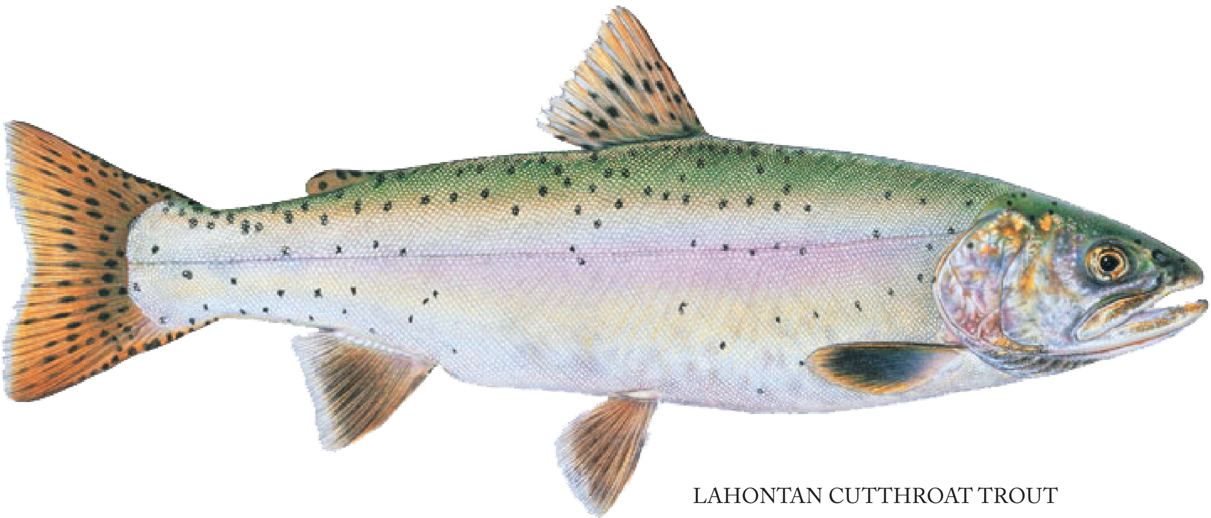
Lahontan Cutthroat Trout

(*Oncorhynchus clarkii henshawi*)

Data: Lahontan Cutthroat Trout Recovery Plan, 1995; A Business Plan for the Conservation of the Lahontan Cutthroat Trout: A 10-Year Plan for Conservation Through its Range, 2010; Lahontan Cutthroat Trout Status Update, 2009; Updated Goals and Objectives for the Conservation of Lahontan Cutthroat Trout, 2019

Partners: The states of California, Nevada, and Oregon, and the US Fish and Wildlife Service, US Forest Service, US Bureau of Land Management, Pyramid Lake Paiute Tribe, and Summit Lake Paiute Tribe



LAHONTAN CUTTHROAT TROUT
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Introduction

The Lahontan Cutthroat Trout (LCT; *Oncorhynchus clarkii henshawi*) evolved in the hydrographically isolated Lahontan Basin of northeastern California, southeastern Oregon, and northern Nevada (Figure 1) where ancient Lake Lahontan ebbed and flowed over millions of years. The LCT was listed as endangered by the U.S. Fish and Wildlife Service on October 13, 1970 (35 FR 16047 16048), and downlisted and reclassified as threatened (40 FR 29863 29864) in 1975 to facilitate management and allow regulated angling. The recovery plan for LCT was approved in 1995. A status review in 2009 determined that LCT continues to meet the definition of threatened. In 2019, the LCT Management Oversight Group (MOG) approved updated goals and objectives for the conservation of LCT (UGOs) that incorporate recent science, improved knowledge, and a widely accepted conservation framework to guide efforts in conjunction with the existing recovery plan.

