Conservation Success Index: Bonneville Cutthroat Trout

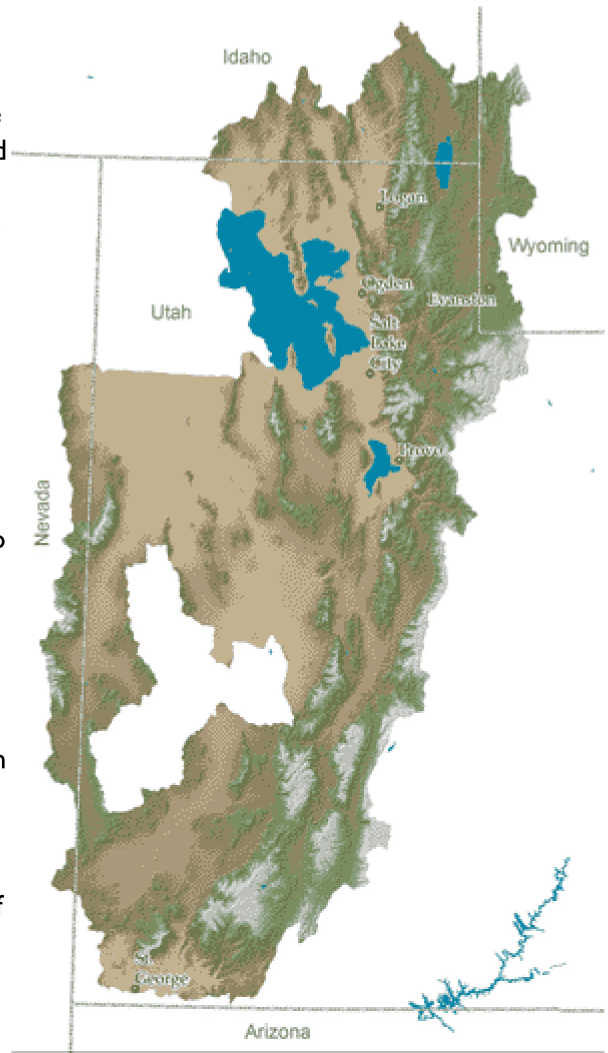
ONCORHYNCHUS CLARKII UTAH

Rev. 1.0 - 10/2010

SPECIES SUMMARY

Once thought to be extinct, Bonneville cutthroat trout (BCT) were rediscovered in recent decades and relatively pure populations continue to persist along the periphery of the Bonneville Basin in Utah, Idaho, Wyoming, and Nevada. BCT evolved in ancient Lake Bonneville and its tributaries during the Pleistocene period, after the Bear River was diverted from the Snake River drainage into the Great Basin by a massive lava flow. The subspecies now occupies only a portion of its historic range and was unsuccessfully petitioned for listing under the ESA in 1998. BCT is currently considered a species of special management concern in all of the states where it is found.

Historic Range Relief Map

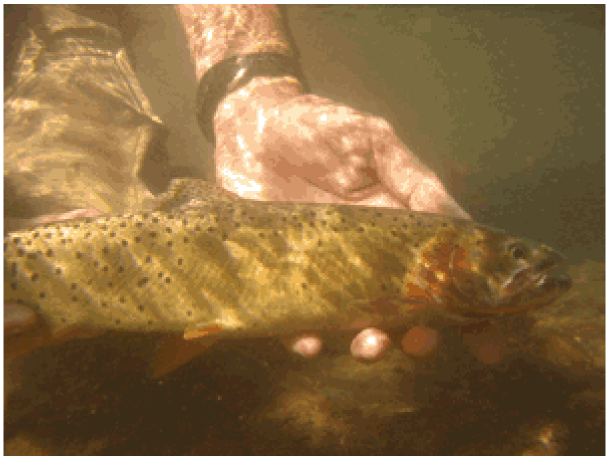


Like Lahontan cutthroat trout, BCT have adapted to survive in relatively warm water and marginal habitats, and migratory life forms historically grew to be quite large in lakes and large rivers. Some populations within the Bear River drainage in southern Idaho and northern Utah continue to exhibit the species' impressive range of life history strategies and habitat requirements, migrating seasonally between turbid, lower elevation mainstem rivers and cold, clear, high elevation tributary streams. These adaptations, along with their unique ability to persist in the presence of non-native salmonids, make the conservation and restoration of this species a priority.

Key CSI Findings

- Life history diversity and habitat and population connectivity are greatest in the upper Bear and Weber River drainages

- BCT populations are vulnerable to future climate change
- General conservation priorities are protection in higher elevation northern subwatersheds, restoration in lower elevation northern subwatersheds, and reintroduction in southern subwatersheds

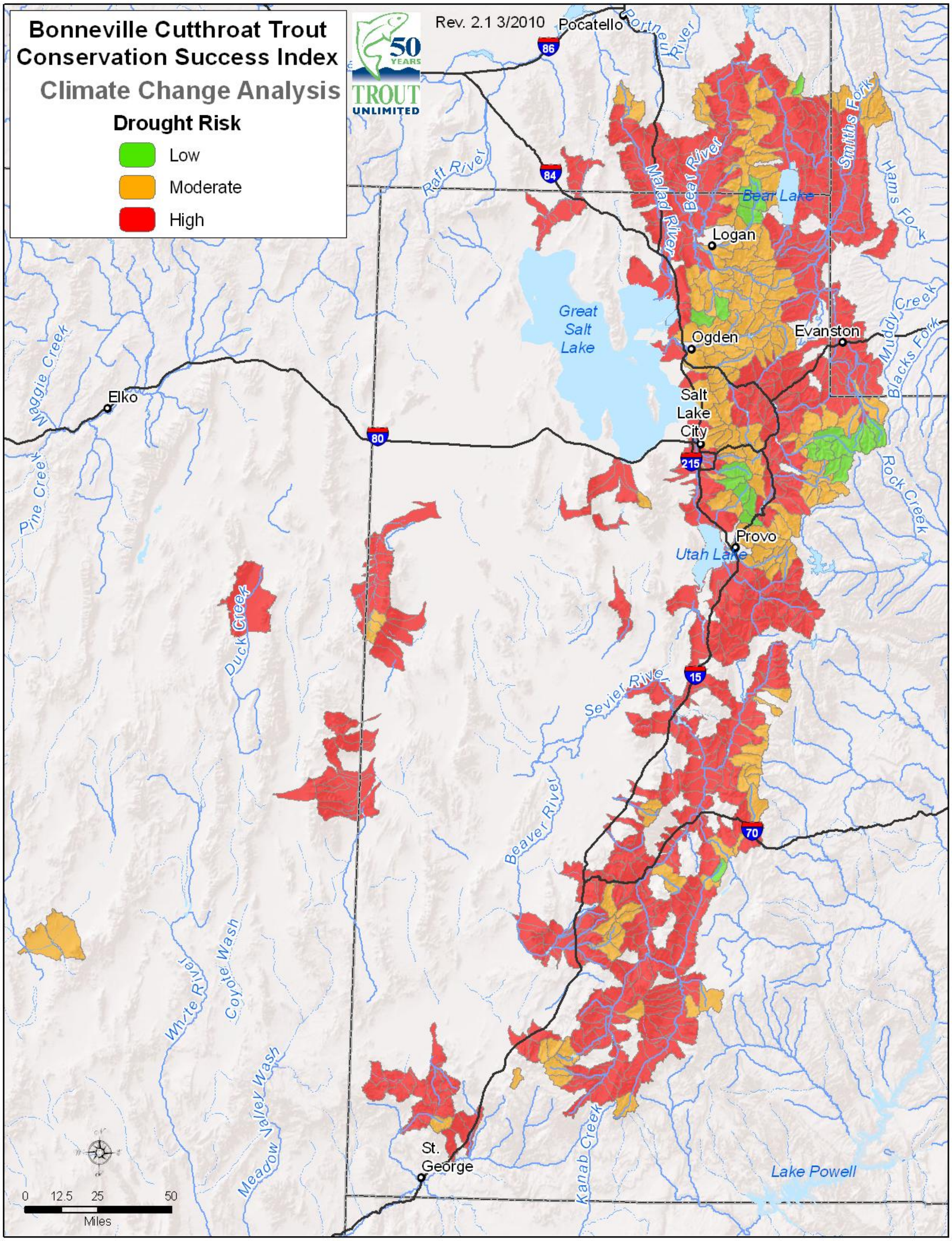


According to the Range-Wide Status Assessment for BCT the subspecies occupies only about 35% of its historic range in the Bonneville Basin. However, 97% of occupied subwatersheds scored in the top two categories for CSI Range-Wide Conditions, suggesting that BCT populations are well distributed within the subwatersheds where they remain. Total CSI scores for BCT were moderate to high, with 90% of occupied subwatersheds scoring in the top three categories but only 13% scoring in the top category (80-100 out of 100). Scores and distribution maps reflect a pattern of range constriction towards higher elevations and northern latitudes that has been relatively common among cutthroat trout subspecies across the West. Most of the historically occupied subwatersheds in the southern range of BCT no longer support extant populations.

