation and protection of areas of critical environmental concern" in the development of plans for public lands. Although the BLM has a multiple-use mandate under the FLPMA which allows for grazing, mining, and off-road vehicle use, the BLM also has the ability under the FLPMA to establish and implement special management areas such as Areas of Critical Environmental Concern, wilderness, research areas, etc., that can reduce or eliminate actions that adversely affect species of concern (including listed species). Of the 1,030.1 km (640.1 mi) of streams currently occupied by LCT, approximately 34.1 percent (351.4 km, 218.4 mi) occur on public lands managed by the BLM (Tables 7 and A2.5) and 186.6 km (115.7 mi) are in designated wilderness or wilderness study areas. Additionally, in 1973, the BLM established the 4,984 ha (12,316 ac) Lahontan Cutthroat Trout Wilderness Study Area/Instant Study Area near the Summit Lake Indian Reservation which encompasses the headwaters of Mahogany Creek, the main spawning tributary to Summit Lake. The primary management for this area is the protection of LCT habitat. The Black Rock Desert–High Rock Canyon Emigrant Trails National Conservation Area Resource Management Plan, of which the Lahontan Cutthroat Trout Wilderness Study Area is apart of, was approved on July 22, 2004 (BLM 2004, pp. 2-15-2-16).

<u>The Lacey Act</u>**:** The Lacey Act (P.L. 97-79), as amended in 16 U.S.C. 3371, makes unlawful the import, export, or transport of any wild animals whether alive or dead taken in violation of any United States or Indian Tribal law, treaty, or regulation, as well as the trade of any of these items acquired through violations of foreign law. The Lacey Act further makes unlawful the selling, receiving, acquisition or purchasing of any wild animal, alive or dead. The designation of "wild animal" includes parts, products, eggs, or offspring.

<u>Summary of Factor D</u>

In summary, the ESA is the primary Federal law that provides protection for LCT since its listing as endangered in 1970. Other Federal and State regulatory mechanisms, except State listing of LCT as threatened in Oregon, 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. Therefore, we continue to believe other laws and regulations have limited ability to protect the species in absence of the ESA.

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

<u>Climate Change</u>

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

Research has shown that the annual mean temperature in North America has increased from 1955 to 2005; 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). Other effects of climate change include, but are not limited to, changes in types of precipitation (Knowles *et al*. 2006, p. 4557), earlier spring run-off (Stewart *et al*. 2005, p. 1152), longer and more intense fire seasons (Brown *et al*. 2004, pp. 375-385; Westerling *et al*. 2006, pp. 941-942; Bachelet *et al*. 2007, pp. 16-17), and more frequent extreme weather events (Diffenbaugh *et al*. 2005, pp. 15775-15777; Rosenzweig *et al*. 2007, p. 109). These changes in climate and subsequent effects can be attributed to the combined effects of greenhouse gases, sulphate aerosols, and natural external forcing (Karoly *et al*. 2003, p. 1203; Barnett *et al*. 2008, p. 1082).

Warming trends seen over the past 50 years in the United States are predicted to continue to increase (Field *et al*. 2007, pp. 626-627). The Intergovernmental Panel on Climate Change states that of all ecosystems, freshwater ecosystems will have the highest proportion of species threatened with extinction due to climate change (Kundzewicz *et al.* 2007, p. 192). Species with narrow temperature tolerances and cold-water species (*e.g.*, salmonids) will likely experience the greatest effects from climate change, and it is anticipated that populations located at the margins of the species' hydrologic and geographic distributions will be affected first (Meisner 1990, pp. 288-290; Bates *et al*. 2008, p. 104). 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). 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). Additionally, these studies predict the loss of suitable habitat for salmonids, mainly at the southern extent of their range and at lower elevations.

In response to increasing temperatures, LCT will likely shift their distribution to higher elevations to find adequate cooler stream temperatures (Keleher and Rahel 1996, p. 9; Poff *et al*. 2002, p. 8). This will likely increase fragmentation of populations, and coupled with increases in stochastic events, will further disrupt metapopulation dynamics which increase the probability of extinction (Dunham *et al*. 1997, p. 1130; Fagan 2002, pp. 3244-3246; Opdam and Wascher 2004, pp. 292-293; Frankham 2005, p. 137; Wilcox *et al*. 2006, p. 859). Restoring physical connections among aquatic habitats may be the most effective and efficient step in restoring or maintaining the productivity and resilience of many aquatic populations (Bisson *et al*. 2003, p. 219; Dunham *et al*. 2003b, pp. 191-192; Rieman *et al*. 2003, p. 202; Dunham *et al*. 2007, p. 343). The focus should be to protect aquatic communities in areas where they remain robust and restore habitat structure and life history complexity of native species where aquatic ecosystems have been degraded (Gresswell 1999, p. 214).

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 fire, drought, and floods. These effects are discussed below.

Increased Stream Temperature

Recent literature has documented increases in stream temperatures across the globe (Webb *et al*. 2008, pp. 909-911); however, the magnitude varies considerably due to the very complex and site-specific processes influencing stream 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 stream temperature (Stefan and Preud'homme 1993, pp. 27-29; Poole and Berman 2001, pp. 789-792).

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). LCT can survive wide daily temperature fluctuations of 14-20°C (25-35°F) (Coffin 1983, p. 9). However, high temperatures suppress appetite and growth (Meeuwig *et al.* 2004, pp. 211-212) and can 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 1999b, 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).

Dunham *et al*. (1999, p. 884) note that most LCT populations have a downstream distribution limit corresponding closely to a mean July air temperature of 18°C (64°F). In some streams, LCT have been observed in water temperatures exceeding 28°C (81°F) (Dunham *et al*. 2003a, pp. 1045-1046); however, in the laboratory, Dickerson and Vinyard (1999b, p. 518) found that no LCT survived more than 2 days while being held at 28˚C (82˚F) and 64 percent died after 7 days while being held at 26˚C (79˚F). Additionally, LCT being held at 24˚C (75˚F) weighed significantly less than fish being held below 24˚C (75˚F) (Dickerson and Vinyard 1999b, p. 518; Meeuwig *et al*. 2004, p. 211). Dunham *et al*. (2003a, p. 1046) report that LCT were observed in water temperatures which have been found to cause sublethal (greater than 22°C [72°F]) and lethal (greater than 24°C [75°F]) impacts to LCT in the laboratory. Optimum temperature conditions for feeding and growth in the laboratory for LCT are between 12°C (54°F) and 18°C (64°F) (Meeuwig *et al*. 2004, pp. 211-212). Populations in less than optimal habitat may be present in reduced numbers and age classes.

Increasing stream temperatures due to climate change will cause further fragmentation of LCT populations, may give nonnative fish a competitive advantage, and may increase the threat from disease. Our analysis of the available information indicates that currently, most conservation populations are isolated in small stream segments (52 populations, or 72.2 percent of all conservation populations, over 279.4 km [173.6 mi], or 36.5 percent of occupied streams) (Table 3). Three conservation populations are strongly connected (occurring in more than five streams), which represents 23.4 percent (185.0 km [115.0 mi]) of occupied habitat. Four conservation populations are considered to have moderate connectivity (occurring in three to four streams), representing 7.5 percent (57.7 km [35.8 mi]) of occupied habitat, and 13 conservation populations are weakly connected (two to three streams), representing 31.7 percent (242.5 km [150.6 mi]) of occupied habitat (Table 3). Loss of downstream habitat due to increases in water temperature in currently occupied habitat will further restrict populations to smaller headwater reaches where the risk of extirpation is greater. Additionally, some potential reintroduction streams at lower elevations may become unsuitable due to high temperatures.

Nonnative fish may have a competitive advantage if stream temperatures increase (De Staso and Rahel 1994, pp. 292-293; Dunham *et al.* 2002, p. 380; Rahel and Olden 2008, pp. 522-525). McHugh and Budy (2005, p. 2793) reported that colder stream temperatures upstream limited brown trout to the lower reaches of a watershed in Utah. Some studies have demonstrated a shift in trout-occupied habitat upstream into waters which once were too cold, after stream temperatures increased (Jager *et al*. 1999, pp. 232-236; Hari *et al*. 2006, p. 23). Cold-water species are expected to decline due to increasing temperatures; however, cool- and warm-water species are expected to benefit (Field *et al*. 2007, p. 631). Impacts from species such as smallmouth bass (*Micropterus dolomieu*), which are found throughout the mainstem Humboldt River but are nonnative there, may increase (Fritts and Pearsons 2006, pp. 857-858). Of 6,600 km (4,100 mi) of streams sampled in Nevada, 70 percent contained nonnatives (Lomnicky *et al*. 2007, p. 1086). Nonnative fish co-occur with LCT in approximately 36.4 percent of currently occupied habitat. Increased stream temperatures could allow for nonnatives to expand their range even further throughout the historical range of LCT.

While disease is not currently a major threat to LCT, increasing temperatures may cause higher stress levels which may increase their susceptibility to disease (McCullough 1999, pp. 104-105). 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 *Myxobolus 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). The Great Basin is predicted to have a slight increase in precipitation either due to more winter precipitation (Christensen *et al.* 2007, pp. 856, 890) or due to an increase in extreme precipitation events during June and July (Diffenbaugh *et al*. 2005, pp. 15776-15777). Predicted winter and spring warming causes 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). A reduction in streamflow will reduce the amount of LCT occupied habitat and limit recovery waters.

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). 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.

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). Reduced flows during the summer months can increase water temperature (Gu and Li 2002, p. 54), reduce available habitat for aquatic species (Bjornn and Reiser 1991, p. 123), and stress riparian vegetation (Smith *et al.* 1991, pp. 95-96).

Our analysis of the available information indicates that the majority of LCT conservation populations are isolated (52 populations, of 72.2 percent of the total) (Table 3) and occur in short stream segments of 8 km (5 mi) or less, with a mean stream length of 4.4 km (2.75 mi) and a median of 4.6 km (2.83 mi) (range 0.6-7.9 km [0.4-4.9 mi]) (Table 6). Additionally, the majority of currently occupied habitat is 3.1 m (10 ft) or less in width (Table 8). Habitat size is an indicator of cutthroat trout persistence (Hilderbrand and Kershner 2000, p. 515; Young *et al*. 2005, p. 2405), and any reduction in stream habitat due to reduced streamflow is expected to have a negative effect on LCT. Recent examples due to drought conditions occurred in 2007, when a LCT salvage operation was conducted on Eightmile Creek (Quinn River watershed) because the entire creek had been reduced to one pool. Additionally in 2007, a LCT reintroduction project on Happy Creek (Quinn River watershed) had to be postponed because of low flow.

Extreme year-to-year variability in numbers of each LCT age class (ages 1-6) indicates variability in recruitment and survival among years (Neville and DeGraaf 2006, pp. 13-17; Ray *et al*. 2007, pp. 70-82). Data from several LCT populations indicate that recruitment is strongly associated with average stream flow from March through June and that survival is a strong function of population density (Ray *et al*. 2007, pp. 102-121). Because of this variability, other stressors such as poor habitat conditions and introductions of nonnative salmonids can significantly depress LCT populations and frequently cause localized extinctions (Peacock and Kirchoff 2007, p. 83).

Reduced streamflow will also impact lake ecosystems with the most negative impacts on terminal lakes such as Summit, Pyramid, and Walker Lakes. Potential impacts from climate change include altered hydrology and nutrient inputs which may cause changes throughout the entire food web (Hauer *et al*. 1997, pp. 913-918). Decreased inflows coupled with increasing demand for water resources and increased evaporation rates (due to increased temperatures) will increase the salinity and alkalinity and may cause eutrophication (nutrient over-enrichment) of these terminal lakes, making them less suitable for LCT (Melack *et al*. 1997, p. 982; Schindler 1997, pp. 1044-1045; Poff *et al*. 2002, p. 15; Kundzewicz *et al.* 2007, pp. 179, 184, 191-192; Bates *et al*. 2008, p. 29). The impacts of doubling atmospheric carbon dioxide levels were modeled for Pyramid Lake (Hostetler and Giorgi 1995, pp. 48-49). The authors predict that surface temperatures in Pyramid Lake will increase 2.8°C (5.4°F), which will stabilize the water column and prohibit turnover in the lake (Hostetler and Giorgi 1995, pp. 48-49). Lack of turnover would deteriorate water quality (*i.e.*, increase anoxic conditions) and decrease productivity (Hostetler and Giorgi 1995, p. 52). Walker Lake may be the most susceptible due to its low volume, current poor water quality, and over allocation of water rights (Beutel *et al*. 2001, pp. 94-97; Yuan *et al*. 2004, p. 9).

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 and increased evaporation rates in lakes due to extended surface exposure to warmer temperatures. The life history of salmonids is closely associated with flow regimes (Bjornn and Reiser 1991, pp. 87-90). 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). 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. Since LCT spawn in the spring, any change in the timing, or magnitude of spring runoff could disrupt recruitment and survival.

Winter conditions can strongly influence survival of salmonids (Huusko *et al*. 2007, pp. 469-470). 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). 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 48.3 cm (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.

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). The frequency and magnitude of disturbances such as drought, fire, and floods is expected to increase with climate change (Westerling *et al*. 2006, pp. 941-942; Field *et al*. 2007, p. 627). Streams found within the historical range of LCT, which have naturally high variability in both streamflow and temperature, are more vulnerable to extreme events (Hurd *et al*. 1999, pp. 1402-1404).

The percentage of the western United States in drought conditions has gradually increased over the last century and the current drought rivals the drought conditions in the 1930's (Cook *et al*. 2004, p. 1016). The average number of fires has decreased recently; however, the size of fires and the acres burned in the United States has increased significantly overall since the 1960's (Table 16). In the western portion of the Great Basin alone, over 2.9 million ha (7.3 million acres) have burned between 1999 and 2007 (Table 17) which have impacted several currently occupied LCT streams (Figures A4.1-A4.18). Cheatgrass (*Bromus tectorum*, a nonnative species) invasion throughout the Great Basin has significantly altered the fire regime in the sagebrush-steppe ecosystem (Brooks 2008, pp. 40-41). Ziska *et al*. (2005, pp. 1329-1331) found that cheatgrass responded positively to increased carbon dioxide levels which may aid in the continued expansion of this invasive species and contribute to increased fire frequency. Hurd *et al*. (1999, pp. 1408-1409) predicted that water resources in California and the Great Basin regions of the United States were the most vulnerable to climate change. Small upland streams in the central Great Basin have been shown to be sensitive to disturbances and the results are destabilized, incised streams which changes the structure and function of these systems (Germanoski and Miller 2004, pp. 117-121). As mentioned previously, most occupied LCT streams are isolated. When a disturbance such as drought or flood event occurs in occupied habitat, LCT populations are either eradicated or severely depleted. If an isolated population is extirpated due to disturbance, other individuals from another population cannot naturally repopulate the habitat once the habitat has recovered. A population which has been reduced dramatically can repopulate; however, the long-term persistence of these populations is in question due to the loss of genetic diversity (Frankham 2005, pp. 135-136; Wilcox *et al*. 2006, p. 861).

Table 16. Fire statistics in the United States by decade (Data source: National Interagency Fire Center).

Decade	Average Number of Fires	Average Area ha (ac) Burned	Average Size ha (ac) per Fire
2000-2007	78,465	2,938,980 (7,262,377)	37.8 (93.5)
1990-1999	84,215	1,419,104 (3,506,683)	16.5 (40.7)
1980-1989	163,329	1,714,242 (4,235,983)	10.8 (26.6)
1970-1979	155,112	1,292,736 (3,194,421)	8.6 (21.2)
1960-1969	119,772	1,850,123 (4,571,754)	15.4 (38.0)

Table 17. Area ha (ac) burned in the western portion of the Great Basin 1999-2007 (Data source: Western Great Basin Coordination Center).

Year	Hectares (ac) Burned
1999	757,554 (1,871,956)
2000	282,960 (699,210)
2001	264,766 (654,253)
2002	31,384 (77,551)
2003	7,100 (17,546)
2004	16,572 (40,950)
2005	702,376 (1,735,609)
2006	545,869 (1,348,871)
2007	360,239 (890,171)

Climate Change Summary

The impacts to LCT 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, affecting currently occupied streams and making lower-elevation reaches either marginal or unsuitable for LCT. Rising stream temperatures may provide nonnative fish a competitive advantage over LCT and may increase their susceptibility to various diseases. Reductions in streamflow are predicted to have a negative impact on LCT populations because of the fragmented nature of LCT populations, the small size of occupied stream habitats, the close association of recruitment and survival to stream flow, and decreased water quality in some lakes. Degraded systems exhibit greatly reduced resiliency to accommodate natural disturbances such as floods, fire, and drought, thereby exacerbating the effects of those events, which further reduces the persistence of these populations (Wilcox *et al*. 2006, pp. 860-862). These degraded conditions, combined with variability in LCT numbers, place greater importance on the quantity and quality of the habitat needed for survival and recovery of LCT. These impacts associated with climate change will likely intensify the threats to LCT previously described under Factors A and C.

Fisheries Management

LCT was reclassified from endangered to threatened in 1975 and a 4(d) rule was published to facilitate management by the States and allow regulated angling (Service 1975, p. 29,864) Fishing regulations vary by State, Tribe, and waterbody (see Factor B above). State and Tribal fishery managers also manage many unoccupied waters within the historical range of LCT as recreational fisheries for nonnative species.

To address the complexity of issues related to recovery of LCT, the Service determined that Basin-specific interagency and interdisciplinary teams, as well as public stakeholder participation, would be beneficial for developing LCT recovery efforts. In 1998, the Service organized a Management Oversight Group to address LCT recovery rangewide. Interagency teams were then organized by geographic area to develop strategies for LCT restoration and recovery efforts in their respective watersheds. In 1998, the Truckee River Basin Recovery Implementation Team was formed, followed by the Walker River Basin Recovery Implementation Team in 1999, and the Northwest DPS and Humboldt DPS Teams in 2000. The Tahoe Basin Recovery Implementation Team was formed in 2007 for recovery activities in the Lake Tahoe watershed. The teams each meet several times a year to discuss recovery activities and work plans aimed to coordinate recovery of LCT. Additionally, a rangewide LCT meeting is held every year to disseminate information collected (*i.e.*, research, population monitoring, project status) to all team members working to recover LCT.

Captive Propagation

Captive propagation of imperiled fish stocks is a growing conservation tool intended to restore extirpated populations in historical habitats and provide important life history information on poorly understood species (Rakes *et al*. 1999, p. 31). This is particularly true for the lacustrine form of LCT in the Western Lahontan Basin where all but one of the lacustrine populations were extirpated by the 1940's and very little was documented about their life history strategies. Currently, hatchery production is the only mechanism by which LCT are maintained in Pyramid, Walker, and Fallen Leaf Lakes. Much of that production goes toward supporting recreational harvest and has not historically been intended or designed to establish self-sustaining recovery populations.

To achieve recovery of LCT in the Western Lahontan Basin, captive propagation of stocks locally adapted to these watersheds, as described above in the Genetics section, is the only mechanism available to reestablish these wild populations and presumably the life history characteristics of the lake form into historical lake habitats. The success of captive propagation and reintroduction programs for recovery depends upon a number of conditions, including an appropriate donor population, genetics planning, management and monitoring, restoration of the receiving habitat appropriate to life history traits, and political support from management agencies. There are well-funded and focused efforts to restore watershed connectivity from

Walker Lake to the Walker River, from Pyramid Lake to the Truckee River, and for habitat restoration and native fish management in Lake Tahoe.

With the full development and readiness of the Pilot Peak broodstock at the Lahontan National Fish Hatchery Complex, we now have an available source of the wild lacustrine form known to have originated from the Tahoe-Truckee-Pyramid Lake watershed (Peacock and Kirchoff 2007, pp. 70-73). Beginning in spring 2009, the Lahontan National Fish Hatchery Complex Pilot Peak broodstock program will achieve a target number of 1,600 spawning age females. This will provide 500,000-600,000 eggs to meet the needs of a variety of new and emerging recovery and propagation programs identified by the Western Lahontan Basin's three Recovery Implementation Teams.

This broodstock has been used in preliminary and limited recovery activities in the Truckee River for streamside incubation of fry in an effort to imprint and establish a natural spawning population from Pyramid Lake. Excess broodstock have also been used to evaluate movement patterns using radio-telemetry tags in the mainstem Truckee River. Larger-scale recovery efforts are underway in Fallen Leaf Lake with a more rigorous assessment of the impacts of nonnative trout and identification of measures to reduce or eliminate those impacts to benefit LCT reintroduction.

Fundamental to the success of these reintroduction and recovery programs in the Walker River, Pyramid Lake/Truckee River, and Lake Tahoe watersheds will be the expansion of production capabilities of the wild Pilot Peak strain. Increased production of Pilot Peak fish is needed to meet the growing demand for recreational LCT fishing in lieu of nonnative fish management, in concert with recovery programs intended to establish self-sustaining lacustrine LCT populations. To that end, a Hatchery Management Plan should be formed to develop, coordinate, and implement production programs of Pilot Peak strain LCT.

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 1995 LCT Recovery Plan identifies both general and population level objectives that must be met before the species can be delisted (Service 1995, pp. 47-48, 50). The Service is currently using these objectives to guide recovery activities. The general and population level recovery objectives, as presented in the 1995 LCT Recovery Plan, are summarized below.

General Objectives

The primary objective of the Recovery Plan is to restore LCT to levels where population segments can be delisted. As the first general recovery objective, LCT may be considered for delisting by population segment when management has been instituted to enhance and protect habitat required to sustain appropriate numbers of viable self-sustaining populations. As the second general recovery objective, the number of viable populations necessary for survival of fluvial and lacustrine LCT will be validated by population viability analysis and research. Recovery objectives should be targeted to allow for a 95 percent chance of persisting for 100 years.

Specific overall objectives address one or more of the five listing factors, and include: (1) manage and secure habitat to maintain all existing LCT populations (Factor A); (2) establish 148 self-sustaining fluvial LCT populations within native range (Factors A, B, C, and E); (3) determine appropriate numbers of self-sustaining lacustrine LCT populations within native range to assure persistence for the next 100 years (Factors A and E); (4) implement research and perform population viability analyses to validate recovery objectives (Factors A and E); and (5) revise the recovery plan (Factors A, B, C, D, and E). A viable population is considered to be one that has been established for 5 or more years and has three or more age classes of self-sustaining LCT as determined through monitoring described in the Recovery Plan's Narrative Outline for Recovery Actions Addressing Threats (Service 1995, pp. 47-48).

Population Level Objectives

As noted above (Application of the 1996 Distinct Population Segment (DPS) Policy), it is inappropriate to discuss DPSs that are not listed through a formal rulemaking process, and recovery plans do not designate DPSs. Since no DPSs of LCT are formally listed, we will discuss the DPS delineations of the LCT Recovery Plan in terms of watershed within the three major basins. To achieve population level objectives, management should be implemented to enhance and protect habitat necessary to sustain the following numbers of self-sustaining viable populations within each basin as follows (Factors A, B, C, and E):

Western Lahontan Basin population segment – Maintain a total of 21 populations in the following native watersheds: Truckee River (7 fluvial and 2 lacustrine populations), Carson River (6 fluvial populations), and Walker River (5 fluvial and 1 lacustrine populations). Maintain 13 fluvial populations existing out of range in California (9) and

Utah (4) as remnant sources of Truckee, Carson, and Walker River strain LCT. Reintroduce populations as appropriate to establish a minimum distribution of 6 viable, self-sustaining fluvial populations each in the Truckee, Carson, and Walker River watersheds. Conduct research to validate recovery criteria for lacustrine-adapted fish.

Northwestern Lahontan Basin population segment – Maintain a total of 26 populations in the following native watersheds: Quinn River (11 fluvial populations), Black Rock Desert (4 fluvial and 1 lacustrine populations), and Coyote Lake (10 fluvial populations). Maintain nine fluvial populations existing out of native range in the Alvord Lake watershed as remnant sources of Coyote Lake strain LCT. Reintroduce a total of 12 fluvial populations distributed among the Quinn (1) and Black Rock Desert (11). Conduct research to validate recovery criteria for lacustrine-adapted fish.

Humboldt River Basin population segment – Maintain a total of 93 fluvial populations distributed among the Marys River subwatershed (17), the North Fork Humboldt River subwatershed (12), the East Humboldt River area (6), the South Fork Humboldt River subwatershed (20), the Maggie Creek subwatershed (7), the Rock Creek subwatershed (6), the Reese River subwatershed (9), the Little Humboldt River subwatershed (15), and the lower Humboldt River area (1).

While we continue to support and implement the recovery strategy outlined in the Recovery Plan, many of the objectives are either too general or not up-to-date with current scientific literature. We describe below the progress made toward achieving the Recovery Plan's general and population level objectives.

The first general objective focuses on managing and securing currently occupied habitat to maintain existing populations. Much effort has been expended by land management agencies to improve riparian habitat through improved management of land use activities (*i.e*., improved grazing management) (Table A2.11). While many improvements have been made, over 40 percent of the currently occupied habitat is still categorized in fair or poor condition (Table 11). Additionally, there is little information on the condition of non-occupied potential LCT habitat for potential reintroduction sites. The Recovery Plan only briefly addresses the need for larger connected habitat patches; however, information on the required size of these habitat patches was not available at the time. Recent literature on the amount of habitat needed and the size of each population to maintain population viability (see Factor A) should be used to guide future management decisions.

The second general objective and the population level objectives for each basin do not address threats due to small isolated populations and the need for large, well-connected habitat patches, as described previously in Factor A. Additional populations for the Western and Northwest Lahontan Basins are discussed in the Recovery Plan; however, no information on the size of habitat needed or the need for connected habitats is presented. Moreover, the Recovery Plan aims only to maintain existing populations in the Eastern Lahontan Basin. Numerous populations have been lost since 1995 and most LCT populations which are co-occurring with nonnative species are being replaced (Table A2.2). In addition, a definition of viable population also should optimally consider a habitat-size and population-size component based on current, peer-reviewed literature.

The general recovery objectives also included five specific objectives, as discussed above. Objective 3 addresses lacustrine populations and the need to determine population sizes required for long-term persistence. For the two self-sustaining lacustrine populations, this objective has been met for the Independence Lake population (Risler *et al*. 2006, pp. 1-68) but has not been established yet for the Summit Lake population. Recovery objectives for other current lacustrine populations in Pyramid and Walker Lakes, as well as recovery potential of other historical lake habitats, were not addressed in the Recovery Plan (see Objective 5 below).

Objective 4 calls for an active research program, which has been and continues to be implemented for LCT. A rangewide genetic analysis has been conducted and population viability analysis research has been accomplished for one lacustrine population (Independence Lake) and numerous fluvial populations within the Quinn and Humboldt River watersheds (Peacock and Kirchoff 2007, pp. 1-109; Rissler *et al*. 2006, pp. 1-68; Ray *et al*. 2007, pp. 1-205). Genetic research has also identified the closest genetic stock of LCT to historical lacustrine populations in the Truckee watershed (Peacock and Kirchoff 2007, pp. 70-73), which has been used to develop a broodstock to aid in recovery efforts in the Western Lahontan Basin. Recent research on LCT, as well as other cutthroat subspecies (as cited throughout this document), published since 1995 should be used to consider management improvements and refine future recovery actions.

Objective 5 to revise (update) the Recovery Plan has not been implemented; however, two Short-Term Action Plans were developed in 2003 for the Truckee and Walker River watersheds (Service 2003c, pp. 1-71; 2003d, pp. 1-44). These plans were implemented to address the complex issues facing LCT recovery in these two watersheds which were not addressed in the 1995 Recovery Plan. The Truckee River Recovery Implementation Team and Walker River Recovery Implementation Team are currently using these Short-Term Action Plans to guide recovery efforts in these watersheds.

In summary, since the Recovery Plan was published in 1995, there have been substantial improvements in understanding the threats and long-term persistence needs of inland cutthroat trout in general which can be directly applied to LCT. In addition, many LCT-specific studies have been completed (many of which were suggested in the Recovery Plan) which has increased our understanding of both fluvial and lacustrine populations.

IV. SYNTHESIS

The historical range of LCT has been significantly reduced over the past 200 years due to anthropogenic impacts. LCT currently occupy approximately 8.6 percent of their historical stream habitat and 46.8 percent of their historical lake habitat; however, only two of the lakes have self-sustaining populations. Since the mid 1990’s, LCT have been introduced/established in 12 new waters, have remained in 147 streams, and have been extirpated from 32 streams (Table A2.2).

LCT populations have been and continue to be impacted by nonnative species interactions, habitat fragmentation and isolation, degraded habitat conditions, drought, and fire. Nonnative fish co-occur with LCT in 36.4 percent of currently occupied stream habitat and all currently occupied historical lake habitat except for Walker Lake. Most LCT populations which co-occur with nonnative species are decreasing and the majority of population extinctions which have occurred since the mid 1990's have been caused by nonnative species. Additionally, nonnative fish occupy habitat in nearly all unoccupied LCT historical stream and lake habitat, making repatriation of LCT extremely difficult. The majority of LCT populations are isolated and confined to small habitats (width) and short stream lengths. These factors reduce gene flow between populations, and reduce the ability of populations to recover from catastrophic 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 8 km (5 mi) of habitat, and have no nonnative species present. Currently, only 28.2 percent of LCT conservation populations occupy habitat greater than 8 km (5 mi) in length and over 83 percent of currently occupied streams have fewer than 94 fish/km (150 fish/mi). Pyramid and Walker Lakes are important habitat for the lacustrine form of LCT. Conditions in these lakes have deteriorated over the past 100 years and continue to decline, most dramatically in Walker Lake. The present or threatened destruction, modification, or curtailment of LCT's habitat and range continues to be a significant threat and in some instances is increasing in magnitude and severity.

Recreational fishing for LCT in popular fishing waters is regulated and augmented by hatcheries; however, harvest from recreational fishing in the Western Lahontan Basin does appear to pose a threat to LCT recovery because it impedes our ability to establish recovery populations, to understand the life history needs of lacustrine LCT, and to identify the actions needed to achieve recovery. Other occupied waters are either closed to fishing or have catch and release regulations. While LCT in small streams may be vulnerable to overharvest, most occupied habitats are in remote areas and receive little fishing pressure. Scientific and educational sampling is controlled by State and Tribal permitting processes and new, non-lethal techniques have been developed for genetic analyses. Overutilization for commercial, recreational, scientific, or education purposes is not believed to be a significant threat at this time except for priority recovery waters in the Western Lahontan Basin.

Whirling disease is currently not a threat to LCT; however, it has the potential to become more widespread due to warmer waters that could result from climate change. Brown and brook trout are known piscivores; however, the extent to which these nonnative species prey on LCT is unknown. Most historical waters in the western portion of LCT's range, including lakes, and to a more limited extent in the Quinn River watershed and North Fork Little Humboldt River sub-watershed, are occupied by brown trout. Brook trout are the most common nonnative salmonid which co-occur with LCT and are found in nearly every major historical LCT watershed. Lake trout are known to prey on LCT. Efforts to manage the impacts from lake trout to reintroduced LCT are ongoing in Fallen Leaf Lake and strategies have been identified to abate these impacts. These strategies will be used in the other large historical lakes within the Western Lahontan Basin where lake trout are found to increase the success of reintroductions into these lakes. Disease is not believed to be a significant threat at this time. Predation from nonnative fish continues to be a threat where their distribution overlaps with LCT. The presence of nonnative predatory fish within unoccupied historical LCT habitat continues to impede recovery efforts in these waters.

The ESA is the primary Federal law that provides protection for LCT since its listing as endangered in 1970. 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 LCT at this time.

The impacts to LCT 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 such as drought and fire. These impacts will likely increase the magnitude and severity of other existing threats to LCT. Adding stressors predicted by climate change may exacerbate the current threats to LCT populations throughout its range, many of which already have multiple stressors affecting their persistence.

The creation of recovery implementation teams in the major Lahontan Basins has allowed for the planning and implementation of watershed specific recovery efforts. Recent fisheries management actions to reduce or eliminate nonnatives, and the focus on large connected habitat and the lacustrine form have been a positive step. Larger treatments aimed at reducing the threats from nonnative species, which incorporate mainstem streams, rivers, lakes, and private lands, will be needed to address current and future threats to LCT. Continued development of the Pilot Peak strain will aid in recovery efforts in the Western Lahontan Basin. Stocking of nonnative fish within historical stream and lake habitats and management for these nonnative species for recreational purposes continues to occur and is a significant threat to LCT.

We conclude that LCT still meets the definition of threatened throughout its range. LCT in the Western and Northwest Lahontan Basins are the most tenuous due to only a few isolated small populations, the presence of nonnative species in most fluvial and lacustrine habitats, complexity of threats on the lacustrine form of LCT, and poor water quality in Walker Lake. While the Eastern Lahontan Basin has the largest intact habitat for LCT, populations also suffer from nonnative species, and small isolated populations.

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*
__X_ No Change

New Recovery Priority Number and Brief Rationale: 9 (no change).

VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

1. **Work with stakeholders to revise the Recovery Plan**

    The 1995 LCT Recovery Plan states that it should be revised after ecological, genetic, population viability, and other research has been completed. Significant knowledge has been gained regarding the needs of LCT for long-term viability, the genetic make up of extant populations, and the development of a native broodstock for the Western Lahontan Basin. A revised recovery plan should re-prioritize recovery actions and provide for reduction of nonnative (stocked) species conflicts, ensurance of recreational opportunities, protection of quality habitat, and identification of key habitat restoration opportunities.

2. **Collaborate with State and Tribal representatives to develop a hatchery management plan**

    A hatchery management plan should be developed to aid in coordination of fisheries management between the Service, State, and Tribal hatchery programs. The development of a native Western Lahontan Basin LCT broodstock is making it possible to move away from nonnative fish production to native fish production while maintaining quality recreational opportunities and LCT recovery activities.

3. **Improve LCT database for future reviews and effectiveness monitoring**

    Develop a relational database of all relevant information that is linked to an improved conservation assessment. With a database that is actively maintained and updated as new information becomes available, it will be possible to track progress in real-time and identify critical uncertainties, issues, information gaps, etc., so that actions can be taken to address issues in a timely manner. This will make future assessments much less labor intensive, more transparent, and more scientifically defensible.

4. **Work with the States and Tribes to develop regulations to help conserve LCT**

    Nevada and California fishing regulations on many important LCT recovery waters make no distinctions between catching LCT and the various nonnative trout. Harvest of LCT is affecting our ability to understand the life history needs of the lacustrine form and being able to identify the necessary actions for achieving self-sustaining populations. A reduction in the harvest number or specific protection for LCT would allow for meeting both recovery needs and providing a recreational fishery.