Historical and Current Distribution

Recent work on the taxonomy of cutthroat trout supports recognizing several unique evolutionary forms comprising the LCT lineage (Peacock et al. 2018). These forms include the Western Lahontan Basin (Truckee, Carson, Walker rivers, including Summit Lake); the Northwestern Lahontan Basin (Quinn River); Eastern Lahontan Basin (Humboldt and Reese rivers); Coyote Lake Basin (Willow and Whitehorse rivers). There are two other forms in the LCT lineage—Paiute Cutthroat Trout from the East Carson River drainage, which has been listed as threatened, and LCT from the Alvord Lake Basin (Virgin-Thousand and Trout Creek drainages), where the native cutthroat trout form is extirpated.

These LCT forms developed several life history strategies and traits adapting to the diversity of river, stream, and lake habitats with resident, migratory, adfluvial and lacustrine characteristics. Lacustrine forms of LCT are uniquely adapted to persist in the desert terminal lakes of the Lahontan Basin—they have an unusual tolerance for alkaline and saline waters. Some forms have adapted to thrive in oligotrophic alpine lakes (e.g., Lake Tahoe and Independence Lake). For recovery purposes, the U.S. Fish and Wildlife Service and recovery partners organized LCT forms into three Geographic Management Units (GMUs): Western (Truckee, Carson, Walker and Susan rivers); Eastern (Humboldt River); and Northwestern (Quinn River/Black Rock Desert)(Figure 1). These

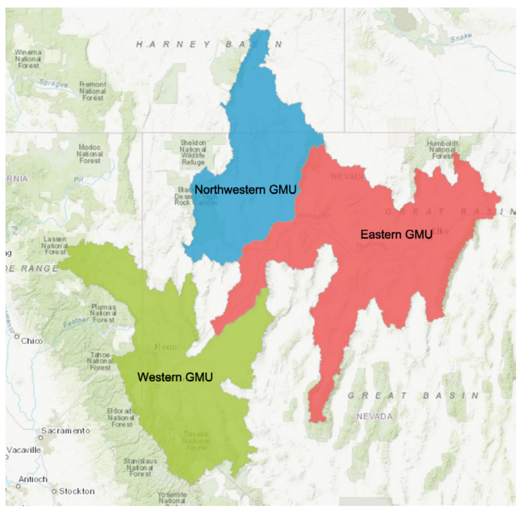

Figure 1. Lahontan Cutthroat Trout historical distribution.

GMUs have been further divided in the UGOs into 10 smaller Management Units for conservation implementation to meet specific recovery objectives.

In 1800, it is believed that more than 370,000 surface acres of lakes (in 12 larger lake systems) and more than 7,400 miles of stream habitat was occupied or had the potential to be occupied by LCT (USFWS 2009). After the mid-1800s, immigration and settlement within the Lahontan Basin and Northern California resulted in impacts to LCT due to overharvest, mining, timber harvest, pollution, water diversions, dams and reservoirs, and introduction of non-native trout forms. By the mid-1900s, LCT were extirpated from a majority of larger drainage basins and generally restricted to isolated headwater, or small lake, systems. The LCT has been extirpated from more than 90 percent of historical habitat (Dunham et al. 1997; Dunham et al. 2003).

Currently, LCT have been documented to occur throughout its historical range except in the Susan River drainage. About 70 self-sustaining LCT populations exist in about 10.5 percent of the historical habitat (752 stream miles and 1,394 surface acres). Less than 10 percent of stream populations remain, mostly in small, isolated, headwater habitat fragments with low levels of genetic diversity (Peacock et al. 2018). These small stream populations may have lower abundances due to poor habitat quality and may not be resilient long term. Significant portions of historical habitat are no longer suitable trout habitat due to climatic and anthropogenic factors. LCT currently occupy about 15 percent of the remaining potentially suitable habitat (LCT MOG 2019). There are also less than 30 out-of-basin LCT populations.

Lahontan Cutthroat Trout native to the Western GMU are most imperiled; few extant populations persist in these watersheds. In the Truckee River basin, there are only two naturally reproducing stream populations and a single naturally reproducing native lake population (Independence Lake). The Carson River has five remaining native fluvial populations, whereas the Walker Lake LCT population and all but one Walker basin fluvial population were effectively extirpated by the late 20th century. All seven fluvial populations in the Walker Basin today are derived from one small extant population, By-Day Creek. The lacustrine population of Walker Lake was maintained by stocking of hatchery-reared LCT, but was fully extirpated by 2009 due to reduced inflows and lower lake elevations and subsequent water chemistry changes.