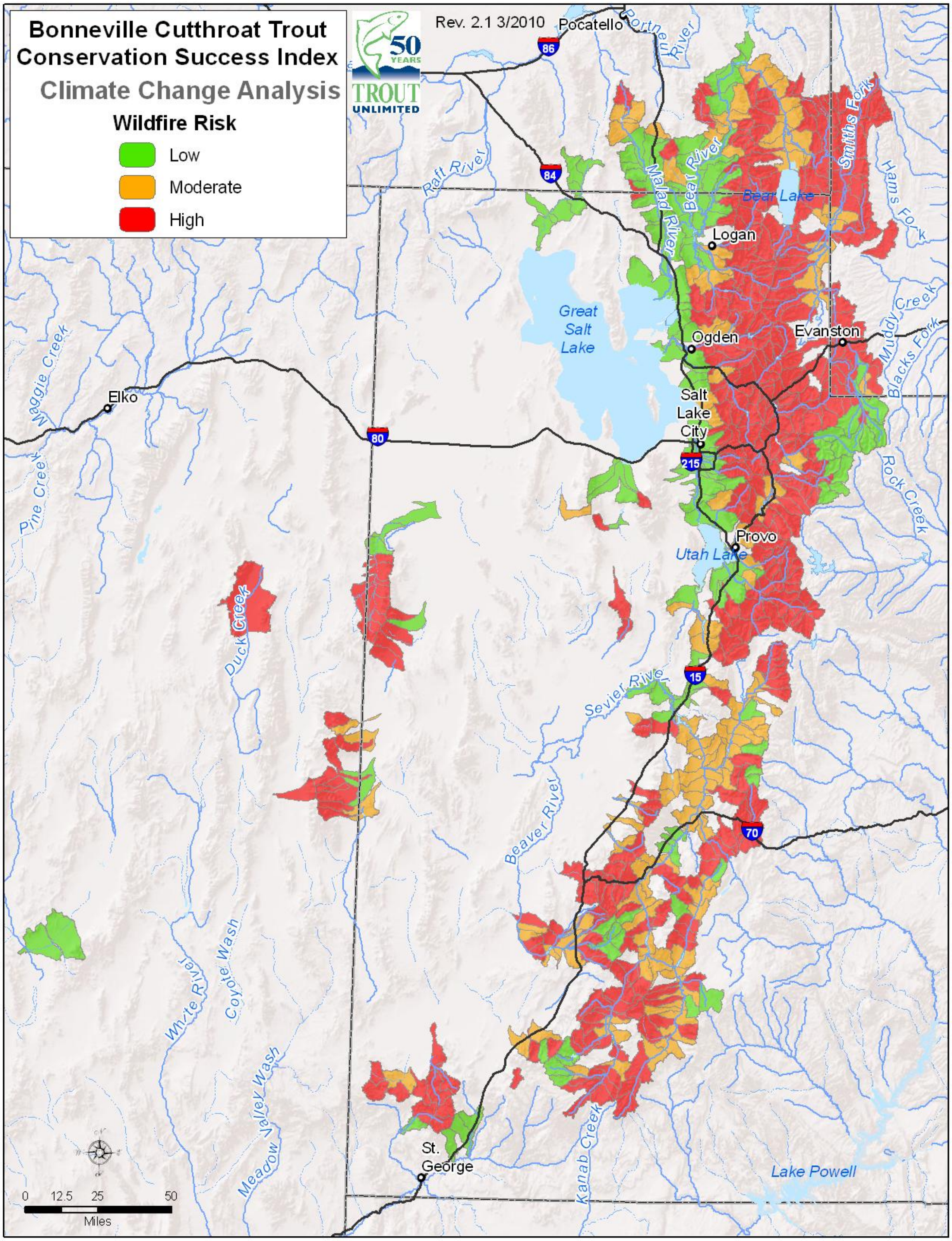
Population and Habitat Integrity scores are highest for subwatersheds in the upper Weber and Bear River drainages, largely due to the presence of connected habitats and life history diversity in those two systems. Life history diversity, in fact, appears to be the greatest limiting factor in the overall Population Integrity scores for the subspecies, with a median score of 1 out of 5 across occupied subwatersheds. The greatest limiting factor for BCT habitat is land stewardship. The median score for land stewardship in occupied subwatersheds is 1, reflecting the fact that most BCT populations are located on unprotected public and private lands.

Future Security scores across subwatersheds suggest that the greatest future threat to BCT might be climate change, as the subspecies is somewhat isolated in a desert basin and will have limited access to higher elevation refugia if lower elevation habitats warm up or dry out. As such, conservation actions should focus on protecting connected habitats and life history diversity in the northern range, and restoring connectivity and reintroducing BCT populations in lower elevation habitats and throughout the southern range.

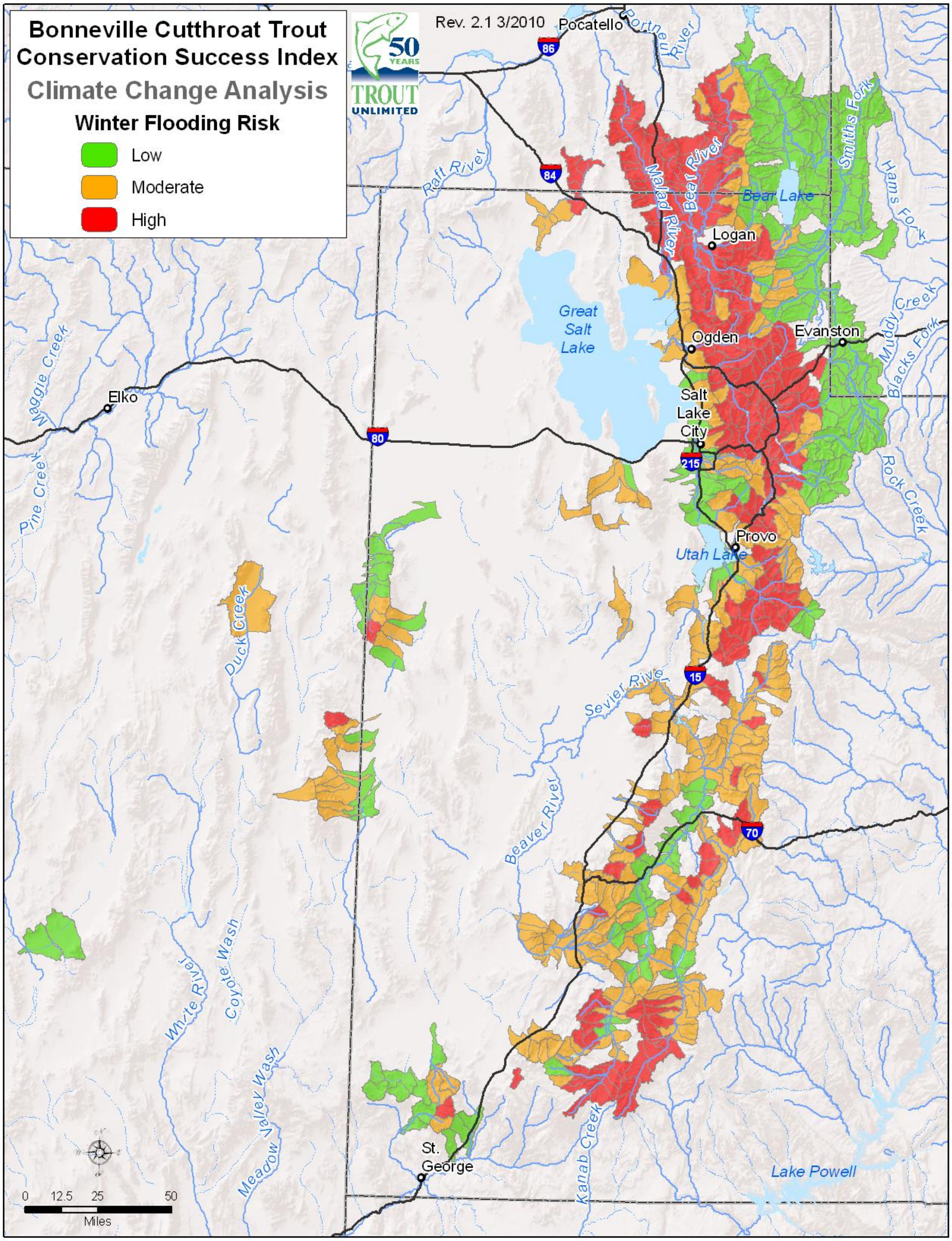
Prepared by Warren T. Colyer, TU, 11/29/06



