



# Conservation Success Index: Little Kern Golden Trout

*ONCORHYNCHUS MYKISS WHITEI*

Rev. 1.0 - 6/2009

## **SPECIES SUMMARY**

The Kern River basin drains the southern extent of the Sierra Nevadas in California. The system was connected to the San Joaquin River and first occupied by ancestral rainbow trout around 10,000 years ago. As the connection to the San Joaquin River valley and Tule Lake dried up and natural barriers within the system developed, three distinct forms of trout developed through isolation: the Little Kern golden trout (*Oncorhynchus mykiss whitei*) found in the Little Kern River, the California golden trout (*Oncorhynchus mykiss aguabonita*) found in the South Fork Kern River and Golden Trout Creek basins, and the Kern River rainbow trout (*Oncorhynchus mykiss gilberit*) found in the mainstem and tributaries of the Kern River.

Little Kern golden trout were historically found in 100 miles of stream above the natural waterfall barrier at the mouth of the Little Kern River. As the region was settled in the late 1800s, individuals were moved above additional barriers that had historically kept the subspecies out of the headwaters. Additionally, settlers introduced non-native trout species to the basin and its alpine lakes. By the mid-1970s, the net effect of these two activities was that the subspecies became restricted to short segments of headwater streams and portions of stream outside of its native range (Coyote Creek). Additional stress to the subspecies came from habitat degradation associated with livestock grazing. In 1978 the subspecies was listed as threatened under the Endangered Species Act.

Beginning in 1975, California Department of Fish and Game initiated a series of restoration activities designed to return the subspecies to its historic range. The primary activity was to apply piscicide to most tributary streams and mainstem Little Kern to eliminate non-native rainbow trout. Additional efforts were intended to mitigate the effects of livestock grazing and recreational uses in the basin. While treatments have been successful in expanding the extent of Little Kern golden trout, the primary outstanding conservation concern is the low-level presence and continued introgression of rainbow trout genes into the Little Kern golden trout genome.

Our CSI analysis incorporated data from the 2008 *SOS: California's Native Fish Crisis* report and the Genomic Variation Lab at University of California - Davis, and information from Molly Stephens (UC - Davis), Christy McGuire (California Department of Fish and Game), and Arnold Roessler (US Fish and Wildlife Service). We are grateful for these contributions to our understanding of this subspecies. Data for several CSI indicators affecting Little Kern golden trout are unavailable or uncertain, including: a clear understanding of the historic distribution (confounded by the history of translocations), a complete picture of the natural barriers in the system, and abundance data that would allow comparisons of productivity between different streams. A complete list of data sources is provided in the framework documentation. This analysis is summarized at the catchment scale (1,000 – 11,000 acres), a finer scale than the typical CSI.

Key CSI Findings

- Populations of Little Kern golden trout currently occupy the entire historical distribution of the subspecies, plus additional habitat above natural barriers. Introgressed populations occur in the lower and middle mainstem Little Kern River and in adjacent Coyote Creek.
- Tributaries and the upper portion of the Little Kern River have the highest population integrity scores. Additional information on population density and natural barriers would further inform the population integrity analysis.
- Habitat integrity scores are high due to the occurrence of the subspecies on protected public lands and the absence of sources of acute anthropogenic habitat degradation.
- Little Kern golden trout are at low risk to the future threats of resource extraction, energy development, and land conversion.
- Introduced species and changes in fire regime, winter flooding, and drought associated with potential climate change represent the largest threat to the future security of the subspecies.

Our CSI analysis shows that the range-wide conditions related to species distribution are high for Little Kern golden trout. The subspecies occupies a stream network and catchment area nearly equivalent to the size and extent of its historic distribution. All streams in the current distribution are second order or higher, with the exception of Table Meadow Creek, Tamarack Creek, Shotgun Creek Deep Creek, Lion Creek, and Willow Creek, suggesting that the small populations may persist in relatively stable environmental conditions. The lack of information on the historic distribution of the subspecies adds some uncertainty to the range-wide conditions analysis.

Most population integrity scores for Little Kern golden trout are high. Because of indications of small amounts rainbow trout introgression in all populations, most populations have moderately high genetic purity scores. Populations in the mainstem Little Kern River (below Rifle Creek) and Coyote Creek are introgressed in excess of 0.20 (with rainbow trout and California golden trout, respectively) and are considered functionally extirpated. Although these catchments may contain pure individuals and valuable genotypes, the consensus among management agencies is that conservation efforts should be focused on populations with introgression levels less than 0.10 – 0.20. The presence of introgressed individuals affects the population extent scores: the largest continuous habitat patches are higher in the basin and catchments lower in the system receive lower scores (additional information on natural barriers would lower population extent scores). All populations are generalized as persisting at high densities within the connected Little Kern system (estimated at 500 fish/mile; field information on the density of individuals would further inform this indicator). Disease vulnerability scores reflect the absences of any known debilitating pathogens in the basin. Based on the criteria described by Rieman and others and Hildebrand and Kershner, the Little Kern golden trout in the Little Kern River meet the desired persistence threshold, with 10 equivalent populations. Again, because persistence analyses look at connected habitat, additional information on natural barriers in the system would likely reduce the number of populations meeting the persistence criteria.

All habitat integrity scores are high. The lone source of habitat degradation in the Little Kern basin mapped within the CSI is the road network that exists in the Fish Creek and Clicks Creek catchments. Fish Creek has ½ mile of road in its riparian zone and this catchment receives a moderate water quality score. The CSI lacks a specific indicator for addressing instream habitat conditions and the legacy effects of over a century of logging and cattle and sheep grazing may not be fully reflected in the habitat integrity score. Nonetheless, the lack of the primary anthropogenic sources of habitat degradation that

typically affect salmonids suggests that the Little Kern golden trout occurs within a landscape within which population restoration would be particularly appropriate and successful.

The CSI analysis of future security suggests the Little Kern golden trout is at low to moderate risk. Because the subspecies' entire distribution lies within the Golden Trout Wilderness Area of Sequoia National Forest, Sequoia National Park, and Giant Sequoia National Monument, there is no risk of land conversion, energy development, or resource extraction. The primary predicted threat to future security comes as a result of the + 3°C climate change predicted by 2050 and increased disturbances that will accompany the temperature change. Our analysis suggests that the Little Kern golden trout is at highest risk to increased winter flooding associated with rain-on-snow events in the higher elevation catchments in the basin. The subspecies is at high risk to the effects of altered fire regimes associated with earlier spring warming in mid-elevation zones (except in Coyote Creek, Rifle Creek, Shotgun Creek, and the Upper Little Kern River, where risk is low) and moderate risk to drought (except in the mid-elevation Little Kern basin catchments, where risk is low). Based on the current distribution of the subspecies relative to air temperature, the subspecies is at low to moderate risk to increased summer temperatures.

Recommendations to increase resistance and resilience to climate change include a reduction of other remaining stressors, restoration of any riparian, wetland, and we meadow areas that are not in high condition, and partial reconnection of stream systems to allow greater fish movement within the native range. However, restoring connectivity also may increase risk from non-native fish introductions and thus must proceed with caution.

An additional future security risk is the introduction or persistence of non-native species in the basin. Based on the continued presence of introgressed individuals, Coyote Creek, and the lower reaches of the mainstem Little Kern have the lowest possible introduced species scores. Because of the history of unauthorized trout introductions in the Kern system, the remaining catchments received moderate scores.

Total CSI scores and conservation strategies are consistent with the current management direction for Little Kern golden trout. The purest populations in the Little Kern basin – those in tributaries off the mainstem – should remain the conservation and protection focus. Because introgressed individuals persist in the mainstem Little Kern, population restoration/reintroduction activities should be directed at eliminating non-native trout or highly introgressed Little Kern golden trout from the system. New information regarding fish densities and population extents may further refine CSI scores for population integrity and provide additional guidance for restoration activities. Given the limited variation in populations and habitats documented across the basin and suggested by the CSI, directing population and habitat restoration to those areas with the highest future security may be appropriate. Local knowledge will be required to direct habitat restoration activities designed to mitigate instream habitat degradation associated with historical land uses. Because of the presence of California golden trout in its headwaters, the introduced Coyote Creek population's primary conservation value may be as a source of unique genetic material.

