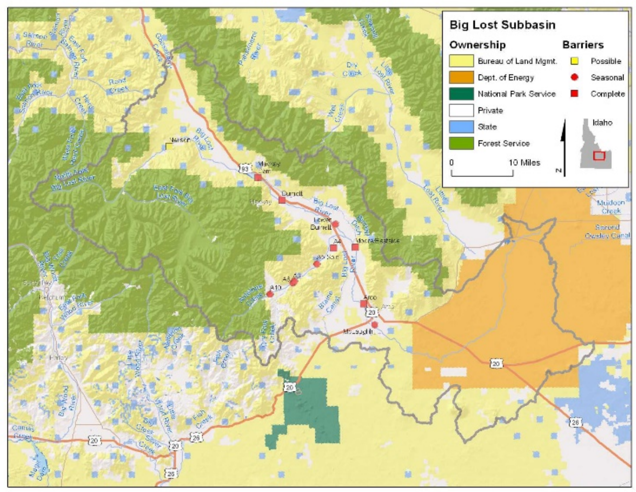
# Conservation Success Index: Big Lost Wild Trout

Rev. 1.0 - 6/2009

## SPECIES SUMMARY

The Big Lost River is one of several sinks river drainages in northeastern Idaho. It infiltrates completely into the porous volcanic geology of the northern Snake River Plain and has had no surface connection to the Snake River for at least 10,000 years. The Big Lost River formally terminates at the Big Lost River Sinks. However, the river also naturally loses water at the Chilly Sinks above Mackay Reservoir and the Darlington Sinks near Darlington, Idaho because of the porous nature of the valley floor.

Trout are not native to the Big Lost River Basin. When trout were first introduced into the Big Lost River is unclear, but both rainbow trout and brook trout are thought to have been stocked around 1890. Since then, several subspecies of cutthroat trout have been stocked into high mountain lakes and the Big Lost River, as have golden trout, kokanee, brown trout, and grayling. Rainbow trout and brook trout are the primary components of the trout fishery, but Snake River fine-spotted cutthroat trout have been stocked since 2000 because they are thought to be more resistant to whirling disease infection.




**Big Lost Subbasin Map**

The Big Lost River was once renowned for its trout fishery, but in the 1980's anglers reported that trout populations were declining and subsequent surveys by Idaho Department of Fish and Game showed continued decline through the mid-1990's. Harvest by anglers, habitat degradation, water withdrawal, grazing, water quality, whirling disease, and fish stocking have all been implicated in the decline of Big Lost trout populations. Recent fish survey data show that trout populations have rebounded to levels above those in the 1980's. Compared to the 1980's, a recent creel survey showed that angler effort has increased but harvest has decreased, reflecting a shift towards catch-and-release angling.

Our CSI analysis incorporated data from the U.S.D.A. Forest Service, Gregory Aquatics, and 2007 fish surveys completed by the Idaho Department of Fish and Game. A complete list of data sources is provided separately.

Key CSI Findings

- Trout densities are generally high except near dewatered stream segments and in marginal tributary habitats
- Much of the Big Lost River Basin is managed as a wild trout fishery, but triploid rainbow trout are stocked into Mackay Reservoir, East Fork, and Wildhorse Creek. Snake River fine-spotted cutthroat trout are stocked into the North Fork and West Fork.
- Whirling disease is prevalent in the basin, but trout are only susceptible at lower elevations
- Watershed conditions are poor along the mainstem where land has been converted to agricultural fields and pastures are maintained by sprinkler irrigation
- The East Fork, Antelope Creek, Pass Creek, Sage Creek, and the mainstem Big Lost are major waters that are 303(d) listed because of sediment, nutrient, streamflow, and temperature problems
- Wild trout are at low risk to the future threats of land conversion and invasive species
- Uncharacteristic wildfires, climate warming, and resource extraction pose the greatest future risk to wild trout in the Big Lost River Basin

**Photo by K. Fesenmyer.**

Our CSI analysis showed 34 subwatersheds have the potential to support wild trout in at least a very limited capacity. Much of the Big Lost River and its tributaries are managed as a wild trout fishery, reflected in high subwatershed scores for management emphasis. In 2008, triploid rainbow trout were stocked into Mackay Reservoir, East Fork, and Wildhorse Creek. Snake River fine-spotted cutthroat trout were stocked into the North Fork and West Fork to supplement populations established in 2000.

