Conservation Success Index: Central Valley Spring/Summer Chinook Salmon

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Rev. 1.0 - 10/2010

SPECIES SUMMARY

Spring/summer chinook were once widely distributed in the Central Valley, but have now been extirpated from much of their historic range, especially in the San Joaquin basin. Remaining spring/summer chinook migrate in spring, hold during summer in pools, and spawn in the early fall. Juveniles out-migrate within one year and adults grow to maturity for 1-3 years in the Pacific.

Spring/summer chinook in the Sacramento River and tributaries occur within the Central Valley Evolutionary Significant Unit (ESU) designated by the National Marine Fisheries Service (NMFS). All populations in the ESU are listed as threatened under the Endangered Species Act. Major limiting factors for these chinook populations include habitat loss and alteration associated with water infrastructure development (dams); conversion of critical estuary habitats; flow and entrainment issues associated with diversions and canals; and hatchery and harvest issues. Detailed information on chinook status, life history, and abundance is available in California Trout's SOS: California's Native Fish Crisis report.

Trout Unlimited's CSI for salmon and steelhead is a compilation and assessment of information related to species' distribution, populations, habitat features, and future threats. The CSI assembles GIS data available from national or state resource management agencies in a database and summarizes the data by watershed. A categorical score (5 through 1, reflecting exceptional through poor condition) is then assigned to the data based on the best scientific understanding of the influence of the particular data on salmon and steelhead. These species-specific analyses – 15 "indicators" – are modified from the CSI for inland trout to better address the unique life history and habitat requirements of salmon and steelhead. Indicators are organized into four thematic groups:

- Range-wide Condition indicators compare the current distribution to the historical distribution of spring/summer chinook across watershed (~5,000 acres) and population (~ 100,000 acres) scales. Current distribution summaries use data from CDFG's Calfish, while historical distribution information is approximated from historical accounts.
- Population Integrity indicators reflect the strength of spring/summer chinook populations at the population scale and are taken directly from the Wild Salmon Center's North American Salmon Stronghold expert database.
- Habitat Integrity indicators assess habitat condition based on stressors that can be readily captured by GIS data. Each indicator takes into account a variety of factors related to watershed condition (primarily roads), temperature, watershed connectivity (barriers), water quality (primarily land uses), and flow regime. Nonetheless, because of the Central Valley's highly

managed water storage and delivery systems, CSI conclusions on temperature and flow stressors may not accurately reflect instream condition.

- Future Security indicators anticipate the threats spring/summer chinook will face in the near future. Indicators account for a variety of factors related to land conversion (urban and vineyard), resource extraction (renewable and non-renewable), climate change, sedimentation, and land stewardship.

The CSI is based on information provided by California Department of Fish and Game and the National Marine Fisheries Service. Analyses were developed with assistance from The Nature Conservancy – California and the National Marine Fisheries Service. Additional information on data sources and methods can be found in a document under the Rule Sets link.

