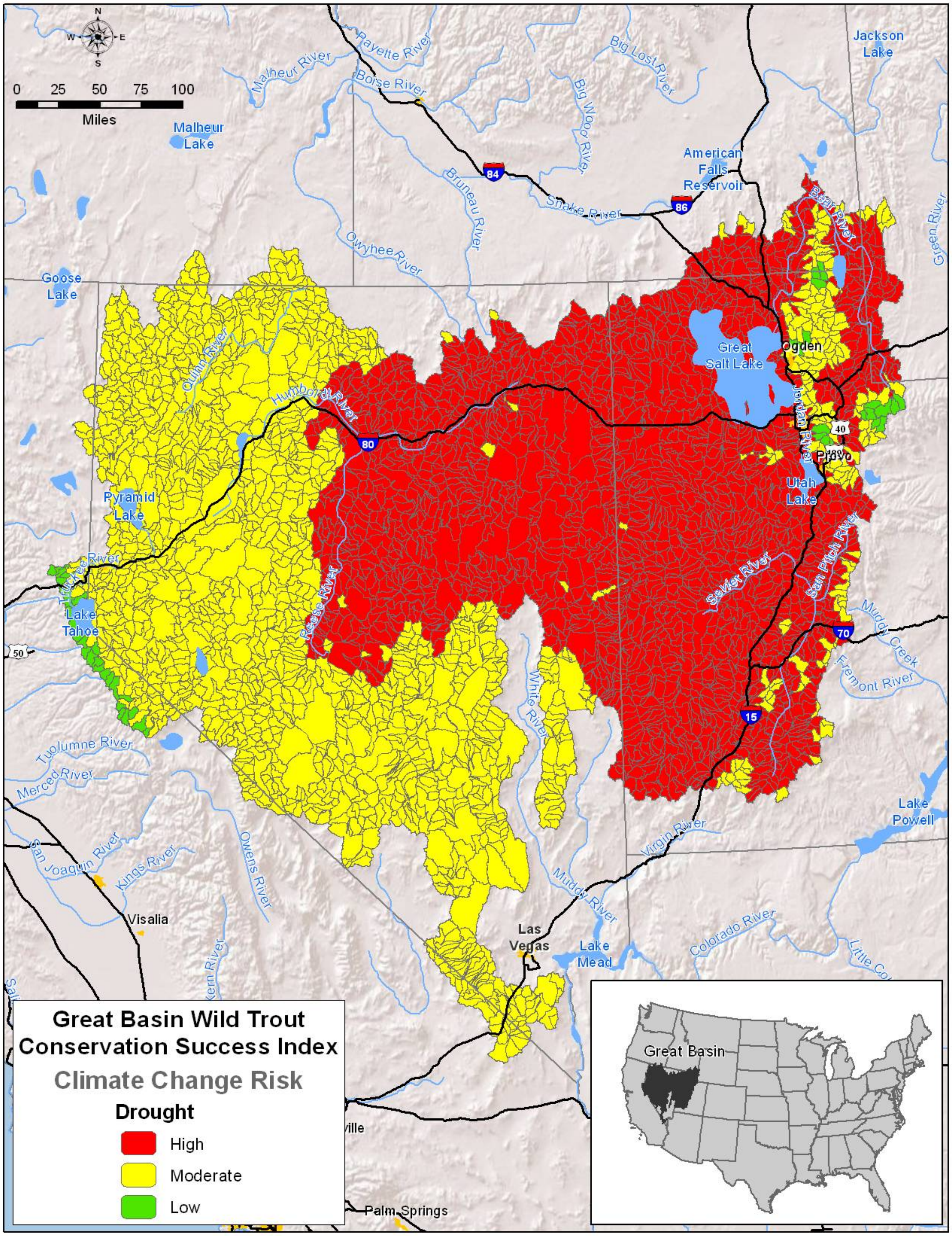
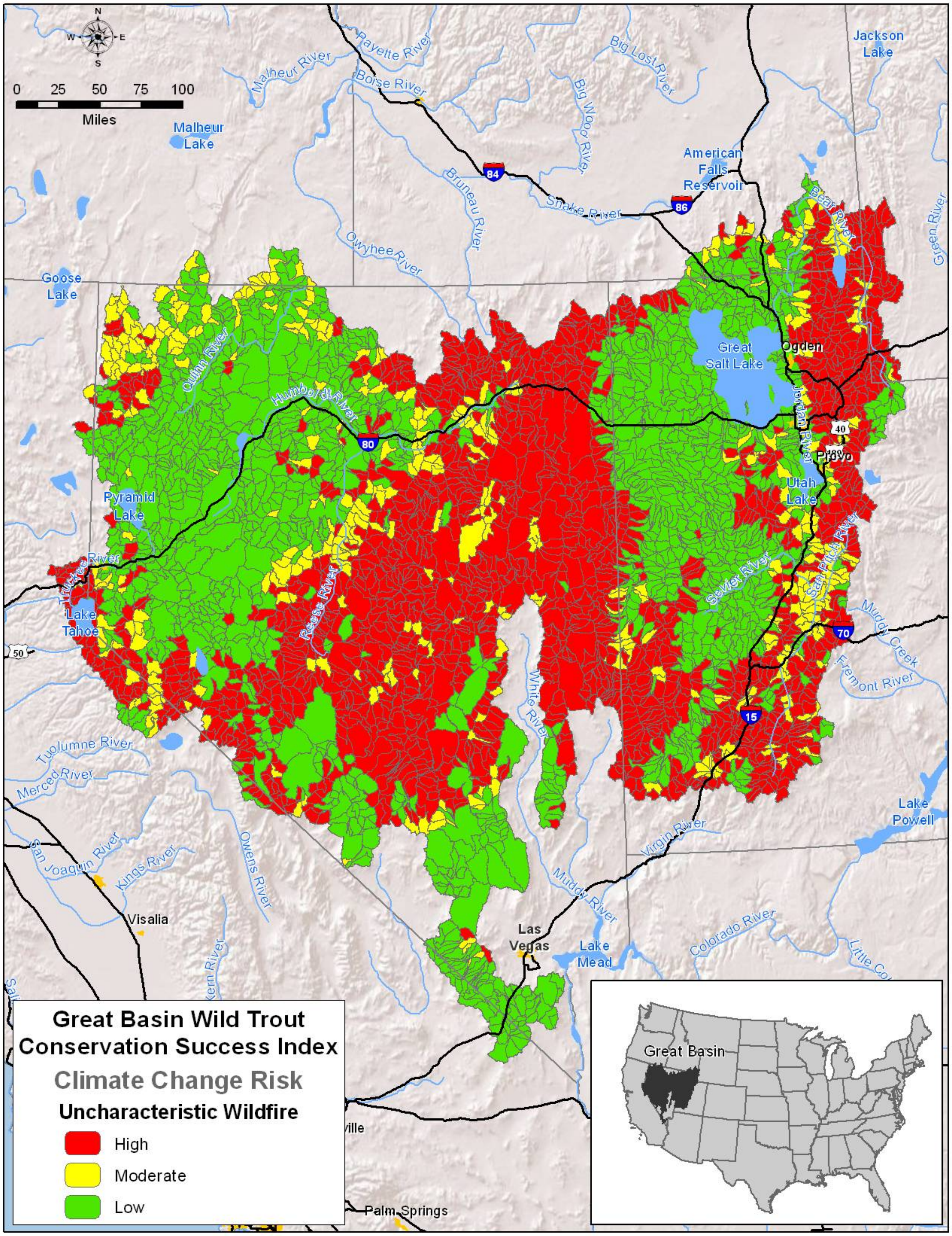
# Conservation Success Index: Great Basin Wild Trout

