Conservation Success Index: Lahontan Cutthroat Trout

ONCORHYNCHUS CLARKII HENSHAWI

Rev. 1.2 - 3/2010

SPECIES SUMMARY

The Lahontan cutthroat trout has a long evolutionary history of isolation and adaptation in the Lahontan basin in Nevada, eastern CA and southern Oregon, and is one of the four major sub-species of cutthroat trout. Its eastern counterpart, the "Humboldt cutthroat trout", is actually considered to be a separate un-described sub-species but both forms are treated together here as Lahontan cutthroat trout (LCT), as they are by management and regulatory agencies.

Photo by Steve Ambruzs

LCT historically expressed a variety of movement life histories, including resident, fluvial, and lacustrine (lake) forms. The western lake form is uniquely adapted to persist in the desert terminal lakes of the Lahontan basin. It has an unusually high tolerance for alkaline and saline waters and its position as top predator in the food web made it the largest of the cutthroat trout: it holds the world-record size of 41 lb from Pyramid Lake. The eastern form is adapted to the highly variable desert and montane stream environment of the Great Basin. However, non-native fishes, and habitat fragmentation and degradation have led to the decline of many populations. Only 8.6% of the historical stream habitat is currently occupied and the fish has been lost from almost 99% of its historic lake habitat; it was one of the first species to be listed under the Endangered Species Act (first as Endangered and later as Threatened) in 1975.

Key CSI Findings

- 25% of occupied subwatersheds had total CSI scores of 71 points or higher (of a total of 100), though the majority (59%) had a moderate score of 61-70.
- LCT have been extirpated from many subwatersheds and subbasins, but within remaining subwatersheds range-wide condition scores showed they are fairly well-distributed and occupy a relatively high amount of 2nd order and larger habitats.
- The overall density and extent of populations was low, but LCT generally maintain high genetic integrity and low disease risk.

- Habitat integrity was high in many parts of the historical range, indicating many possible opportunities for reintroductions.
- Much of the historic LCT range will be highly impacted by climate change, with almost every part of the range being at high risk for at least one, if not several, factors.

Non-native fishes are a major concern for LCT and have been implicated in the majority of recent extirpations. However, most LCT populations remain pure (93% of subwatersheds scored highest for genetic purity) and in some cases LCT have been able to resist or potentially coexist with non-natives such as brook trout, especially in highly variable eastern habitats where LCT are possibly better adapted. Since much of the historical LCT habitat remains in fairly good condition with moderate to high Habitat Integrity scores, there may be ample opportunity to restore or reintroduce LCT into habitats where they have been extirpated if non-natives are aggressively controlled. The majority of conservation populations are in isolated small stream reaches which could be restored and reconnected to improve population sizes and extents.

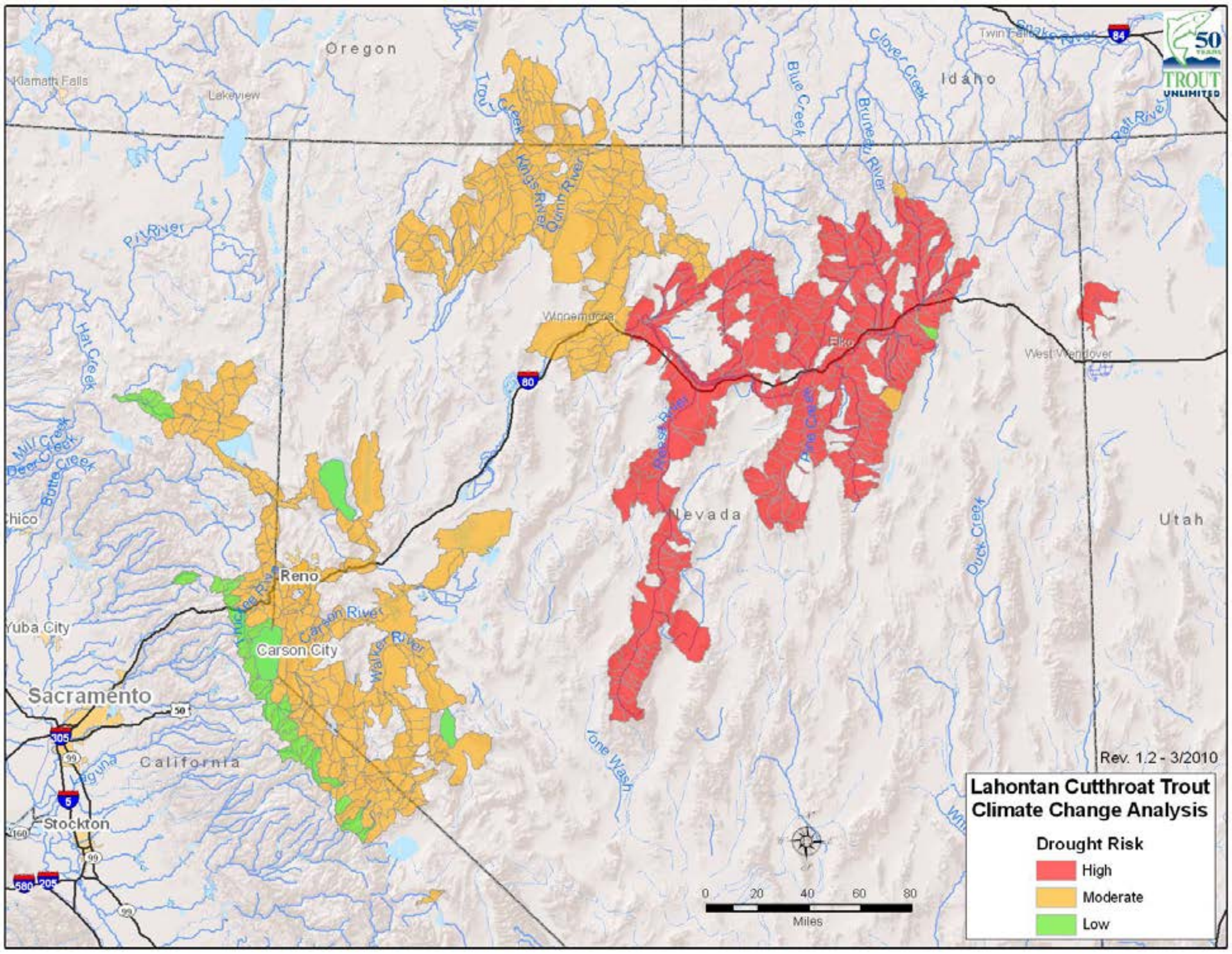
Self-sustaining original strains of LCT still persist in 2 historic lake habitats (Independence and Summit Lakes), both of which are threatened by non-native fishes. In other historic lakes where LCT could potentially be restored, non-natives, isolation from spawning tributaries and water quality need to be addressed to ensure successful conservation of this important ecotype of LCT.

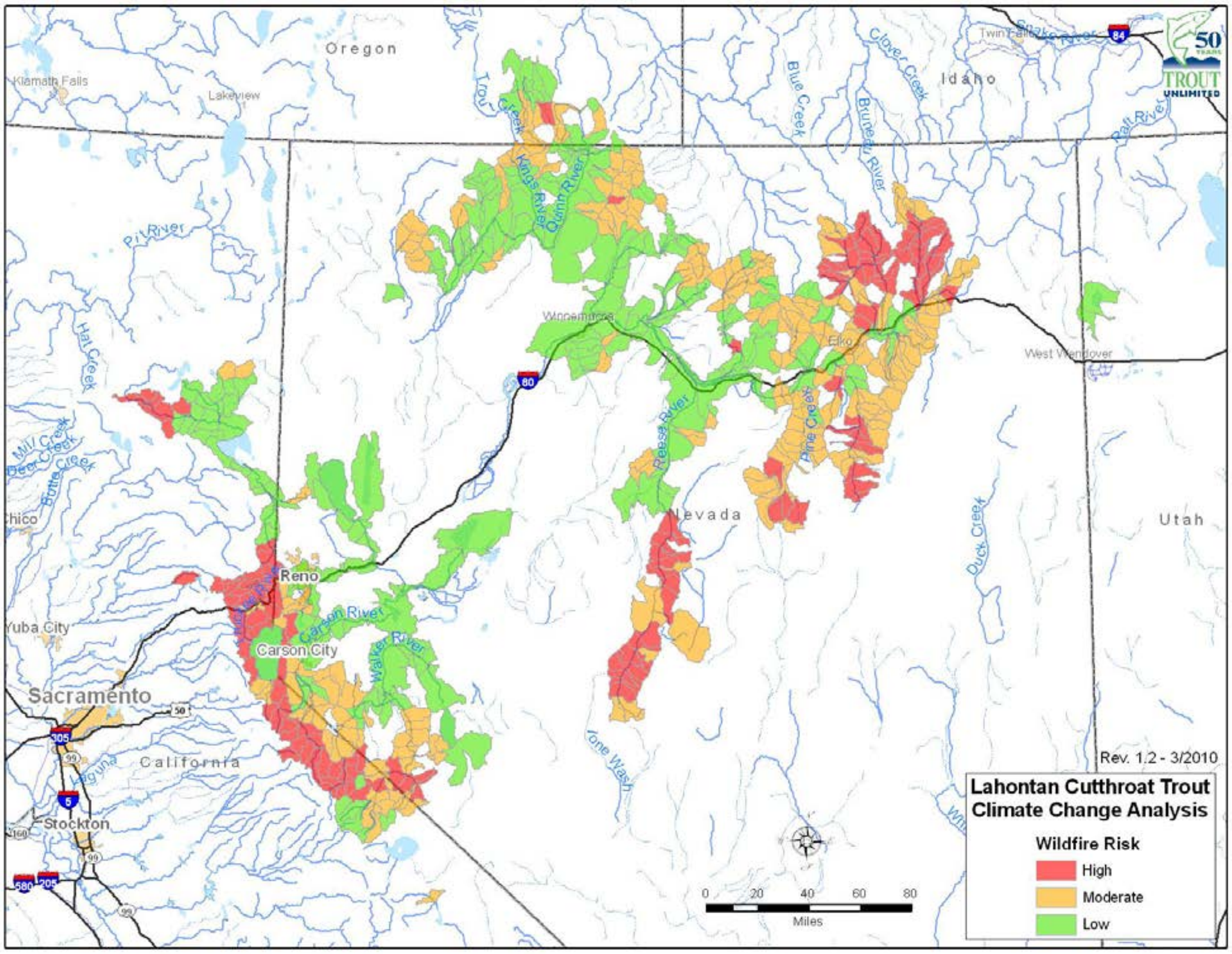
Our analyses show much of the historic LCT habitat will be at high risk from climate change. Large portions of higher-elevation habitats are at moderate to high risk from fire as well as flooding, and all habitats but those in the higher elevations in the Sierra Nevada mountains and a few isolated ranges are at moderate to high thermal and drought risk. Collectively, almost every part of the historic range is at high risk for at least one or more factors. Bolstering populations by improving and reconnecting watersheds to ensure access to multiple localized habitats and refugia and encouraging migratory life histories will be important for securing LCT in the future.