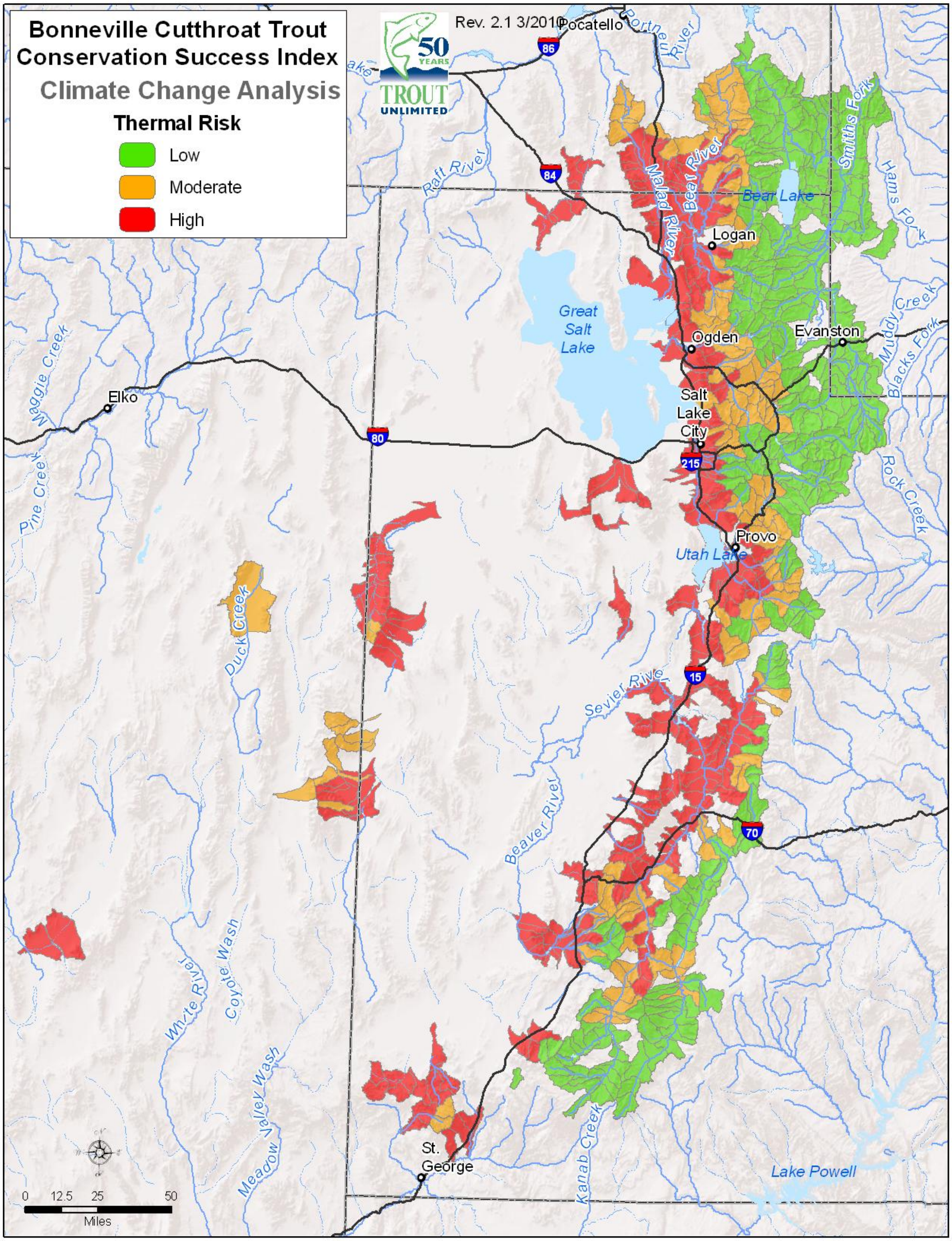
Bonneville Cutthroat Trout
Conservation Success Index
Climate Change Analysis
Drought Risk
Low
Moderate
High
50 YEARS
TROUT UNLIMITED
Rev. 2.1 3/2010
Pocatello
Portneuf River
86
Raft River
84
Malad River
Bear River
Smiths Fork
Hams Fork
Bear Lake
Logan
Great Salt Lake
Ogden
Evanston
Muddy Creek
Blacks Fork
Salt Lake City
215
Elko
Maggie Creek
80
Pine Creek
Rock Creek
Provo
Utah Lake
Duck Creek
15
Sevier River
Beaver River
70
White River
Coyote Wash
Meadow Valley Wash
Kanab Creek
St. George
Lake Powell
0 12.5 25 50
Miles