Rev. 1.0 - 9/2011

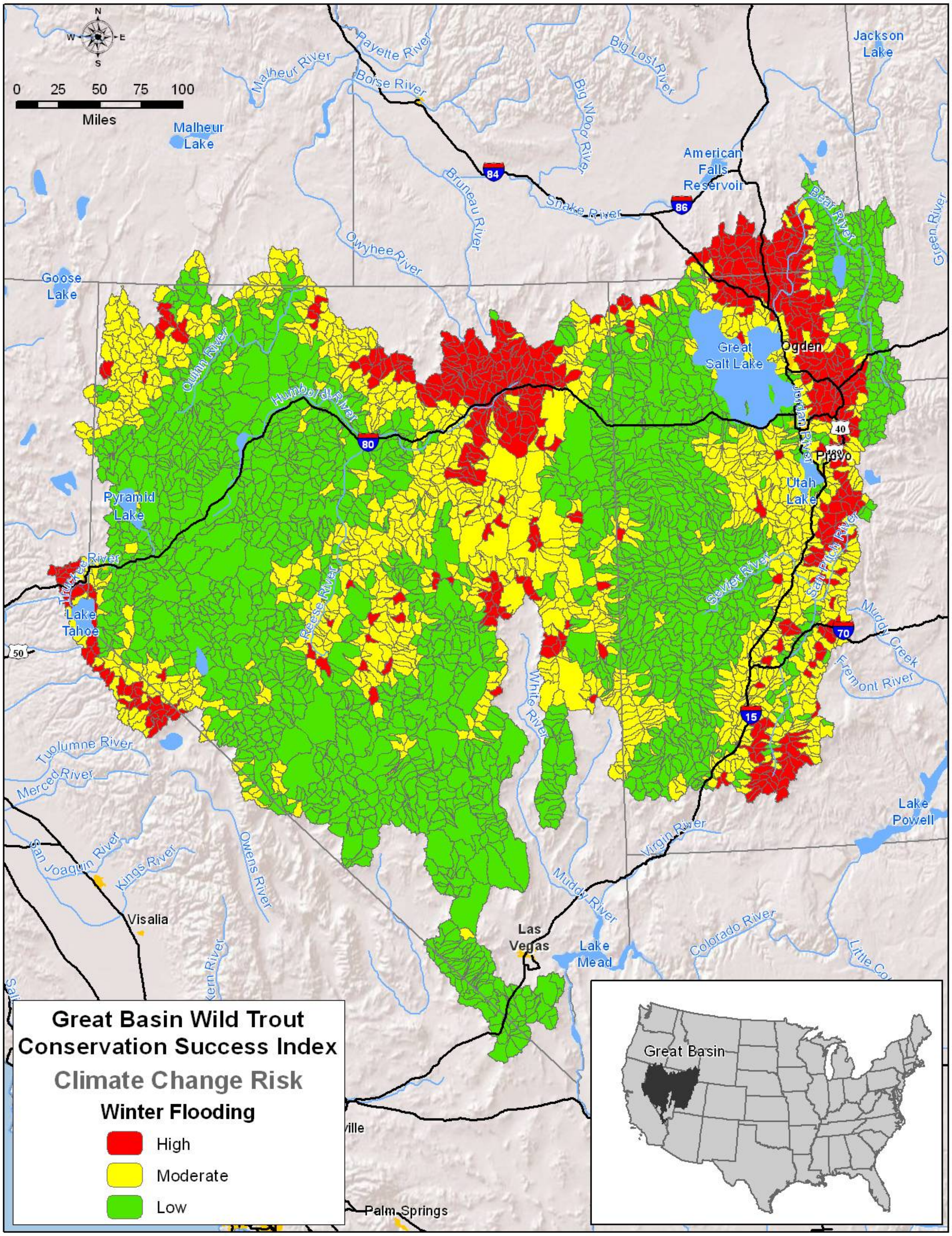
**SPECIES SUMMARY**

Trout Unlimited's mission is to protect, reconnect, restore and sustain coldwater habitats and fisheries across the country. Historically, the United States had a plethora of coldwater resources, but over time they have been impacted by land uses, water uses, pollutants, and other factors. Native trout fisheries have also declined due to overharvest and introduction of non-native species. Good coldwater conservation decisions are made using reliable information describing habitat conditions and future threats both across large geographic areas as well as within individual subwatersheds. This wild trout CSI is intended to inform conservation decision at the subwatershed (~30,000 acre) scale by conveying information about the amount of coldwater and native trout resources, along with information on factors known to influence coldwater habitats and threaten their future security. Wild trout CSI information can be used to inform conservation decisions that are subsequently refined through review of finer-scale information and discussions with project partners to ensure coldwater fisheries persist and can be enjoyed by future generations of anglers

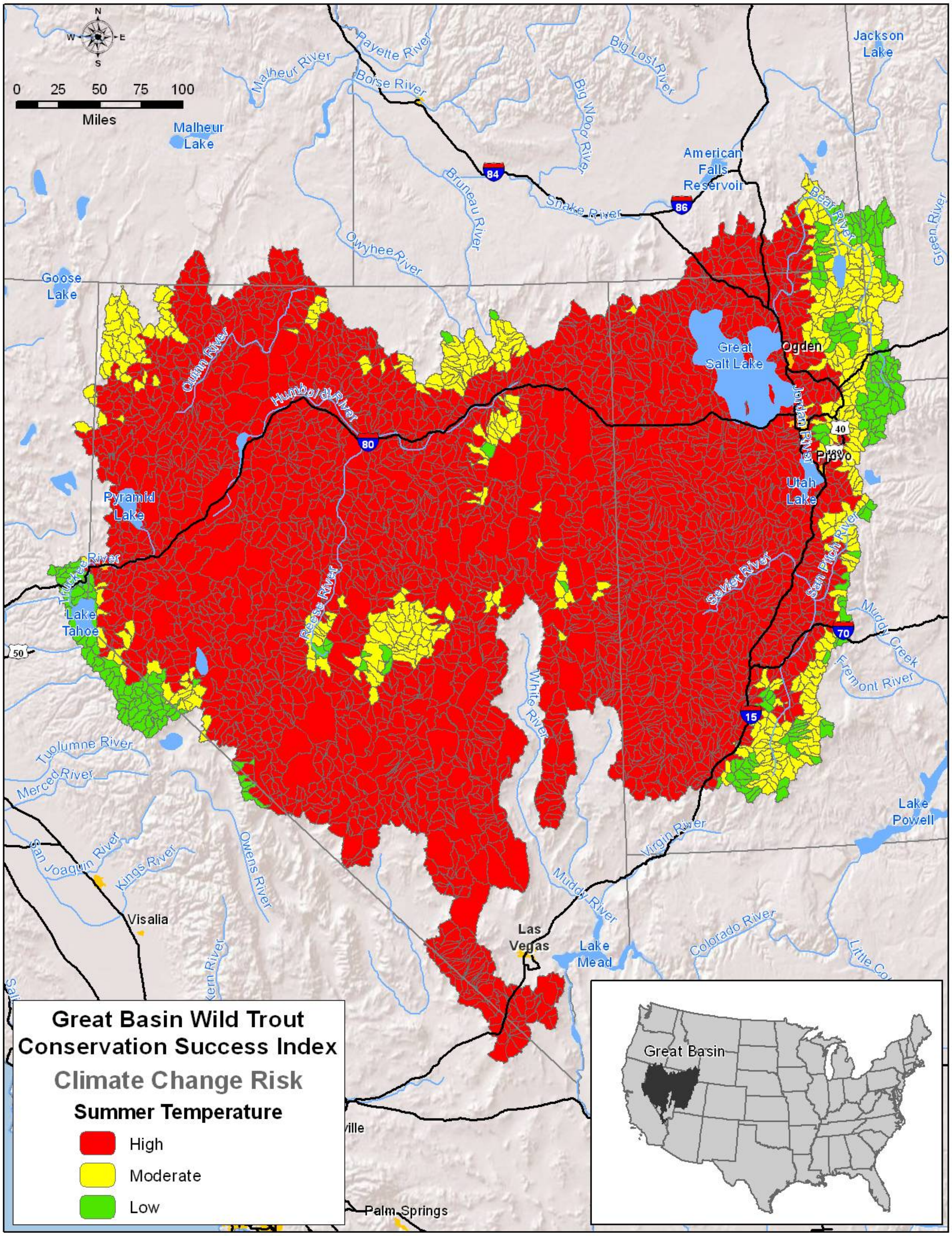

Great Basin Wild Trout
Conservation Success Index
Climate Change Risk
Drought
High
Moderate
Low
Great Basin
0 25 50 75 100
Miles
Malheur Lake
Goose Lake
Pyramid Lake
Lake Tahoe
Great Salt Lake
Utah Lake
Ogden
Provo
Las Vegas
Lake Mead
Lake Powell
Jackson Lake
American Falls Reservoir
Visalia
Palm Springs
Humboldt River
Reese River
Sevier River
San Pitch River
Jordan River
Bear River
Snake River
Owyhee River
Bruneau River
Malheur River
Boise River
Payette River
Big Lost River
Big Wood River
Green River
Quinn River
Truckee River
White River
Virgin River
Muddy River
Colorado River
Fremont River
Muddy Creek
Owens River
Kings River
San Joaquin River
Merced River
Tuolumne River
Kern River