Prepared by Helen Neville 10/15/09, with general background information taken from
Behnke, R.J., 2002 Trout and Salmon of North America, and the USFWS 5-year review (2009).

Table 1. CSI scoring result summary for Lahontan cutthroat trout

	CSI Indicator	Number of Subwatersheds Receiving Scores 1	2	3	4	5	Total Subwatersheds Scored
Range-wide Conditions	Percent historic stream habitat occupied	13	11	10	7	35	76
	Percent subbasins (4th) occupied	0	76	0	0	0	76
	Percent subwatersheds (6th) occupied	22	42	0	6	6	76
	Percent habitat by stream order occupied	15	0	0	1	60	76
	Percent historic lake area occupied	0	0	0	0	76	76
Population Integrity	Population Density	30	4	23	12	5	74
	Population Extent	40	17	0	4	15	76
	Genetic Purity	0	1	0	5	70	76
	Disease vulnerability	0	0	0	76	0	76
	Life history diversity	49	0	0	0	27	76
Habitat Integrity	Land Stewardship	337	3	60	1	80	481
	Watershed connectivity	18	29	32	49	353	481
	Watershed conditions	20	26	106	61	268	481
	Water quality	133	40	93	101	114	481
	Flow regime	34	35	23	69	320	481
Future Security	Land conversion	1	6	32	108	334	481
	Resource extraction	10	41	75	179	176	481
	Energy development	263	33	16	123	46	481
	Climate change	242	199	34	5	1	481
	Introduced species	46	6	15	303	111	481


Lahontan Cutthroat Trout
Climate Change Analysis
Drought Risk
High
Moderate
Low
Rev. 1.2 - 3/2010
0 20 40 60 80
Miles
Oregon
Idaho
Nevada
Utah
California
Reno
Carson City
Sacramento
Winnemucca
Elko
West Wendover
Stockton
Yuba City
Chico
Klamath Falls
Lakeview
Twin Falls
Carson River
Walker River
Pit River
Hat Creek
Mill Creek
Deer Creek
Butte Creek
Clover Creek
Blue Creek
Bruneau River
Raft River
Duck Creek
Reese River
Kings River
Quinn River
Trout Creek
Ione Wash



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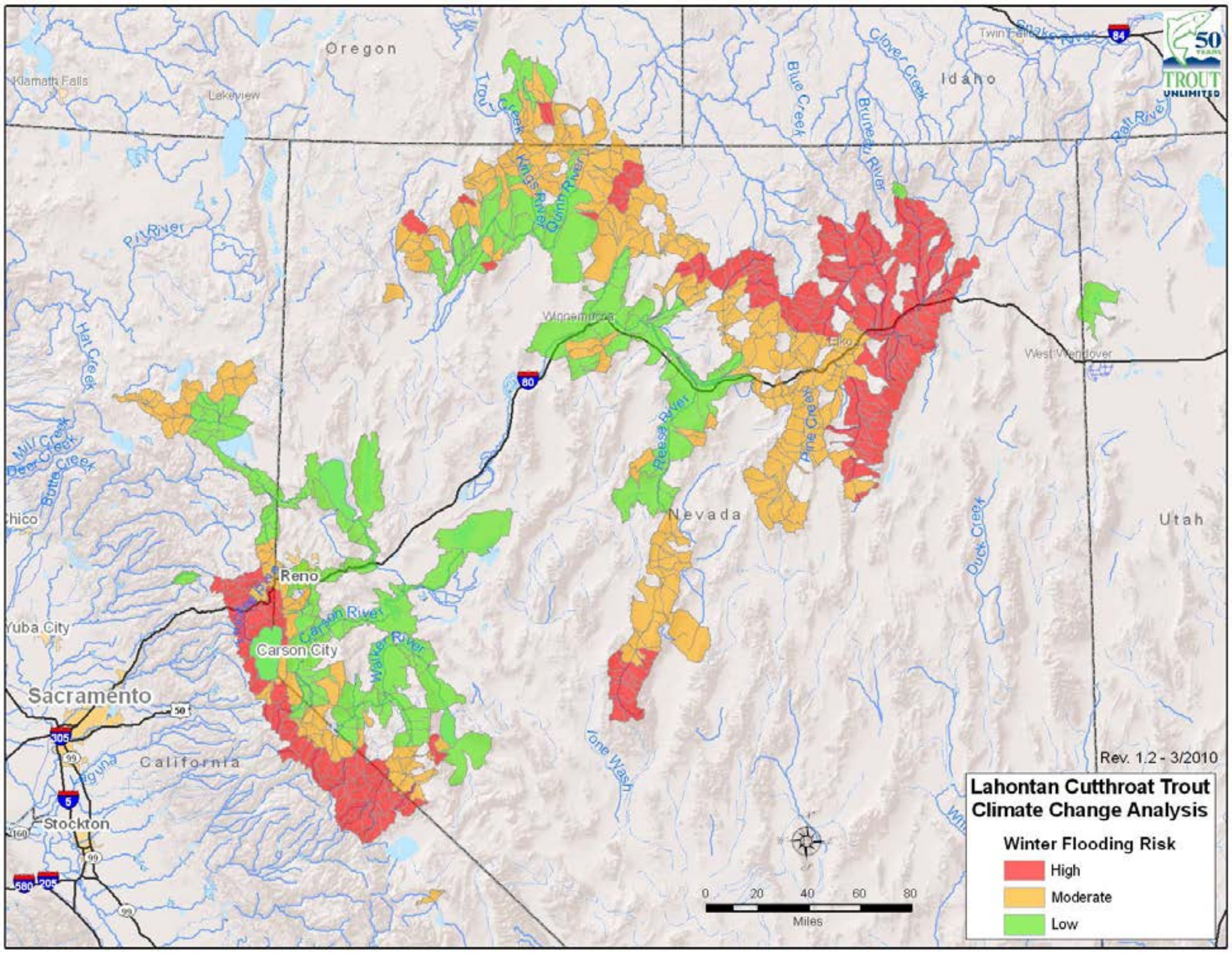
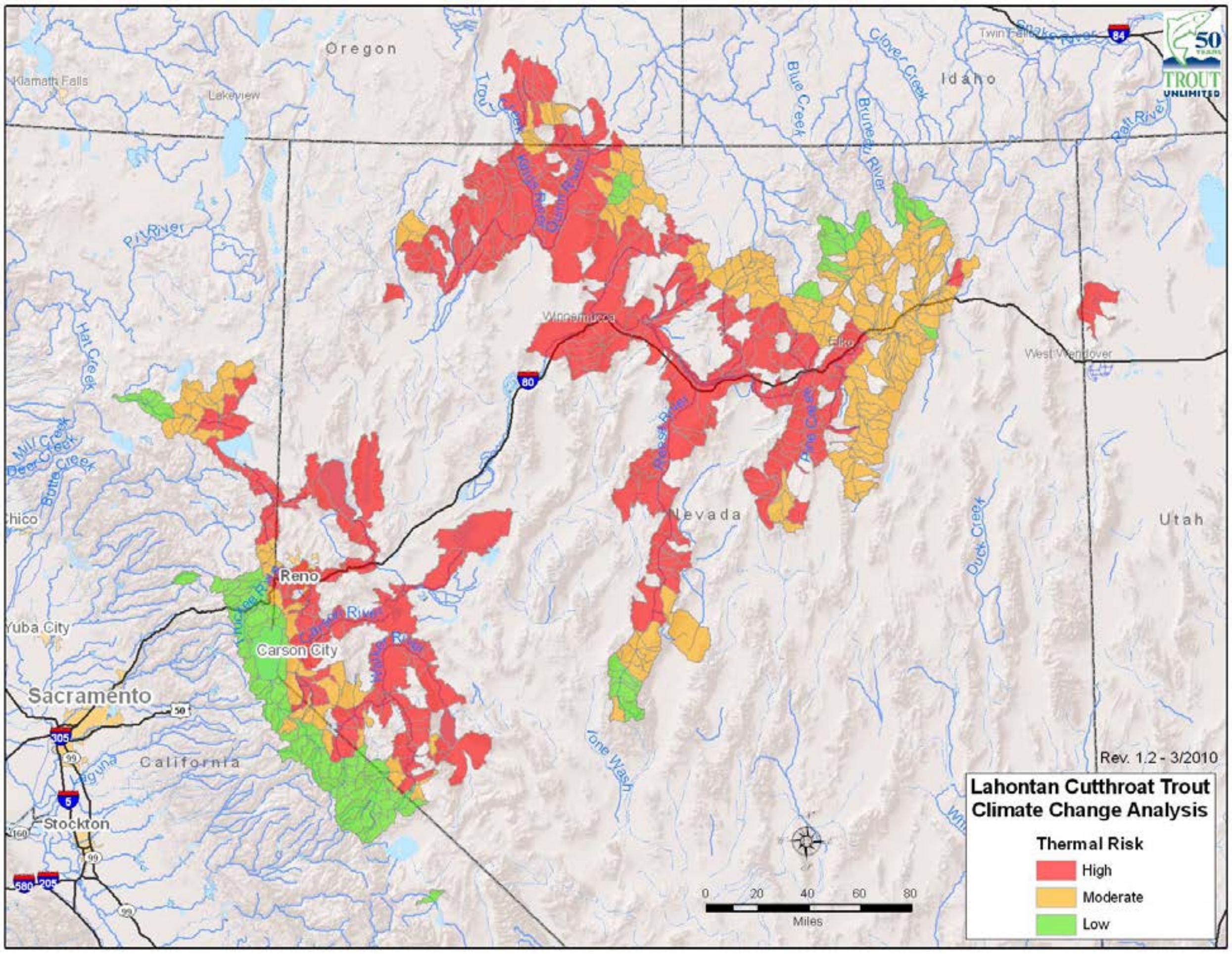
Lakeview
Twin Falls
Winnemucca
Elko
West Wendover
Reno
Carson City
Yuba City
Sacramento
Chico
Stockton
Pit River
Hat Creek
Mill Creek
Deer Creek
Butte Creek
Kings River
Quinn River
Trout Creek
Blue Creek
Clover Creek
Bruneau River
Salmon Falls
Reese River
Pine Creek
Carson River
Walker River
Duck Creek
Ione Wash
80
84
5
305
50
99
580
205
Rev. 1.2 - 3/2010
Lahontan Cutthroat Trout
Climate Change Analysis
Wildfire Risk
High
Moderate
Low
0 20 40 60 80
Miles
50 YEARS
TROUT UNLIMITED


