Conservation Success Index: Paiute Cutthroat Trout

ONCORHYNCHUS CLARKII SELENIRIS

Rev. 1.0 - 6/2009

SPECIES SUMMARY

Silver King Creek drains the Carson-Iceberg Wilderness Area on the east side of the Sierra Nevada Mountains in Alpine County, California and flows into the East Fork of the Carson River. Many of its tributary streams are spring fed systems with steep gradients that flatten out near the confluence with Silver King Creek. Silver King Creek itself is a small, tight drainage punctuated by a steep canyon with a large waterfall and interspersed with sections of lower gradient stream habitat.

First described by J. O. Snyder in 1933, the Paiute cutthroat trout is found only in this system. Historically, it was limited to 9 miles of habitat on the lower main-stem of Silver King Creek and three small tributary creeks - Tamarack Creek, Tamarack Lake Creek and the lower section of Coyote Valley Creek downstream of barrier falls. Llewellyn Falls blocked upstream migration in Silver King Creek, while the steep canyon of Silver King Creek isolated Paiute cutthroat from its Lahontan cutthroat ancestors for thousands of years.

Paiute cutthroat were transferred above waterfalls on Corral Valley Creek, Coyote Valley Creek, and in two smaller drainages within Silver King Creek in the 1910s. Sometime prior to 1924 rainbow, Lahontan cutthroat, and golden trout were introduced into the lower sections of Silver King Creek. Following these introductions, hybridization eliminated pure Paiute cutthroat from its historic habitat; the only pure populations remaining occur as the result of translocations to the headwaters of Silver King Creek and a few isolated areas in other parts of the Sierra Nevada.

In 1967, the Paiute cutthroat was designated as endangered under the Endangered Species Preservation Act of 1966. In 1975, its designation was changed to threatened under the revised Endangered Species Act of 1973 to facilitate management and allow recreational angling (Silver King Creek above Tamarack Lake Creek is currently closed to fishing). Chemical treatments that began in the mid-1960s have eliminated non-native and hybrid trout from the headwaters of Silver King Creek. The 1985 Paiute Cutthroat Recovery Plan guided additional population and habitat restoration activities, including the eventual cessation of grazing in 1994 (to date, the allotment spanning the basin remains "vacant"). The 2004 revision of this plan and the 2007 5-year Status Review suggested additional activities, including chemical treatments, to return the Paiute cutthroat to its historic habitat in Silver King Creek below Llewellyn Falls. In early 2009 the US Fish and Wildlife Service issued a Draft Environment Impact Statement as a step towards chemical treatment.

Hybridization with introduced rainbow trout still poses the largest threat to the Paiute cutthroat trout. Other threats include habitat degradation associated with the legacy of cattle and sheep grazing, accidental harvest associated with the popular Silver King trout fishery downstream, natural factors that threaten any species with a limited distribution, and sedimentation and passage issues associated with beavers that were introduced to the basin in the 1940s.

Our CSI analysis incorporated data from the 2008 *SOS: California's Native Fish Crisis* report, the 2007 5-year Status Review, and the 2004 Revised Recovery Plan. We are grateful for these contributions to our understanding of this species. A complete list of data sources is provided separately. This analysis for Paiute cutthroat is summarized at the catchment scale (400 – 4,000 acres), a finer scale than the typical CSI.

Key CSI Findings

- The Pauite cutthroat occupies 12.8 miles of streams in the headwaters of Silver King Creek. None of its historic habitat is currently occupied.
- Two loosely connected population groups of Paiute cutthroat currently exist in the Silver King Creek basin – one in the Coyote Valley and Corral Valley Creek drainage and one in the Upper Silver King Creek drainage (Bull Canyon, Fly Valley, and Four Mile Canyon Creeks).
- High population integrity scores are decreased by the limited extent and density of those populations.
- Habitat integrity scores are high, reflecting the absence of sources or indicators of habitat disturbance, including urban and agricultural influences, 303(d) listed streams, roads, and canal and dam structures. All current and historic habitat in the basin is protected in the Carson-Iceberg Wilderness Area.
- Pauite cutthroat are at low risk to the future threats of resource extraction, land conversion, energy development, stream temperature changes, and resource extraction.
- Genetic introgression with non-native trout species and changes in fire regime and winter flooding associated with potential climate change represent the greatest additional future risk to Paiute cutthroat.

Despite being extirpated from its historic range, our CSI analysis shows that the range-wide conditions related to species distribution are high for Paiute cutthroat trout. Translocations have allowed the species to occupy a stream network and catchment area equivalent in size and extent to its historic distribution. All streams in the current distribution are second order or higher with the exception of the upper portion of Coyote Valley Creek, suggesting that the populations may persist in relatively stable environmental conditions.

Most population integrity scores for Paiute cutthroat are moderate. The current populations of the species persist in precariously short segments of stream. This limited population extent serves to mitigate the positive effects of isolation from non-native trout in the lower reaches of Silver King Creek. Except for the robust population of Paiute cutthroat in the mainstem of Silver King Creek above Llewellyn Falls, all catchments score low for population density. Based on the Hilderbrand and Kershner criteria, the Silver King basin contains no populations that meet the desired persistence threshold.

The Silver King Creek basin is lacking all sources or indicators of stream habitat degradation, including: 303(d) listed streams; roads; anthropogenic barriers to fish passage like diversions and dams; and agricultural and urban areas. Accordingly, all catchments score high for habitat integrity. The CSI lacks a specific indicator for addressing instream habitat conditions. Degraded habitat certainly does exist in the basin, likely from the legacy effects of over a century of cattle and sheep grazing, logging during the Comstock mining era, or sedimentation and passage issues associated with beavers that were introduced into the basin in the 1940s. As a result, some habitat integrity scores may not fully reflect local instream conditions: the lack of acute anthropogenic stressors across the watershed may inflate the habitat integrity scores of degraded catchments in need of habitat restoration.

The CSI analysis of future security suggests the Paiute cutthroat is at low risk. All current and historic habitat in Silver King Creek for the species is found in the Carson-Iceberg Wilderness in Humboldt-Toiyabe National Forest. This management status diminishes the threats associated with land conversion and the development of water, mineral, and energy resources. The primary threat to future security comes from non-native trout that remain present in Silver King Creek below the natural barriers of Llewellyn Falls and the falls on Coyote Valley Creek.

The CSI considers the effects of a + 3°C climate change scenario on the species. Though lower in the higher elevation headwater streams in the western and southern portion of the current distribution, our analysis suggests that the Paiute cutthroat is at high risk to increased winter flooding associated with rain-on-snow events, high risk to the effects of altered fire regimes associated earlier spring warming in mid-elevation zones, and moderate risk to drought. Only Four Mile Canyon is at low risk for all climate change indicators. Based on the current distribution of the species relative to air temperature, the species is at low risk to increased summer temperatures.

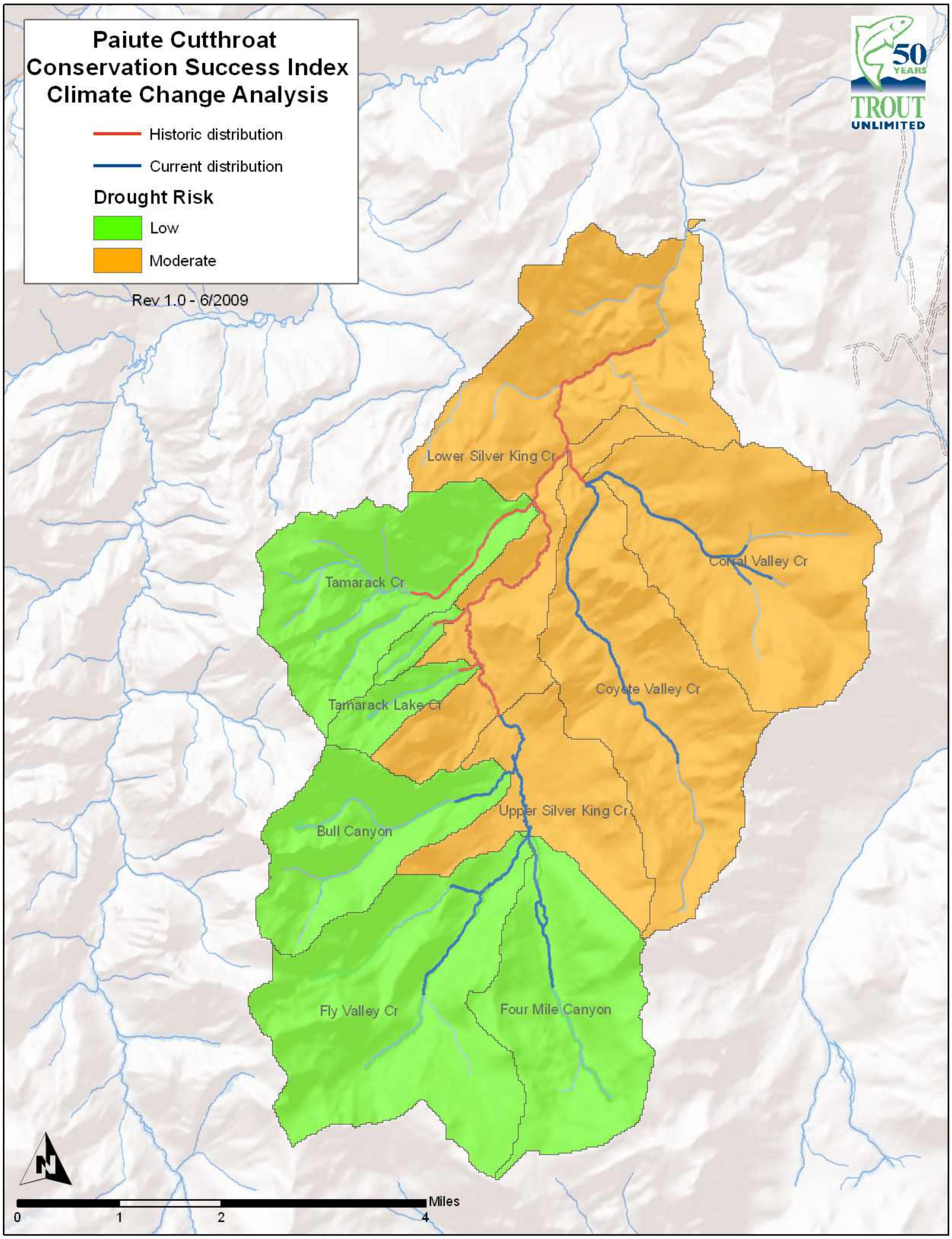
Total CSI scores are high across the current distribution of Paiute cutthroat trout. Across scoring groups, our CSI analysis strongly suggests that reintroduction of Paiute cutthroat is warranted in the high-scoring historic range. Continued population and habitat restoration will also bolster the population integrity of existing populations.

