

A Business Plan for the Conservation of the Lahontan Cutthroat Trout:

A Ten Year Plan for Conservation
Throughout Its Range

November 2010



Photo credit Steve Ambruzs

Lahontan Cutthroat Trout Keystone Initiative

Conservation need: The Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*, or LCT) has a long evolutionary history in the Lahontan Basin (Figure 1), and is highly distinct from other sub-species of cutthroat trout. It is the only salmonid native to the Lahontan basin. Lahontan cutthroat express a variety of life histories including resident stream, migratory, and lake-dwelling forms. Today the sub-species is imperiled by multiple factors and has been listed under the Endangered Species Act since 1973. Only 8.6% of the historical stream habitat is currently occupied, and self-sustaining native populations remain in less than 1% of historic lake habitat. Non-native fishes have been implicated in most of the Lahontan cutthroat extirpations in the last two decades and are a primary source of decline for most remaining populations. Additionally, the majority of remaining conservation populations inhabit small, isolated stream reaches occupying 8 km or less of small stream habitat. Overall, this is a scenario unlikely to sustain the long-term persistence and viability of many remaining populations. In light of the increasing threat from non-native species and climate change, the window for implementing a turn-around for this species is narrowing.

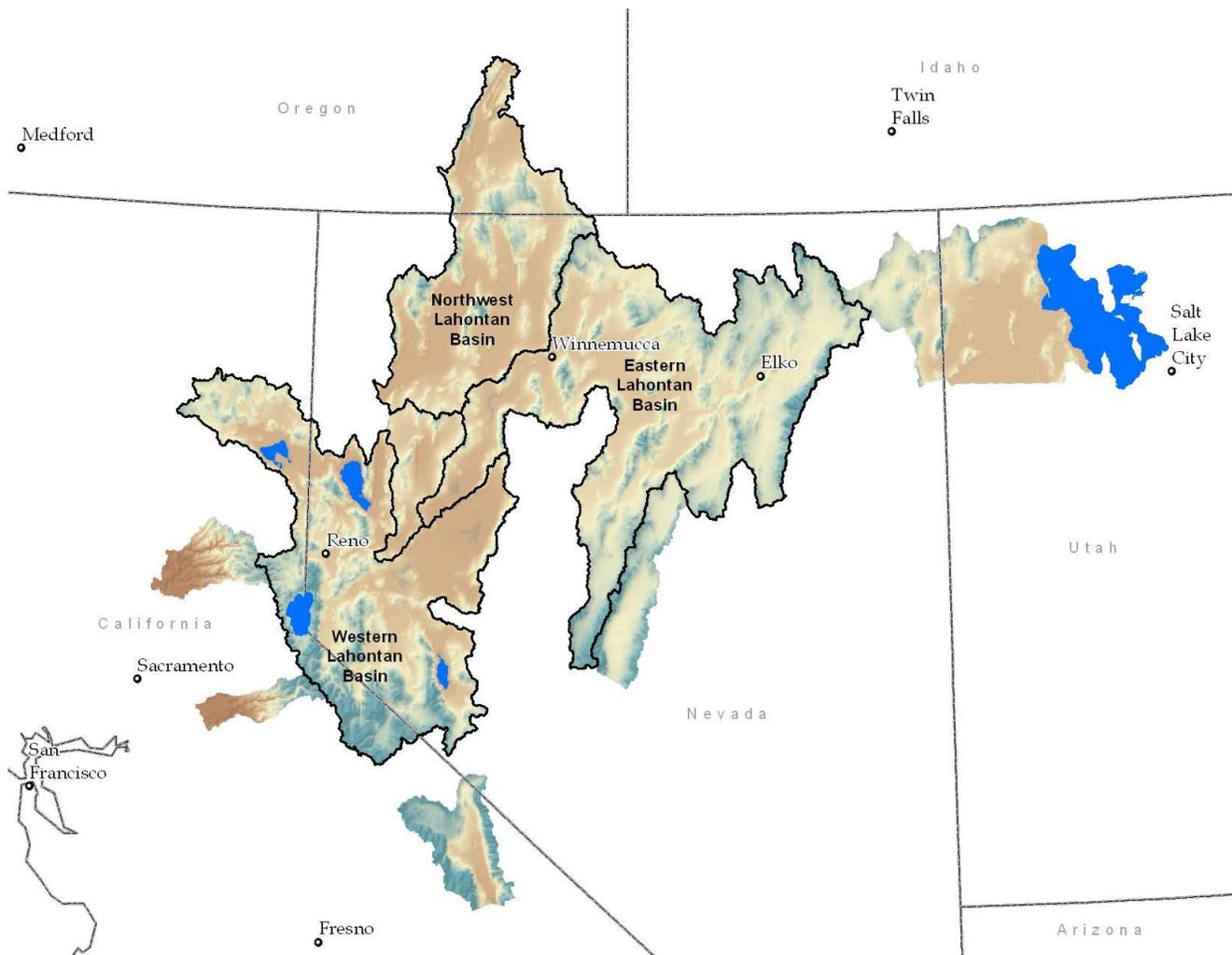


Figure 1. The Lahontan Basin, showing historical range of LCT divided into major internal basins used as LCT management units discussed in this document.

Performance targets:

- Create 10 new streams with genetically pure strains of Lahontan cutthroat trout;
- Create five population strongholds or metapopulations (larger, interconnected, more resilient populations);
- Protect existing pure populations from non-natives;
- Create sustainable lake Lahontan cutthroat populations
 - Maintain sustainable Lahontan cutthroat populations in Summit and Independence Lakes
 - Restore natural reproduction and recruitment of Lahontan cutthroat in Walker Lake, Pyramid Lake and Lake Tahoe; and
- Increase Lahontan Cutthroat angling opportunities.

Key partners: Nevada Department of Wildlife (NDOW), US Fish and Wildlife Service (USFWS), Trout Unlimited, Bureau of Land Management (BLM), US Forest Service, Natural Resources Conservation Service, University of Nevada – Reno, The Nature Conservancy, Oregon Department of Fish and Wildlife (ODFW), California Department of Fish and Game, Bureau of Reclamation, the Paiute and Shoshoni Tribes.

Major threats include:

- Competition, predation and hybridization from non-native trout;
- Migration barriers;
- Decreased stream flows;
- Habitat degradation and loss
- Small isolated populations; and
- Climate change

Seven key strategies are proposed under this Initiative to address on-going and future threats to Lahontan cutthroat trout and ensure a diverse conservation portfolio that will improve the long-term persistence and adaptive potential of this sub-species in a changing climate. If restoration projects that currently have high potential are completed under this Initiative, the reintroduction of 18 stream populations and efforts to expand, reconnect and protect existing populations will lead to a doubling of the total number of occupied stream kilometers, the creation of 7 population strongholds and metapopulations, substantial improvement in range-wide population representation, redundancy, and resiliency, improved sustainability of targeted lake populations, and improved angling opportunities. Furthermore, several progressive strategies proposed should lay the foundation for many other projects not detailed here, allowing the Initiative to achieve even greater ultimate gains.

SPECIES DESCRIPTION AND CONSERVATION NEED

The Lahontan cutthroat trout has a long evolutionary history of isolation and adaptation in the Lahontan basin (Figure 1), having first established in this basin possibly as early as the mid-Pleistocene epoch several hundred-thousand years ago. As a result of this legacy, it is highly distinct from other cutthroat trout (there are up to 14 sub-species total, depending on how they're defined) and is one of the four major cutthroat trout sub-species (Behnke 1992). LCT historically accessed a wide array of stream and river systems throughout their range, and occupied a suite of freshwater and alkaline lakes in the western part of their distribution. Residing in such diverse and variable habitats, they historically expressed a variety of movement life histories, including resident, fluvial, and lacustrine forms (Behnke 1992). Based on geographical, genetic, ecological and behavioral (life history) differences, since 1995 the subspecies has been characterized and managed by three major basins (Figure 1), including (1) the Western Lahontan Basin comprised of the Truckee, Carson, and Walker River watersheds; (2) the Northwestern Lahontan

Basin comprised of the Quinn River, Black Rock Desert, and Coyote Lake watersheds; and (3) the Eastern Lahontan Basin comprised of the Humboldt River and tributaries (Coffin & Cowan 1995). The western lake form of LCT is uniquely adapted to persist in the desert terminal lakes of the Lahontan basin, with an unusually high tolerance for alkaline and saline waters. Its eastern counterpart, the “Humboldt cutthroat trout”, is actually considered to be a separate un-described sub-species (Behnke 1992) but both forms are treated together as Lahontan cutthroat trout (LCT) by management agencies and in this document.