Population densities are highest in the East Fork, upper Antelope Creek, and the mainstem below Mackay Reservoir. They are lowest in marginal tributary habitat and near dewatered segments on the mainstem and lower Antelope Creek. The extent of connected habitat varied but was highest in the upper basin. The size structure of trout populations showed good ratios of small fish (1 to 6 inches) to large fish (>6 inches) in some headwater streams. However, some populations with fewer small fish scored moderately. Size structure was poor where densities were low in marginal tributary habitat, near dewatered stream segments, and just upstream of the Chilly Diversion. The Big Lost River below Mackay Reservoir had many large rainbow trout that likely moved downstream after being stocked into the reservoir.

Whirling disease is prevalent in the basin, and recent research has shown wild trout to be susceptible at warmer temperatures in lower elevation streams in the Basin. Subwatersheds where trout have been shown to be susceptible scored low. Other watersheds scored low because whirling disease is suspected to be present or it occurs in adjacent watersheds.

Habitat Integrity scored high to moderate in higher elevation tributaries of the Big Lost River Basin but low along the lower mainstem. Watersheds of headwater tributary streams are primarily managed by the Salmon-Challis National Forest and protected as roadless areas except along stream corridors. Several tributaries are listed as 303(d) impaired by the State of Idaho because of livestock grazing and water withdrawal impacts to aquatic habitat. The Bureau of Land Management is responsible for the lower elevation shrublands along larger streams. Private land dominates along the lower mainstem where habitat integrity was low because of extensive canal networks that divert water, water diversion structures that disconnect habitat, land that has been converted to pasture and agricultural fields, and streamflows that are disrupted by Mackay Reservoir; the lower mainstem is also listed as 303(d) impaired. The lower Big Lost River is dry most of the year because water is lost to the Chilly and Darlington Sinks and is withdrawn for irrigation. The loss of water from the Big Lost River has increased because landowners have switched from flood irrigation to sprinkler irrigation. Sprinkler irrigation does not result in return flows and lowers the water table, increasing the loss of streamflows into the porous valley floor. Because the CSI is a broad, watershed-scale assessment, habitat integrity indicators may not accurately reflect local instream habitat conditions in upstream watersheds degraded from grazing impacts, such as the East Fork of the Big Lost River.