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<u>Personal Communications</u>

Bigelow, Jay. 2009. Hatchery Manager, U.S Fish and Wildlife Service, Lahontan National Fish Hatchery Complex, Gardernerville, Nevada. Telephone conversation with Jay Bigelow on January 27, 2009. Subject: we discussed at what age do the Pilot Peak broodstock raised at the Lahontan National Fish Hatchery become sexually mature. We also discussed the acclimation process of stocked LCT into Walker Lake.

Coffin, Patrick. 2009. Fisheries Biologist, Elko District, Bureau of Land Management, Elko, Nevada. Electronic mail received on February 4, 2009. Subject: Marys River barrier assessment report.

Temple, Alan. 2009. Biologist, U.S. Fish and Wildlife Service, Shepherdstown, West Virginia. Telephone conversation with Alan Temple, Branch of Aquatic Resources Training, National Conservation Training Center, on January 8, 2009. Subject: we discussed the number of State and federal biologists who work with Lahontan cutthroat trout who have taken the Principles and Techniques of Electrofishing course.

Appendix 1. *Oncorhynchus clarkii* subsp. *henshawi*: Current and probable historical habitat separated by watershed, prepared for 2009 5-year review.

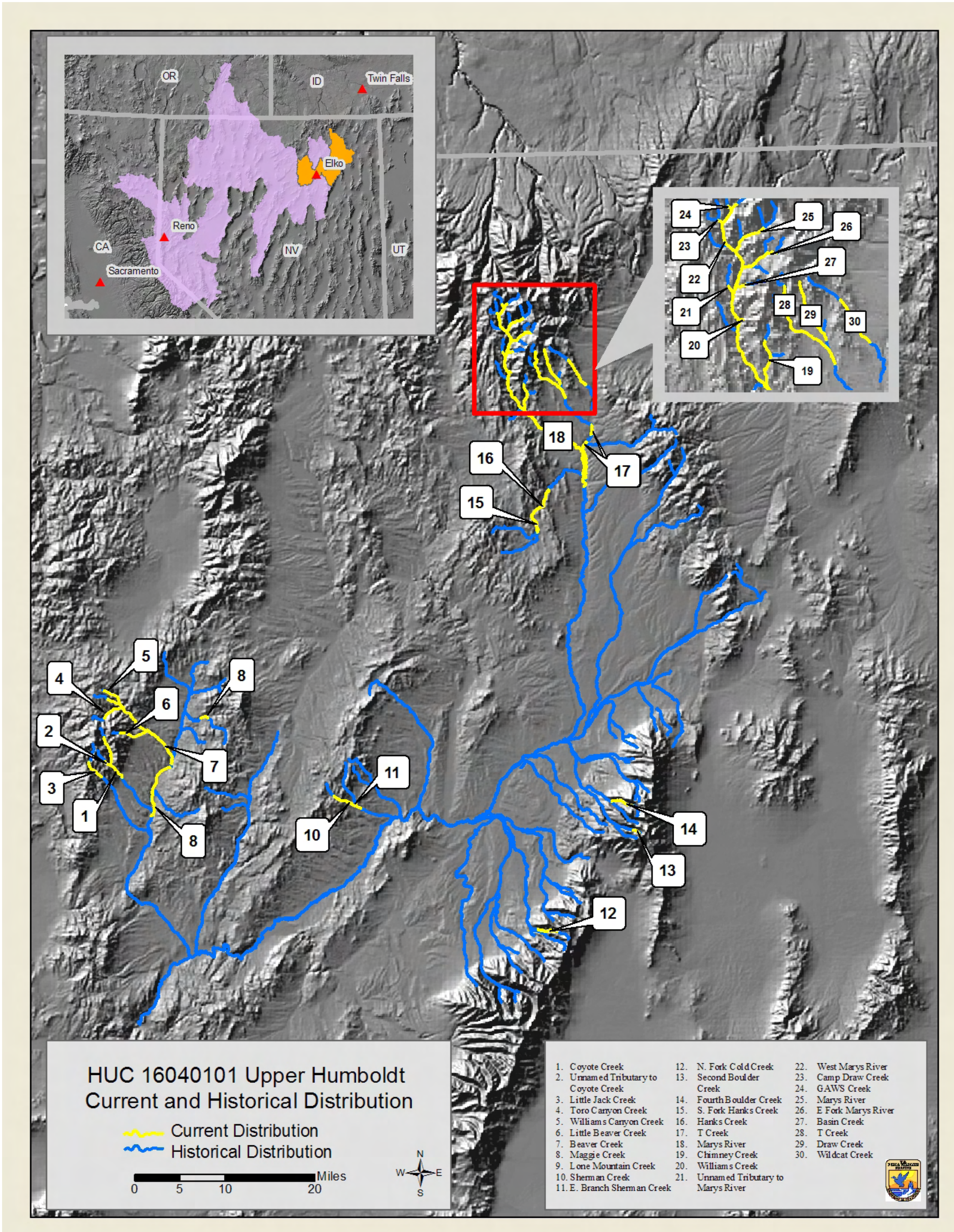

Figure A1.1. Currently occupied and probable historical Lahontan cutthroat trout habitat in the Upper Humboldt River watershed, prepared for 2009 5-year review.

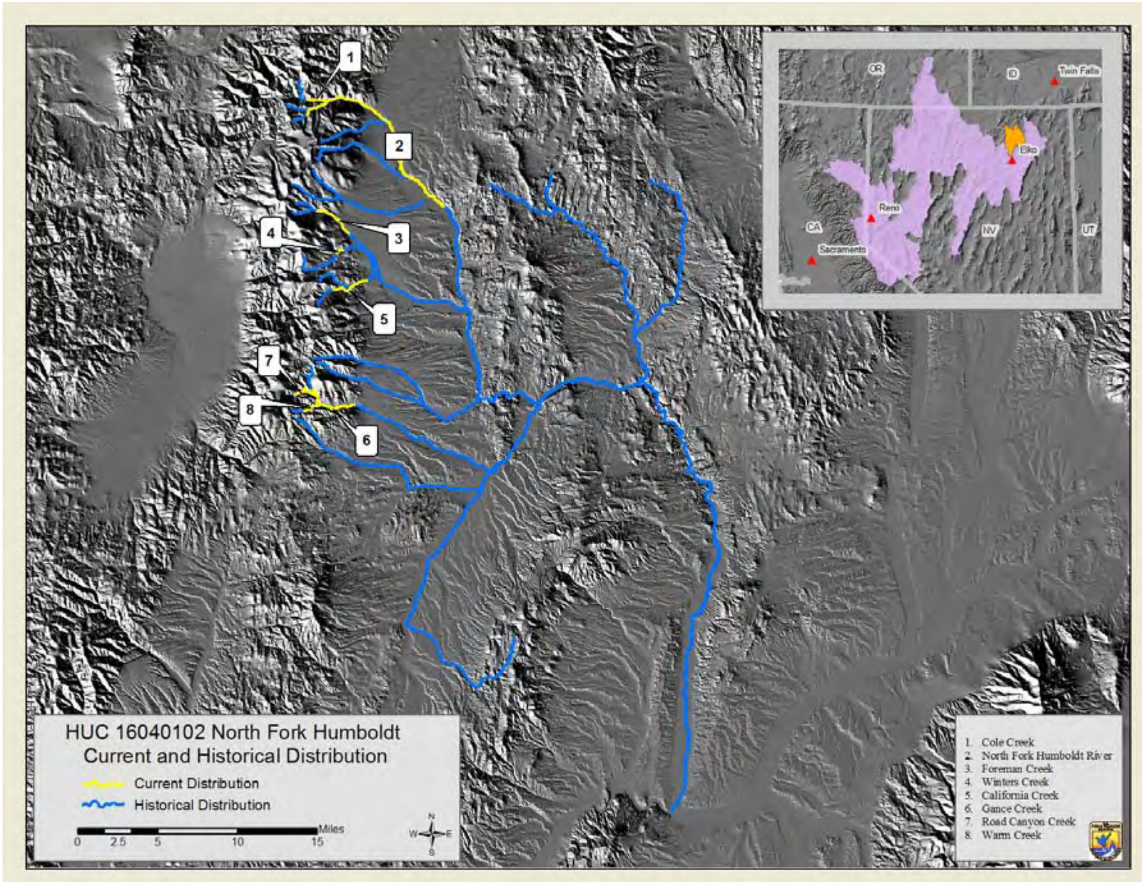

Figure A1.2. Currently occupied and probable historical Lahontan cutthroat trout habitat in the North Fork Humboldt River watershed, prepared for 2009 5-year review.

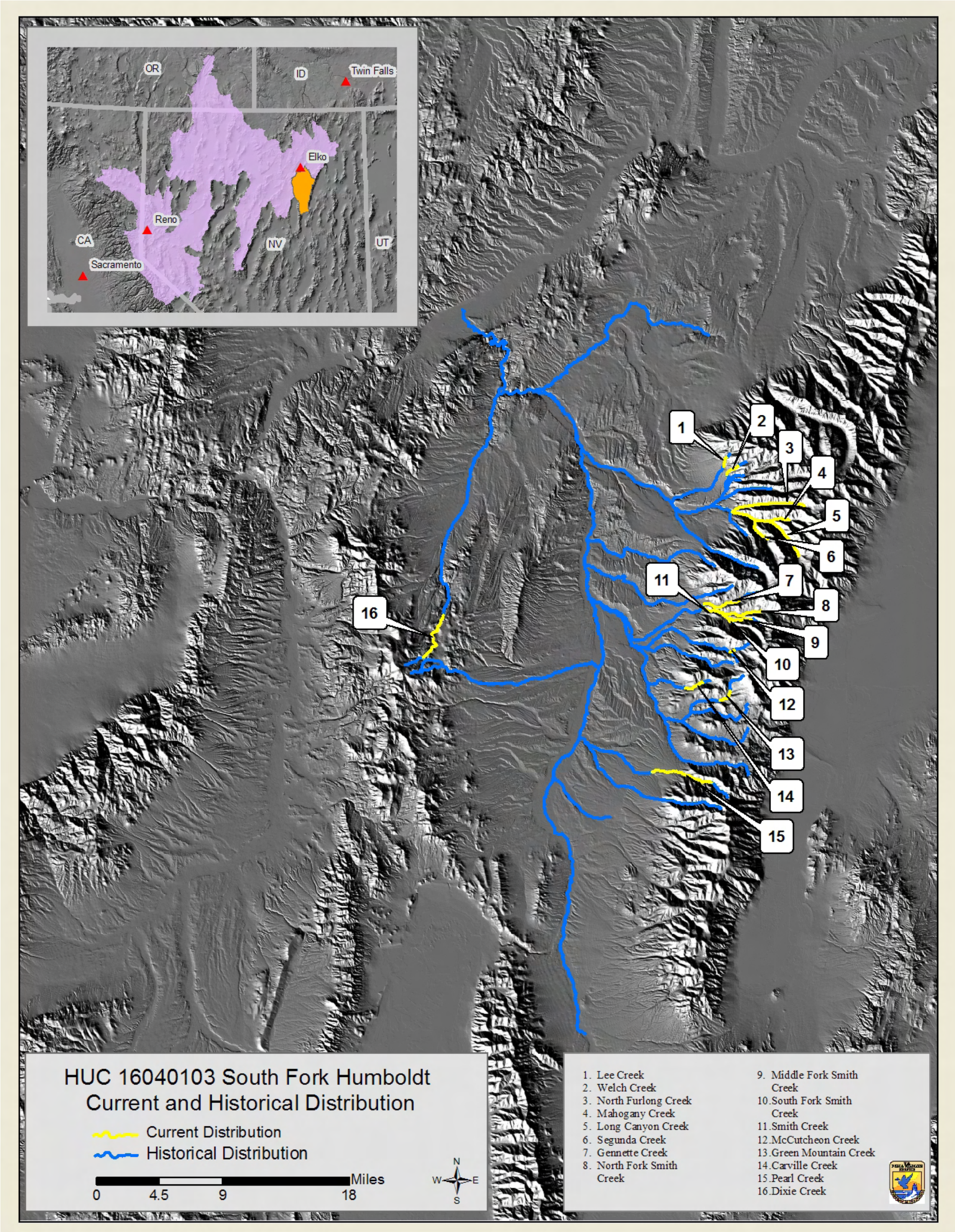

Figure A1.3. Currently occupied and probable historical Lahontan cutthroat trout habitat in the South Fork Humboldt River watershed, prepared for 2009 5-year review.

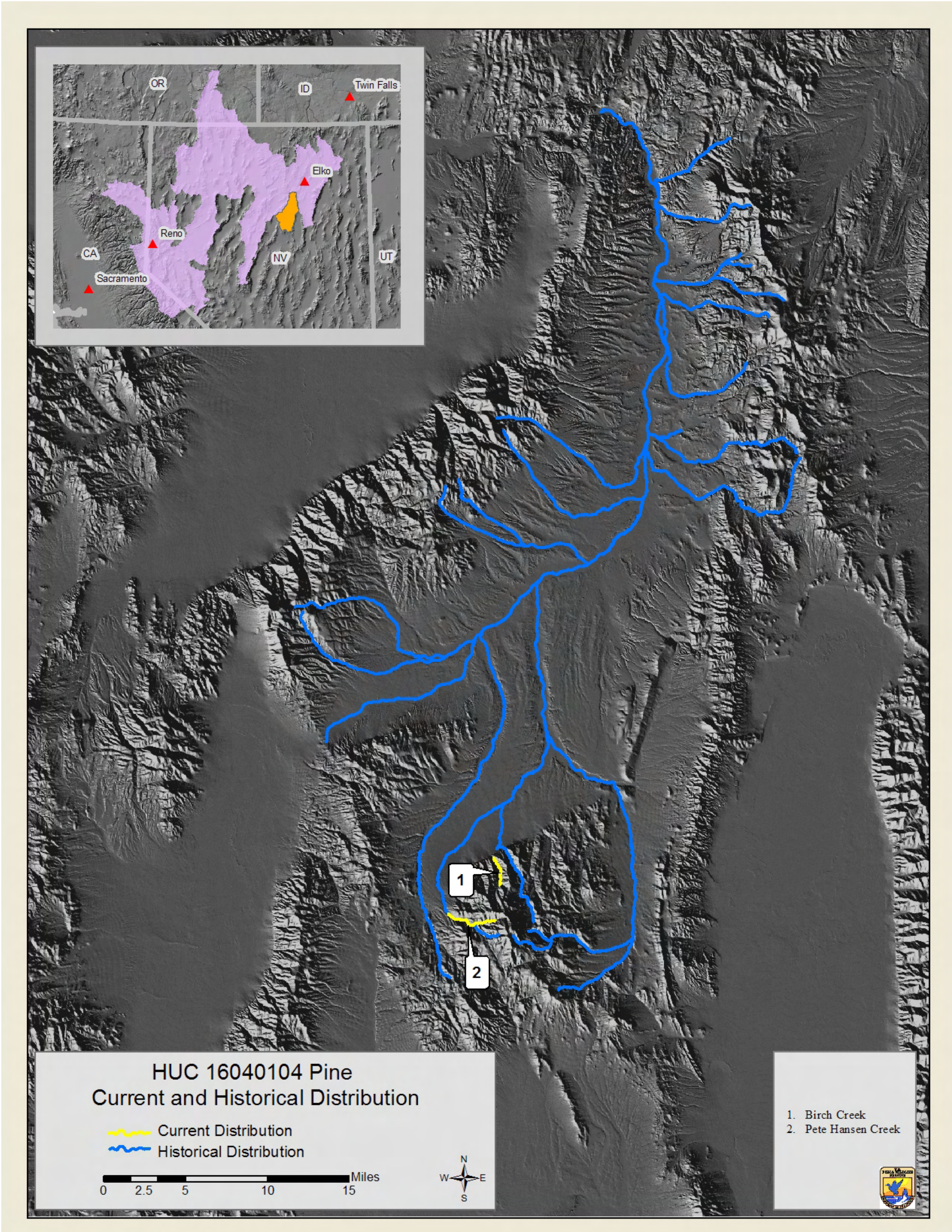

Figure A1.4. Currently occupied and probable historical Lahontan cutthroat trout habitat in the Pine Creek watershed, prepared for 2009 5-year review.

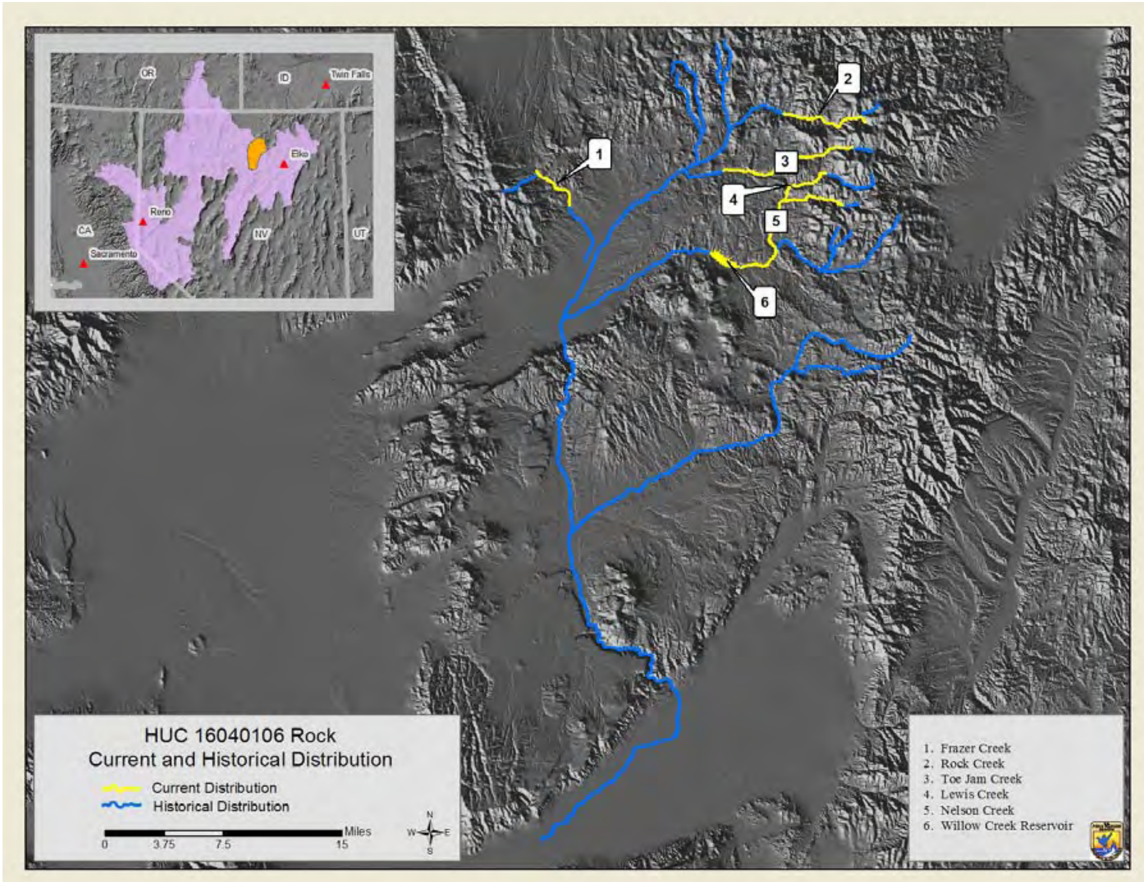

Figure A1.5. Currently occupied and probable historical Lahontan cutthroat trout habitat in the Rock Creek watershed, prepared for 2009 5-year review.

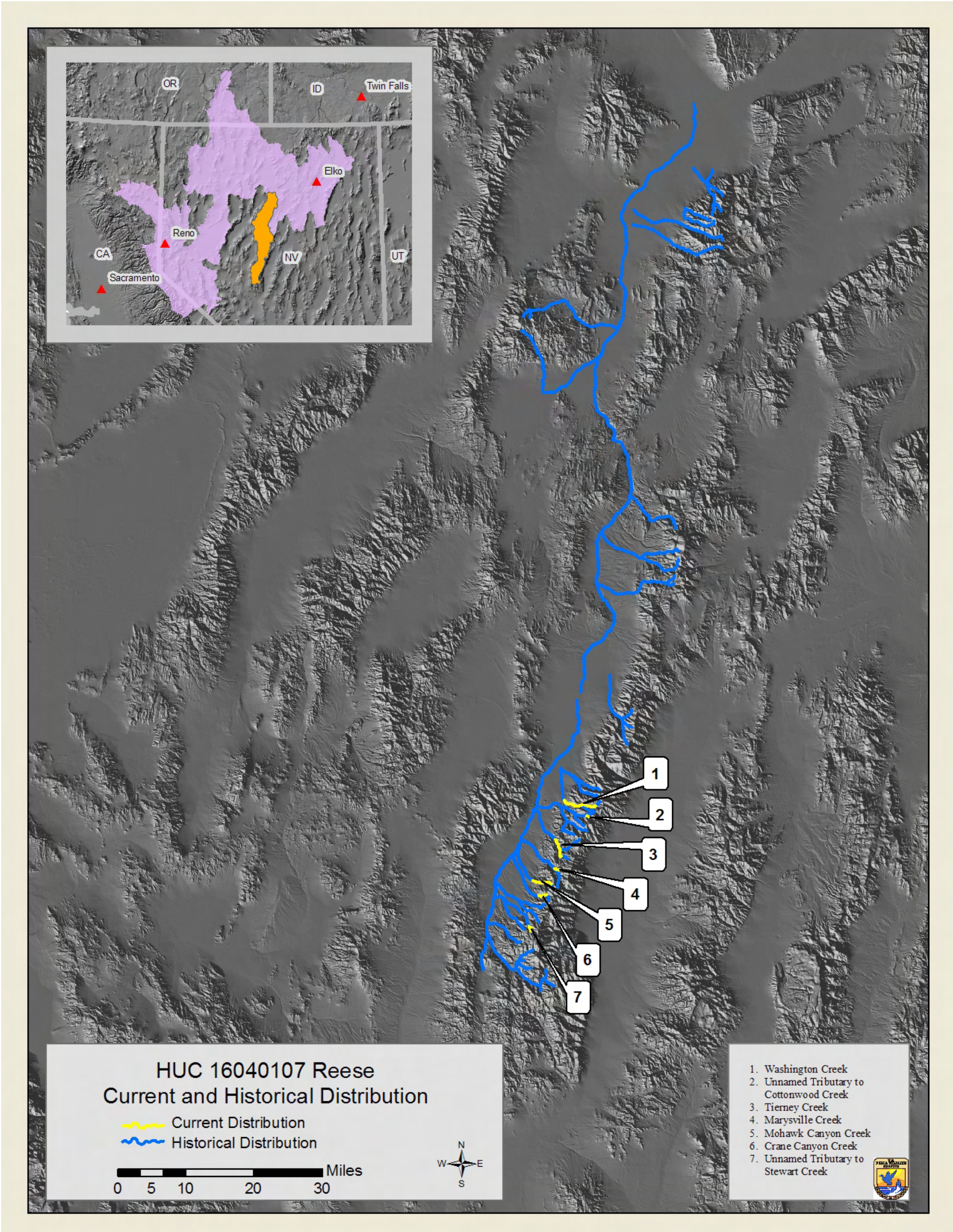

Figure A1.6. Currently occupied and probable historical Lahontan cutthroat trout habitat in the Reese River watershed, prepared for 2009 5-year review.

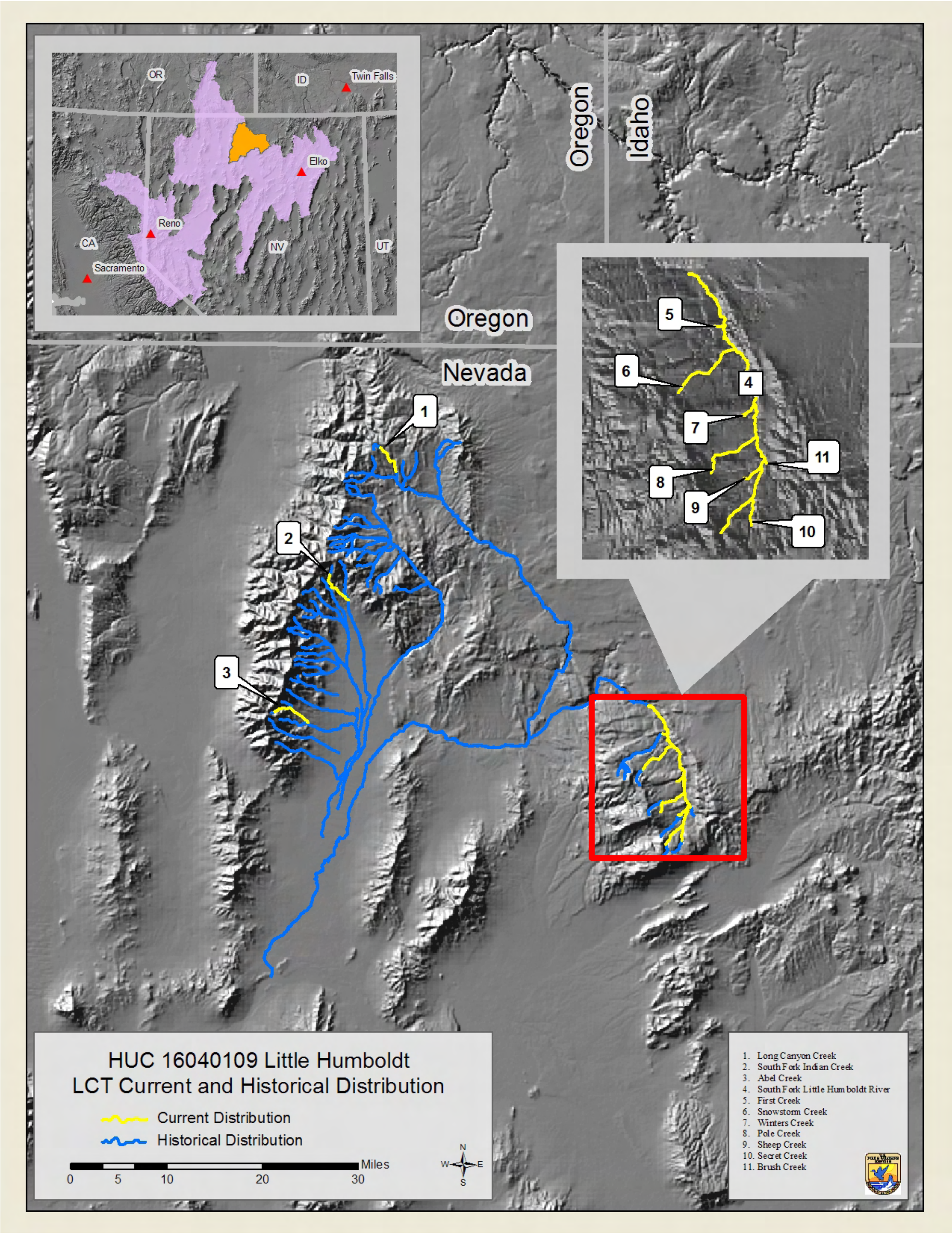

Figure A1.7. Currently occupied and probable historical Lahontan cutthroat trout habitat in the Little Humboldt River watershed, prepared for 2009 5-year review.

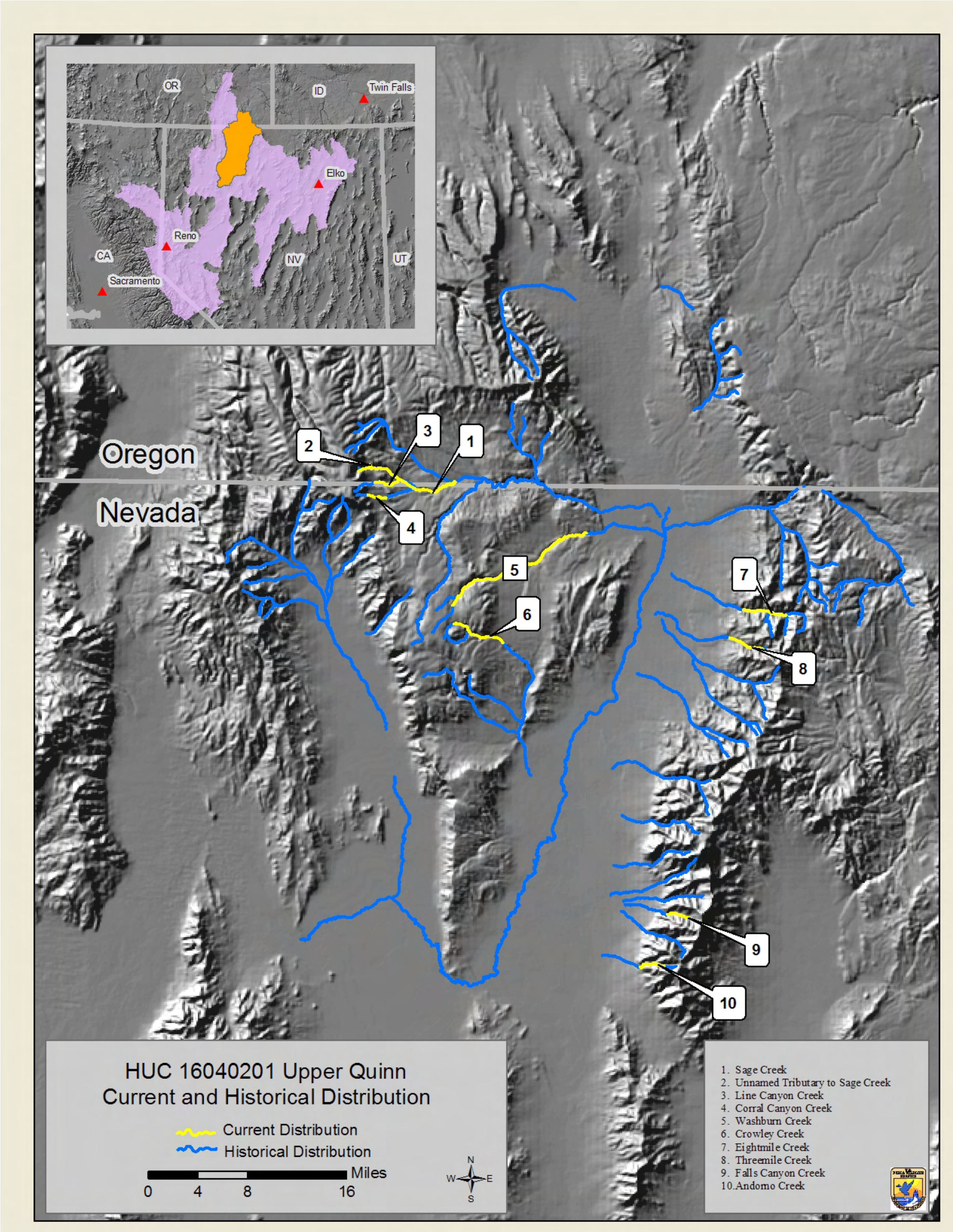

Figure A1.8. Currently occupied and probable historical Lahontan cutthroat trout habitat in the Upper Quinn River watershed, prepared for 2009 5-year review.

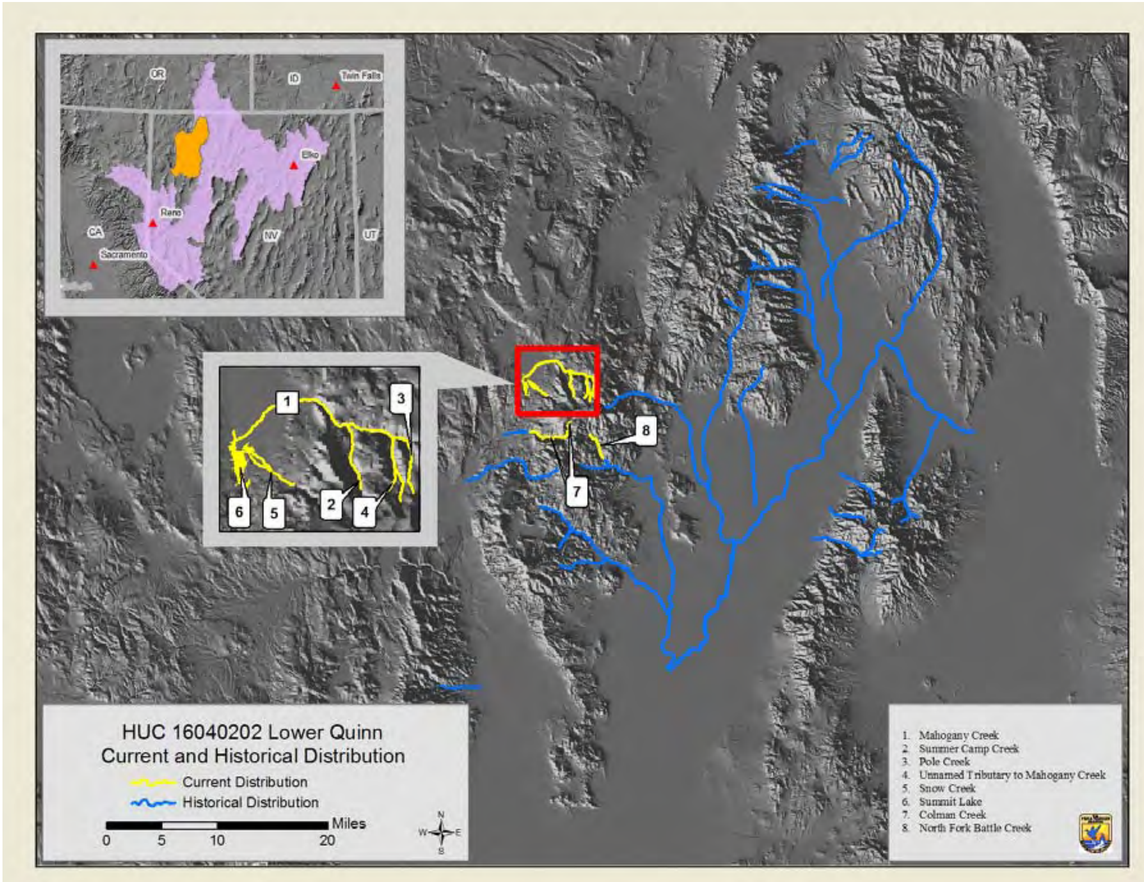

Figure A1.9. Currently occupied and probable historical Lahontan cutthroat trout habitat in the Lower Quinn River watershed, prepared for 2009 5-year review.