The Western Lahontan Basin retains remnants of pluvial Lake Lahontan (Pyramid and Walker lakes). Although the three major river basins that contain LCT in the Western Lahontan Basin (Carson, Walker, and Truckee rivers) were never inundated by the ancient pluvial lake, these streams originate in the eastern Sierra Nevada and drain into these lacustrine habitat remnants. The east and west forks of Walker River join and flow into Walker Lake, although this lake dried up and refilled multiple times in the past 11,000 years (Behnke 1992).

Lake Tahoe is the source for the Truckee River, which flows into Pyramid Lake. Walker and Pyramid are terminal lakes supporting highly alkaline and nitrogen-limited ecosystems. The stream drainages flowing into these lakes historically provided spawning habitat and undoubtedly formed networked ecosystems that supported all life stages prior to water diversions and introduction of non-native fishes in the 20th century.

The majority of naturally sustaining fluvial LCT populations are found in the Humboldt River watershed. The Humboldt River is a large mainstem river that connected stream habitats prior to the European settlement of the Lahontan Basin. Historically, LCT populations were interconnected at various temporal and spatial scales developing fluvial migratory life histories and metapopulation dynamics (Dunham et al 1997; Neville et al. 2006).

Although water still flows into the main stem Humboldt River from ancillary drainages, water diversions, poor habitat quality, and interspecific competition have largely isolated LCT within headwater reaches in either single streams or small groups of tributaries. Recent conservation efforts to reconnect tributaries have been successful in some Humboldt subbasins.

Currently, 13 LCT populations occupy streams in the Quinn River drainage, and most of these habitats are isolated headwater reaches above barriers. Streams in the McDermitt Creek drainage remain interconnected, but non-native salmonids threaten the integrity of this LCT population network (Peacock and Kirchoff 2004). The Quinn River basin was inundated by pluvial Lake Lahontan and in the post-lake period, this system had as many as 46 streams occupied by LCT (Coffin and Cowan 1995). Summit Lake, north of the Black Rock Desert, was formed by a landslide about 12,500 years ago and was subsequently isolated, along with associated streams, from the rest of the western basin drainages. Summit Lake, including Mahogany Creek and Snow Creek, which drain into the lake, maintain a naturally reproducing LCT fishery.

The Coyote Lakes Basin, north of the Quinn River, in Oregon, contains Coyote Lake, a small ephemeral lake, and the Willow and Whitehorse stream systems. This basin was never connected to the larger Lake Lahontan but may have connected to Lake Alvord during the Late Pleistocene. Lake Alvord may have connected to Lake Lahontan earlier in the Pleistocene (Reheis et al. 2002) giving LCT access to these two northern basins. The remaining native LCT are found only in streams of the Willow and Whitehorse systems.

Habitat Requirements

Lahontan Cutthroat Trout are found in a wide variety of cold-water habitats, including large terminal alkaline lakes, alpine lakes, slow meandering rivers, mountain rivers, and small headwater tributary streams. They occur in cool flowing water with available cover of well-vegetated and stable stream banks, in areas where there are stream velocity breaks, and in relatively silt free, rocky riffle-run areas. However, they have demonstrated a tolerance for higher water temperatures for short periods of time.

Historically, LCT were found in large interconnected stream and/or stream and lake ecosystems. Demographic and genetic data reveal a complex population dynamic for the few remaining interconnected stream systems (Ray et al. 2000; Neville et al. 2006). Long-term occupancy of these stream networks was historically achieved via movement of fish among discrete populations and re-colonization of extirpated habitat facilitated by interconnected waterways (Neville et al. 2006).