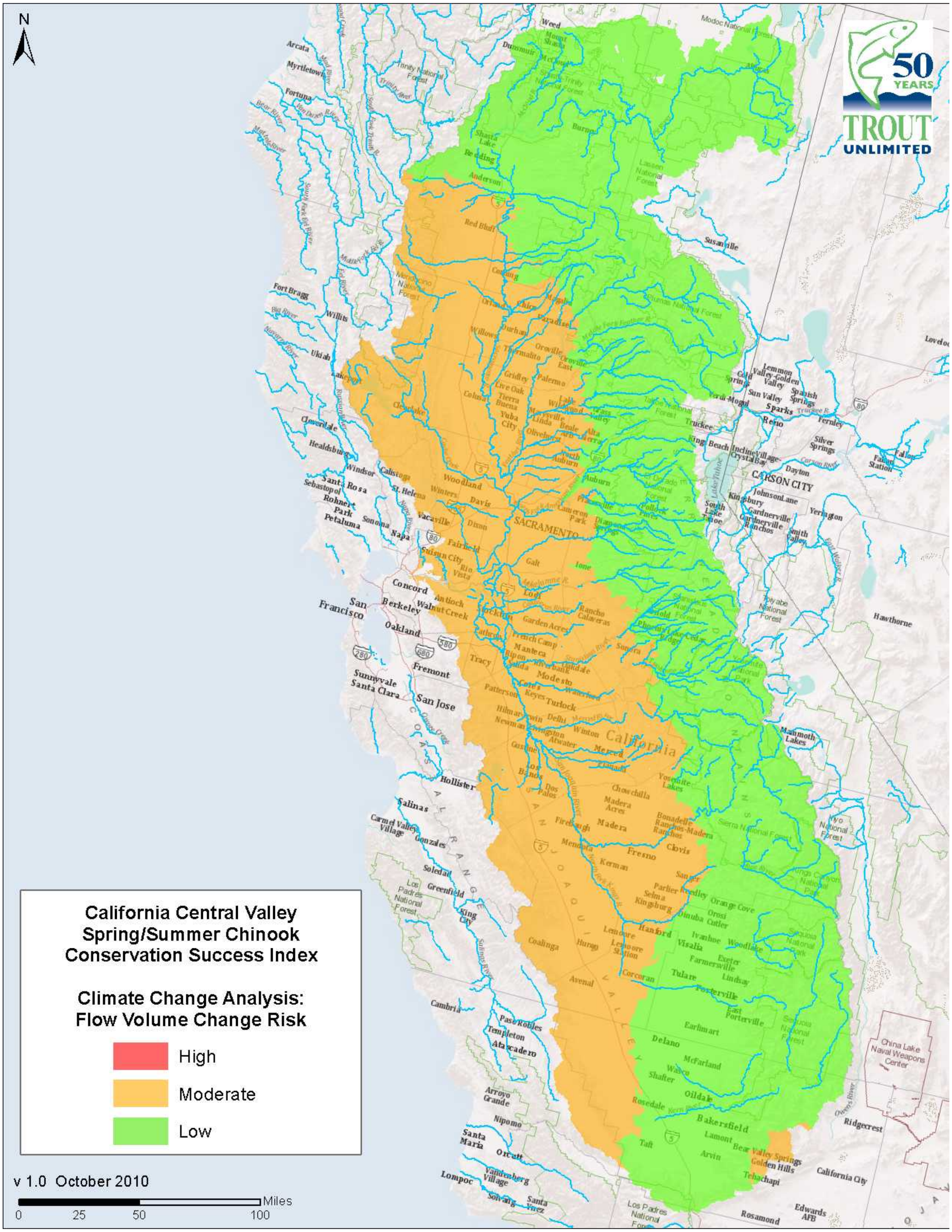
Key Spring/Summer Chinook CSI Findings

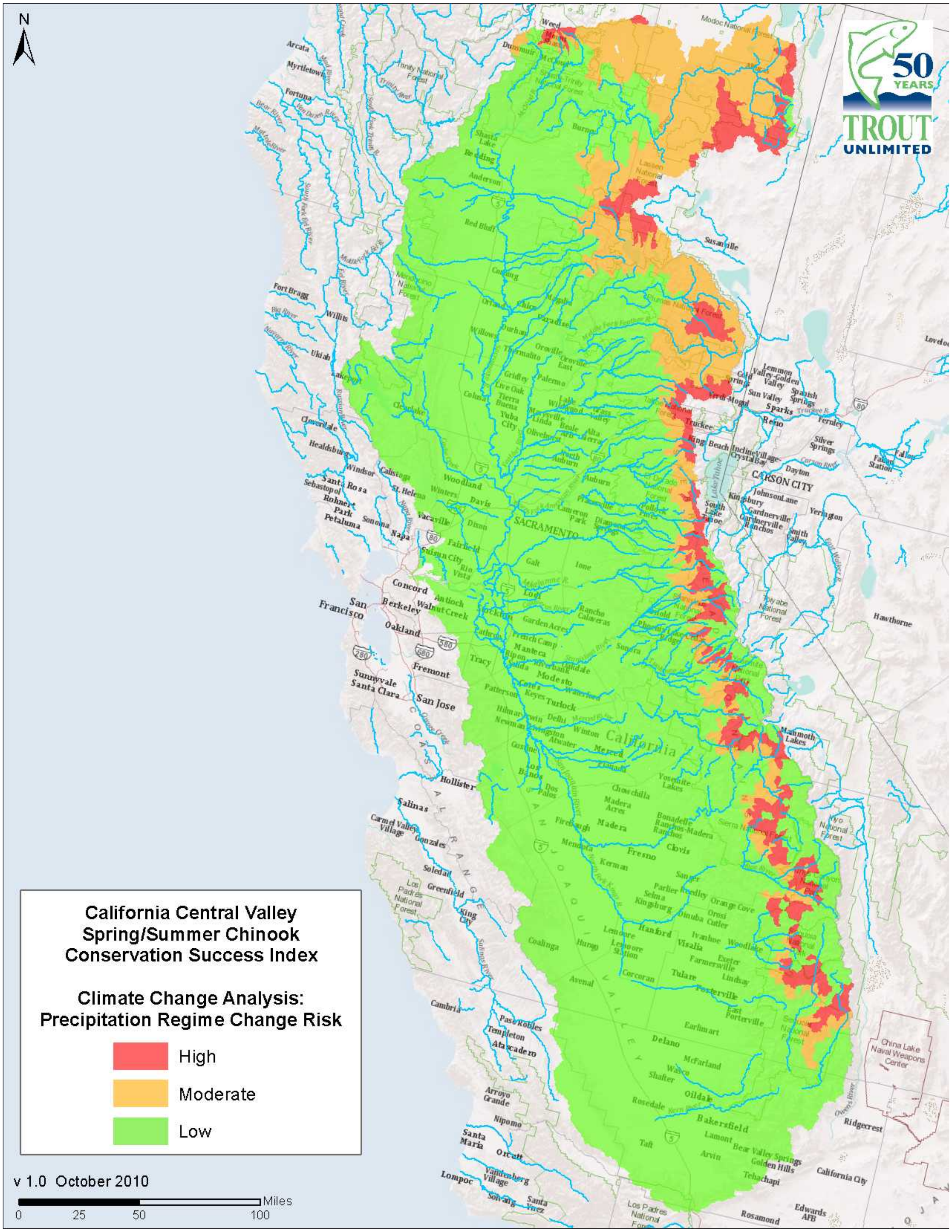
- Spring/summer chinook are extirpated from 72% of their historically occupied watersheds in the Central Valley ESU; strongest remaining populations include Clear, Mill, Deer, and Butte Creeks.
- Lowest habitat integrity scores are associated with the impacts of agricultural and urban development in the Sacramento and San Joaquin Valleys.
- Low overall watershed connectivity scores reflect significant numbers of downstream barriers or within-watershed dams and diversions in the historical distribution of spring/summer chinook. Lowest scoring watersheds include historically occupied drainages in the foothills and northern Sacramento system.
- Highest habitat integrity scores are associated with headwater streams historically not occupied by anadromous salmon and steelhead.
- Rain-dominated watersheds in the Central Valley and foothills are a low risk to changes in precipitation regime related to climate change, while high and mid-elevation watersheds in the Sierra Nevada are at high and moderate risk of transition from snow-dominated to rain or mixed winter precipitation, especially in the Upper Pit, Upper Feather, and Upper Yuba basins.
- Watersheds along the mainstem Sacramento and San Joaquin Rivers are at high risk to increasing summer temperatures related to climate change; higher elevation headwaters in the Sierra Nevada are at the lowest risk.
- Further development of timber resources and new development of local mineral and geothermal resources present a widespread future security risk in the northern and central Sierra Nevada.
- Potential vineyard expansion in the foothills may bring additional water demands during critical low-flow periods.

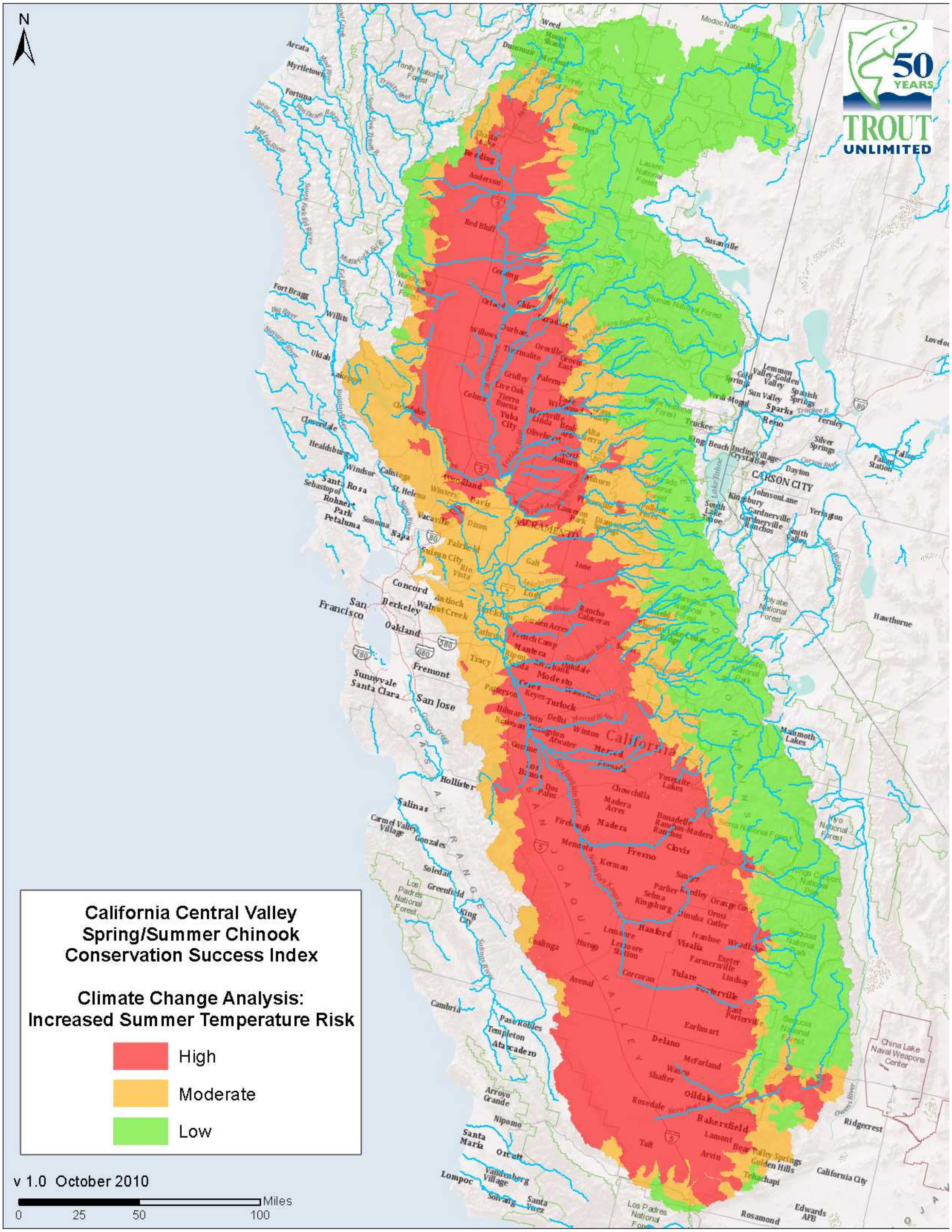
Prepared by Kurt Fesenmyer, November 2010