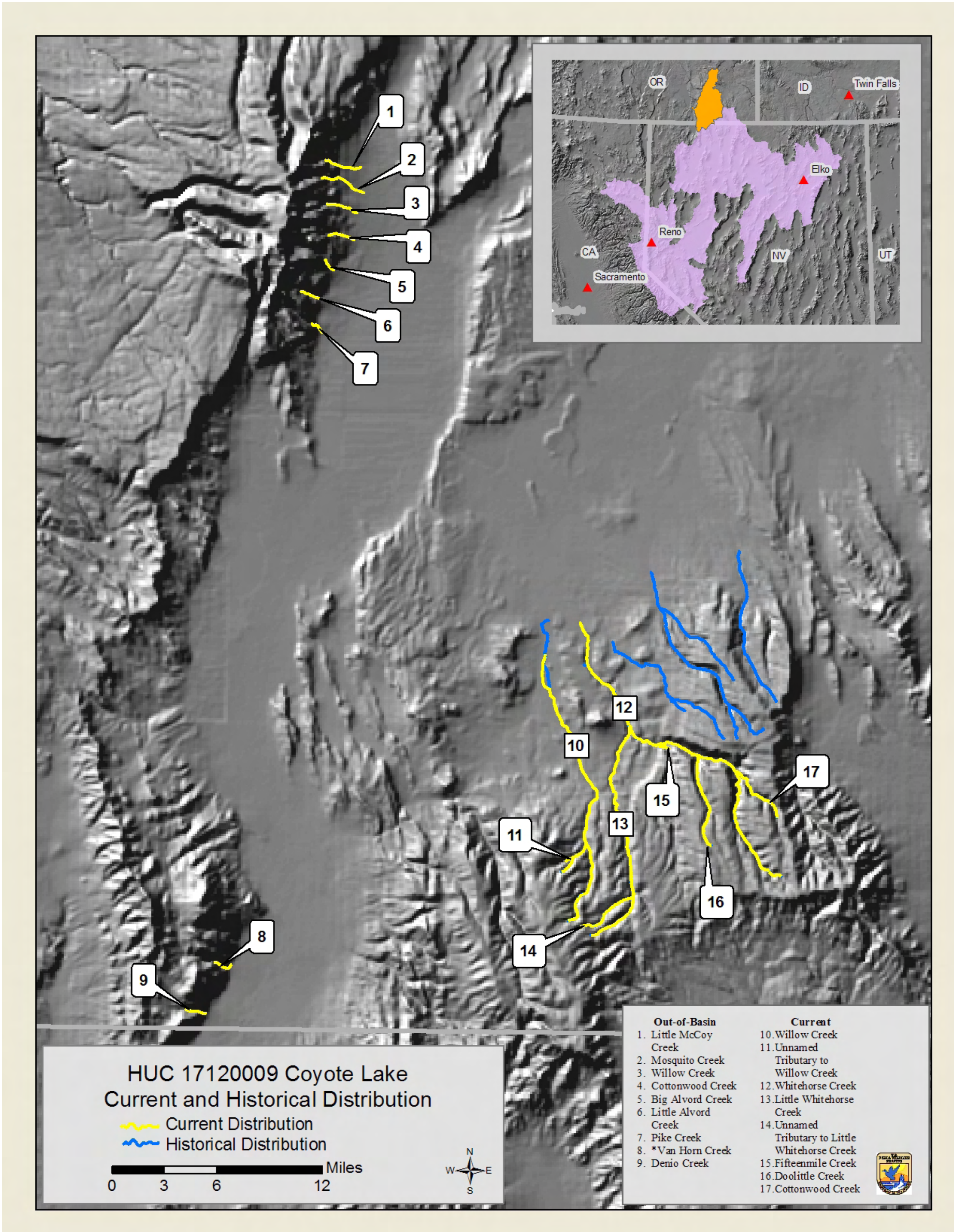

Figure A1.10. Currently occupied and probable historical Lahontan cutthroat trout habitat in the Coyote Lake Basin watershed, prepared for 2009 5-year review. *Van Horn Creek may have been extirpated by brown trout, additional surveys are needed to verify the status of this population.

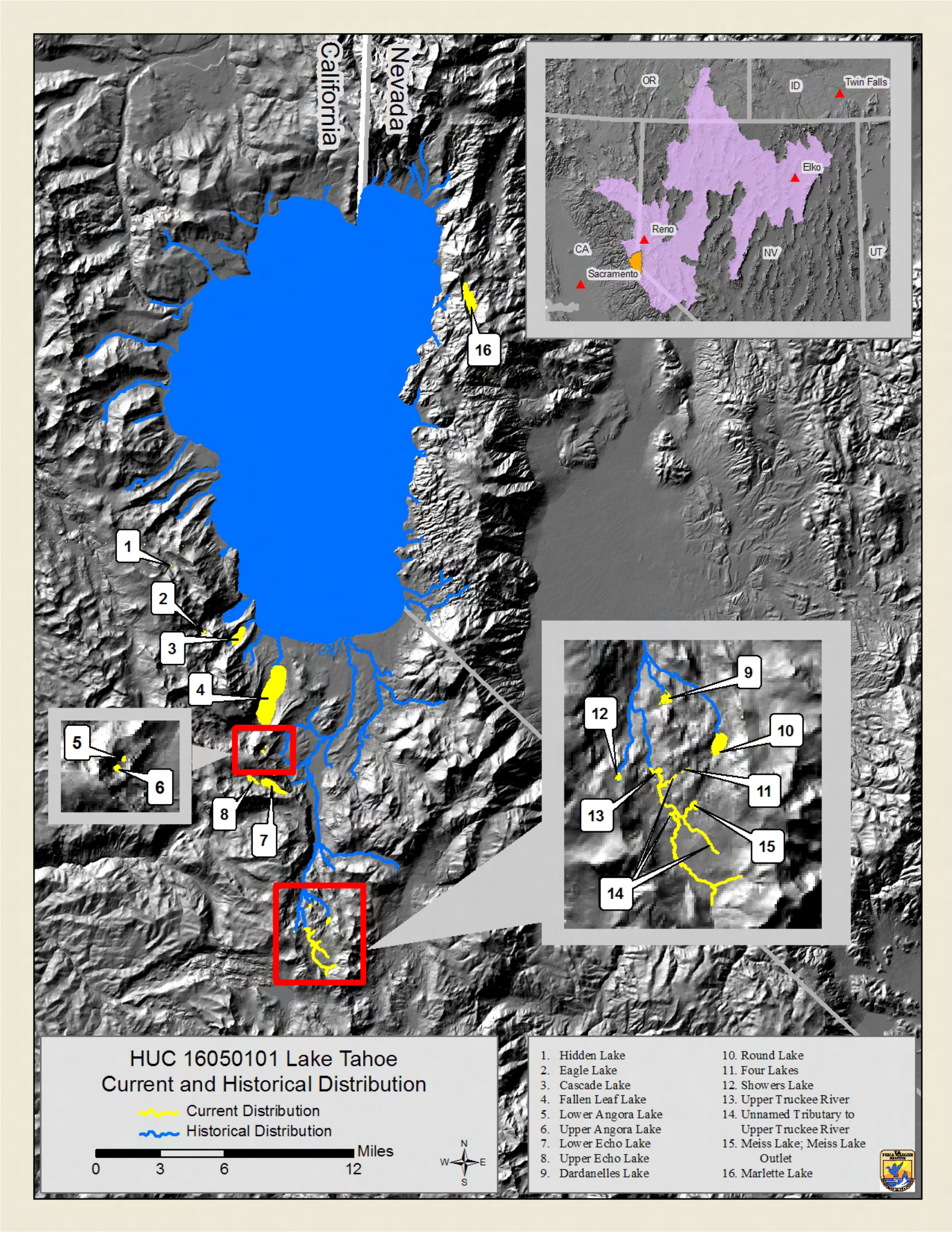

Figure A1.11. Currently occupied and probable historical Lahontan cutthroat trout habitat in the Lake Tahoe watershed, prepared for 2009 5-year review.

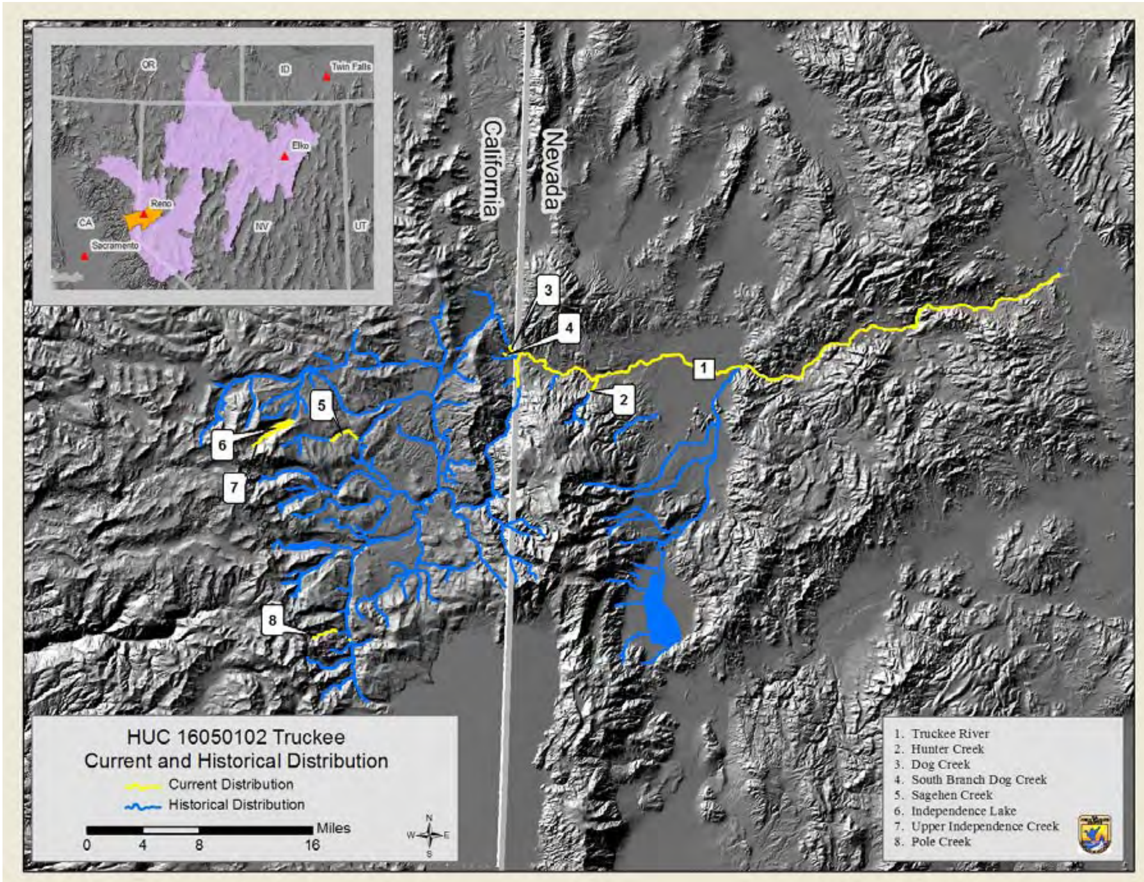

Figure A1.12. Currently occupied and probable historical Lahontan cutthroat trout habitat in the Truckee River watershed, prepared for 2009 5-year review.

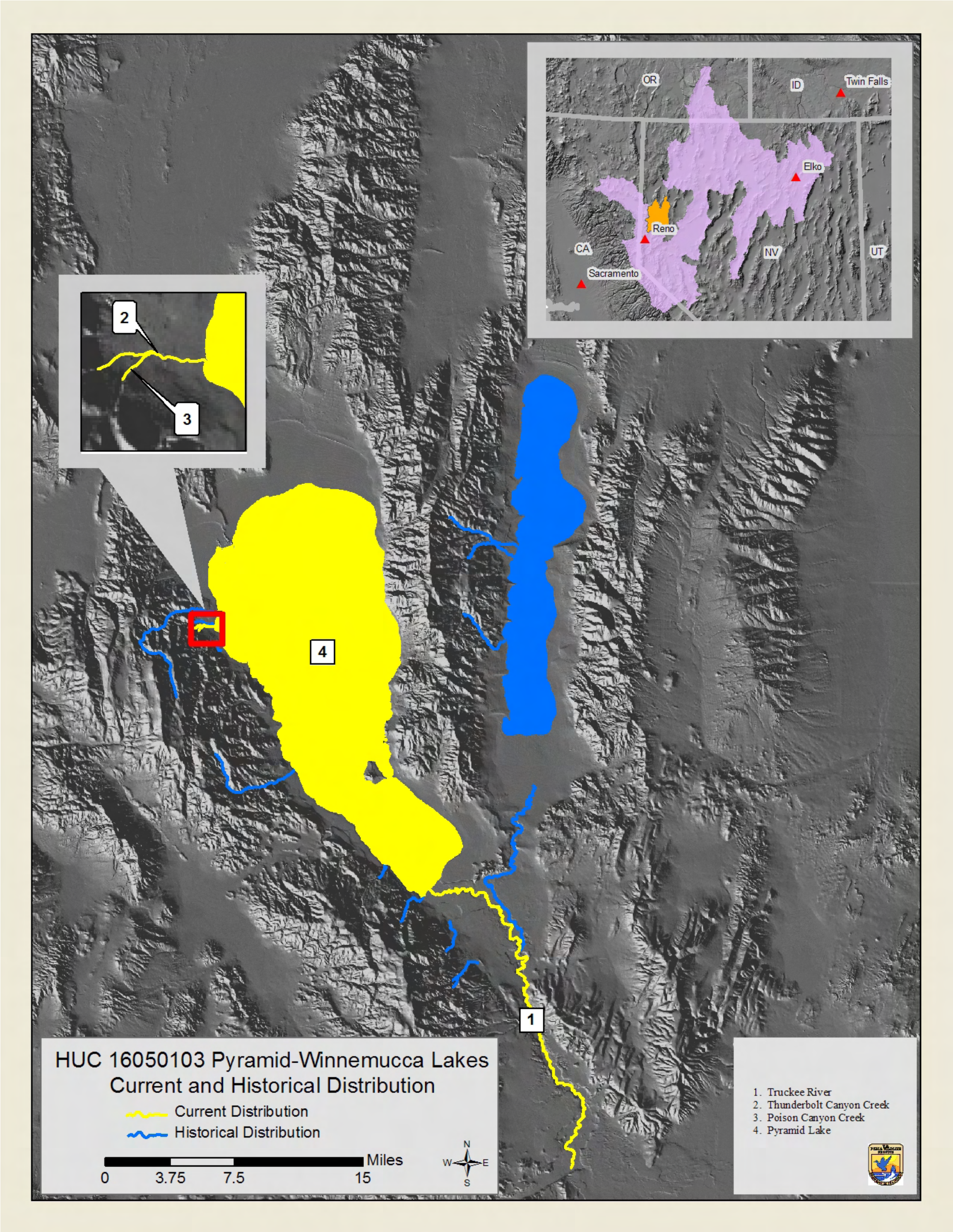

Figure A1.13. Currently occupied and probable historical Lahontan cutthroat trout habitat in the Pyramid Lake watershed, prepared for 2009 5-year review.

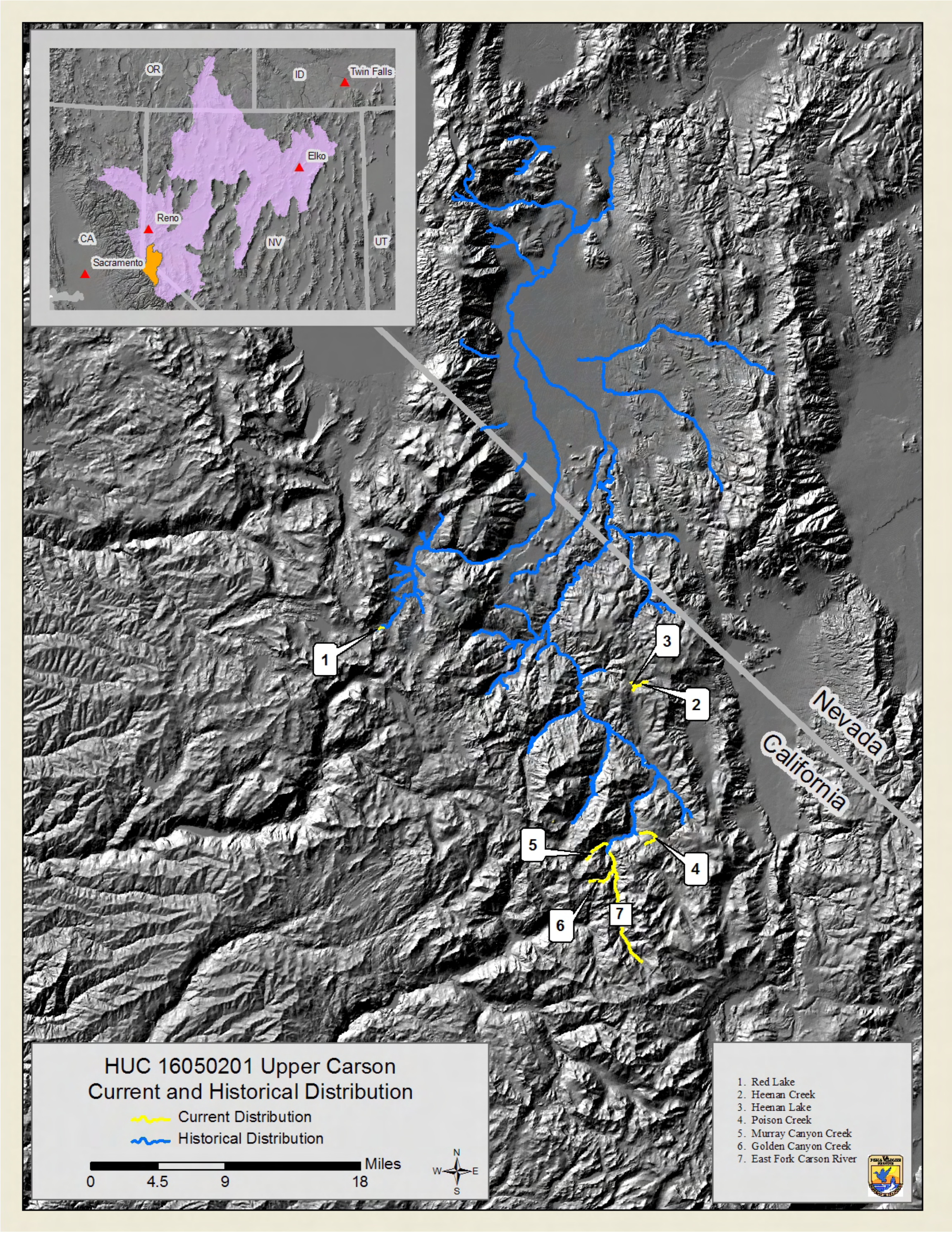

Figure A1.14. Currently occupied and probable historical Lahontan cutthroat trout habitat in the Upper Carson River watershed, prepared for 2009 5-year review.

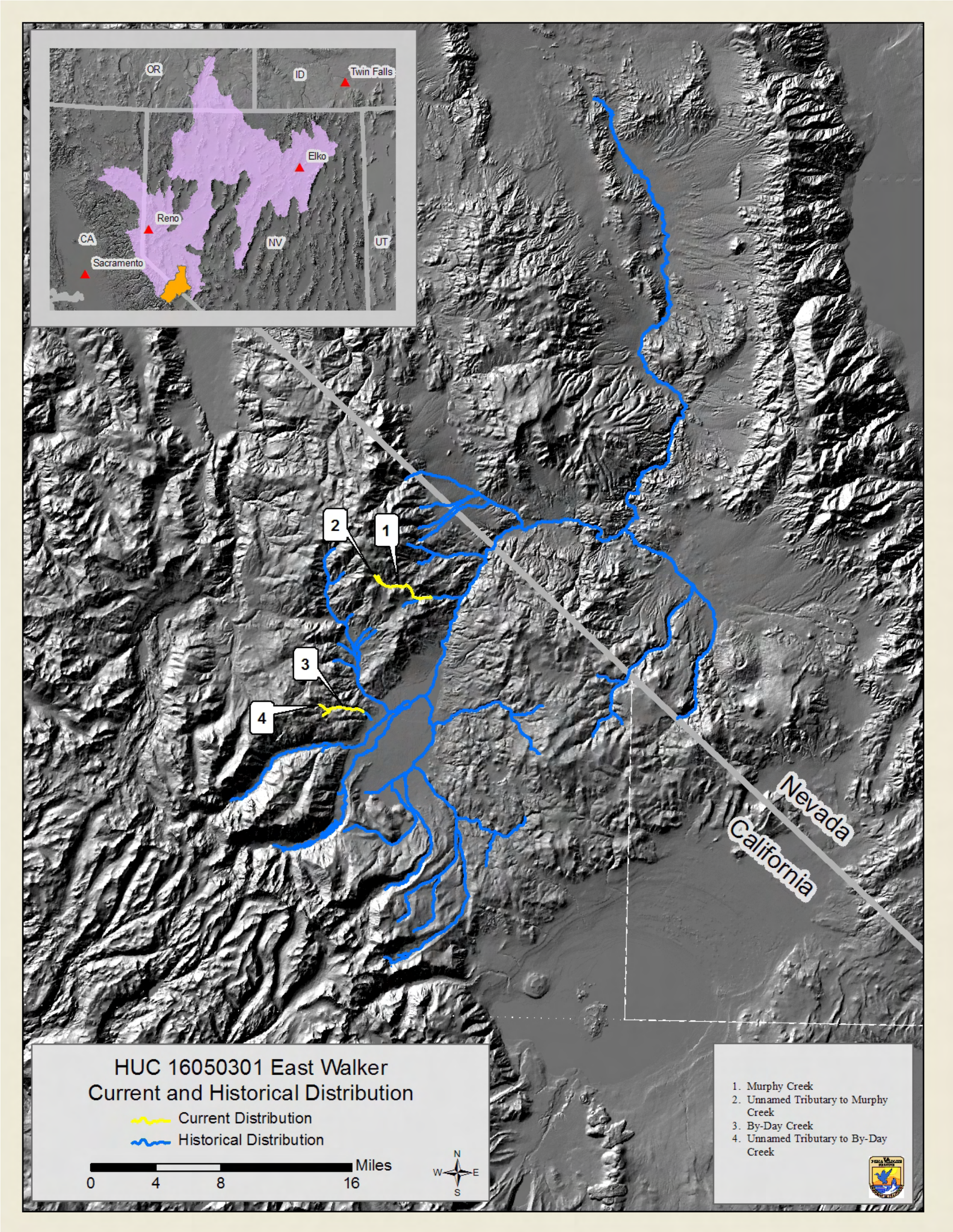

Figure A1.15. Currently occupied and probable historical Lahontan cutthroat trout habitat in the East Walker River watershed, prepared for 2009 5-year review.

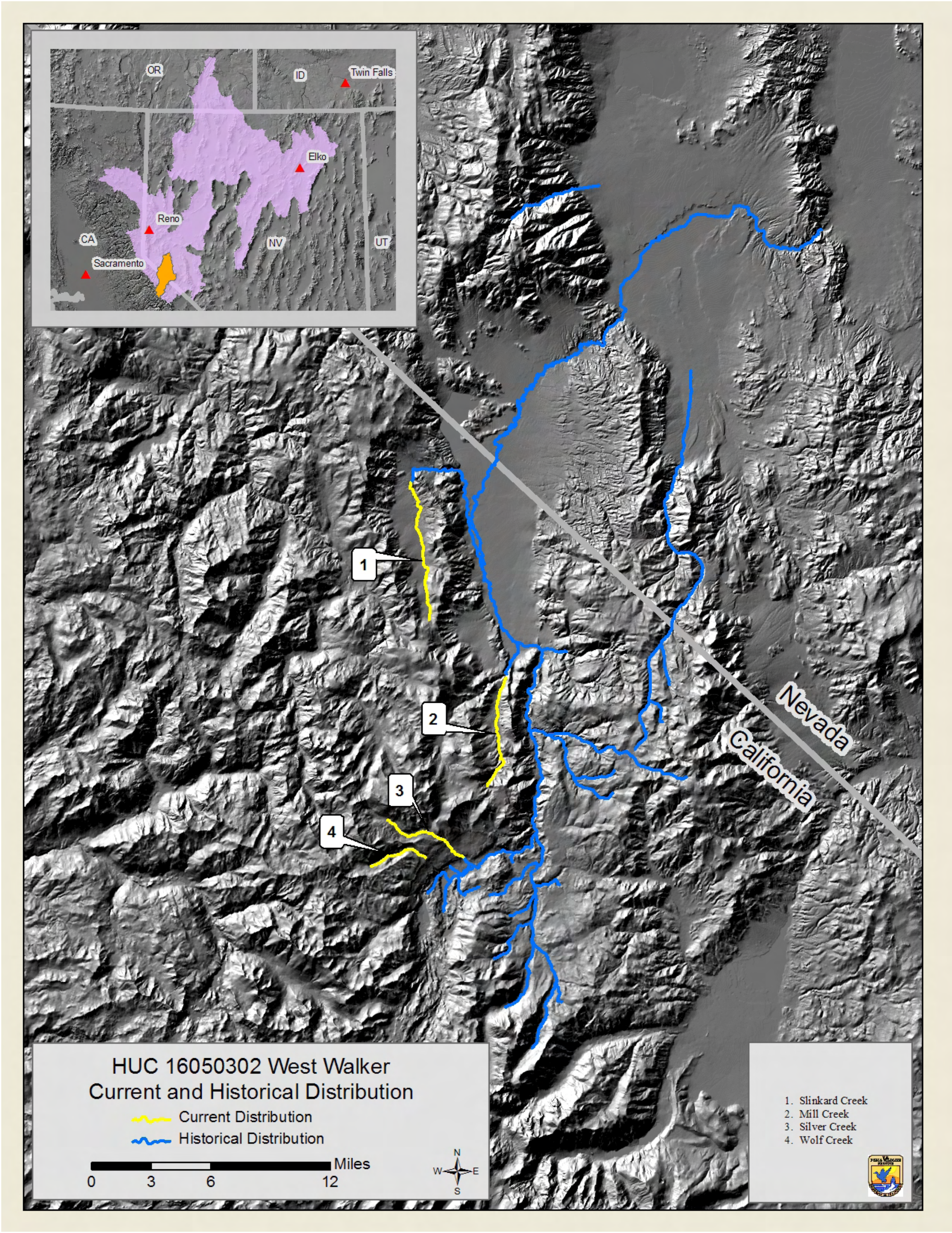

Figure A1.16. Currently occupied and probable historical Lahontan cutthroat trout habitat in the West Walker River watershed, prepared for 2009 5-year review.

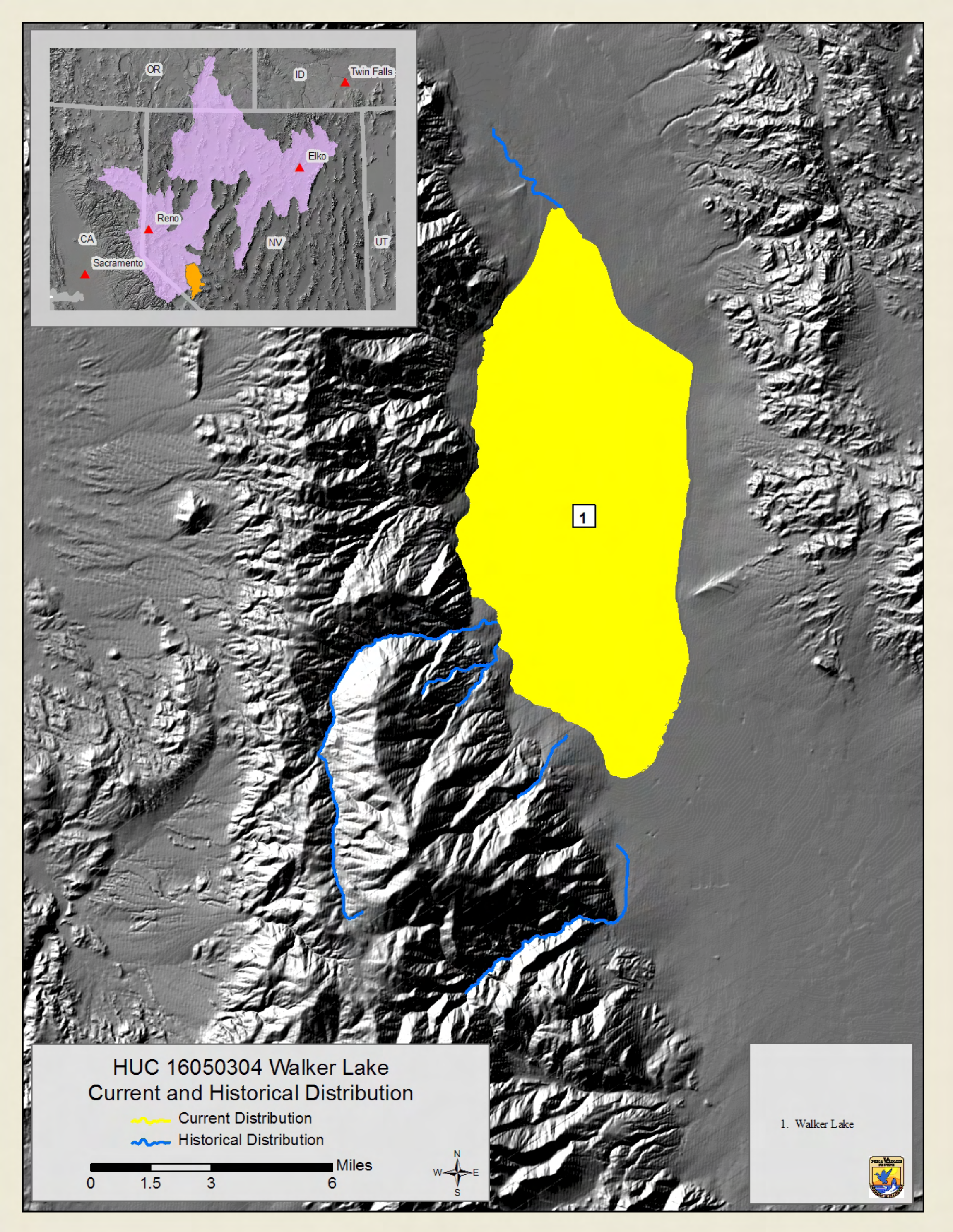

Figure A1.17. Currently occupied and probable historical Lahontan cutthroat trout habitat in the Walker Lake watershed, prepared for 2009 5-year review.

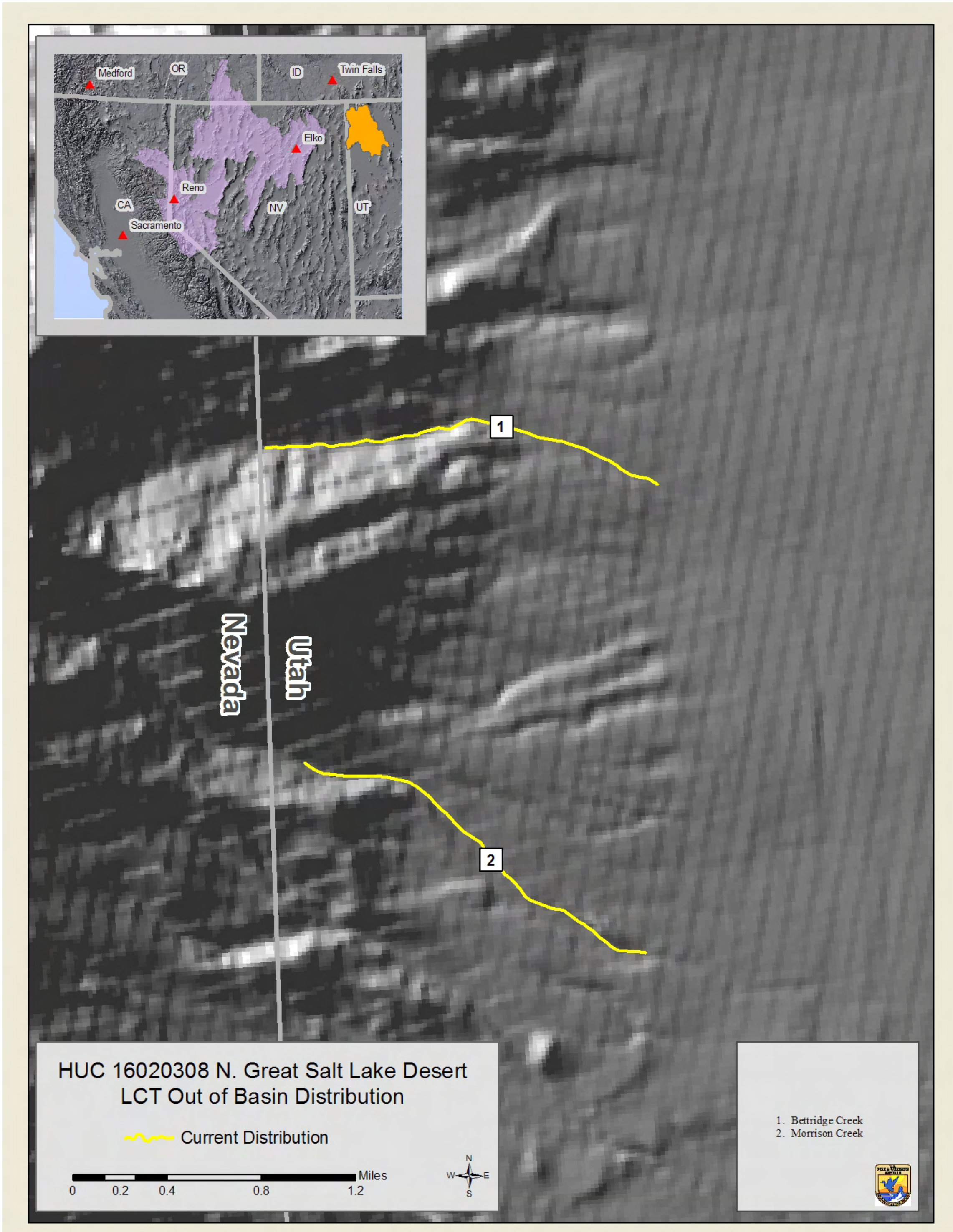

Figure A1.18. Currently occupied out-of-basin Lahontan cutthroat trout habitat in the Northern Great Salt Lake Desert watershed, prepared for 2009 5-year review.