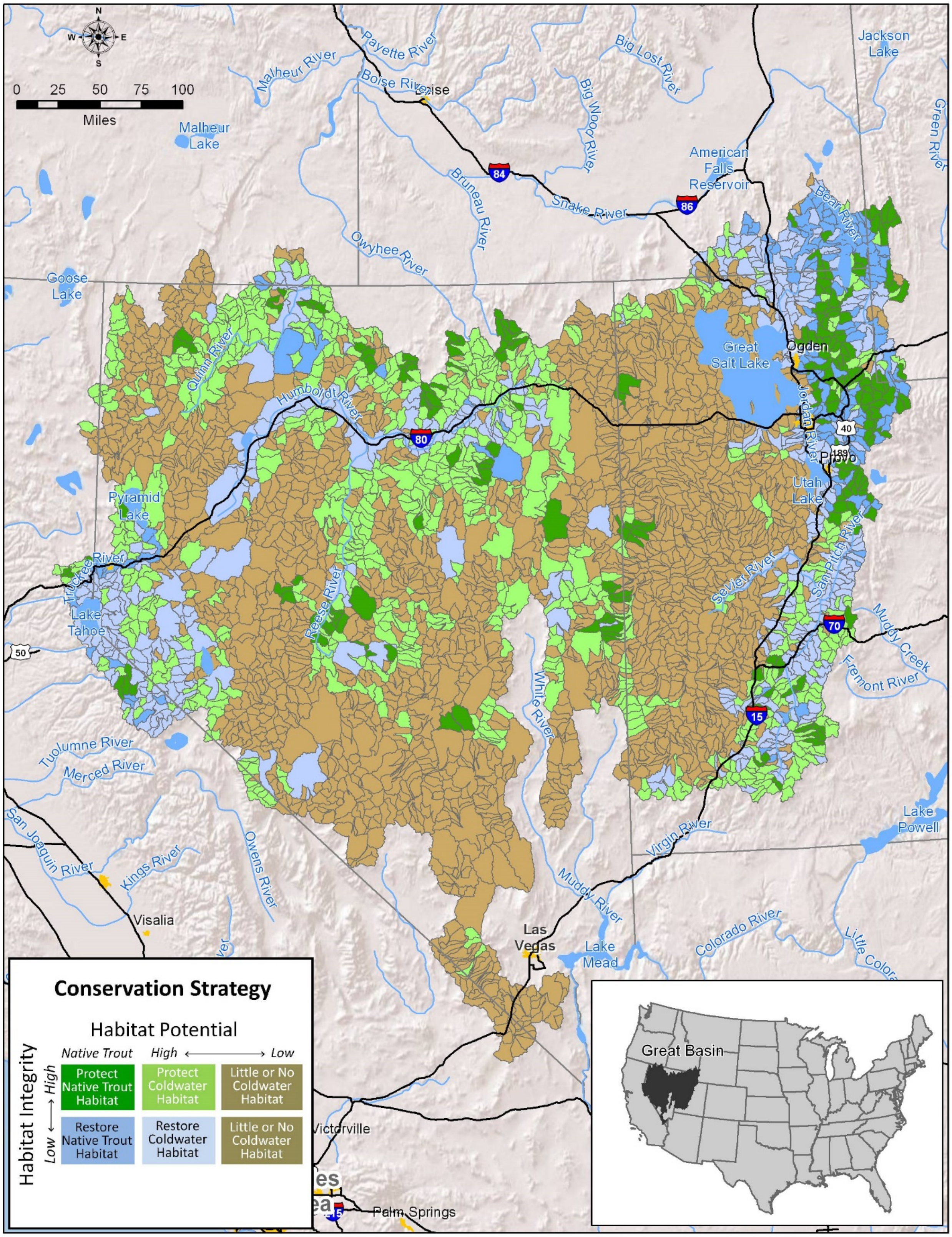


Great Basin Wild Trout
Conservation Success Index
Climate Change Risk
Uncharacteristic Wildfire
High
Moderate
Low
0 25 50 75 100
Miles
Great Basin
Malheur Lake
Goose Lake
Pyramid Lake
Lake Tahoe
Great Salt Lake
Utah Lake
American Falls Reservoir
Jackson Lake
Lake Powell
Lake Mead
Ogden
Provo
Las Vegas
Visalia
Palm Springs
Malheur River
Payette River
Boise River
Big Lost River
Big Wood River
Bruneau River
Snake River
Owyhee River
Bear River
Green River
Quinn River
Humboldt River
Jordan River
Truckee River
Reese River
Sevier River
San Pitch River
Muddy Creek
Fremont River
White River
Tuolumne River
Merced River
San Joaquin River
Kings River
Owens River
Kern River
Virgin River
Muddy River
Colorado River

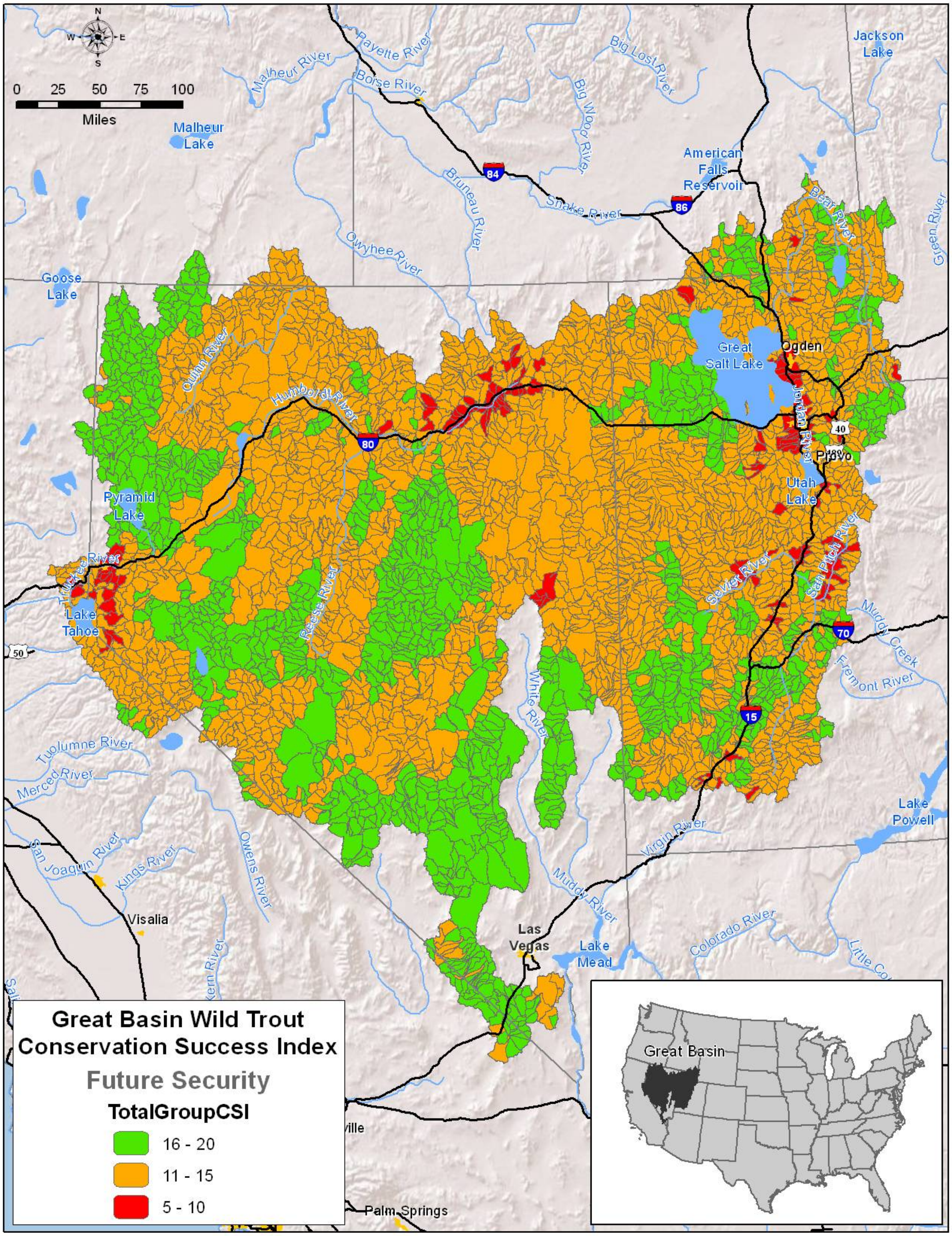


Great Basin Wild Trout
Conservation Success Index
Climate Change Risk
Winter Flooding
High
Moderate
Low
Great Basin
0 25 50 75 100
Miles
Malheur Lake
Goose Lake
Pyramid Lake
Lake Tahoe
Great Salt Lake
Utah Lake
American Falls Reservoir
Jackson Lake
Lake Powell
Lake Mead
Ogden
Provo
Las Vegas
Visalia
Palm Springs
Humboldt River
Reese River
Quinn River
Truckee River
White River
Sevier River
San Pitch River
Jordan River
Bear River
Snake River
Owyhee River
Bruneau River
Malheur River
Payette River
Boise River
Big Lost River
Big Wood River
Green River
Muddy Creek
Fremont River
Virgin River
Muddy River
Colorado River
Owens River
Kings River
San Joaquin River
Merced River
Tuolumne River
Kern River