Since the beginning of European Settlement in the Lahontan Basin, LCT have suffered from impacts associated with human development such as water withdrawals, barriers to migration from dams and irrigation diversions, degradation of habitat from grazing, mining, forestry, and the introduction of non-native species. Following decades of decline, the sub-species was listed under the Endangered Species Act in 1973 (first as endangered, then as threatened in 1975). Today, only 8.6% of the historical stream habitat is currently occupied, and self-sustaining native populations remain in less than 1% of historic lake habitat (according to the U.S. Fish and Wildlife Service’s 5-year review completed in March 2009, pursuant to the Endangered Species Act). Non-native fishes have affected both riverine and lake populations range-wide and were identified as the main threat to LCT in the 5-year review (USFWS 2009). In various parts of the LCT range, non-native fishes are outcompeting and displacing the native cutthroat trout, hybridizing with them, and disrupting delicate lake food webs. As a result, non-native fish have been implicated in most of the LCT extirpations in the last 2 decades and are a primary source of decline for most remaining populations. The 5-year review also identifies habitat fragmentation as a major threat to LCT persistence. The majority of identified ‘conservation populations’ are in small, isolated stream reaches. Over 72% of conservation populations occupy 8 km or less of stream habitat and these streams are generally small, with 74% of conservation populations being found in reaches <3 m in width (USFWS 2009).

Climate change will undoubtedly 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), and LCT may be particularly vulnerable given the high variability in flow and temperature within their range (Platts & Nelson 1988; Galbraith & Price 2009). As with other trout, temperature increases will likely restrict LCT from lower elevation habitats and push them higher into headwater streams, further compounding the impact of fragmentation (e.g., Rahel et al. 1996). Populations will also be at increased risk from fire (Westerling et al. 2006), flooding, drought (Mote et al. 2003), and possibly the facilitated invasions of non-native species and disease pathogens that can better-handle increased temperatures. Dramatic burns and increased drought have already occurred in northern NV over the last decade, directly impacting several LCT populations. Overall, this is a scenario unlikely to sustain the long-term persistence and viability of many remaining populations (Wenger et al., in preparation).

Despite this, there is potential to achieve significant improvement in the conservation status of Lahontan cutthroat trout, and to ensure long-term sustainability and resilience range-wide. This Initiative outlines a suite of strategies that will greatly improve the outlook for this unique sub-species of cutthroat trout.

A CONSERVATION PORTFOLIO FOR LAHONTAN CUTTHROAT TROUT and DEMONSTRATION OF INITIATIVE EFFECTIVENESS

Ensuring the long term persistence of native cutthroat trout in an era of rapid environmental change due to global warming, spread of invasive species, and other factors, will not be possible without a coordinated, strategic effort to maximize the protection and restoration of within-species variability, while spreading risk. Range-wide diversity for native trout includes genetic integrity, life history diversity, and geographic (or ecological) diversity. Similar to a diverse and persistent financial portfolio, a management portfolio that includes multiple examples of population elements and large patches of interconnected habitat as metapopulations or strongholds will improve persistence and secure the evolutionary potential necessary for future adaptation to a changing environment. This approach to conservation can be described in terms of the 3-R’s (Shafer & Stein 2000):

- Representation – saving existing elements of diversity;
- Resiliency – having sufficiently large populations and intact habitats to survive large disturbances and rapid environmental change;
- Redundancy – saving enough different populations so that some can be lost without jeopardizing the subspecies.

For this Initiative, Trout Unlimited completed analyses based on the 3-R strategy (Table 1) to evaluate the current status of the LCT ‘conservation portfolio’ as well as the effectiveness of possible restoration projects under this Initiative in improving the 3-Rs for LCT.

Table 1. Applying the 3-R strategy to develop goals, objectives, and indicators of success in the conservation of Lahontan cutthroat trout.

Management Goal	Objectives	Indicators of Success
Representation	<ol style="list-style-type: none"> 1. Conservation of genetic diversity 2. Protection and restoration of life history diversity 3. Protection of geographic (ecological) diversity 	<ol style="list-style-type: none"> 1a. Presence of genetically pure populations 2a. Presence of all life histories that were present historically 3a. Presence of peripheral populations
Resilience	<ol style="list-style-type: none"> 1. Protect/restore strongholds 2. Protect/restore metapopulations 	<ol style="list-style-type: none"> 1a. Occupied stream habitat exceeds 27.8 km and habitat patch size exceeds 10,000 ha 2a. Occupied stream habitat supports migratory life history and exceeds 50 km and habitat patch size exceeds 25,000 ha
Redundancy	<ol style="list-style-type: none"> 1. Protect multiple populations within each sub-basin 	<ol style="list-style-type: none"> 1a. 5 persistent populations within each sub-basin, or 1b. 1 or more larger strongholds within each sub-basin, or 1c. 1 metapopulation within each larger basin

Details of the analyses can be found in the accompanying portfolio document (Haak 2010). As a summary, the current status of LCT conservation populations in terms of representation, resilience and redundancy is shown in Table 2a and Figure 2 (the latter shows resilience and redundancy only). Table 2b and Figure 3 outline the improvement in these factors for LCT if the projects detailed below are completed under the Initiative. The projects below are those with known high *current* potential, but with the significant progress expected to be made with Safe Harbor Agreements and other progressive efforts, many other projects should be achieved before the completion of the Initiative. Collectively, the subset of projects outlined below will improve redundancy scores for 5 LCT basins (compare changes in colors for basins in Figures 2 and 3). Reintroducing LCT in over 18 stream habitats, and extending and reconnecting currently occupied habitats, will create an additional 451kms of occupied habitat (Note: many of these newly-established populations are not reflected in the total number of populations in Table 2b because their numbers are absorbed under strongholds and metapopulations. This is because currently-isolated populations are counted in the USFWS database as separate populations, but once they are reconnected in the Trout

Unlimited analysis they get counted as one metapopulation. For example, in the Marys River, 3 streams will be reconnected to the mainstem and thus subtracted from the population total; similarly, the two streams where LCT will be reintroduced will fall under the Marys River metapopulation and thus not be counted as new populations. Comparison of Figures 2 and 3 shows visually the addition of new stream populations under the Initiative). These reintroductions in concert with projects to reconnect and extend currently occupied habitat will create 5 strongholds (minimum stream length of 27.8 km and habitat patch size of 10,000 ha, see Table 1), and 2 metapopulations (minimum stream length of 50km and patch size of 25,000ha, see Table 1). Additionally, these projects will improve range-wide genetic integrity and life history diversity (Table 2a and b; Figures 2 and 3).

Table 2a. Range-wide LCT conservation portfolio summary before project completion (only includes populations within historically occupied basins)

Basin	Number of Pops. (pops.)	Occupied Habitat (km)	Representation			Resiliency		Redundancy	Number of Projects Planned
			Genetic Integrity (pops.)	Life Hist. Diversity (pops.)	Geographic Diversity (pops.)	Strong-hold (pops.)	Meta-pop. (pops.)	Persistent and Genetically Pure (Subbasin Total)	
Eastern	27	377	26	7	0	2	2	6	6
Western	15	114	15	2	0	1	0	3	1
North-west	16	232	16	2	7	2	0	4	4
Total	58	723	57	11	7	5	2	13	11

Table 2b. Range-wide LCT conservation portfolio summary *after* project completion (only includes populations within historically occupied basins).