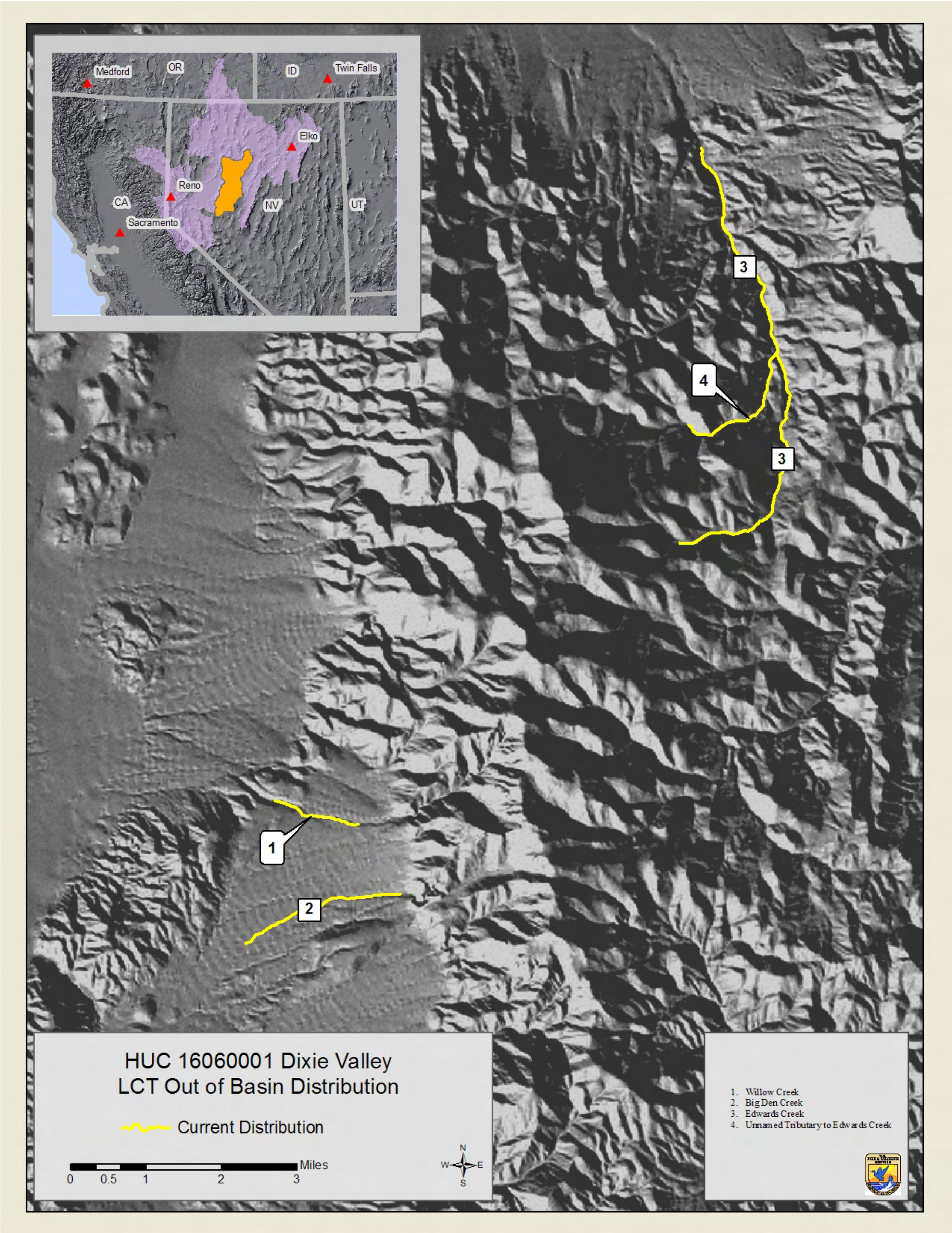

Figure A1.19. Currently occupied out-of-basin Lahontan cutthroat trout habitat in the Dixie Valley watershed, prepared for 2009 5-year review.

Figure A1.20. Currently occupied out-of-basin Lahontan cutthroat trout habitat in the Northern Big Smokey Valley watershed, prepared for 2009 5-year review.

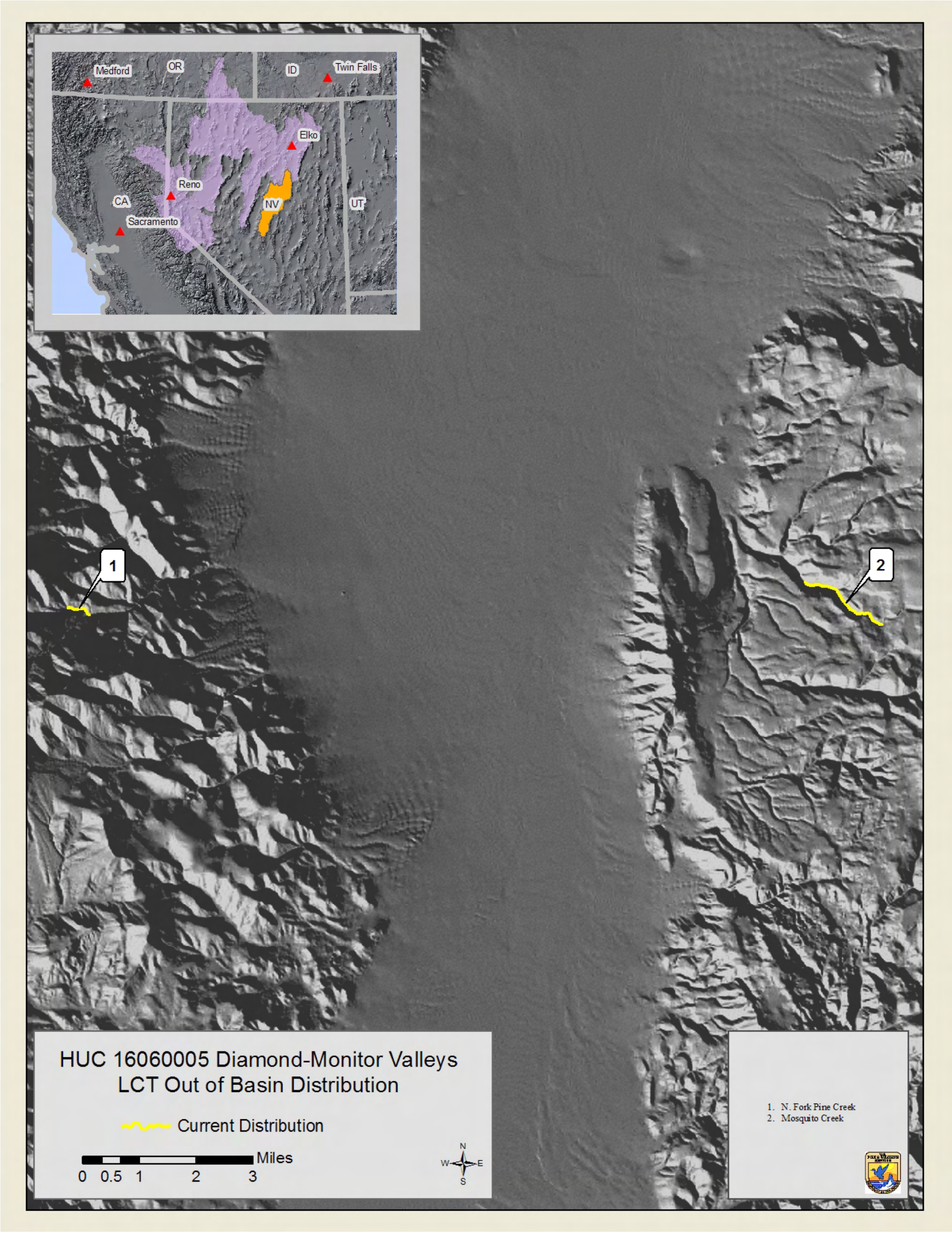

Figure A1.21. Currently occupied out-of-basin Lahontan cutthroat trout habitat in the Diamond-Monitor Valleys watershed, prepared for 2009 5-year review.

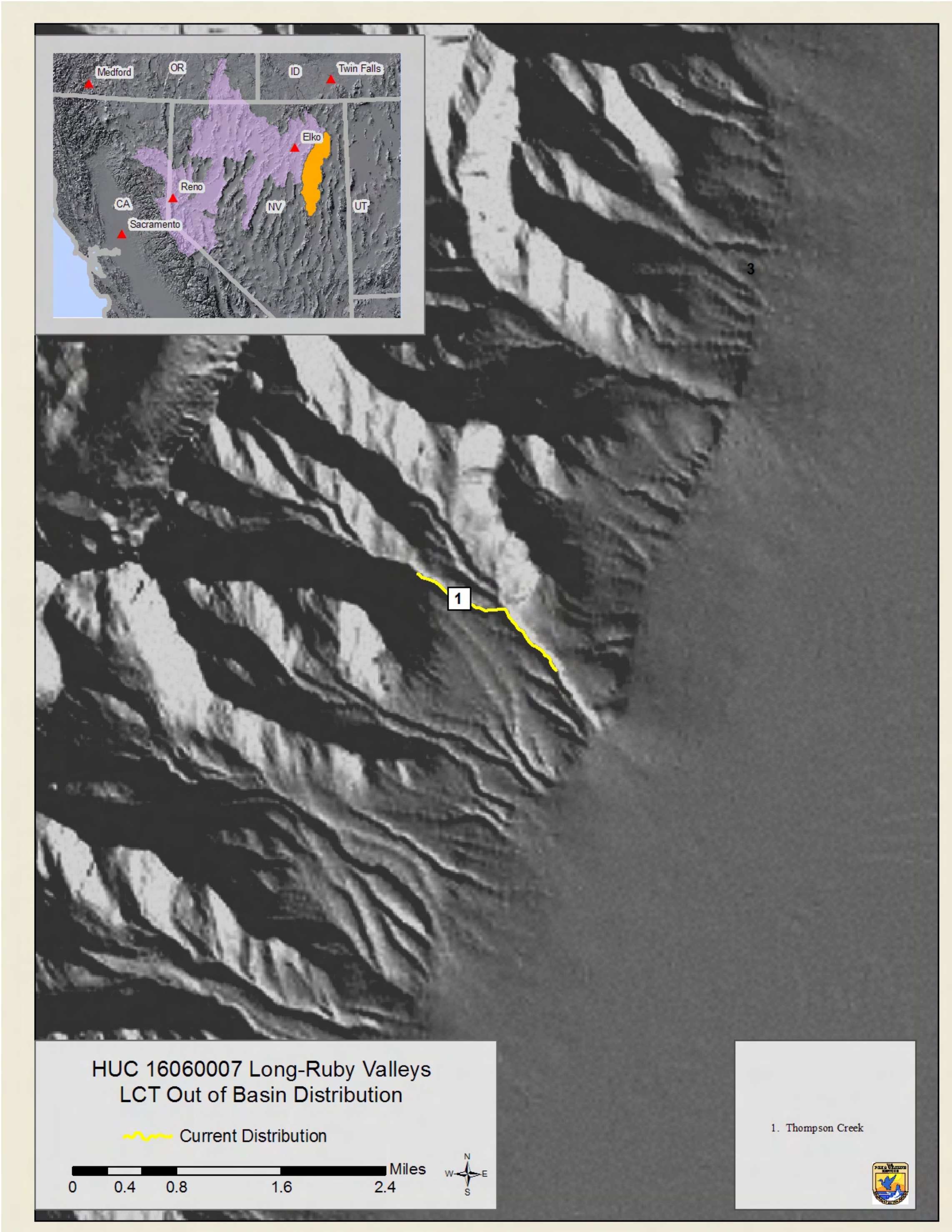

Figure A1.22. Currently occupied out-of-basin Lahontan cutthroat trout habitat in the Long-Ruby Valleys watershed, prepared for 2009 5-year review.

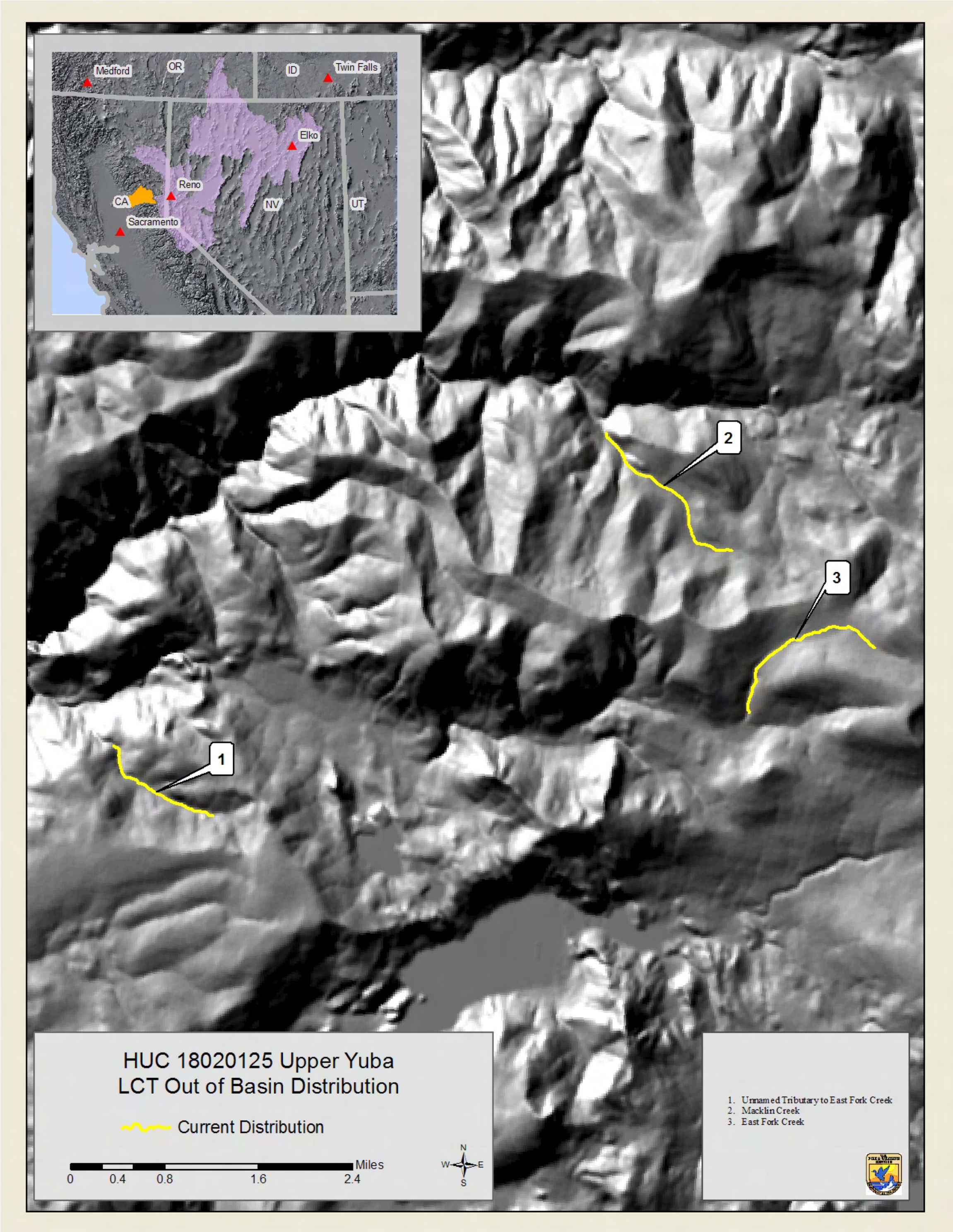

Figure A1.23. Currently occupied out-of-basin Lahontan cutthroat trout habitat in the Upper Yuba River watershed, prepared for 2009 5-year review.

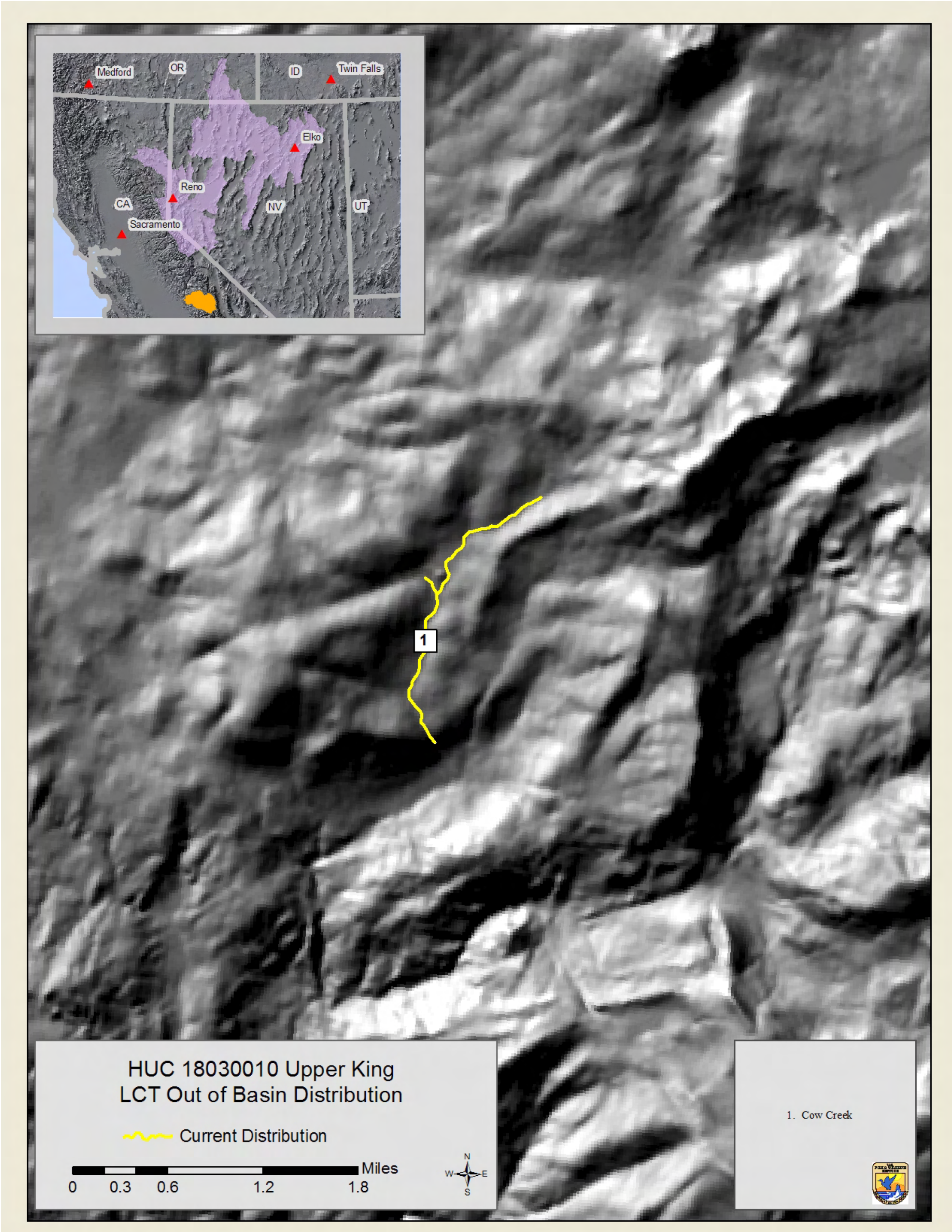

Figure A1.24. Currently occupied out-of-basin Lahontan cutthroat trout habitat in the Upper King River watershed, prepared for 2009 5-year review.

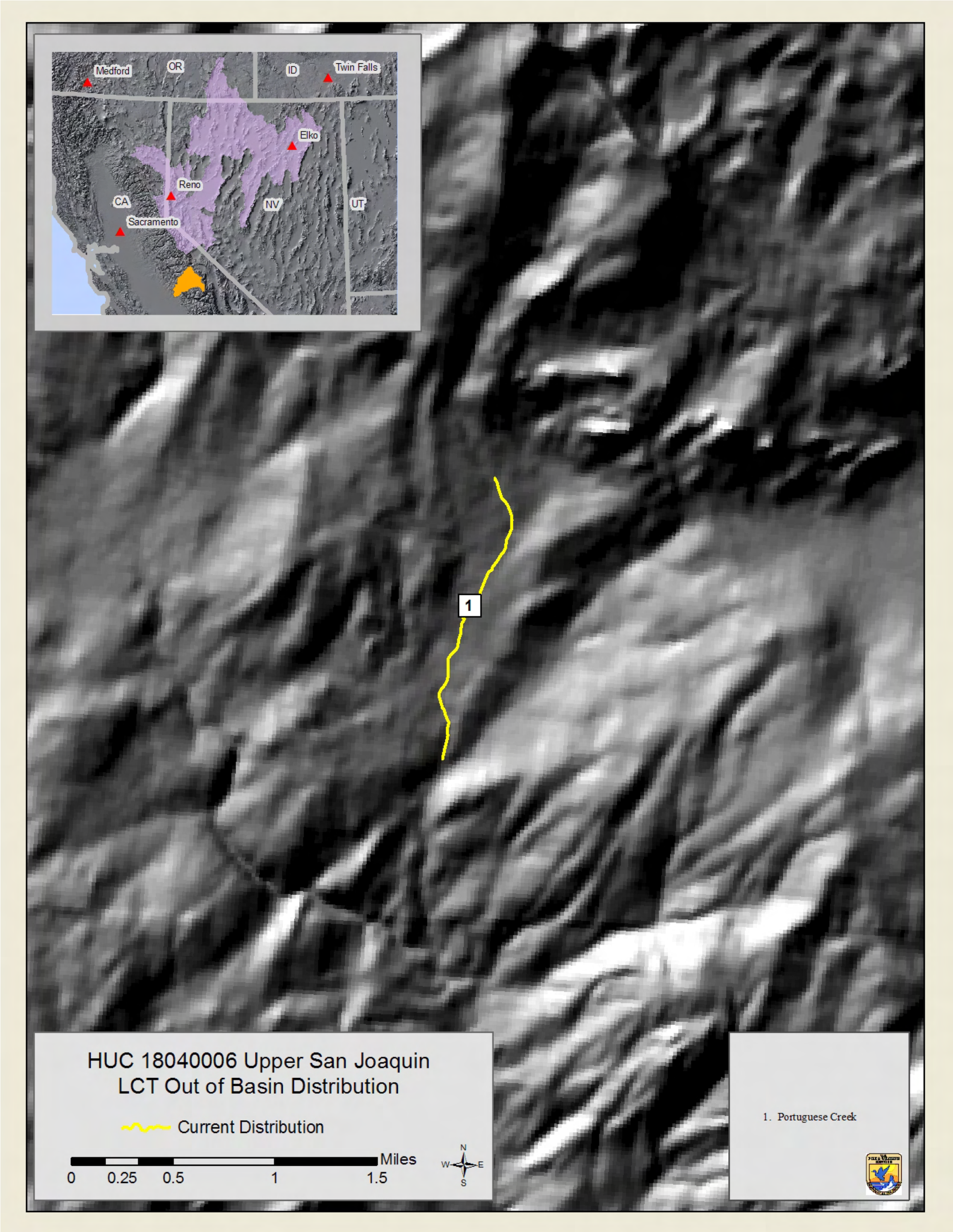

Figure A1.25. Currently occupied out-of-basin Lahontan cutthroat trout habitat in the Upper San Joaquin River watershed, prepared for 2009 5-year review.

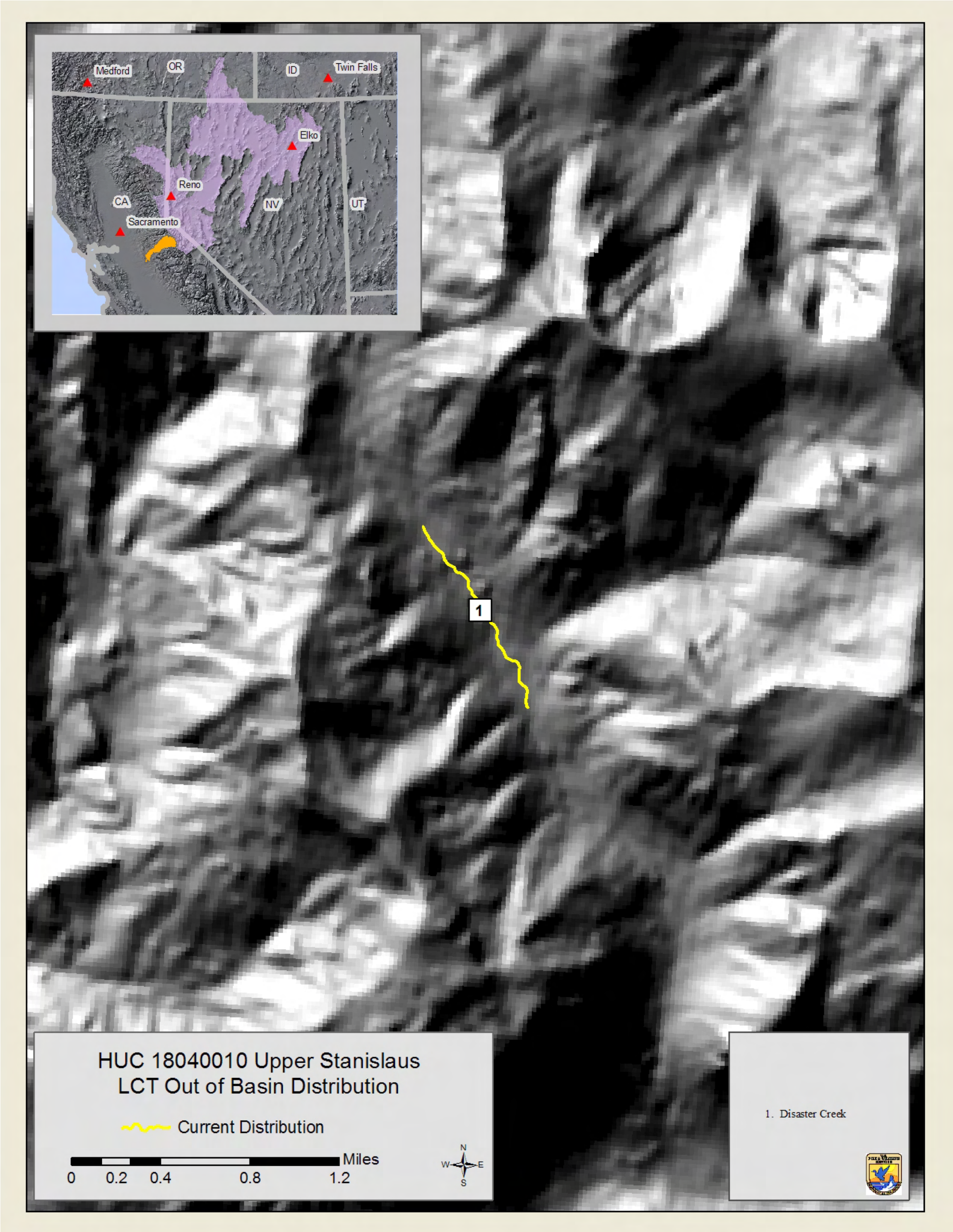

Figure A1.26. Currently occupied out-of-basin Lahontan cutthroat trout habitat in the Upper Stanislaus River watershed, prepared for 2009 5-year review.

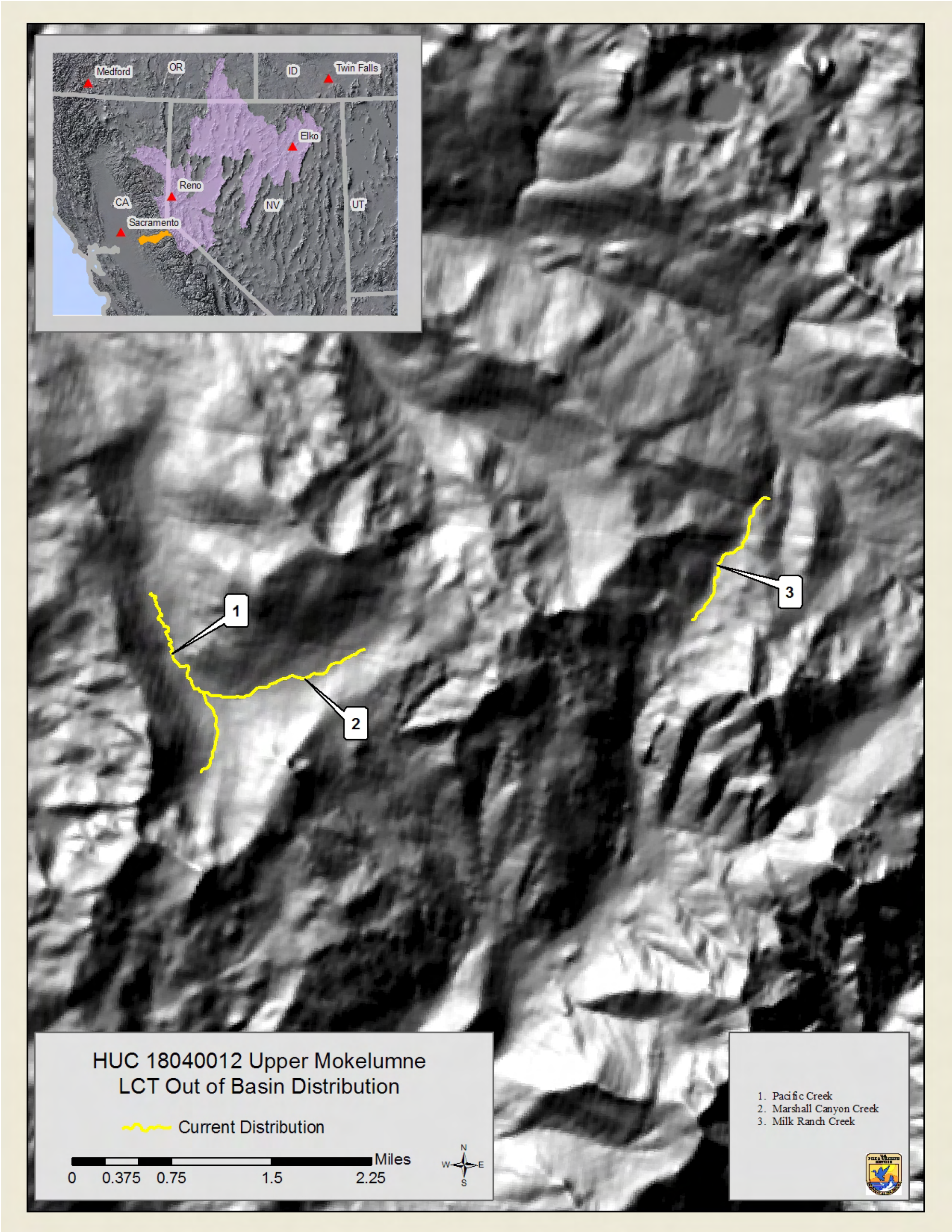

Figure A1.27. Currently occupied out-of-basin Lahontan cutthroat trout habitat in the Upper Mokelumne River watershed, prepared for 2009 5-year review.

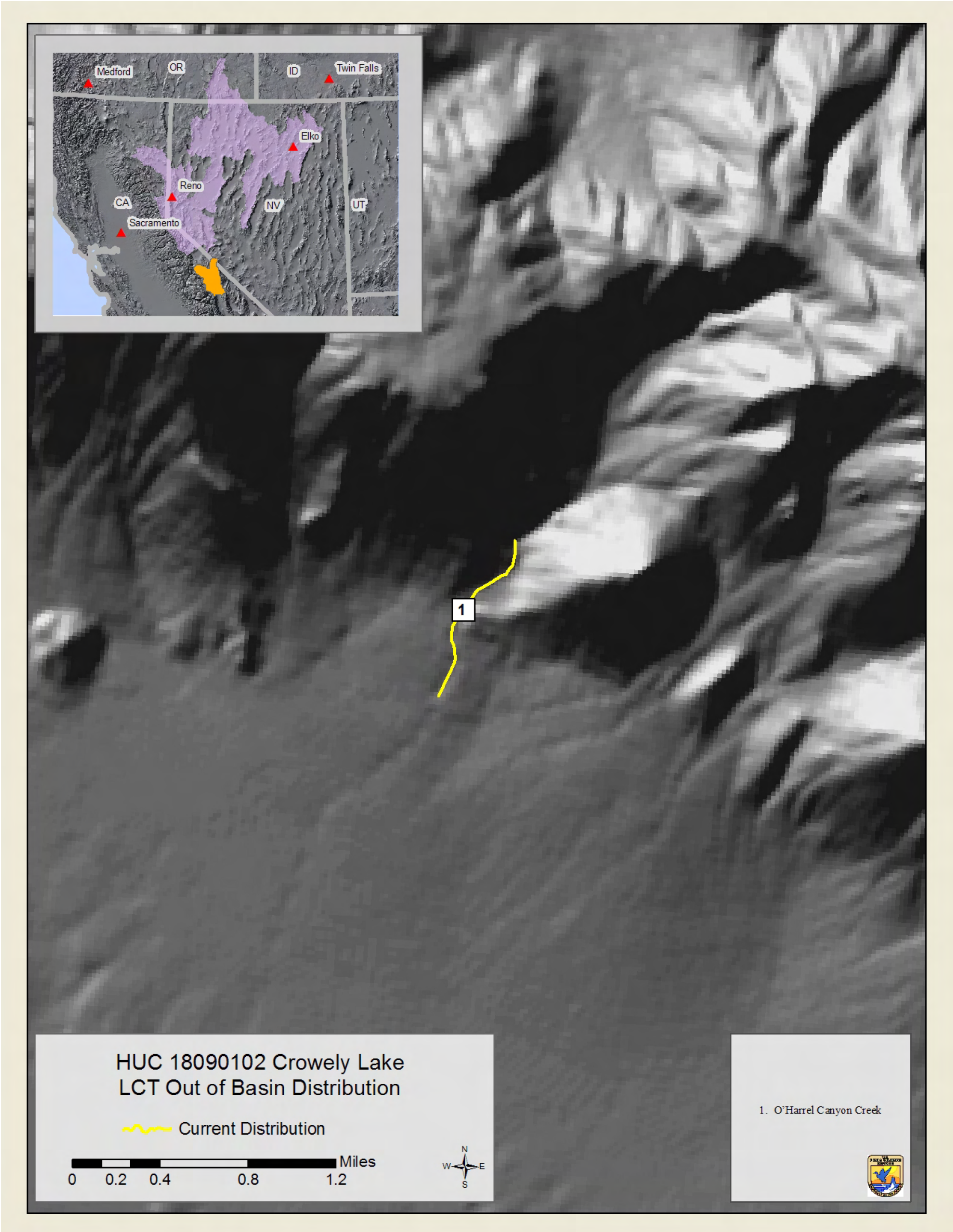

Figure A1.28. Currently occupied out-of-basin Lahontan cutthroat trout habitat in the Crowley Lake watershed, prepared for 2009 5-year review.