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, the National Park Service, University of California - Davis, and California Trout. These entities have made great strides in the conservation of Little Kern golden trout since coordinated efforts began in the 1970s. Consistent with CSI findings related to habitat and population integrity, minimizing the exposure of the Little Kern River

to non-native trout should remain a top priority. Because it occurs entirely on public lands with the highest protection status, there is a significant opportunity to ensure the subspecies' persistence.

Prepared by Kurt Fesenmyer, TU, 4/6/2009

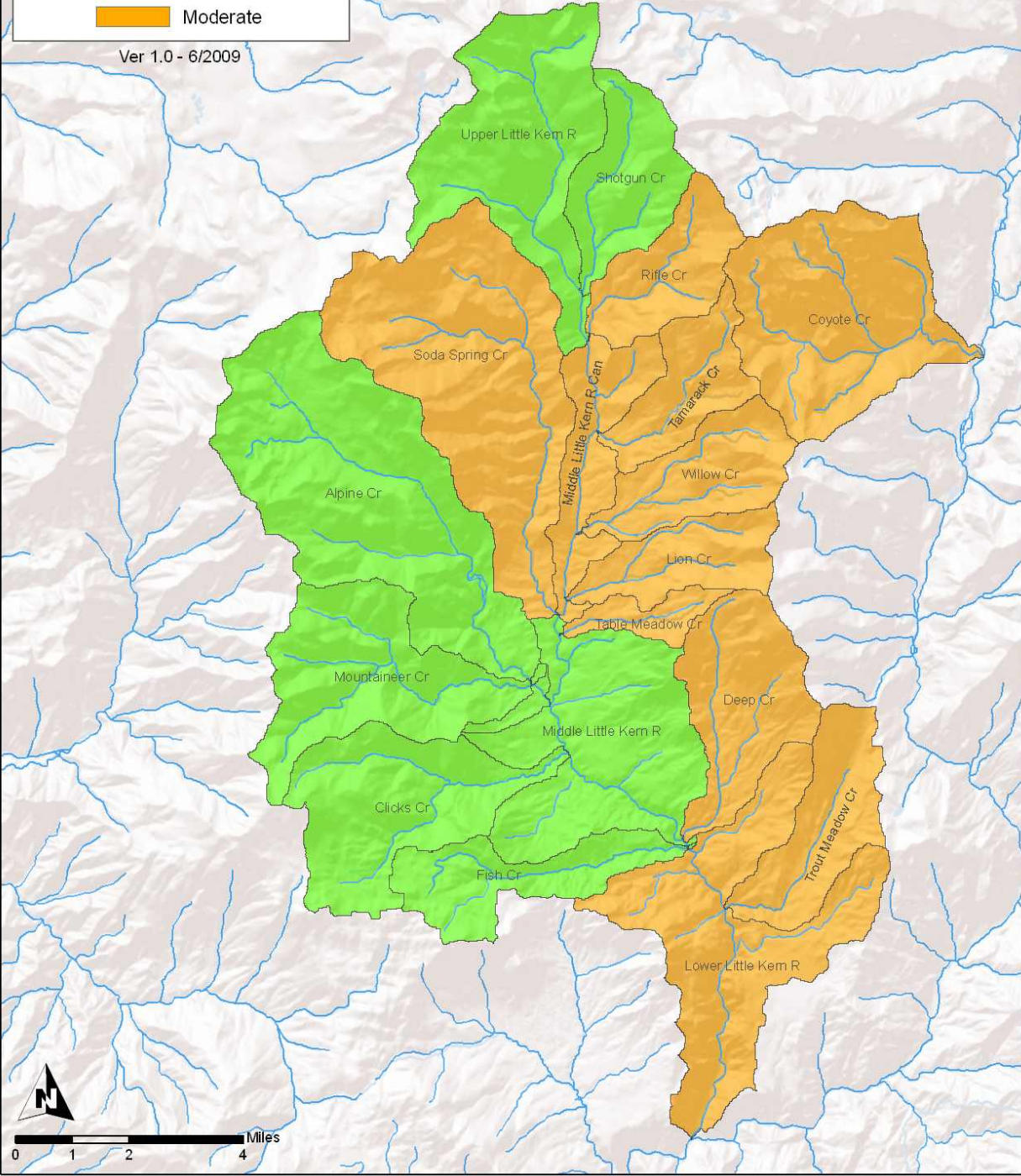
**Table 1.** CSI scoring results for Little Kern golden trout. All indicators are scored from 1 (poorest) to 5 (best): See framework documentation for details.

CSI Indicator	Number of Subwatersheds Receiving Scores					Total Subwatersheds Scored	
	1	2	3	4	5		
<b>Range-wide Conditions</b>	Percent historic stream habitat occupied	0	0	0	0	15	15
	Percent subbasins (4th) occupied	0	0	0	0	15	15
	Percent subwatersheds (6th) occupied	0	0	0	0	15	15
	Percent habitat by stream order occupied	3	1	3	0	8	15
	Percent historic lake area occupied	0	0	0	0	15	15
<b>Population Integrity</b>	Population Density	0	0	0	0	15	15
	Population Extent	2	3	0	0	10	15
	Genetic Purity	0	1	0	12	2	15
	Disease vulnerability	0	0	0	0	15	15
	Life history diversity	0	0	0	0	15	15
<b>Habitat Integrity</b>	Land Stewardship	0	0	0	0	18	18
	Watershed connectivity	0	0	0	0	18	18
	Watershed conditions	0	0	0	0	18	18
	Water quality	0	0	0	1	17	18
	Flow regime	0	0	0	0	18	18
<b>Future Security</b>	Land conversion	0	0	0	0	18	18
	Resource extraction	0	0	0	0	18	18
	Energy development	0	0	0	0	18	18
	Climate change	2	12	0	2	2	18
	Introduced species	3	0	0	15	0	18

**Little Kern Golden Trout  
Conservation Success Index  
Climate Change Analysis**

**Drought Risk**  
Low  
Moderate

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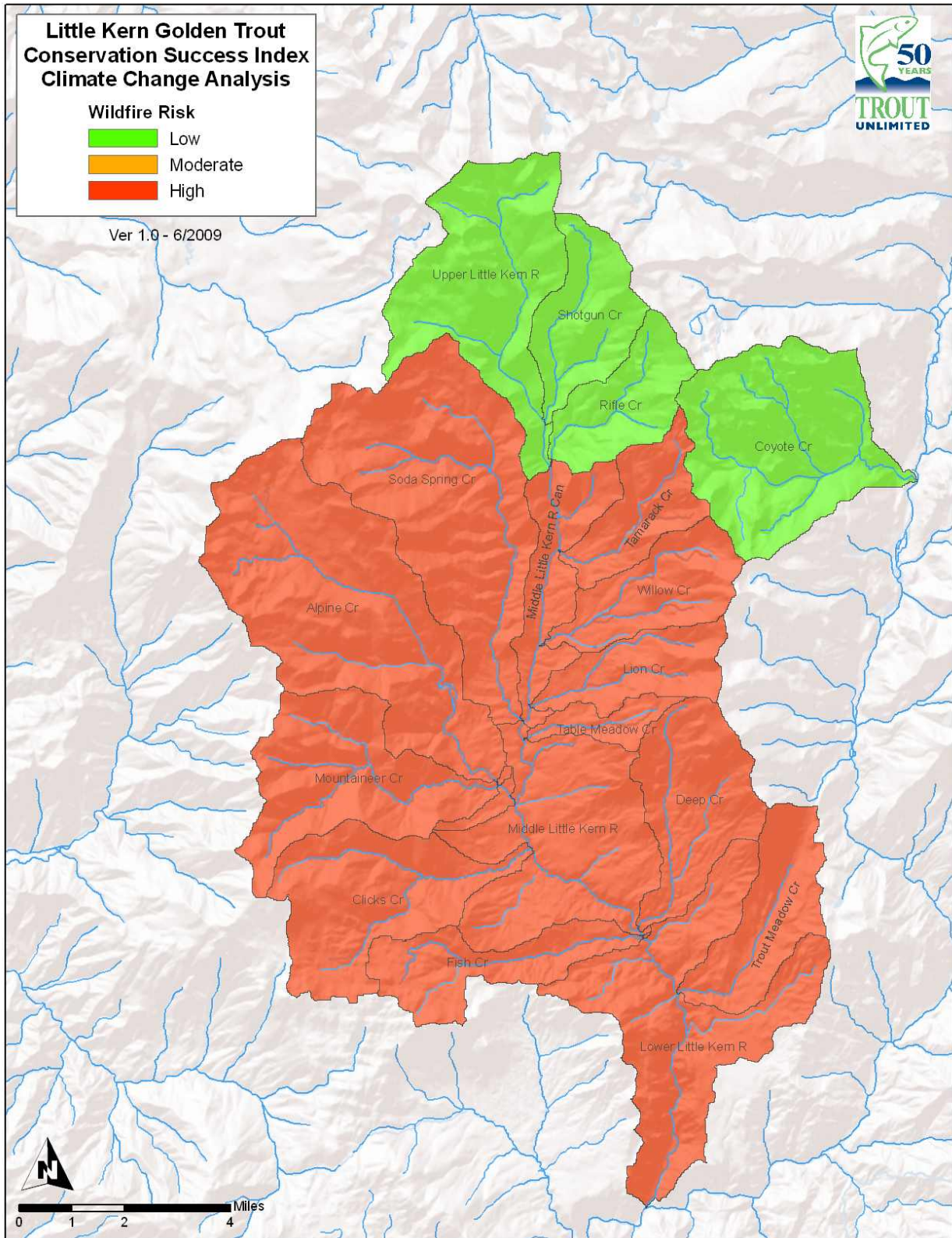