Trout Unlimited strongly supports the continued restoration efforts of California Department of Fish and Game, the U.S. Forest Service, the U. S. Fish and Wildlife Service, and California Trout. These entities have made great strides in the conservation of Paiute cutthroat since coordinated efforts began in the early 1960s. Consistent with CSI findings related to habitat and population integrity, moving forward on eliminating non-native trout from the historical habitat in Silver King Creek should remain a top priority. Providing large interconnected habitats and bolstering population size will increase the persistence of existing populations to both natural and anthropogenic disturbances.

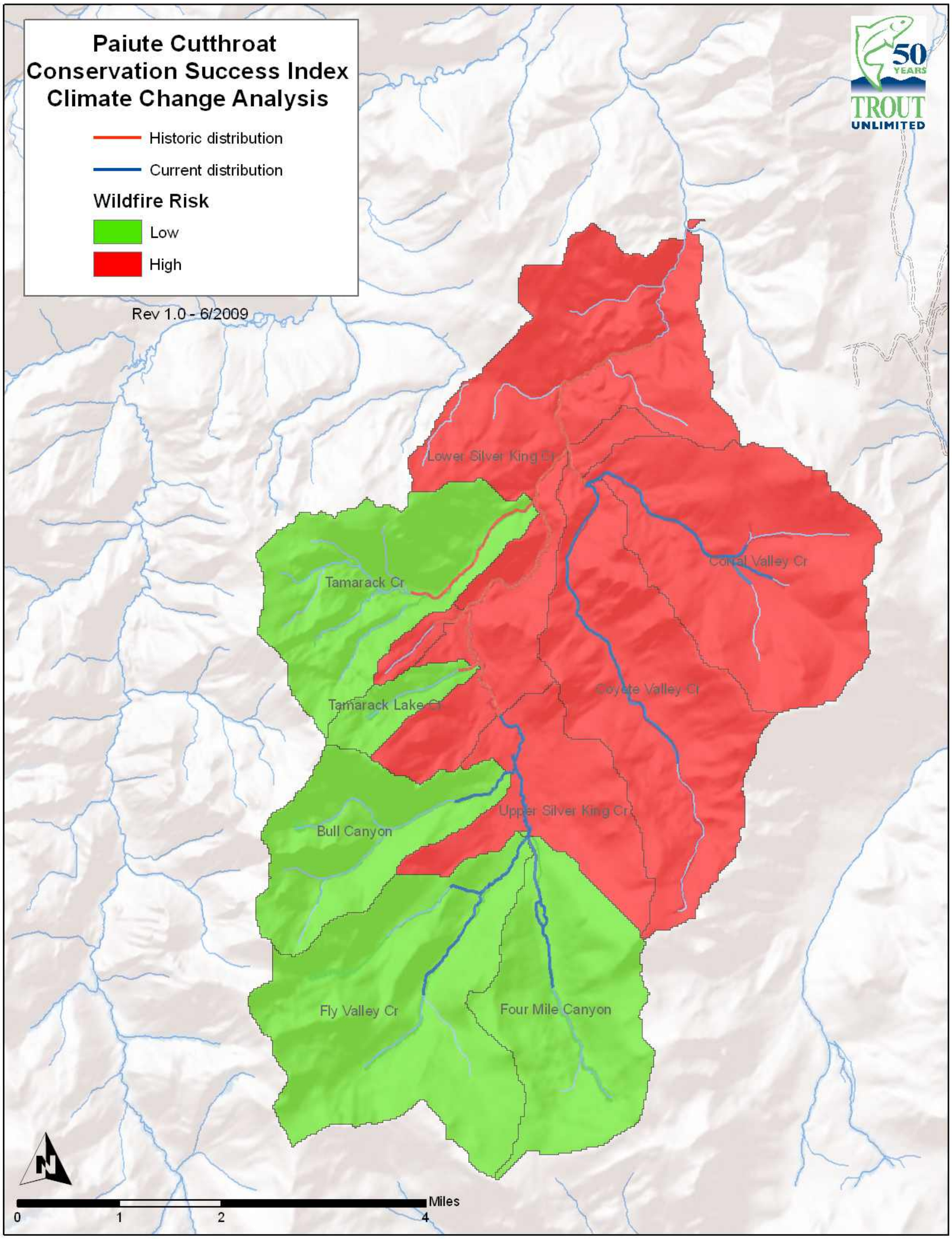
Prepared by Kurt Fesenmyer and Boyd Bouwes, TU, 2/25/2009

Table 1. CSI scoring results for Paiute cutthroat trout. All indicators are scored from 1 (poorest) to 5 (best): see framework documentation for details.