Lacustrine LCT populations have adapted to a wide variety of lake habitats, from small alpine lakes to large desert waters. Unlike most freshwater fish species, native lacustrine strains of LCT have adapted to alkalinity and total dissolved solid levels as high as 3,000 mg/L and 16,000 mg/L, respectively. This ability to tolerate high alkalinity prompted introductions of LCT into saline-alkaline lakes in Nevada, Oregon, and Washington for recreational purposes. LCT were reintroduced into Walker Lake, Nevada, where they were extirpated in the early 20th century due to water diversions, which prevented access to spawning habitat. However, in the last several decades, over-allocated water rights and droughts have severely reduced inflow from the Walker River resulting in unnaturally high levels of alkalinity (> 20,000 mg/L), and the lake no longer supports fish life. Lahontan Cutthroat Trout of the historic Pilot Peak strain have been reintroduced into Pyramid Lake and the Lake Tahoe Basin. These native LCT are currently maintained by hatchery propagation along with significant recent efforts to establish natural reproduction.

Reproduction

Lahontan Cutthroat Trout inhabit lakes and streams, but are obligatory stream spawners. Small, intermittent, tributary streams and headwater reaches are sometimes used as spawning sites (Coffin 1981, Trotter 1987). Spawning generally occurs from April through July, depending upon stream flow, elevation, and water temperature (La Rivers 1962, McAfee 1966, Lea 1968, Moyle 2002). Fecundity of 600–8,000 eggs per female has been reported for lacustrine (lake dwelling) populations (Lea 1968, Cowan 1983, Sigler et al. 1983, Moyle 2002), whereas only 100–300 eggs were found in females collected from small Nevada streams (Coffin 1981). Eggs are deposited in small gravels within riffles or pool crests (USFWS 1995). Eggs generally hatch within 4–6 weeks, depending on water temperature, and fry emerge 13–23 days later (Lea 1968, Moyle 2002).

Sportfishing

Despite being listed as Threatened, LCT can be harvested under a special 4(d) rule under the Endangered Species Act that allows angling and harvest under state regulations. Consequently, LCT have played an important part of the recreational fishing in Nevada, California, and Oregon for the past 40 years. They are raised at state, tribal, and federal hatcheries for both recovery and recreational fishing purposes. There are also numerous other lakes and streams in the historic drainages that are stocked with LCT from the Heenan Lake broodstock established from Independence Lake. In California, some high angler-use, out-of-basin waters are stocked (e.g., Crowley Lake), and some wild, stream populations are managed with special regulations, typically zero-bag limits (e.g., Upper Truckee River and Wolf Creek).

In Nevada, numerous LCT waters are open to fishing and are very popular, including the Truckee River and Pyramid Lake. To protect the integrity of fishable populations, special fishing restrictions exist in some waters. Fishable populations are also supported by hatchery stocking. The sportfish status of LCT and increasing notoriety of successful fisheries like Pyramid Lake has improved angler support for LCT reintroduction and management.

Threats

The significant decline in range and numbers of LCT is primarily attributable to habitat fragmentation and degradation and the introduction of non-native trout throughout the species range along with dam and diversion structures and water withdrawals in the Western GMU. Other impacts include water diversion of rivers and streams as well as degradation of riparian habitat by poor domestic livestock grazing management. All of these threats represent significant impediments to recovery of naturally sustaining, networked populations.

Habitat Degradation Concerns

Major impacts to LCT habitat include: 1) reduction and alteration of stream discharge; 2) alteration of stream channels and morphology; 3) degradation of water quality; and 4) reduction of lake levels and concentrated chemical components in natural lakes. Concentrations of livestock in riparian areas causes habitat alterations of those areas, such as loss of undercut banks and other cover, exposed stream channels, and increased silt loads, which lead to wider and shallower streams that ultimately causes elevated water temperatures during the summer, and colder temperatures during the winter.

Lacustrine habitat has been altered by construction of dams and diversions, pollution, reduced spawning flows, desiccation of lakes, and drought and water withdrawal.