# Little Kern Golden Trout Conservation Success Index Climate Change Analysis

- Wildfire Risk**
- Low
  - Moderate
  - High



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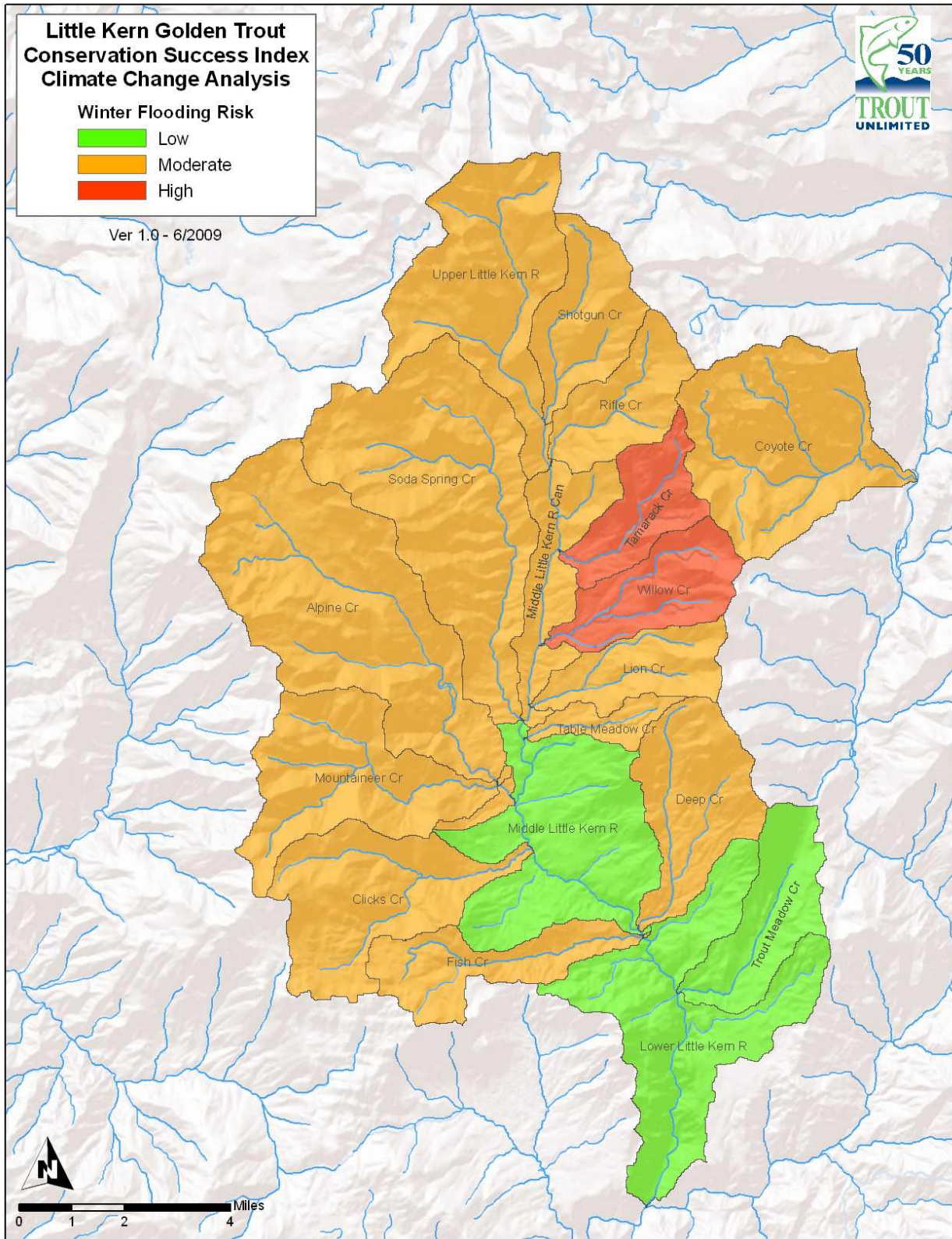
# Little Kern Golden Trout Conservation Success Index Climate Change Analysis

## Winter Flooding Risk

- Low
- Moderate
- High



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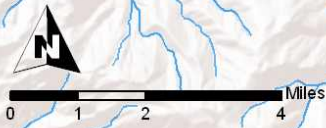
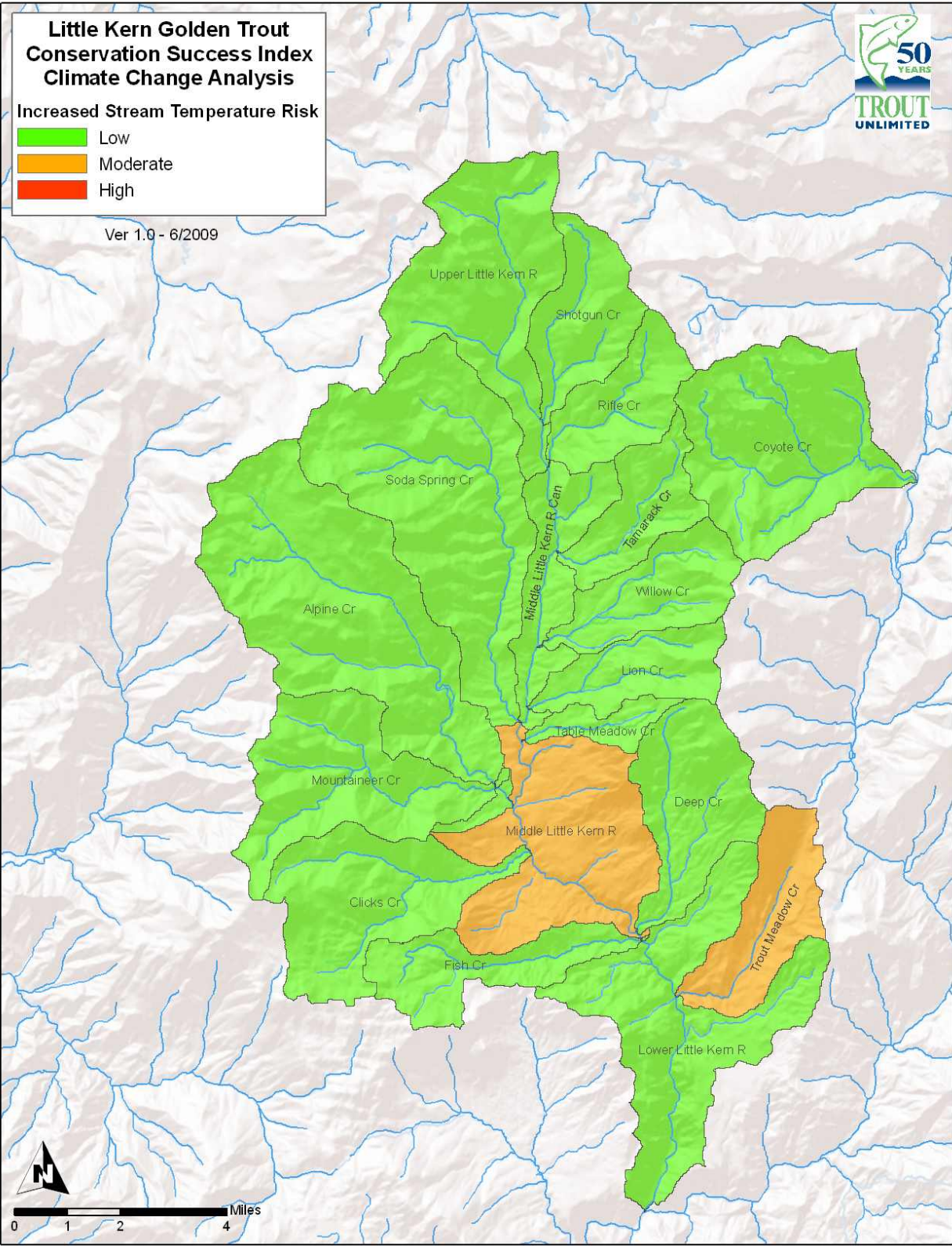