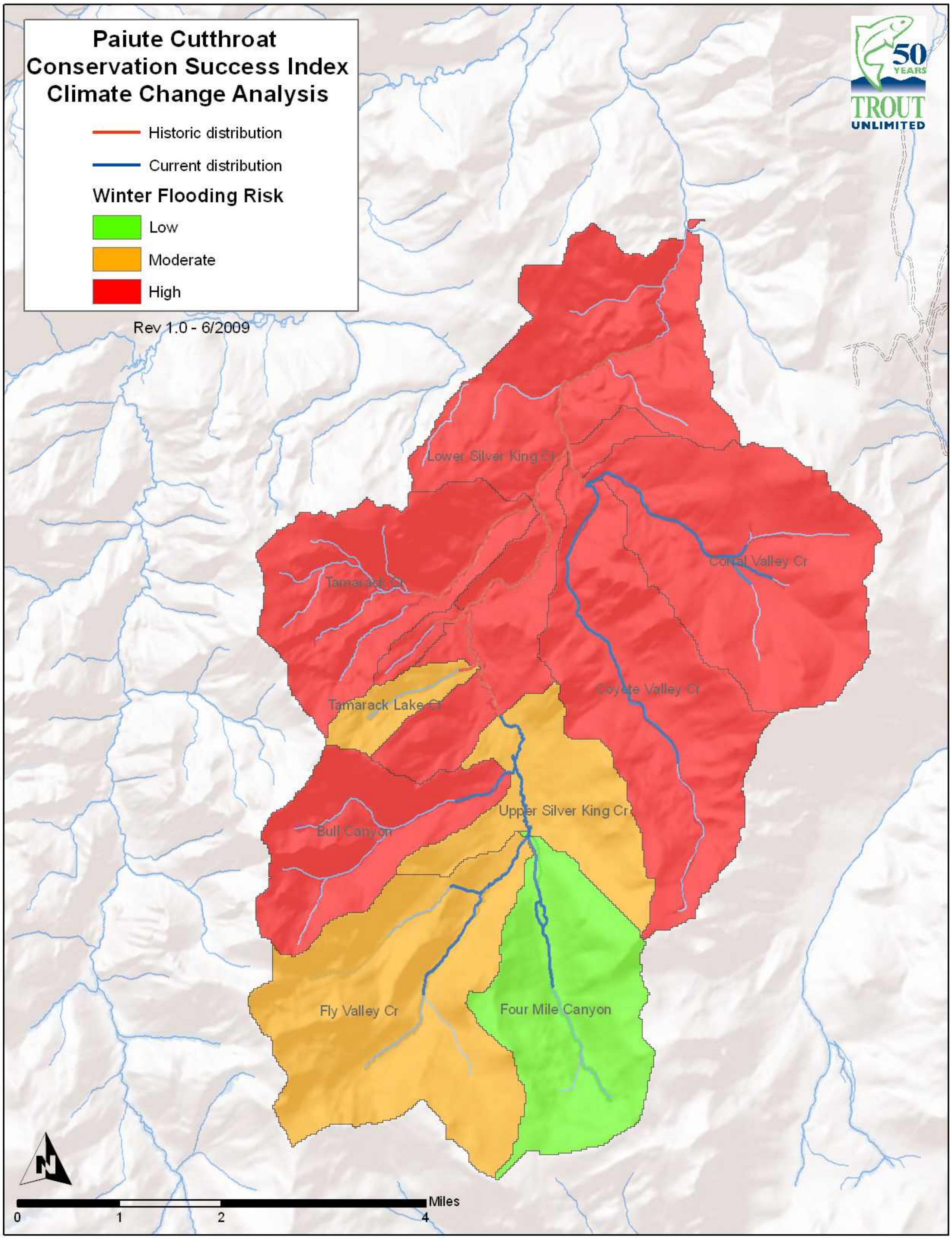
	CSI Indicator	Number of Subwatersheds Receiving Scores 1	2	3	4	5	Total Subwatersheds Scored
Range-wide Conditions	Percent historic stream habitat occupied	0	0	0	0	6	6
	Percent subbasins (4th) occupied	0	0	0	0	6	6
	Percent subwatersheds (6th) occupied	0	0	0	0	6	6
	Percent habitat by stream order occupied	1	0	0	0	5	6
	Percent historic lake area occupied	0	0	0	0	6	6
Population Integrity	Population Density	0	0	4	1	1	6
	Population Extent	2	4	0	0	0	6
	Genetic Purity	0	0	0	0	6	6
	Disease vulnerability	0	0	0	0	6	6
	Life history diversity	0	0	0	0	6	6
Habitat Integrity	Land Stewardship	0	0	0	0	10	10
	Watershed connectivity	0	0	0	0	10	10
	Watershed conditions	0	0	0	0	10	10
	Water quality	0	0	0	0	10	10
	Flow regime	0	0	0	0	10	10
Future Security	Land conversion	0	0	0	0	10	10
	Resource extraction	0	0	0	0	10	10
	Energy development	0	0	0	0	10	10
	Climate change	4	3	0	0	3	10
	Introduced species	5	0	0	5	0	10

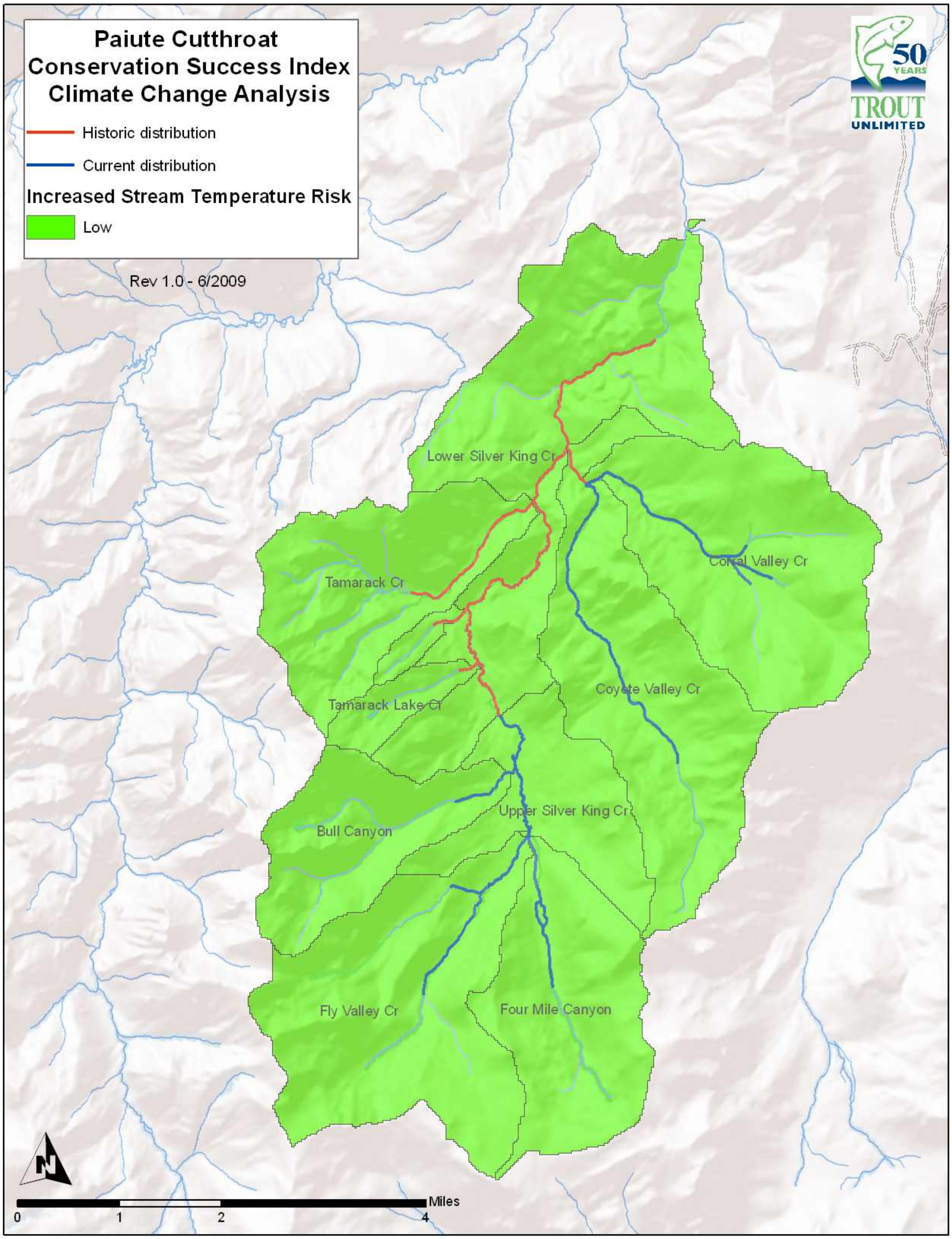


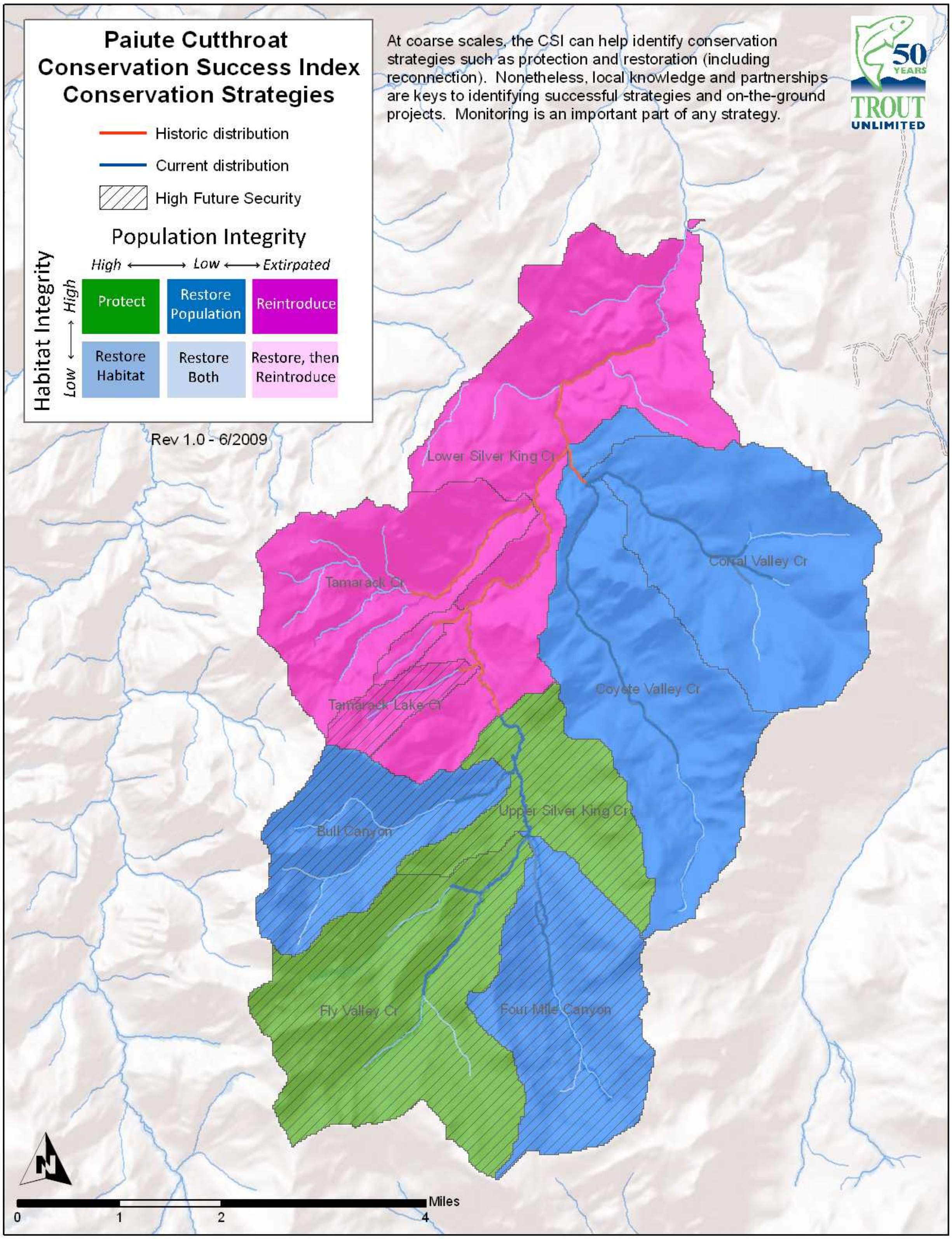
Paiute Cutthroat
Conservation Success Index
Climate Change Analysis
Historic distribution
Current distribution
Drought Risk
Low
Moderate
Rev 1.0 - 6/2009
50 YEARS
TROUT UNLIMITED
Lower Silver King Cr
Tamarack Cr
Corral Valley Cr
Tamarack Lake Cr
Coyote Valley Cr
Upper Silver King Cr
Bull Canyon
Fly Valley Cr
Four Mile Canyon
N
0
1
2
4
Miles