Lahontan Cutthroat Trout
Climate Change Analysis
Winter Flooding Risk
High
Moderate
Low
Rev. 1.2 - 3/2010
0
20
40
60
80
Miles
Oregon
Idaho
Nevada
Utah
California
Klamath Falls
Lakeview
Winnemucca
Elko
West Wendover
Reno
Carson City
Sacramento
Yuba City
Stockton
Chico
Pit River
Hat Creek
Mill Creek
Deer Creek
Butte Creek
Kings River
Quinn River
Reese River
Pine Creek
Carson River
Walker River
Blue Creek
Clover Creek
Bruneau River
Salt River
Duck Creek
Ione Wash
Trout Creek
80
84
5
305
99
50
580
205


Lahontan Cutthroat Trout
Climate Change Analysis
Thermal Risk
High
Moderate
Low
Rev. 1.2 - 3/2010
0
20
40
60
80
Miles
Oregon
Idaho
Nevada
Utah
California
Reno
Carson City
Sacramento
Stockton
Yuba City
Chico
Winnemucca
Elko
West Wendover
Klamath Falls
Lakeview
Twin Falls
Pit River
Hat Creek
Mill Creek
Deer Creek
Butte Creek
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Clover Creek
Bruneau River
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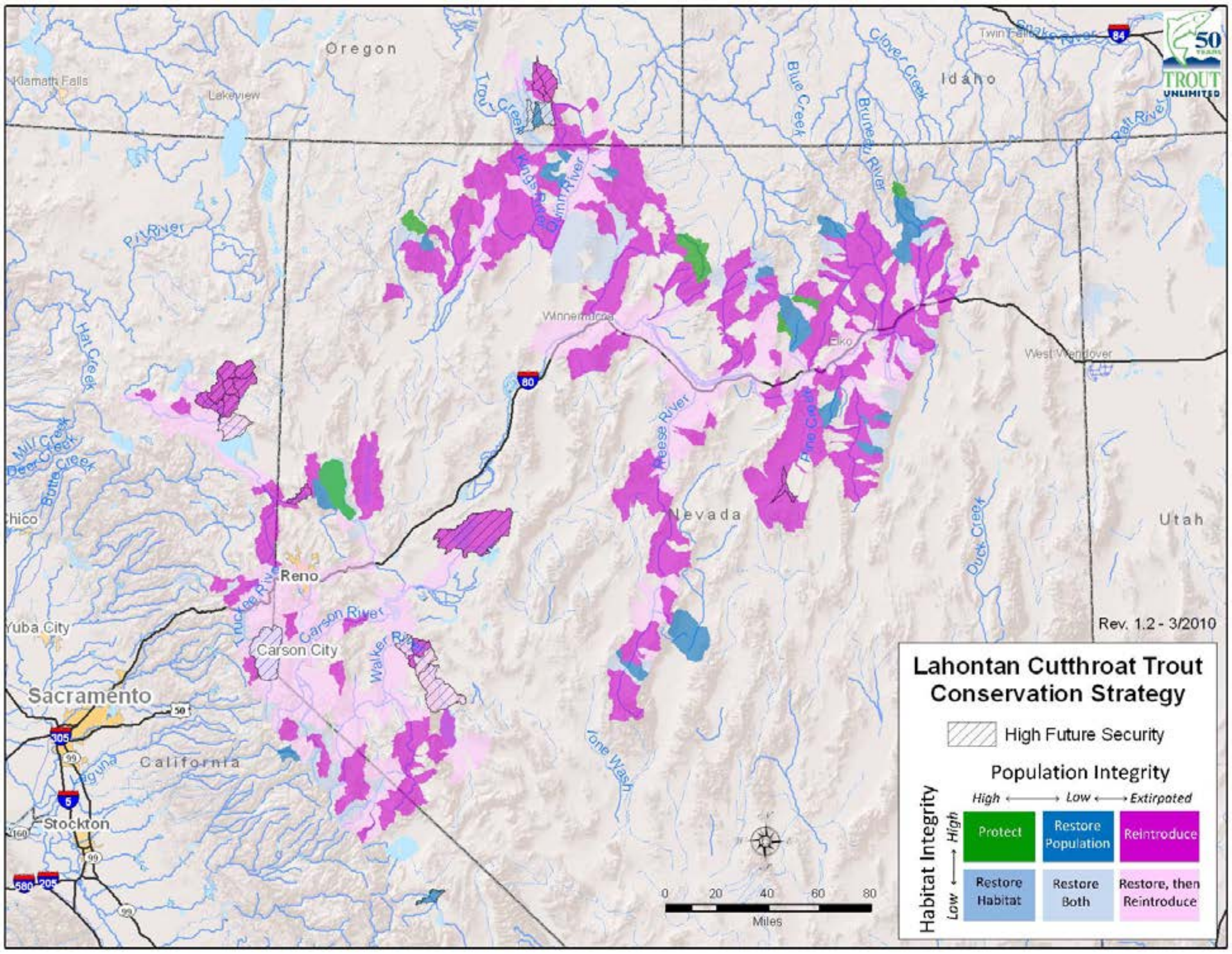
Duck Creek
Reese River
Carson River
Truckee River
Walker River
Quinn River
Ione Wash


Lahontan Cutthroat Trout
Conservation Strategy
High Future Security
Population Integrity
High ⟷ Low ⟷ Extirpated
Habitat Integrity
High ⟷ Low
Protect
Restore Population
Reintroduce
Restore Habitat
Restore Both
Restore, then Reintroduce
Rev. 1.2 - 3/2010
Oregon
Idaho
Nevada
Utah
California
Reno
Carson City
Sacramento
Stockton
Yuba City
Winnemucca
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West Wendover
Klamath Falls
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Truckee River
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Pine Creek
Bruneau River
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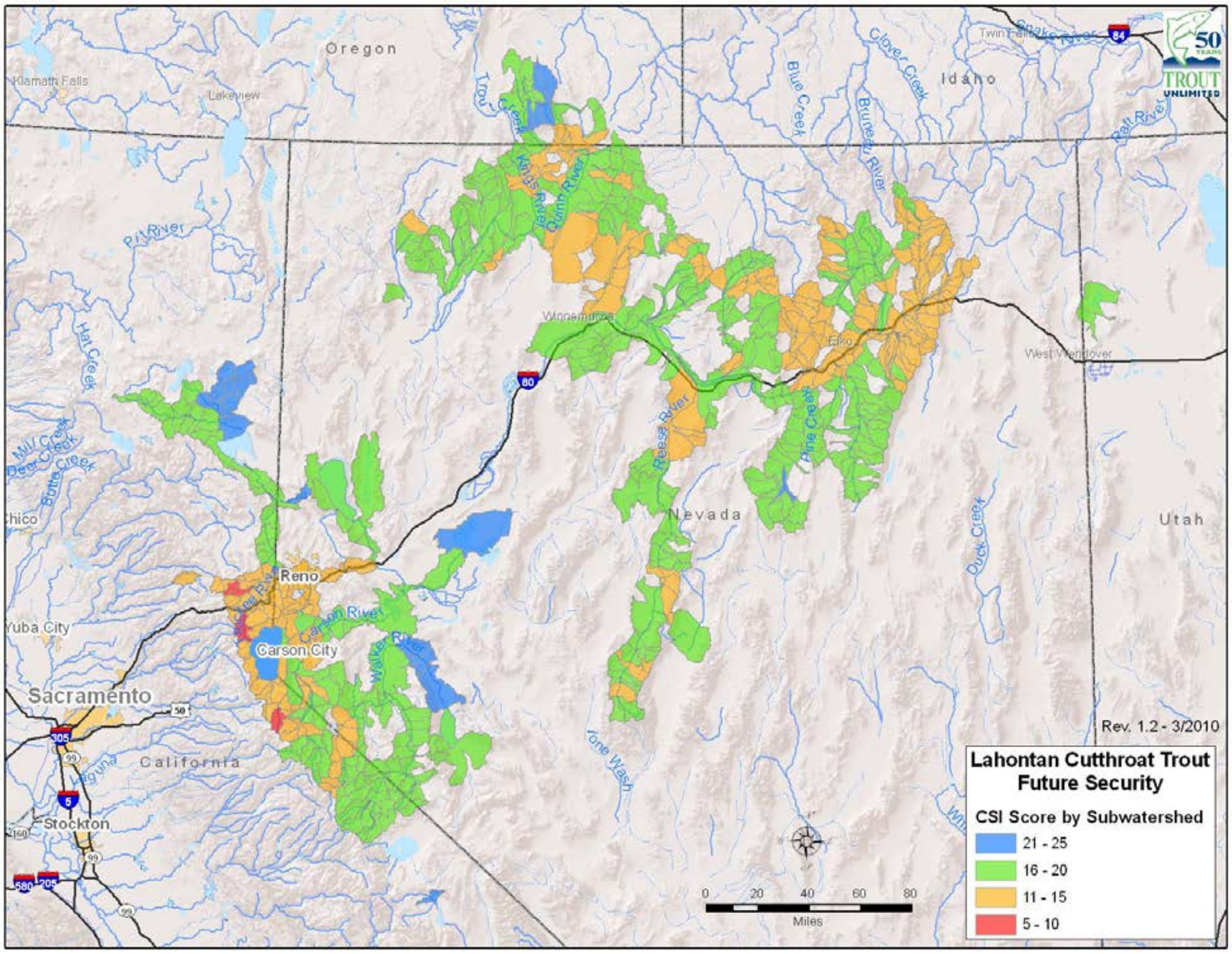
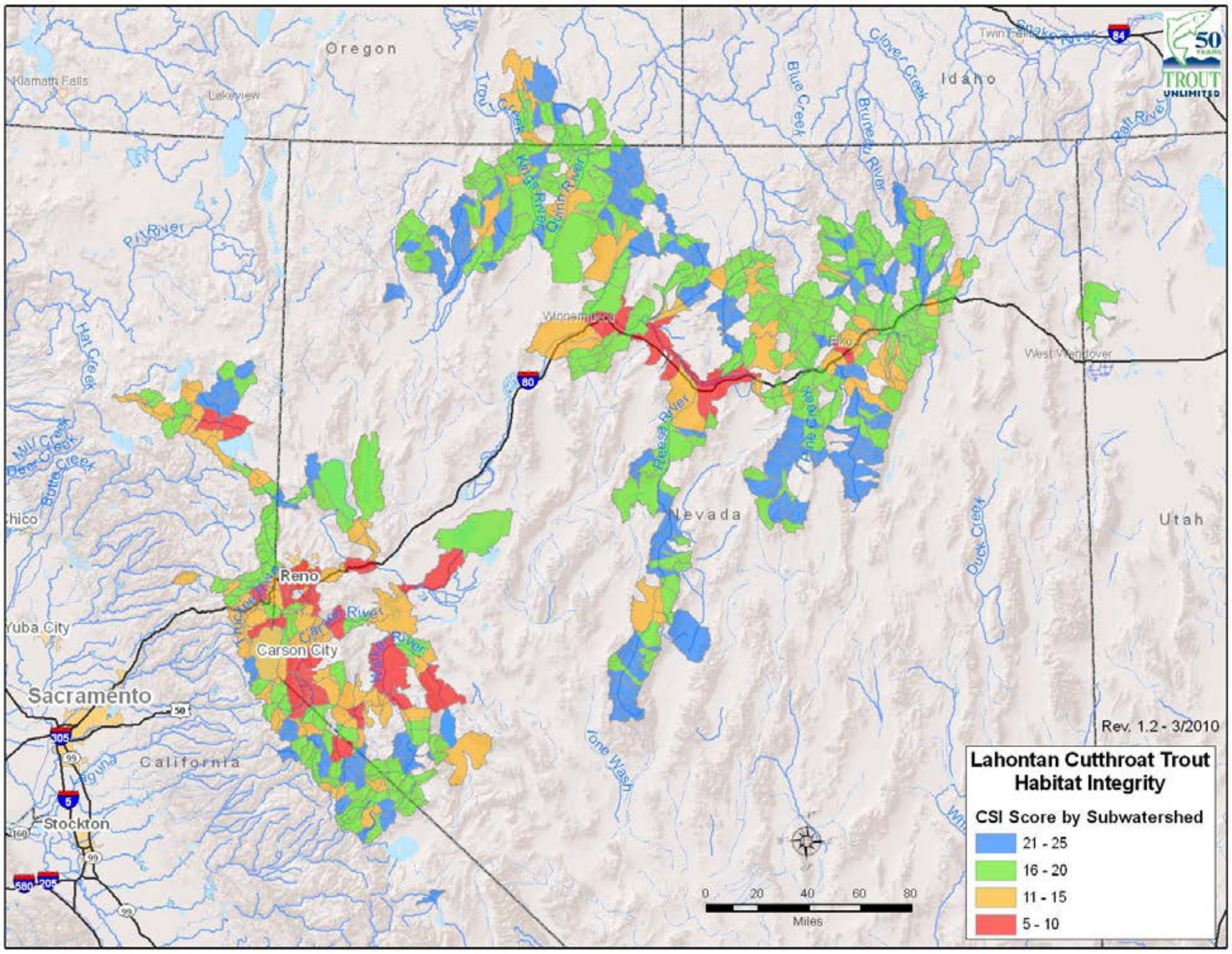
Duck Creek
Ione Wash
Quinn River
Trout Creek
0 20 40 60 80
Miles