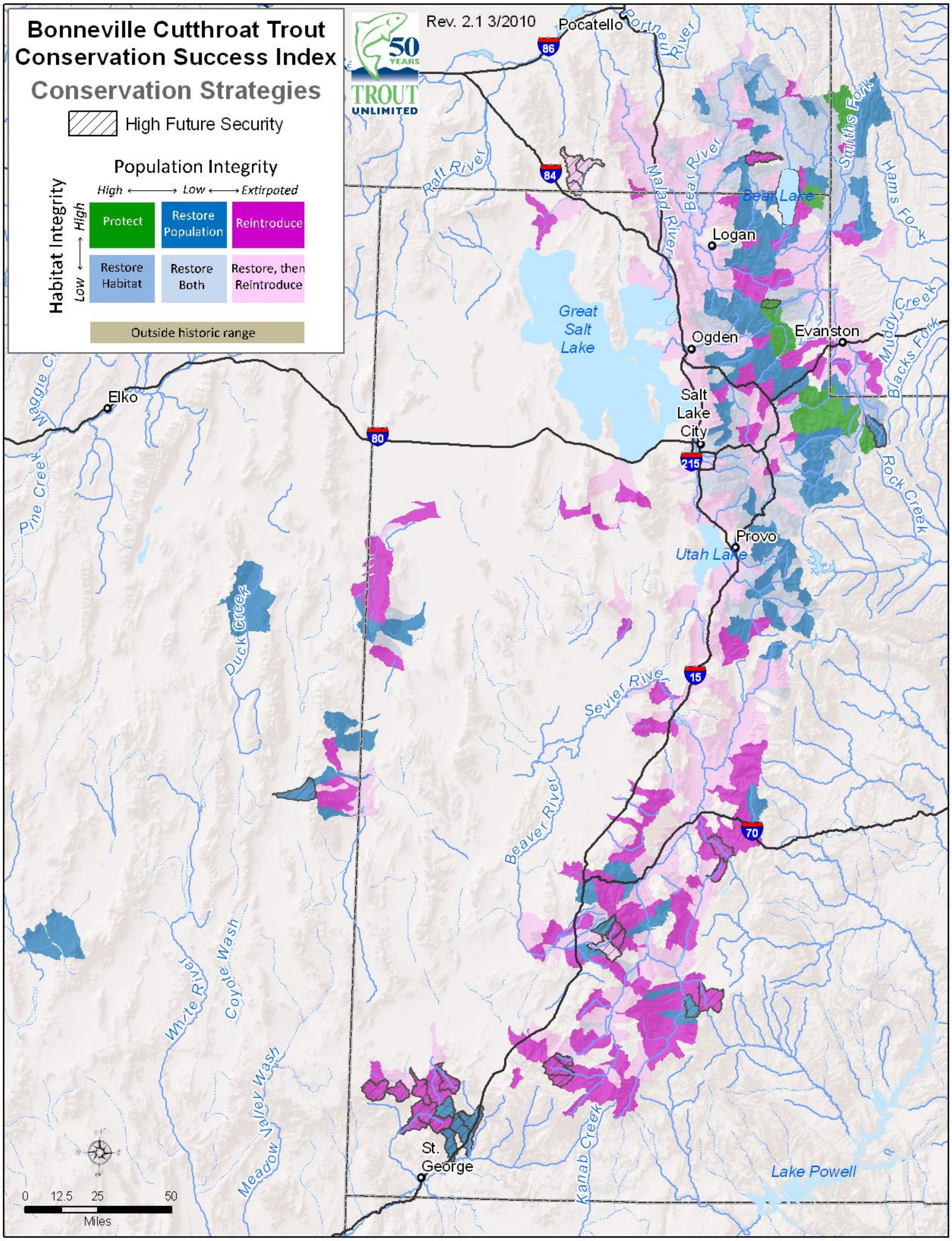
Bonneville Cutthroat Trout
Conservation Success Index
Climate Change Analysis
Wildfire Risk
Low
Moderate
High
50 YEARS
TROUT UNLIMITED
Rev. 2.1 3/2010
Pocatello
Portneuf River
Raft River
Malad River
Bear River
Smiths Fork
Hams Fork
Bear Lake
Logan
Great Salt Lake
Ogden
Evanston
Muddy Creek
Blacks Fork
Salt Lake City
Rock Creek
Provo
Utah Lake
Maggie Creek
Elko
Pine Creek
Duck Creek
Sevier River
Beaver River
White River
Coyote Wash
Meadow Valley Wash
Kanab Creek
St. George
Lake Powell
86
84
80
215
15
70
0 12.5 25 50
Miles

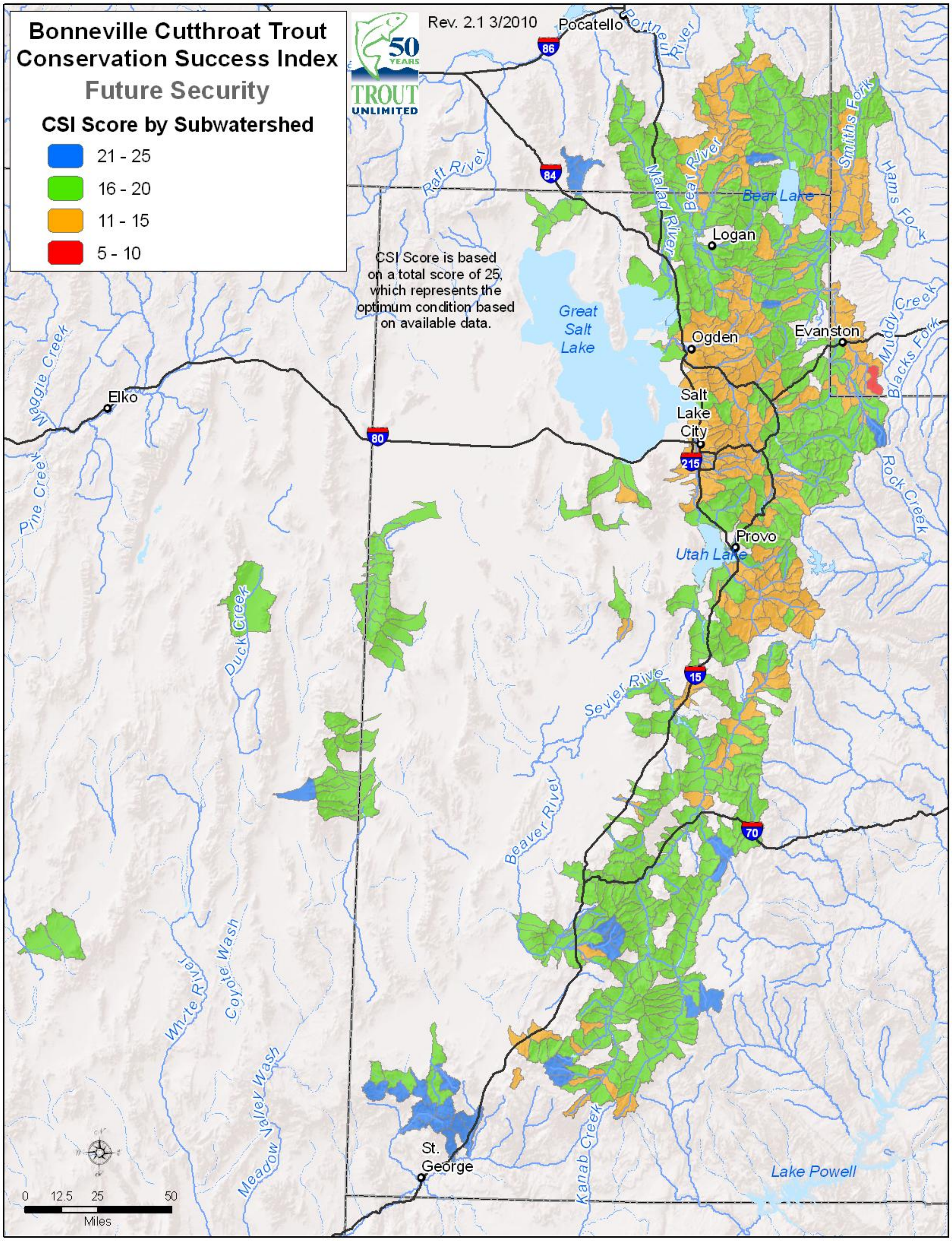


Bonneville Cutthroat Trout
Conservation Success Index
Climate Change Analysis
Winter Flooding Risk
Low
Moderate
High
50 YEARS
TROUT UNLIMITED
Rev. 2.1 3/2010
Pocatello
Portneuf River
86
84
Raft River
Malad River
Bear River
Bear Lake
Smiths Fork
Hams Fork
Logan
Great Salt Lake
Ogden
Evanston
Muddy Creek
Blacks Fork
Maggie Creek
Elko
80
Salt Lake City
215
Rock Creek
Pine Creek
Provo
Utah Lake
Duck Creek
15
Sevier River
Beaver River
70
White River
Coyote Wash
Meadow Valley Wash
Kanab Creek
St. George
Lake Powell
0
12.5
25
50
Miles