# Little Kern Golden Trout Conservation Success Index Climate Change Analysis

Increased Stream Temperature Risk

- Low
- Moderate
- High








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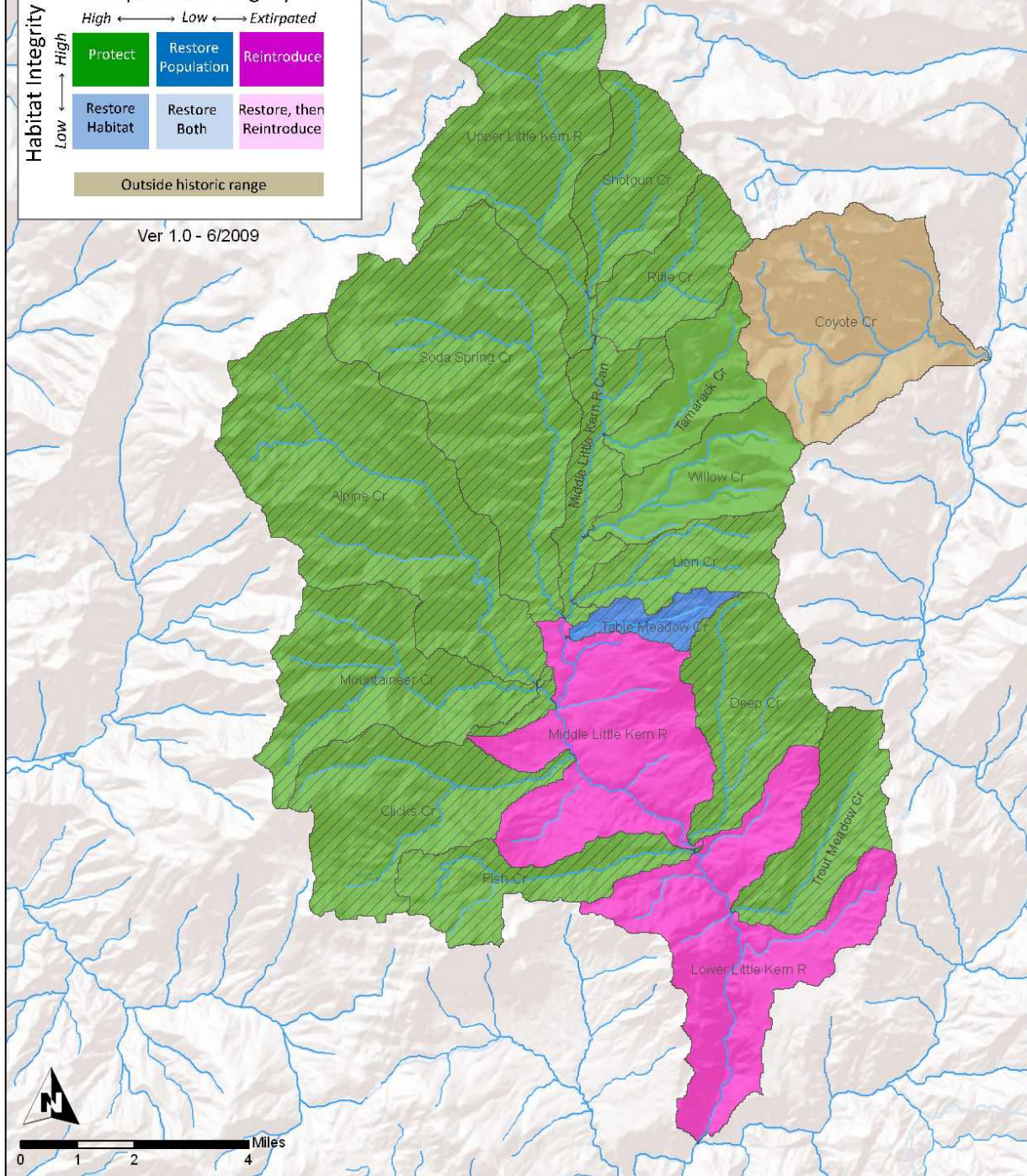
# Little Kern Golden Trout Conservation Success Index Conservation Strategies

 High Future Security

Habitat Integrity		Population Integrity		
		High ←	Low	→ Extirpated
High	 Protect	 Restore Population	 Reintroduce	
Low	 Restore Habitat	 Restore Both	 Restore, then Reintroduce	
		 Outside historic range		

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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.