Basin	Number of Pops. (pops.)	Occupied Habitat (km)	Representation			Resiliency		Redundancy
			Genetic Integrity (pops.)	Life Hist. Diversity (pops.)	Geographic Diversity (pops.)	Strong-hold (pops.)	Meta-pop. (pops.)	Persistent and Genetically Pure (Subbasin Total)
Eastern	27	591	26	10	0	4	3	8
Western	16	162	16	2	0	2	0	4
North-western	16	421	16	3	7	4	1	8
Total	59	1174	58	15	7	10	4	20

Lahontan Cutthroat Trout Portfolio Status Current Conditions

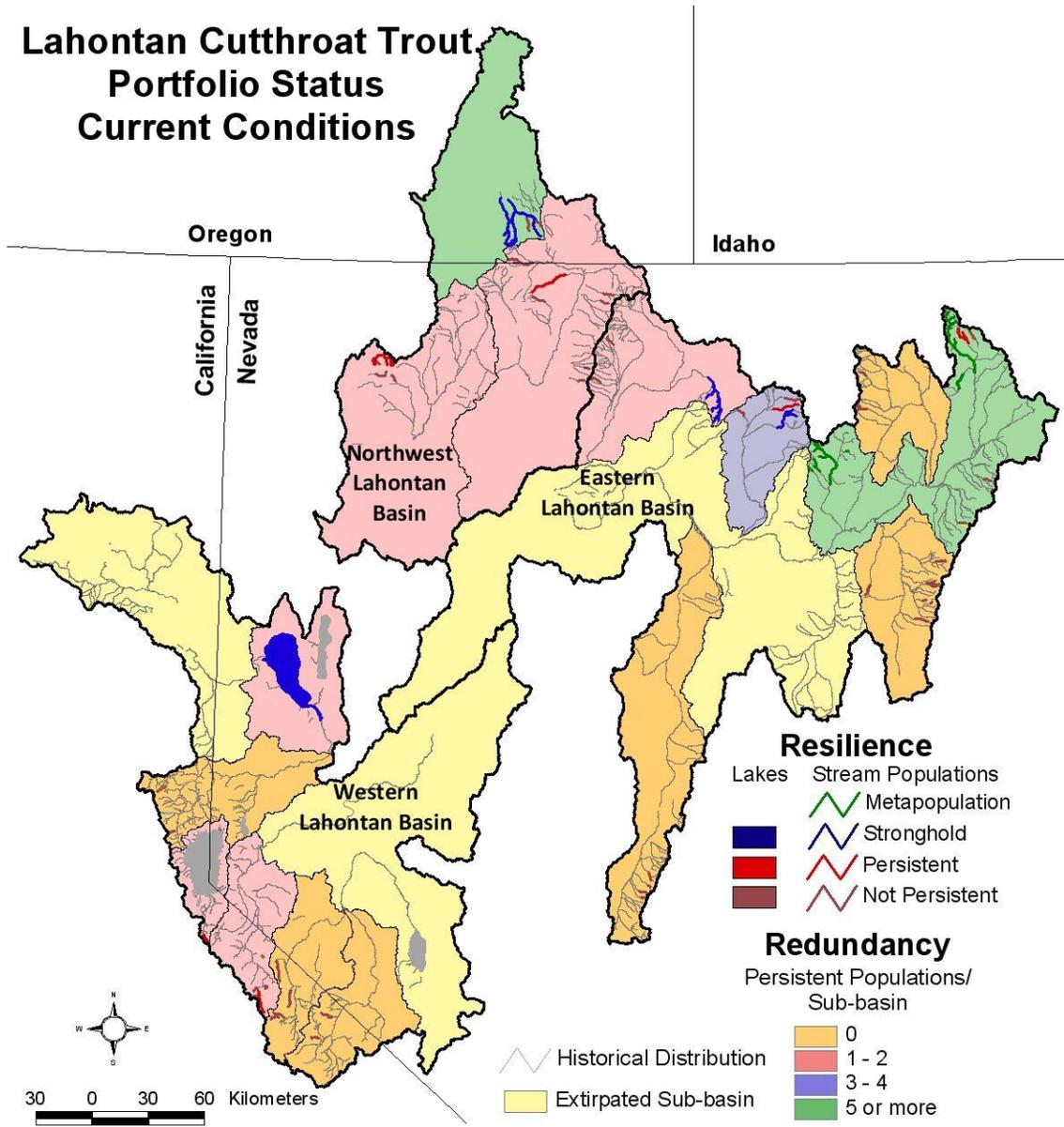


Figure 2. Current status of the Lahontan cutthroat trout conservation portfolio for resilience and redundancy.

Lahontan Cutthroat Trout Portfolio Status After Recovery Projects

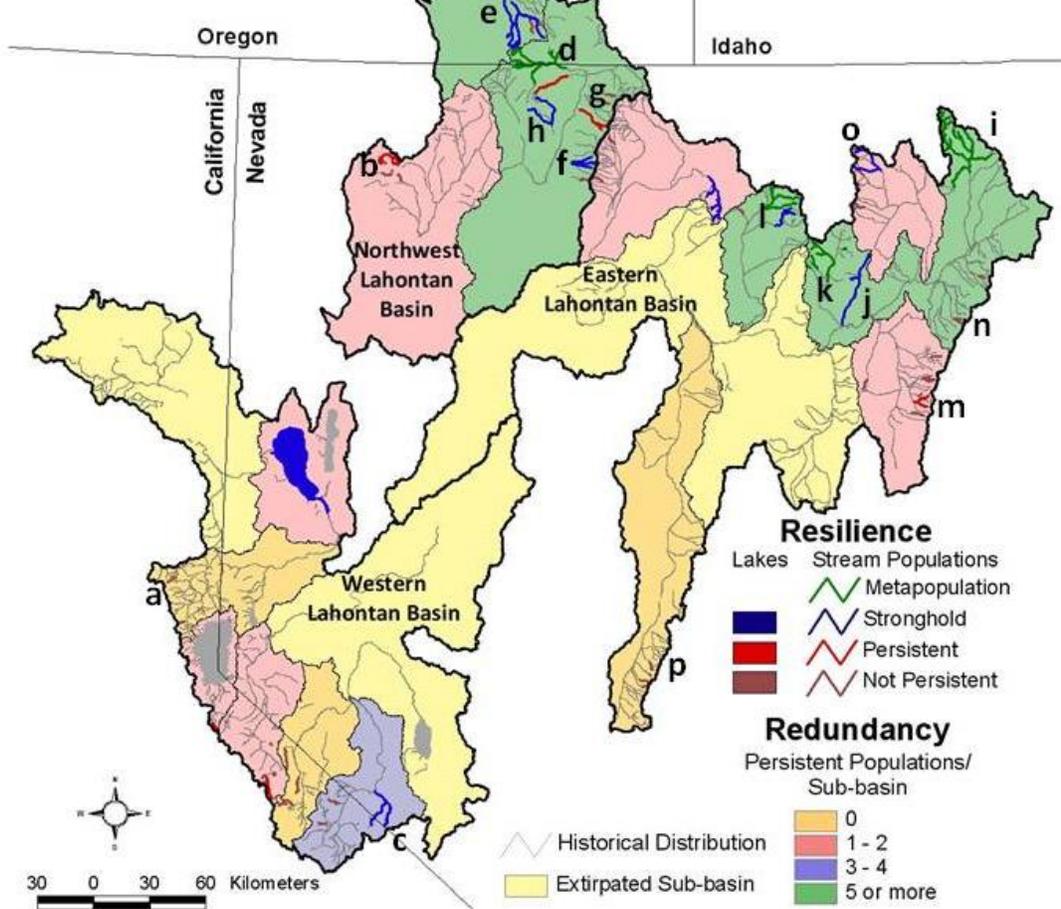


Figure 3. Status of the Lahontan cutthroat trout portfolio for resilience and redundancy after completion of the projects outlined below, which are identified in the text and here by letters a-p.