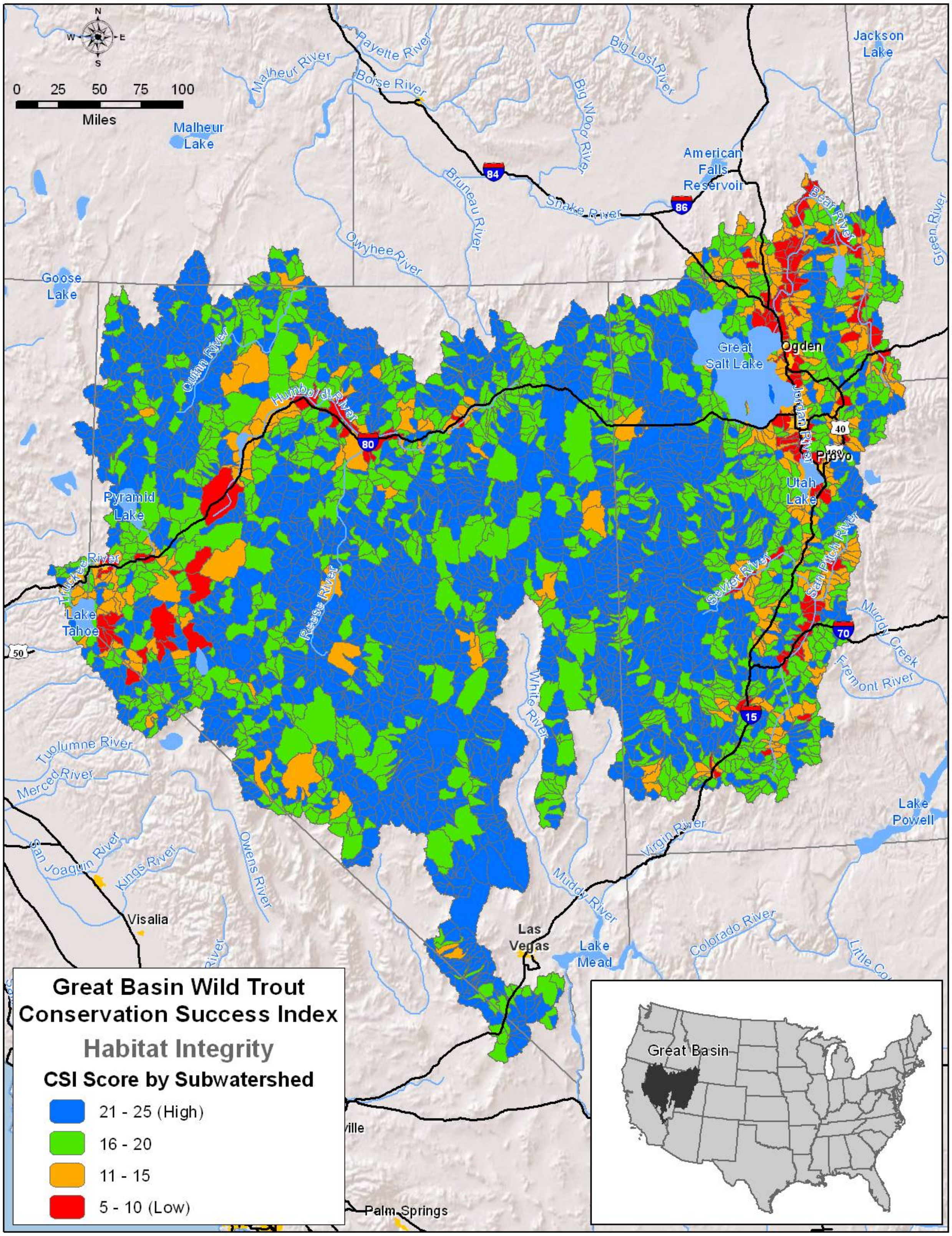

Great Basin Wild Trout
Conservation Success Index
Climate Change Risk
Summer Temperature
High
Moderate
Low
0 25 50 75 100
Miles
N
S
E
W
Great Basin
Malheur River
Malheur Lake
Payette River
Boise River
Big Lost River
Big Wood River
Bruneau River
Snake River
Owyhee River
Jackson Lake
American Falls Reservoir
Bear River
Green River
Goose Lake
Quinn River
Humboldt River
Great Salt Lake
Ogden
Jordan River
Provo
Utah Lake
Pyramid Lake
Truckee River
Lake Tahoe
Reese River
White River
Sevier River
San Pitch River
Muddy Creek
Fremont River
Tuolumne River
Merced River
San Joaquin River
Kings River
Owens River
Visalia
Kern River
Las Vegas
Lake Mead
Muddy River
Virgin River
Colorado River
Lake Powell
Palm Springs
80
84
86
15
70
40
50



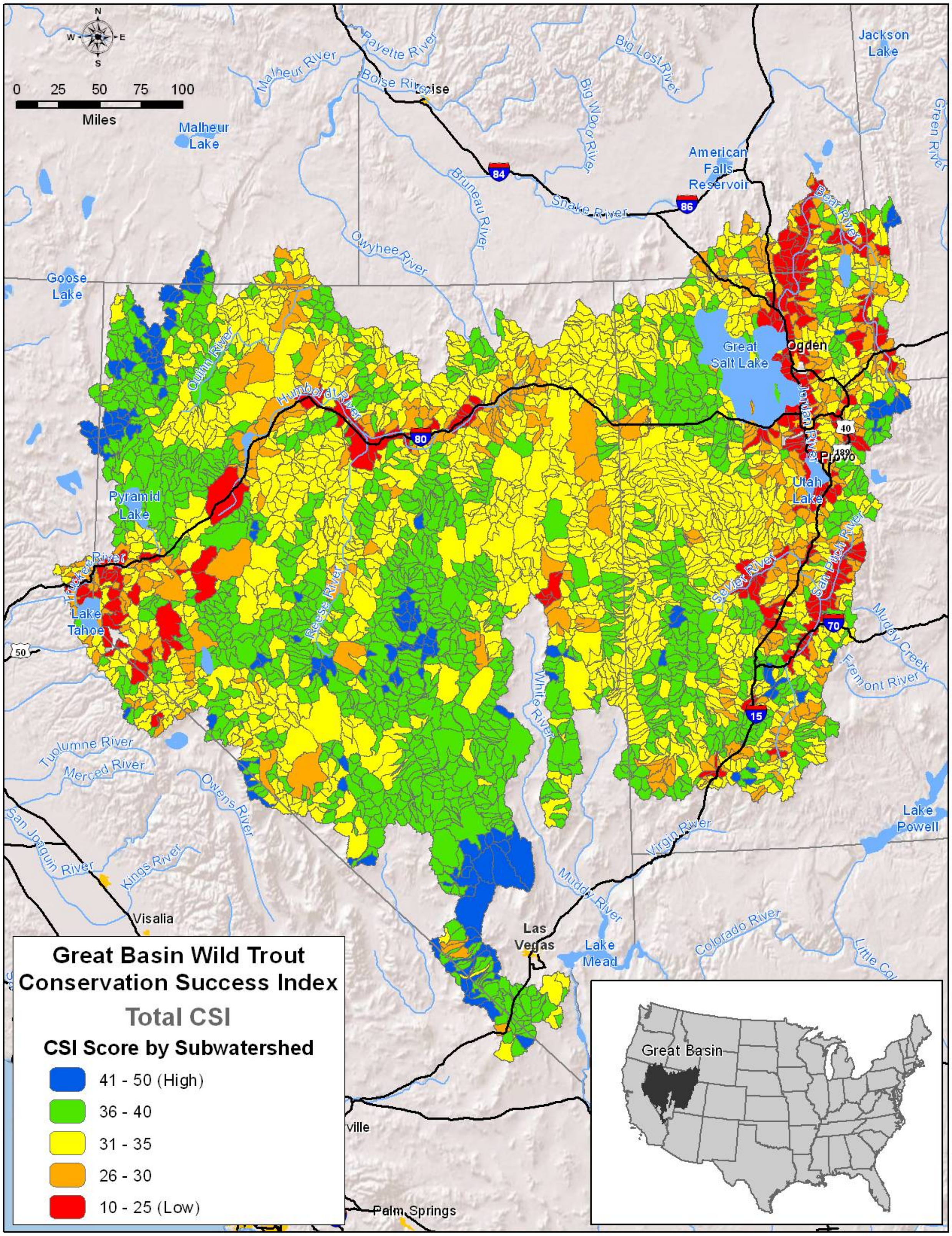
Conservation Strategy
Habitat Potential
Native Trout
High ⟵⟶ Low
Habitat Integrity
Low ⟵⟶ High
Protect Native Trout Habitat
Protect Coldwater Habitat
Little or No Coldwater Habitat
Restore Native Trout Habitat
Restore Coldwater Habitat
Little or No Coldwater Habitat
Great Basin
0 25 50 75 100
Miles
Malheur River
Payette River
Boise River
Boise
Big Lost River
Big Wood River
Jackson Lake
Green River
Malheur Lake
American Falls Reservoir
Bruneau River
Snake River
Bear River
Owyhee River
Goose Lake
Quinn River
Great Salt Lake
Ogden
Humboldt River
Jordan River
Provo
Utah Lake
Pyramid Lake
Truckee River
Lake Tahoe
Reese River
Sevier River
San Pitch River
Muddy Creek
Fremont River
White River
Tuolumne River
Merced River
San Joaquin River
Kings River
Owens River
Visalia
Virgin River
Lake Powell
Muddy River
Las Vegas
Lake Mead
Colorado River
Victorville
Palm Springs