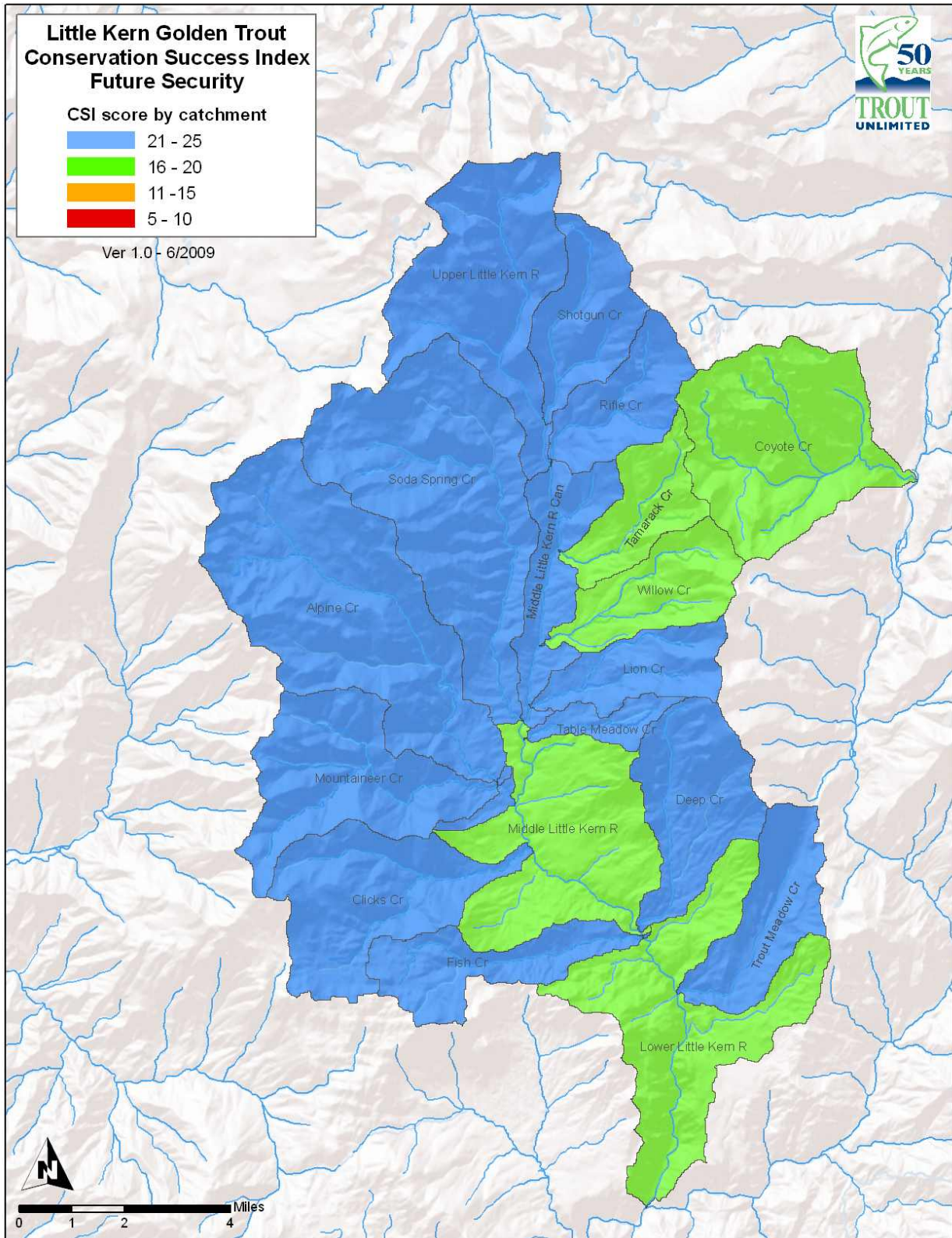


**Little Kern Golden Trout  
Conservation Success Index  
Future Security**

CSI score by catchment



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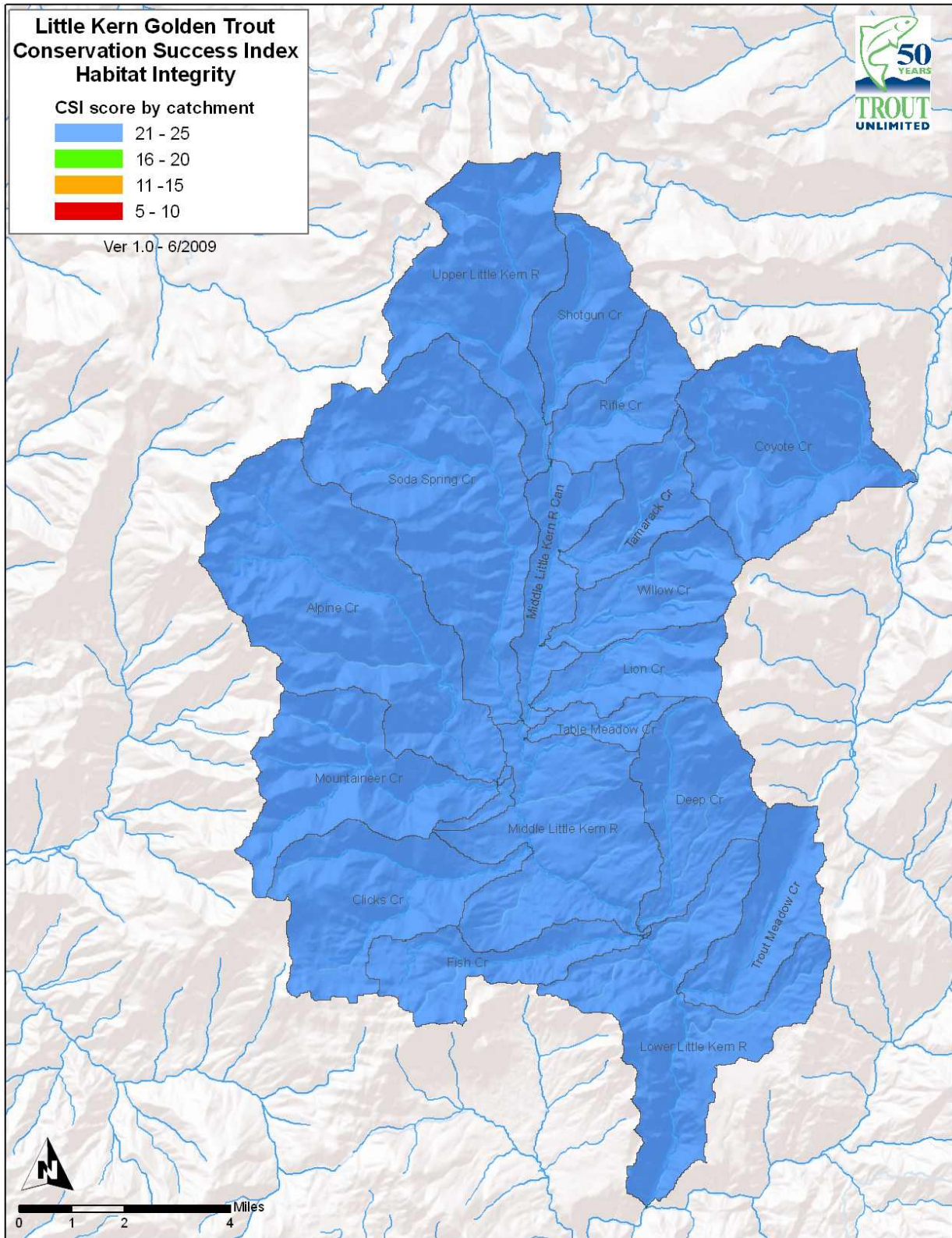


# Little Kern Golden Trout Conservation Success Index Habitat Integrity

CSI score by catchment

- 21 - 25
- 16 - 20
- 11 - 15
- 5 - 10

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# Little Kern Golden Trout Conservation Success Index Population Integrity