KEY STRATEGIES TO BE IMPLEMENTED UNDER THE INITIATIVE:

Key Strategy 1: Reduce threat of non-native fish. LCT did not evolve with other salmonids, and are easily jeopardized by competition (e.g., Dunham et al. 2002a) and hybridization with non-native fish (Peacock & Kirchoff 2004). As a result, non-native fish were identified in the recent LCT status assessment as the primary factor in recent losses of LCT populations and the greatest risk for remaining populations (USFWS 2009). LCT co-occur with nonnatives in over 36% of their stream habitats and in all lake habitat except Walker Lake. Almost all unoccupied historical habitat has non-native fish. Fortunately, range-wide they have maintained high levels of genetic purity, with 87% of populations tested and over 97% presumed pure. Yet ten percent of LCT populations co-occur with rainbow trout, presenting an on-going hybridization threat. In addition to rainbow trout, non-native fish in the

current LCT range include brook trout, brown trout, lake trout, kokanee salmon, and Yellowstone cutthroat trout. Bass and carp are also becoming increasing potential threats as temperatures warm, and although Lahontan redbreast shiners are native to parts of the Lahontan basin, they have been introduced in areas outside of their historical range and may negatively affect Summit Lake LCT.

- a. *Erradicate non-native fishes from occupied and historic LCT habitats.* There is currently no range-wide strategy for addressing the threat of non-native fish, and the on-the-ground needs greatly outweigh current resources (USFWS 2009). In the eastern and northwestern parts of the LCT range, agencies have had good success removing non-native trout from several streams and this has been a key strategy in some of the larger restoration initiatives to date, such as the on-going reestablishment of an LCT metapopulation in McDermitt creek on the NV/OR border. Eradications are more difficult in lake systems, although gill-netting and other methods can be effective; excellent progress has been made in Independence Lake in removing brook trout from the primary LCT spawning stream. In general, stream-scale eradication is effective, and the agencies currently have good working relationships for undertaking these projects. As part of this Initiative, a range-wide plan for prioritizing populations for removal of non-native fishes should be established and executed.
- b. *Improve management regulations.* Stocking management within the LCT range is not adequately geared towards native fisheries, and there is a need for greater enforcement of penalties for illegal introductions. NDOW continues to stock non-native fishes in certain occupied or historical LCT waters, such as the Truckee River, Martin basin and East Fork Quinn River (NDOW 2009). Outside of the Truckee River, this stocking generally occurs below LCT populations that are protected above natural barriers or in historical waters not currently occupied by LCT, yet the practice clearly impedes restoration of connectivity of occupied streams or the reestablishment of LCT in historical habitat. Furthermore, though the agency has switched to using triploid rainbow trout in LCT waters to reduce hybridization, sterilization methods are not 100% effective. Naturalized rainbow trout from past stocking continue to hybridize with LCT, and other naturalized and continually stocked trout species continue to compete with and predate on LCT. Additionally, several populations have been lost recently due to illegal dumping of non-native trout. As part of this initiative a dialogue will be initiated between initiative partners, USFWS, and NDOW to discuss refinement of native trout management.

Key strategy 2: Native population reestablishment, stronghold/metapopulation reconnection and barrier management. Reestablishing populations from appropriate genetic source stock is essential for bolstering range-wide representation of major components of LCT diversity, as well as promoting redundancy to ensure the persistence of key elements of diversity despite inevitable losses in the future. Approximately 18 new populations will be established based on the projects described below, many of which will enable the reestablishment of strongholds and metapopulations. Recent work has demonstrated that the persistence of cutthroat trout including LCT (see also “Recent research” below) is increased when fish can move among different tributaries, express diverse movement life histories (i.e., resident vs. migratory) and access a variety of habitats throughout their life cycle (Rieman & Dunham 2000; Neville et al. 2006b). “Metapopulation dynamics” become important at a large scale, enabling populations that are extirpated to be re-colonized by fish from adjacent populations and thus improving the persistence of the system overall (Hanski 1998). Movements among different habitat types within and among tributaries and mainstem reaches are critical for enabling completion of the trout life cycle (Schlosser & Angermeier 1995), for bolstering reproductive capacity (Jonsson et al. 2001; Morita et al. 2009), and for responding to impacts such as drought, temperature stress, flooding, and fire (Dunham et al. 2003b; Neville et al. 2009). Over 30 isolated LCT populations have gone extinct over the last several decades, and 72% of remaining conservation populations are occupy less than 8 km of stream (USFWS 2009), making their future uncertain. Reconnecting isolated habitats to facilitate metapopulation dynamics, provide access to a variety of complementary habitats (Dunning et al. 1992), and

enable the emergence of various movement strategies will greatly increase the natural resiliency and adaptive potential of local populations, particularly in light of increasing stressors from climate change (Sgro et al. 2010).

At the same time, because of the serious and imminent threat of non-native fish invasion, intentional isolation can be a necessary triage approach for protecting native populations (Fausch et al. 2009). Where needed, barriers will be installed to protect populations from non-native fishes. In most cases these barriers will be removed after non-native fishes have been eradicated downstream, but in several instances permanent barriers should be installed at the base of larger metapopulation or stronghold populations with a greater likelihood of self-sustained persistence (e.g., Maggie Creek).

Key Strategy 3: Genetic and population monitoring. Monitoring the key attributes of populations, including habitat occupancy, abundance, age distribution and genetic variability/purity is essential for evaluating the overall health and likelihood of persistence of populations and the sub-species as a whole (Schwartz et al. 2006). Monitoring is also necessary for documenting the success of conservation efforts (e.g., Whiteway et al. 2010) and to identify and guide any adaptive changes in management or restoration that may be needed. Population monitoring of LCT is carried out by the Nevada Department of Wildlife (NDOW) and Oregon Department of Fish and Wildlife (ODFW), and several additional research and monitoring projects provide baseline information for local LCT populations (see below). Many populations have also been recently evaluated for genetic diversity and purity under the recent genetics management plan (Peacock & Kirchoff 2007), providing a genetic baseline for future genetic monitoring.

There is, however, a need for more consistent, frequent, and statistically-rigorous monitoring range-wide to track the trajectory of the species as a whole and determine factors related to the persistence or extirpation of local populations, particularly in light of climate change. Monitoring to validate successful eradications or reintroductions and to track habitat improvements and LCT responses to conservation actions also needs to be carried out as this Initiative progresses. Establishing a successful monitoring program will depend on the cooperation of the various agencies involved (NDOW, ODFW, BLM, USFS, USGS, USFWS, tribal entities), and implementation will require the allocation of considerable resources to support the necessary personnel and field work. To ensure the success of this strategy, a Monitoring Working Group will be established to develop and implement a range-wide stream monitoring protocol. Local watersheds where monitoring programs should be established or continued to track success of restoration programs include Maggie Creek, Willow/Rock creeks (Nevada), Willow/Whitehorse Creeks (Oregon) and McDermitt creek.

Key Strategy 4: Initiate a Water transactions program.

Stream de-watering and diversion for irrigation or hydroelectric facilities has decreased the amount and quality of accessible habitat for many LCT populations and has also contributed to habitat fragmentation. The recent status assessment identifies water management as a substantial threat to LCT (USFWS 2009). This is particularly the case in the western basin in watersheds such as the Truckee River and Walker Lake/River, although the threat is likely high in the eastern and northwestern basins as well where impacts are poorly documented.