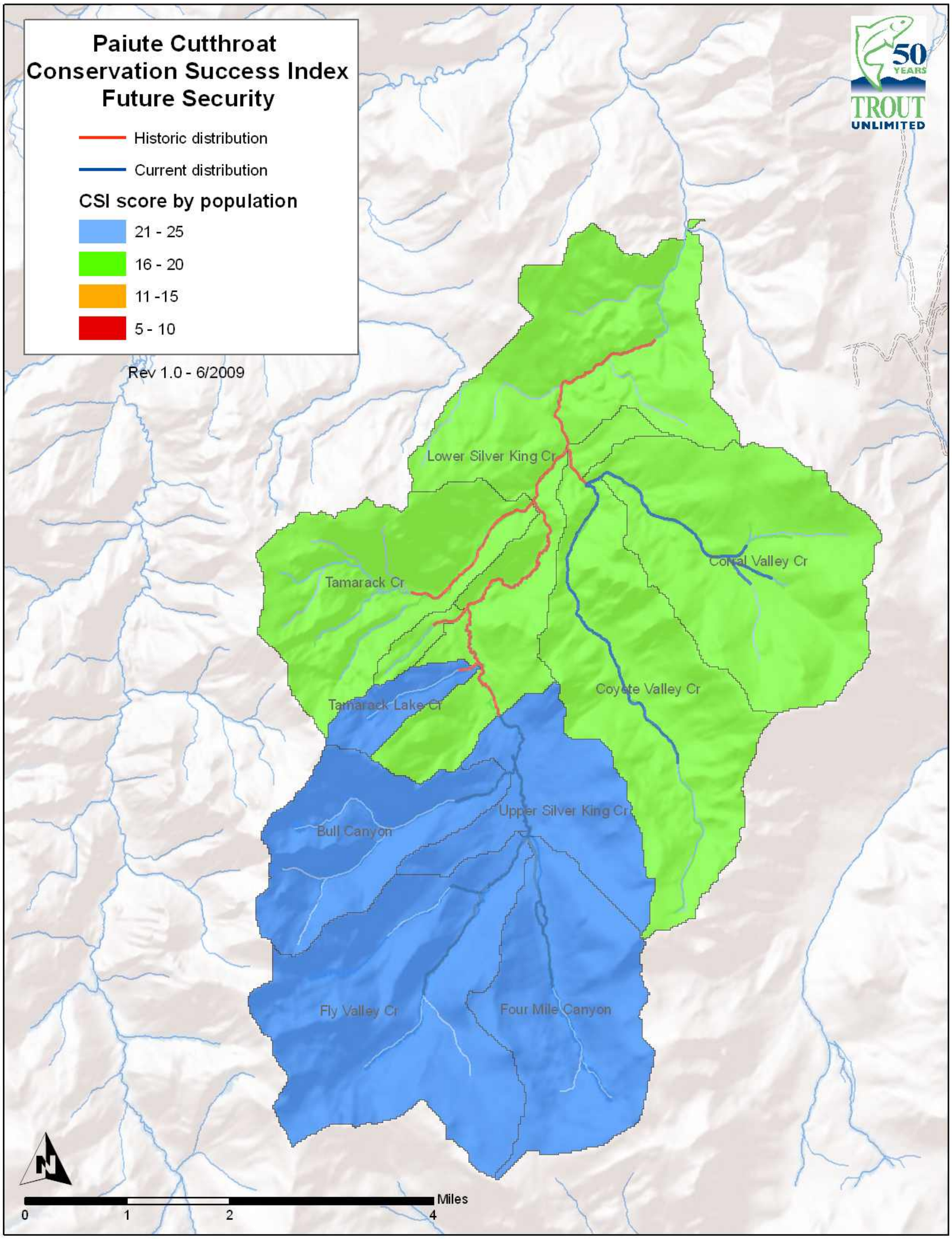
Paiute Cutthroat
Conservation Success Index
Climate Change Analysis
Historic distribution
Current distribution
Wildfire Risk
Low
High
Rev 1.0 - 6/2009
50 YEARS
TROUT UNLIMITED
Lower Silver King Cr
Tamarack Cr
Corral Valley Cr
Tamarack Lake Cr
Coyote Valley Cr
Upper Silver King Cr
Bull Canyon
Fly Valley Cr
Four Mile Canyon
N
Miles
0
1
2
4