Appendix 2. *Oncorhynchus clarkii* subsp. *henshawi*: Nevada Fish and Wildlife Office (NFWO) analysis of data collected using the protocol developed by May and Albeke 2008, prepared for 2009 5-year review.

Table A2.1. Stream lengths km (mi) of presumed historical and currently occupied LCT stream habitat separated by watershed (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

HUC Number	Watershed Name	Historical Stream Length km (mi)	Currently Occupied Stream Length km (mi)	Percentage
Eastern Lahontan Basin, NV		**6,040.4 (3,753.3)**	**478.9 (297.6)**	**7.9**
16040101	Upper Humboldt River	1,621.8 (1,007.8)	200.0 (124.2)	12.3
16040102	N.F. Humboldt River	485.9 (302.0)	46.9 (29.2)	9.7
16040103	S.F. Humboldt River	594.0 (369.1)	64.1 (39.9)	10.8
16040104	Pine Creek	513.1 (318.9)	8.5 (5.3)	1.7
16040105	Middle Humboldt River	560.6 (348.3)	0 (0)	0
16040106	Rock Creek	399.0 (247.9)	62.2 (38.7)	15.6
16040107	Reese River	806.4 (501.1)	24.6 (15.3)	3.0
16040108	Lower Humboldt River	263.5 (163.7)	0 (0)	0
16040109	Little Humboldt River	795.9 (494.5)	72.6 (45.1)	9.1
Northwest Lahontan Basin, OR and NV		**1,791.8 (1,113.4)**	**234.2 (145.5)**	**13.0**
Quinn River Watershed, OR and NV		1,600.3 (994.4)	115.9 (72.0)	7.2
16040201	Upper Quinn River	955.6 (593.8)	73.2 (45.5)	7.7
16040202	Lower Quinn River	644.7 (400.6)	42.6 (26.5)	6.6
Coyote Lake Basin, OR				
17120009	Coyote Lake Basin, OR	191.4 (118.9)	118.3 (73.5)	61.8
Western Lahontan Basin, CA and NV[A]		**3,219.0 (2000.2)**	**232.4 (144.4)**	**7.2**
Truckee River Watershed, CA and NV[B]		1,056.7 (656.6)	155.6 (96.7)	14.7
16050101	Lake Tahoe	214.4 (133.2)	9.7 (6.0)	4.5

16050102	Truckee River[C]	700.1 (435.0)	97.1 (60.4)	13.9
16050103	Pyramid Lake[D]	142.1 (88.3)	48.8 (30.4)	34.4
Carson River Watershed, CA and NV[E]		645.8 (401.3)	27.2 (16.9)	4.2
16050201	Upper Carson River[E]	449.2 (279.1)	27.2 (16.9)	6.1
16050202	Middle Carson River	120.8 (75.0)	0 (0)	0
16050203	Lower Carson River	75.8 (47.1)	0 (0)	0
Walker River Watershed, CA and NV[F]		917.2 (569.9)	49.4 (30.7)	5.4
16050301	E.F. Walker River	453.7 (281.9)	13.8 (8.6)	3.0
16050302	W.F. Walker River[F]	278.7 (173.2)	35.7 (22.2)	12.8
16050303	Middle Walker River	139.8 (86.9)	0 (0)	0
16050304	Lower Walker River	45.0 (28.0)	0 (0)	0
Susan River Watershed, CA				
18080003	Susan River	599.4 (372.4)	0 (0)	0
Out-of-Basin, UT, NV, OR, and CA			**84.8 (52.7)**	
16020308	N. Great Salt Lake Desert, UT		5.6 (3.5)	
16060001	Dixie Valley, NV		19.8 (12.3)	
16060004	Big Smoky Valley, NV		8.4 (5.2)	
16060005	Diamond-Monitor Valley, NV		3.5 (2.2)	
16060007	Long-Ruby Valley, NV		2.2 (1.4)	
17120009	Coyote Lake Basin, OR[G]		22.2 (13.8)	
18020125	Upper Yuba River, CA		7.0 (4.4)	
18030010	Upper King River, CA		3.5 (2.2)	
18040006	Upper San Joaquin River, CA		2.5 (1.5)	

18040010	Upper Stanislaus River, CA		1.6 (1.0)	
18040012	Upper Mokelumne River, CA		7.0 (4.4)	
18090102	Crowley Lake, CA		1.4 (0.9)	

A. Of the 232.4 km (144.4 mi) of occupied LCT habitat within the Western Lahontan Basin, 138.4 km (86 mi) are maintained by hatchery stocking and 50.2 km (31.2 mi) of occupied habitat are outside the historical range of LCT above natural barriers. See further explanation below. B. Of the 155.6 km (96.7 mi) of occupied habitat in the Truckee River watershed (all three HUCs), 140.7 km (87.4 mi) are maintained by hatchery stocking. C. Of the 97.1 km (60.4 mi) of occupied habitat in the Truckee River (HUC 16050102), 91.9 km (57.1 mi) are maintained by hatchery stocking. D. All of the occupied stream habitat in the Pyramid Lake watershed (HUC 16050103) is maintained by hatchery stocking. E. All of the occupied LCT habitat in the Carson River watershed is outside the historical range above natural barriers. F. Of the 49.4 km (30.7 mi) of occupied LCT habitat in the Walker River watershed, 23.0 km (14.3 mi) [all within the W.F. Walker River watershed (HUC 16050302)] are outside the historical range above natural barriers. G. Streams within the Coyote Lake Basin flowing off the eastern slope of the Steens Mountains are outside the historical range of LCT.

Table A2.2. Comparison of occupied stream and lake habitat in 1995 and 2008 (See superscript definitions below for further explanation).

Stream/Lake Name	Occupied in 1995	Occupied in 2008	Last year surveyed	Number of populations gained (+), lost (-), unchanged (=), or unknown (UNK)
Western Lahontan Basin				
Truckee R. Watershed, CA and NV				**+5; -4; =7**
Truckee River (Nevada)[S]	N	Y	2008	+
Independence Creek	Y	Y	2008	=
Pole Creek	Y	Y	2005	=
Upper Truckee River	Y	Y	2008	=
Bronco Creek	Y	N	2005	-
Hill Creek	Y	N		-
W.F. Gray Creek	Y	N	2001	-
E.F. Martis Creek	Y	N	2005	-
Sagehen Creek [S]	N	Y	2006	+
Hunter Creek [S]	N	Y	2008	+
Dog Creek [S]	N	Y	2008	+
Poison Canyon Creek[C]	Y	Y	2008	=
Thunderboldt Canyon Creek[C]	Y	Y	2008	=
Pyramid Lake [S]	Y	Y	2008	=
Independence Lake	Y	Y	2008	=
Fallen Leaf Lake [S]	N	Y	2008	+
Carson R. Watershed, CA				**=6; 1 UNK**
E.F. Carson River[H]	Y	Y	2008	=
Murray Canyon Creek[H]	Y	Y	2008	=
Raymond Meadows Creek[H]	Y	UNK	2001	UNK
Poison Flat Creek[H]	Y	Y	2008	=
Golden Canyon Creek[H]	Y	Y	2008	=
Heenan Creek	Y	Y	2008	=
Heenan Lake [S]	Y	Y	2008	=

Walker R. Basin, CA and NV				**+2; -1; =5**
By-Day Creek	Y	Y	2008	=
Murphy Creek	Y	Y	2005	=
Slinkard Creek	Y	Y	2007	=
Mill Creek[H]	Y	Y	2004	=
Bodie Creek[A]	Y	N	1990	-
Silver Creek[H]	N	Y	2008	+
Wolf Creek[H]	N	Y	2005	+
Walker Lake [S]	Y	Y	2008	=
Northwest Lahontan Basin				
Black Rock Desert Watershed, NV				**+1; =5**
Mahogany Creek	Y	Y	2006	=
Summer Camp Creek	Y	Y	2006	=
Pole Creek	Y	Y	2006	=
Snow Creek	Y	Y	2006	=
Colman Creek[D]	N	Y	2008	+
Summit Lake	Y	Y	2008	=
Quinn R. Watershed, OR and NV				**+4; -6; =8; 1 UNK**
Sage Creek	Y	Y	2004	=
Line Canyon Creek	Y	Y	2004	=
Corral Canyon Creek	Y	Y	2004	=
Indian Creek (Oregon)[T]	Y	N	2007 [T]	-
Washburn Creek	Y	Y	2005	=
Crowley Creek	Y	Y	2003	=
Pole Creek[TR]	N	Y	2003[T] 2008[R]	+
Riser Creek[TR]	Y	Y	2003[T] 2008[R]	=
Eight-mile Creek	Y	Y	2008	=
Three-mile Creek	Y	Y	2008	=
S.F. Flat Creek[A]	Y	N	1992	-
Falls Canyon Creek	N	Y	2003	+
Rock Creek[E]	Y	N	2000	-
E.F. Quinn River[A]	Y	N	1992	-
Rebel Creek[A]	Y	N	1986	-
Andorno Creek	N	Y	2007	+
Upper Leonard Creek[G]	Y	N	2008	-
N.F. Battle Creek[D]	N	Y	2008	+

Coyote Lake Watershed, OR				**=8; 2 UNK**
Whitehorse Creek	Y	Y	2005	=
Little Whitehorse Creek	Y	Y	2005	=
Fifteen-mile Creek	Y	Y	2005	=
Doolittle Creek	Y	Y	2005	=
Cottonwood Creek	Y	Y	2005	=
Little Whitehorse Creek trib.	Y	Y	2005	=
Willow Creek	Y	Y	2004	=
Willow Creek trib.	Y	Y	2004	=
Antelope Creek	Y	UNK		UNK
Twelve-mile Creek	Y	UNK		UNK
Eastern Lahontan Basin				
Marys R. Watershed, NV				**-1; =16**
Marys River	Y	Y	2004	=
Anderson Creek	Y	Y	2002	=
Camp Draw Creek	Y	Y	2004	=
Chimney Creek	Y	Y	2001	=
Conners Creek	Y	Y	2006	=
Cutt Creek	Y	N	2007	-
Draw Creek	Y	Y	2001	=
E.F. Marys River	Y	Y	2002	=
Hanks Creek	Y	Y	2006	=
Marys River Basin Creek	Y	Y	2004	=
T Creek	Y	Y	2002	=
W.F. Marys Creek	Y	Y	2002	=
Wildcat Creek	Y	Y	2002	=
Basin Creek	Y	Y	2004	=
GAWS Creek	Y	Y	2004	=
Short Creek	Y	Y	2006	=
Williams Basin Creek	Y	Y	2004	=
N.F. Humboldt R. Watershed, NV				**-5; =7**
N.F. Humboldt River	Y	Y	2006	=
California Creek	Y	Y	2002	=
Foreman Creek	Y	Y	2002	=
Gance Creek	Y	Y	2007	=
Cole Canyon Creek	Y	Y	2002	=
Road Canyon Creek	Y	Y	2007	=

Warm Creek	Y	Y	2007	=
Mahala Creek	Y	N	2000	-
Pie Creek	Y	N	2004	-
Jim Creek	Y	N	2002	-
Winters Creek[B]	Y	N	2007	-
Dorsey Creek	Y	N	1999	-
E.F. Humboldt R. Watershed, NV				**-1; =5**
Fourth Boulder Creek	Y	Y	2001	=
Second Boulder Creek	Y	Y	2001	=
E.F. Sherman Creek	Y	Y	2003	=
Sherman Creek	Y	Y	2003	=
Conrad Creek	Y	N	2001	-
N.F. Cold Creek	Y	Y	1998	=
S.F. Humboldt R. Watershed, NV				**-5; =16**
Dixie Creek	Y	Y	2008	=
Lee Creek	Y	Y	1998	=
N. Furlong Creek	Y	Y	2003	=
Pearl Creek	Y	Y	2006	=
Welch Creek	Y	Y	1998	=
Carville Creek	Y	Y	2002	=
Gennette Creek	Y	Y	1999	=
Cottonwood Creek	Y	N	2000	-
Mitchell Creek[E]	Y	N	1998	-
N.F. Mitchell Creek[E]	Y	N	1998	-
Green Mountain Creek[T]	Y	N	2003[T]	-
N.F. Green Mountain Creek[TH]	Y	Y	2003[T]	=
Mahogany Creek	Y	Y	2000	=
Segunda Creek	Y	Y	2006	=
Long Canyon Creek	Y	Y	2000	=
Rattlesnake Creek	Y	N	1994	-
McCutcheon Creek	Y	Y	1999	=
Smith Creek	Y	Y	1999	=
M.F Smith Creek	Y	Y	1999	=
N.F. Smith Creek	Y	Y	1999	=
S.F. Smith Creek	Y	Y	1999	=
Maggie Creek Watershed, NV				**=8**
Maggie Creek	Y	Y	1997	=

Beaver Creek	Y	Y	2007	=
Coyote Creek	Y	Y	2007	=
Little Jack Creek	Y	Y	2007	=
Toro Canyon Creek	Y	Y	2007	=
Williams Canyon Creek	Y	Y	2007	=
Little Beaver Creek	Y	Y	2007	=
Lone Mountain Creek[C]	Y	Y	2000	=
Pine Creek Watershed, NV				**=2**
Birch Creek	Y	Y	2003	=
Pete Hanson Creek	Y	Y	2003	=
Rock Creek Watershed, NV				**=6**
Frazier Creek	Y	Y	2007	=
Lewis Creek	Y	Y	2007	=
Nelson Creek	Y	Y	2007	=
Upper Rock Creek	Y	Y	2007	=
Toe Jam Creek	Y	Y	2007	=
Upper Willow Creek	Y	Y	2007	=
Reese R. Watershed, NV				**=9**
Marysville Creek[TH]	Y	Y	2005	=
Tierney Creek	Y	Y	2002	=
Washington Creek	Y	Y	2004	=
Crane Canyon Creek	Y	Y	2001	=
Stewart Creek	Y	Y	2004	=
N.F. Stewart Creek	Y	Y	2004	=
M.F. Stewart Creek	Y	Y	2004	=
Cottonwood Creek[TH]	Y	Y	2001	=
Mohawk Creek	Y	Y	2007	=
Little Humboldt R. Watershed, NV				**-8; =10**
S.F. Little Humboldt River	Y	Y	2005	=
Secret Creek	Y	Y	2005	=
Sheep Creek	Y	Y	2005	=
Pole Creek	Y	Y	2005	=
First Creek[C]	Y	Y	2005	=
Snowstorm Creek[C]	Y	Y	2005	=
Brush Creek	Y	Y	2005	=
Indian Creek	Y	N	1996	-
S.F. Indian Creek	Y	Y	1996	=

Abel Creek	Y	Y	2002	=
Long Canyon Creek	Y	Y	1998	=
Lye Creek[A]	Y	N	1994	-
Mullinex Creek[A]	Y	N	1995	-
Deep Creek[A]	Y	N	1995	-
Road Canyon Creek[A]	Y	N	1994	-
N.F. Little Humboldt River[A]	Y	N	1992	-
Dutch John Creek[A]	Y	N	1994	-
Round Corral Creek[A]	Y	N	1995	-
Lower Humboldt R. Watershed, NV				**1 UNK**
Rock Creek	Y	UNK		UNK
Out-of-Basin Populations				
Out-of-Basin, NV				**-1; =10**
Decker Creek	Y	Y	2000	=
Santa Fe Creek	Y	Y	1997	=
Shoshone Creek	Y	Y	1997	=
Edwards Creek	Y	Y	1999	=
Topia Creek	Y	Y	1999	=
W.F. Deer Creek[T]	Y	N	2007[T]	-
Mosquito Creek	Y	Y	1996	=
Willow Creek	Y	Y	2000	=
N.F. Pine Creek	Y	Y	2000	=
S.F. Thompson Creek	Y	Y	1985	=
Big Den Creek	Y	Y	2000	=
Out-of-Basin, OR				**=8; 1 UNK**
Little Alvord Creek	Y	Y	2004	=
Pike Creek	Y	Y	2004	=
Cottonwood Creek	Y	Y	2004	=
Little McCoy Creek	Y	Y	2004	=
Willow Creek	Y	Y	2004	=
Big Alvord Creek	Y	Y	2004	=
Mosquito Creek	Y	Y	2004	=
Van Horn Creek[G*]	Y	UNK	2006	UNK
Denio Creek	Y	Y	2006	=
Out-of-Basin, CA				**=10**
Macklin Creek	Y	Y	2002	=
E.F. Creek (Austin Meadow)	Y	Y	2005	=
E.F. Creek trib	Y	Y	1998	=
Disaster Creek	Y	Y		=

Marshall Canyon Creek	Y	Y	2001	=
Milk Ranch Creek	Y	Y	2007	=
Pacific Valley Creek	Y	Y	2001	=
W.F. Portuguese Creek	Y	Y	2007	=
Cow Creek	Y	Y	2007	=
O'Harrel Creek	Y	Y	2007	=
Out-of-Basin, UT				**=1, 1 UNK**
Bettridge Creek	Y	Y	2006	=
Morrison Creek[F]	Y	UNK	2006	UNK
Total				**+12; -32; =147; 7 UNK**

A= extirpated prior to 1995 or was found extirpated during 1995 surveys by nonnative salmonids; B= limited habitat, occupancy is based on good water years, streams are used for spawning habitat; C= discovered after 1995; therefore, we assume they were occupied in 1995; D= repatriated after 1995; E=Stream was found barren during last survey; F=possibly extirpated due to fire; G= only nonnative salmonids were found during last survey (G* see table A2.16 for more details); H= occupied habitat is outside the historical range above a natural barrier; T= entire stream was treated with rotenone and is ready for repatriation (W.F. Deer was returned to a native redband rainbow stream); TH= treated with rotenone; however, a small headwater population still exists; TR= treated with rotenone and repatriated; S= maintained by stocking program.

Table A2.3. Stream length km (mi) of currently occupied habitat in each fish density category fish/km (fish/mile) separated by watershed (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

HUC Number	Watershed Name	Fish Density Categories					
		0-31/km (0-50/mi)	32-94/km (51-150/mi)	94-250/km (151-400/mi)	> 250/km (> 400/mi)	Unknown	Total Stream Miles
Eastern Lahontan Basin							
16040101	Upper Humboldt River	159.2 (98.9)	28.2 (17.6)	12.5 (7.7)			200.0 (124.2)
16040102	N.F. Humboldt River	34.6 (21.5)	2.1 (1.3)	5.5 (3.4)	4.7 (3.0)		47.0 (29.2)
16040103	S.F. Humboldt River	31.2 (19.4)	29.3 (18.2)	3.6 (2.2)			64.1 (39.9)
16040104	Pine Creek		3.0 (1.9)	5.5 (3.4)			8.5 (5.3)
16040106	Rock Creek	28.6 (17.8)	10.4 (6.5)	17.1 (10.6)	6.1 (3.8)		62.2 (38.7)
16040107	Reese River	17.7 (11.0)	4.8 (3.0)	2.1 (1.3)			24.6 (15.3)
16040109	Little Humboldt River	24.6 (15.3)	42.3 (26.3)	5.6 (3.5)			72.6 (45.1)
Northwest Lahontan Basin							
16040201	Upper Quinn River	73.2 (45.5)					73.2 (45.5)
16040202	Lower Quinn River	12.6 (7.8)	30.0 (18.7)				42.6 (26.5)
17120009	Coyote Lake Basin, OR	7.9 (4.9)	110.4 (68.6)				118.3 (73.5)
Western Lahontan Basin							
16050101	Lake Tahoe		2.1 (1.3)	7.5 (4.7)			9.7 (6.0)
16050102	Truckee River		85.5 (53.1)	3.1 (1.9)		8.6 (5.3)	97.1 (60.4)
16050103	Pyramid Lake		45.9 (28.5)			2.9 (1.8)	48.9 (30.4)
16050201	Upper Carson	7.1 (4.4)	1.2 (0.7)	19.0 (11.8)			27.2 (16.9)
16050301	E.F. Walker River			13.8 (8.6)			13.8 (8.6)

16050302	W.F. Walker River		12.7 (7.9)	19.8 (12.3)	3.1 (2.0)		35.7 (22.2)
Out-of Basin							
16020308	N. Great Salt Lake Desert, UT			2.8 (1.7)		2.8 (1.7)	5.6 (3.5)
16060001	Dixie Valley, NV				11.0 (6.9)	8.8 (5.5)	19.8 (12.3)
16060004	Big Smoky Valley, NV	4.6 (2.8)			3.9 (2.4)		8.4 (5.2)
16060005	Diamond-Monitor Valley, NV	0.7 (0.5)	2.8 (1.7)				3.5 (2.2)
16060007	Long-Ruby Valley, NV	2.2 (1.4)					2.2 (1.4)
17120009	Coyote Lake Basin, OR	20.7 (12.9)	1.5 (0.9)				22.2 (13.8)
18020125	Upper Yuba River, CA		4.4 (2.8)		2.6 (1.6)		7.0 (4.4)
18030010	Upper King River, CA	3.5 (2.2)					3.5 (2.2)
18040006	Upper San Joaquin River, CA	2.5 (1.5)					2.5 (1.5)
18040010	Upper Stanislaus River, CA					1.6 (1.0)	1.6 (1.0)
18040012	Upper Mokelumne River, CA		7.0 (4.4)				7.0 (4.4)
18090102	Crowley Lake, CA	1.4 (0.9)					1.4 (0.9)
Total		432.2 (268.6)	423.9 (263.4)	117.8 (73.2)	31.5 (19.6)	24.7 (15.4)	1,030.0 (640.1)

Table A2.4. Stream length km (mi) of currently occupied habitat for each stream width category separated by watershed (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

HUC Number	Watershed Name	Stream Width m (ft) Category					
		<1.5 (<5)	1.5-3.1 (5-10)	3.1-4.6 (10-15)	4.6-6.1 (15-20)	>7.6 (> 25)	Unknown
Eastern Lahontan Basin							
16040101	Upper Humboldt River	67.6 (42.0)	67.8 (42.2)	17.4 (10.8)	47.0 (29.2)		
16040102	N.F. Humboldt River	9.7 (6.0)	37.3 (23.2)				
16040103	S.F. Humboldt River	8.9 (5.5)	32.6 (20.3)	22.7 (14.1)			
16040104	Pine Creek	3.0 (1.9)	5.5 (3.4)				
16040106	Rock Creek	51.8 (32.2)	10.4 (6.5)				
16040107	Reese River	22.5 (14.0)	2.1 (1.3)				
16040109	Little Humboldt River	37.5 (23.3)	13.6 (8.4)	21.4 (13.3)			
Northwest Lahontan Basin							
16040201	Upper Quinn River	27.5 (17.1)	45.7 (28.4)				
16040202	Lower Quinn River	27.0 (16.8)	15.6 (9.7)				
17120009	Coyote Lake Basin, OR	27.1 (16.9)	90.0 (55.9)				1.2 (0.7)
Western Lahontan Basin							
16050101	Lake Tahoe	2.1 (1.3)		7.6 (4.7)			
16050102	Truckee River		13.8 (8.6)			84.0 (51.8)	
16050103	Pyramid Lake	2.9 (1.8)				45.9 (28.5)	
16050201	Upper Carson	3.3 (2.1)	4.9 (3.1)	3.3 (2.0)	15.7 (9.8)		
16050301	E.F. Walker River	5.9 (3.7)	7.9 (4.9)				
16050302	W.F. Walker River	22.7 (14.1)	13.0 (8.1)				
Out-of Basin							
16020308	N. Great Salt Lake Desert, UT	5.6 (3.5)					
16060001	Dixie Valley, NV	19.8 (12.3)					
16060004	Big Smoky Valley, NV	8.4 (5.2)					
16060005	Diamond-Monitor Valley, NV	2.8 (1.7)	0.7 (0.5)				
16060007	Long-Ruby Valley, NV		2.2 (1.4)				

17120009	Coyote Lake Basin, OR	6.8 (4.2)	14.1 (8.8)	1.3 (0.8)			
18020125	Upper Yuba River, CA	2.6 (1.6)	4.4 (2.8)				
18030010	Upper King River, CA		3.5 (2.2)				
18040006	Upper San Joaquin River, CA		2.5 (1.5)				
18040010	Upper Stanislaus River, CA	1.6 (1.0)					
18040012	Upper Mokelumne River, CA	2.0 (1.2)	5.1 (3.2)				
18090102	Crowley Lake, CA	1.4 (0.9)					
Total		370.5 (230.2)	392.8 (244.1)	73.6 (45.7)	62.7 (38.9)	129.2 (80.3)	1.2 (0.7)

Table A2.5. Stream length km (mi) of currently occupied habitat by land ownership separated by watershed (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

HUC Number	Watershed Name	Land Ownership					
		BLM	USFS	Private	State	BIA	BOR
Eastern Lahontan Basin							
16040101	Upper Humboldt River	81.0 (50.4)	49.3 (30.7)	60.0 (37.3)	9.5 (5.9)		
16040102	N.F. Humboldt River	0.7 (0.4)	16.3 (10.1)	28.7 (17.8)	1.3 (0.8)		
16040103	S.F. Humboldt River	4.5 (2.8)	53.2 (33.0)	6.5 (4.1)			
16040104	Pine Creek	8.5 (5.3)					
16040106	Rock Creek	11.7 (7.2)		45.0 (27.9)	5.6 (3.5)		
16040107	Reese River		22.8 (14.2)	1.8 (1.1)			
16040109	Little Humboldt River	35.4 (22.0)	17.0 (10.6)	1.0 (0.6)	19.0 (11.8)		
Northwest Lahontan Basin							
16040201	Upper Quinn River	44.5 (27.6)	13.6 (8.5)	15.0 (9.4)			
16040202	Lower Quinn River	31.4 (19.5)		7.9 (4.9)			
17120009	Coyote Lake Basin, OR	98.5 (61.2)		19.6 (12.2)			
Western Lahontan Basin							
16050101	Lake Tahoe		9.7 (6.0)				
16050102	Truckee River	2.7 (1.7)	13.9 (8.6)	73.3 (45.5)		4.2 (2.6)	3.1 (1.9)
16050103	Pyramid Lake			4.8 (3.0)		44.0 (27.3)	
16050201	Upper Carson	0.1 (0.1)	25.7 (15.9)		1.4 (0.9)		
16050301	E.F. Walker River		11.8 (7.3)	0.3 (0.2)	1.8 (1.1)		
16050302	W.F. Walker River	0.6 (0.4)	18.8 (11.7)	1.4 (0.9)	14.8 (9.2)		
Out-of Basin							
16020308	N. Great Salt Lake Desert, UT	1.6 (1.0)		3.3 (2.1)	0.6 (0.4)		
16060001	Dixie Valley, NV	15.3 (9.5)		4.5 (2.8)			
16060004	Big Smoky Valley, NV		8.4 (5.2)				
16060005	Diamond-Monitor Valley, NV		3.5 (2.2)				
16060007	Long-Ruby Valley, NV		2.2 (1.4)				
17120009	Coyote Lake Basin, OR	15.0 (9.3)		7.2 (4.5)			

18020125	Upper Yuba River, CA		3.1 (1.9)	3.9 (2.4)			
18030010	Upper King River, CA		3.5 (2.2)				
18040006	Upper San Joaquin River, CA		2.5 (1.5)				
18040010	Upper Stanislaus River, CA		1.6 (1.0)				
18040012	Upper Mokelumne River, CA		7.0 (4.4)				
18090102	Crowley Lake, CA		1.4 (0.9)				
Total		351.4 (218.4)	285.3 (177.3)	284.4 (176.7)	54.1 (33.6)	51.5 (32.0)	3.1 (1.9)

Table A2.6. Stream length km (mi) of currently occupied habitat which are sympatric with non-native fish separated by watershed (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

HUC Number	Watershed Name	Brook Trout	Brown Trout	Rainbow Trout	Other	None	Unknown
Eastern Lahontan Basin							
16040101	Upper Humboldt River	66.2 (41.1)				133.7 (83.1)	
16040102	N.F. Humboldt River	27.1 (16.8)				19.9 (12.4)	
16040103	S.F. Humboldt River	48.7 (30.3)		12.1 (7.5)		15.4 (9.6)	
16040104	Pine Creek					8.5 (5.3)	
16040106	Rock Creek				6.1 (3.8)	56.1 (34.9)	
16040107	Reese River	8.5 (5.3)	2.1 (1.3)	2.1 (1.3)		16.1 (10)	
16040109	Little Humboldt River	7.1 (4.4)	5.6 (3.5)			59.8 (37.1)	
Northwest Lahontan Basin							
16040201	Upper Quinn River	3.1 (1.9)		3.1 (1.9)		70.1 (43.6)	
16040202	Lower Quinn River				30.3 (18.9)	12.3 (7.6)	
17120009	Coyote Lake Basin, OR					118.3 (73.5)	
Western Lahontan Basin							
16050101	Lake Tahoe	7.6 (4.7)				2.1 (1.3)	
16050102	Truckee River	8.6 (5.4)	87.6 (54.4)	87.5 (54.4)	85.5 (53.1)	3.1 (1.9)	
16050103	Pyramid Lake				45.9 (28.5)	2.9 (1.8)	
16050201	Upper Carson					27.2 (16.9)	
16050301	E.F. Walker River					13.8 (8.6)	
16050302	W.F. Walker River	7.8 (4.9)				27.8 (17.3)	
Out-of Basin							
16020308	N. Great Salt Lake Desert, UT					5.6 (3.5)	
16060001	Dixie Valley, NV	3.6 (2.3)				14.2 (8.8)	1.4 (1.2)
16060004	Big Smoky Valley, NV	2.6 (1.6)	4.6 (2.8)	2.6 (1.6)		3.8 (2.4)	
16060005	Diamond-Monitor Valley, NV	3.5 (2.2)	3.5 (2.2)	2.8 (1.7)			
16060007	Long-Ruby Valley, NV	2.2 (1.4)					
17120009	Coyote Lake Basin, OR					22.2 (13.8)	

18020125	Upper Yuba River, CA					7.0 (4.4)	
18030010	Upper King River, CA					3.5 (2.2)	
18040006	Upper San Joaquin River, CA					2.5 (1.5)	
18040010	Upper Stanislaus River, CA					1.6 (1.0)	
18040012	Upper Mokelumne River, CA					7.0 (4.4)	
18090102	Crowley Lake, CA					1.4 (0.9)	
Total		196.6 (122.2)	103.4 (64.2)	110.1 (68.4)	167.9 (104.3)	656.0 (407.6)	1.9 (1.2)

Table A2.7. Stream length km (mi) of conservation populations in each connectivity category separated by watershed (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

HUC Number	Watershed Name	Isolated Stream Length km (mi)	Weakly Networked (2-3 streams) Stream Length km (mi)	Moderately Networked (3-4 streams) Stream Length km (mi)	Strongly Networked (5 or more streams) Stream Length km (mi)	Total Stream Length km (mi)
Eastern Lahontan Basin						
16040101	Upper Humboldt River	26 (16.2)	16.7 (10.4)		125.2 (77.8)	168 (104.4)
16040102	N.F. Humboldt River	4.7 (2.9)	37.4 (23.2)			42.1 (26.2)
16040103	S.F. Humboldt River	24.8 (15.4)	16.9 (10.5)			41.8 (26)
16040106	Rock Creek	33.6 (20.9)	28.6 (17.8)			62.2 (38.7)
16040107	Reese River	13.3 (8.3)				13.3 (8.3)
16040109	Little Humboldt River	7.1 (4.4)			59.8 (37.1)	66.8 (41.5)
Northwest Lahontan Basin						
16040201	Upper Quinn River	49.3 (30.7)	3.5 (2.2)	17.7 (11)		70.5 (43.8)
16040202	Lower Quinn River	12.3 (7.6)		30.3 (18.9)		42.6 (26.5)
17120009	Coyote Lake Basin, OR	4.6 (2.9)	113.7 (70.7)			118.3 (73.5)
Western Lahontan Basin						
16050101	Lake Tahoe			9.7 (6)		9.7 (6)
16050102	Truckee River	3.1 (1.9)	2.2 (1.4)			5.2 (3.3)
16050103	Pyramid Lake		23.2 (14.4)			23.2 (14.4)
16050201	Upper Carson	26 (16.2)				26 (16.2)
16050301	E.F. Walker River	13.8 (8.6)				13.8 (8.6)
16050302	W.F. Walker River	35.7 (22.2)				35.7 (22.2)
Out-of Basin						
16020308	N. Great Salt Lake Desert, UT	5.6 (3.5)				5.6 (3.5)
16060004	Big Smoky Valley, NV	3.8 (2.4)				3.8 (2.4)

18020125	Upper Yuba River, CA	7.1 (4.4)				7.1 (4.4)
18040012	Upper Mokelumne River, CA	7.1 (4.4)				7.1 (4.4)
18090102	Crowley Lake, CA	1.4 (0.9)				1.4 (0.9)
Total		279.4 (173.6)	242.4 (150.6)	57.7 (35.8)	185.0 (115.0)	764.4 (475.0)

Table A2.8. Number of conservation populations in each connectivity category separated by watershed (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

HUC Number	Watershed Name	Isolated Stream Reach	Weakly Networked Stream Reach (2-3 streams)	Moderately Networked Stream Reach (3-4 streams)	Strongly Networked Stream Reach (5 or more streams)	Total Number of Conservation Populations
Eastern Lahontan Basin						
16040101	Upper Humboldt River	5	2		2	9
16040102	N.F. Humboldt River	1	2			3
16040103	S.F. Humboldt River	5	2			7
16040106	Rock Creek	3	1			4
16040107	Reese River	4				4
16040109	Little Humboldt River	1			1	2
Northwest Lahontan Basin						
16040201	Upper Quinn River	6	1	1		8
16040202	Lower Quinn River	2		2		4
17120009	Coyote Lake Basin, OR	1	3			4
Western Lahontan Basin						
16050101	Lake Tahoe			1		1
16050102	Truckee River	1	1			2
16050103	Pyramid Lake		1			1
16050201	Upper Carson	5				5
16050301	E.F. Walker River	2				2
16050302	W.F. Walker River	5				5
Out-of Basin						
16020308	N. Great Salt Lake Desert, UT	2				2
16060004	Big Smoky Valley, NV	2				2
18020125	Upper Yuba River, CA	3				3
18040012	Upper Mokelumne	3				3