Lahontan Cutthroat Trout
Future Security
CSI Score by Subwatershed
21 - 25
16 - 20
11 - 15
5 - 10
Rev. 1.2 - 3/2010
Miles
0
20
40
60
80
Oregon
Idaho
Nevada
Utah
California
Reno
Carson City
Sacramento
Stockton
Yuba City
Chico
Klamath Falls
Lakeview
Winnemucca
Elko
West Wendover
Pit River
Hat Creek
Mill Creek
Deer Creek
Butte Creek
Kings River
Quinn River
Reese River
Pine Creek
Duck Creek
Carson River
Walker River
Blue Creek
Clover Creek
Bruneau River
Salt River
Snake River
Trout Creek
Truckee River
Mono Wash
Twin Falls
Laguna
TROUT UNLIMITED
50 YEARS



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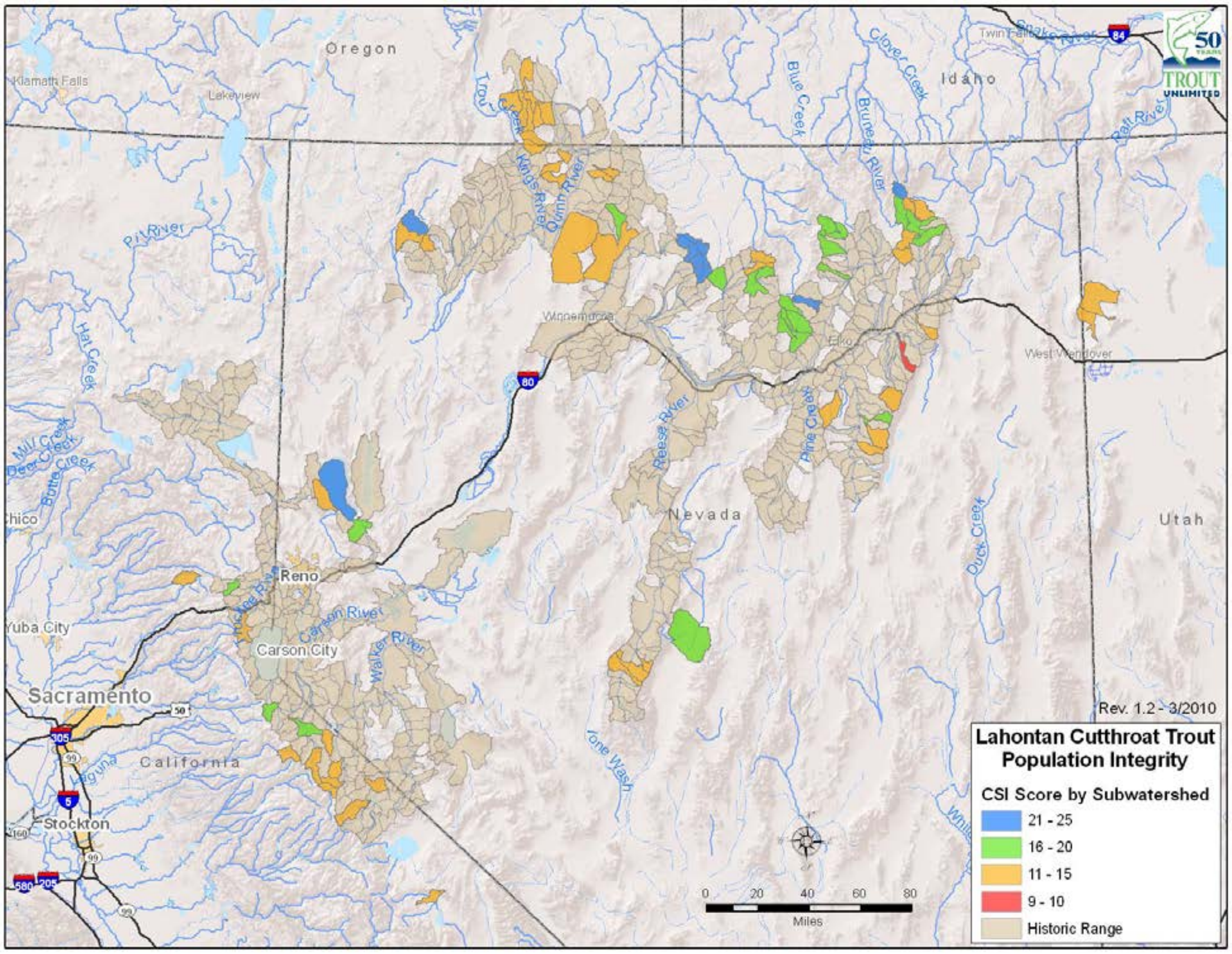
Butte Creek
Quinn River
Kings River
Trout Creek
Blue Creek
Clover Creek
Bruneau River
Raft River
Reese River
Carson River
Walker River
Duck Creek
Ione Wash
Rev. 1.2 - 3/2010
Lahontan Cutthroat Trout Habitat Integrity
CSI Score by Subwatershed
21 - 25
16 - 20
11 - 15
5 - 10
0 20 40 60 80
Miles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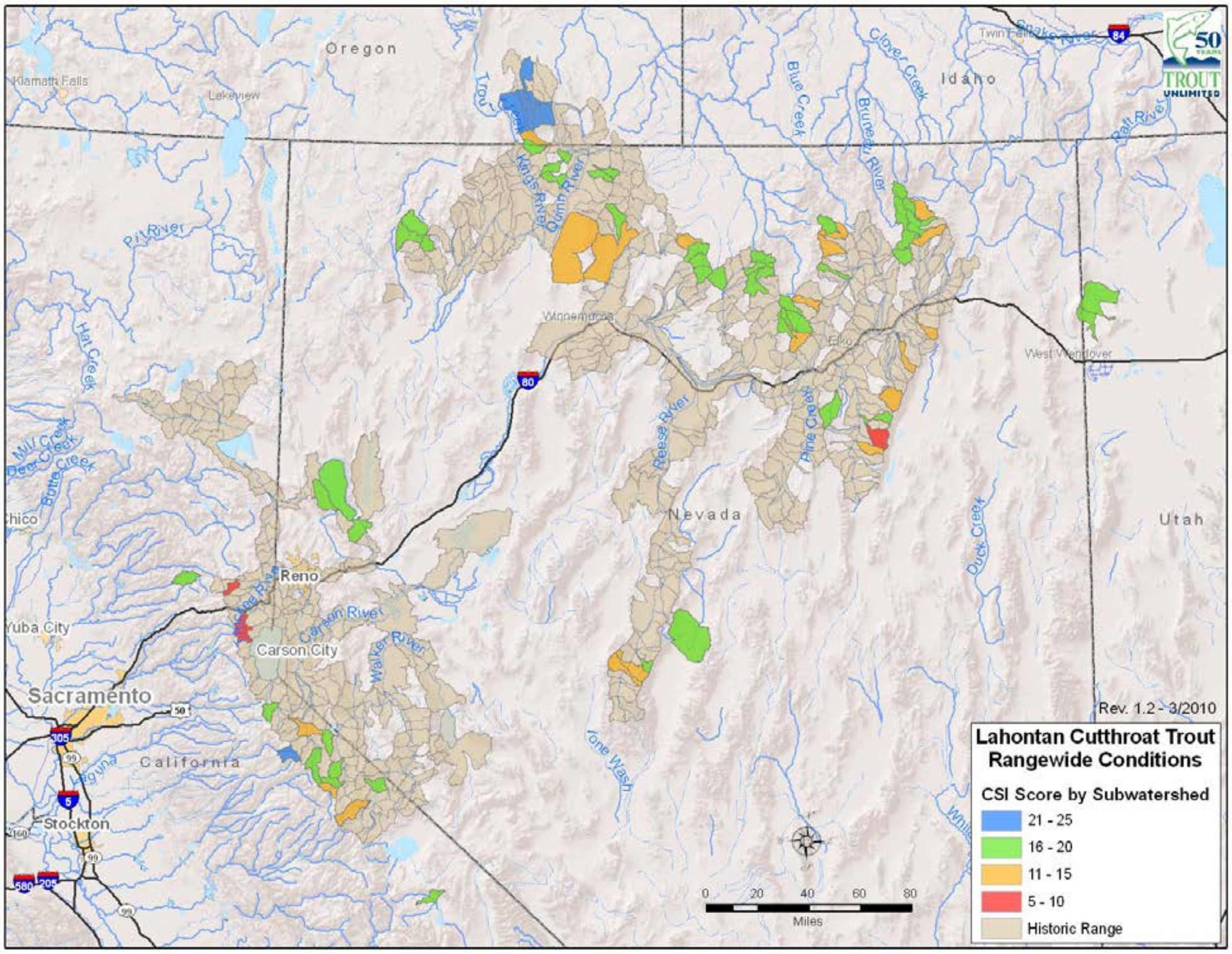
Kings River
Quinn River
Blue Creek
Bruneau River
Clover Creek
Raft River
Reese River
Pine Creek
Duck Creek
Ione Wash
Rev. 1.2 - 3/2010
Lahontan Cutthroat Trout Population Integrity
CSI Score by Subwatershed
21 - 25
16 - 20
11 - 15
9 - 10
Historic Range
0 20 40 60 80
Miles
50
TROUT UNLIMITED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Carson City
Sacramento
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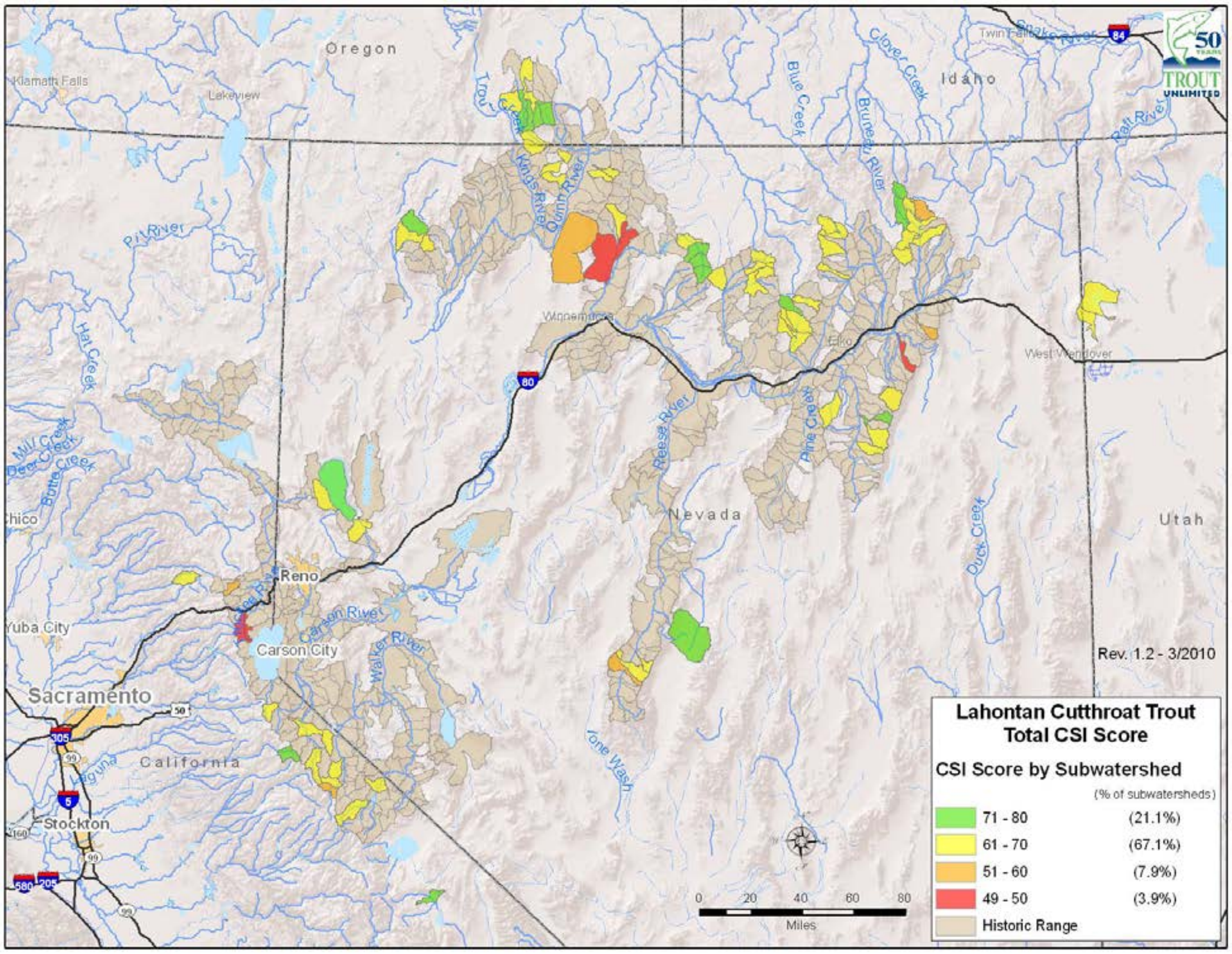
Chico
Kings River
Quinn River
Blue Creek
Clover Creek
Bruneau River
Pit River
Hat Creek
Mill Creek
Deer Creek
Butte Creek
Reese River
Pine Creek
Duck Creek
Carson River
Walker River
Ione Wash
Miles
0 20 40 60 80
Rev. 1.2 - 3/2010
Lahontan Cutthroat Trout
Rangewide Conditions
CSI Score by Subwatershed
21 - 25
16 - 20
11 - 15
5 - 10
Historic Range