Non-native Fish Concerns

Non-native Rainbow Trout, Brook Trout, and Brown Trout have become established in all basins inhabited by LCT, contributing to the loss of many LCT populations. Additionally, Kokanee Salmon and Lake Trout are established in Lake Tahoe and Fallen Leaf Lake. In 2019, evidence of a recent invasion of Rainbow Trout in Independence Lake was detected by the discovery of some hybridized fish. This important wild lacustrine LCT population is now in serious jeopardy, requiring extensive management actions to prevent further damage.

Fluvial LCT populations have been displaced by competition and predation from introduced Brown Trout and Brook Trout, and from hybridization with Rainbow Trout. Non-native fish stocking for recreational fishing has been reduced or eliminated in areas important for recovery. In locations in which non-native fish stocking is needed to maintain recreational fisheries, fishery managers are using sterile triploid Rainbow Trout and Tiger Trout to minimize the potential for hybridization with LCT.

Population Viability Concerns

Habitat loss and fragmentation have become serious extinction threats for species globally (Green 2003, Reed 2004). Isolation and small population size increase vulnerability to local extirpation through demographic stochasticity in the short term, and genetic stochasticity in the long term (Lande 1998, Frankham and Brook 2004, Munzbergova 2006). Loss of genetic variability through the process of random genetic drift can reduce the ability of natural populations to adaptively respond to changing environmental conditions. In the case of wide-ranging species, the aim is often to identify genetically distinct groups of populations whose genetic differences reflect local adaptive differences (Waples 1998, Solorzano et al. 2004, Ficetola and De Bernardi 2005). The genetic challenge to recovery of imperiled species is to preserve enough variation to facilitate adaptive responses to changing environments and maintain evolutionary potential.

Climate Change

Climate change will pose additional threats to inland cutthroat trout due to their narrow temperature tolerance and specific habitat needs (Rieman et al. 2007, Williams et al. 2009). Lahontan Cutthroat Trout may be particularly vulnerable given the high variability in flow and temperature within their range (Platts and Nelson 1988, Galbraith and Price 2009). Temperature increases will likely restrict LCT from lower elevation habitats and push them higher into headwater streams, further compounding the impact of fragmentation (Rahel et al. 1996). Populations will also be at increased risk from fire (Westerling et al. 2006), flooding, drought (Mote et al. 2003), and invasions of non-native species and disease pathogens that can express enhanced resilience to increased temperatures. Dramatic burns and severe drought are increasing, directly impacting several LCT populations. Increased wildfire frequency and intensity diminishes the capacity of habitats, making it unlikely to sustain the long-term persistence and viability of many remaining populations (Wenger et al. 2017).

Conservation

Ongoing and future conservation for LCT is focused on the conservation biology principles of Representation, Redundancy, and Resiliency (3 R's), which form the framework of the recently completed UGOs.

Conservation measures implemented to improve the status of LCT include:

- Fish population analyses and manipulations (genetic evaluations, extensive population surveys, fish translocations and fish stockings);
- Watershed management planning;
- Habitat analyses and manipulations (habitat inventory, habitat improvement activities, changes in grazing practices, and riparian fencing and enclosures);
- Land exchanges and acquisitions to secure important LCT habitat;
- Development of fishery management plans and appropriate fishing regulations and angling closures; and
- Reduction or elimination of stocking of non-native trout in recovery waters, and stocking LCT instead of non-native fish.

LCT Population Surveys, genetic analyses, and fish population manipulation

Key actions will include:

- Maintain genetic diversity of extant LCT populations by securing existing populations and expanding occupied habitat;
- Conduct standardized population surveys and implement a genetic monitoring program to assess the effectiveness of habitat improvement projects on population size and maintenance of genetic diversity;
- Reduce impacts of non-native salmonids by reducing or eliminating repro-

ducing populations of these species. Conduct non-native trout suppression efforts in selected waters where priority LCT populations are at-risk. Stop artificial stocking of non-native fishes in LCT recovery waters; and

- Review and update fishery management and production plans on a prescribed schedule to incorporate current science.