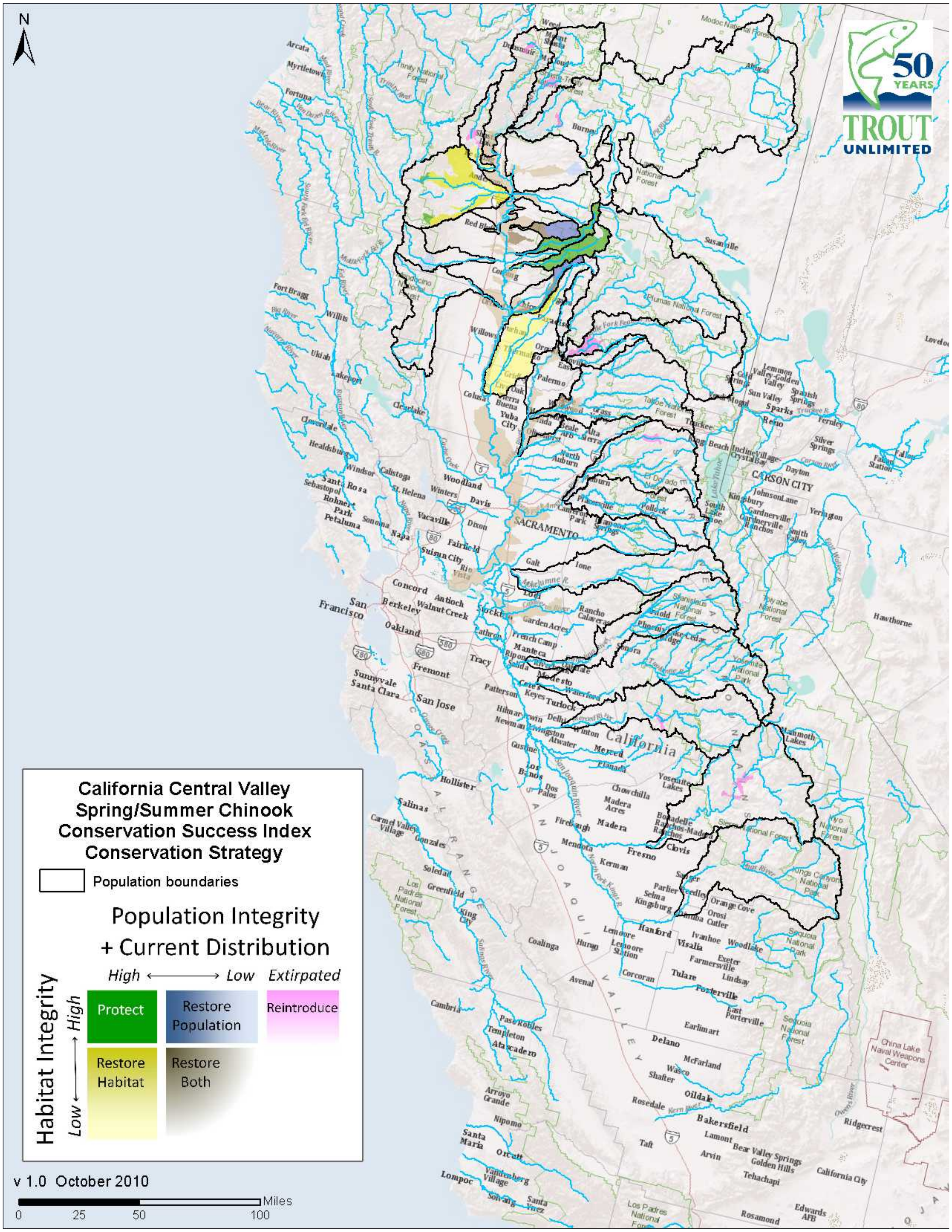
Table 1. CSI scoring result summary for Spring/Summer Chinook

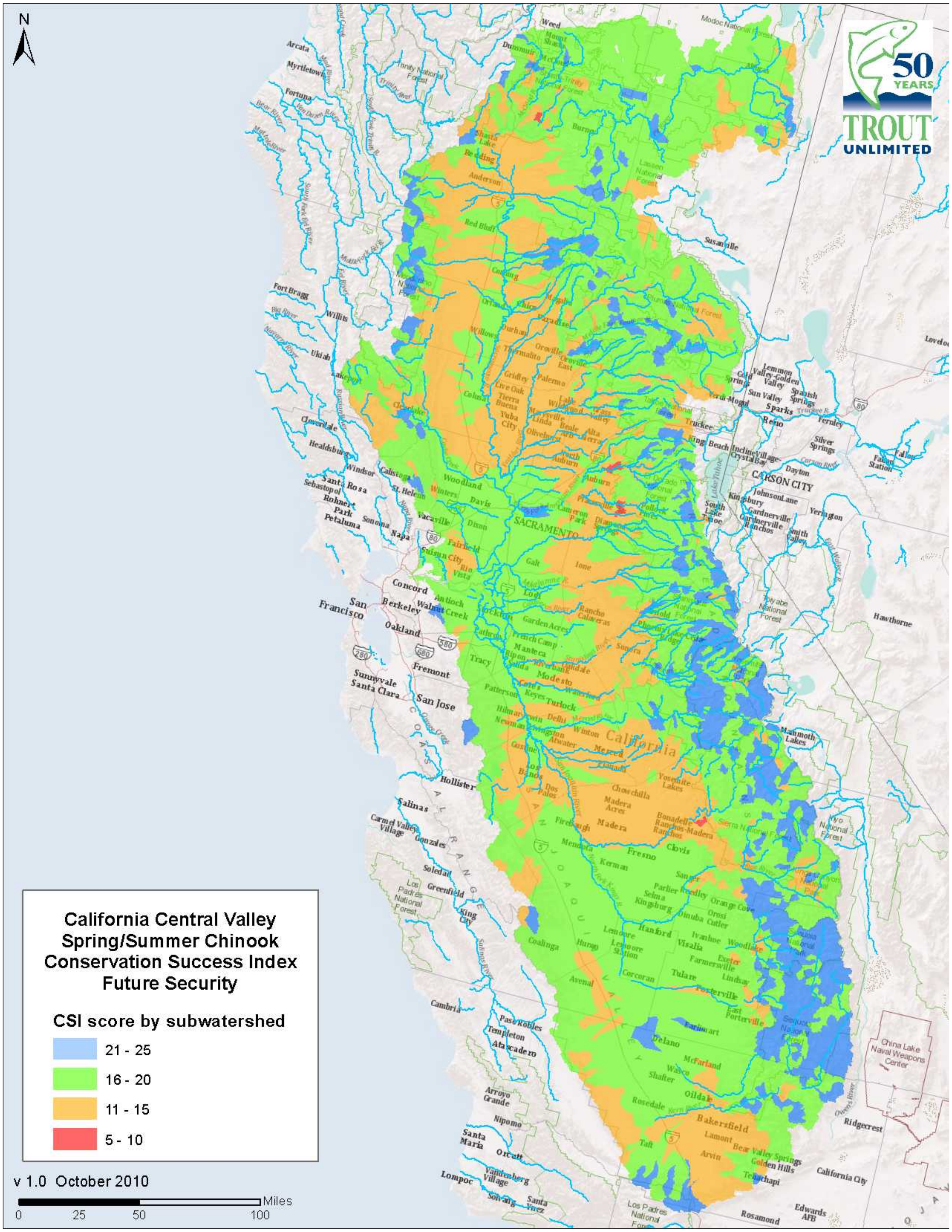
		Number of Subwatersheds Receiving Scores					Total Subwatersheds Scored
	CSI Indicator	**1**	**2**	**3**	**4**	**5**	
Range-wide Conditions	Percent watersheds occupied by population	1	8	0	0	57	66
	Percent historic stream habitat occupied	3	3	0	1	71	78
Population Integrity	Population viability	7	20	19	4	15	65
	Hatchery influence	6	9	5	13	33	66
	Life history diversity	0	5	37	3	20	65
Habitat Integrity	Watershed conditions	525	1029	706	194	422	2876
	Temperature	837	260	264	552	963	2876
	Watershed connectivity	173	93	78	522	2010	2876
	Water quality	361	138	244	476	1657	2876
	Flow regime	359	164	232	625	1496	2876
Future Security	Land conversion	20	50	78	155	2573	2876
	Resource extraction	323	848	904	453	348	2876
	Climate change	1097	0	326	826	627	2876
	Sedimentation	302	25	1	0	2548	2876
	Land Stewardship	1878	86	21	88	803	2876