Lahontan Cutthroat Trout
Total CSI Score
CSI Score by Subwatershed
(% of subwatersheds)
71 - 80 (21.1%)
61 - 70 (67.1%)
51 - 60 (7.9%)
49 - 50 (3.9%)
Historic Range
Rev. 1.2 - 3/2010
Oregon
Idaho
Nevada
Utah
California
Reno
Carson City
Sacramento
Stockton
Yuba City
Winnemucca
Elko
West Wendover
Twin Falls
Klamath Falls
Lakeview
Chico
Carson River
Walker River
Reese River
Pine Creek
Bruneau River
Blue Creek
Clover Creek
Duck Creek
Pit River
Hat Creek
Kings River
Quinn River
0 20 40 60 80
Miles

Conservation Success Index:
Lahontan Cutthroat trout *Oncorhynchus clarki*:
Subwatershed Scoring and Rule Set

Introduction:

The CSI is an aggregate index comprised of four different component groups: Range-wide Condition; Population Integrity; Habitat Integrity; and Future Security. Each CSI group has five indicators that describe a specific component of each group. Each indicator is scored from 1 to 5 for each subwatershed, with a score of 1 indicating poor condition and a score of 5 indicating good condition. Indicator scores are then added to obtain the subwatershed condition for a Group, and Group scores are added for a CSI score for a subwatershed (Figure 1). CSI scores can then be summarized to obtain the general range of conditions within the historical or current distribution of the species.

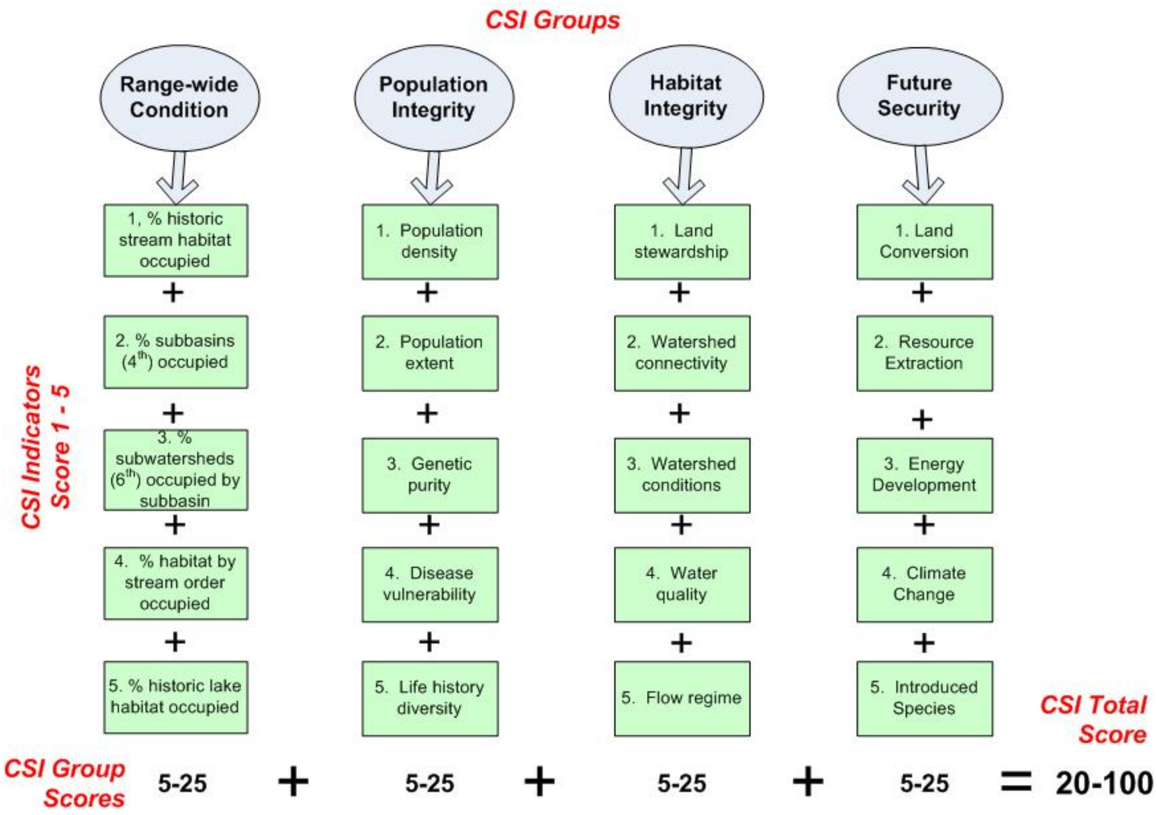


Figure 1. Each subwatershed is scored from 1 to 5 using 20 indicators within four main groups. Indicator scores are added per group to obtain an overall group score. Group scores are then added to obtain a composite CSI score for each subwatershed.

CSI Groups and Indicators

The CSI consists of four main groups of indicators:

1. Range-wide condition
2. Population integrity
3. Habitat integrity
4. Future Security

Below is an overview of each CSI group and the indicators within each group. Each section contains an overview of the group indicators

Range-wide Condition: *Indicators for range-wide condition:*

Overview:

1. Percent of historic stream habitat occupied
2. Percent of subbasins occupied by populations.
3. Percent of subwatersheds (6^{th} level HUC) occupied within subbasin.
4. Percent of habitat by stream order occupied.
5. Percent of historic lake or by surface area occupied.