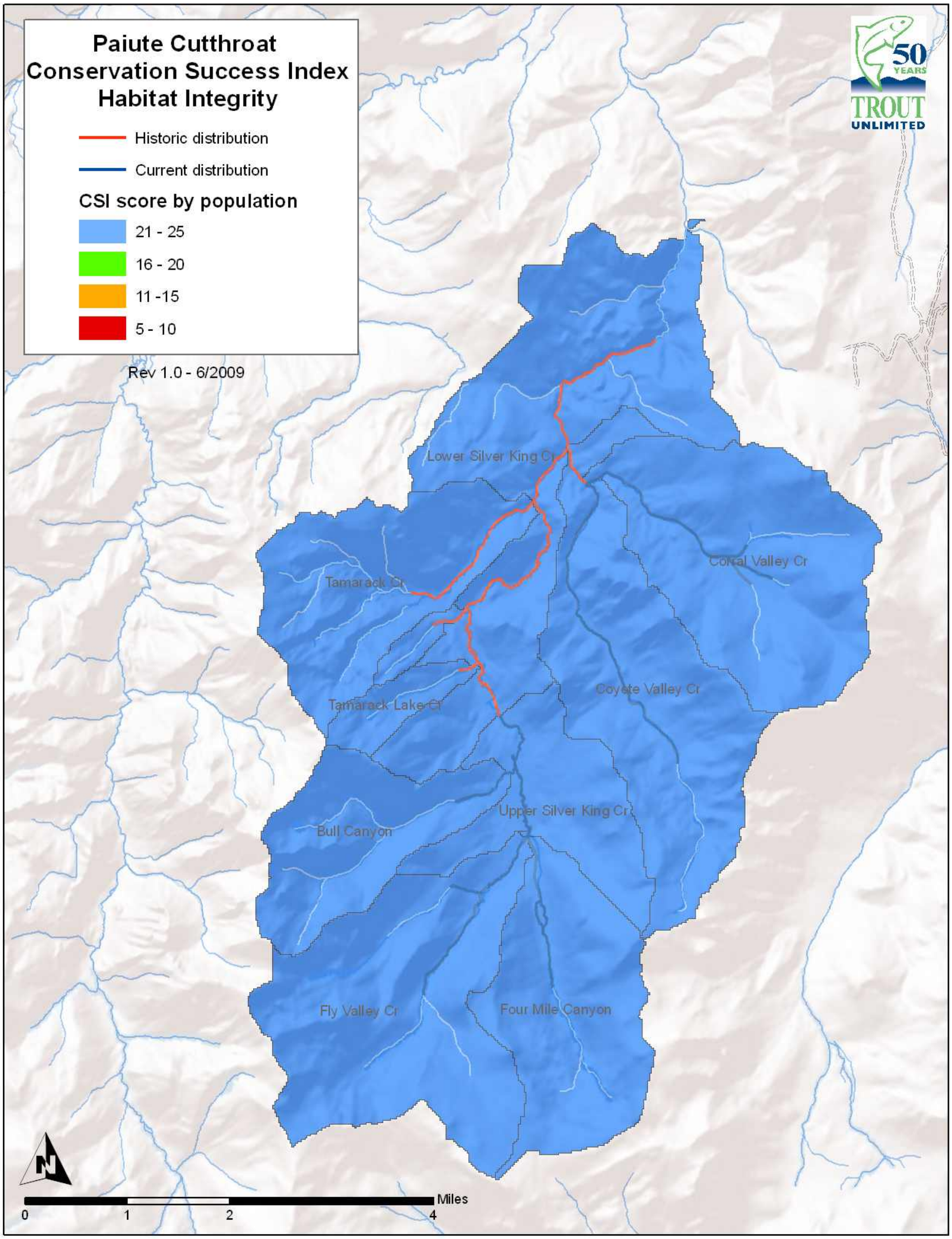

Paiute Cutthroat
Conservation Success Index
Climate Change Analysis
Historic distribution
Current distribution
Winter Flooding Risk
Low
Moderate
High
Rev 1.0 - 6/2009
50 YEARS
TROUT UNLIMITED
Lower Silver King Cr
Corral Valley Cr
Tamarack Cr
Tamarack Lake Cr
Coyote Valley Cr
Upper Silver King Cr
Bull Canyon
Fly Valley Cr
Four Mile Canyon
N
Miles
0
1
2
4


Paiute Cutthroat
Conservation Success Index
Climate Change Analysis
Historic distribution
Current distribution
Increased Stream Temperature Risk
Low
Rev 1.0 - 6/2009
50 YEARS
TROUT UNLIMITED
Lower Silver King Cr
Tamarack Cr
Corral Valley Cr
Coyote Valley Cr
Tamarack Lake Cr
Upper Silver King Cr
Bull Canyon
Fly Valley Cr
Four Mile Canyon
N
Miles
0
1
2
4

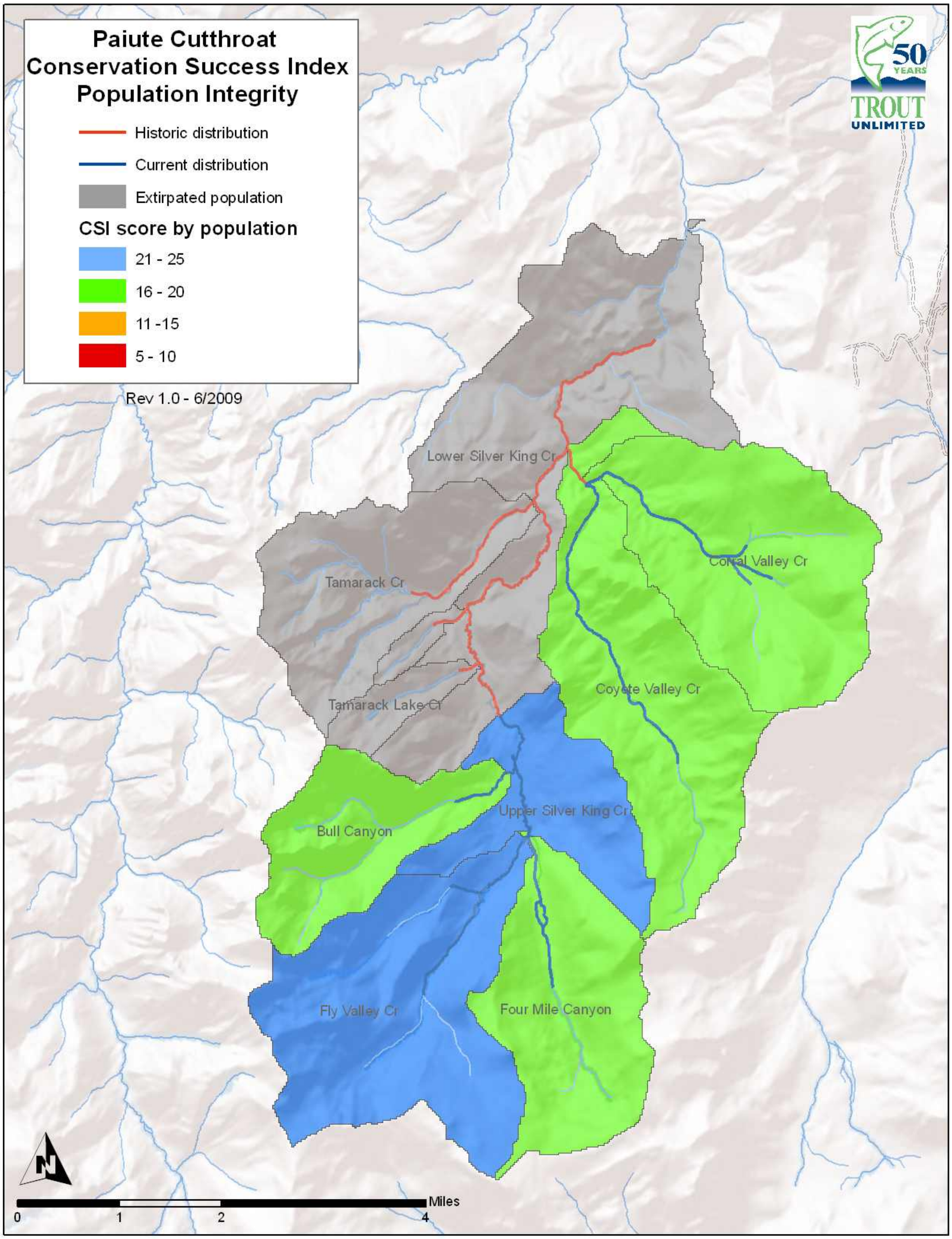


Paiute Cutthroat
Conservation Success Index
Conservation Strategies
Historic distribution
Current distribution
High Future Security
Population Integrity
High ⟷ Low ⟷ Extirpated
Habitat Integrity
High ⟷ Low
Protect
Restore Population
Reintroduce
Restore Habitat
Restore Both
Restore, then Reintroduce
Rev 1.0 - 6/2009
At coarse scales, the CSI can help identify conservation strategies such as protection and restoration (including reconnection). Nonetheless, local knowledge and partnerships are keys to identifying successful strategies and on-the-ground projects. Monitoring is an important part of any strategy.
50 YEARS
TROUT UNLIMITED
Lower Silver King Cr
Corral Valley Cr
Tamarack Cr
Coyote Valley Cr
Tamarack Lake Cr
Upper Silver King Cr
Bull Canyon
Fly Valley Cr
Four Mile Canyon
N
Miles
0
1
2
4