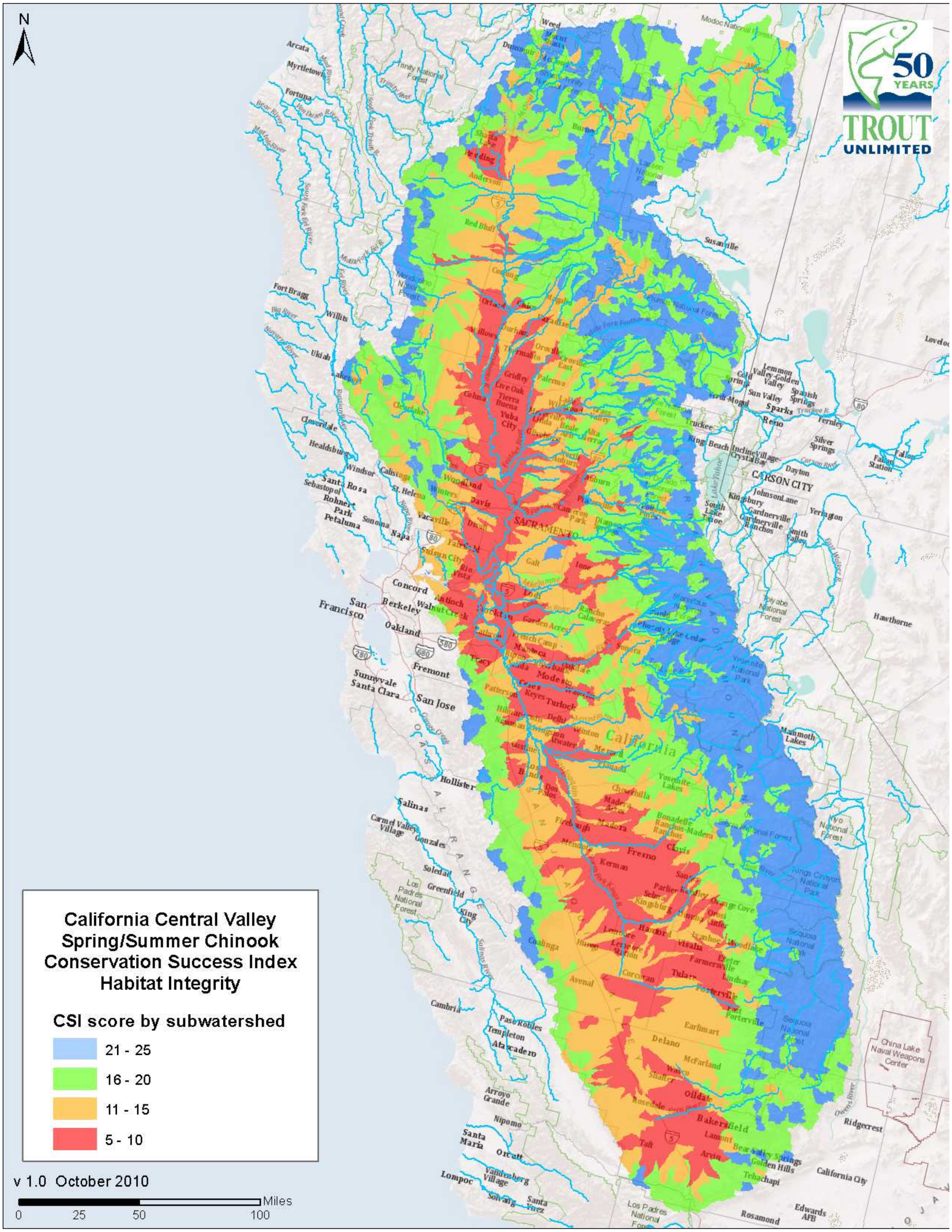

California Central Valley
Spring/Summer Chinook
Conservation Success Index
Climate Change Analysis:
Flow Volume Change Risk
High
Moderate
Low
v 1.0 October 2010
0 25 50 100 Miles
N
50 YEARS
TROUT UNLIMITED

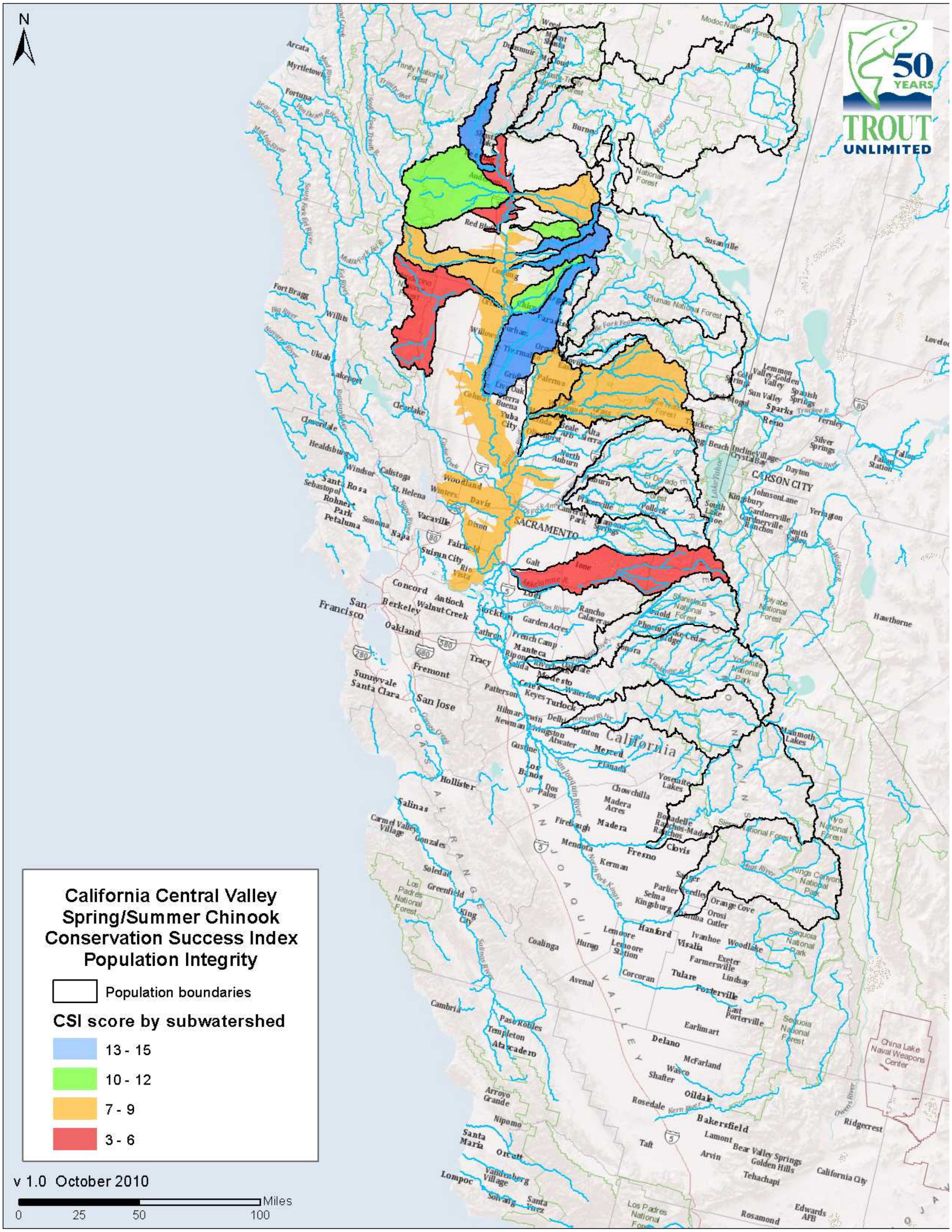

California Central Valley
Spring/Summer Chinook
Conservation Success Index
Climate Change Analysis:
Precipitation Regime Change Risk
High
Moderate
Low
v 1.0 October 2010
Miles
0
25
50
100
N
50 YEARS
TROUT UNLIMITED
SACRAMENTO
CARSON CITY
San Francisco
Oakland
San Jose
Fresno
Bakersfield
Reno