Great Basin Wild Trout
Conservation Success Index
Future Security
TotalGroupCSI
16 - 20
11 - 15
5 - 10
Great Basin
0 25 50 75 100
Miles



Great Basin Wild Trout
Conservation Success Index
Habitat Integrity
CSI Score by Subwatershed
21 - 25 (High)
16 - 20
11 - 15
5 - 10 (Low)
0 25 50 75 100
Miles
N
S
E
W
Great Basin
Malheur Lake
Goose Lake
Pyramid Lake
Lake Tahoe
Great Salt Lake
Utah Lake
American Falls Reservoir
Jackson Lake
Lake Powell
Lake Mead
Ogden
Provo
Las Vegas
Visalia
Palm Springs
Malheur River
Payette River
Boise River
Big Lost River
Big Wood River
Bruneau River
Snake River
Owyhee River
Green River
Bear River
Quinn River
Humboldt River
Truckee River
Reese River
White River
Jordan River
Sevier River
San Pitch River
Muddy Creek
Fremont River
Virgin River
Muddy River
Colorado River
Tuolumne River
Merced River
San Joaquin River
Kings River
Owens River
84
86
80
40
70
15
50


Great Basin Wild Trout
Conservation Success Index
Total CSI
CSI Score by Subwatershed
41 - 50 (High)
36 - 40
31 - 35
26 - 30
10 - 25 (Low)
Great Basin
0 25 50 75 100
Miles
Malheur Lake
Goose Lake
Pyramid Lake
Lake Tahoe
Great Salt Lake
Utah Lake
American Falls Reservoir
Jackson Lake
Lake Mead
Lake Powell
Ogden
Provo
Las Vegas
Visalia
Palm Springs
Humboldt River
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Green River
Quinn River
Truckee River
Tuolumne River
Merced River
Owens River
San Joaquin River
Kings River
Virgin River
Muddy River
Colorado River
Fremont River
Muddy Creek

v. 1  September 2011

# Conservation Success Index:
# Wild Trout – Great Basin
# Subwatershed Scoring and Rule Set

**Introduction**:

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

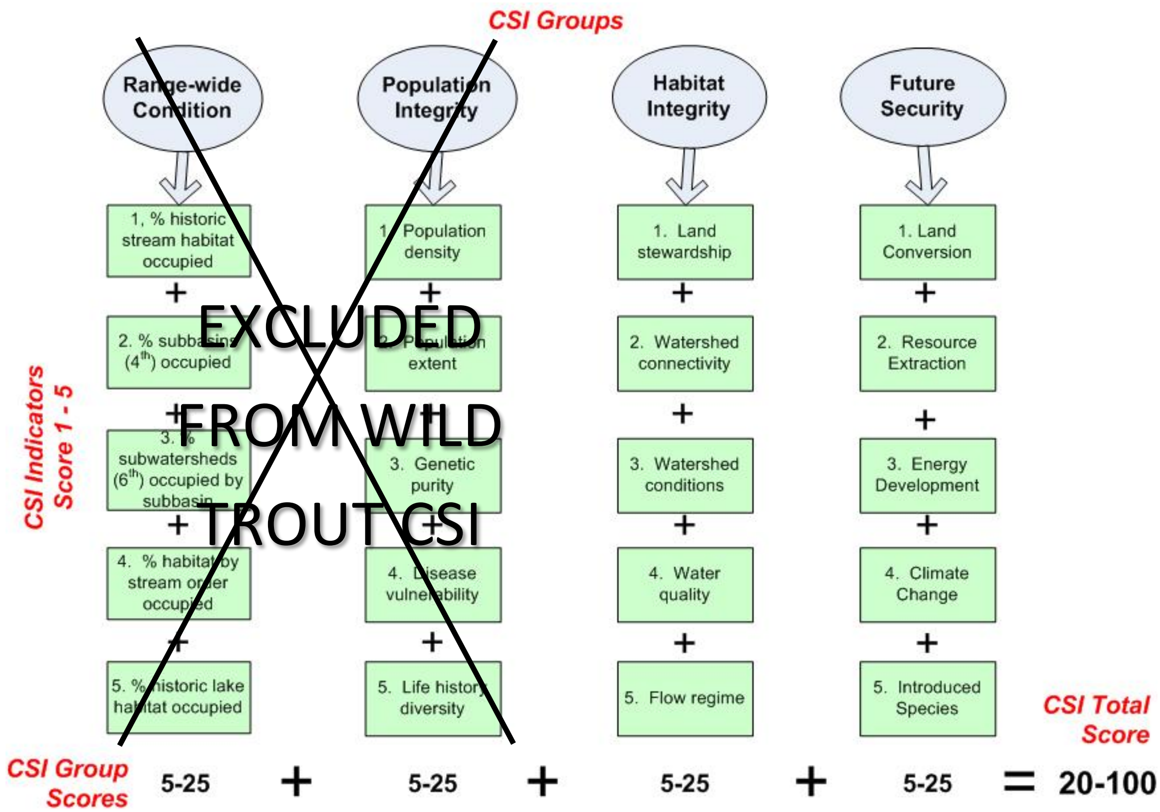



Figure 1. Each subwatershed is scored from 1 to 5 using 20 indicators within four main groups.  Indicator scores are added per group to obtain an overall group score. Group scores are then added to obtain a composite CSI score for each subwatershed.

For the Wild Trout application the original CSI has been modified by only including the Habitat Integrity and Future Security indicators, thus resulting in total scores ranging from 10 (low) to

50 (high). Basic information on potential trout habitat suitability and native trout populations is also summarized, although it is not formally incorporated into a group of indicators and scored.

Below is an overview of wild trout habitat suitability potential, native fish population information, and Habitat Integrity and Figure Security CSI groups and the indicators within each group.

***Wild Trout Habitat Suitability Potential****: Miles of potentially suitable wild trout habitat, defined as Good or Fair*.

Wild trout habitat suitability potential was modeled as a function of environmental variables known to influence coldwater streams and trout habitat. These variables were compared to stream segments (1:100,000 map scale) where trout populations are known to exist versus stream segments were trout were not believed to exist historically. Known trout populations and historical trout habitat were determined from rangewide cutthroat trout databases developed by recovery teams.[1-5] The presence of trout was predicted as a function of these environmental variables: mean annual flow (cfs) as a measure of stream size; mean annual velocity (f/s) as a measure of current velocity; stream slope (m/m); mean annual precipitation (cm / yr); mean annual August temperature in the entire watershed upstream of a stream segment; and percent forested land cover. Predictions were made using a Random Forest model[6] that was fit to all basins at once, and the model was then used to predict potential habitat suitability for all stream segments across the Interior West. The model had good predictive capability, owing to the fact that it described well stream segments where trout occur; in-sample model Area Under the Curve (AUC) of a Receiver Operating Characteristic (ROC)[7] plot was 0.867 indicating good model discrimination ability. Model predictions ranged from 0.0 to 1.0, and these were reclassified to Good = 0.66 – 1.0; Fair = 0.33 – 0.66; Poor = 0.0 – 0.33. In some cases, Good or Fair suitability designations in large rivers may indicate overwintering or migratory habitat.[8] This is a reflection of the fact that many larger rivers were designated has historical cutthroat trout habitat where fish may have used them for migration, overwintering, or for other life history functions.