Introgressed populations

CSI score by catchment

21 - 25

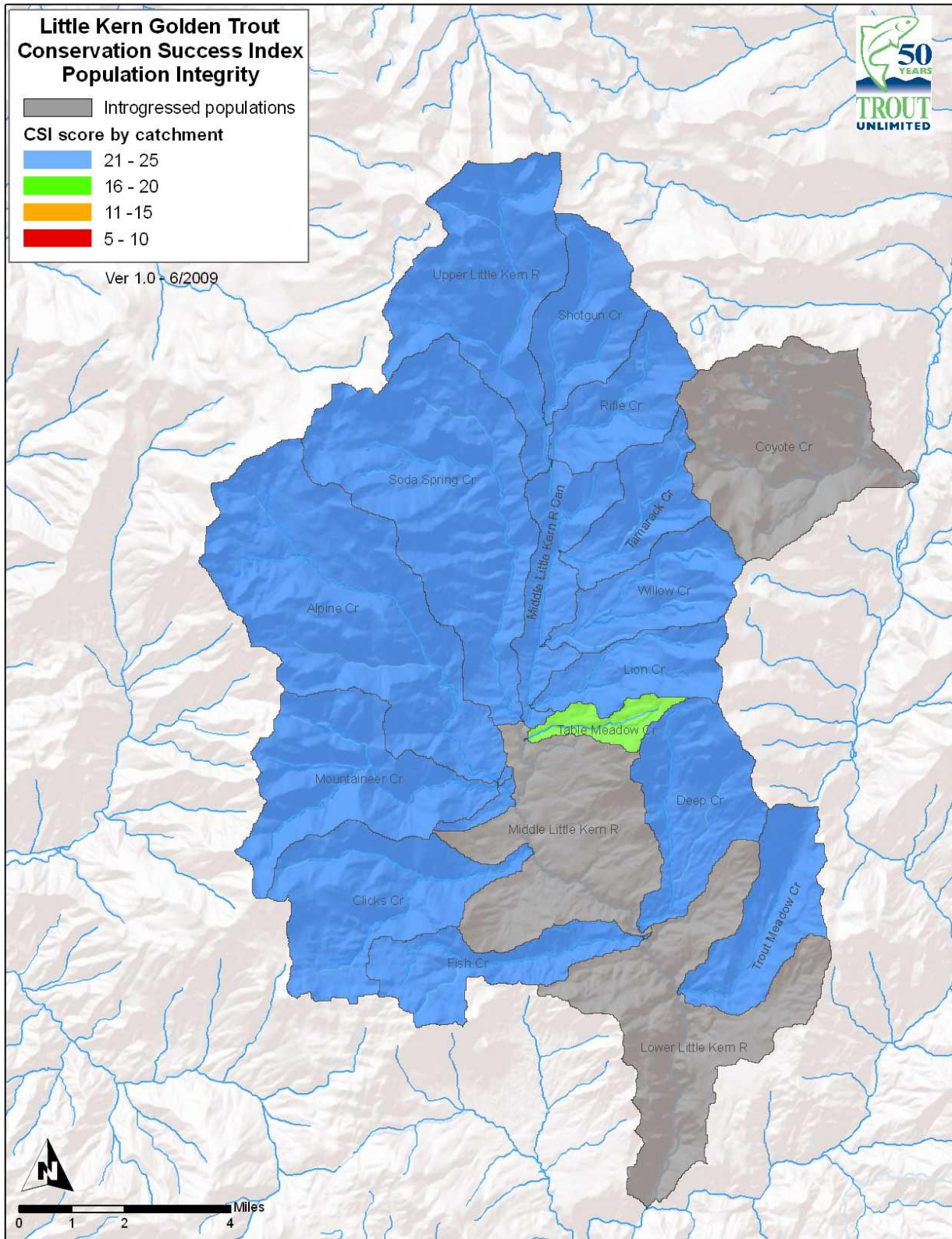
16 - 20

11 - 15

5 - 10



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# Little Kern Golden Trout Conservation Success Index Range-wide Conditions

Introgressed populations

CSI score by catchment

21 - 25

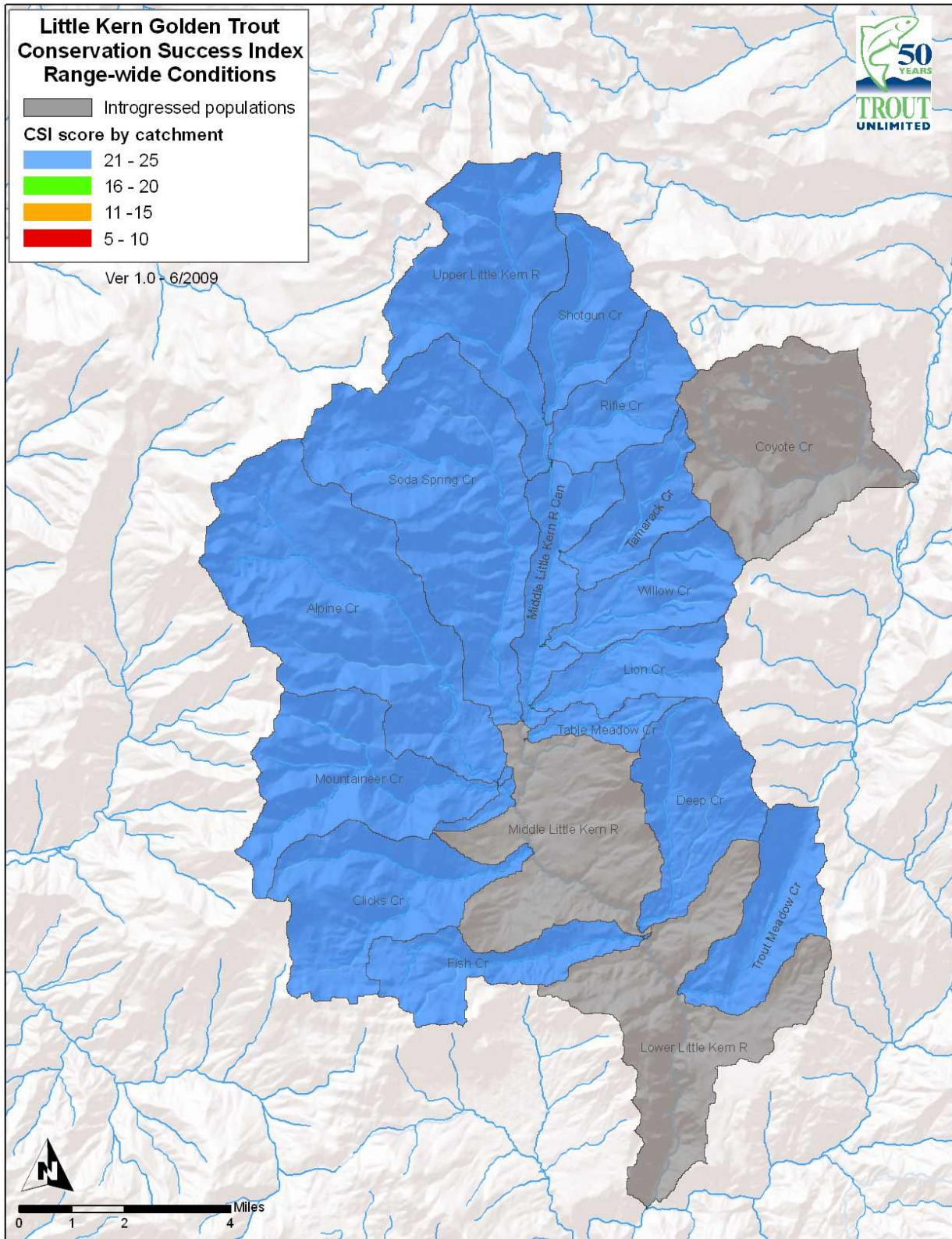
16 - 20

11 - 15

5 - 10

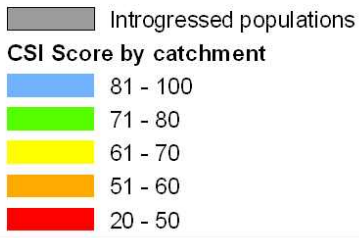


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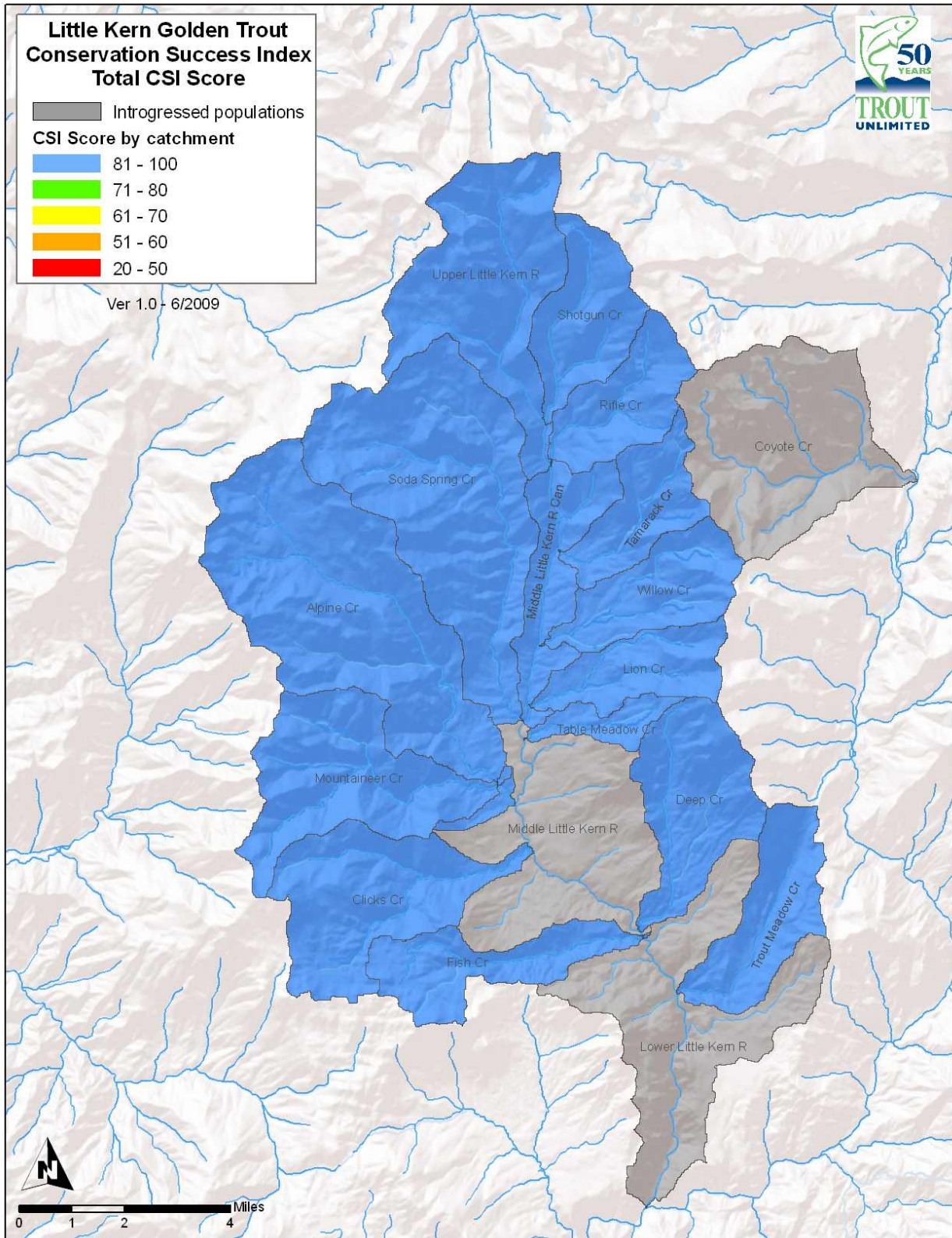