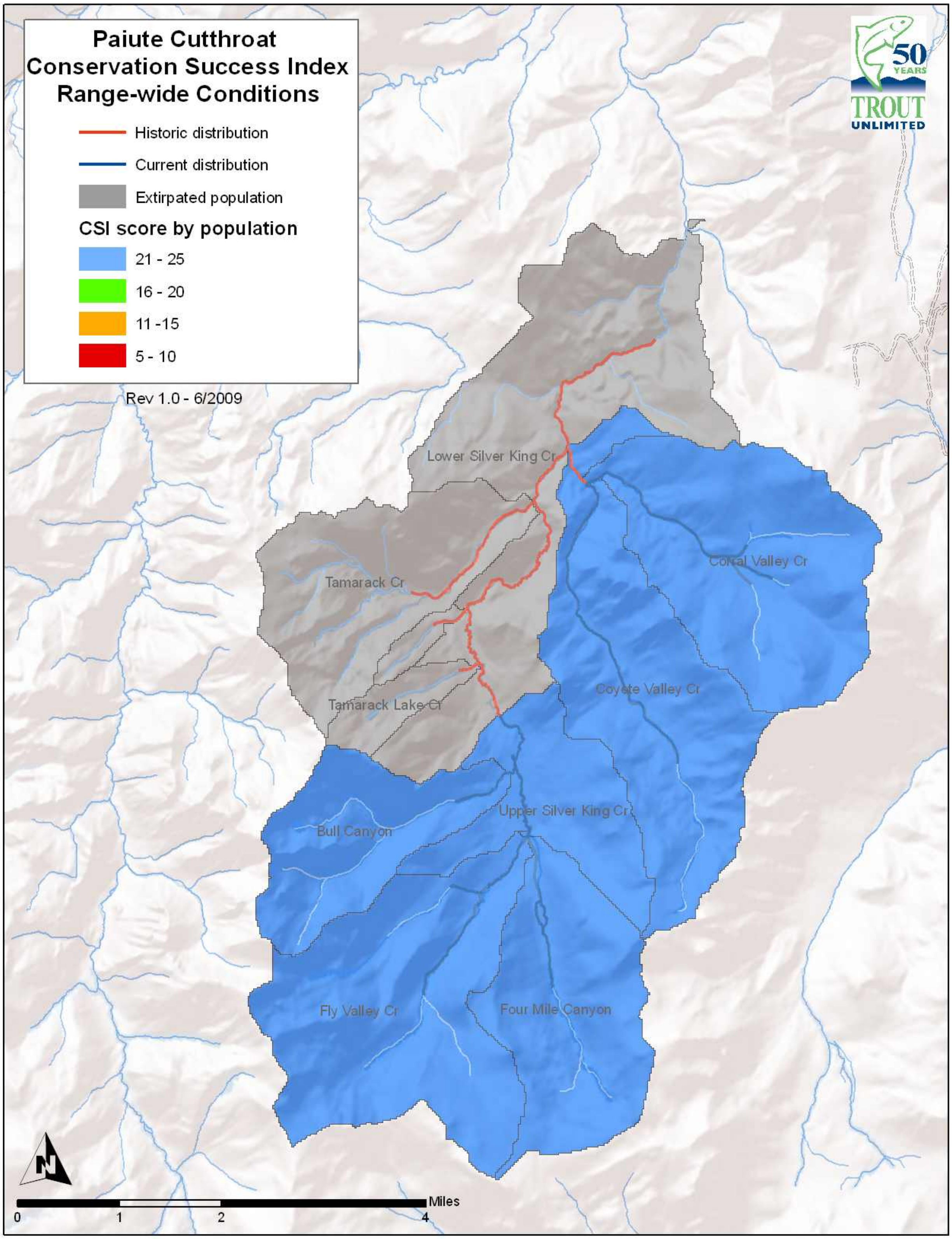

Paiute Cutthroat
Conservation Success Index
Future Security
Historic distribution
Current distribution
CSI score by population
21 - 25
16 - 20
11 -15
5 - 10
Rev 1.0 - 6/2009
50 YEARS
TROUT UNLIMITED
Lower Silver King Cr
Tamarack Cr
Corral Valley Cr
Coyote Valley Cr
Tamarack Lake Cr
Upper Silver King Cr
Bull Canyon
Fly Valley Cr
Four Mile Canyon
N
Miles
0
1
2
4



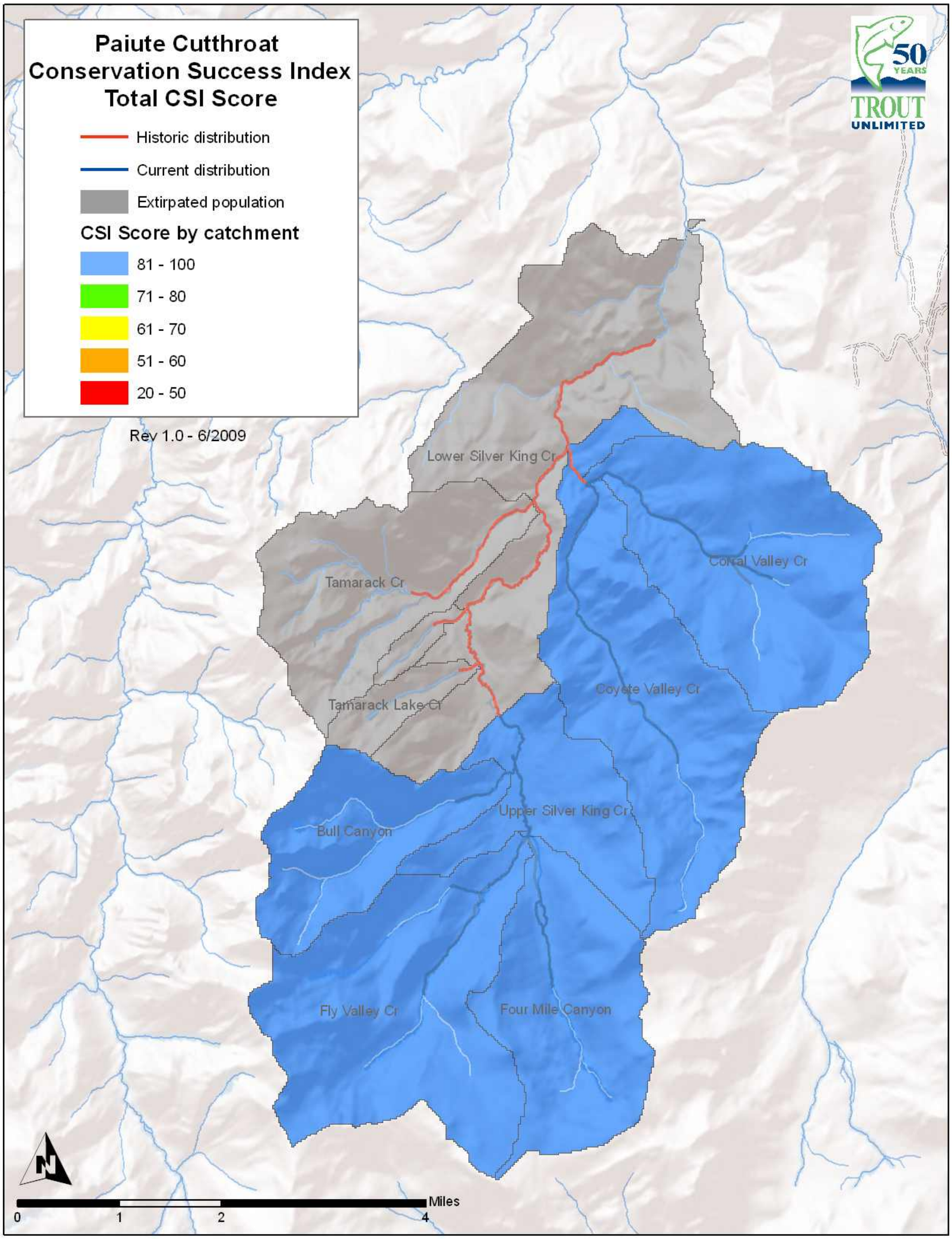
Paiute Cutthroat
Conservation Success Index
Habitat Integrity
Historic distribution
Current distribution
CSI score by population
21 - 25
16 - 20
11 -15
5 - 10
Rev 1.0 - 6/2009
50 YEARS
TROUT UNLIMITED
Lower Silver King Cr
Tamarack Cr
Corral Valley Cr
Tamarack Lake Cr
Coyote Valley Cr
Upper Silver King Cr
Bull Canyon
Fly Valley Cr
Four Mile Canyon
N
Miles
0
1
2
4



Paiute Cutthroat
Conservation Success Index
Population Integrity
Historic distribution
Current distribution
Extirpated population
CSI score by population
21 - 25
16 - 20
11 -15
5 - 10
Rev 1.0 - 6/2009
50 YEARS
TROUT UNLIMITED
Lower Silver King Cr
Tamarack Cr
Tamarack Lake Cr
Corral Valley Cr
Coyote Valley Cr
Upper Silver King Cr
Bull Canyon
Fly Valley Cr
Four Mile Canyon
N
0
1
2
4
Miles



Paiute Cutthroat
Conservation Success Index
Range-wide Conditions
Historic distribution
Current distribution
Extirpated population
CSI score by population
21 - 25
16 - 20
11 -15
5 - 10
Rev 1.0 - 6/2009
50 YEARS
TROUT UNLIMITED
Lower Silver King Cr
Corral Valley Cr
Tamarack Cr
Coyote Valley Cr
Tamarack Lake Cr
Upper Silver King Cr
Bull Canyon
Fly Valley Cr
Four Mile Canyon
N
Miles
0
1
2
4



Paiute Cutthroat
Conservation Success Index
Total CSI Score
Historic distribution
Current distribution
Extirpated population
CSI Score by catchment
81 - 100
71 - 80
61 - 70
51 - 60
20 - 50
Rev 1.0 - 6/2009
50 YEARS
TROUT UNLIMITED
Lower Silver King Cr
Tamarack Cr
Tamarack Lake Cr
Corral Valley Cr
Coyote Valley Cr
Upper Silver King Cr
Bull Canyon
Fly Valley Cr
Four Mile Canyon
N
Miles
0
1
2
4

Conservation Success Index:
California Native Trout: McCloud Redband Trout, Goose Lake Redband Trout, Paiute Cutthroat Trout and Eagle Lake Rainbow 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 or catchment, 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 or catchment condition for a Group, and Group scores are added for a CSI score for a subwatershed or catchment (Figure 1). CSI scores can then be summarized to obtain the general range of conditions within the historical or current distribution of the species.