Development of Watershed-based Fishery Management Plans

Key actions will include:

- Develop cooperative management plans to manage major watersheds focusing on reducing degradation of riparian, stream, and lake ecosystems leading to improved water temperature profiles and manage for LCT for recreational fishing;
- Develop cooperative management plans to remove movement barriers and provide fish passage to interconnected habitats; and
- Assess the impact of climatic changes and drought or other catastrophic events, such as wildfires, on the recovery of LCT.

LCT Habitat Manipulations

Restoration of LCT habitat must address habitat and water quality and quantity issues. Restoration of a natural hydrograph, in seasonal variation, if not in historic volume, is key to the restoration and maintenance of riparian habitat and channel function. Current efforts to manage LCT have been directed toward improving instream and riparian conditions, addressing land use practices conditions, and restoring limited stream fragments.

Key actions will include:

- Secure and improve riparian and instream habitat for the restoration of LCT fluvial populations;
- Identify critical stream and riparian zone habitats for cooperative management projects and recovery of LCT;
- Restore and enhance water flow, including restoring the natural hydrograph, not necessarily historic volumes, in key habitats;
- Address public and private land management practices to improve watershed habitats for LCT and reduce livestock and agricultural impacts;
- Monitor and evaluate natural catastrophe impacts like fire and drought; and
- Investigate opportunities to locate, design, and construct fish migration barriers that will exclude non-native trout and help create new connected habitats following non-native trout eradication projects.

Lahontan Cutthroat Management related to public use and supplemental stocking

Key actions will include:

- Revise current management plans to clarify the role of hatchery-produced fish conservation and recreational fishing;

- Evaluate the use of broodstock eggs to establish self-sustaining populations of LCT in the Western GMU if wild LCT are not available. LCT strains native to each GMU basin should be used for basin-specific recovery activities; and
- Manage sportfishing to preclude adverse angling impacts on LCT through the use of special fishing regulations and use of LCT for recreational fishing in place of non-natives.

Highest Priority Actions for LCT by major watershed (Figure 2)

1) Western Lahontan Basin (Truckee, Carson, and Walker River sub-basins)

Prevent further losses of genetic variation of extant populations and suitable habitat, and restore historically occupied habitat.

- Use the Pilot Peak strain LCT for LCT restoration in the Pyramid-Truckee-Tahoe corrido because it is the most suitable strain adapted for these terminal lake and interconnected habitats. Seek to establish a naturally reproducing population in the Truckee River by implementing fish passage improvement projects and efforts to minimize hybridization with Rainbow Trout. Continue to supplement Pyramid and Tahoe Basin fisheries with hatchery-produced Pilot Peak fish.
- Implement management actions to prevent and reduce further hybridization of the Independence Lake LCT population. Tag as many individual fish as possible, and collect genetic samples for each fish so that hybrid fish can be detected and removed when encountered at the lake, or inlet stream, during spawning trap operations. Continue to operate other ongoing non-native removal efforts, and conduct genetic analyses to support hybrid identification and removal.
- Support continuing efforts to maintain and enhance Summit Lake LCT population resiliency to support long-term persistence.
- Support efforts to achieve funding from the Lake Tahoe Restoration Act to help with priority LCT conservation in the Tahoe Basin including: non-native trout suppression and removal in the Upper Truckee River and Fallen Leaf Lake; habitat improvements; and expanded production of hatchery LCT to increase LCT angling opportunities in the basin.
- Engage stakeholders and the public to increase awareness and support for LCT restoration.
- Establish a new hatchery rearing program for Walker River Basin strain of LCT at CDFW's Hot Creek Hatchery. Build public support for LCT restoration by increasing angling opportunities and positive experiences with hatchery Walker LCT produced for recreation. Operate under conservation hatchery breeding protocols so that LCT may be used to support restoration efforts, if needed. Investigate lacustrine life history traits expression of Walker LCT by stocking fish produced in differing lake habitats.