**Little Kern Golden Trout  
Conservation Success Index  
Total CSI Score**



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## Conservation Success Index: California Native Trout: Little Kern Golden Trout, California Golden Trout, and Kern River 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.

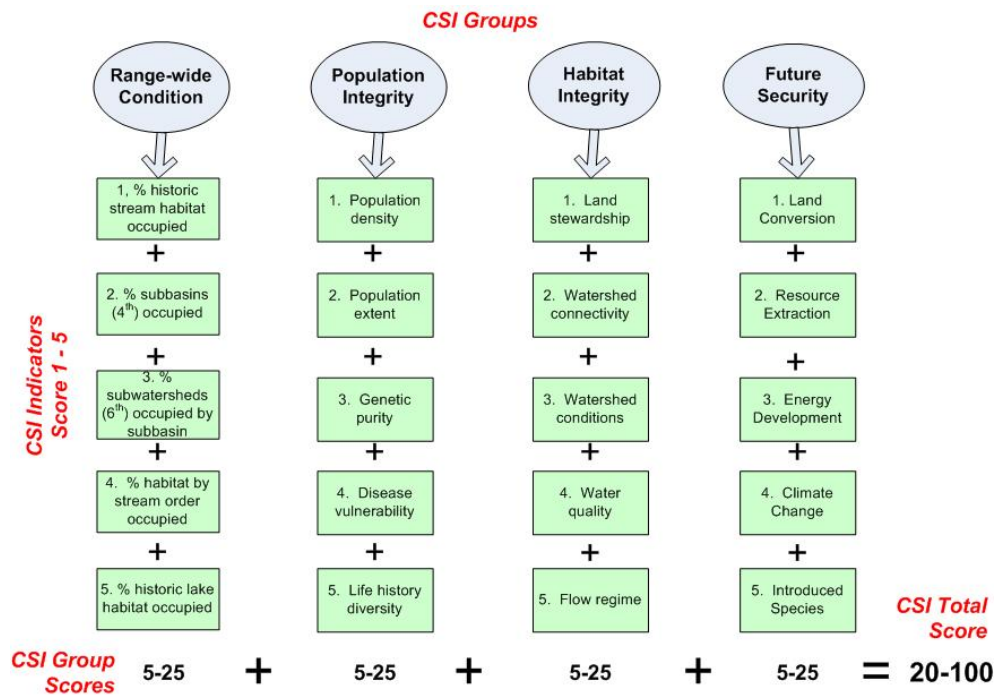


Figure 1. Each subwatershed or catchment is scored from 1 to 5 using 20 indicators within four main groups. Indicator scores are added per group to obtain an overall group score. Group scores are then added to obtain a composite CSI score for each subwatershed or catchment.

### 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. Species names are abbreviated as follows: California Golden trout (CAGT), Little Kern Golden trout (LKGT), and Kern River rainbow trout (KRRT).

**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<sup>th</sup> 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 distribution of CAGT from the Conservation Assessment and Strategy for CAGT,<sup>1</sup> Stephens, 2007,<sup>2</sup> and SOS Report,<sup>3</sup> and LKGT from Stephens, 2007<sup>2</sup> and SOS Report;<sup>3</sup> and KRRT from ### and SOS Report.<sup>3</sup> Because data is lacking on natural barriers in the system and the historical distribution of all three species, the historical distribution for each is assumed to equal the perennial and intermittent stream network. Subwatersheds based on NRCS data<sup>4</sup> (for KRRT); catchments based on NHD Plus<sup>5</sup> (for CAGT and LKGT).

**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 distribution of CAGT from the Conservation Assessment and Strategy for CAGT,<sup>1</sup> Stephens, 2007,<sup>2</sup> and SOS Report,<sup>3</sup> and LKGT from Stephens, 2007<sup>2</sup> and SOS Report;<sup>3</sup> and KRRT from ### and SOS Report.<sup>3</sup> Because data is lacking on natural barriers in the system and the historical distribution of all three species, the historical distribution for each is assumed to equal the perennial and intermittent stream network. Subwatersheds based on NRCS data<sup>4</sup> (for KRRT); catchments based on NHD Plus<sup>5</sup> (for CAGT and LKGT).

**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 distribution of CAGT from the Conservation Assessment and Strategy for CAGT,<sup>1</sup> Stephens, 2007,<sup>2</sup> and SOS Report,<sup>3</sup> and LKGT from Stephens, 2007<sup>2</sup> and SOS Report;<sup>3</sup> and KRRT from ### and SOS Report.<sup>3</sup> Because data is lacking on natural barriers in the system and the historical distribution of all three species, the historical distribution for

each is assumed to equal the perennial and intermittent stream network. Subwatersheds based on NRCS data<sup>4</sup> (for KRRT); catchments based on NHD Plus<sup>5</sup> (for CAGT and LKGT).

**Indicator:** 4. Habitat by stream order occupied.

**Indicator Scoring:**

Occupied 2 <sup>nd</sup> 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.<sup>6</sup>

**Data Sources:** The current distribution of CAGT from the Conservation Assessment and Strategy for CAGT,<sup>1</sup> Stephens, 2007,<sup>2</sup> and SOS Report,<sup>3</sup> and LKGT from Stephens, 2007<sup>2</sup> and SOS Report;<sup>3</sup> and KRRT from ### and SOS Report.<sup>3</sup> Because data is lacking on natural barriers in the system and the historical distribution of all three species, the historical distribution for each is assumed to equal the perennial and intermittent stream network.

**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.<sup>7</sup>

**Data Sources:** The current distribution of CAGT from the Conservation Assessment and Strategy for CAGT,<sup>1</sup> Stephens, 2007,<sup>2</sup> and SOS Report,<sup>3</sup> and LKGT from Stephens, 2007<sup>2</sup> and



SOS Report;<sup>3</sup> and KRRT from ### and SOS Report.<sup>3</sup> Because data is lacking on natural barriers in the system and the historical distribution of all three species, the historical distribution for each is assumed to equal the perennial and intermittent stream network and not include any lakes.