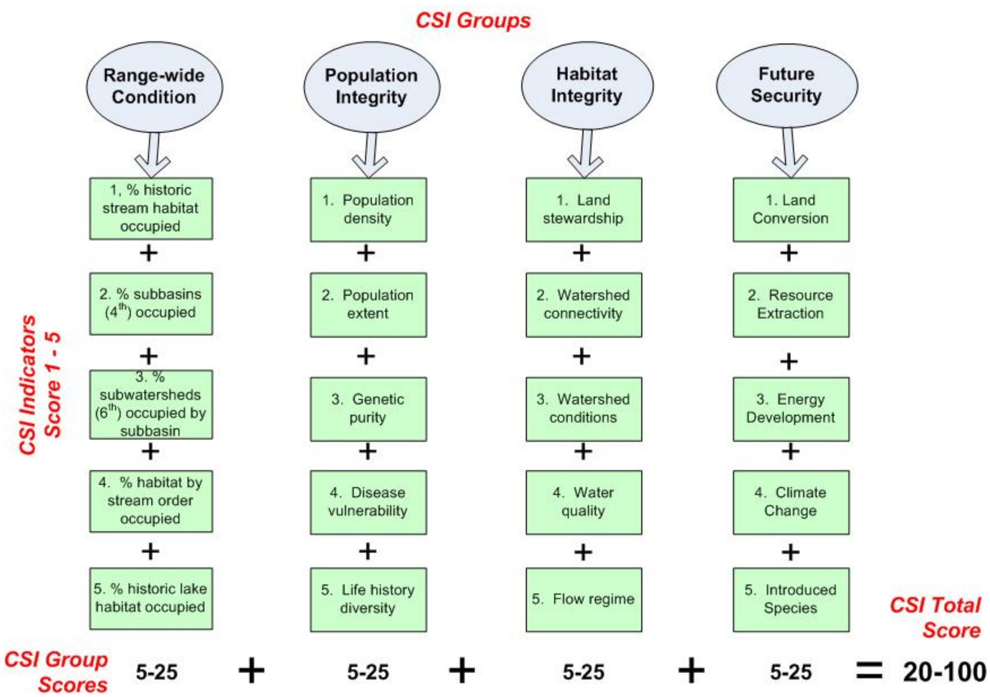


Figure 1. Each subwatershed or catchment is scored from 1 to 5 using 20 indicators within four main groups. Indicator scores are added per group to obtain an overall group score. Group scores are then added to obtain a composite CSI score for each subwatershed or catchment.

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

Indicator: 1. Percent of historic streams occupied by populations

Indicator Scoring:

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

Explanation: The percentage of streams currently occupied by the species, based on sampling data.

Rationale: Populations occupying a larger extent of habitat will have an increased likelihood of persistence.

Data Sources: The current and historical distribution of McCloud Redband Trout provided by Shasta-Trinity National Forest;[1] current and historical distribution of Paiute cutthroat trout from USFWS;[2;3] current and historical distribution of Eagle Lake rainbow trout from Pine Creek RMPG;[4] current distribution of Goose Lake redband from Oregon DFW[5] and Modoc National Forest,[6] historic distribution assumed to be all perennial streams in the upper Pit/Goose Lake system, excluding the mainstem North and South Fork Pit and mainstem Pit below Alturas; subwatersheds based on NRCS data[7] (for Goose Lake Redband Trout); catchments based on NHD Plus[8] (all other species).

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 historically occupied subbasins that are currently occupied by the species. The same percentage is applied to all subwatersheds or catchments scored.

Rationale: Larger river basins often contain populations functioning as distinct populations.

Data Sources: The current and historical distribution of McCloud Redband Trout provided by Shasta-Trinity National Forest;[1] current and historical distribution of Paiute cutthroat trout from USFWS;[2;3] current and historical distribution of Eagle Lake rainbow trout from Pine Creek RMPG;[4] current distribution of Goose Lake redband from Oregon DFW[5] and Modoc National Forest,[6] historic distribution assumed to be all perennial streams in the Upper Pit/Goose Lake system; subbasins based on NRCS data[7]

Indicator: 3. Percent subwatersheds or catchments occupied within subbasin.

Indicator Scoring:

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

Explanation: The percentage of historically occupied subwatersheds or catchments 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 percentage of subwatersheds or catchments are likely to be more broadly distributed and have an increased likelihood of persistence.

Data Sources: The current and historical distribution of McCloud Redband Trout provided by Shasta-Trinity National Forest;[1] current and historical distribution of Paiute cutthroat trout from USFWS;[2;3] current and historical distribution of Eagle Lake rainbow trout from Pine Creek RMPG;[4] current distribution of Goose Lake redband from Oregon DFW[5] and Modoc National Forest,[6] historic distribution assumed as all perennial streams in the Upper Pit/Goose Lake system, excluding the mainstem North and South Fork Pit and mainstem Pit below Alturas; subwatersheds based on NRCS data[7] (for Goose Lake Redband Trout); catchments based on NHD Plus[8] (all other species).

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.[9]

Data Sources: The current distribution of McCloud Redband Trout provided by Shasta-Trinity National Forest;[1] current distribution of Paiute cutthroat trout from USFWS;[2;3] current distribution of Eagle Lake rainbow trout from Pine Creek RMPG;[4] subwatersheds based on NRCS data[7] (for Goose Lake Redband Trout); current distribution of Goose Lake redband from Oregon DFW[5] and Modoc National Forest;[6] catchments based on NHD Plus[8] (all other species); stream order was determined using the NHD Plus.[8]

Indicator: 5. 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: Percentage of natural and artificial lakes that contain populations of wild trout.

Rationale: Lakes often harbor unique life histories and large populations that are important to long-term persistence of the species.[10]

Data Sources: The current distribution of McCloud Redband Trout provided by Shasta-Trinity National Forest;[11] current distribution of Paiute cutthroat trout from USFWS;[2;3] current distribution of Eagle Lake rainbow trout from Pine Creek RMPG;[4] current distribution of Goose Lake redband from Oregon DFW[5] and Modoc National Forest[6], subwatersheds based on NRCS data[7] (for Goose Lake Redband Trout); catchments based on NHD Plus[8] (all other species); lakes from the National Hydrography Dataset.[12]

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

Overview:

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

Indicator: 1. Population density.

Indicator Scoring:

Fish / mile	CSI Score
1 – 50 (total pop < 500)	1
1 – 50 (total pop ≥ 500)	2
51 - 150	3
151 - 400	4
>400	5

Explanation: Population density within each subwatershed or catchment. When multiple populations were present within a subwatershed or catchment, 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.[13;14]

Data Sources: Density of McCloud Redband trout from the Draft McCloud Redband Conservation Agreement;[15] density of Paiute cutthroat trout from USFWS;[2;3] abundance data for Goose Lake redband from Oregon DFW [16;17] and personal communication with Claude Singleton (BLM), Stewart Reid (Western Fishes), and Marty Yamagiwa (USFS); subwatersheds based on NRCS data[7] (for Goose Lake Redband Trout); catchments based on NHD Plus[8] (all other species). Because of incomplete data, some subwatersheds/catchments were scored based on expert opinion considering the landscape context. Scoring rules were based, in part, on May and Albeke[14] and Williams et al.[18]

Indicator: 2. Population extent.

Indicator Scoring:

Connectivity	CSI Score
< 6.2 mi (<10 km) connected habitat	1
6.2 – 12.4 mi (10-20 km) connected habitat	2
12.4 – 18.6 mi (20-30 km) connected habitat	3
18.6 – 31.1 mi (30-50 km) connected habitat	4
> 31.1 mi (>50 km) connected habitat	5

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

Rationale: Populations with less available habitat are more vulnerable to extirpation[19] as a result of small, localized disturbances.

Data Sources: Score based on extent of connected habitat for the contiguous populations using populations identified for population density (see above). McCloud barriers data from Steve Bachmann, USFS (personal communication). Paiute cutthroat barriers data from USFWS;[2;3] Eagle Lake rainbow trout barriers described in Pine Creek RMPG;[4] Goose Lake redband barriers from Oregon DFW[20] and personal communication with Claude Singleton (BLM), Stewart Reid (Western Fishes), and Marty Yamagiwa (USFS). Natural barriers from National Hydrography Dataset.[21] Scoring rules were based, in part, on May and Albeke[14] and Williams et al.[18]

Indicator: 3. Genetic integrity.

Indicator Scoring:

Genetic purity	CSI Score
< 80%	1
80 – 89 %	2
	3
90 – 98 %	4
99 - 100 %	5

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

Rationale: McCloud Redband trout genetics from the Draft McCloud Redband Conservation Agreement;[15] Paiute cutthroat genetics from UC-Davis;[22] Eagle Lake rainbows are not hydridized, but history of hatchery selection for fish size and reproduction timing degrade genetic integrity by 1 point; Goose Lake redband hybridization estimations from ODFW,[23] Claude Singleton (BLM), Stewart Reid (Western Fishes), and Marty Yamagiwa (USFS) (personal communication); subwatersheds based on NRCS data[7] (for Goose Lake Redband Trout); catchments based on NHD Plus[8] (all other species). Because of incomplete data, some subwatersheds/catchments were scored based on expert opinion considering the landscape context. Scoring rules were based, in part, on May and Albeke[14] and Williams et al.[18]

Indicator: 4. Disease vulnerability

Indicator Scoring:

Disease Risk	CSI Score
Disease/pathogens present in target species	1
Disease/pathogens in habitat but not target fish	2
None present but proximity < 6.2 mi (10 km)	3
None present but proximity > 6.2 mi (10 km)	4
No diseases/pathogens present	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: Stocking hatchery fish contributes to the 1 point degradation of the mainstem and tributaries of the Upper McCloud. The proximity of the popular Silver King Creek fishery contributes to the 1 point degradation to the otherwise isolated populations of Paiute cutthroat. Hatchery dependent Eagle Lake rainbows = 3. Goose Lake redband considers the presence of active stocking of non-native salmonids.[23]

Indicator: 5. Life history diversity.