Indicator: 1. Percent historic stream habitat occupied.

Indicator Scoring:

Occupied stream habitat	CSI Score
0 – 9%	1
10 – 19%	2
20 – 34%	3
35 – 49%	4
50 – 100%	5

Explanation: Historic habitat is all perennial streams and connected natural lakes across the historic range of the species. Lakes less than 2 hectares connected to streams are considered stream habitat while lakes greater than 2 hectares or isolated lakes are considered to be lake habitat.

Rationale: Species that occupy a larger proportion of their historic range will have an increased likelihood of persistence.

Data Sources: Lahontan Cutthroat Trout 5-Year Review: Summary and Evaluation, U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office. Reno, Nevada, March 30, 2009

Indicator: 2. Percent subbasins occupied.

Indicator Scoring:

Subbasins occupied	CSI Score
1-49%	1
50-69%	2
70-79%	3
80-89%	4
90-100%	5

Explanation: The percentage of subbasins within the historical range of the species that are currently occupied by the species. The same percentage is applied to all subwatersheds scored.

Rationale: Larger river basins often correspond with Distinct Population Segments or Geographic Management Units that may have distinct genetic or evolutionary legacies for the species(Williams et al. 477-92).

Data Sources: Lahontan Cutthroat Trout 5-Year Review: Summary and Evaluation, U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office. Reno, Nevada, March 30, 2009. Subwatersheds and subbasins based on Watershed Boundary Dataset, NRCS, 2008.

Indicator: 3. Percent subwatersheds occupied within subbasin.

Indicator Scoring:

Subwatersheds occupied by subbasin	CSI Score
1 – 20%	1
21-40%	2
41-60%	3
61-80%	4
81-100%	5

Explanation: The percentage of subwatersheds in the historic range of the species that are currently occupied by the species within each subbasin. The percentage is the same for all subwatersheds within a subbasin.

Rationale: Species that occupy a larger proportion of their historic subwatersheds are likely to be more broadly distributed and have an increased likelihood of persistence.

Data Sources: Lahontan Cutthroat Trout 5-Year Review: Summary and Evaluation, U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office. Reno, Nevada, March 30, 2009. Subwatersheds and subbasins based on Watershed Boundary Dataset, NRCS, 2008.

Indicator: 4. Habitat by stream order occupied.

Indicator Scoring:

Occupied 2nd order streams and higher	CSI Score
0 – 9%	1
10 – 14%	2
15 – 19%	3
20 – 24%	4
25 – 100%	5

Explanation: The percentage of currently occupied habitat that is first order streams.

Rationale: Species that occupy a broader range of stream sizes will have an increased likelihood of persistence. This is especially true because small, first order streams tend to have more variable environmental conditions and smaller populations than larger streams(Peterson et al. 557-73).

Data Sources: Lahontan Cutthroat Trout 5-Year Review: Summary and Evaluation, U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office. Reno, Nevada, March 30, 2009. Stream order was determined using the National Hydrography Dataset Plus(USEPA and USGS).

Indicator: 5. Historic lake habitat occupied.

Indicator Scoring:

Occupied lake habitat	CSI Score
0 – 9%	1
10 – 19%	2
20 – 34%	3
35 – 49%	4
50 – 100%	5

Explanation: Historic lake populations only considered natural lakes while current populations have been identified in reservoirs thus leading to an increase in lake habitat for some subwatersheds.

Rationale: Lakes often harbor unique life histories and large populations that are important to long-term persistence of the species(Young).

Data Sources: Lahontan Cutthroat Trout 5-Year Review: Summary and Evaluation, U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office. Reno, Nevada, March 30, 2009.

Population Integrity: *Indicators for the integrity of populations*.

Overview:

1. Population density
2. Population extent
3. Genetic purity
4. Disease vulnerability
5. Life history diversity

Indicator: 1. Population density.

Indicator Scoring:

Fish / mile	Total Population	CSI Score
1 - 50	≤500	1
1 - 50	≥500	2
51 - 150	≥1	3
151 - 400	≥1	4
>400	≥1	5

Explanation: Population density within each subwatershed. When multiple populations were present within a subwatershed, population density was calculated as a weighted average with the length of each stream occupied by a population as the weight.

Rationale: Small populations, particularly those below an effective size of 500 individuals, are more vulnerable to extirpation(Soule;May and Albeke -139).

Data Sources: Lahontan Cutthroat Trout 5-Year Review: Summary and Evaluation, U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office. Reno, Nevada, March 30, 2009.

Indicator: 2. Population extent.

Indicator Scoring:

Connectivity	CSI Score
Population Isolated	1

Weakly Networked	2
Moderately Networked	4
Strongly Networked	5

Explanation: Population connectivity is the amount of connected habitat available to the population.

Rationale: Populations with less available habitat are more vulnerable to extirpation(Colyer, Kershner, and Hilderbrand 954-63) as a result of small, localized disturbances.

Data Sources: Lahontan Cutthroat Trout 5-Year Review: Summary and Evaluation, U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office. Reno, Nevada, March 30, 2009.

Indicator: 3. Genetic integrity.

Indicator Scoring:

Genetic Stability Ranking	CSI Score
Not Tested - Suspected Hybridized	2
Not Tested - Suspected Unaltered	4
Unaltered (< 1%)	5

Explanation: Genetic integrity represents the genetic purity of the population.

Rationale: Hybridization and loss of the native genome via introgression with non-native salmonids are among the leading factors in the decline of native salmonids(Fausch et al. -44). Introgression with other subspecies can also cause a loss of genetic variation.

Data Sources: Lahontan Cutthroat Trout 5-Year Review: Summary and Evaluation, U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office. Reno, Nevada, March 30, 2009.

Indicator: 4. Disease vulnerability.

Indicator Scoring:

Disease Risk	CSI Score
Limited disease risk	4

Explanation: The risk of each population to disease.

Rationale: Non-native pathogens and parasites, including the myxozoan parasite that causes whirling disease, can infect native trout and reduce their populations.

Data Sources: Lahontan Cutthroat Trout 5-Year Review: Summary and Evaluation, U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office. Reno, Nevada, March 30, 2009.

Indicator: 5. Life History Diversity **–** Life History table; resident, fluvial, and ad-fluvial

Indicator Scoring:

Conservation population	CSI Score
One life history form present: Resident only	1
Two life histories present: Fluvial and Resident with historic lakes but no current adfluvial forms	3
Two or three life histories present: Fluvial and resident with no lake populations; Any combination with Adfluvial present	5

Explanation: The number of life histories present in the population: resident, fluvial, adfluvial.

Rationale: Loss of life history forms, particularly migratory forms, increases the risk of extirpation and may reduce genetic diversity(Bascompte, Possingham, and Roughgarden 128-37;Colyer, Kershner, and Hilderbrand 954-63;Rieman et al.).

Data Sources: Lahontan Cutthroat Trout 5-Year Review: Summary and Evaluation, U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office. Reno, Nevada, March 30, 2009.

***Habitat Integrity**: Indicators for the integrity of aquatic habitats.*

Overview:

1. Land stewardship
2. Watershed connectivity
3. Watershed conditions
4. Water quality
5. Flow regime

Indicator: 1. Land stewardship.

Indicator Scoring:

Protected perennial habitat	Subwatershed protection	CSI Score
none	any	1
1 – 9%	<25%	1
1 – 9%	≥25%	2
10 – 19%	<25%	2
10 – 19%	≥25%	3
20 – 29%	<50%	4
20 – 29%	≥50%	5
≥30%	any	5

Explanation: The percent of perennial stream habitat AND percent subwatershed that is protected lands. Protected lands are federal or state lands with regulatory or congressionally-established protections, such as: federal or state parks and monuments, national wildlife refuges, wild and scenic river designations, designated wilderness areas, inventoried roadless areas on federal lands, Research Natural Areas, Areas of Critical Environmental Concern, others areas of special protective designations, or private ownership designated for conservation purposes (e.g., easements).

Rationale: Stream habitat and subwatersheds with higher proportions of protected lands typically support higher quality habitat than do other lands.

Data Sources: Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas(ESRI) and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset(USDA Forest Service).

Indicator: 2. Watershed connectivity.

Indicator Scoring:

Number of stream/canal intersections	Current/historic connectivity 6th	CSI Score
GE 12	LT 50%	1
8 – 11	50 – 74%	2
5 – 7	75 – 89%	3
1 – 4	90 – 94%	4
0	95 – 100%	5

Current/historic connectivity $4^{th:}$

- >90%: +1
- <50%: -1

Score for worst case

Explanation: The number of stream-canal intersections and reduction in historical connectivity in the subwatershed and subbasin. Connectivity is measured by determining the longest continuous section of stream habitat uninterrupted by man-made structures impassable by fish in the subwatershed and dividing that by the longest continuous section of historically connected stream habitat. Connectivity is also computed for the subbasin. Man-made barriers may include dams, water diversion structures, or human-caused dewatered stream segments that impede fish movement.

Rationale: Increased hydrologic connectivity provides more habitat area and better supports multiple life histories, which increases the likelihood of persistence(Colyer, Kershner, and Hilderbrand 954-63). Diversions, when they do not directly inhibit fish passage, can represent false movement corridors, cause fish entrainment, and act as population sinks(Schrank and Rahel 1528-37;Roberts and Rahel 951-61).

Data Sources: Stream network and barrier sources from Lahontan Cutthroat Trout 5-Year Review: Summary and Evaluation, U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office. Reno, Nevada, March 30, 2009.

Indicator: 3. Watershed condition.

Indicator Scoring:

Land conversion	CSI Score
GE 30%	1
20 – 29%	2
10 – 19%	3
5 – 9%	4
0 - 4%	5

CSI score is downgraded 1 point if road density is ≥1.7 and <4.7 mi/square mile. If road density is ≥4.7 mi/square mile it is downgraded 2 points

CSI score is downgraded 2 points if grazing is known to occur in the subwatershed

Explanation: The percentage of converted lands in the subwatershed.

Rationale: Habitat conditions are the primary determinant of persistence for most populations(Harig, Fausch, and Young 994-1004). Converted lands are known to degrade aquatic habitats(Shepard, Spoon, and Nelson 191-211;White and Rahel 881-94). Road density is computed for the subwatershed; roads are known to cause sediment-related impacts to stream habitat(Eaglin and Hubert 844-46;Lee et al. 1057-496;Waters 1-251). Lee et al.(Lee et al. 1057-496) recognized 6 road density classifications as they related to aquatic habitat integrity and noted densities of 1.7 and 4.7 mi/mi^2 as important thresholds.