The Walker Basin Restoration Program was established in accordance with Public Law 111-85 in October 2009 for the primary purpose of restoring and maintaining Walker Lake, a natural desert lake in Nevada at the terminus of the Walker River stream system of Nevada-California. The Lake's elevation has been steadily declining since the early 1900s, resulting in a steady increase in salinity, or Total Dissolved Solids (TDS), to levels which today threaten its complete ecological collapse.

The major elements of the Walker Basin Restoration Program are the following:

- A water rights acquisition program with willing sellers (approximately \$73 million) designed to reduce upstream water use and lead to permanent increases in freshwater inflows at the Lake;

- A three-year water leasing demonstration program (approximately \$25 million) to be developed, managed and administered by the Walker River Irrigation District (WRID) to compliment the water rights acquisition program;
- Related research, program evaluation, modeling, and decision support activities (approximately \$5 million) at the University of Nevada-Reno and the Desert Research Institute; and
- An associated conservation and stewardship program (approximately \$10 million) that will include both directed measures and requests for proposals for water conservation, land stewardship, and other projects.

Using the Walker Basin Restoration Program as a model, the initiative would explore developing a program supporting innovative, voluntary transactions to improve streamflows in Lahontan Cutthroat trout streams of Oregon, Nevada, and California. As a result of legal water withdrawals for irrigation during the peak growing season, stretches of many streams and rivers run low—and sometimes dry—with significant consequences for imperiled trout, and other fish and wildlife. Using permanent acquisitions, leases, purchased water saved through efficiency gains, and other innovative approaches, such as auctions, such a Program would support program partners who assist farmers, ranchers, and irrigation districts in restoring flows to benefit existing habitat.

In the eastern and northwestern basins, there is a need to identify where water withdrawals and diversions are impacting LCT populations, and to explore initiating a water transactions program.

Key Strategy 5: Riparian and habitat improvement.

Aside from the water impacts above, various other factors degrade LCT stream habitats including grazing, non-angling recreation, timber harvest, roads, and mining (USFWS 2009). Live stock grazing is the most ubiquitous form of degradation and occurs in 95% of stream lengths housing conservation populations; in the eastern and northwestern basins, all populations experience grazing. Mining is a smaller threat range-wide but has had serious impacts on several local populations recently and may become a greater threat as market prices increase. A large number of LCT streams have burned in recent decades. The overall result of various forms of stream degradation is that 40% of LCT stream habitat is currently in fair-poor condition, with little information on the characteristics of unoccupied historical habitat (USFWS 2009). This amount is certain to increase with increased temperatures, droughts and fires in the future. However, significant gains have been made in several watersheds (e.g., Maggie and Susie creeks) to improve riparian vegetation, in-stream flows and quality, sediment transport, and localized habitat important for trout (e.g., pools). This Initiative will include support for riparian fencing, prescriptive grazing and management, water development (piping and guzzlers, etc) and nutrient/forage supplementation to manipulate livestock away from riparian areas, monitoring habitat improvements, and resting pastures to allow for habitat recovery.

Key Strategy 6: Initiative Coordinator and Safe Harbors biologist. To ensure timely and effective implementation of this Initiative, an LCT Initiative Coordinator position will be established. The Coordinator will: 1) provide essential on-the-ground contact and collaboration among the Initiative partners and various agencies and entities involved in LCT restoration and recovery, 2) coordinate and guide Initiative proposals to make sure proposed activities are in keeping with Initiative goals and time-lines, and 3) implement Trout-Unlimited related field activities such as the continuing Maggie creek monitoring. The position will be established at and supervised by Trout Unlimited but housed at an appropriate agency, to be determined.

Starting in 2004, NDOW took the proactive approach to obtain umbrella Safe Harbor Agreements (SHAs) with the U.S. Fish and Wildlife for the northwestern and eastern basins to help protect landowners who have or may acquire LCT on their private lands. Landowners were worried about federal restrictions being placed on private lands if LCT

were present, and it was obvious that this concern was limiting LCT recovery efforts on private as well as public lands. SHAs encourage conservation measures on non-federal lands to benefit LCT by providing regulatory assurances that property-use restrictions will not be imposed if LCT increase in numbers or expand their distribution on enrolled properties. To date, much of the LCT recovery work that has been completed has occurred on public lands with little private land interaction, but future progress for LCT restoration is highly dependent on the cooperation of private landowners. Currently, there are over 45 streams that have identified Safe Harbor potential in the upper Humboldt River Basin (Eastern basin), with an additional 31 streams in the Quinn and Black Rock basins (Northwestern basin). Several key areas where private land agreements will facilitate near-term large-scale restoration work are the eastern Marys River basin, the Rock/Willow creek watershed and Susie creek. Under this Initiative, a Safe Harbors biologist position will be established at the Nevada Department of Wildlife to initiate and monitor the impact of private lands agreements.

Key Strategy 7. Conservation hatchery management. There is a great need to expand hatchery rearing of LCT for conservation purposes. LCT are being reared for restoration in the western basin (i.e., the Pilot Peak strain being used for Walker and Pyramid Lake production), but there are currently no hatcheries supporting broodstock to restore or reintroduce populations in local streams in the eastern and northwestern basins. The production of LCT in hatcheries requires different hatchery practices (e.g., rearing for different emergence times, separation of many localized broodstocks, following a strict conservation breeding protocol) and ultimately will require new facilities. While funding these facilities is beyond the scope of this initiative, a hatchery genetics and management plan will be an essential step towards the creation of LCT conservation broodstocks and guiding stocking management for the benefit of LCT.

SELECTED AREAS WITH HIGH POTENTIAL FOR RESTORATION OR MONITORING UNDER THE INITIATIVE

Western Lahontan Basin:

Only two of the five currently occupied lakes (Independence and Summit Lakes) have self-sustaining populations of Lahontan cutthroat – all others are maintained completely by hatchery stocking programs. Independence Lake (Figure 3 a) houses the only native LCT population physically residing in the Truckee River watershed (there is an out-of-basin population in Pilot Peak, UT, which originated from this watershed). Extensive work in this system, including a Population Viability Analysis, has demonstrated that nonnative salmonids need to be extirpated or controlled and reestablishment of the downstream spawning migration may be required to prevent the extirpation of this strain of Lahontan cutthroat and restore the population to some semblance of its historical abundance. Experimental removal of brook trout from Independence Creek (the only Lahontan cutthroat spawning tributary) has already resulted in an increase in Lahontan cutthroat recruitment and survival, and changes in certain life history traits (*i.e.*, juvenile Lahontan cutthroat are spending more time in Independence Creek prior to migrating to the lake)(Rissler et al. 2006).

Little is known about the size and demographics of the Summit Lake (Figure 3b) Lahontan trout population. Although no nonnative salmonids occur here, nonnative minnows have recently been introduced to the lake with unknown effects. Research to quantify and characterize the Lahontan cutthroat population in this lake and associated tributary (Mahogany Creek) and a better understanding of the potential impacts of the introduced minnows is vital.

Walker Basin Restoration Program: In January , 2010, the Bureau of Reclamation approved a grant authorizing the National Fish and Wildlife Foundation to assume the leadership role in implementing the Walker Basin Restoration Program. This authorization was directed by Congress in accordance with Public Law (PL) 111-85 (2010 Energy and Water Appropriations Act) and provides up to \$66.2 million to support water rights acquisition, a three-year demonstration water leasing program, additional research, and various conservation and stewardship activities to assist with the restoration of Walker Lake. In addition to the \$66.2 million, approximately \$52 million previously

authorized by Congress for water rights acquisition was re-programmed to the Foundation from the Nevada System of Higher Education.

A more detailed strategy is being developed to implement the objectives of the Walker Basin Restoration Program, this includes establishing a water acquisition program, establishment of a competitive grant program to invest the \$10 million available for conservation and stewardship activities and creation of a locally-based Walker Basin Advisory Council to advise on activities associated with the Walker Basin Restoration Program.