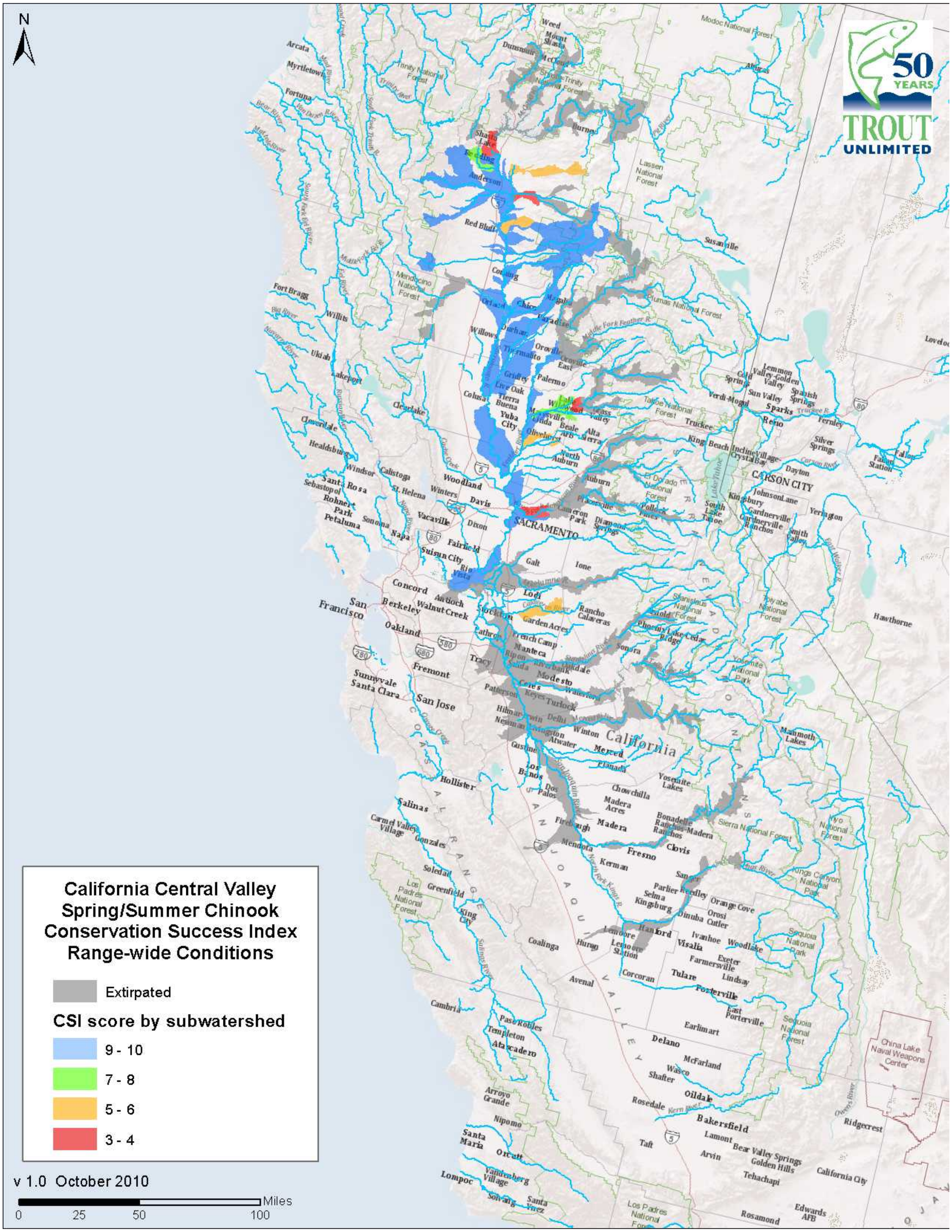

N
50 YEARS
TROUT UNLIMITED
California Central Valley
Spring/Summer Chinook
Conservation Success Index
Climate Change Analysis:
Increased Summer Temperature Risk
High
Moderate
Low
v 1.0 October 2010
Miles
0 25 50 100


California Central Valley
Spring/Summer Chinook
Conservation Success Index
Conservation Strategy
Population boundaries
Population Integrity
+ Current Distribution
High ⟷ Low
Extirpated
Habitat Integrity
High
Low
Protect
Restore Population
Reintroduce
Restore Habitat
Restore Both
v 1.0 October 2010
Miles
0
25
50
100
N
50 YEARS
TROUT UNLIMITED


California Central Valley
Spring/Summer Chinook
Conservation Success Index
Future Security
CSI score by subwatershed
21 - 25
16 - 20
11 - 15
5 - 10
v 1.0 October 2010
Miles
0 25 50 100
N
50 YEARS
TROUT UNLIMITED


California Central Valley
Spring/Summer Chinook
Conservation Success Index
Habitat Integrity
CSI score by subwatershed
21 - 25
16 - 20
11 - 15
5 - 10
v 1.0 October 2010
Miles
0 25 50 100
50 YEARS
TROUT UNLIMITED


California Central Valley
Spring/Summer Chinook
Conservation Success Index
Population Integrity
Population boundaries
CSI score by subwatershed
13 - 15
10 - 12
7 - 9
3 - 6
v 1.0 October 2010
Miles
0 25 50 100
N
50 YEARS
TROUT
UNLIMITED


N
California Central Valley
Spring/Summer Chinook
Conservation Success Index
Range-wide Conditions
Extirpated
CSI score by subwatershed
9 - 10
7 - 8
5 - 6
3 - 4
v 1.0 October 2010
Miles
0
25
50
100
50 YEARS
TROUT UNLIMITED

Conservation Success Index: California and Southern Oregon Salmon (Coho, Winter Steelhead, Summer Steelhead, Fall Chinook, Spring/Summer Chinook, and Winter Chinook) 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 contains indicators that describe a specific component of each group. Each indicator is scored from 1 to 5 for each watershed (whether subwatershed (HUC12) or planning watershed (CalWater PW)), with a score of 1 indicating poor condition and a score of 5 indicating good condition. Indicator scores are then added to obtain the watershed condition for a Group, and Group scores are added for a CSI score for a watershed (Figure 1). CSI scores can then be summarized to obtain the general range of conditions within the historical or current distribution of the species.

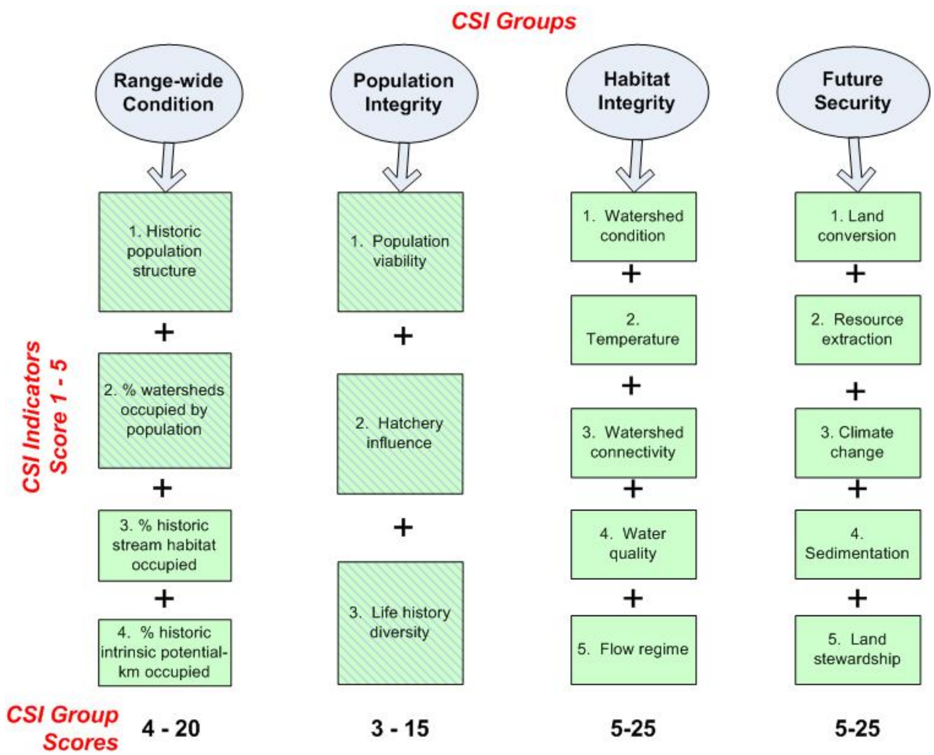


Figure 1. Each indicator is scored from 1 to 5 across 17 indicators within four main groups. Solid green indicator boxes reflect watershed scale summaries; larger striped green indicators reflect population-scale summaries. Indicator scores are added per group to obtain an overall group score.

Indicator scoring by species:
Each indicator is not calculated for all species. The matrix below describes which Rangewide Condtion indicators are calculated for each species, as well as the maximum possible score for indicator totals by species. Although data may be available at the ESU scale, certain data are not available the watershed scale; scores equaling zero indicate that data is not available. Consult the information on "watersheds included" in the indicator descriptions.

SPECIES/RUN	ESU	RW1	RW2	RW3	RW4	Max RW score	Max PI score	Max HI score	Max FS score
Coho	Central CA Coast	x	x	x	x	20	15	25	25
	Southern OR/Northern CA Coast	x	x	x	x	20	15	25	25
Winter steelhead	Central CA Coast	x	x	x	x	20	15	25	25
	Central Valley	x	x	x		15	15	25	25
	Klamath Mountains Province	x	x	x	x	20	15	25	25
	Northern CA	x	x	x	x	20	15	25	25
	South-central CA Coast	x	x	x		15	15	25	25
	Southern CA	x	x	x		15	15	25	25
Summer steelhead	Northern CA	x				5	15	25	25
	Klamath Mountains Province					0	15	25	25
Fall chinook	CA coastal	x	x	x	x	20	15	25	25
	Central Valley		x	x		10	15	25	25
	Southern OR/Northern CA Coast	x	x	x	x	20	15	25	25
	Upper Klamath - Trinity Rivers	x	x	x	x	20	15	25	25
Spr/summ chinook	CA coastal					0	15	25	25
	Central Valley		x	x		10	15	25	25
	Southern OR/Northern CA Coast					0	15	25	25
	Upper Klamath - Trinity Rivers					0	15	25	25
Winter chinook	Central Valley		x	x		10	15	25	25

<u>Rangewide Condition Indicator 1:</u> Historical population structure OR historical habitat extent by population

Indicator Scoring:

Historical population structure	Maximum historical habitat extent	CSI Score
Ephemeral	< 10 km	1
Dependent	10 – 30 km	2
Potentially independent	30 – 60 km	3
		4
Functionally independent	> 60 km	5

Scored at the population scale

Explanation: Historical population structure at the population scale. In the absence of historical population structure information, the maximum historical habitat extent is used as a proxy.