Data Sources: Converted lands were determined using the National Land Cover Database(USGS), with all Developed, Pasture/Hay, and Cultivated Crops land cover types considered to be converted lands. Road density was determined using ESRI/TeleAtlas streets. Presence of grazing from Lahontan Cutthroat Trout 5-Year Review: Summary and Evaluation, U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office. Reno, Nevada, March 30, 2009

Indicator: 4. Water quality.

Indicator Scoring:

Miles 303(d) Streams	Agricultural Land	Number Active Mines	Road mi/ Stream mi	CSI Score
>0	58-100%	≥10	0.5 – 1.0	1
	28-57%	7-9	0.25 – 0.49	2
	16-27%	4-6	0.24 - 0.10	3
	6-15%	1-3	0.05 – 0.09	4
	0-5%	0	0 – 0.04	5

Score for worst case.

Explanation: The presence of 303(d) impaired streams, percentage agricultural land, number of active mines, and miles of road within 150 ft of perennial streams in the subwatershed.

Rationale: Decreases in water quality, including reduced dissolved oxygen, increased turbidity, increased temperature, and the presence of pollutants, reduces habitat suitability for salmonids. Agricultural land can impact aquatic habitats by contributing nutrients and fine sediments, and deplete dissolved oxygen. Mining activity can deteriorate water quality through leachates and sediments. Roads along streams can also contribute large amounts of fine sediments that smother benthic invertebrates, embed spawning substrates, and increase turbidity(Lloyd 34-45;Davies-Colley and Smith 1085-101).

Data Sources: 303(d) impaired streams was determined using Idaho Department of Environmental Quality data(IDEQ). The National Land Cover Database(USGS) was used to identify agricultural lands; Hay/Pasture and Cultivated Crops were defined as agricultural land.

Active mines were identified by using the Mineral Resources Data System(USGS). Road density within a 150 ft buffer was computed using ESRI/TeleAtlas roads and the National Hydrography Dataset Plus(USEPA and USGS).

Indicator: 5. Flow regime.

Indicator Scoring:

Number of dams	Storage (acre-ft)/stream mile	CSI Score
≥5	≥2,500	1
3 – 4	1,000 – 2,499	2
2	250 – 999	3
1	1- 249	4
0	0	5

Score for worst case.

Explanation: Number of dams and acre-feet of reservoir storage per perennial stream mile.

Rationale: Natural flow regimes are critical to proper aquatic ecosystem function(Poff et al. 769-84). Dams, reservoirs, and canals alter flow regimes(Benke 77-88). Reduced or altered flows reduce the capability of watersheds to support native biodiversity and salmonid populations.

Data Sources: The National Inventory of Dams(USACE) was the data source for dams and their storage capacity. Data on canals were obtained from the National Hydrography Dataset Plus(USEPA and USGS).

Future Security *Indicators for the future security of populations and aquatic habitats.*

Overview:

1. Land conversion
2. Resource extraction
3. Flow modification
4. Climate change
5. Introduced species

Indicator: 1. Land conversion.

Indicator Scoring:

Land Vulnerable to Conversion	CSI Score
81 – 100%	1
61 – 80%	2
41 - 60%	3
21 - 40%	4
0 – 20%	5

Explanation: The potential for future land conversion is modeled as a function of slope, land ownership, roads, and urban areas. Land is considered vulnerable to conversion if the slope is less than 15%, it is in private ownership and not already converted, it is within 0.5 miles of a road, and within 5 miles of an urban center.

Rationale: Conversion of land from its natural condition will reduce aquatic habitat quality and availability(Stephens et al. 1320-30).

Data Sources: Slope was computed from elevation data from the National Hydrography Dataset Plus(USEPA and USGS). Land cover was determined from the National Land Cover Database(USGS), and all land cover classes except developed areas, hay/pasture, and cultivated crops cover types were considered for potential conversion. Urban areas were determined using 2000 TIGER Census data(ESRI), roads from ESRI/TeleAtlas, and land ownership using USGS data on Land Ownership in Western North America(USGS).

Indicator: 2. Resource extraction.

Indicator Scoring:

Forest management	Hard Metal Mine Claims	CSI Score
51-100%	51 -100%	1
26 – 50%	26-50%	2
11 – 25%	11-25%	3
1 – 10%	1 – 10%	4
0%	0%	5

Score for worst case.

Explanation: Percentage of subwatershed available for industrial timber production (productive forest types only, minimum stand size of 40 acres) and the percent of subwatershed with hard metal mining claims (assuming an average of 20 acres per claim) outside of protected areas. Protected lands were removed from availability and include: federal or state parks and monuments, national wildlife refuges, wild and scenic river designations, designated wilderness areas, inventoried roadless areas on federal lands, Research Natural Areas, Areas of Critical

Environmental Concern, others areas of special protective designations, or private ownership designated for conservation purposes.

Rationale: Productive forest types have a higher likelihood of being managed for timber production than unproductive types, and, hence, future logging poses a future risk to aquatic habitats and fishes(Eaglin and Hubert 844-46). Areas with hard metal claims pose a future risk to mining impacts than areas without claims. Claims indicate areas with potential for hard mineral mining, and mining can impact aquatic habitats and fishes (Rahn et al. 38-53).

Data Sources: Timber management potential identifies productive forest types using the existing vegetation type in the Landfire dataset.(USFS) The number of mining claims was determined using Bureau of Land Management data(Hyndman and Campbell), and each claim was assumed to potentially impact 20 acres. Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas(ESRI) and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset(USDA Forest Service).

Indicator: 3. Energy Development.

Indicator Scoring:

Leases or reserves	**New Dams 4th**	**New Dams 6th**	**CSI Score**
51-100%	≥0	≥1	1
26 – 50%	3		2
11 – 25%	2		3
1 – 10%	1		4
0%	0		5

Score for worst case

Explanation: The acreage of oil, gas, and coal reserves; geothermal or wind development areas; and the number of dam sites located for potential development outside of protected areas within each subbasin and subwatershed.

Rationale: Increased resource development will increase road densities, modify natural hydrology, and increase the likelihood of pollution to aquatic systems. Changes in natural flow regimes associated with dams are likely to reduce habitat suitability for native salmonids and increase the likelihood of invasion by non-native species.(Fausch 685-701) If lands are protected then the watersheds will be less likely to be developed.

Data Sources: Wind resources ("Good" and better) from Wind Powering America/National Renewable Energy Lab (NREL).(Wind Powering America and National Renewable Energy Laboratory) Coal leases are mineable types from the Coal Fields of the United States dataset.(USGS) Geothermal known and closed lease areas and oil and gas leases and agreements from BLM Geocommunicator. [*](USBLM)   Potential dam sites are based on Idaho National Laboratory (INL) hydropower potential data(INL). Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas(ESRI) and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset(USDA Forest Service).

Indicator: 4. Climate change.

Indicator Scoring:

TU Climate Change Analysis	
Climate Risk Factors	**CSI Score**
High, Any., Any	1
Mod., Mod., Mod.	2
Mod., Mod., Low	3
Low, Low, Mod.	4
Low, Low, Low	5

Explanation: Climate change is based on TU Climate Change analysis, which focuses on 3 identified risk factors related to climate change:

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[*] Several geospatial data types are available from Geocommunicator, and they have the following definitions:

Lease: Parcel leased for oil and gas production.

Agreement: An 'agreement' between operator and host (private or public) to evaluate geological, logistic, geophysical, etc issues involving a concession. The agreement essentially allows a technical evaluation of lease feasibility.

Unit Agreements: Multiple entities go in collectively on an agreement. Implied: there are limits to the number of agreements that one individual entity can have outstanding, and a unit agreement allows them to get around the limit.

Communitization: Combining smaller federal tracts to meet the necessary minimum acreage required by the BLM (for spacing purposes).

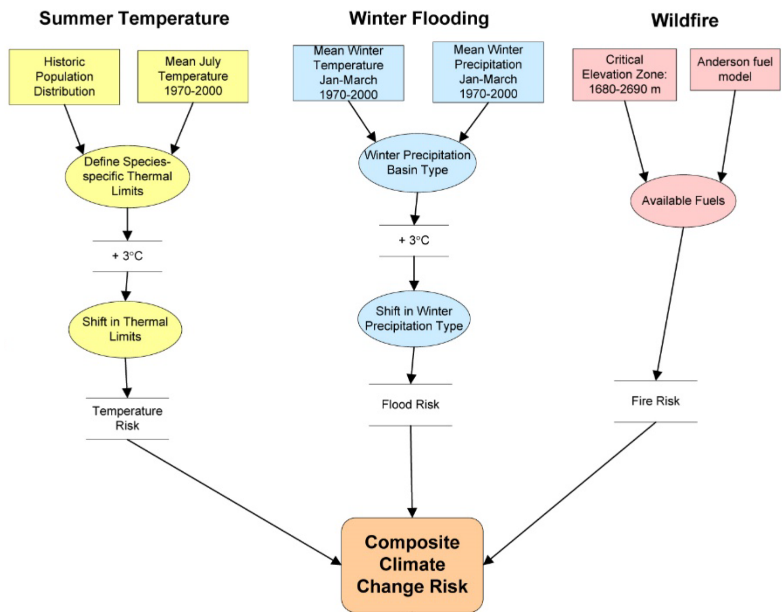
Authorized: Bid on and sold lease or authorization, ready for production.

Lease Sale Parcel: Parcel slated for auction but not yet sold.

Closed: Not retired, just expired and may become available and open to resubmittal.

Other Agreements: Catch-all for other agreement types.

a. Increased Summer Temperature: loss of lower-elevation (higher-stream order) habitat impacts temperature sensitive species
b. Uncharacteristic Winter Flooding: rain-on-snow events lead to more and larger floods
c. Uncharacteristic Wildfire: earlier spring snowmelt coupled with warmer temperatures results in drier fuels and longer burning, more intense wildfire



Each of the three factors is ranked as low, moderate, or high. Increased summer temperature due to climate change was modeled as a 3°C increase. Uncharacteristic winter flooding can result from basins transitioning from snow dominated to rain-on-snow dominated with increased winter flooding. Uncharacteristic wildfires result from changes in climate and fire fuels.

Rationale: Climate change is likely to threaten most salmonid populations because of warmer water temperatures, changes in peak flows, and increased frequency and intensity of disturbances such as floods and wildfires.(Williams et al. 533-48;Williams et al. 236-46) A 3°C increase in summer temperature has the potential to impact coldwater species occupying habitat at the edge of their thermal tolerance. Increased winter flooding can cause local populations to be extirpated. Wildfire can change aquatic habitats, flow regimes, temperatures, and wood inputs that are important to salmonids.(Dunham et al. 183-96) Drought is expected to reduce water availability(Hoerling and Eischeid 18-19,35;Westerling et al. 940-43) and the availability of aquatic habitat. These risks are further discussed by Williams et al.(Williams et al. 533-48)

Data Sources: Temperature and precipitation data were obtained from the PRISM Group.(PRISM Group) Elevation data was obtained from the National Elevation Dataset,(USGS) and LANDFIRE data for the Anderson Fire Behavior Fuel Model 13(USFS) was used as input for wildfire risk. The Palmer Drought Severity Index was used for drought risk(Palmer -58), but was adjusted for elevation (elevations above 2690 have lower risk(Westerling et al. 940-43)) and the deviation from mean annual precipitation (areas with more precipitation on average have lower risk).