Figure 1. Diagnostic measures describing the performance of the regression tree model predicting potential trout habitat suitability.

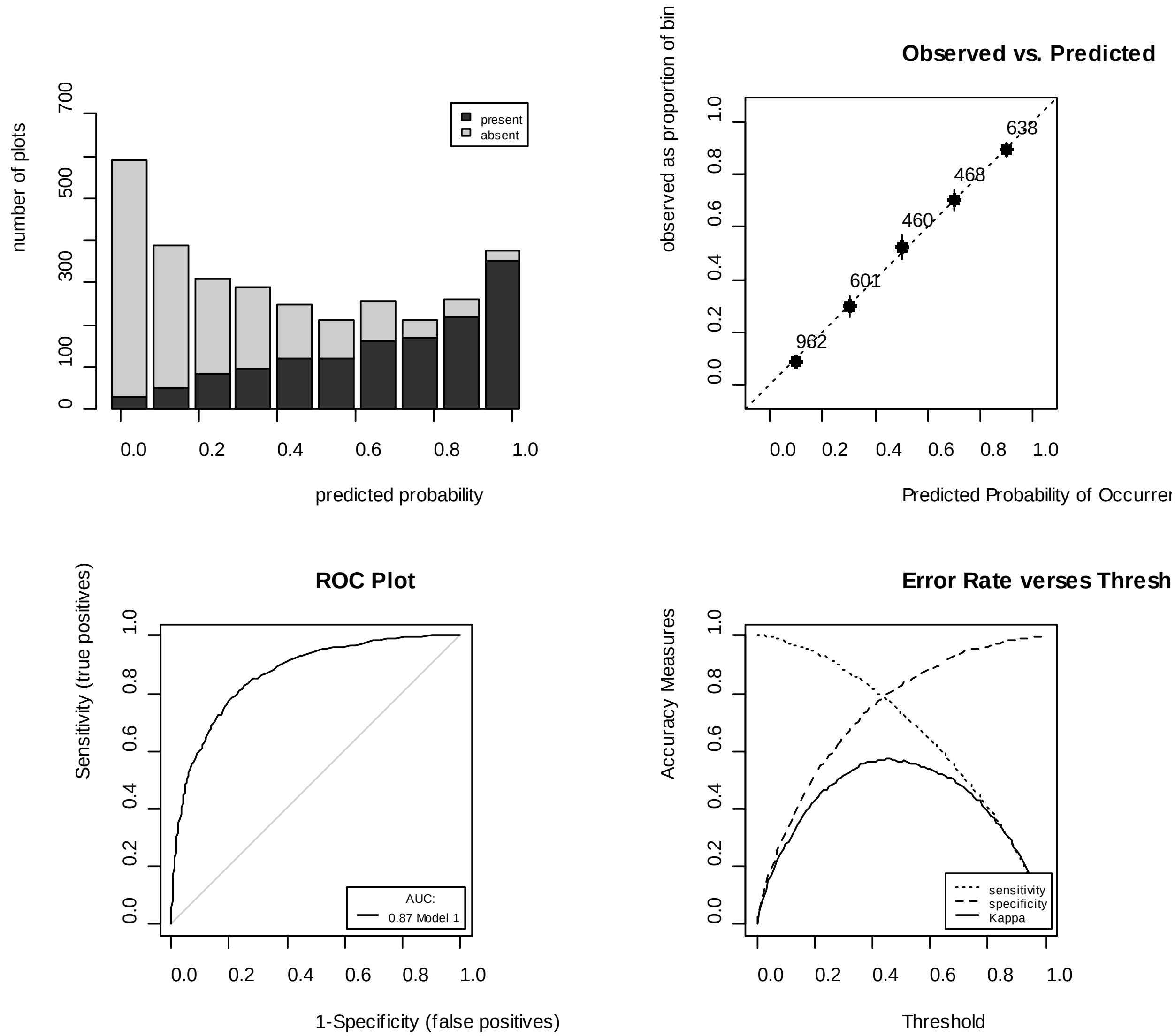


Figure 2.  Plots showing how potential habitat suitability varies in relation to the different environmental variables (all other variables held and their mean value).  Higher values indicate better trout habitat suitability.

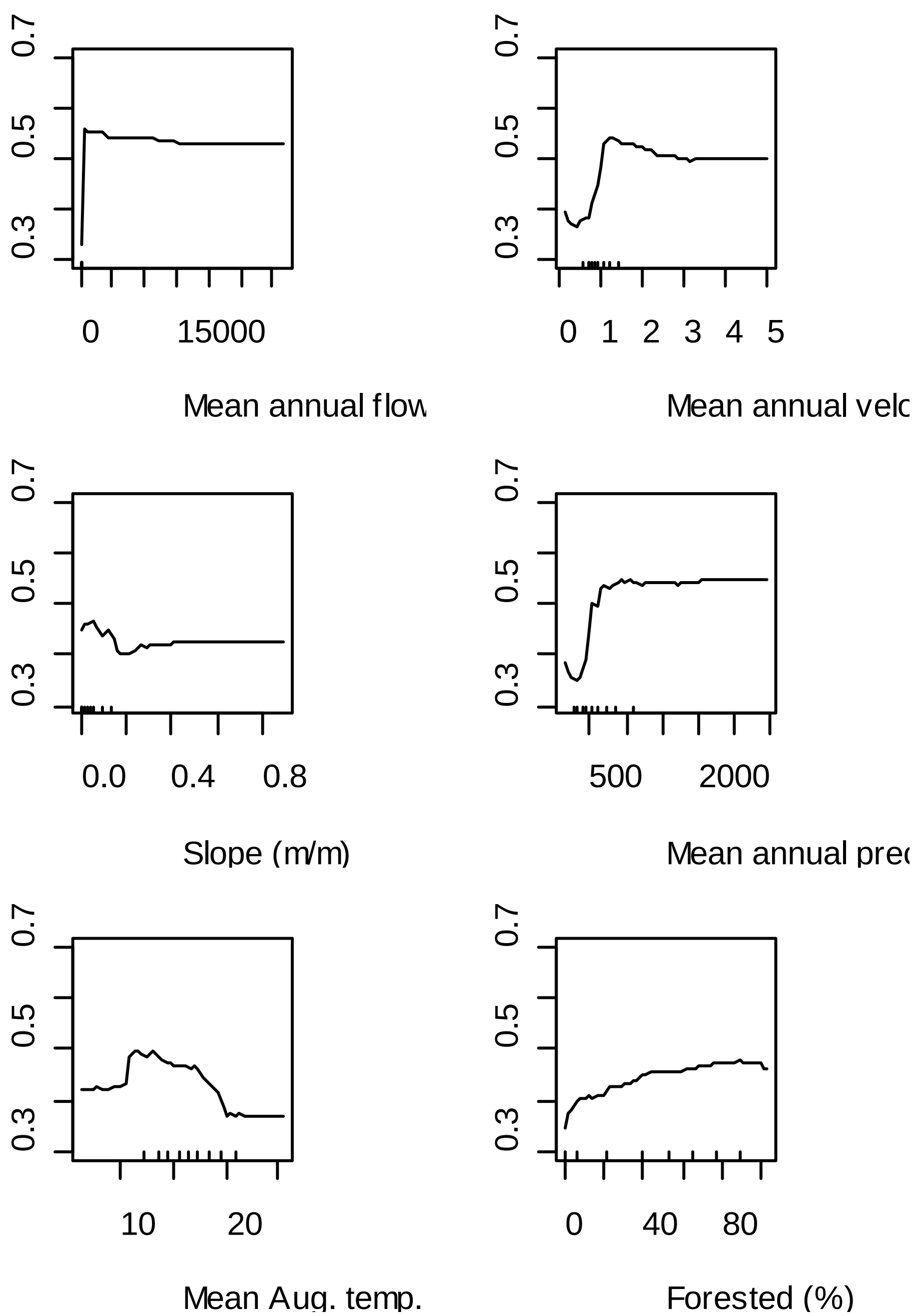
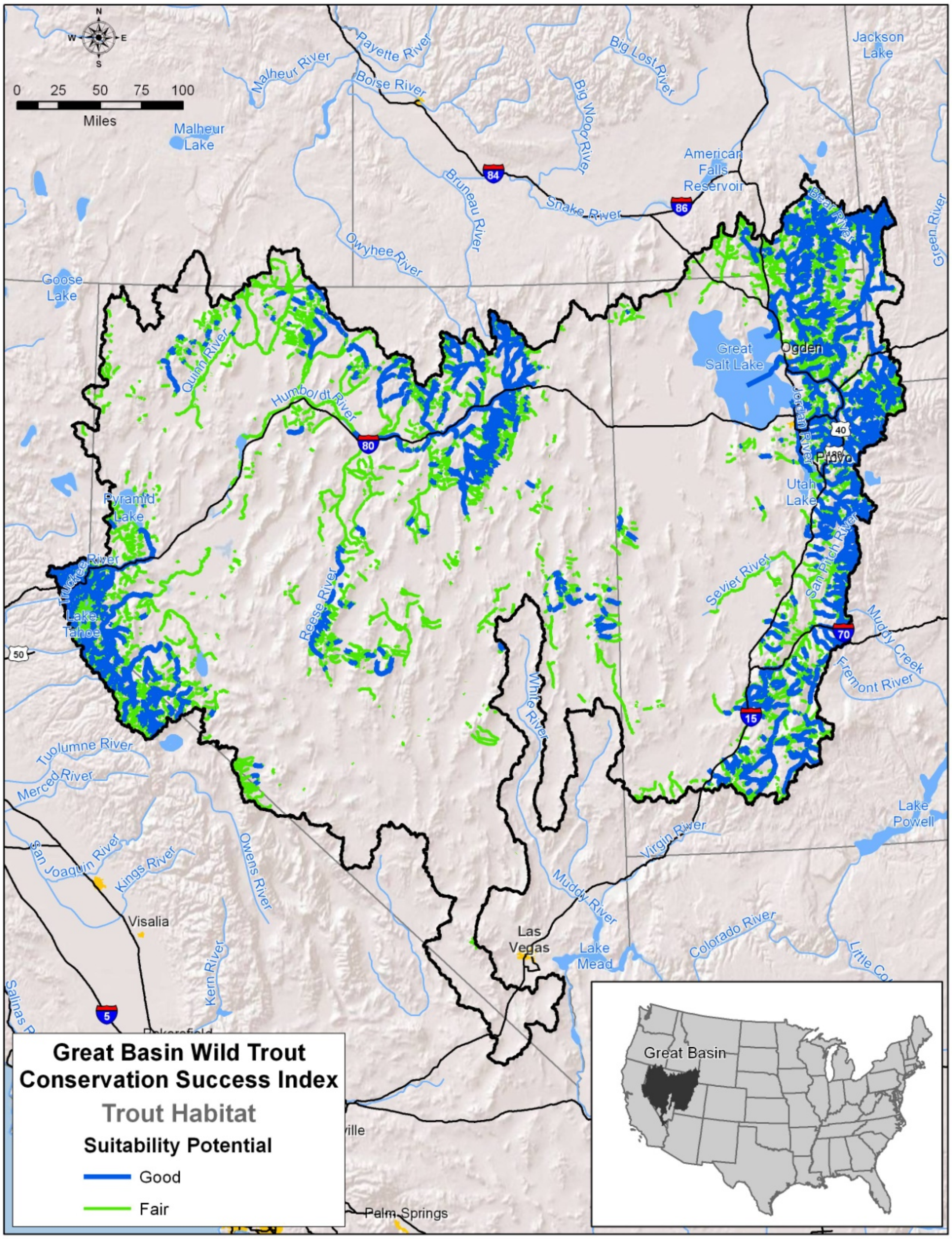