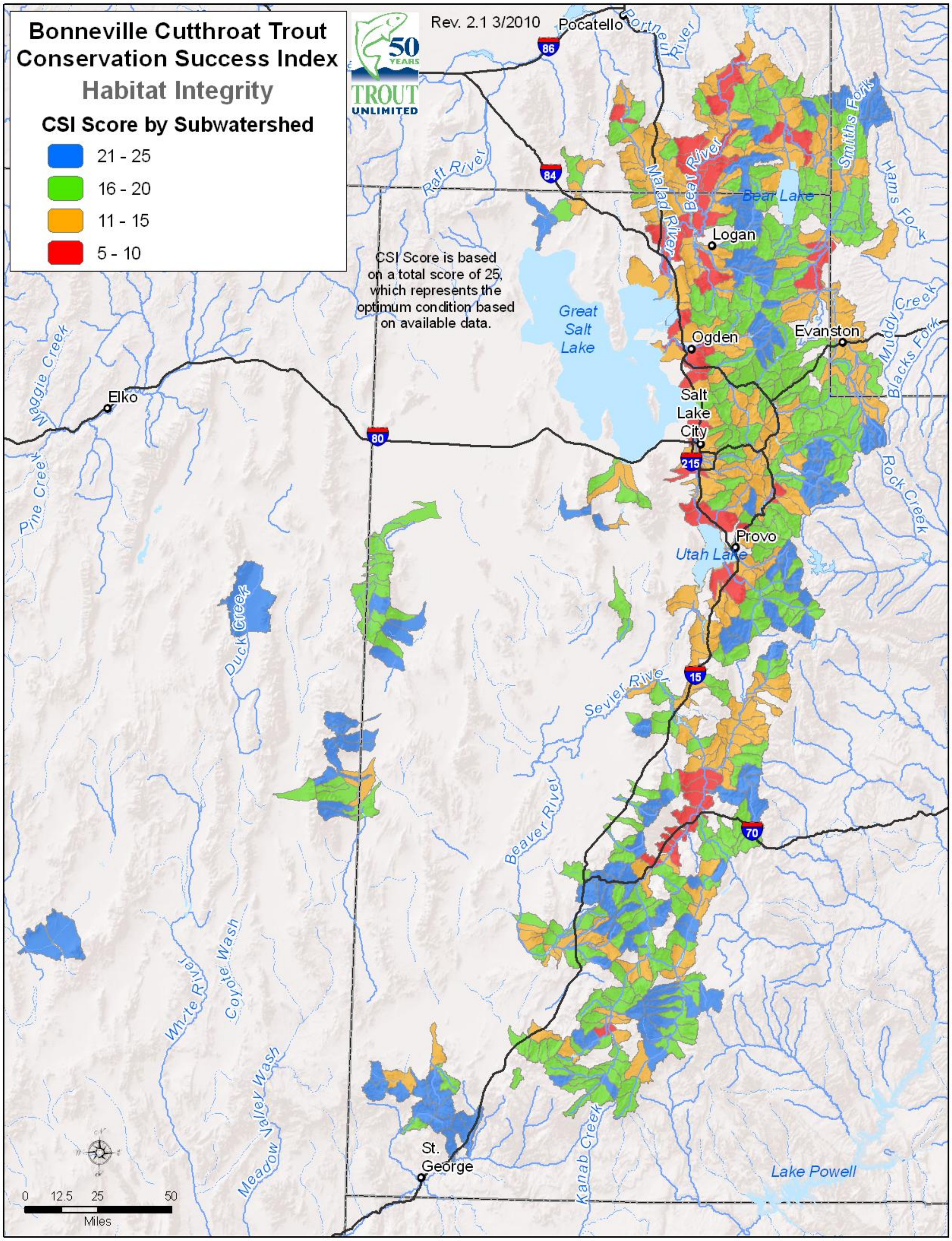


Bonneville Cutthroat Trout
Conservation Success Index
Climate Change Analysis
Thermal Risk
Low
Moderate
High
Rev. 2.1 3/2010
50 YEARS
TROUT UNLIMITED
Pocatello
Portneuf River
Raft River
Malad River
Bear River
Bear Lake
Smiths Fork
Hams Fork
Logan
Great Salt Lake
Ogden
Evanston
Muddy Creek
Blacks Fork
Salt Lake City
Elko
Maggie Creek
Pine Creek
Rock Creek
Provo
Utah Lake
Duck Creek
Sevier River
Beaver River
White River
Coyote Wash
Meadow Valley Wash
Kanab Creek
St. George
Lake Powell
0 12.5 25 50
Miles

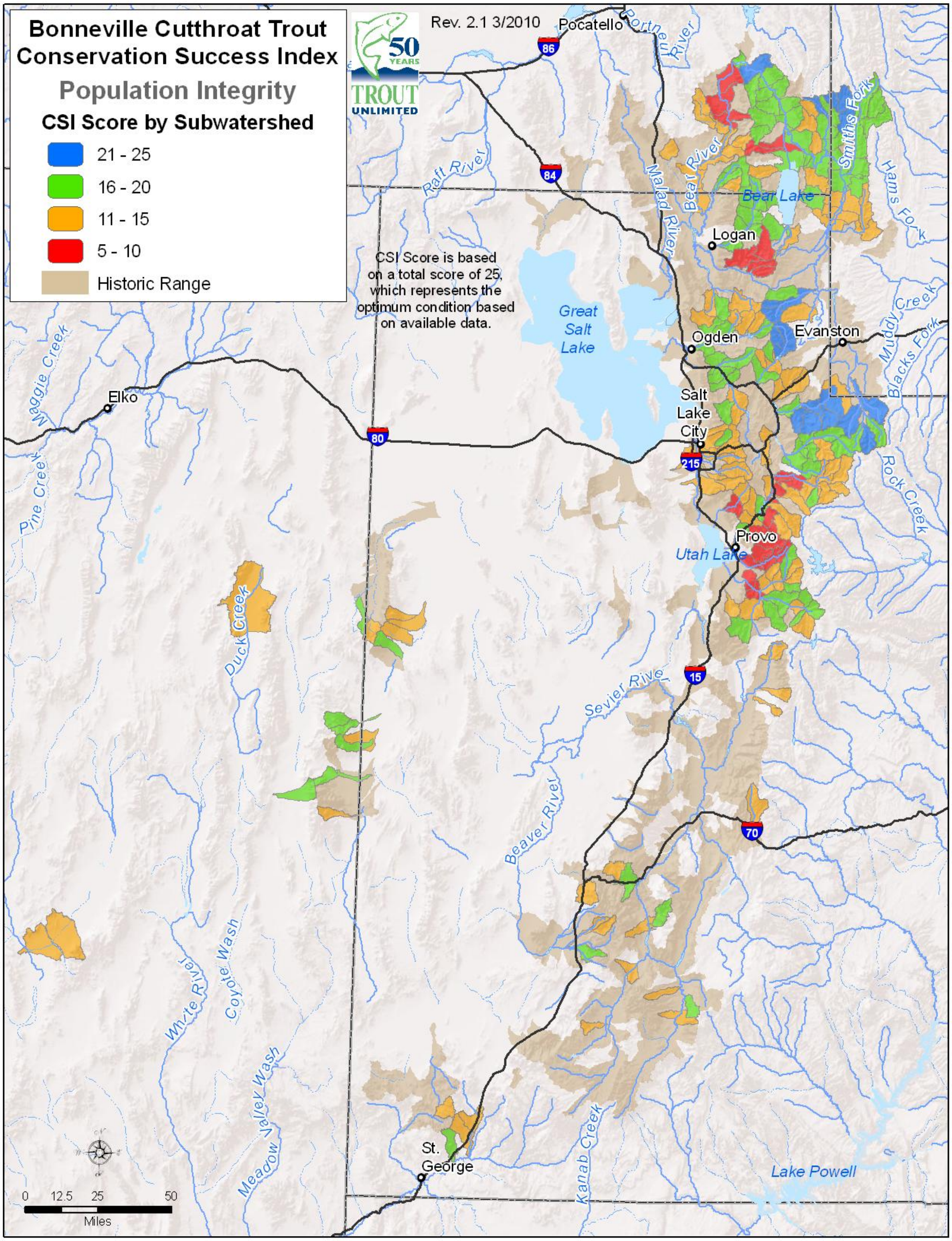

Bonneville Cutthroat Trout
Conservation Success Index
Conservation Strategies
High Future Security
Population Integrity
High ⟷ Low ⟷ Extirpated
Habitat Integrity
Low ⟷ High
Protect
Restore Population
Reintroduce
Restore Habitat
Restore Both
Restore, then Reintroduce
Outside historic range
Rev. 2.1 3/2010
50 YEARS
TROUT UNLIMITED
Pocatello
Portneuf River
Raft River
Malad River
Bear River
Bear Lake
Smiths Fork
Hams Fork
Logan
Great Salt Lake
Ogden
Evanston
Muddy Creek
Blacks Fork
Salt Lake City
Elko
Maggie Cr
Pine Creek
Rock Creek
Provo
Utah Lake
Duck Creek
Sevier River
Beaver River
White River
Coyote Wash
Meadow Valley Wash
Kanab Creek
St. George
Lake Powell
86
84
80
215
15
70
0 12.5 25 50
Miles