	River, CA					
18090102	Crowley Lake, CA	1				1
Total		52	13	4	3	72

Table A2.9. Number of conservation populations by occupied stream length separated by watershed (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

HUC Number	Watershed Name	Stream Length km (mi) Category			
		< 8 (< 5)	8-16.1 (5-10)	16.1-24.1 (10-15)	> 24.1 (> 15)
Eastern Lahontan Basin					
16040101	Upper Humboldt River	4	1	1	2
16040102	N.F. Humboldt River	2	1		1
16040103	S.F. Humboldt River	6	1		
16040106	Rock Creek	1	1	1	1
16040107	Reese River	4			
16040109	Little Humboldt River	2			1
Northwest Lahontan Basin					
16040201	Upper Quinn River	6		2	
16040202	Lower Quinn River	3			1
17120009	Coyote Lake Basin, OR	2			2
Western Lahontan Basin					
16050101	Lake Tahoe		1		
16050102	Truckee River	2			
16050103	Pyramid Lake	1			
16050201	Upper Carson	3	1		
16050301	E.F. Walker River	2			
16050302	W.F. Walker River	4	1		
Out-of Basin					
16020308	N. Great Salt Lake Desert, UT	2			
16060004	Big Smoky Valley, NV	2			
18020125	Upper Yuba River, CA	3			
18040012	Upper Mokelumne River, CA	3			
18090102	Crowley Lake, CA	1			

Table A2.10. Stream lengths km (mi) of land use activities occurring with conservation populations (conservation populations are a subset of all currently occupied streams) separated by watershed (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

HUC Number	Watershed Name	Land Use Activities								
		Recreation (non-angling)	Livestock	Roads	Angling	Mining	De-watering	Timber Harvest	Water Storage	Occupied Habitat
Eastern Lahontan Basin										
16040101	Upper Humboldt River	168.1 (104.4)	168.1 (104.4)	87.7 (54.5)	150.9 (93.7)	64.9 (40.3)				168.1 (104.4)
16040102	N.F. Humboldt River	42.2 (26.2)	42.2 (26.2)	42.2 (26.2)	42.2 (26.2)	42.2 (26.2)	27.0 (16.8)			42.2 (26.2)
16040103	S.F. Humboldt River	34.6 (21.5)	41.7 (25.9)	9.7 (6.0)	32.4 (20.1)		8.1 (5.0)			41.9 (26.0)
16040106	Rock Creek	62.3 (38.7)	62.3 (38.7)	56.2 (34.9)	62.3 (38.7)	10.5 (6.5)				62.3 (38.7)
16040107	Reese River	13.4 (8.3)	13.4 (8.3)		8.5 (5.3)	2.1 (1.3)				13.4 (8.3)
16040109	Little Humboldt River	67.0 (41.6)	67.0 (41.6)	7.1 (4.4)	67.0 (41.6)					67.0 (41.6)
Northwest Lahontan Basin										
16040201	Upper Quinn River	70.5 (43.8)	70.5 (43.8)	67.5 (41.9)	3.1 (1.9)	5.0 (3.1)				70.5 (43.8)
16040202	Lower Quinn River	42.7 (26.5)	42.7 (26.5)	34.9 (21.7)	30.4 (18.9)					42.7 (26.5)
17120009	Coyote Lake Basin, OR	118.2 (73.5)	118.2 (73.5)	105.8 (65.8)	113.7 (70.7)		71.0 (44.2)		71.0 (44.1)	118.2 (73.4)
Western Lahontan Basin										
16050101	Lake Tahoe	9.7 (6.0)			9.7 (6.0)					9.7 (6.0)
16050102	Truckee River	2.3 (1.4)	2.3 (1.4)	3.1	2.3 (1.4)					5.3 (3.3)

				(1.9)						
16050103	Pyramid Lake	23.2 (14.4)	23.2 (14.4)	23.2 (14.4)	23.2 (14.4)		23.2 (14.4)			23.2 (14.4)
16050201	Upper Carson	26.1 (16.2)	7.1 (4.4)							26.1 (16.2)
16050301	E.F. Walker River	13.8 (8.6)	13.8 (8.6)	13.8 (8.6)						13.8 (8.6)
16050302	W.F. Walker River	35.7 (22.2)	35.7 (22.2)	35.7 (22.2)	12.7 (7.9)			10.0 (6.2)		35.7 (22.2)
Out-of Basin										
16020308	N. Great Salt Lake Desert, UT	5.6 (3.5)	5.6 (3.5)	2.7 (1.7)						5.6 (3.5)
16060004	Big Smoky Valley, NV						3.9 (2.4)			3.9 (2.4)
18020125	Upper Yuba River, CA	5.2 (3.2)	5.2 (3.2)	7.1 (4.4)	2.6 (1.6)			4.5 (2.8)		7.1 (4.4)
18040012	Upper Mokelumne River, CA	7.1 (4.4)	7.1 (4.4)							7.1 (4.4)
18090102	Crowley Lake, CA	1.4 (0.9)	1.4 (0.9)							1.4 (0.9)

Table A2.11. Stream lengths km (mi) and number of conservation populations in which various conservation actions have been conducted (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

Conservation Action	Stream Length km (mi)	Percent of occupied habitat	Number of conservation populations	Percent of conservation populations
Bank stabilization	8.5 (5.3)	1.1	2	2.8
Barrier construction	51.2 (31.8)	6.7	8	11.1
Barrier removal	134.3 (83.4)	17.6	7	9.7
Channel restoration	59.4 (36.9)	7.8	4	5.6
Chemical removal of competing/hybridizing species	60.2 (37.4)	7.9	10	13.9
Culvert replacement	175.3 (108.9)	22.9	7	9.7
Diversion modification	128.4 (79.8)	16.8	6	8.3
Fish ladders to provide access	23.2 (14.4)	3.0	2	2.8
Increase irrigation efficiency	30.4 (18.9)	4.0	2	2.8
Installation of fish screens to prevent loss	101.5 (63.1)	13.3	4	5.6
In-stream cover habitat	30.4 (18.9)	4.0	2	2.8
Land-use mitigation direction and requirements (e.g. Forest Plan direction, regulation, permit req., coordination stipulations, etc)	175.2 (108.8)	22.9	25	34.7
None	80.1 (49.8)	10.5	13	18.1
Other (List in comments)	376.4 (233.9)	49.2	24	33.3
Physical removal of competing/hybridizing species	130.8 (91.3)	17.1	9	12.5
Population covered by special protective mgt emphasis (e.g. Nat'l Park, wi1derness, special mgt area, conservation easement, etc.)	263.3 (163.6)	34.4	23	31.9

Population Restoration/Expansion	93.3 (58.0)	12.2	14	19.4
Population supplementation (e.g. to implement genetic swamping or to reduce potential of bottle necking, etc.)	31.0 (19.3)	4.1	2	2.8
Public outreach efforts at site (Interpretative site)	53.6 (33.3)	7.0	4	5.6
Re-founding pure population	77.2 (48.0)	10.1	13	18.1
Riparian fencing	436.0 (271.0)	57.0	23	31.9
Riparian restoration	341.3 (212.1)	44.6	19	26.4
Special Angling Regulations	338.9 (210.6)	44.3	33	45.8
Water lease/In-stream flow enhancement	159.4 (99.1)	20.9	6	8.3
Woody debris placement	5.9 (3.7)	0.8	1	1.4

Table A2.12. Total stream length km (mi) recorded for each habitat quality category and corresponding habitat determinant. Since the habitat determinants change between excellent and good categories and fair and poor categories, percentages were calculated on the total stream length in excellent or good condition 594.4 km (368.2 miles) and total stream length in fair or poor condition 417.5 km (259.4 miles) (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

	Stream Length km (mi) by Habitat Quality Category					
Habitat Determinant	Excellent	Good	Fair	Poor	Total Stream Length km (mi)	Percentage
Pool habitat within 35 to 60% of total stream habitat area	10.1 (6.3)	104.9 (65.2)			115.1 (71.5)	19.4
Stream shading within 50 to 70% during mid-day	26.6 (16.5)	209.9 (130.4)			236.4 (146.9)	39.8
Streambank stability greater than 90%	49.1 (30.5)	254.6 (158.2)			303.7 (188.7)	51.1
Streambank vegetative cover greater than 25%	49.1 (30.5)	424.2 (263.6)			473.3 (294.1)	79.7
Water temperatures within 8 to 16 C during spawning and incubation periods	2.3 (1.4)	37.5 (23.3)			39.7 (24.7)	6.7
Amount of stream habitat in excess of 6 miles		83.4 (51.8)			83.4 (51.8)	14.0
Substrate fine sediment (less than 6.3mm) levels		57.8 (35.9)			57.8 (35.9)	9.7

generally within 0 to 24%						
Amount of pool habitat is below 35% of total stream habitat area			266.5 (165.6)	18.2 (11.3)	284.7 (176.9)	68.2
Mid-day stream shading either less than 50% or greater than 70%			20.4 (12.7)	1.9 (1.2)	22.4 (13.9)	5.4
Streambank stability less than 75%			93.0 (57.8)	9.7 (6)	102.7 (63.8)	24.6
Streambank vegetative cover less than 25%			72.6 (45.1)	6.1 (3.8)	78.7 (48.9)	18.9
Substrate fine sediments (less than 6.3mm) exceed 25%			314.9 (195.7)	14 (8.7)	328.9 (204.4)	61.3
Water temperatures in summer consistently above 16C			45.9 (28.5)	6.1 (3.8)	52.0 (32.3)	12.5

Table A2.13. Stream length km (mi) of currently occupied habitat in each habitat quality category separated by watershed (NFWO analysis of data collected using the protocol developed by May and Albeke 2008).

HUC Number	Watershed Name	Habitat Quality Category				
		Excellent	Good	Fair	Poor	Unknown
Eastern Lahontan Basin						
16040101	Upper Humboldt River		81.7 (50.8)	112.3 (69.8)	5.9 (3.7)	
16040102	N.F. Humboldt River		24.9 (15.5)	22.0 (13.7)		
16040103	S.F. Humboldt River		44.5 (27.6)	19.7 (12.2)		
16040104	Pine Creek			8.5 (5.3)		
16040106	Rock Creek		6.1 (3.8)	50.0 (31.1)	6.1 (3.8)	
16040107	Reese River		10.5 (6.5)	14.1 (8.8)		
16040109	Little Humboldt River	13.6 (8.4)	22.3 (13.9)	36.6 (22.7)		
Northwest Lahontan Basin						
16040201	Upper Quinn River	6.7 (4.2)	52.7 (32.7)	7.6 (4.7)	6.2 (3.8)	
16040202	Lower Quinn River		42.6 (26.5)			
17120009	Coyote Lake Basin, OR		118.3 (73.5)			
Western Lahontan Basin						
16050101	Lake Tahoe			9.7 (6.0)		
16050102	Truckee River		92.8 (57.7)	4.3 (2.7)		
16050103	Pyramid Lake			45.9 (28.5)		2.9 (1.8)
16050201	Upper Carson		8.2 (5.1)	15.7 (9.8)		3.3 (2.1)
16050301	E.F. Walker River			13.8 (8.6)		
16050302	W.F. Walker River	22.9 (14.2)	12.7 (7.9)			
Out-of Basin						
16020308	N. Great Salt Lake Desert, UT			5.6 (3.5)		
16060001	Dixie Valley, NV	3.6 (2.3)	11.0 (6.8)			5.1 (3.2)
16060004	Big Smoky Valley, NV	2.3 (1.4)	1.6 (1.0)	2.0 (1.2)		2.6 (1.6)
16060005	Diamond-Monitor Valley, NV			0.7 (0.5)		2.8 (1.7)
16060007	Long-Ruby Valley, NV		2.2 (1.4)			
17120009	Coyote Lake Basin, OR		3.6 (2.2)	18.7 (11.6)		

18020125	Upper Yuba River, CA		1.9 (1.2)	5.2 (3.2)		
18030010	Upper King River, CA		3.5 (2.2)			
18040006	Upper San Joaquin River, CA		2.5 (1.5)			
18040010	Upper Stanislaus River, CA					1.6 (1.0)
18040012	Upper Mokelumne River, CA			5.1 (3.2)	2.0 (1.2)	
18090102	Crowley Lake, CA		1.4 (0.9)			

Table A2.14. Area ha (ac) of each currently occupied watershed which has burned between 1999 and 2008 (Data source: Bureau of Land Management ,Nevada State Office).

HUC Number	Watershed Name	HUC Area Ha (ac)	Area Burned Ha (ac)	Percentage of HUC Area Burned
Eastern Lahontan Basin				
16040101	Upper Humboldt River	713,731 (1,763,668)	189,702 (468,763)	26.6
16040102	N.F. Humboldt River	259,744 (641,841)	37,339 (92,266)	14.4
16040103	S.F. Humboldt River	335,673 (829,465)	59,263 (146,443)	17.7
16040104	Pine Creek	259,406 (641,005)	66,203 (163,591)	25.5
16040106	Rock Creek	235,355 (581,574)	148,808 (367,713)	63.2
16040107	Reese River	606,303 (1,498,207)	89,325 (220,728)	14.7
16040109	Little Humboldt River	455,406 (1,125,333)	69,558 (171,882)	15.3
Northwest Lahontan Basin				
16040201	Upper Quinn River	913,714 (2,257,837)	117,383 (290,059)	12.8
16040202	Lower Quinn River	846,152 (2,090,888)	54,159 (133,830)	6.4
17120009	Coyote Lake Basin, OR	559,937 (1,383,635)	1,860 (4,595)	0.3
Western Lahontan Basin				
16050101	Lake Tahoe	132,166 (326,590)	1,811 (4,474)	1.4
16050102	Truckee River	312,302 (771,714)	34,145 (84,374)	10.9
16050103	Pyramid Lake	361,206 (892,559)	19,108 (47,217)	5.3
16050201	Upper Carson	243,659 (602,095)	6,777 (16,747)	2.8
16050301	E.F. Walker River	284,011 (701,806)	270 (668)	0.1
16050302	W.F. Walker River	255,407 (631,125)	19,648 (48,551)	7.7
Out-of Basin				
16020308	N. Great Salt Lake Desert, UT	1,096,465 (2,709,424)	10,022 (24,764)	1
16060001	Dixie Valley, NV	1,048,881 (2,591,841)	74,870 (185,008)	7.1
16060004	Big Smoky Valley, NV	494,993 (1,223,155)	28,054 (69,322)	5.7
16060005	Diamond-Monitor Valley, NV	808,158 (1,997,002)	8,946 (22,106)	1.1
16060007	Long-Ruby Valley, NV	1,066,918 (2,636,412)	26,071(64,423)	2.4
18020125	Upper Yuba River, CA	341,562 (844,018)	6,696 (16,546)	2
18030010	Upper King River, CA	400,061 (988,573)	9,669 (23,892)	2.4

18040006	Upper San Joaquin River, CA	440,296 (1,087,995)	3,875 (9,576)	0.9
18040010	Upper Stanislaus River, CA	259,947 (642,344)	10,181 (25,157)	3.9
18040012	Upper Mokelumne River, CA	205,564 (507,959)	7,840 (19,374)	3.8
18090102	Crowley Lake, CA	498,325 (1,231,389)	7,978 (19,714)	1.6

Table A2.15. Stream length km (mi) of currently occupied streams burned between 1999-2008 separated by watershed (Data source: Bureau of Land Management ,Nevada State Office).

HUC Number	Watershed Name	Stream Name	Occupied Length km (mi) Burned	Total Length km (mi) Burned in HUC
Eastern Lahontan Basin				
16040101	Upper Humboldt River	Beaver Creek	6.3 (3.9)	28.8 (17.9)
		Little Beaver Creek	5.3 (3.3)	
		Toro Canyon Creek	2.1 (1.3)	
		Maggie Creek	1.9 (1.2)	
		Lone Mountain Creek	1.6 (1.0)	
		Sherman Creek	1.0 (0.6)	
		Hanks Creek	7.9 (4.9)	
		Wildcat Creek	2.9 (1.8)	
16040103	S.F. Humboldt River	Dixie Creek	6.9 (4.3)	7.9 (4.9)
		Pearl Creek	1.0 (0.6)	
16040106	Rock Creek	Frazer Creek	6.1 (3.8)	16.7 (10.4)
		Nelson Creek	7.6 (4.7)	
		Rock Creek	2.9 (1.8)	
		Willow Creek	0.2 (0.1)	
16040109	Little Humboldt River	First Creek	0.2 (0.1)	16.9 (10.5)
		Snowstorm Creek	5.5 (3.4)	
		S.F. Little Humboldt River	11.3 (7.0)	
Northwest Lahontan Basin				
16040202	Lower Quinn River	Pole Creek	4.3 (2.7)	11.4 (7.1)
		Summer Camp Creek	0.8 (0.5)	
		Mahogany Creek	6.3 (3.9)	
Western Lahontan Basin				
16050302	W.F. Walker River	Slinkard Creek	2.9 (1.8)	7.9 (4.9)
		Mill Creek	5.0 (3.1)	

Out-of Basin				
16020308	N. Great Salt Lake Desert, UT	Bettridge Creek	2.1 (1.3)	3.7 (2.3)
		Morrison Creek	1.6 (1.0)	

Table A2.16. Addendum. Information for Van Horn Creek, an Out-of-Basin stream found in the Pueblo Mountains in Oregon was requested to be included until the status of this population can be verified. The last survey conducted by Oregon Department of Fish and Wildlife in 2006 only found brown trout. This information was not used in any of the analyses throughout the document.

HUC Number	Watershed Name	Occupied Stream Length	Fish Density Category	Stream Width Category	Land Ownership	Habitat Condition Category	Nonnatives Present
Out-of-Basin							
17120009	Coyote Lake Basin, OR	2.1 km (1.3 mi)	0-31/km (0-50/mi)	1.5-3.1 m (5-10 ft)	BLM	Fair	Brown trout

Appendix 3. Phylogenetic analyses of various Lahontan cutthroat trout populations (From Peacock and Kirchoff 2007, pp. 27, 64, 70, 72, and 76).

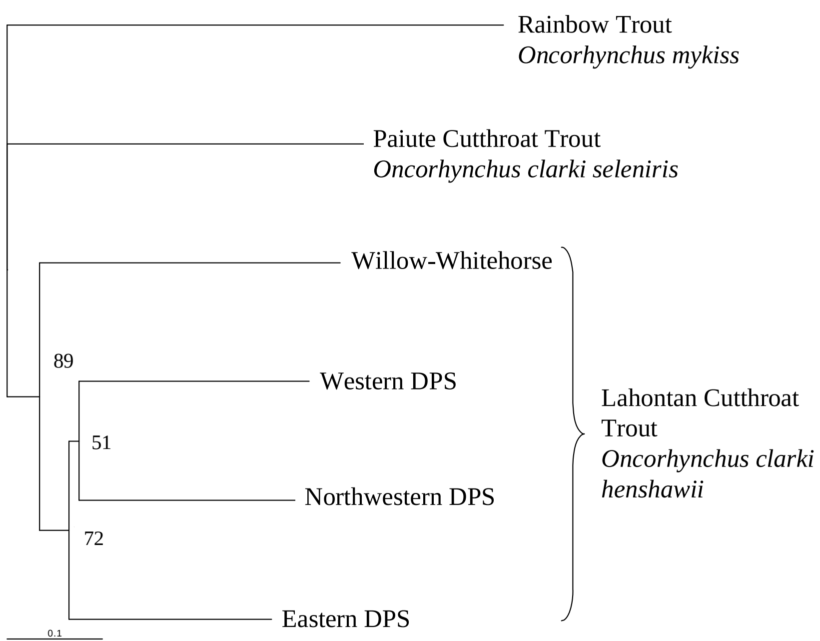

Figure A3.1. Phylogenetic analysis of DPS designation, using a Cavalli-Sforza genetic distance measure and neighbor-joining tree, with rainbow trout and Paiute cutthroat as outgroups. Two thousand iterations were conducted in the program POPULATIONS (version 1.2.6). Populations comprising each DPS are listed in Table 1. Native extant populations were grouped per DPS designation for this analysis. Scale represents genetic distance. (From Peacock and Kirchoff 2007, p. 27).

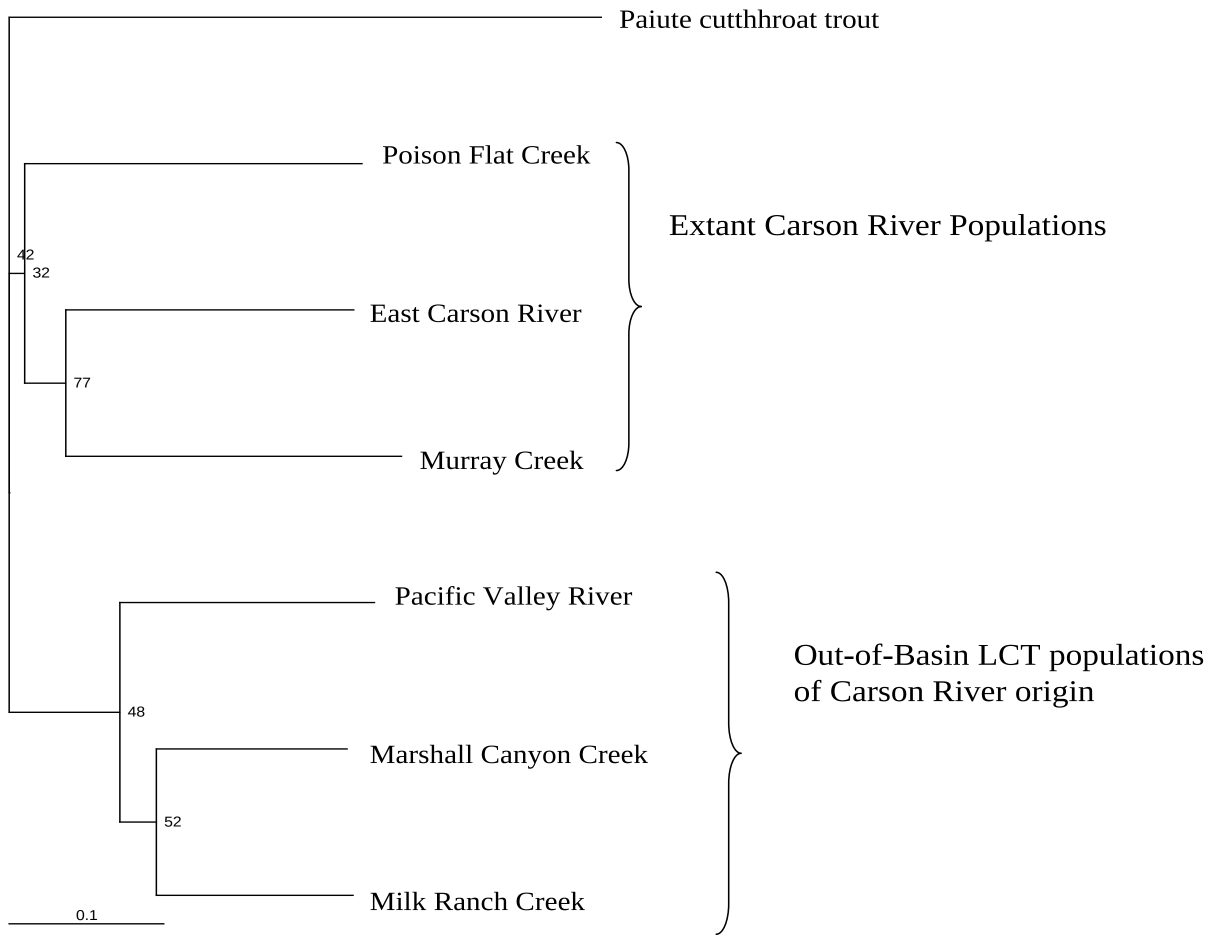

Figure A3.2. Phylogenetic analysis of Carson River LCT populations using a Cavalli-Sforza genetic distance measure and a neighboring-joining tree with Paiute cutthroat trout as outgroup. Two thousand iterations were conducted in the program POPULATIONS (version 1.2.26) with bootstrap values indicated at the tree nodes. Populations group weakly into two separate clades, extant in-basin populations (East Carson River, Murray and Poison Flat creeks) and out-of-basin populations derived from Carson River LCT (Pacific Valley River, Marshall Canyon and Milk Ranch creeks). Scale represents genetic distance. (From Peacock and Kirchoff 2007, p. 64).

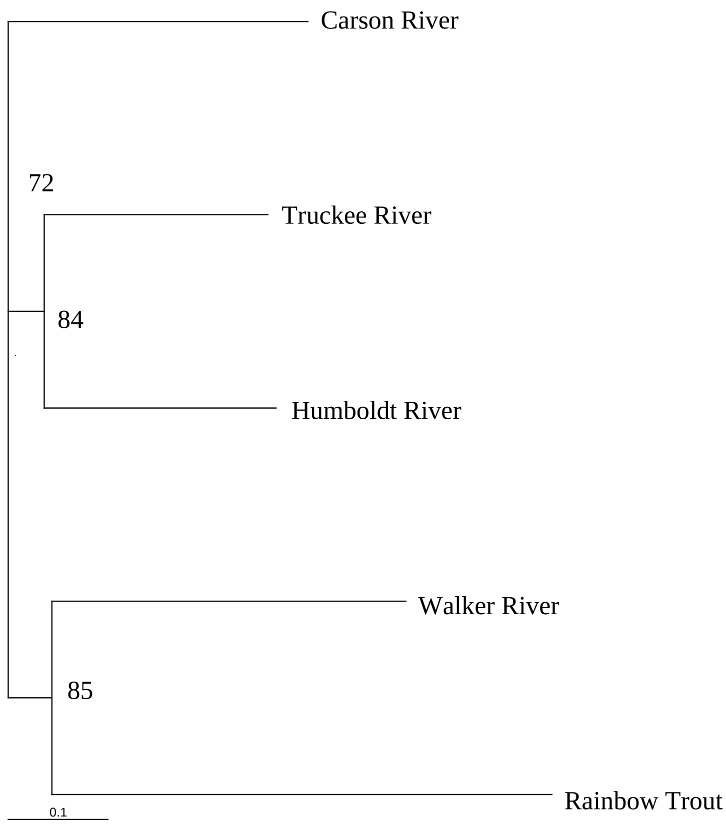

Figure A3.3. Phylogenetic analysis of Western basin and Humboldt River watersheds using a Cavalli-Sforza genetic distance measure and a neighboring-joining tree with rainbow trout as the outgroup. Two thousand iterations were conducted in the program POPULATIONS (version 1.2.26) with bootstrap values indicated at the tree nodes. The Truckee, Carson and Humboldt rivers cluster with strong bootstrap support. The Walker River LCT populations do not cluster with other LCT populations but with rainbow trout (see text). Scale represents genetic distance. (From Peacock and Kirchoff 2007, p. 70).

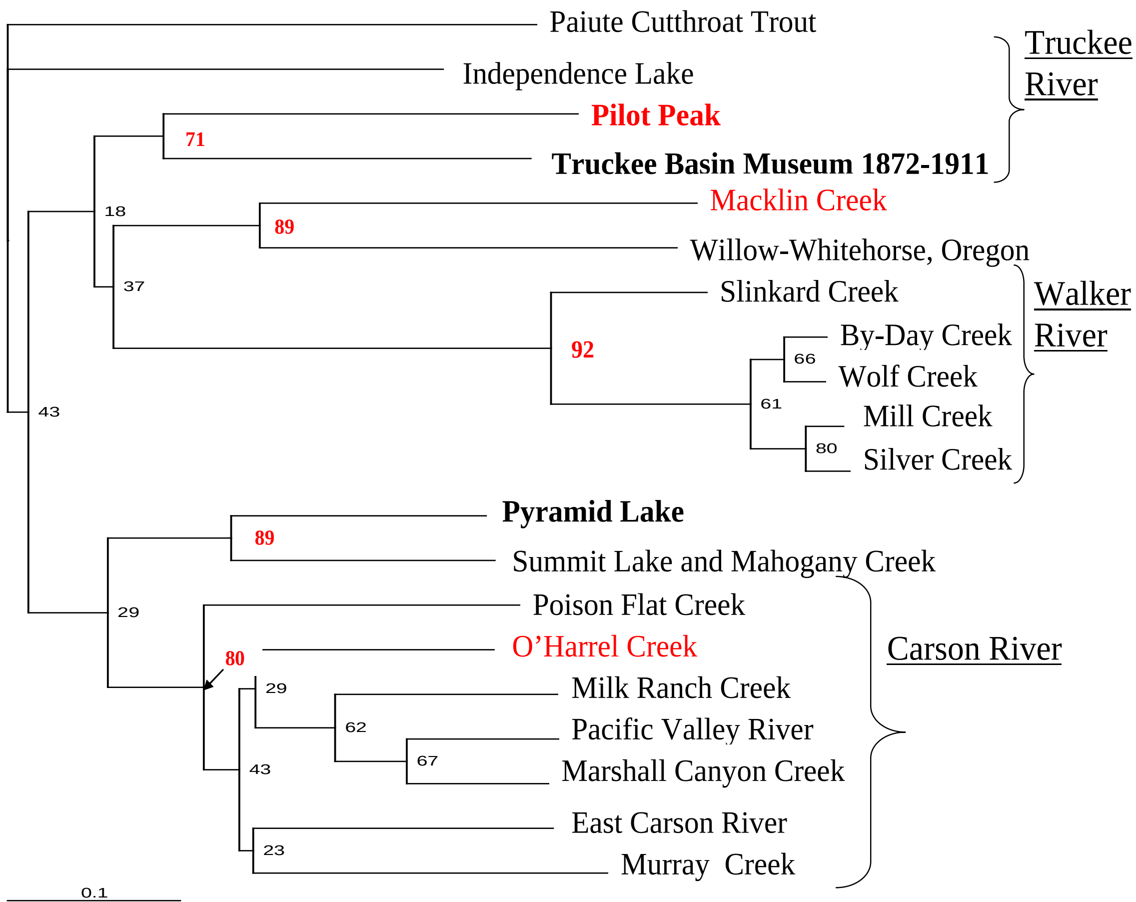

Figure A3.4. Phylogenetic analysis Western basin populations with putative or known origins using a Cavalli-Sforza genetic distance measure and a neighboring-joining tree with rainbow trout as outgroup. Three thousand iterations were conducted in the program POPULATIONS (version 1.2.26) with bootstrap values indicated at the tree nodes. Out-of-basin populations of putative Western basin origin are highlighted in red. Pilot Peak LCT (Bettridge, Morrison and Pilot Peak broodstock) cluster with Truckee River basin historical museum samples with strong bootstrap support (71 percent), Macklin Creek of putative Truckee basin origin cluster with Willow-Whitehorse LCT (89 percent) and O'Harrel Creek of putative Walker basin origin clusters weakly with out-of-basin Carson River populations. Pyramid and Summit Lakes cluster with strong bootstrap support (89 percent). Scale represents genetic distance. (From Peacock and Kirchoff 2007, p. 72).

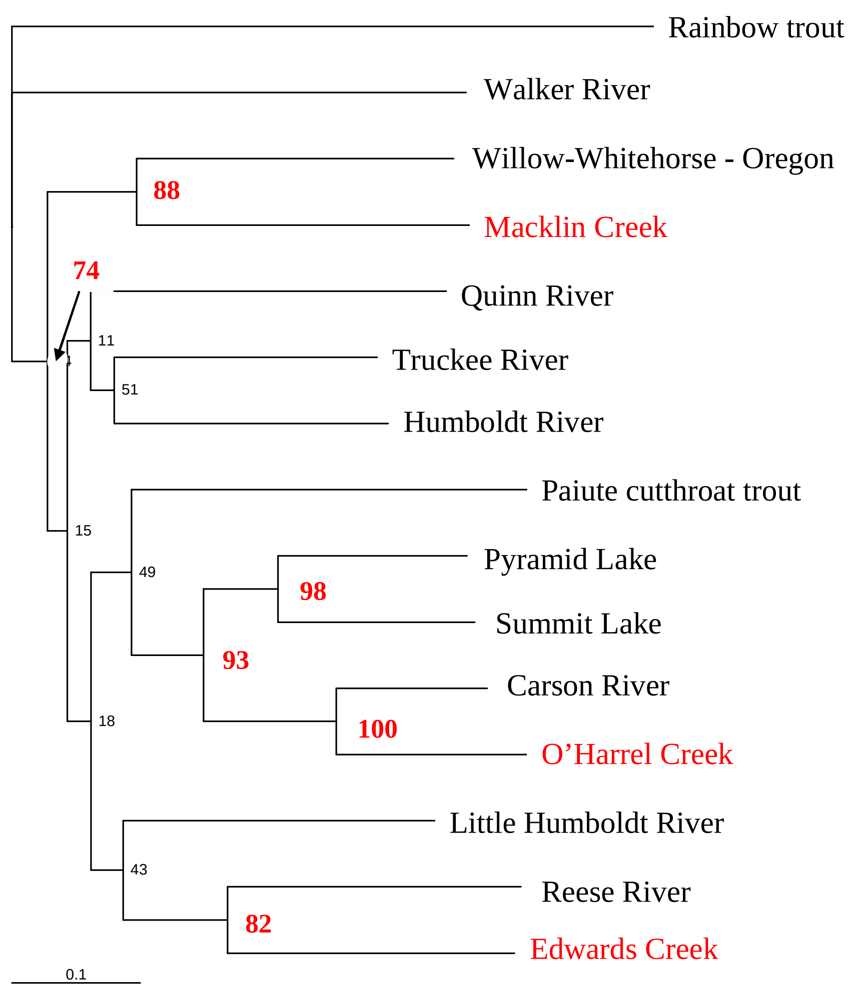

Figure A3.5. Phylogenetic analysis of LCT populations grouped by watershed and out-of-basin LCT populations of putative Western basin origin using a Cavalli-Sforza genetic distance measure and a neighboring-joining tree with rainbow trout as outgroup. Three thousand iterations were conducted in the program POPULATIONS (version 1.2.26) with bootstrap values indicated at the tree nodes. LCT in Macklin and Edwards creeks were thought to be of Truckee River origin. Macklin clusters with Willow-Whitehorse populations (88 percent) in Coyote Lakes basin, Oregon. Edwards Creek LCT cluster with Reese River LCT populations (82 percent) and O'Harrel Creek of putative Walker River watershed origin clusters with Carson River LCT populations (100 percent). Walker River LCT populations do not cluster with any extant LCT populations. Scale represents genetic distance. (From Peacock and Kirchoff 2007, p. 76).