Figure 3.  Model predictions of potential wild trout habitat suitability for Great Basin.




***Native Trout Occupied and Historical Habitat**: Miles of habitat currently and historically occupied by native trout populations*.

Known cutthroat trout populations and historical cutthroat trout habitat were determined from rangewide cutthroat trout databases developed by recovery teams. [1-5]  Currently occupied habitat is for populations labeled as Conservation Populations, ie, populations that are genetically pure or otherwise have some unique characteristics, such as a migratory life history, important for subspecies conservation and recovery. Historical habitat is estimated by professional judgment during subspecies' status assessments.

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

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

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

**Data Sources**: Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas [9] and the U.S. Department of

Agriculture, Forest Service's National Inventoried Roadless Areas dataset [10]. Stream habitat was determined using all streams in the National Hydrography Dataset Plus [11].

**Indicator**: 2. Watershed connectivity.

**Indicator Scoring**:

| Number of stream/canal intersections | CSI Score |
|---|---|
| ≥12 | 1 |
| 8 – 11 | 2 |
| 5 – 7 | 3 |
| 1 – 4 | 4 |
| 0 | 5 |

**Explanation**: The number of stream-canal intersections.

**Rationale**: Increased hydrologic connectivity provides more habitat area and better supports multiple life histories, which increases the likelihood of persistence [12]. Diversions, when they do not directly inhibit fish passage, can represent false movement corridors, cause fish entrainment, and act as population sinks [13;14].

**Data Sources**: Connectivity was determined using all streams was determined using all streams in the National Hydrography Dataset Plus [11].

**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, and the density of roads.

**Rationale**: Habitat conditions are the primary determinant of persistence for most populations [15]. Converted lands are known to degrade aquatic habitats [16;17]. Road density is computed for the subwatershed; roads are known to cause sediment-related impacts to stream habitat [18-20]. Lee et al. [19] 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 [21], with all Developed, Pasture/Hay, and Cultivated Crops land cover types considered to be converted lands. Road density was determined using Integrated Road Transportation of Idaho data [22].

**Indicator**: 4. Water quality.

**Indicator Scoring**:

| Miles 303(d) Streams | Agricultural Land | Number Active Mines | Number active oil/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 | 0.10 - 0.24 | 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, number of active oil and gas wells, and miles of road within 150 ft of 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 and other native fishes. 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 [23-25]. Roads along streams can also contribute large amounts of fine sediments that smother benthic invertebrates, embed spawning substrates, and increase turbidity [26;27].

**Data Sources**: 303(d) impaired streams was determined using U.S. Environmental Protection Agency data [28]. The National Land Cover Database [21] 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 [29]. Active oil and gas wells from Wyoming Oil and Gas Conservation Commission [30]. Road density within a 150 ft buffer was computed using ESRI roads [31] and the National Hydrography Dataset Plus [11].

**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 |

Score for worst case.

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

**Rationale**: Natural flow regimes are critical to proper aquatic ecosystem function [32]. Dams, reservoirs, and canals alter flow regimes [33]. Reduced or altered flows reduce the capability of watersheds to support native biodiversity and salmonid populations.

**Data Sources**: The National Inventory of Dams [34] was the data source for dams and their storage capacity. Data on canals were obtained from the National Hydrography Dataset Plus [11]. Perennial streams were obtained from the National Hydrography Dataset Plus [11].

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

**Overview**:

1. Land conversion
2. Resource extraction
3. Energy development
4. Climate change

5. Introduced species

**Indicator**: 1. Land conversion.

**Indicator Scoring**:

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

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

**Rationale**: Conversion of land from its natural condition will reduce aquatic habitat quality and availability [35;36].

**Data Sources**: Slope was computed from elevation data from the National Hydrography Dataset Plus [11]. Land cover was determined from the National Land Cover Database [21], and all land cover classes except developed areas, hay/pasture, and cultivated crops cover types were considered for potential conversion. Urban areas were determined using 2000 TIGER Census data [37], roads from ESRI Roads [31], and land ownership using USGS data on Land Ownership in Western North America [38].

**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.

**Mine claims data currently unavailable for Great Basin. Scoring will be updated when the data can be incorporated.*

**Explanation**: Percentage of subwatershed available for 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 were removed from availability and include: federal or state parks and monuments, national wildlife refuges, wild and scenic river designations, designated wilderness areas, inventoried roadless areas on federal lands, Research Natural Areas, Areas of Critical Environmental Concern, others areas of special protective designations, or private ownership designated for conservation purposes.

**Rationale**: Productive forest types have a higher likelihood of being managed for timber production than unproductive types, and, hence, future logging poses a future risk to aquatic habitats and fishes [18]. Areas with hard metal claims pose a future risk to mining impacts than areas without claims. Claims indicate areas with potential for hard mineral mining, and mining can impact aquatic habitats and fishes [39].