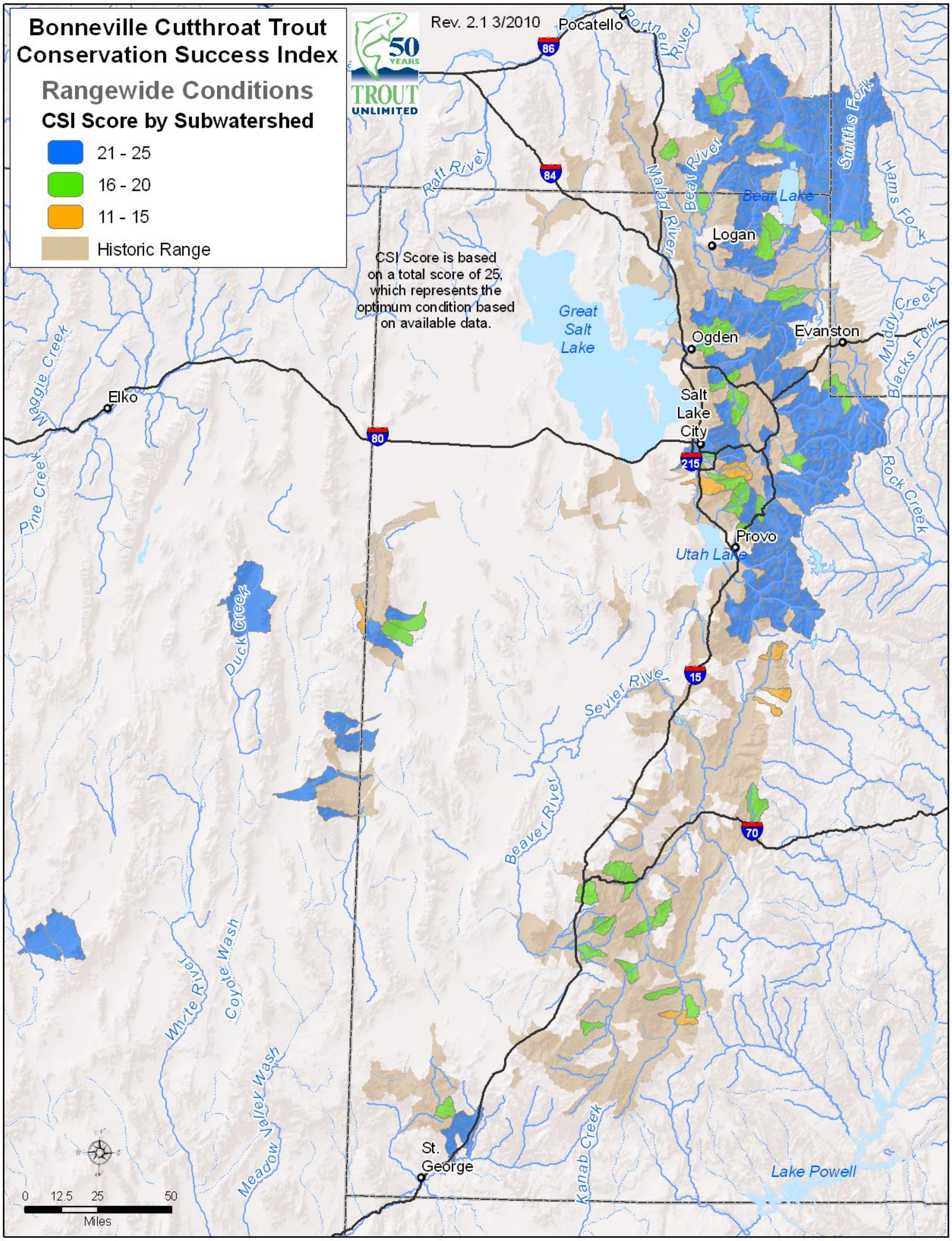
Bonneville Cutthroat Trout
Conservation Success Index
Future Security
CSI Score by Subwatershed
21 - 25
16 - 20
11 - 15
5 - 10
Rev. 2.1 3/2010
50 YEARS
TROUT UNLIMITED
CSI Score is based on a total score of 25, which represents the optimum condition based on available data.
Pocatello
Portneuf River
Raft River
Malad River
Bear River
Smiths Fork
Hams Fork
Bear Lake
Logan
Great Salt Lake
Ogden
Evanston
Muddy Creek
Blacks Fork
Salt Lake City
Elko
Maggie Creek
Pine Creek
Rock Creek
Provo
Utah Lake
Duck Creek
Sevier River
Beaver River
White River
Coyote Wash
Meadow Valley Wash
Kanab Creek
St. George
Lake Powell
0 12.5 25 50
Miles



Bonneville Cutthroat Trout
Conservation Success Index
Habitat Integrity
CSI Score by Subwatershed
21 - 25
16 - 20
11 - 15
5 - 10
50 YEARS
TROUT UNLIMITED
Rev. 2.1 3/2010
CSI Score is based on a total score of 25, which represents the optimum condition based on available data.
Pocatello
Portneuf River
Raft River
Malad River
Bear River
Smiths Fork
Hams Fork
Bear Lake
Logan
Great Salt Lake
Ogden
Evanston
Muddy Creek
Blacks Fork
Salt Lake City
Elko
Maggie Creek
Pine Creek
Rock Creek
Provo
Utah Lake
Duck Creek
Sevier River
Beaver River
White River
Coyote Wash
Meadow Valley Wash
Kanab Creek
Lake Powell
St. George
86
84
80
215
15
70
0 12.5 25 50
Miles



Bonneville Cutthroat Trout
Conservation Success Index
Population Integrity
CSI Score by Subwatershed
21 - 25
16 - 20
11 - 15
5 - 10
Historic Range
Rev. 2.1 3/2010
50 YEARS
TROUT UNLIMITED
CSI Score is based on a total score of 25, which represents the optimum condition based on available data.
Pocatello
Portneuf River
Raft River
Malad River
Bear River
Smiths Fork
Hams Fork
Bear Lake
Logan
Great Salt Lake
Ogden
Evanston
Muddy Creek
Blacks Fork
Salt Lake City
Rock Creek
Provo
Utah Lake
Elko
Maggie Creek
Pine Creek
Duck Creek
Sevier River
Beaver River
White River
Coyote Wash
Meadow Valley Wash
St. George
Kanab Creek
Lake Powell
0 12.5 25 50
Miles