**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.<sup>8,9</sup>

**Data Sources:** Because of incomplete data, some subwatersheds/catchments were scored based on literature descriptions summarized in the SOS Report<sup>3</sup> of typical densities of the species (CAGT: 128 – 836 fish/mi = CSI score 5; LKGT: 500 fish/mi = CSI score 5; KRRT: 58-135 fish/mi = CSI score 3). Scoring rules were based, in part, on May and Albeke<sup>9</sup> and Williams et al.<sup>10</sup>

**Indicator:** 2. Population extent.

**Indicator Scoring:**

Connectivity	CSI Score
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< 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<sup>11</sup> 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). Anthropogenic barriers within the distribution of CAGT from the Conservation Assessment and Strategy for CAGT<sup>1</sup> and SOS Report,<sup>3</sup> and LKGT from SOS Report;<sup>3</sup> and KRRT from ### and SOS Report.<sup>3</sup> Major natural barriers data from National Hydrography Dataset,<sup>12</sup> but data is lacking on smaller natural barriers in the system. Scoring rules were based, in part, on May and Albeke<sup>9</sup> and Williams et al.<sup>10</sup>

**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:** Introgression values for CAGT from Stephens, 2007<sup>2</sup> and Cordes et al 2006,<sup>13</sup> LKGT from Stephens, 2007;<sup>2</sup> and KRRT from ###. 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<sup>9</sup> and Williams et al.<sup>10</sup>

**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:** No records exist reporting whirling disease or other pathogens in the Kern system.

**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.<sup>11;14;15</sup>

**Data Sources:** No records exist of non-resident life histories for LKGT or CAGT. KRRT assumed to have historically expressed fluvial life histories.<sup>3</sup> Scoring rules were based, in part, on May and Albeke<sup>9</sup> and Williams et al.<sup>10</sup>

**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
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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<sup>16</sup> and the U.S. Department of Agriculture, Forest Service’s National Inventoried Roadless Areas dataset.<sup>17</sup>

**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 4<sup>th</sup>:

- >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.<sup>11</sup> Diversions, when they do not directly inhibit fish passage, can represent false movement corridors, cause fish entrainment, and act as population sinks.<sup>18;19</sup>

**Data Sources:** Anthropogenic barriers within the distribution of CAGT from the Conservation Assessment and Strategy for CAGT<sup>1</sup> and SOS Report,<sup>3</sup> and LKGT from SOS Report;<sup>3</sup> and KRRT from ### and SOS Report.<sup>3</sup> Major natural barriers data from National Hydrography Dataset,<sup>12</sup> but data is lacking on smaller natural barriers in the system.

**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  $\geq 1.7$  and  $< 4.7$  mi/square mile.

If road density is  $\geq 4.7$  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.<sup>20</sup> Converted lands are known to degrade aquatic habitats.<sup>21;22</sup> Road density is computed for the subwatershed; roads are known to cause sediment-related impacts to stream habitat.<sup>23-25</sup> Lee et al.<sup>24</sup> recognized 6 road density classifications as they related to aquatic habitat integrity and noted densities of 1.7 and 4.7 mi/mi<sup>2</sup> as important thresholds.

**Data Sources:** Converted lands were determined using the National Land Cover Database,<sup>26</sup> with all Developed, Pasture/Hay, and Cultivated Crops land cover types considered to be converted lands. Road density was determined using TIGER Census<sup>27</sup> and National Forest roads data.<sup>28;29</sup>

**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 ephemeral 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 withdrawals, and saline water discharge.<sup>7;28</sup> Roads along streams can also contribute large amounts of fine sediments that smother benthic invertebrates, embed spawning substrates, and increase turbidity.<sup>30;31</sup>

**Data Sources:** 303(d) impaired streams from USEPA.<sup>32</sup> The National Land Cover Database<sup>26</sup> 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.<sup>33</sup> Oil and gas wells from USGS. Road density within a 150 ft buffer was computed using TIGER Census<sup>27</sup> and National Forest roads data<sup>28;29</sup> and the National Hydrography Dataset.<sup>12</sup>

**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.<sup>34</sup> Dams, reservoirs, and canals alter flow regimes.<sup>35</sup> Reduced or altered flows reduce the capability of watersheds to support native biodiversity and salmonid populations.

**Data Sources:** The National Inventory of Dams<sup>36</sup> provided data on dams and their storage capacity. Data on canals were obtained from the National Hydrography Dataset<sup>12</sup> Perennial and intermittent streams were obtained from the National Hydrography Dataset.<sup>12</sup>

*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.<sup>37</sup>

**Data Sources:** Slope was computed from the National Elevation Dataset.<sup>38</sup> Land cover was determined from the National Land Cover Database,<sup>26</sup> 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,<sup>39</sup> roads from TIGER Census<sup>27</sup> and National Forest data,<sup>28;29</sup> and land ownership using Public, Conservation, and Trust Lands

v05.2.<sup>40</sup> Conservation easement data from The Pacific Forest Trust and the California Protected Areas Database.<sup>41</sup>

**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,<sup>42</sup> and each claim was assumed to potentially impact 20 acres. Timber management potential identifies productive forest types from the existing vegetation type in Landfire<sup>43</sup> without formal protection as protected areas. Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas,<sup>16</sup> and the U.S. Department of Agriculture, Forest Service’s National Inventoried Roadless Areas dataset.<sup>17</sup>

**Indicator:** 3. Energy Development.

**Indicator Scoring:**

Leases or reserves	New Dams 4 <sup>th</sup>	New Dams 6 <sup>th</sup>	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.<sup>44</sup> 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).<sup>45</sup> Coal leases are mineable types from the Coal Fields of the United States dataset.<sup>46</sup> Geothermal known and closed lease areas and oil and gas leases and agreements from BLM Geocommunicator.<sup>47</sup> Potential dam sites are based on Idaho National Laboratory (INL) hydropower potential data<sup>48</sup>. Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas<sup>16</sup> and the U.S. Department of Agriculture, Forest Service’s National Inventoried Roadless Areas dataset<sup>17</sup>.

**Indicator:** 4. Climate change.

**Indicator Scoring:**

TU Climate Change Analysis	
Climate Risk Factors	CSI Score

\* 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.

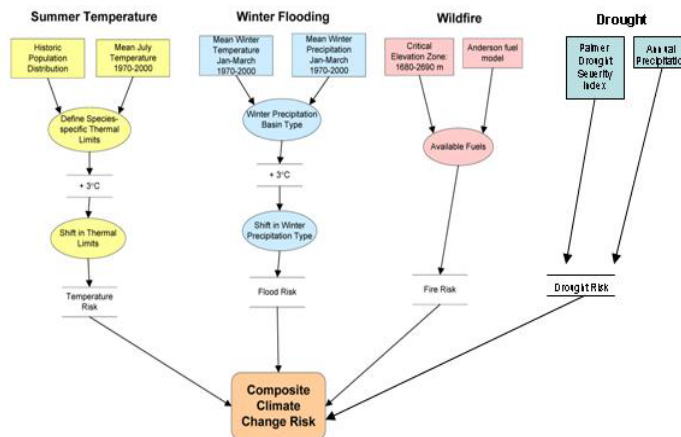
*Other Agreements:* Catch-all for other agreement types.



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:

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



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.<sup>49;50</sup> 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.<sup>51</sup> These risks are further discussed by Williams et al.<sup>49</sup>

**Data Sources:** Temperature and precipitation data were obtained from the PRISM Group.<sup>52</sup> Elevation data were obtained from the National Elevation Dataset<sup>38</sup>, and LANDFIRE data for the

Anderson Fire Behavior Fuel Model 13<sup>43</sup> was used as input for wildfire risk. CAGT thresholds: low < 20 C, high > 22 C. LKGT threshold: low < 20 C, high > 22. KRRT thresholds: low < 20 C, high > 22 C.

**Indicator:** 5. Introduced species.

**Indicator Scoring:**

Present in basin	Present in catchment	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.<sup>53</sup> 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.<sup>54</sup>

**Data Sources:** Based Stephens 2007,<sup>2</sup> if an individual was present within the sample population with greater than 50% rainbow or other trout genes, introduced species are assumed present within the catchment and all downstream catchments. Based on CAGT Assessment, brown trout are present below Templeton barrier.<sup>1</sup> Road density calculated for the Watershed Conditions indicator also informs the introduced species indicator.

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