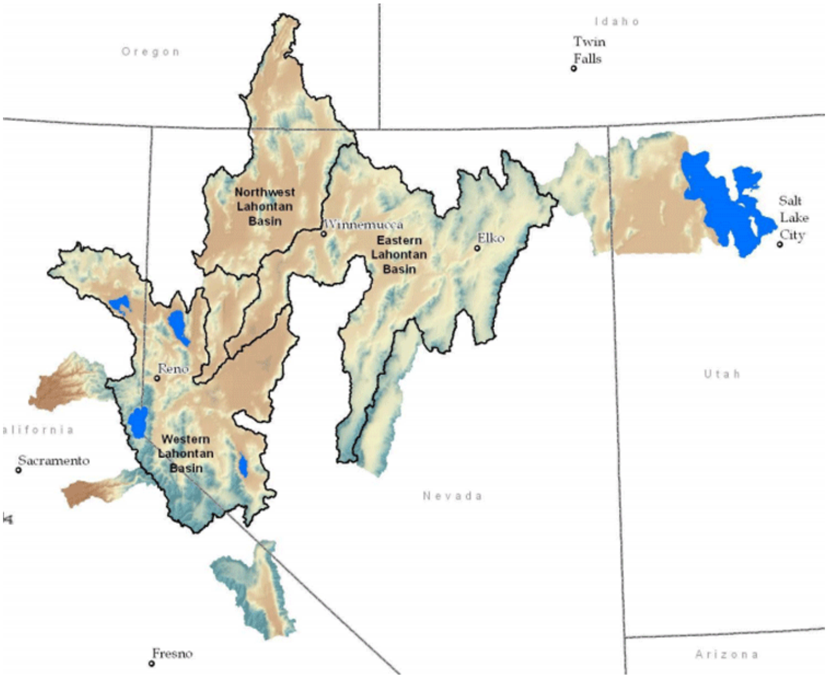

Figure 2. Lahontan Cutthroat Trout watersheds.

2) Northwestern Lahontan Basin (Quinn River, Black Rock Desert, and Coyote Lake sub-basins)

- Prevent further losses of genetic variation of extant populations and suitable habitats.
- Support efforts to acquire the Disaster Peak Ranch by Western Rivers Conservancy so that habitats in the McDermitt Creek system can be secured and efforts to restore a resilient meta-population system in the GMU can be achieved.
- Continue to monitor population and genetic status of LCT in the GMU along with habitat assessments and improvements.

3) Eastern Lahontan Basin (Humboldt and Reese Rivers)

- Prevent further losses of genetic variation of extant populations and suitable habitats.
- Maintain existing and establish new connected metapopulations in five Humboldt GMU sub-basins (described in UGOs). Complete efforts to remove non-natives and develop large interconnected habitats in the North Fork Humboldt River. Implement actions to remove non-natives and establish connected population in the upper Reese River tributaries.
- Develop and implement plans to ad-

dress hybridization issues in Marys River sub-basin.

- Develop a process to strategically engage local stakeholders to help recovery partners collaboratively develop and implement unit-based conservation action plans. Develop a "template for success" with stakeholders in the South Fork Humboldt sub-basin (pilot project) that can be used to build partnerships with stakeholders in other parts of the LCT range. Initiate a multi-step, multi-year process that results in a Collaborative Conservation Action Plan.

WNTI Completed/Ongoing Projects

- 2017 - TROUT at WHCCD (Transforming Research Opportunities for Undergraduate Training at West Hills Community College District) (CA)
- 2016 - Lahontan Cutthroat Trout Recovery Interpretive Panel (CA)
- 2016 - Exploration Lahontan Cutthroat Trout (LCT) Camp (NV)
- 2009 - McDermitt Creek Fish Migration Barrier to Protect a Lahontan Cutthroat Trout population (NV)
- 2009 - Susie Creek Fish Barrier to Protect High Priority Recovery Habitat for Lahontan Cutthroat Trout in Humboldt County (NV)
- 2008 - Lower McDermitt Creek Fish Barrier to Protect Lahontan Cutthroat Metapopulation (NV)
- 2008 - Maggie Creek fish migration barrier to protect a Lahontan Cutthroat Trout population in the Maggie Creek Subbasin (NV)

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