**Data Sources**: Timber management potential identifies productive forest types using the existing vegetation type in the Landfire dataset [40]. The number of mining claims was determined using Bureau of Land Management data [41], and each claim was assumed to potentially impact 20 acres. Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas [9] and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset [10].

**Indicator**: 3. Energy Development.

**Indicator Scoring**:

| Leases or reserves* | New Dams 4th New Dams 6th | CSI Score |
|---|---|---|

| | | | |
|---|---|---|---|
| 51-100% | ≥4 | ≥1 | 1 |
| 26 – 50% | 3 | | 2 |
| 11 – 25% | 2 | | 3 |
| 1 – 10% | 1 | | 4 |
| 0% | 0 | | 5 |

Score for worst case

**Oil & Gas lease data currently unavailable for Great Basin. Scoring will be updated when the data can be incorporated.*

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

**Rationale**: Increased resource development will increase road densities, modify natural hydrology, and increase the likelihood of pollution to aquatic systems. Changes in natural flow regimes associated with dams are likely to reduce habitat suitability for native salmonids and increase the likelihood of invasion by non-native species[42]. If lands are protected then the watersheds will be less likely to be developed.

**Data Sources**: Oil and gas leases and agreements from BLM Geocommunicator [43]. Potential dam sites are based on Idaho National Laboratory (INL) hydropower potential data [44]. Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas [9] and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset [10].

**Indicator**: 4. Climate change.

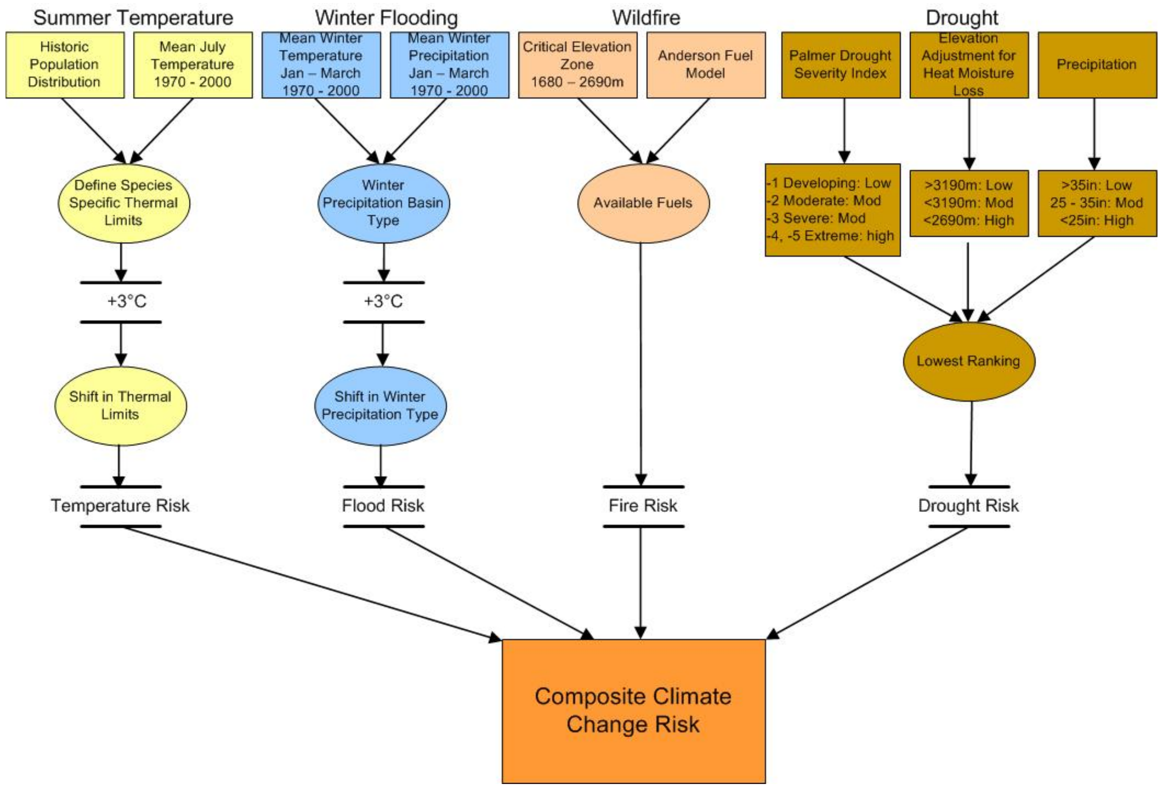
**Indicator Scoring**:

| TU Climate Change Analysis | |
|---|---|
| **Climate Risk Factors** | **CSI Score** |
| High, High, Any., Any | 1 |
| High, Any, Any, Any | 2 |

| | |
|---|---|
| Mod., Mod., Mod., (Mod or Low) | 3 |
| Mod, Mod, Low, Low | 4 |
| Low, Low, Low, (Mod or Low) | 5 |

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

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




Each of the four factors is ranked as low, moderate, or high. Increased summer temperature due to climate change was modeled as a 3°C increase. Uncharacteristic winter flooding can result from basins transitioning from snow dominated to rain-on-snow dominated with increased winter flooding. Uncharacteristic wildfires result from changes in climate and fire fuels. Drought risk is based on the Palmer Drought Severity Index, but was adjusted for elevation and precipitation.

**Rationale**: Climate change is likely to threaten most salmonid populations because of warmer water temperatures, changes in peak flows, and increased frequency and intensity of disturbances such as floods and wildfires [45;46]. A 3°C increase in summer temperature has the potential to impact coldwater species occupying habitat at the edge of their thermal tolerance. Increased winter flooding can cause local populations to be extirpated. Wildfire can change aquatic habitats, flow regimes, temperatures, and wood inputs that are important to salmonids [47]. Drought is expected to reduce water availability [48;49] and the availability of aquatic habitat. These risks are further discussed by Williams et al.[45]

**Data Sources**: Temperature and precipitation data were obtained from the PRISM Group[50]. Elevation data was obtained from the National Elevation Dataset [51], and LANDFIRE data for the Anderson Fire Behavior Fuel Model 13 [40] was used as input for wildfire risk. The Palmer Drought Severity Index was used for drought risk [52], but was adjusted for elevation (elevations above 2690 have lower risk [49]) and the deviation from mean annual precipitation (areas with more precipitation on average have lower risk).

**Indicator**: 5. Introduced species.

**Indicator Scoring**:

If introduced species have been documented in a subwatershed

| Present in 4th | Present in 6th | 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 |

Score worst case.

If introduced species have not been documented in a subwatershed

| Present in 4th | Road Density | CSI Score |
|---|---|---|
| Yes | >4.7 | 1 |
| Yes | 3.7 – 4.7 | 2 |
| Yes | 2.7 – 3.7 | 3 |
| Yes | <2.7 | 4 |
| No | any | 5 |

Score worst case.

If introduced species have not been documented in a subwatershed or subbasin

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

Score worst case.

*This analysis relies solely on the road density surrogate to estimate effects from introduced species*

**Explanation**: The presence of introduced, injurious species in a subbasin and subwatershed and road density. Road density is the length of road per subwatershed area, and represents the potential for future introduction of non-native species into the subwatershed.

**Rationale**: Introduced species can reduce native fish populations through predation, competition, hybridization, and the introduction of non-native parasites and pathogens [53]. In the absence of data on presence of non-native species in a subwatershed or subbasin, road density can be used as a surrogate for risk of non-native fish introductions by perpetrators [54].

**Data Sources**: Data on non-native, injurious species were obtained from a variety of sources. Wyoming Game and Fish Department considers white sucker, longnose sucker, and burbot to be the non-native species of highest concern to the flannelmouth sucker, bluehead sucker, and roundtail chub (K. Gelwicks, Wyoming Game and Fish Department, personal communication). The non-native white sucker hybridizes readily with the flannelmouth sucker and bluehead sucker [55;56], and burbot are suspected to prey on native warmwater fishes [57]. Non-native trout can also cause population declines or extirpation of Colorado River cutthroat trout through competition, predation, and hybridization. Information on the presence of non-native species was obtained from recent Wyoming Game and Fish Department stream surveys targeted at the three warmwater species, recent surveys by Utah Division of Wildlife Resources, and Colorado Division of Wildlife fish database, and the geodatabase associated with the Colorado River cutthroat trout range-wide assessment [4]. Although Quist et al.[58] found that non-native creek chubs had high diet overlap with roundtail chub in Muddy Creek, Wyoming, creek chub were considered to have minimal impacts on native fish populations. The longnose sucker has also been found to hybridize with native suckers [59].

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