Appendix 4. *Oncorhynchus clarkii* subsp. *henshawi*: Recent fire occurrences (1999-2008) in historical and currently occupied Lahontan cutthroat trout habitat, prepared for 2009 5-year review.

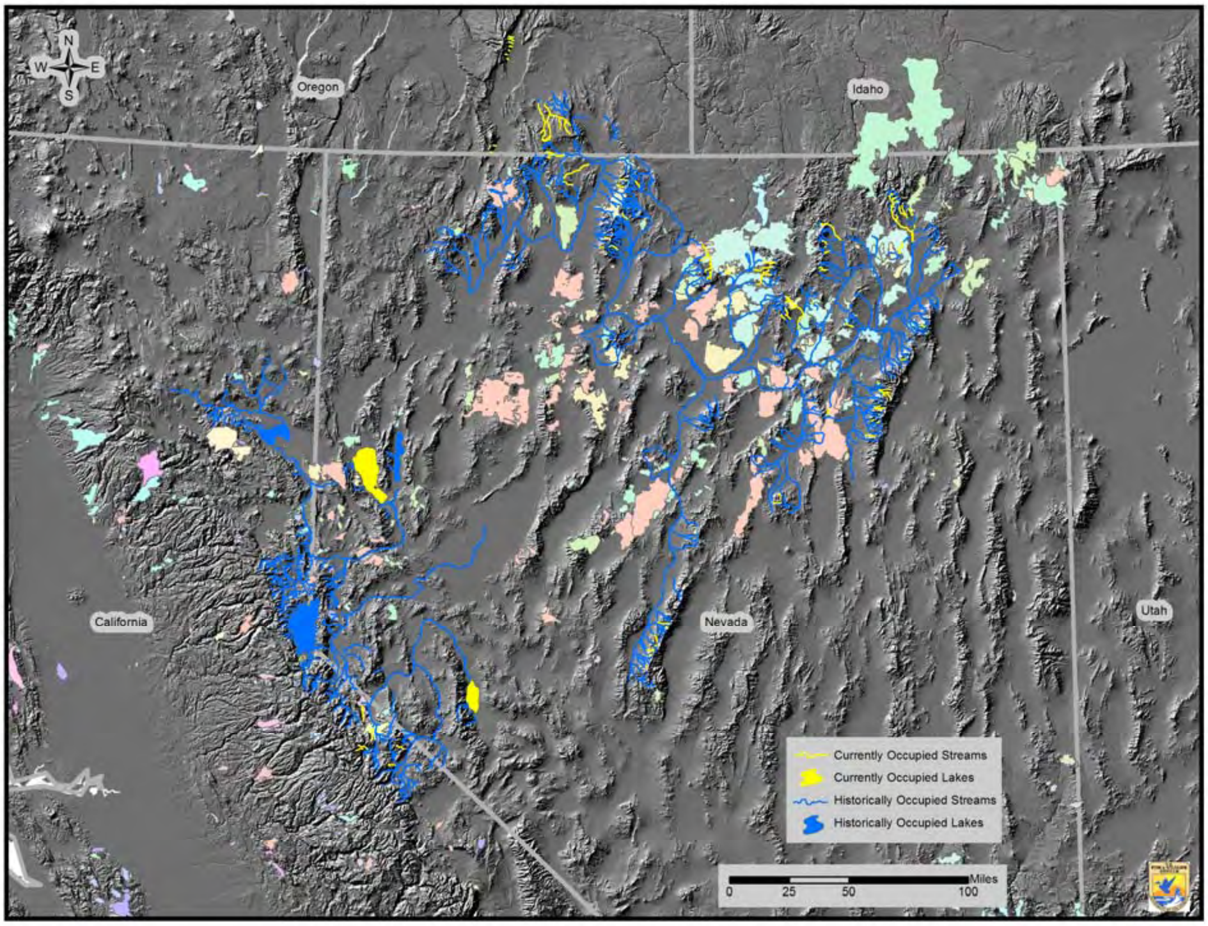

Figure A4.1. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat, prepared for 2009 5-year review.

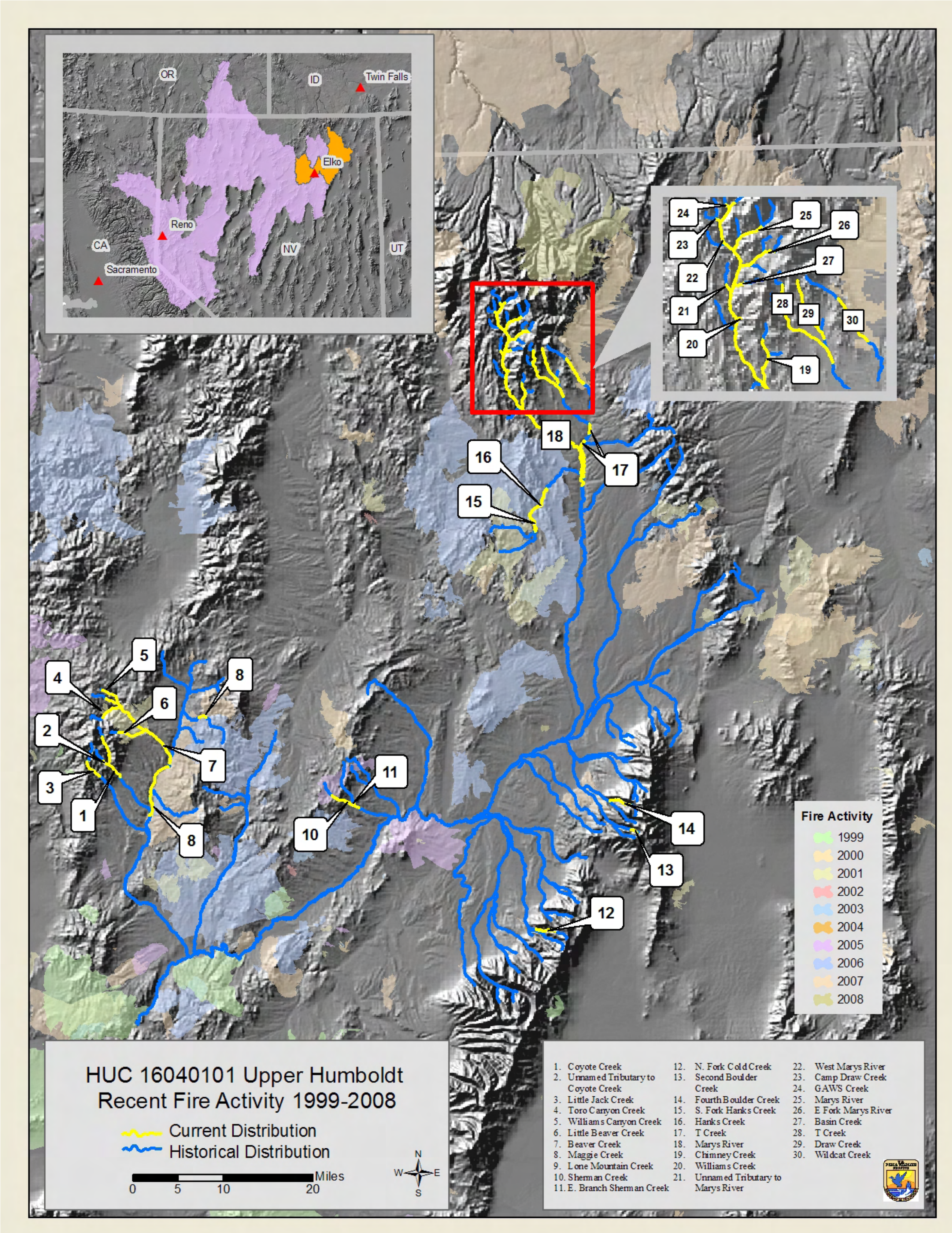

Figure A4.2. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the Upper Humboldt River watershed, prepared for 2009 5-year review.

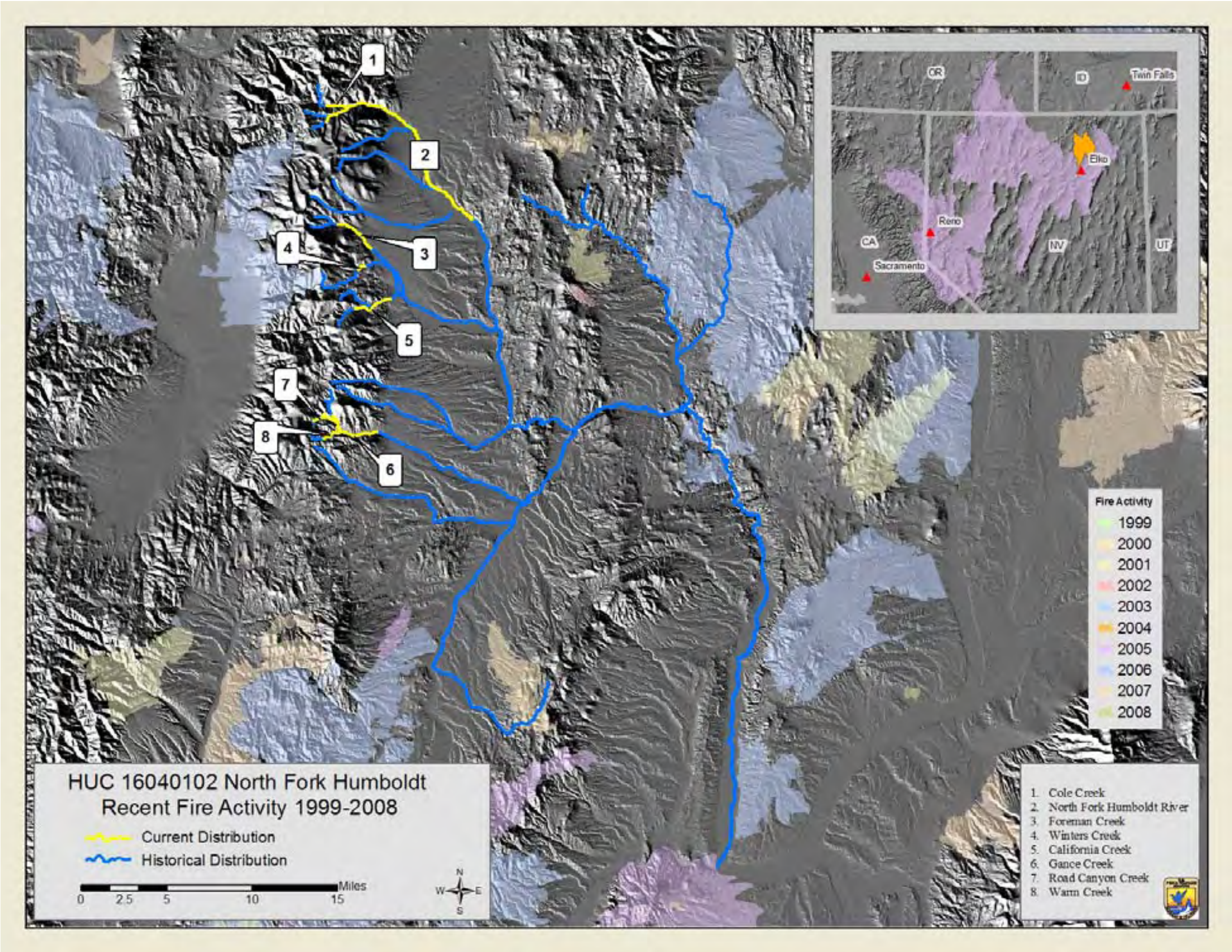

Figure A4.3. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the North Fork Humboldt River watershed, prepared for 2009 5-year review.

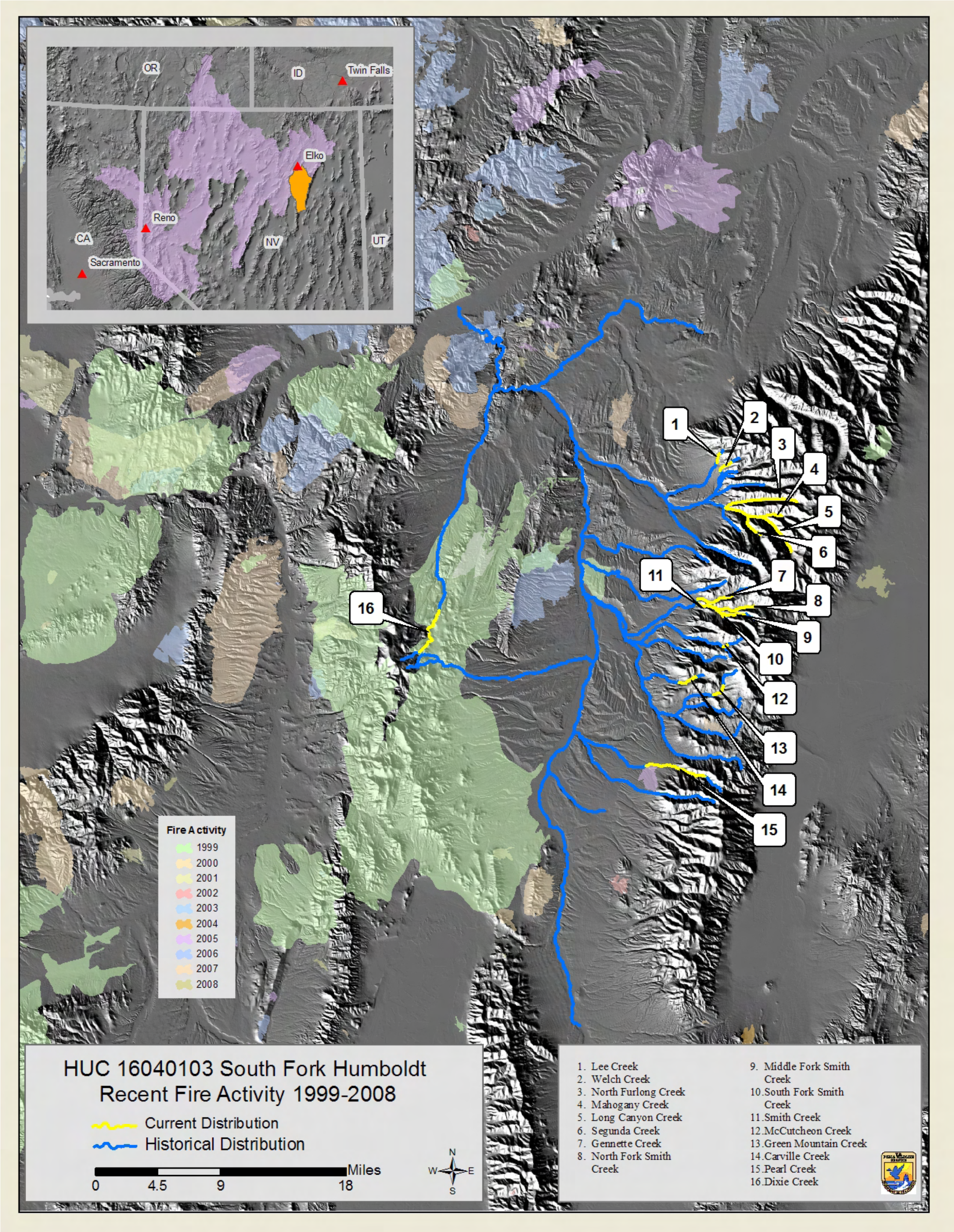

Figure A4.4. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the South Fork Humboldt River watershed, prepared for 2009 5-year review.

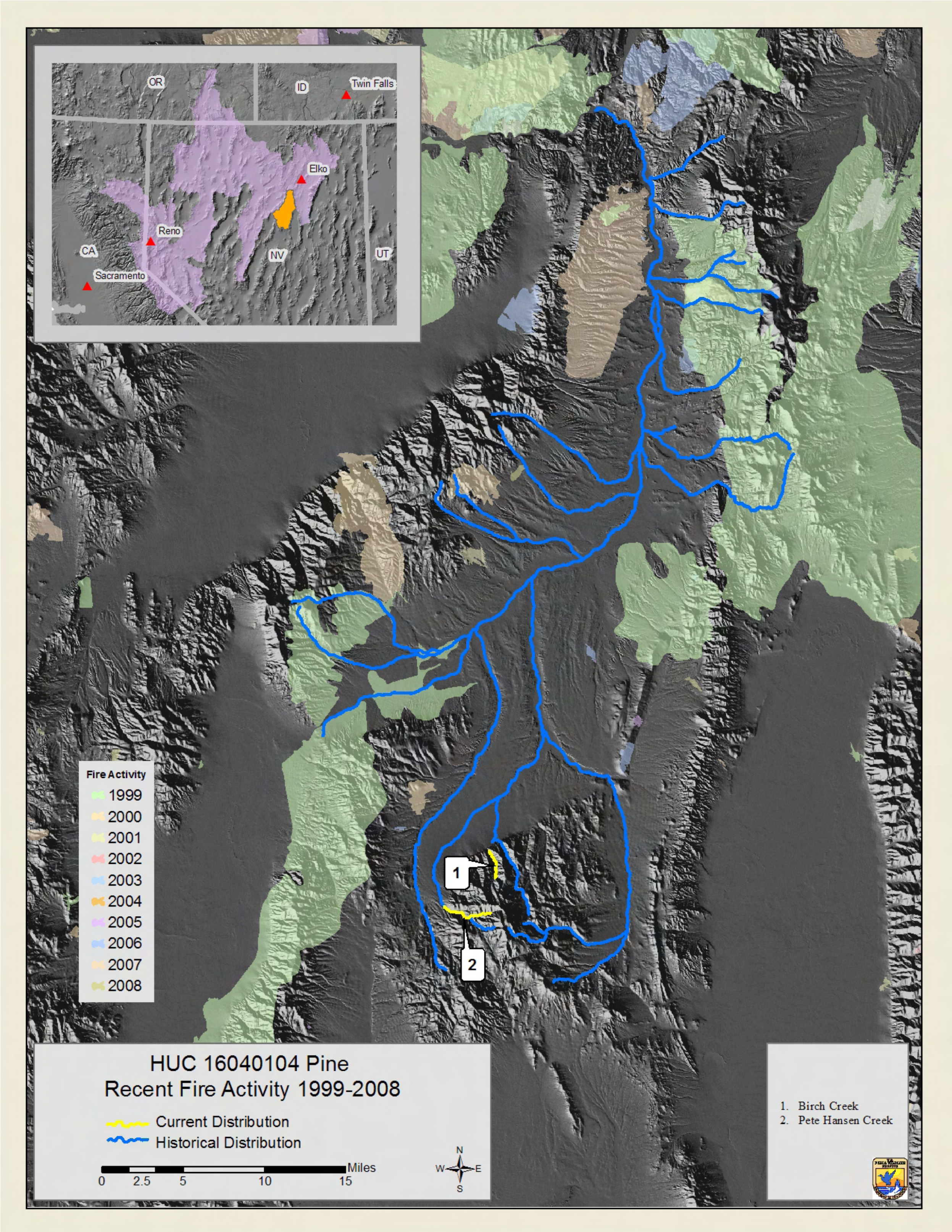

Figure A4.5. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the Pine Creek watershed, prepared for 2009 5-year review.

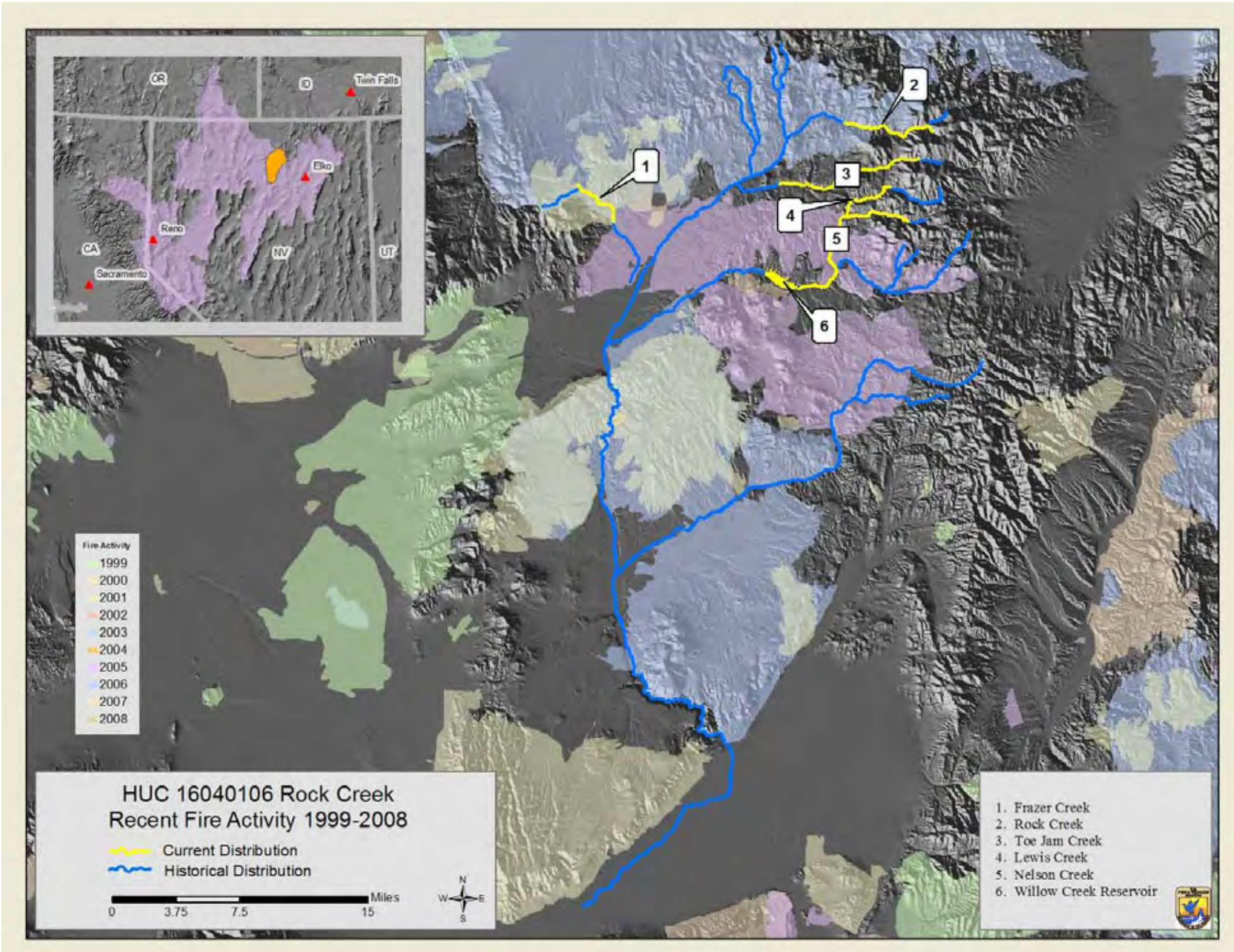

Figure A4.6. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the Rock Creek watershed, prepared for 2009 5-year review.

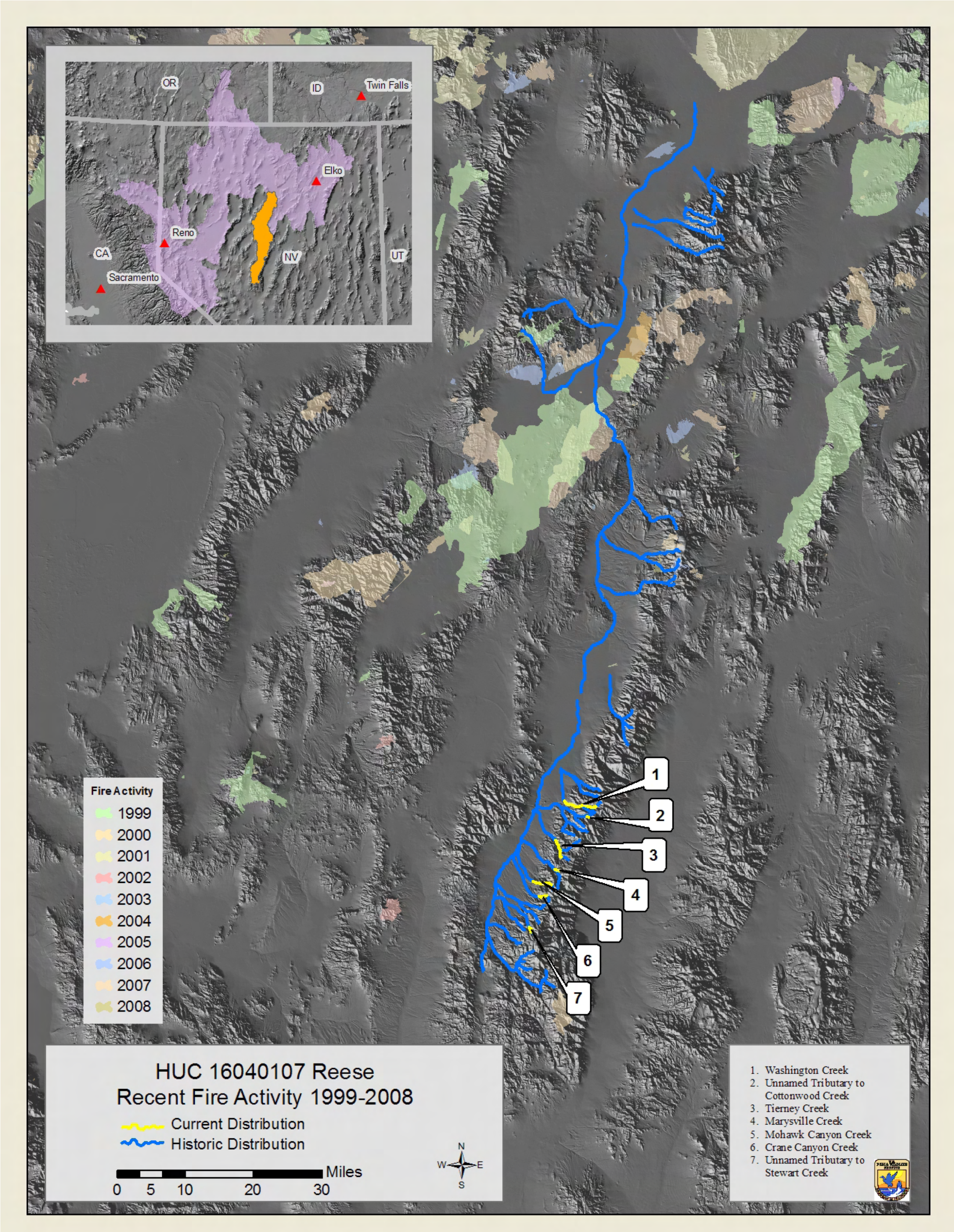

Figure A4.7. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the Reese River watershed, prepared for 2009 5-year review.

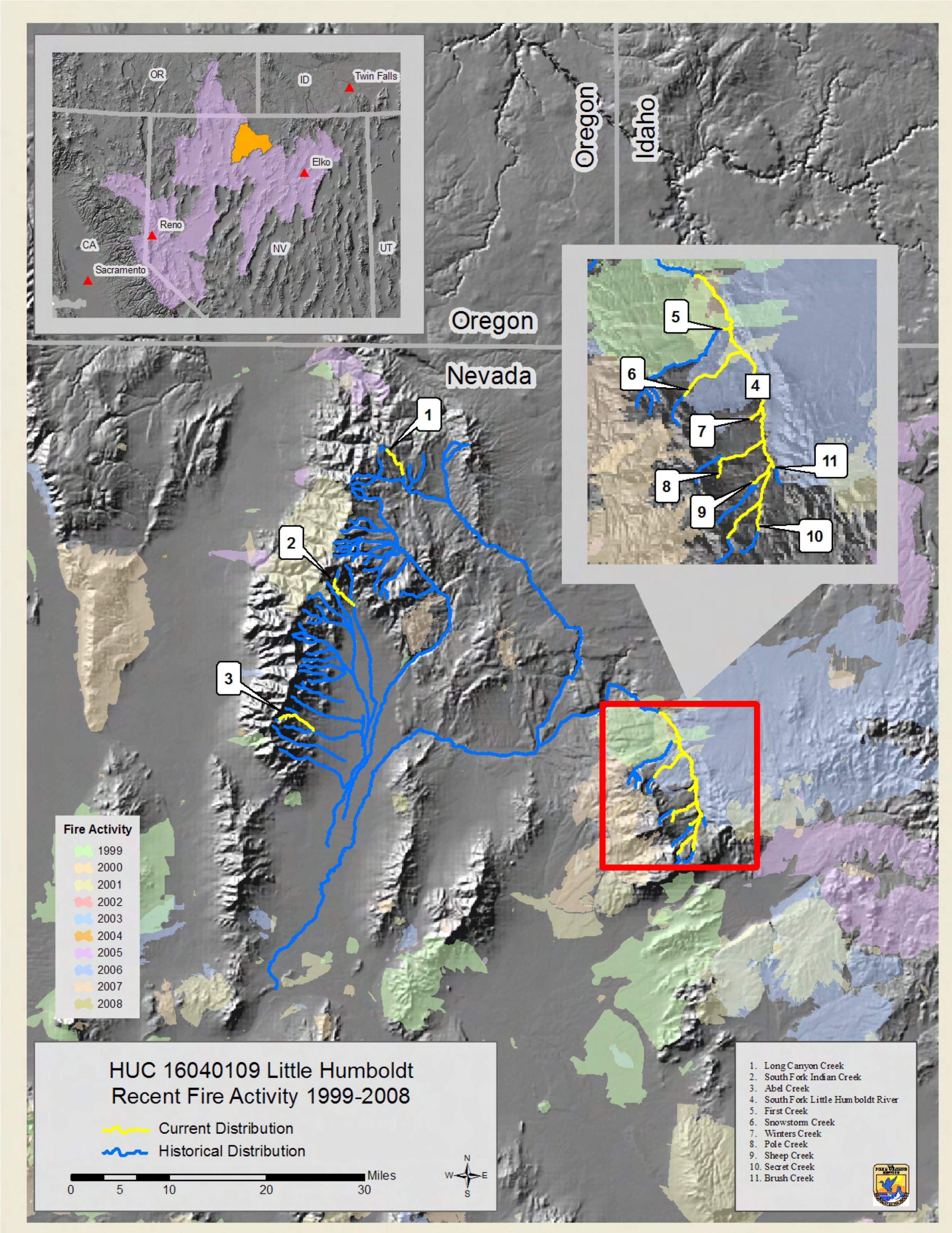

Figure A4.8. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the Little Humboldt River watershed, prepared for 2009 5-year review.

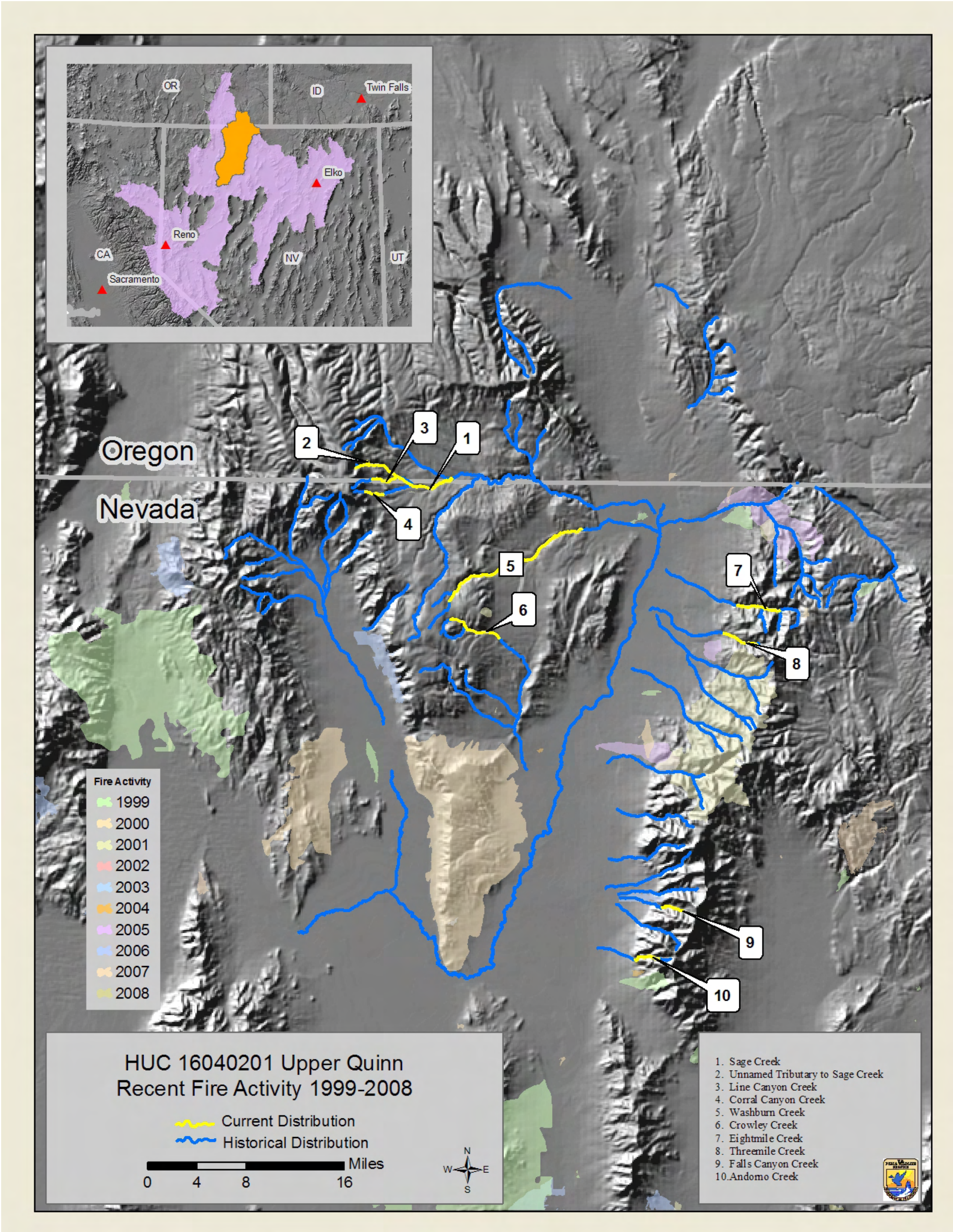

Figure A4.9. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the Upper Quinn River watershed, prepared for 2009 5-year review.