Bonneville Cutthroat Trout
Conservation Success Index
Rangewide Conditions
CSI Score by Subwatershed
21 - 25
16 - 20
11 - 15
Historic Range
50 YEARS
TROUT UNLIMITED
Rev. 2.1 3/2010
CSI Score is based on a total score of 25, which represents the optimum condition based on available data.
Pocatello
Portneuf River
Raft River
Malad River
Bear River
Smiths Fork
Hams Fork
Bear Lake
Logan
Great Salt Lake
Ogden
Evanston
Muddy Creek
Blacks Fork
Salt Lake City
Elko
Maggie Creek
Pine Creek
Rock Creek
Provo
Utah Lake
Duck Creek
Sevier River
Beaver River
White River
Coyote Wash
Meadow Valley Wash
Kanab Creek
St. George
Lake Powell
86
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215
15
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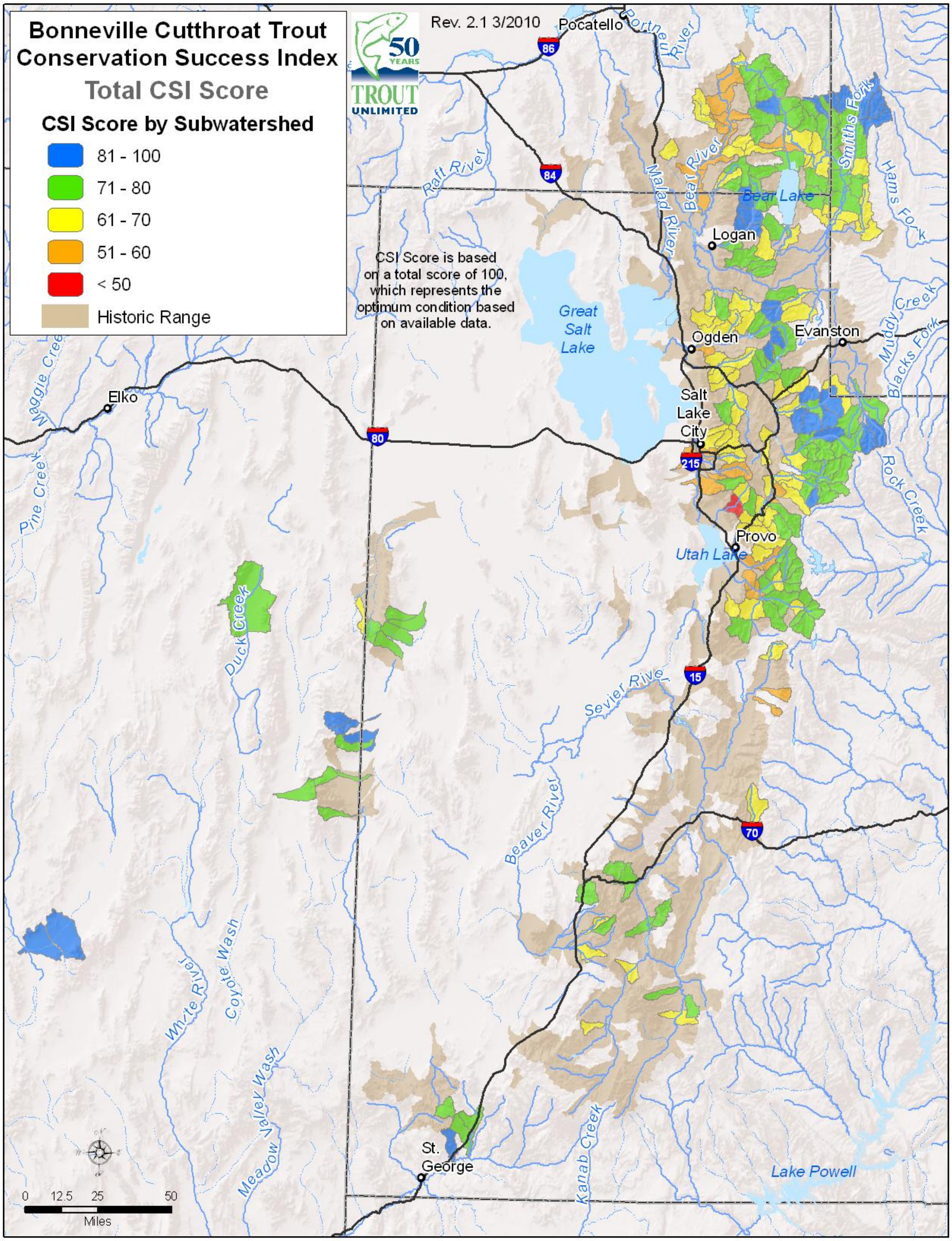
0 12.5 25 50
Miles


Bonneville Cutthroat Trout
Conservation Success Index
Total CSI Score
CSI Score by Subwatershed
81 - 100
71 - 80
61 - 70
51 - 60
< 50
Historic Range
50 YEARS
TROUT UNLIMITED
Rev. 2.1 3/2010
CSI Score is based on a total score of 100, which represents the optimum condition based on available data.
Pocatello
Portneuf River
Raft River
Malad River
Bear River
Smiths Fork
Hams Fork
Bear Lake
Logan
Great Salt Lake
Ogden
Evanston
Muddy Creek
Blacks Fork
Salt Lake City
Rock Creek
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Beaver River
White River
Coyote Wash
Meadow Valley Wash
Kanab Creek
St. George
Lake Powell
0 12.5 25 50
Miles
86
84
80
215
15
70

v. 2.1 March 2010

Conservation Success Index:
Bonneville Cutthroat Trout:
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.

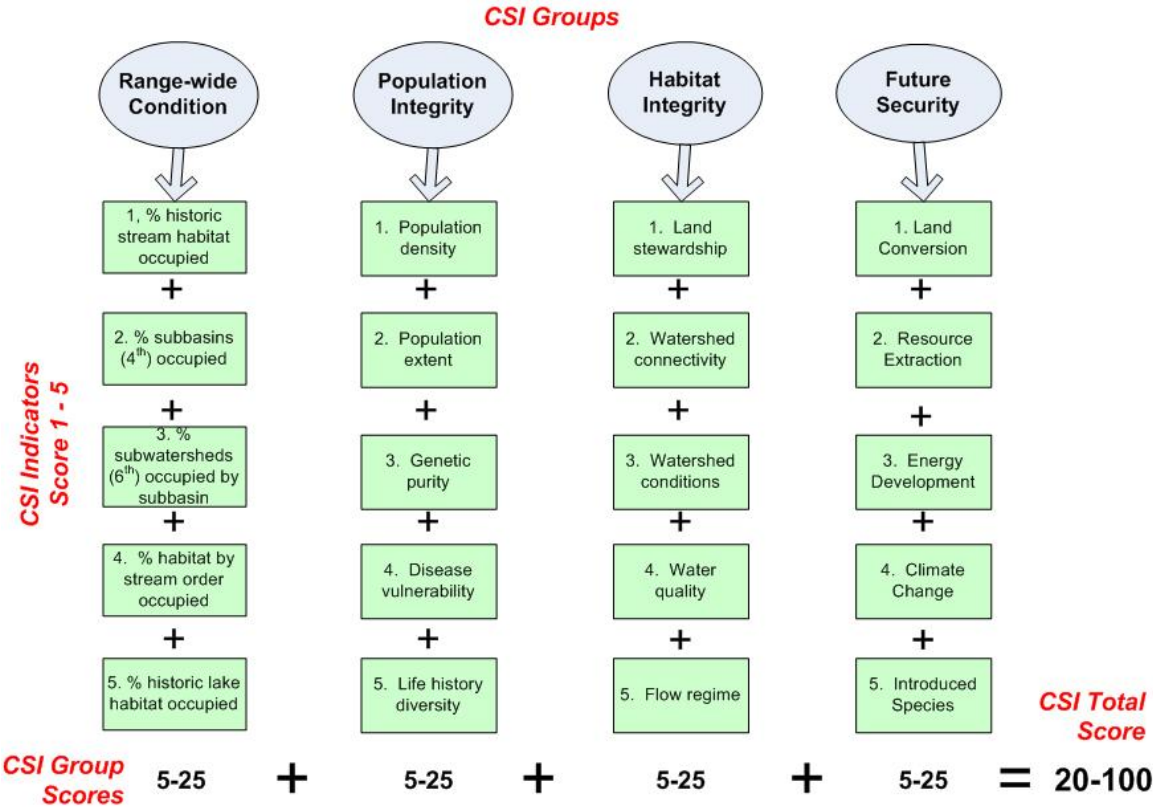

Figure 1. Each subwatershed is scored from 1 to 5 using 20 indicators within four main groups. Indicator scores are added per group to obtain an overall group score. Group scores are then added to obtain a composite CSI score for each subwatershed.

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 habitat 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: Conservation and Sportfishing Management Strategy for Bonneville Cutthroat Trout, Utah Bonneville Cutthroat Trout Conservation Team, April 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: Conservation and Sportfishing Management Strategy for Bonneville Cutthroat Trout, Utah Bonneville Cutthroat Trout Conservation Team, April 2009.
Watershed Boundary Dataset, NRCS.

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: Conservation and Sportfishing Management Strategy for Bonneville Cutthroat Trout, Utah Bonneville Cutthroat Trout Conservation Team, April 2009.
Watershed Boundary Dataset, NRCS.

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: Conservation and Sportfishing Management Strategy for Bonneville Cutthroat Trout, Utah Bonneville Cutthroat Trout Conservation Team, April 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: Conservation and Sportfishing Management Strategy for Bonneville Cutthroat Trout, Utah Bonneville Cutthroat Trout Conservation Team, April 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 or fish/10 acres for lake populations	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: Conservation and Sportfishing Management Strategy for Bonneville Cutthroat Trout, Utah Bonneville Cutthroat Trout Conservation Team, April 2009.
Scoring rules were based, in part, on May and Albeke(May and Albeke -139) and Williams et al.(Williams et al. 477-92).