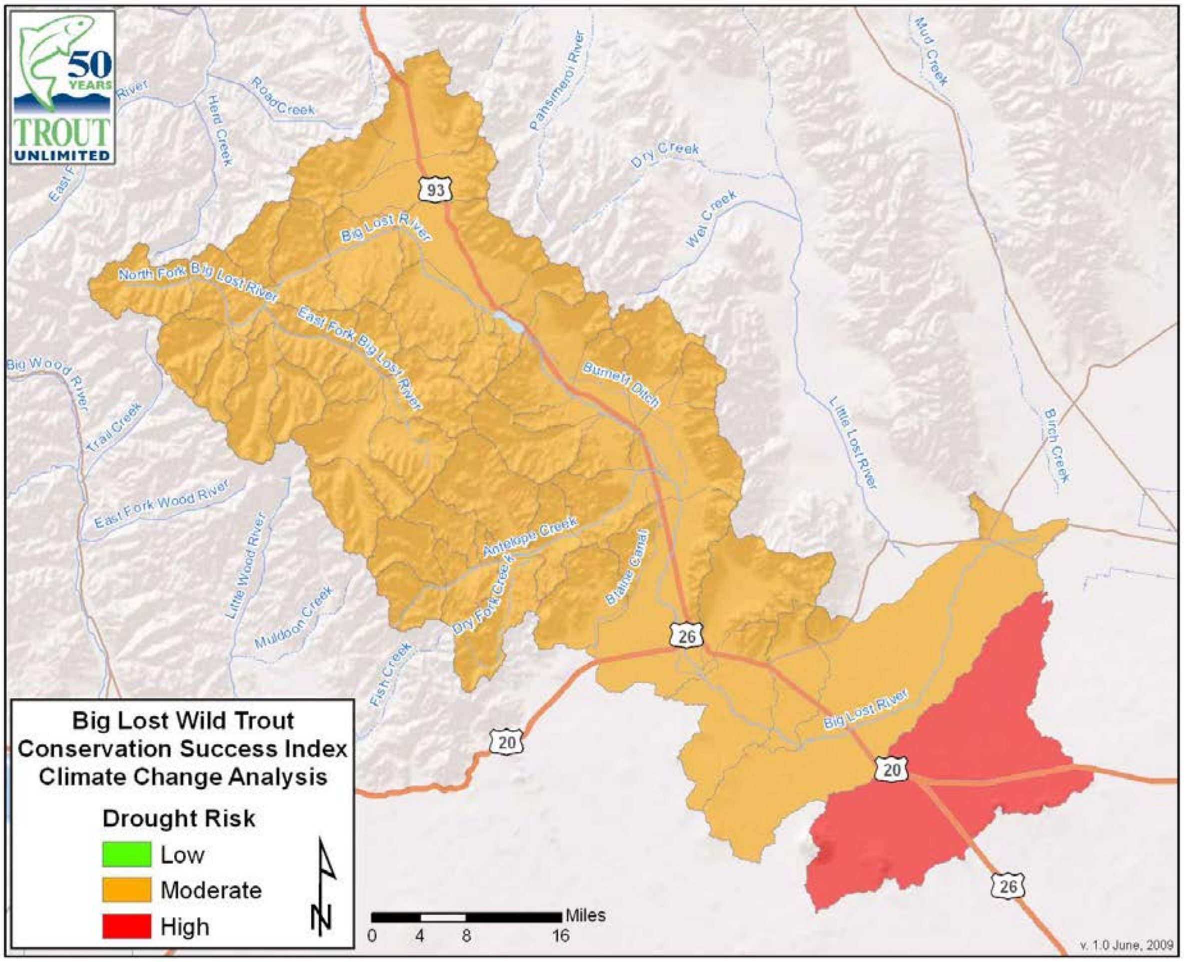
**Photo: East Fork of the Big Lost River. The East Fork has a history of grazing impacts, but past instream habitat projects and recent willow plantings were undertaken to sustain wild trout habitat and populations in this upper portion of the Big Lost River Basin. Photo by D. Dauwalter.**