Indicator: 5. Introduced species.

Indicator Scoring:

Road Density	CSI Score
>4.7	1
3.7 – 4.7	2
2.7 – 3.7	3
1.7 – 2.7	4
<1.7	5

Explanation: The presence of introduced, injurious species in a subbasin and subwatershed and road density. Road density is the length of road per subwatershed, and represents the potential for future introduction of species not native to the basin.

Rationale: Introduced species are likely to reduce native salmonid populations through predation, competition, hybridization, and the introduction of non-native parasites and pathogens(Fausch et al. -44). In the absence of data on presence of non-native species, road density can be used as a surrogate for risk of non-native fish introductions by purpotrators(Rahel 431-43).

Data Sources: Information on presence of introduced species from Lahontan Cutthroat Trout 5-Year Review: Summary and Evaluation, U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office. Reno, Nevada, March 30, 2009. Roads from ESRI/TeleAtlas.

Reference List

Bascompte, J., H. Possingham, and J. Roughgarden. "Patchy populations in stochastic environments: critical number of patches for persistence." The American Naturalist 159 (2002): 128-37.

Benke, Arthur C. "A perspective on America's vanishing streams." Journal of the North American Benthological Society 9.1 (1990): 77-88.

Colyer, Warren T., Jeffrey L. Kershner, and Robert H. Hilderbrand. "Movements of fluvial Bonneville cutthroat trout in the Thomas Fork of the Bear River, Idaho-Wyoming." North American Journal of Fisheries Management 25 (2005): 954-63.

Davies-Colley, R. J. and D. G. Smith. "Turbidity, suspended sediment, and water clarity: a review." Journal of the American Water Resources Association 37.5 (2001): 1085-101.

Dunham, J. B., et al. "Effects of fire on fish populations: landscape perspectives on persistence of native fishes and nonnative fish invasions." Forest Ecology and Management 178 (2003): 183-96.

Eaglin, Gregory S. and Wayne A. Hubert. "Effects of logging and roads on substrate and trout in streams of the Medicine Bow National Forest, Wyoming." North American Journal of Fisheries Management 13 (1993): 844-46.

ESRI. Protected areas (1:100,000). 2004. Redlands, California, U.S. Tele Atlas North America, Inc. / Geographic Data Technology, Inc., ESRI.
Ref Type: Catalog

ESRI. US MapData Places (2000 TIGER). [1998 - 2002]. 2005. Redlands, CA, ESRI.
Ref Type: Catalog

Fausch, K. D. "A paradox of trout invasions in North America." Biological Invasions 10.5 (2008): 685-701.

Fausch, Kurt D., Rieman, Bruce E., Young, Michael K., and Dunham, Jason B. Stategies for conserving native salmonid populations at risk from nonnative fish invasions: tradeoffs in using barriers to upstream movement. General Technical Report RMRS-GTR-174, -44. 2006. Fort Collins, Colorado, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
Ref Type: Report

Harig, Amy L., Kurt D. Fausch, and Michael K. Young. "Factors influencing success of greenback cutthroat trout translocations." North American Journal of Fisheries Management 20 (2000): 994-1004.

Hoerling, M. P. and J. Eischeid. "Past peak water in the Southwest." Southwest Hydrology 6 (2007): 18-19,35.

Hyndman, P. C. and Campbell, H. W. BLM mining claim recordation system: mining claim density. 1996. Fort Collins, Colorado, Open-File Report 99-325. Natural Resource Ecology Labaoratory, U.S. Geological Survey.
Ref Type: Catalog

IDEQ. Streams of Idaho: 305(b) & 303(d) integrated report - water quality - 2002. 2002. Boise, Idaho, Idaho Department of Environmental Quality.

Ref Type: Catalog

INL. Hydropower Resource Assessment. 2004. Idaho Falls, Idaho, Idaho National Laboratory.
Ref Type: Catalog

Lee, Danny C. et al. "Broadscale Assessment of Aquatic Species and Habitats." An assessment of ecosystem components in the Interior Columbia Basin and portions of the Klamath and Great Basins: Volume III. Ed. T. M. Quigley and S. J. Arbelbide. Portland, Oregon: USDA Forest Service, General Technical Report PNW-GTR-405, 1997. 1057-496.

Lloyd, Denby S. "Turbidity as a water quality standard for salmonid habitats in Alaska." North American Journal of Fisheries Management 7.1 (1987): 34-45.

May, Bruce E. and Albeke, S. Range-wide status of Bonneville cutthroat trout (*Oncorhynchus clarki utah*): 2004. Bonneville Cutthroat Trout Status Update Interagency Coordination Workgroup, Publication Number 05-02, -139. 2005. Salt Lake City, Utah, Utah Division of Wildlife Resources.
Ref Type: Report

Palmer, W. C. Meteorological drought. Research Paper No. 45, -58. 1965. U.S. Weather Bureau.
Ref Type: Report

Peterson, Douglas P., et al. "Analysis of trade-offs between threats of invasion by nonnative brook trout (*Salvelinus fontinalis*) and intentional isolation for native westslope cutthroat trout (*Oncorhynchus clarkii lewisi*)." Canadian Journal of Fisheries and Aquatic Sciences 65 (2008): 557-73.

Poff, N. LeRoy, et al. "The natural flow regime." BioScience 47.11 (1997): 769-84.

PRISM Group. PRISM 800m Normals (1971 - 2000). [1972 - 2000]. 2008. Corvallis, Oregon, Oregon State University.
Ref Type: Catalog

Rahel, Frank J. "Unauthorized Fish Introductions: Fisheries Management of the People, for the People, or by the People." Propagated fish in resource management. Ed. Mary J. Nickum et al. 44 ed. Bethesda, Maryland: American Fisheries Society Symposium 44, 2004. 431-43.

Rahn, P. H., et al. "Water quality impacts from mining in the Black Hills, South Dakota, USA." Environmental Geology 27.1 (1996): 38-53.

Rieman, Bruce E., Lee, Danny C., McIntyre, John D., Overton, K., and Thurow, Russell. Consideration of extinction risks for salmonids. Fish habitat relationships technical bulletin, Number 14. 1993. Logan, Utah, US Department of Agriculture, Forest Service.
Ref Type: Report

Roberts, James J. and Frank J. Rahel. "Irrigation canals as sink habitat for trout and other fishes in a Wyoming drainage." Transactions of the American Fisheries Society 137 (2008): 951-61.

Schrank, Amy J. and Frank J. Rahel. "Movement patterns in inland cutthroat trout (*Oncorhynchus clarki utah*): management and conservation implications." Canadian Journal of Fisheries and Aquatic Sciences 61 (2004): 1528-37.

Shepard, Bradley B., Ron Spoon, and Lee Nelson. "A native westslope cutthroat trout population responds positively after brook trout removal and habitat restoration." Intermountain Journal of Sciences 8.3 (2002): 191-211.

Soule, M. E. Where Do We Go From Here? Viable Populations for Conservation. Cambridge, England: Cambridge University Press, 1987.

Stephens, Scott E., et al. "Predicting risk of habitat conversion in native temperate grasslands." Conservation Biology 22.5 (2008): 1320-30.

USACE. National Inventory of Dams. 2008. U.S. Army Corps of Engineers.

Ref Type: Catalog

USBLM. Geocommunicator. 2008. USBLM and USFS.

Ref Type: Catalog

USDA Forest Service. National inventoried roadless areas (IRAs). 2008. Salt Lake City, Utah, Geospatial Service and Technology Center, U.S. Department of Agriculture, Forest Service.

Ref Type: Catalog

USEPA and USGS. National Hydrography Dataset Plus - NHDPlus (1:100,000 scale). 2005. Sioux Falls, South Dakota, U.S. Environmental Protection Agency and U.S. Geological Survey.

Ref Type: Catalog

USFS. LANDFIRE. [Rapid Refresh]. 2008. Wildland Fire Leadership Council and U.S. Forest Service.

Ref Type: Catalog

USGS. National Land Cover Database. 2001. Sioux Falls, South Dakota, U.S. Geological Survey.

Ref Type: Catalog

USGS. Land Ownership in Western North America, 180 m. [1986-2003]. 2004. Boise, Idaho, Sage-grouse rangewide conservation assessment, Snake River Field Station, U.S. Geological Survey.

Ref Type: Catalog

USGS. Mineral Resources Data System (MRDS) (Active). [2005]. 2008. Reston, Virginia, U.S. Geological Survey.

Ref Type: Catalog

USGS. National Elevation Dataset (30m) (1:24,000). 2008. Sioux Falls, SD, USGS EROS Data Center.

Ref Type: Catalog

USGS. Coal Fields of the United States. 2009. Reston, VA, USGS Eastern Energy Team, National Atlas of the United States.

Ref Type: Catalog

Waters, Thomas F. Sediment in Streams: Sources, Biological Effects, and Control. Bethesda, Maryland: American Fisheries Society Monograph 7, 1995, 1-251.

Westerling, A. L., et al. "Warming and earlier spring increases western U.S. forest wildfire activity." Science 313 (2006): 940-43.

White, Seth M. and Frank J. Rahel. "Complementation of habitats for Bonneville cutthroat trout in watersheds influenced by beavers, livestock, and drought." Transactions of the American Fisheries Society 137 (2008): 881-94.

Williams, Jack E., et al. "The Conservation Success Index: synthesizing and communicating salmonid condition and management needs." Fisheries 32.10 (2007): 477-92.

Williams, Jack E., et al. "Potential consequences of climate change to persistence of cutthroat trout populations." North American Journal of Fisheries Management 29 (2009): 533-48.

Williams, Jack E. et al. "Climate Change and Western Trout: Strategies for Restoring Resistance and Resilience in Native Populations." Wild Trout IX: Sustaining wild trout in a changing world. Ed. Robert F. Carline and C. LoSapio. Bozeman, Montana: Wild Trout Symposium, 2007. 236-46.

Wind Powering America and National Renewable Energy Laboratory. Wind Resource Potential. 2003. National Renewable Energy Laboratory, USDOE.
Ref Type: Catalog

Young, Michael K. Conservation assessment for inland cutthroat trout. General Technical Report RM-GTR-256. 1995. Fort Collins, Colorado, U.S. Forest Service.
Ref Type: Report