Rationale: Population boundaries, identities, and status are based on similar environmental conditions, genetic and spatial relationships, and IP-km. Functionally independent populations are viable in the absence of other populations, while dependent populations require dispersers to supplement their abundance and genetic diversity.[1]

Watersheds included: Currently occupied watersheds (containing >0.1 miles of occupied habitat) for all coho; all winter steelhead; Northern CA summer steelhead; CA coastal, Southern OR/Northern CA, and Upper Klamath-Trinity Rivers fall chinook.
Watersheds excluded: Currently unoccupied watersheds (extirpated and contributing) for all species/runs; Klamath Mountains summer steelhead; Central Valley fall chinook; all spring/summer Chinook; winter Chinook

Scale: Population. The CSI score is the same for all currently occupied watersheds within a population.

Data Sources: Coho, Chinook, and steelhead historical population structure in the North Central California Coast recovery domain from Bjorkstedt et al 2005;[1] coho population structure in the Southern Oregon/Northern California ESU from Williams et al 2006.[2]

Historic Northern California and Klamath Rivers Province winter steelhead distribution approximated from intrinsic potential models where IP > 0 and excluding areas with a mean gradient > 12%[3]; historic Central Valley winter steelhead distribution approximated from intrinsic potential models where or IP = 1 and excluding areas with a mean August temperture > 24°C;[4] Southern Oregon/Northern California Coast fall chinook historic distribution approximated from intrinsic potential models, where IP > 0;[5] Central Valley fall, spring/summer, and winter chinook historic distributions based on historic accounts.[6]

Rangewide Condition Indicator 2: Percent of historic watersheds occupied by populations

Indicator Scoring:

Occupied watersheds	CSI Score
< 20%	1
20 – 39%	2
40 – 59%	3
60 – 79%	4
≥ 80%	5

Explanation: The percentage of historically occupied watersheds currently occupied by population, based on sampling data and intrinsic potential models. Fine-scale intrinsic potential data was coarsened to match the 1:100,000 scale of current distribution data. Populations not predicted to have been historically occupied but are currently occupied receive a score of 5.

Rationale: Species that occupy a larger percentage of their historic stream habitat are likely to persist.

Watersheds included: Currently occupied watersheds (containing >0.1 miles of occupied habitat) for all coho; all winter steelhead; all fall chinook; Central Valley spring/summer chinook
Watersheds excluded: Currently unoccupied watersheds (extirpated and contributing) for all species/runs; all summer steelhead; Central California Coast and Southern Oregon/Northern California spring/summer Chinook; winter Chinook

Scale: Population. The CSI score is the same for all currently occupied watersheds within a population.

Data Sources: *Historic distributions:* Historic coho distribution approximated from intrinsic potential models, where IP > 0 and excluding areas with mean August temperature > 21.5ºC;[5] historic South Central Coast and Southern California winter steelhead distribution approximated from intrinsic potential models where IP = 1 (95% envelope)[7;8]; historic Central California Coast, Northern California, and Klamath Rivers Province winter steelhead distribution approximated from intrinsic potential models where IP > 0 and excluding areas with a mean gradient > 12%[3]; historic Central Valley winter steelhead distribution approximated from intrinsic potential models where or IP = 1 and excluding areas with a mean August temperture > 24°C;[4] Central California Coast and Southern Oregon/Northern California Coast fall chinook historic distribution approximated from intrinsic potential models, where IP > 0;[5] Central Valley fall, spring/summer, and winter chinook historic distributions based on historic accounts;[6] historic winter steelhead and fall chinook distribution in the Upper Klamath River from Hamilton et al 2005.[9]

Current distributions: Current coho distribution from Calfish[10] in California and Streamnet[11] in Oregon; current winter and summer steelhead distribution from Calfish[12;13] in California and Streamnet[11] in Oregon; current fall chinook distribution from Calfish[14] and NOAA[15] in California and Streamnet[11] in Oregon; current spring/summer chinook distribution from Calfish[14]

and NOAA[16;17] in California and Streamnet[11] in Oregon; current winter Chinook distribution from NOAA.
Species must occupy at least 0.1 miles to be considered currently or historically present.

Subwatersheds based on NRCS data;[18] planning watersheds based on CalWater 2.2.1.[19]

Rangewide Condition Indicator 3: Percent of historic stream habitat occupied by watershed

Indicator Scoring:

Occupied stream habitat	CSI Score
< 20%	1
20 – 39%	2
40 – 59%	3
60 – 79%	4
≥ 80%	5

Explanation: The percentage of historically occupied streams currently occupied by the species, based on sampling data and intrinsic potential models. Fine-scale intrinsic potential data is coarsened to match the 1:100,000 scale of current distribution data. Watersheds not predicted to have been historically occupied but are currently occupied receive a score of 5.

Rationale: Species that occupy a larger percentage of their historic stream habitat are likely to persist.

Watersheds included: Currently occupied watersheds (containing >0.1 miles of occupied habitat) for all Coho; all Winter Steelhead; all Fall Chinook; Central Valley Spring/Summer Chinook; Winter Chinook
Watersheds excluded: Currently unoccupied watersheds (extirpated and contributing) for all species/runs; all summer steelhead; Central California Coast and Southern Oregon/Northern California spring/summer chinook

Scale: Watershed. Only currently occupied watersheds receive CSI scores.

Data Sources: See data sources for Rangewide Condition Indicator 2

<u>Rangewide Condition Indicator 4:</u> Percent historic intrinsic potential-kilometers currently occupied by watershed

Indicator Scoring:

Current IP-km/Historic IP-km	CSI Score
< 20%	1
20 – 39%	2
40 – 59%	3
60 – 79%	4
≥ 80%	5

Explanation: The ratio of the sum of IP-km for a species'current distribution vs. historical distribution. Watersheds not predicted to have been historically occupied (and thus receiving no IP score) but which are currently occupied receive a score of 5.

Rationale: The ratio of current to historical IP-km reflects the habitat quality of the habitat occupied, especially when compared to the % historical distribution by watershed.

Watersheds included: Currently occupied watersheds (containing >0.1 miles of occupied habitat) for all coho; Central CA coast, Klamath Mountains, and Northern CA winter steelhead; CA coastal, Southern OR/Northern CA, and Upper Klamath-Trinity Rivers fall chinook.
Watersheds excluded: Currently unoccupied watersheds (extirpated and contributing) for all species/runs; Central Valley, South-central, and Southern winter steelhead; all summer steelhead; Central Valley fall chinook; all spring/summer Chinook; winter Chinook

Scale: Watershed. Only currently occupied watersheds receive CSI scores.

Data Sources: *Historic distributions:* Historic coho distribution and habitat quality approximated from intrinsic potential models, where IP > 0 and excluding areas with mean August temperature > 21.5ºC;[5] historic Central California Coast, Northern California, and Klamath Rivers Province winter steelhead distribution and habitat quality approximated from intrinsic potential models where IP > 0 and excluding areas with a mean gradient > 12%[3]; Central California Coast and Southern Oregon/Northern California Coast fall chinook historic distribution approximated from intrinsic potential models, where IP > 0.[5]

Current distributions: Current coho distribution from Calfish[10] in California and Streamnet[11] in Oregon; current winter steelhead distribution from Calfish[12] in California and Streamnet[11] in Oregon; current fall chinook distribution from Calfish[14] and NOAA[15] in California and Streamnet[11] in Oregon.

Subwatersheds based on NRCS data;[18] planning watersheds based on CalWater 2.2.1.[19]

<u>Population Integrity Indicator 1:</u> Population viability.

Indicator Scoring:

Viability: productivity or abundance	CSI Score
Critically low	1
Below average	2
Moderate	3
Above average	4
High	5

Explanation: Expert opinion estimates of population viability, as a function of abundance or productivity.

Rationale: Small populations are more vulnerable to extirpation.[20]

Scale: Population. The CSI score is the same for all currently occupied watersheds within a population.

Data Sources: North American Salmon Stronghold Partnership California population database.

Population Integrity Indicator 3: Hatchery influence.

Indicator Scoring:

% Natural Origin Spawners	CSI Score
0 – 24 %	1
25 – 49 %	2
50 – 74 %	3
75 – 95 %	4
> 95 %	5

Explanation: Categorizes populations based on the absence/presence of hatcheries by management regime.

Rationale: Hatchery fish exhibit less genetic diversity and reduced fitness relative to wild fish.[21] Transplanted stocks lack local adaptations.

Scale: Population. The CSI score is the same for all currently occupied watersheds within a population.

Data Sources: Percent natural origin spawner categorical scores from North American Salmon Stronghold Partnership California population database.

<u>Population Integrity Indicator 5:</u> Life history diversity.