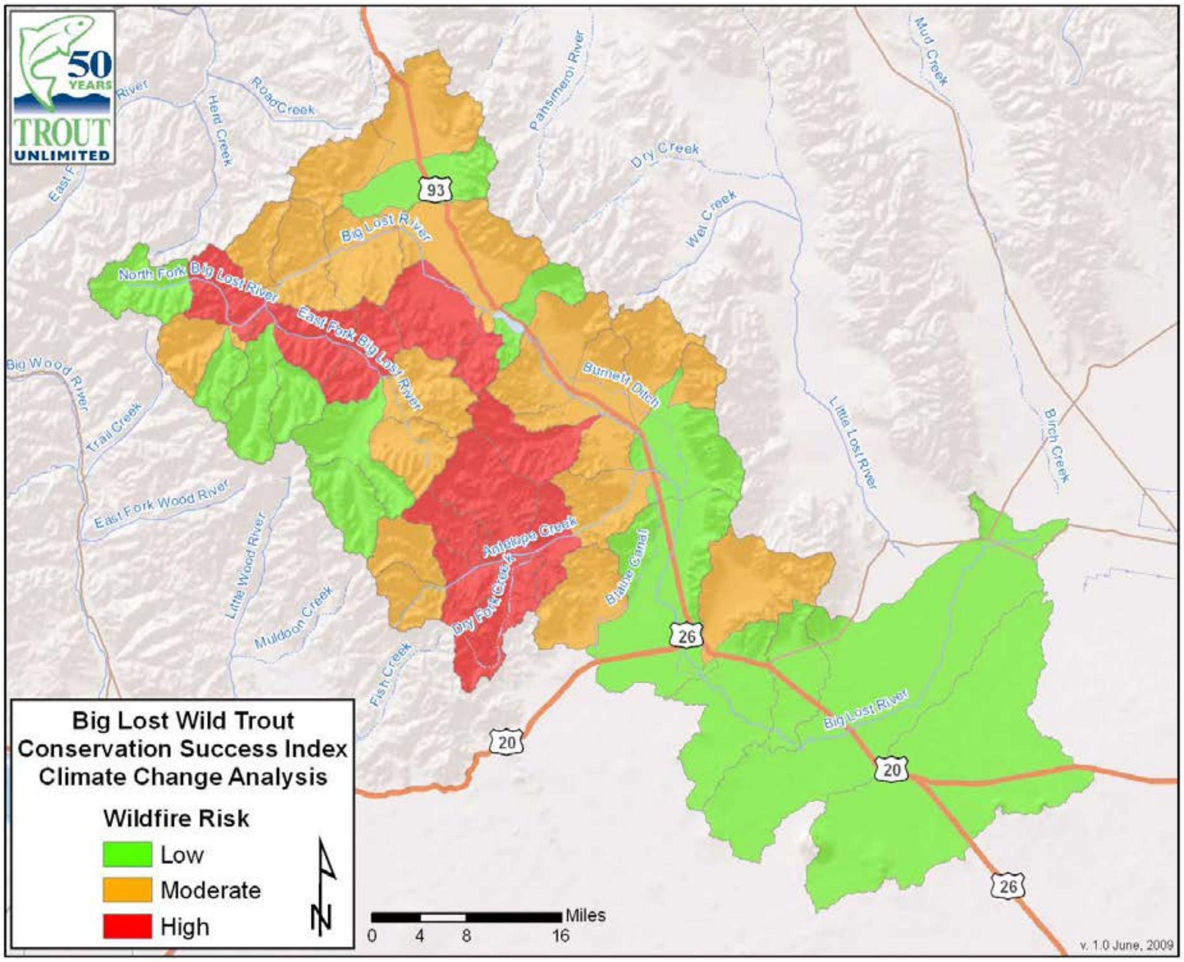
Most subwatersheds scored high for Future Security. There is low potential for existing unconverted lands to be converted for agriculture. Several watersheds have hundreds of mine claims and have high resource extraction risk. Only two subwatersheds have been identified for future hydropower development. Risk of winter flooding due to climate change is low throughout the basin, but several mid-elevation subwatersheds have a high risk for uncharacteristic wildfires. The lower Big Lost River Basin has high risk to temperature change under a 3°C climate warming scenario. This indicates that streamflows and riparian vegetation must be restored in a way that ensures cooler water temperatures that buffer against a warming climate. Only the Navarre Creek subwatershed scored moderately low for future security because of high risk to resource extraction, energy development, and climate change.