Under this Initiative, Rough and Bodie creeks (Figure 3c) present 52 km of habitat where a relatively large population of LCT could be established following the eradication of brook trout. This would be an important step in replicating Walker River headwater populations into a stronghold habitat with high likelihood of persistence.

Northwestern Lahontan basin:

McDermitt Creek (Quinn River watershed, Figure 3 d) is a large watershed that straddles the Nevada-Oregon border that has been undergoing extensive restoration of connectivity and subsequent Lahontan cutthroat reintroductions. 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 non-natives throughout the entire watershed. Several creeks have been restocked but temporary barriers have not yet been removed. Once the project is complete, approximately 88.5 km (55 mi) of connected habitat will be available for Lahontan cutthroat, which will be transplanted throughout the watershed from a currently-occupied source stream. This will be an excellent system in which to establish a formal monitoring protocol for tracking population responses to large-scale connectivity restoration and establishing appropriate targets for future restoration efforts.

The Willow/Whitehorse watershed (Figure 3e) is a large and relatively interconnected system in the Coyote lakes basin in Oregon. Recently, it was found to be highly genetically distinctive from other LCT, enough to merit its own management unit (ie. a 4th management basin; Peacock et al 2010). The Oregon Department of Fish and Wildlife has a comprehensive monitoring protocol based on 51 sites and last implemented in 2005 (Gunckel & Jacobs 2005). Continuation of this monitoring program should be supported under this Initiative.

There is an immediate opportunity to reconnect a metapopulation of three tributaries (Falls Canyon, Horse Canyon, and McConnel creeks, Figure 3f) encompassing 24 kilometers of habitat in the Quinn River Basin. Currently, LCT occupy < 2km of habitat above a large waterfall in Falls Canyon creek, providing a genetically-appropriate source for future reintroductions throughout the basin. Pending funding, one temporary barrier will be installed on McConnel Creek, and staged eradications of non-native trout will be executed in all three tributaries. These streams are all on Forest Service land and provide excellent LCT habitat; there is no risk of future invasion by non-natives and no need for a permanent barrier to protect these populations.

Several additional creeks with potential for the re-establishment of LCT include Flatt and S. Fork Flatt creeks (Figure 3g) and Pole creek (Figure 3h).

Eastern Lahontan Basin:

The Marys River (Figure 3i) is a large Lahontan cutthroat system which has been the focus of previous restoration work and a great deal of basic scientific research on the demographics and genetics of Lahontan cutthroat (see below). The river has good connectivity and habitat integrity in its western subwatershed but extensive habitat fragmentation and degradation, and non-native trout, in its eastern subwatershed. The Bureau of Land Management recently identified 34 irrigation diversions/stabilization structures as fish barriers along the Marys River. Fifteen of these structures were determined to be complete fish barriers. This drainage of approximately 500km² will be a productive system for future efforts to eradicate brook and rainbow trout (the latter residing in an

isolated stream), restore connectivity in the eastern subwatershed, and monitor habitat and Lahontan cutthroat responses.

Susie Creek (and Camp creek Figure 3j) historically had Lahontan cutthroat trout but this population was extirpated in the 1930's in response to habitat degradation associated with ranching and agricultural uses. Since 1991 BLM and partners have undertaken extensive restoration efforts and almost the entire watershed is now fenced for the purpose of applying prescriptive livestock grazing on approximately 25 miles of stream habitat. Susie Creek is identified as a potential reintroduction site in the 1995 LCT Recovery Plan (Coffin & Cowan 1995) and is included in the priority metapopulation recovery area for the Maggie Creek subbasin (2005 Nevada Department of Wildlife LCT Species Management Plan for the Upper Humboldt River Drainage Basin). This watershed will be an ideal site for LCT reintroduction because it has improved dramatically, does not contain non-native trout, and it will be blocked from future invasion by a barrier that will be installed before LCT are reintroduced.

Several decades of restoration and continuing monitoring work has been undertaken in Maggie Creek (Figure 3k). Extensive on-the-ground and remote-sensing monitoring has documented tremendously-improved riparian habitat and function in the mainstem river, primarily due to changes in rangeland management since 1993 (Evans 2009; Simonds et al. 2009). Additionally, in 2005 BLM and partners replaced culverts that previously isolated the three major tributaries to Maggie Creek with passage structures which allow for approximately 80.5 km (50 mi) of seasonal connectivity between these tributaries and the mainstem of Maggie Creek. Trout Unlimited has been monitoring population trends and genetic patterns in this watershed since 2001. A permanent barrier will be installed in 2011 at the bottom of the watershed. Similar restoration work and monitoring is on-going in the Rock/Willow creek watershed (Figure 2l, Simonds et al. 2009)

The high-elevation habitat in the Ruby Mountain range provides some of the best potential habitat for Lahontan cutthroat but is inundated by non-native fish, particularly brook trout. One nonnative eradication treatment/connectivity project is underway here, and much potential exists for future work in this range if cooperation with private landowners (through SHAs) can be established. A temporary barrier has been built below the confluence of the two forks of Green Mountain Creek (South Fork Humboldt River watershed, Figure 3m), and both forks have been treated to eradicate brook trout below a remnant population of LCT, creating approximately 17.7 km (11 mi) of habitat. The future plan is to isolate, treat, and repopulate an adjacent tributary (Toyn Creek) which will add an additional 12.1 km (7.5 mi), collectively forming a connected LCT population with approximately 29.8 km (18.5 mi) of habitat. John Day creek, Figure 2n) also presents a location where reintroduction into high-quality habitat in the Ruby Mountains is possible. Other streams in this area may be possible restoration sites if Safe Harbor Agreements can be achieved.

Pratt Creek (Figure 3o) represents another large stream in the North Fork Humboldt River where LCT could be reintroduced.

The Reese River (Figure 3p) is another river system with on-going restoration work and potential. In 2004, a project was initiated to eradicate hybridized Lahontan cutthroat in Cottonwood and San Juan Creeks. 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. San Juan is currently being restocked over several years, and Cottonwood has a remnant LCT population in the headwaters. Marysville creek (several tributaries down the range) now has a permanent barrier and has been treated. Once eradication of nonnative brook trout is confirmed, Lahontan cutthroat will be reintroduced to occupy approximately 12.9 km (8 mi) of habitat in this isolated stream. Future potential exists to continue eradications and reconnections moving down the Reese river drainage, and there is potential for a large (but logistically difficult) reconnection/treatment effort in the headwaters of the Reese River, which resides primarily in a Wilderness Area.

RECENT RESEARCH TO GUIDE AND PROVIDE BASELINES FOR RESTORATION AND MONITORING

A large body of research has been completed on Lahontan cutthroat trout in recent years. Collectively, these studies provide important insight about potential LCT responses to the key strategies of this Initiative, such as non-native species eradication and habitat restoration or reconnection work. Recent work on LCT demonstrates 1) that a migratory life history emerges in LCT populations where diverse and interconnected habitat is available (Neville et al. 2006b; Ray et al. 2007; Umek 2007), 2) that isolated streams have undergone genetic bottlenecks signaling population instability (Neville et al. 2006b; Peacock & Kirchoff 2007), 3) that demographic connectivity via density-dependent movement is important for population persistence (Ray et al. 2007), 4) that metapopulation dynamics in interconnected LCT habitats allow for re-colonization of vacant habitats (Dunham 1996; Neville et al. 2006b) and 5) that LCT numbers and age-structure respond positively to restored connectivity (Neville, in preparation for Maggie Creek). This work also suggests LCT recruitment is likely affected by a complex balance between spring flows high enough to create spawning habitat but low enough to avoid mortality of young-of-year fish (i.e., flushing of gravels without extreme flooding, Ray et al 2007); that suitable LCT habitat is partly defined by temperature (Dunham et al. 1999b; Dunham et al. 2003a); that LCT are more likely to occur in larger and interconnected habitats (Dunham et al. 1997; Dunham et al. 2002c), and that LCT densities are higher at lower stream width:depth ratios, which are often indicative of higher-quality riparian habitats (Dunham et al. 2002b). Finally, the one long-term study of LCT responses to brook trout removals shows increased LCT densities and shifting life histories in response to brook trout removal (Rissler et al. 2006).