Indicator Scoring:

Life History Diversity	CSI Score
Extremely simplified or single life history strategy	1
Few life histories present and significantly simplified from historical	2
Few life histories present and modest representation of historical	3
Robust, multiple, and/or rare life histories, with majority of historical present	4
All life history strategies present	5

Explanation: The variety of life histories – age/year classes, sizes, fecundity, run timing, and other traits - present in a population.

Rationale: The variety of life histories present in a population contributes to genetic variation essential for responding to environmental changes and facilitates the ability to occupy a greater variety of habitats, mitigating risks across space and time.[22]

Scale: Population. The CSI score is the same for all currently occupied watersheds within a population.

Data Sources: North American Salmon Stronghold Partnership California population database.

<u>Habitat Integrity Indicator 1:</u> Watershed conditions and instream habitat

Indicator Scoring:

Miles 303(d) listed for sediment	Road density (miles/miles²)	Road mi/ Stream mi	CSI Score
	≥ 4.7	0.5 – 1.0	1
	3 – 4.7	0.25 – 0.49	2
> 0.1	2.5 - 3	0.10 - 0.24	3
	1.6 – 2.5	0.05 – 0.09	4
	< 1.6	0 – 0.04	5

Score for worst case

Subtract 1 point if ≥ 3 instream sand or gravel mines present within 200 meters of perennial or intermittent streams in the watershed

Explanation: The presence of 303(d) listed streams for sediment, road density in miles/miles², miles of road within 100 meters of all perennial, intermittent, and ephemeral streams, and presence of sand or gravel mines in a watershed.

Rationale: Fine sediments smother benthic invertebrates, embed spawning substrates, and increase turbidity.[23;24] Roads are a common contributor of sediments. Areas of high road densities may also reflect a history of intensive logging, an additional contributor of sediments to streams. Lee et al.[25] 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. NOAA's California Coho Recovery Plan identifies road densities of 1.6, 2.5, and 3.0 mi/mi^2 as important indicators of habitat integrity. Sand and gravel mines within 200 meters of the streams alter flows, disrupt downstream gravel recruitment, and eliminate habitat.

Scale: Watershed

Data Sources: Aggregate rock, sand, gravel mines from California Department of Conservation.[26] 2006 303(d) listed streams data from USEPA.[27;28] Road data is a composite of USFS Northwest Forest plan,[29] Oregon BLM,[30] US Census Bureau TIGER data,[31] and USFS CA National Forest data.[32-41] Streams from the National Hydrography Dataset (NHD Plus).[42]

<u>Habitat Integrity Indicator 2:</u> Temperature

Indicator Scoring:

Miles 303(d) listed for temperature	Percent stream habitat above temperature threshold	Mean Riparian vegetation height (m)	CSI Score
	81 – 100%	0 - 1	1
	61 – 80%	1 - 5	2
> 0.1	41 - 60%	5 – 10	3
	21 - 40%	10 – 20	4
	0 – 20%	> 20	5

Score for worst case

Explanation: Miles of 303(d) listed streams for temperature within each watershed and percent of stream habitat identified by a 21.5°C (coho) or 24°C (steelhead and chinook) August mean air temperature mask.

Rationale: 303(d) impairment for temperature reflects a departure from anticipated natural water temperatures that sustain coldwater fish. Impairment is often a function of poor riparian condition, disruption of natural flows, or altered hydrology. Intrinsic potential models identify an August mean air temperature of 21.5°C as corresponding to the natural limit of historic coho distribution, 24°C as the limit of historic steelhead distribution.[3;4;7;8] Riparian vegeation provides shading and contributes large woody debris.

Scale: Watershed

Data Sources: 2006 303(d) listed streams data from USEPA.[27;28] Mean August temperature data for the period between 1960 and 1990 from PRISM dataset.[43] Existing vegetation height data from Landfire.[44]

<u>Habitat Integrity Indicator 3:</u> Watershed connectivity.

Indicator Scoring:

Passage status	Barriers within WS	Barriers downstream	CSI Score
Extirpated above barrier			1
Accessible	≥ 12	> 4	2
Accessible	5 -11	2 -3	3
Accessible	1 – 4	1	4
Accessible	0	0	5

Score for worst case

Those watersheds that were not historically accessible by anadromous fish (Passage status = "Contributing") are scored solely on the basis of barriers within watershed

Explanation: The count of all barriers (complete and partial, anthropogenic and natural) within each watershed, the counts of partial barriers along the mainstem between the bottom of the watershed and the terminus of the river system at the ocean, and the portion of historical habitat isolated above complete anthropogenic barriers.

Rationale: Increased hydrologic connectivity provides more habitat area and better supports multiple life stages, an important viability criteria which increases the likelihood of persistence.[22] Diversions, even when they do not directly inhibit fish passage, can represent false movement corridors, cause fish entrainment, and act as population sinks.

Scale: Watershed and connected downstream stream network

Data Sources: Barriers data from the May 2009 California Fish Passage Assessment Database[45] and Oregon's Fish Passage Barriers dataset.[46] Stream data and additional natural barriers from National Hydrography Dataset (NHD Plus).[42]

<u>Habitat Integrity Indicator 4:</u> Water quality.

Indicator Scoring:

Miles 303(d) listed for toxins or nutrients	Agricultural and Urban Land	Number Active Mines	Number Active Oil/Gas Wells	CSI Score
	58-100%	≥10	≥ 400	1
	28-57%	7-9	300 - 399	2
>0.1	16-27%	4-6	200 - 299	3
	6-15%	1-3	50 - 199	4
	0-5%	0	0 - 49	5

Score for worst case.

Explanation: The presence of 303(d) impaired streams for nutrients or toxins[1], active mines, active oil and gas wells, and percentage urban and agricultural land. Converted lands in estuary habitats are counted twice towards agricultural and urban percentages.

Rationale: Impaired water quality, including reduced dissolved oxygen, increased turbidity, and the presence of pollutants from agricultural and urban runoff, reduces habitat suitability for salmon. Agricultural and urban land can impact aquatic habitats by contributing nutrients and depleting dissolved oxygen. Mining activity can deteriorate water quality through leachates and sediments.

Scale: Watershed

Data Sources: The National Land Cover Database[47] was used to identify urban and agricultural lands; Hay/Pasture and Cultivated Crops were defined as agricultural land. Land areas with an elevation ≤ 5 meters are considered historic estuary habitats. Active mines were identified by using the Mineral Resources Data System.[48] 2006 303(d) listed streams data from USEPA.[27;28] Active oil and gas wells from USGS.[49]

[1] Toxins include heavy metals, PCBs, pesticides such as DDT, pH, and pathogens such as fecal coliform, while nutrients include nitrogen, phosphorus, and dissolved oxygen.

<u>Habitat Integrity Indicator 5:</u> 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

Score for worst

Subtract 1 point if the watershed ratio of diversions to perennial/intermittent stream miles exceeds 0.4 (the watershed mean for the CA/OR analysis area)

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

Rationale: Natural flow regimes are critical to proper aquatic ecosystem function.[50] Dams, reservoirs, diversions, and canals alter flow regimes.[51] Reduced or altered flows reduce the capability of watersheds to support native biodiversity and salmonid populations.

Scale: Watershed

Data Sources: The National Inventory of Dams[52] provides data on dams and storage capacity. Perennial and intermittent streams and canals data from the National Hydrography Dataset (NHD Plus).[42] California water rights data from the State Water Resources Control Board.[53] Oregon water rights data from Water Resources Department.[54]

Future Security 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 for urban, exurban, or agricultural (vineyard) purposes. Public land, lands currently converted, redwood or Pacific Douglas Fir forest types, or private 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.[55]

Scale: Watershed

Data Sources: Urban and exurban development in 2030 using the Spatially Explicit Regional Growth Model v3 for the US Forests on the Edge project.[56] Vineyard development is predicted as a function of topographic suitability (slope, elevation, and aspect values derived from the National Elevation Dataset[57]), soil suitability (drainage class, available water content, depth to restrictive layer, frost free days, and pH from US General Soil Map (STATSGO2)[58]), and climate suitability (growing degree days based on PRISM data provided by Oregon State University's Integrated Plant Protection Center[59]).[60;61][2] Land cover was determined from the National Land Cover Database[47] (all land cover classes except developed areas, open water, and

[2] Topographic suitability for vineyard production is the mean of elevation, slope and aspect suitability, where: Elevation (0 – 400 m = 10; 400 – 800 m = 6; > 800 m = 3), Slope (0 – 1% = 0; 1 – 5% = 3; 5 – 15% = 6; 15 – 20% = 3; 20 – 30% = 0; > 30% = NULL), Aspect (-1 - 90º = 0; 90 - 135º = 3; 135 - 225º = 6; 225 - 270º = 3; 270 - 360º = 0).