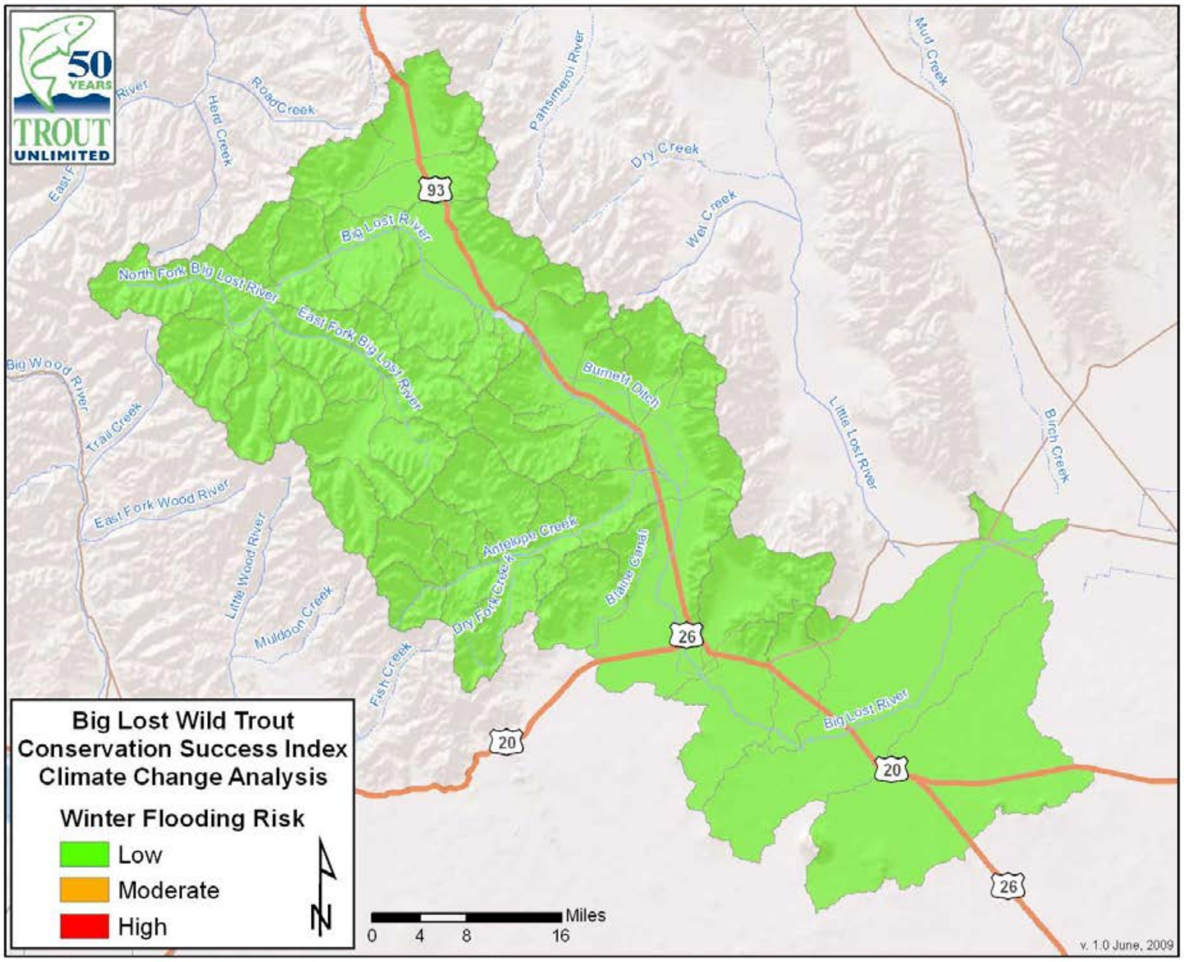
The U.S. Forest Service, Idaho Department of Fish and Game, Gregory Aquatics, and Trout Unlimited have actively been restoring trout habitat in the Big Lost River Basin. Since 2004, fish passage has been provided on six water diversion structures. Riparian vegetation was recently planted along the East Fork of the Big Lost River where there has been a history of grazing impacts in stream habitat. Trout Unlimited recently acquired a 5 cubic feet per second water right for a fish ladder on the Chilly Diversion. Acquisitions of non-consumptive will continue to improve streamflows and reconnect stream segments and populations. Providing large interconnected habitats will increase the persistence of existing wild trout populations to both natural and anthropogenic disturbances.

The wild trout fishery in the Big Lost River is an important socioeconomic and recreational component of communities in and around the Big Lost River Basin. Idaho Department of Fish and Game, the U.S.D.A. Forest Service, Gregory Aquatics, and Trout Unlimited have and will continue to work to ensure this high quality fishery persists into the future.