The below lists several watersheds and lakes where recent research and monitoring could provide a foundation of data for future monitoring and evaluation of restoration activities that may occur under the Initiative.

Range-wide:

Several comprehensive reports and published papers provide a foundation of information on genetic and demographic/distributional characteristics of Lahontan cutthroat trout populations throughout their range. The genetics management plan for LCT was completed in 2007 (Peacock and Kirchoff), and resolved relationships among populations that were not clear in the Recovery Plan (Coffin and Cowan 1995). The report also evaluated the appropriateness of the 3 management units, the historical genetic structure in the Tahoe/Truckee Pyramid Lakes system (based on museum samples), and the relationship of several out-of-basin populations to within-basin populations for prioritizing recovery of native LCT populations. These analyses provide an important range-wide baseline for genetic monitoring, which can capture many characteristics indicative of population 'health' (e.g., levels of genetic variability, migratory connectivity, or a history of genetic bottlenecks Dunham et al. 1999a; Neville et al. 2006a), and can be more effective and cost-efficient than traditional field methods (Schwartz et al. 2006). Additionally, Ray et al (2007) presented analyses of demographic data and population viability modeling on 13 streams in the Humboldt and Quinn Rivers, many of which may be targets for restoration under the Initiative. This work investigated population dynamics and environmental factors influencing persistence (and, conversely, extinction risk), based on 9 consecutive years of data on seven stream and 6-8 years of data on the remaining streams. Dunham et al (2002b) analyzed much of the same data to determine that LCT densities were positively related to stream width/depth ratios and connectivity to migratory habitats, and negatively related to the presence of brook trout.

Work in specific locations included in the Initiative:

Independence Lake: Rissler et al (2006) completed a comprehensive study of the ecology and life history of LCT in Independence lake, including a population viability analysis (PVA) which predicted the extinction of LCT in this lake if non-native salmonids (brook trout and kokanee salmon) were not controlled. Removal of brook trout from the sole tributary supporting LCT (Independence creek) has since led to increased recruitment and survival of LCT, and the on-going response of LCT is being quantified and incorporated into an updated PVA.

Willow-Whitehorse (Coyote Lake basin): Gunckel and Jacobs (2005) completed a comprehensive demographic assessment of LCT at 51 sites in the Willow-Whitehorse system in an effort to establish a scientifically valid protocol for long-term monitoring in this watershed. Recent genetic analyses have also characterized the genetic variability within and among these streams, along with fish from 7 streams in the Steens Mountains (Alvord basin) that were established using Willow-Whitehorse fish in the 1970's and '80's. The genetic uniqueness of these populations suggests they merit creation of a 4th management unit for LCT (Peacock et al. 2010).

Maggie Creek: Trout Unlimited initiated demographic and genetic monitoring of LCT at 44 sampling sites in the three tributaries to Maggie creek in 2001. The goal of this on-going work is to evaluate LCT responses to habitat restoration initiated in 1993, as well as the removal of 4 dispersal barriers that renewed seasonal connectivity between the tributaries and the mainstem river. Trout Unlimited now has data from 5 years before and 3 years after the barriers were removed and is analyzing responses based on fish numbers, age class distribution, and genetic data (Neville in preparation).

South Fork Little Humboldt River: This is one of the most pristine interconnected systems currently available to LCT. Umek (2007) analyzed demographic (fish numbers and size/age distribution) and genetic data from fish in 6 tributaries and the mainstem river, characterizing population structure and dispersal dynamics in this networked system.

Marys River: The work of Dunham (2006), Dunham et al (2002c) and Ray et al (2007) provide long-term demographic data from 3 streams in the interconnected western basin of the Marys River. A telemetry study of winter movements of LCT has also been completed in the western basin, documenting occasional long-range movement of fish into the lower mainstem Marys River from the headwaters (Ambruzs 2008). Neville (2003) and Neville et al (2006) provide additional demographic and genetic data collected in 1999/2000 from the occupied portion of the mainstem and all of the tributaries to the Marys River. Data from the isolated eastern streams may be particularly valuable for monitoring LCT responses to any future restoration and eradication of brook trout.

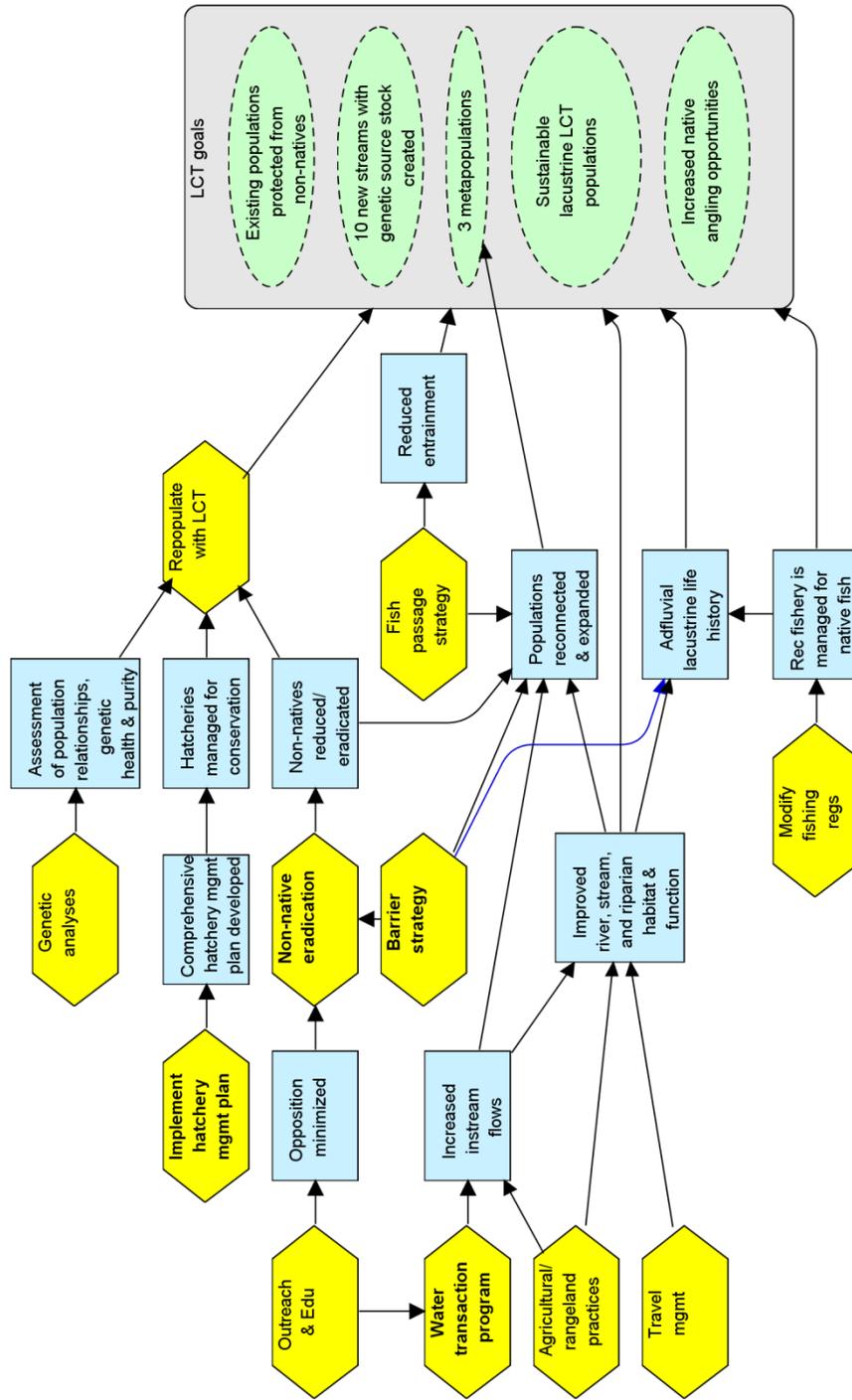
Strategies	Cost	NFWF	Other Sources	Subtotals
1. Reduce threat of non-native fishes	• 15 temporary barriers at \$100K each, total of \$1.5M over 10 years	\$ 750,000	\$ 750,000	\$ 1,500,000
	• Chemical Treatment: \$50,000 chemical costs/year over 10 years	\$ 200,000	\$ 300,000	\$ 500,000
	• 2 field crews/GMU for eradication activities, \$75k/crew; \$4.5 M over 10 years (also cover range-wide monitoring needs)	\$ 1,250,000	\$ 3,250,000	\$ 4,500,000
	• Gill netting: \$10K/week for 6 weeks/season: Total \$300k over 10yrs		\$ 300,000	\$ 300,000
	• Lake Tahoe: \$250K/summer: Total of \$1.2M over 5 years		\$ 1,200,000	\$ 1,200,000
	• Native trout management outreach and education, 2 year program	\$ 100,000		\$ 100,000
Subtotal		\$ 2,300,000	\$ 5,800,000	\$ 8,100,000