Climatic suitability is the mean of growing degree day (30 year normals from April 1 – October 31, base 50º F) and frost-free day suitability, where: Growing Degree Days (< 2500 = 3; 2500 – 3500 = 10; 3500 – 4400 = 3), Frost-free Days (< 140 = NULL; 140 – 160 = 0; 160 -180 = 3; 180 – 200 = 6; > 200 = 10).

Soil suitability is the mean of pH, drainage class, depth to restrictive layer (double weighted), and available water-holding capacity suitability, where: pH (< 5.5 = 3; 5.5 – 8.0 = 10; > 8.0 = 3), Depth to Restrictive Layer in cm (< 40cm = 0; 40 – 80cm = 3; 80 – 120cm = 6; > 120cm = 10), Drainage Class (very poorly drained = 0; poorly drained = 2; somewhat poorly drained & excessively drained = 5; moderately well drained & somewhat excessively drained = 8; well drained = 10), Available Water-holding Capacity (< 0.15 cm water/cm soil = 6; >= 0.15 inch water/inch soil = 10).

Final model takes the mean of topographic, climatic, and soil suitability models. Areas vulnerable to vineyard conversion have means scores >= 7.

cultivated crops cover types were considered for potential conversion), redwood and Pacific Douglas fir forest types from Landfire Existing Vegetation Type,[44] land ownership using Public, Conservation, and Trust Lands v05.2,[62] and conservation easement data from the California Protected Areas Database[63] and Oregon TNC.

<u>Future Security Indicator 2:</u> Resource extraction and development.

Indicator Scoring:

Percent subject to forest management or energy/mineral development	New Dams in subbasin	New Dams in WS	CSI Score
51 -100%	≥0	≥1	1
26-50%	> 5		2
11-25%	3 - 5		3
1 – 10%	1 - 2		4
0%	0		5

Score for worst case

Explanation: Total percentage of watershed zoned for industrial timber production on private land or possessing energy or hard metal mineral resources or the number of dam sites located for potential development outside of protected areas. Protected lands are federal or state lands with regulatory or congressionally-established protections, such as: National or State Parks and Monuments, National Wildlife Refuges, Wild and Scenic River designations, designated wilderness areas, inventoried roadless areas, Research Natural Areas, Areas of Critical Environmental Concern, others areas of special protective designations (including Late Successional Reserves), or private ownership designated for conservation purposes. Total acreage for private land is reduced by half on private lands with Habitat Conservation Plans (HCP) in place. Acreage on public lands without protection is reduced by three quarters.

Rationale: Increased resource development will increase road densities, modify natural hydrology, and increase the likelihood of pollution to aquatic systems. Protected lands will experience less anthropogenic disturbance than other lands. Timber harvest and their associated disturbance is most significant (in decreasing likelihood) on industrial timberlands, industrial timberlands with HCPs in place, and on unprotected public lands. Dam construction is likely to be associated with habitat loss, changes in natural flow regimes, reduced habitat suitability for salmon, and increased likelihood of invasion by non-native species.

Scale: Watershed

Data Sources: Timber management potential identifies private forests zoned for timber production in the North Coast County Timber Production Zones[64] dataset. For private lands elsewhere in California and in Oregon, timber management potential identifies productive forest types from the Existing Vegetation Type in Landfire[44] in contiguous patches ≥ 40 acres without formal protection as protected areas, Late Successional Reserves under the Northwest Forest Plan,[65] or enrolled under a Habitat Conservation Plan. Wind resources ("Good" and better) from Wind Powering America/National Renewable Energy Lab (NREL)[66] and limited by elevational and slope thresholds. Geothermal resource areas include nominations, authorized agreements, known leasing areas, and producing and non-producing leases; oil and gas resource acres include oil and gas leases and agreements from BLM Geocommunicator.[*67] The number of mining claims was determined using Bureau of Land Management data,[68] and each claim was assumed to potentially impact 20 acres. Solar resource areas have annual average direct normal irradiance of 600 KwH/m²/day,[69] slopes less than 5%,[57] existing vegetation heights less than 10 meters,[44] and occur within contiguous patches of at least 160 acres. Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas,[70] and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset.[71] Potential dam sites are based on Idaho National Laboratory national hydropower potential data.[72]

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

Lease: Parcel leased for oil and gas production.

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

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

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

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

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

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

Other Agreements: Catch-all for other agreement types.

Future Security Indicator 3: Habitat loss from climate change

Indicator Scoring:

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

Explanation and Rationale: Vulnerability of salmon to climate change is based on a composite analysis of the following three risk factors related to climate change:

a. Increased Summer Temperature: Increasing air temperatures will increase water temperatures, displacing species from portions of their current distribution. For each watershed, we calculate the mean risk of exceeding a species-specific temperature threshold at current climate and forecast for 2050. The Coho salmon threshold for rearing juvenile fish is an August mean air temperature of 21.5ºC.[3] The steelhead and Chinook threshold for rearing juvenile fish is an August mean air temperature of 24ºC.

Warming status	Warming risk
Currently exceeding threshold	High
Exceeding in 2050	Moderate
Not exceeding in 2050	Low

b. Changes in flow volume: Changes in precipitation will be most pronounced in systems with surface runoff flow regimes. For each watershed, base flow index (BFI) is summarized (where surface flows have a BFI < 50 and groundwater/snow systems have a BFI >= 50) and adjusted by predicted annual precipitation change in 2050 to predict flow risk.

Current base flow regime type	Predicted annual precipitation change	Flow Risk
Surface	Decrease > 10%	High
Groundwater/snow	Decrease >10%	Moderate
Surface	Increase or decrease < 10%	Moderate
Groundwater/snow	Increase or decrease < 10%	Low
Surface	Increase > 10%	Low

c. Changes in precipitation and flow regime: Transitions in California and Oregon's winter precipitation regimes may be associated with changes in spring peak flow timing and magnitude, summer low flow magnitude, and increased likelihood of rain-on-snow events. For each watershed, we predict the transition in precipitation regime, where regimes include snow-dominated (Dec – Feb mean temp < - 1ºC), mixed (Dec – Feb mean temp between – 1ºC and 1ºC), and rain-dominated (Dec – Feb mean temp > 1ºC), based on current climate and 2050 forecasts.

Precipitation regime transition type	**Precipitation regime risk**
Snow to rain	High
Snow to mixed	High
Mixed to rain	Moderate
Mixed to mixed	Moderate
Rain to rain	Low
Snow to snow	Low

Scale: Watershed

Data Sources: Mean August temperature data for the period between 1960 and 1990 from PRISM dataset.[43] Temperature and precipitation predictions provided by The Nature Conservancy's climatewizard.org.[73;74] Base flow index grid from USGS.[75]

<u>Future Security Indicator 4:</u> Sedimentation and scour risk

Indicator Scoring:

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

Inherent geomorphic risk	**Risk**
> 30%	High
15 – 30%	Moderate
0 – 15%	Low

Mean Fire Regime Condition Class within unstable patches	**Risk**
> 70	High
31 – 70	Moderate
< 30 or inherent risk "Low"	Low

Percent of unstable slope patches traversed by roads	**Risk**
>70%	High
30 – 70%	Moderate
< 30% or inherent risk "Low"	Low

Explanation: Percent of each watershed identified as having an inherent high geomorphic risk (shallow slope landslides only), the mean Fire Regime Condition Class (FRCC) within those unstable patches (where high FRCC scores reflect high departure from expected fire regime), and the percent of high geomorphic risk patches traversed by roads.

Rationale: Landslides contribute debris and sediment detrimental to salmon. Landslide frequency may increase with road construction on landslide-prone slopes, changes in precipitation intensity and seasonality associated with climate change, and changes in typical fire intensity due to fuel build up.

Scale: Watershed

Data Sources: Elevation data were obtained from the National Elevation Dataset.[57] Relative potential for shallow landslides predicted using the SMORPH model, where high risk areas have value = 3.[76] FRCC data from LANDFIRE.[44] Road data is a composite of USFS Northwest Forest plan,[29] Oregon BLM,[30] US Census Bureau TIGER data,[31] and USFS CA National Forest data.[32-41]

Future Security Indicator 5: Land stewardship.

Indicator Scoring:

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

Explanation: The percent of stream habitat and percent watershed with a formal protected status. Protected lands are federal or state lands with regulatory or congressionally-established protections, such as: National 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 watersheds with higher proportions of protected lands will experience less anthropogenic disturbance than other lands.

Scale: Watershed

Data Sources: Perennial and intermittent streams from National Hydrography Dataset (NHD Plus);[42] protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas[70] and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset.[71] Late Successional Reserves from the Northwest Forest Plan.[77]

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