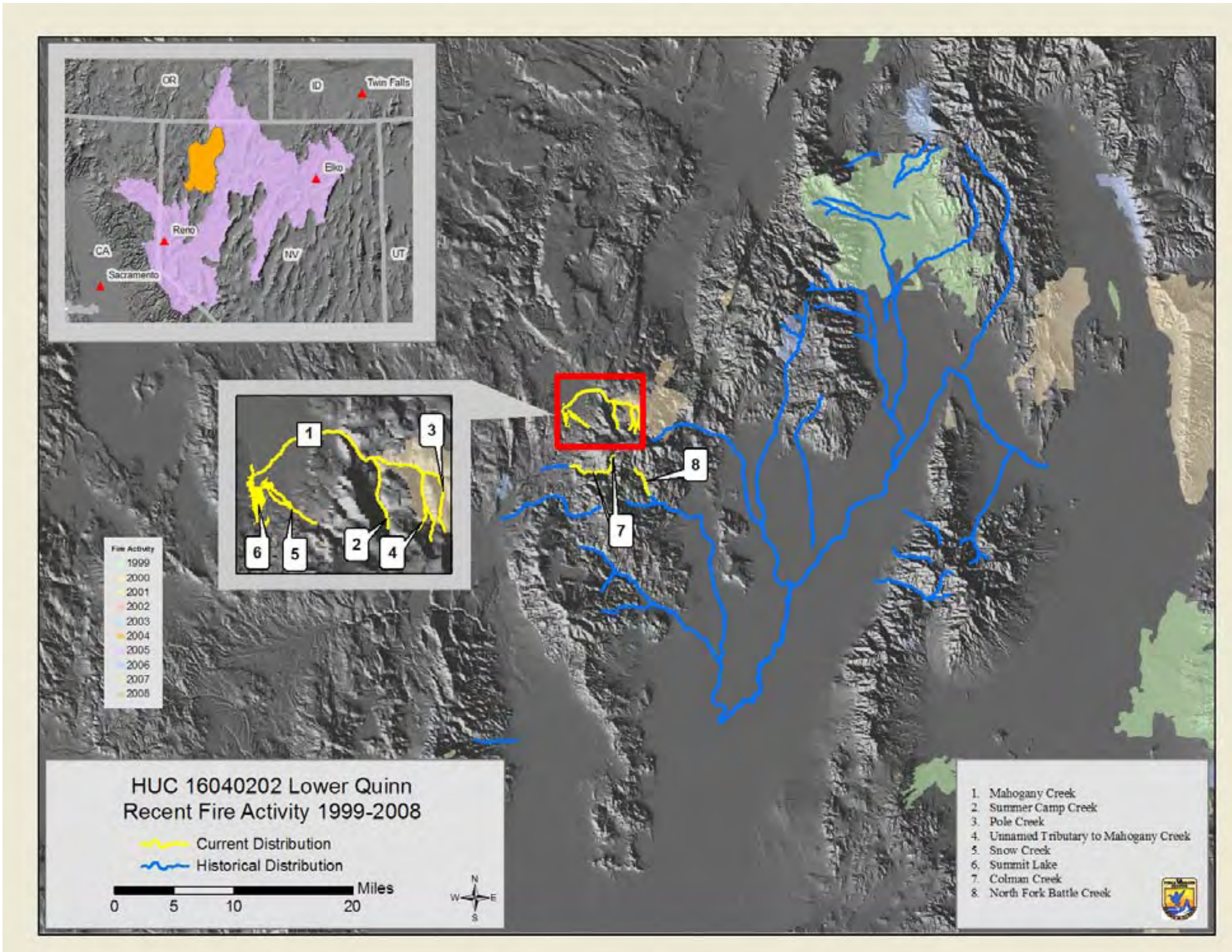

Figure A4.10. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the Lower Quinn River watershed, prepared for 2009 5-year review.

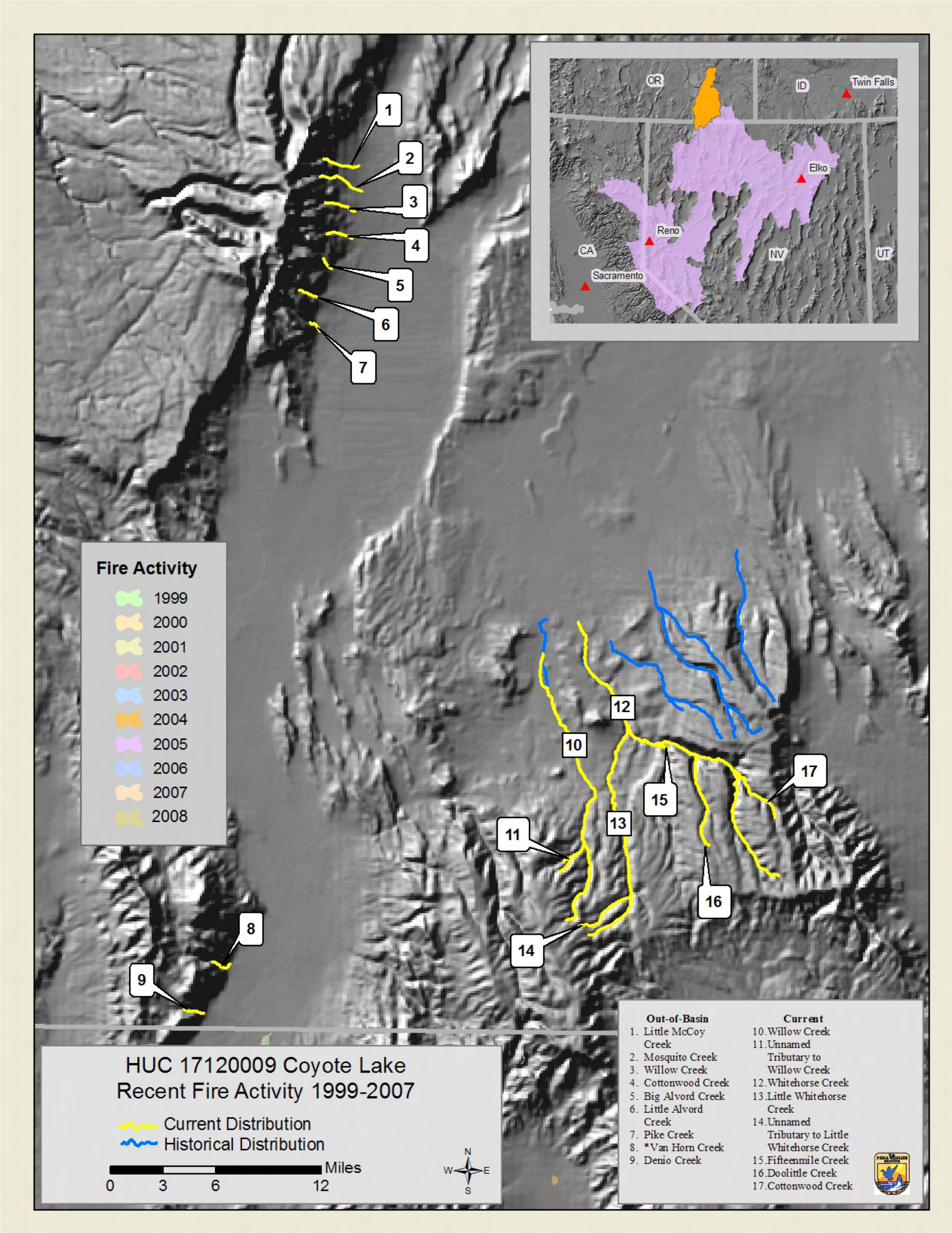

Figure A4.11. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the Coyote Lake Basin, prepared for 2009 5-year review.

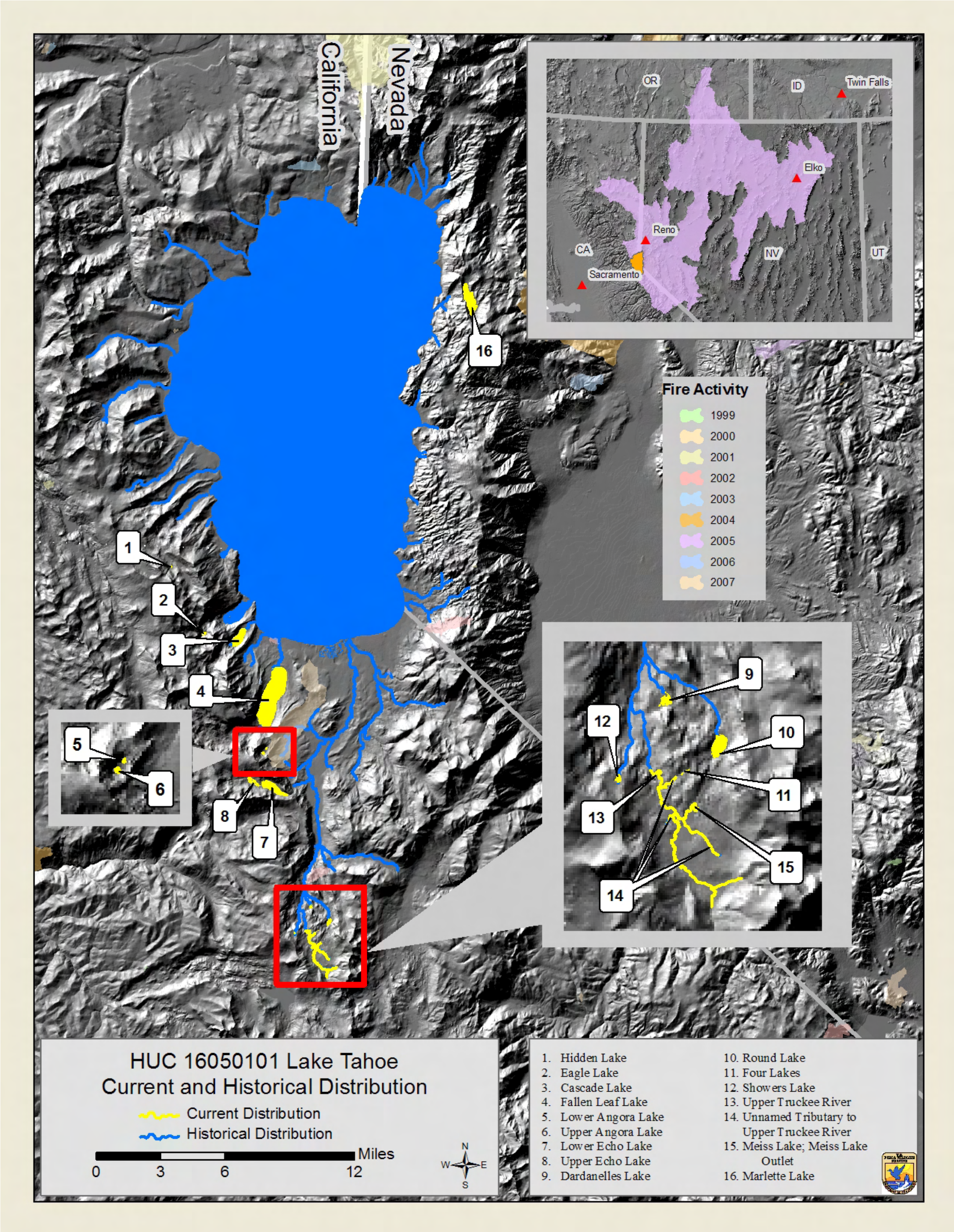

Figure A4.12. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the Lake Tahoe watershed, prepared for 2009 5-year review.

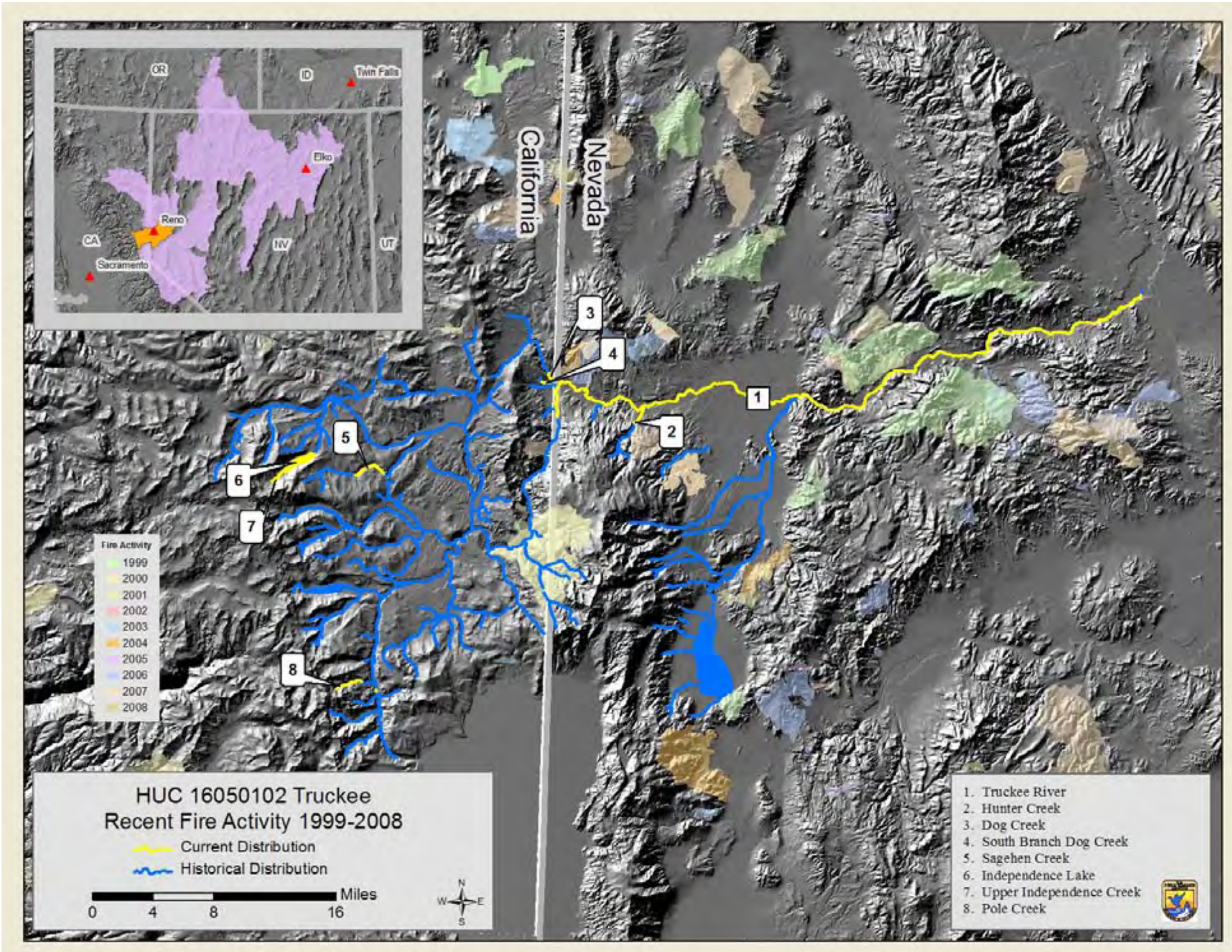

Figure A4.13. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the Truckee River watershed, prepared for 2009 5-year review.

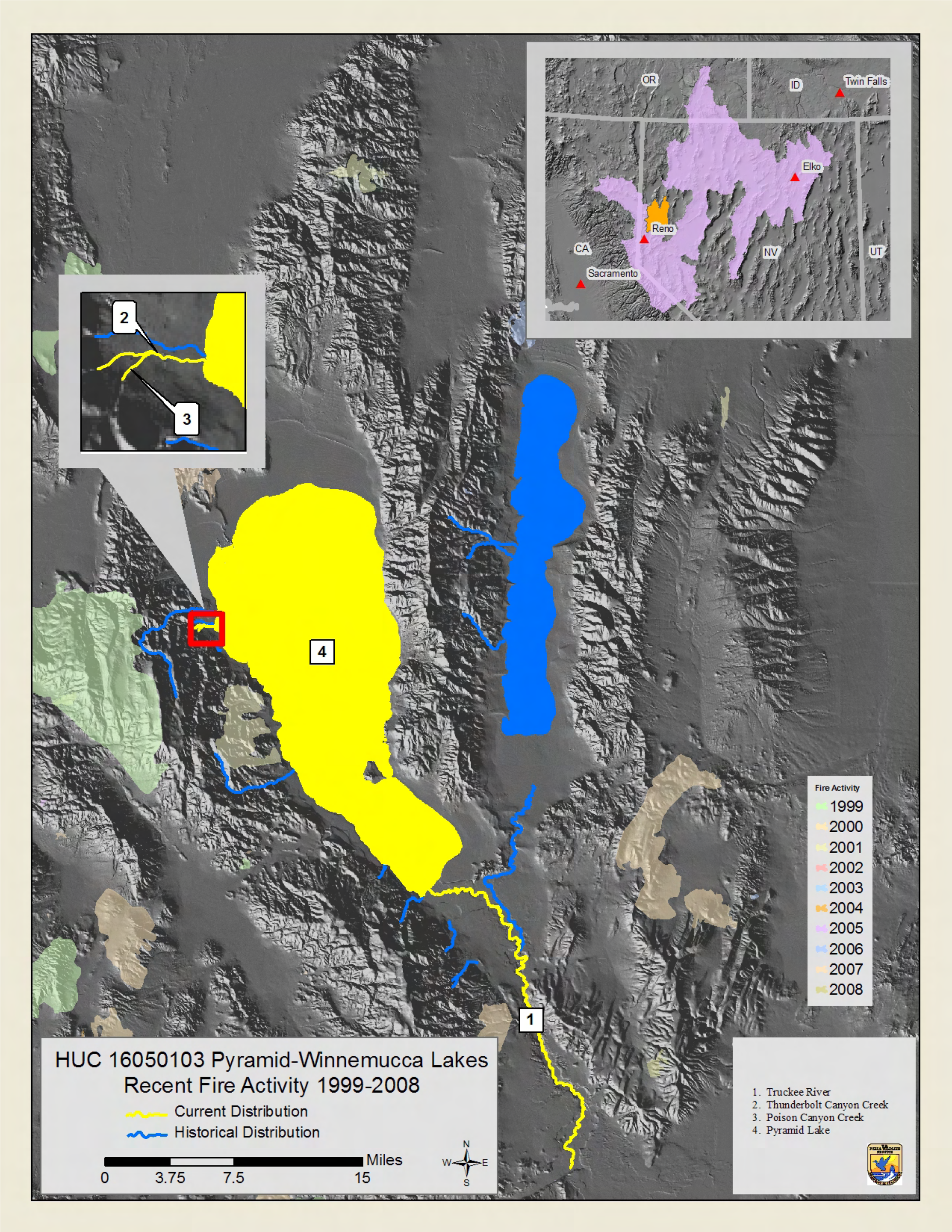

Figure A4.14. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the Pyramid Lake watershed, prepared for 2009 5-year review.

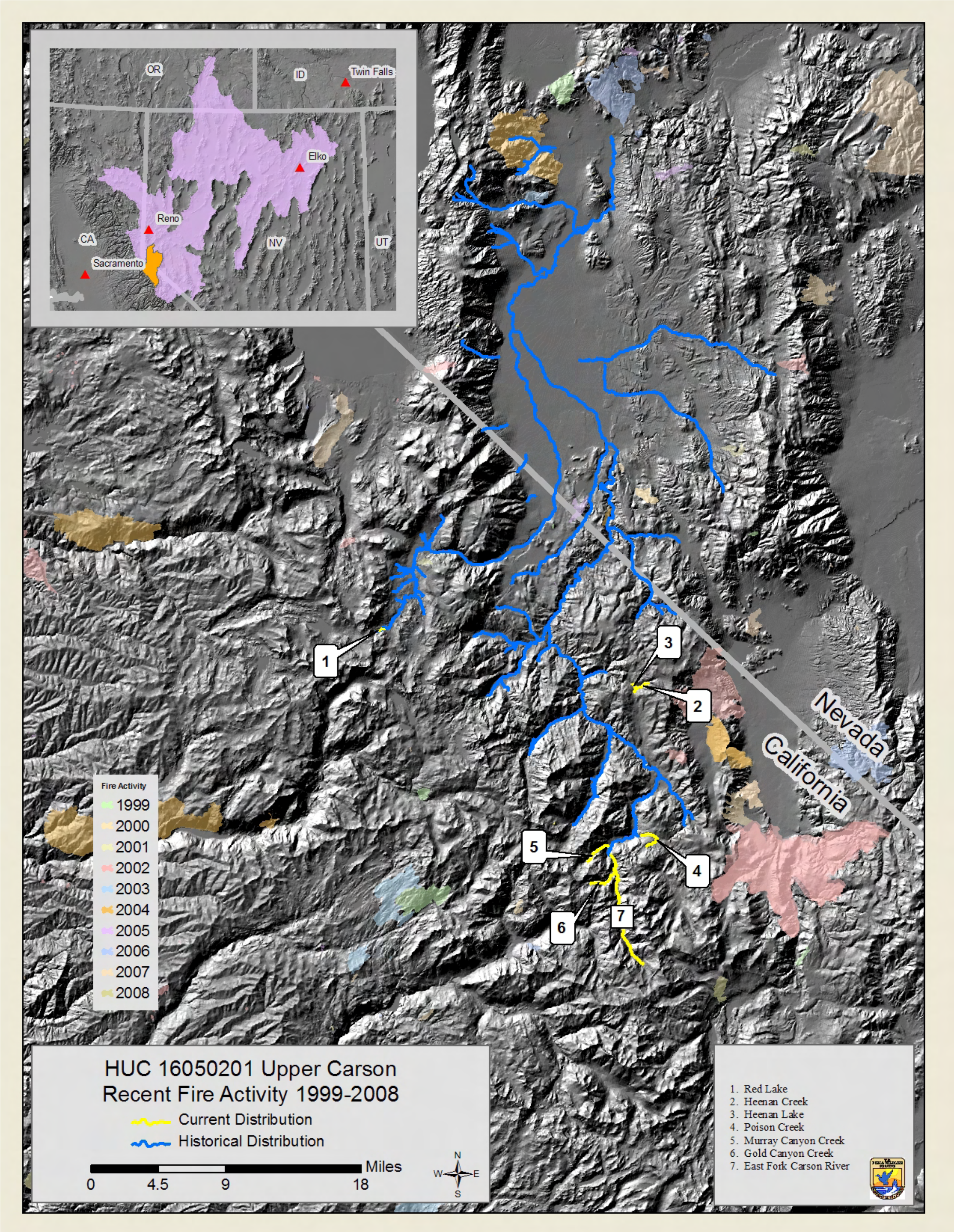

Figure A4.15. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the Upper Carson River watershed, prepared for 2009 5-year review.

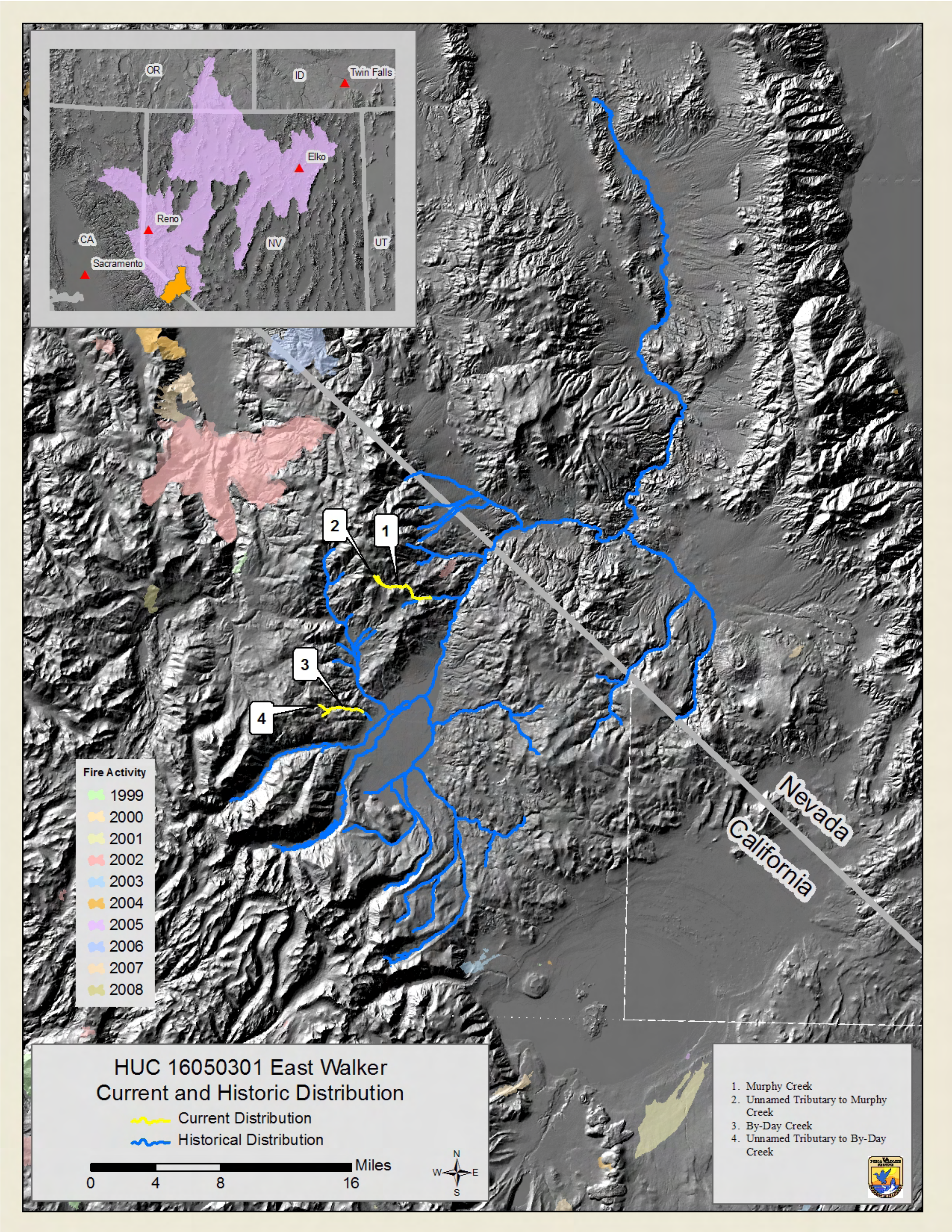

Figure A4.16. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the East Walker River watershed, prepared for 2009 5-year review.

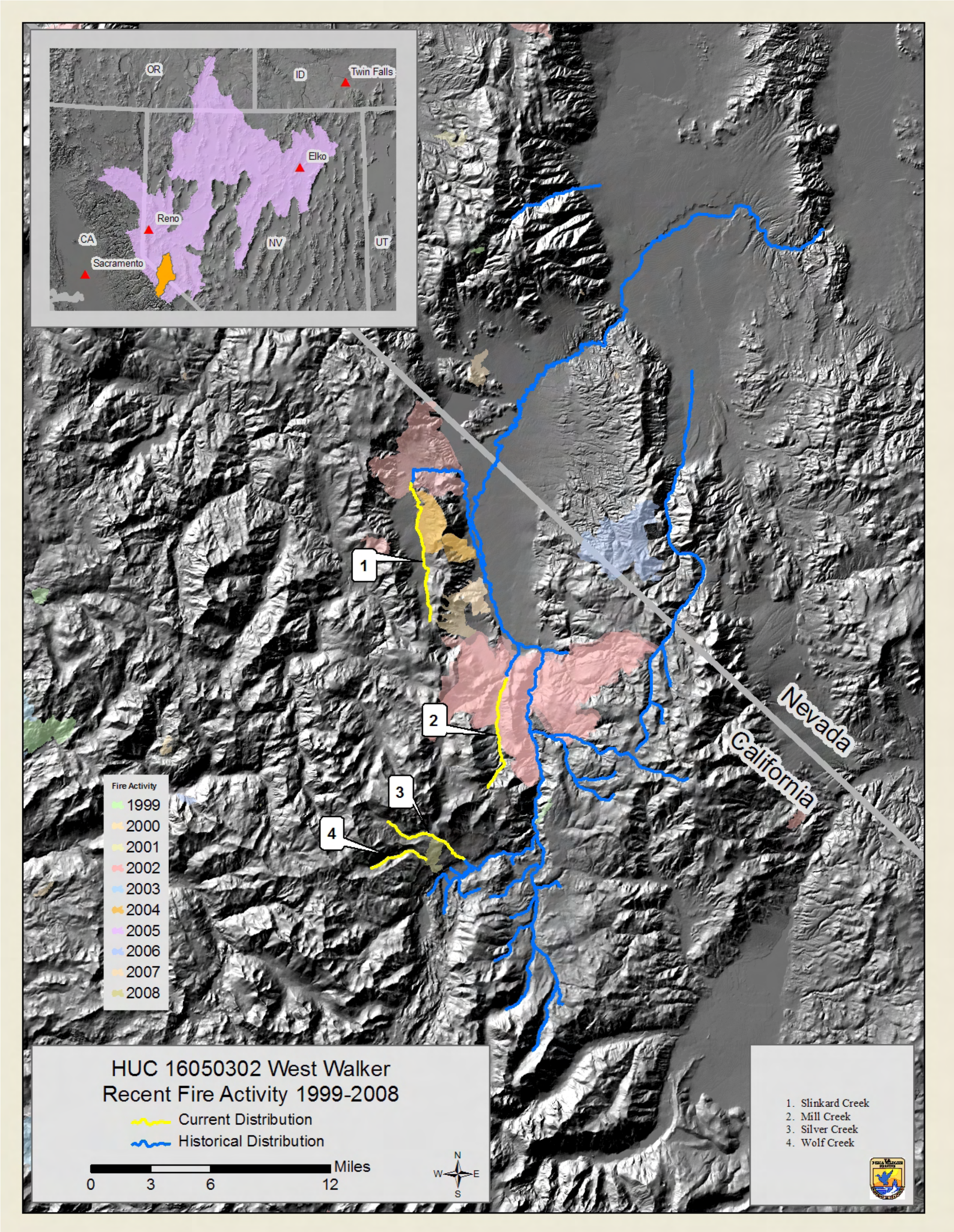

Figure A4.17. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the West Walker River watershed, prepared for 2009 5-year review.

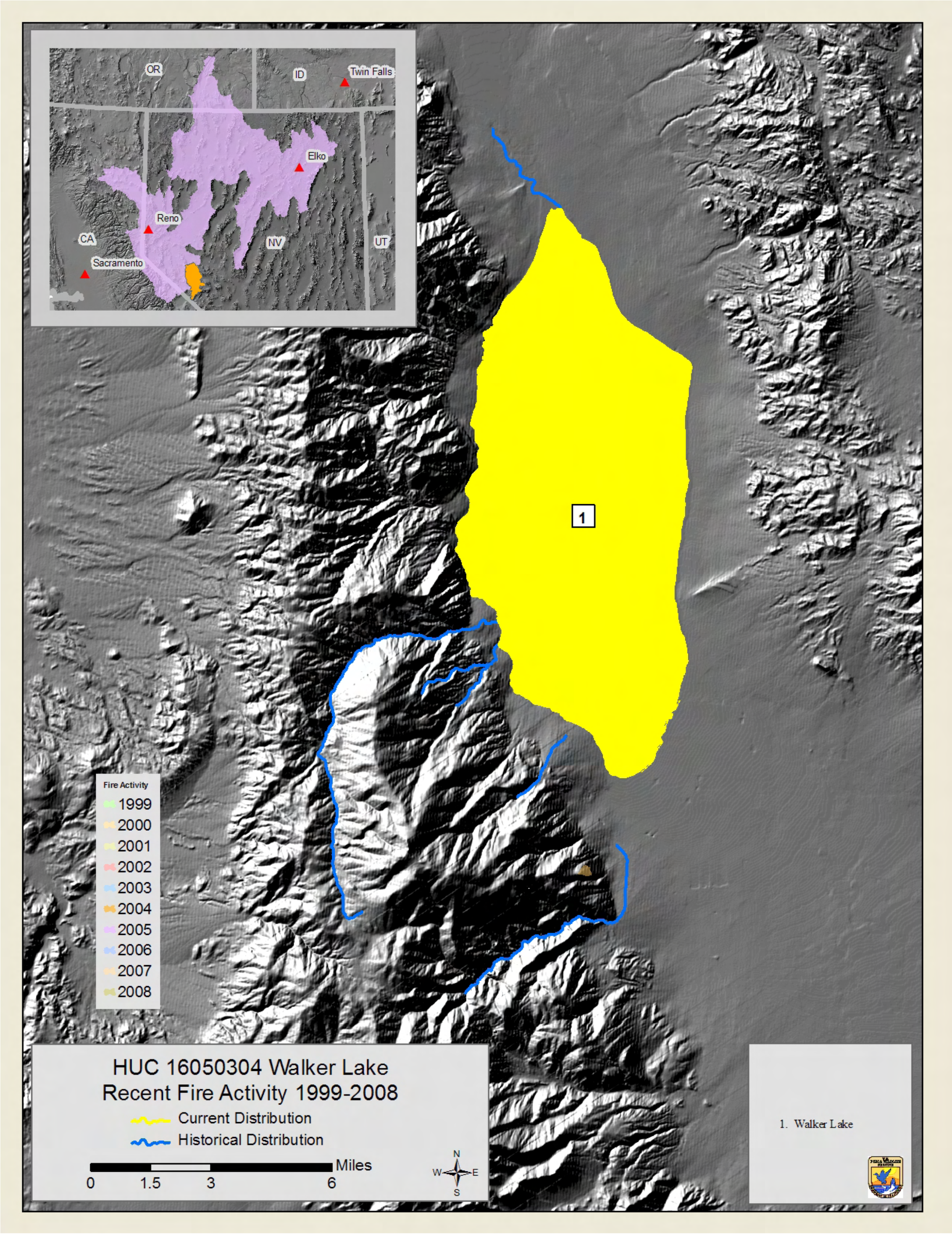

Figure A4.18. Recent fire occurrences (1999-2008) within the historical and currently occupied Lahontan cutthroat trout habitat in the Walker Lake watershed, prepared for 2009 5-year review.

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

Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*)

Current Classification: Threatened

Recommendation Resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X__ No change needed

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

FIELD OFFICE APPROVAL:

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

Approve ______ Date 3/18/09

REGIONAL OFFICE APPROVAL:

Lead Assistant Regional Director, U.S. Fish and Wildlife Service, Region 8

Approve ______ Date 3/30/09

COOPERATING REGIONAL OFFICE

X Concur _____ Do Not Concur

Acting Signature ______ Date 3/18/09
Project Leader/Field Supervisor, Oregon Fish and Wildlife Office, Region 1