2. Native population reestablishment, stronghold/metapopulation reconnection and barrier management (see barrier report)	<ul style="list-style-type: none"> \$350K for permanent barriers in each major meta-population (5): total of \$1.75M over 10 years 	\$ 1,050,000	\$ 700,000	\$ 1,750,000
	<ul style="list-style-type: none"> Permanent barrier Rough and Bodie: \$700k 	\$ 350,000	\$ 350,000	\$ 700,000
	<ul style="list-style-type: none"> Barrier maintenance and removal of temp barriers: \$1M over 10 years 	\$ 1,000,000		\$ 1,000,000
	<ul style="list-style-type: none"> Marys removal/retrofit 15 barriers \$250k each 	\$ 1,875,000	\$ 1,875,000	\$ 3,750,000
	<ul style="list-style-type: none"> Walker: 44 total—40 rock structures \$250K each, 4 concrete \$1M: \$14M total over 10yrs 		\$ 14,000,000	\$ 14,000,000
	<ul style="list-style-type: none"> Truckee: 18 at \$250K, 6 at \$1M, tribe 6, remaining are just rocks: \$10.5M total over 10yrs 		\$ 10,500,000	\$ 10,500,000
Subtotal		\$ 4,275,000	\$ 27,425,000	\$ 31,700,000

3. Genetic and population monitoring	<ul style="list-style-type: none"> Intensive monitoring for reintroductions and response to habitat restoration (initially McDermitt): \$600k/yr for 3 watersheds 3 x over 10 years; \$900,000 	\$ 900,000	\$ 900,000	\$ 1,800,000
	<ul style="list-style-type: none"> Summit & Independence Lake: \$200K/yr for 5 years; \$1M 	\$ 500,000	\$ 500,000	\$ 1,000,000
	<ul style="list-style-type: none"> Remote sensing: \$600k for 3 basins, including ground crew 	\$ 300,000	\$ 300,000	\$ 600,000
	<ul style="list-style-type: none"> Genetic lab work and analyses: \$75k/year; \$750k total 		\$ 750,000	\$ 750,000
Subtotal		\$ 1,700,000	\$ 2,450,000	\$ 4,150,000

4. Water transactions program	<ul style="list-style-type: none"> Walker consolidation for irrigation deliveries : \$15M total over 10 yrs 		\$ 15,000,000	\$ 15,000,000
	<ul style="list-style-type: none"> Water rights transactions and program development costs for an initial leasing program outside the Walker Basin (\$175/acre to lease water): total of \$1.75 M over 10 years 	\$ 1,750,000		\$ 1,750,000
Subtotal		\$ 1,750,000	\$ 15,000,000	\$ 16,750,000

5. Riparian and habitat improvement	<ul style="list-style-type: none"> Riparian fencing 200 miles fencing \$6500/mi over 10 years 	\$ 750,000	\$ 550,000	\$ 1,300,000
	<ul style="list-style-type: none"> Water development, piping and guzzlers, nutrient or forage supplementation to manipulate livestock \$200k/year 	\$ 700,000	\$ 1,300,000	\$ 2,000,000
	<ul style="list-style-type: none"> Monitoring habitat improvements (private contracts for landowners) 50k/year 	\$ 250,000	\$ 250,000	\$ 500,000
	<ul style="list-style-type: none"> Resting pastures 150,000 AUMs at \$12/AUM 	\$ 900,000	\$ 900,000	\$ 1,800,000
Subtotal		\$ 2,600,000	\$ 3,000,000	\$ 5,600,000
6. Initiative Coordinator and Safe Harbors biologist	<ul style="list-style-type: none"> Initiative Coordinator position at TU, \$70,000/year over 10 years 	\$ 700,000		\$ 700,000
	<ul style="list-style-type: none"> Start up and biologist position at NDOW \$75,000/year \$375k over 5 years 	\$ 375,000		\$ 375,000
	Subtotal	\$ 1,075,000	\$ -	\$ 1,075,000
7. Conservation hatchery mgmt	<ul style="list-style-type: none"> Mgmt plan: \$300K for a 2-yr effort (2 states, Mono county, private fish culturists, Walker & Pyramid tribes, etc.) Need ongoing genetics mgmt plan, incl. training. 	\$ 300,000		\$ 300,000
	Subtotal	\$ 300,000		\$ 300,000
Grand Total		\$ 13,700,000	\$ 53,675,000	\$ 67,375,000



Significant ancillary benefits:

Western efforts: White fish, cui-ui (Truckee), Paiute sculpin, Tahoe suckers, Tui chub, white pelicans, bald eagles (Tahoe), red-sided shiners, speckled dace, Yosemite toad, yellow-legged frog, leopard frogs, sage grouse (Mono population), western pond turtles

Eastern efforts: Paiute sculpin*, mountain suckers, Tahoe suckers, bald eagles, red-sided shiners, speckled dace, Columbia-spotted frog*, leopard frogs, sage grouse, riparian & migratory birds TBD, western toad, river otters.

NFWF financial leadership: The total cost of securing the long-term viability of Lahontan cutthroat will cost in excess of \$89 million. The Foundation’s initiative would cost \$14 million over 10 years, equating about 16% of the total.

Risks: Western Lahontan Basin terminal lakes will be the most expensive and highest risk for conservation success. These western basins have the most dollars and the highest human populations (Lake Tahoe, Reno, and Carson City). The Foundation can make a significant difference in the headwaters of the Walker River, which is in the Sierra Meadows Keystone Initiative, and in the California portion of the Truckee River Basin. The Northwestern and Eastern Basins offer the greatest chance for securing larger populations of Lahontan cutthroat, with the lowest risk to achieving this conservation outcome. Key risks to this Initiative include:

- Finding non-federal match;
- Assuring private landowner cooperation for restoration/reintroductions
- California, Nevada, and Oregon all have budget deficit problems; and
- Terminal Lakes – Walker, Pyramid, and Lake Tahoe are very expensive, long-term experiments in restoration.

Opportunities:

- The federal and state fish partners are committed to the initiative;
- Bureau of Land management and Forest Service are excellent partners;
- Natural Resources Conservation Service is potentially a very good partner in the western terminal lakes and the Eastern Basin;
- Many corporations reside in Reno. The Lahontan is as close to a state fish as it comes in Nevada;
- The Walker Lake water transactions program offers a unique opportunity to play a critical role in recovery of Lahontan cutthroat; and
- Overall, with the Walker Lake water transactions program plus an additional \$500K per year, a large percentage of the remaining populations can be expanded in range and size – offering long-term security from climate change.

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