Indicator: 2. Population extent.

Indicator Scoring:

Degree of Connectedness	CSI Score
Population Isolated	1
Weakly Connected	2
	3
Moderately Connected	4
Strongly Connected	5

Note that a score not represented in the scoring table (3) can exist for a subwatershed, as multiple conservation population scores are length-weighted and summarized by the subwatershed.

Explanation: Population extent 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: Conservation and Sportfishing Management Strategy for Bonneville Cutthroat Trout, Utah Bonneville Cutthroat Trout Conservation Team, April 2009.
Scoring rules were based, in part, on May and Albeke(May and Albeke -139) and Williams et al.(Williams et al. 477-92).

Indicator: 3. Genetic purity.

Indicator Scoring:

Genetic purity (introgression)	CSI Score
< 80%	1
80% - 89%, Not Tested – Hybridized	2
Co-existence	3
90 – 99%	4
Unaltered, Not Tested – Unaltered	5

Explanation: Genetic purity 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: Conservation and Sportfishing Management Strategy for Bonneville Cutthroat Trout, Utah Bonneville Cutthroat Trout Conservation Team, April 2009.

Indicator: 4. Disease vulnerability.

Indicator Scoring:

Disease Vulnerability	CSI Score
Population is Infected	1
Significant Disease Risk	2
Moderate Disease Risk	3
Minimal Disease Risk	4
Limited Disease Risk	5

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: Conservation and Sportfishing Management Strategy for Bonneville Cutthroat Trout, Utah Bonneville Cutthroat Trout Conservation Team, April 2009.

Indicator: 5. Life history diversity.

Indicator Scoring:

Conservation population	CSI Score
One life history form present: Resident only	1
	2
Two life histories present: Fluvial and Resident with historically connected, downstream lakes but no current adfluvial forms	3
	4
Two or three life histories present: Fluvial and resident with no historic downstream lake populations; Any combination with Adfluvial present	5

Note that a score not represented in the scoring table (2, 4) can exist for a subwatershed, as multiple conservation population scores are length-weighted and summarized by the subwatershed.

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: Conservation and Sportfishing Management Strategy for Bonneville Cutthroat Trout, Utah Bonneville Cutthroat Trout Conservation Team, April 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 occupied 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

*If subwatershed only contains currently unoccupied habitat then scores are based only on subwatershed protection: <25% =1; 25 – 50%=3; >50%=5.

Explanation: The percent of occupied 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.

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 4th:

- >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 Conservation and Sportfishing Management Strategy for Bonneville Cutthroat Trout, Utah Bonneville Cutthroat Trout Conservation Team, April 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.

Explanation: The percentage of converted lands in the subwatershed, road density.

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 calculated for the subwatershed. Riparian vegetation was determined using the National Land Cover Database(USGS), using Woody Wetlands, Emergent Herbaceous Wetlands, Deciduous Forest, Evergreen Forest, and Mixed Forest land cover classes.

Indicator: 4. Water quality.

Indicator Scoring:

Miles 303(d) Streams	Agricultural Land	Number Active Mines	Road mi/ Stream mi	Number OG Wells	CSI Score
>0	58-100%	≥10	0.5 – 1.0	≥ 400	1
	28-57%	7-9	0.25 – 0.49	300 - 399	2
	16-27%	4-6	0.24 - 0.10	200 - 299	3
	6-15%	1-3	0.05 – 0.09	50 - 199	4
	0-5%	0	0 – 0.04	0 - 49	5

Score for worst case.

Explanation: The presence of 303(d) impaired streams, percentage agricultural land, number of active mines and oil and gas wells, 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. Oil and gas development is associated with road building, water withdrawls, and saline water discharge.(Rice, Ellis, and Bullock;Murray-Gulde et al. 705-13) 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 from USEPA. 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 TIGER 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. Energy development
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. Lands encumbered by a conservation easement are not available for conversion.

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), TIGER roads[33], 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, High, Any., Any	1
High, Any, Any, Any	2
Mod., Mod., Mod, (Mod or Low)	3
Mod, Mod, Low, Low	4
Low, Low, Low, (Mod or Low)	5

Explanation: Climate change is based on TU Climate Change analysis, which focuses on 4 identified risk factors related to climate change:

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
d. Drought: moisture loss under climate warming will overwhelm any gains in precipitation and lead to higher drought risk

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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.

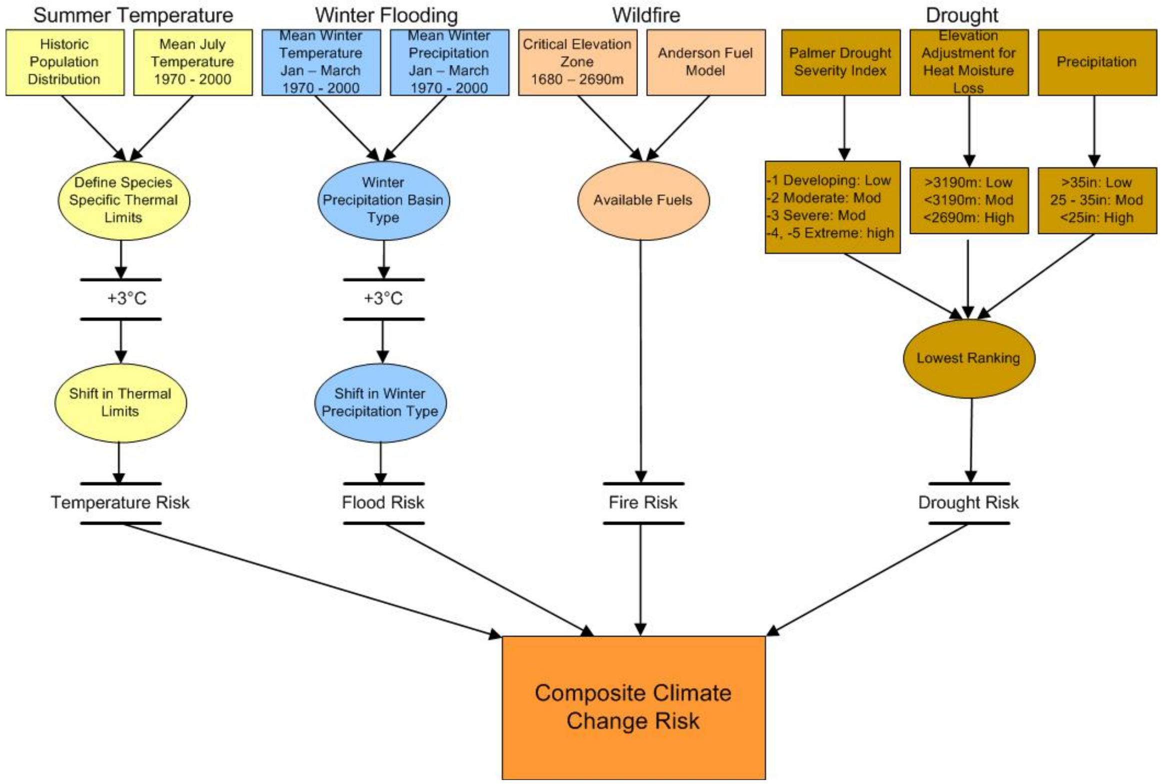
Communitization: Combining smaller federal tracts to meet the necessary minimum acreage required by the BLM (for spacing purposes).

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.



Each of the four 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. Drought risk is based on the Palmer Drought Severity Index, but was adjusted for elevation and precipitation.

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:

Present in subbasin	Present in subwatershed	Road Density	CSI Score
Yes	Yes	Any	1
Yes	No	> 4.7	2
Yes	No	1.7 – 4.7	3
Yes	No	<1.7	4
No	No	Any	5

Explanation: The presence of introduced, injurious species in any stream reach connected to the subbasin and subwatershed (see Watershed Connectivity region group); also 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: Roads were obtained from ESRI, Tele Atlas North American / Geographic Data Technology dataset on roads.(ESRI)

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