Indicator Scoring:

Life History Diversity	CSI Score
One life history form present: resident only	1
One historical life history was lost	3
All historical life history forms 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.[19;24;25]

Data Sources: Life History Diversity of McCloud Redband trout based on data from the Draft McCloud Conservation Agreement[26] and personal communication with Steve Bachmann, USFS, and Curtis Knight, Caltrout. Paiute cutthroat trout from USFWS.[2;3] Eagle Lake rainbow trout from Pine Creek RMPG;[4] Goose Lake redband from ODFW[16;17] and Modoc National Forest. Scoring rules were based, in part, on May and Albeke[14] and Williams et al.[18]

***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%=2; >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[27] and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset.[28] McCloud Redband also considers areas designated as Late Successional Reserves by the Northwest Forest Plan.[29]

Indicator: 2. Watershed connectivity.

Indicator Scoring:

Number of stream/canal intersections	Current/historical connectivity subwatershed or catchment	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/historical connectivity 4th:

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

Score for worst case

Explanation: The number of stream-canal intersections and reduction in perennial stream 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 connected perennial 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.[19] Diversions, when they do not directly inhibit fish passage, can represent false movement corridors, cause fish entrainment, and act as population sinks.[30;31]

Data Sources: McCloud barriers data from Steve Bachmann, USFS (personal communication). Paiute cutthroat barriers data from USFWS;[2;3] Eagle Lake rainbow trout barriers described in Pine Creek RMPG;[4] Goose Lake redband barriers from Oregon DFW[20] and personal communication with Claude Singleton (BLM), Stewart Reid (Western Fishes), and Marty Yamagiwa (USFS). Stream data and additional natural barriers from National Hydrography Dataset.[21]

Indicator: 3. Watershed condition.

Indicator Scoring:

Land conversion	CSI Score

≥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 or catchment and the density of roads.

Rationale: Habitat conditions are the primary determinant of persistence for most populations.[32] Converted lands are known to degrade aquatic habitats.[33;34] Road density is computed for the subwatershed; roads are known to cause sediment-related impacts to stream habitat.[35-37] Lee et al.[36] 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,[38]with all Developed, Pasture/Hay, and Cultivated Crops land cover types considered to be converted lands. Road density was determined using TIGER Census,[39] National Forest roads data,[40-42] and Oregon BLM data.[43]

Indicator: 4. Water quality.

Indicator Scoring:

Miles 303(d) Streams	Agricultural Land	Number Active Mines	Active oil and gas wells	Road mi/ Stream mi	CSI Score
>0	58-100%	≥10	>= 400	0.5 – 1.0	1
	28-57%	7-9	300 – 399	0.25 – 0.49	2
	16-27%	4-6	200 – 299	0.24 - 0.10	3
	6-15%	1-3	50 – 199	0.05 – 0.09	4
	0-5%	0	0 - 49	0 – 0.04	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 all perennial, intermittent, and ephermeral 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.[7;28] Roads along streams can also contribute large amounts of fine sediments that smother benthic invertebrates, embed spawning substrates, and increase turbidity.[44;45]

Data Sources: 303(d) impaired streams from USEPA.[46] The National Land Cover Database[38] 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.[47] Oil and gas wells from USGS. Road density within a 150 ft buffer was computed using TIGER Census,[39] National Forest roads data,[40-42] and Oregon BLM data[43] and the National Hydrography Dataset.[21]

Indicator: 5. Flow regime.

Indicator Scoring:

Number of dams	Miles of canals	Storage (acre-ft)/stream mile	CSI Score
≥5	≥20	≥2,500	1
3 – 4	10 – 19.9	1,000 – 2,499	2
2	5 – 9.9	250 – 999	3
1	1 – 4.9	1- 249	4
0	0 – 0.9	0	5

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

Rationale: Natural flow regimes are critical to proper aquatic ecosystem function.[48] Dams, reservoirs, and canals alter flow regimes.[49] Reduced or altered flows reduce the capability of watersheds to support native biodiversity and salmonid populations.

Data Sources: The National Inventory of Dams[50] provided data on dams and their storage capacity and supplemented with additional information for Lakin Dam on the McCloud River. Data on canals were obtained from the National Hydrography Dataset[21] Perennial and intermittent streams were obtained from the National Hydrography Dataset.[21]

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. Invasive 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 conservation easements are not available for conversion.

Rationale: Conversion of land from its natural condition will reduce aquatic habitat quality and availability.[51]

Data Sources: Slope was computed from the National Elevation Dataset.[52] Land cover was determined from the National Land Cover Database,[38] and all land cover classes except developed areas and cultivated crops cover types were considered for potential conversion. Urban areas were determined using 2000 TIGER Census data,[53] roads from TIGER Census[39] and National Forest data,[40;41] and land ownership using Public, Conservation, and Trust Lands v05.2.[54] Conservation easement data from The Pacific Forest Trust and the California Protected Areas Database.[55] Stephen's Meadow easement manually added for Eagle Lake rainbow trout.

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 or catchment available industrial timber production and the percent of subwatershed with hard metal mining claims (assuming an average of 20 acres per claim) outside of protected areas. Protected lands 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: Increased resource development will increase road densities, modify natural hydrology, and increase the likelihood of pollution to aquatic systems. If lands are protected then the watersheds will be less likely to be developed.

Data Sources: The number of mining claims was determined using Bureau of Land Management data,[56] and each claim was assumed to potentially impact 20 acres. Timber management potential identifies productive forest types from the existing vegetation type in Landfire[57] without formal protection as protected areas or Late Successional Reserves under the Northwest Forest Plan.[58] Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas,[27] and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset.[28]

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 or catchment.

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 are likely to reduce habitat suitability for native salmonids and increase the likelihood of invasion by non-native species.[59] 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).[60] Coal leases are mineable types from the Coal Fields of the United States dataset.[61] Geothermal known and closed lease areas and oil and gas leases and agreements from BLM Geocommunicator.[*62] Potential dam sites are based on Idaho National

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

Laboratory (INL) hydropower potential data.[63] Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas[27] and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset.[28] Goose Lake redband trout also reports miles of proposed energy transmission corridor by subwatershed.[64] This value is not considered in the scoring.

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

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.

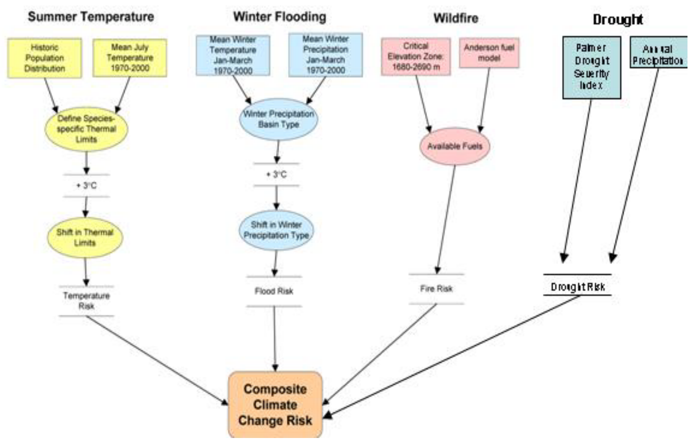
Communitization: Combining smaller federal tracts to meet the necessary minimum acreage required by the BLM (for spacing purposes).

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. Droughts occur as a result of increases in water-loss from higher temperatures and less 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.[65;66] 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.[67] These risks are further discussed by Williams et al.[65]

Data Sources: Temperature and precipitation data were obtained from the PRISM Group.[68] Elevation data were obtained from the National Elevation Dataset[52], and LANDFIRE data for the Anderson Fire Behavior Fuel Model 13[57] was used as input for wildfire risk. McCloud redband thresholds: low < 19 C, high > 21 C. Paiute cutthroat threshold: low < 18 C. Eagle Lake rainbow: low < 20 C, high > 22 C. Goose Lake redband: low < 20 C, high > 22 C.

Indicator: 5. Introduced species.

Indicator Scoring:

Present in basin	Present in catchment/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 a subbasin and subwatershed or catchment 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.[69] 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.[70]

Data Sources: Information on McCloud introduced species from the Draft Conservation Agreement;[26] Paiute cutthroat trout from USFWS;[2;3] Eagle Lake rainbow trout from Pine Creek RMPG;[4] and Goose Lake from ODFW[23] and Upper Pit River Watershed Assessment.[71] Road density calculated for the Watershed Conditions indicator also informs the introduced species indicator.

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