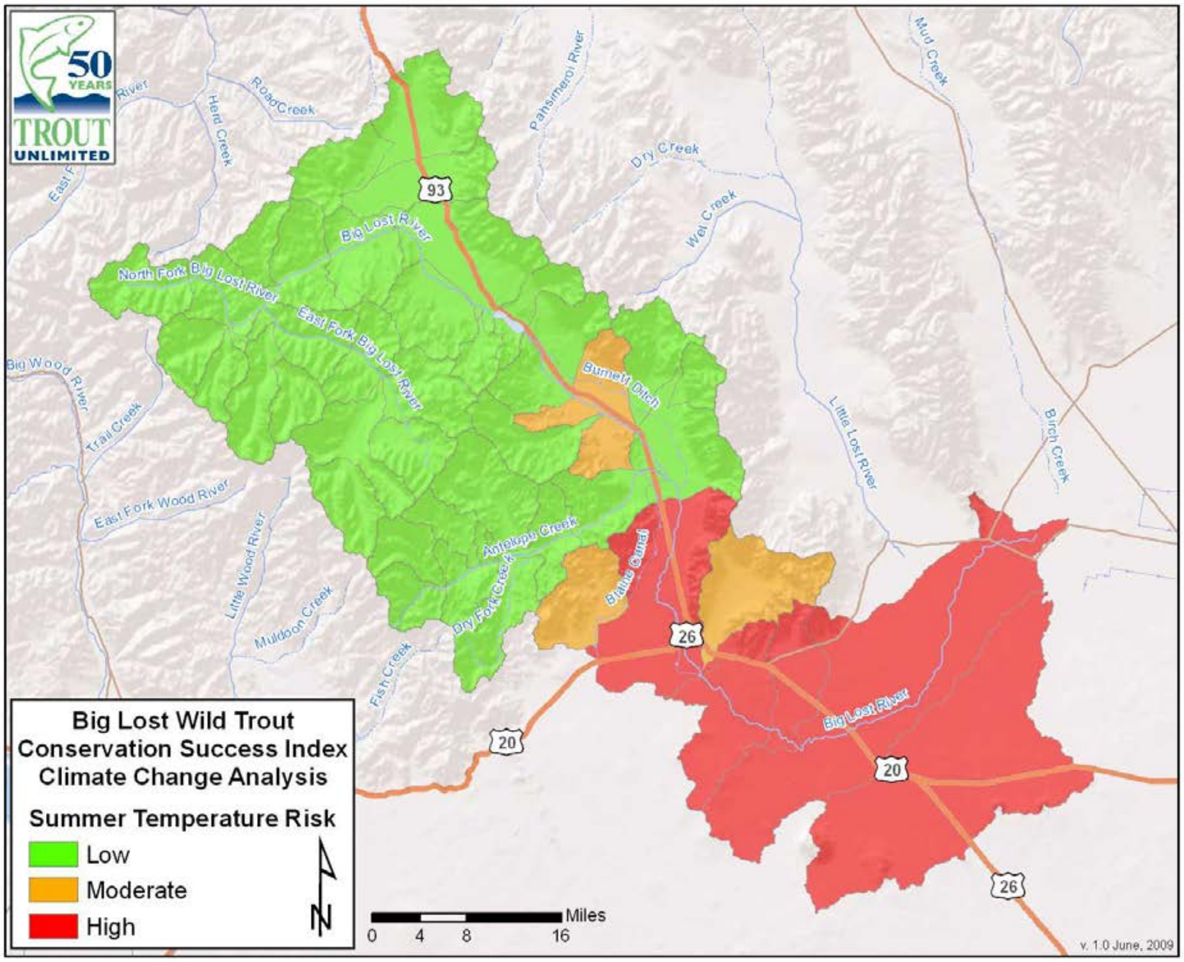
Prepared by Dan Dauwalter and Kurt Fesenmyer, TU, 6/17/2009


Big Lost Wild Trout
Conservation Success Index
Climate Change Analysis
Drought Risk
Low
Moderate
High
Miles
0 4 8 16
v. 1.0 June, 2009
Big Lost River
North Fork Big Lost River
East Fork Big Lost River
Antelope Creek
Dry Fork Creek
Burnett Ditch
Blaine Canal
Little Lost River
Birch Creek
Mud Creek
Pahsimeroi River
Dry Creek
Wet Creek
Big Wood River
Trail Creek
East Fork Wood River
Little Wood River
Muldoon Creek
Fish Creek
Road Creek
Herd Creek
93
26
20

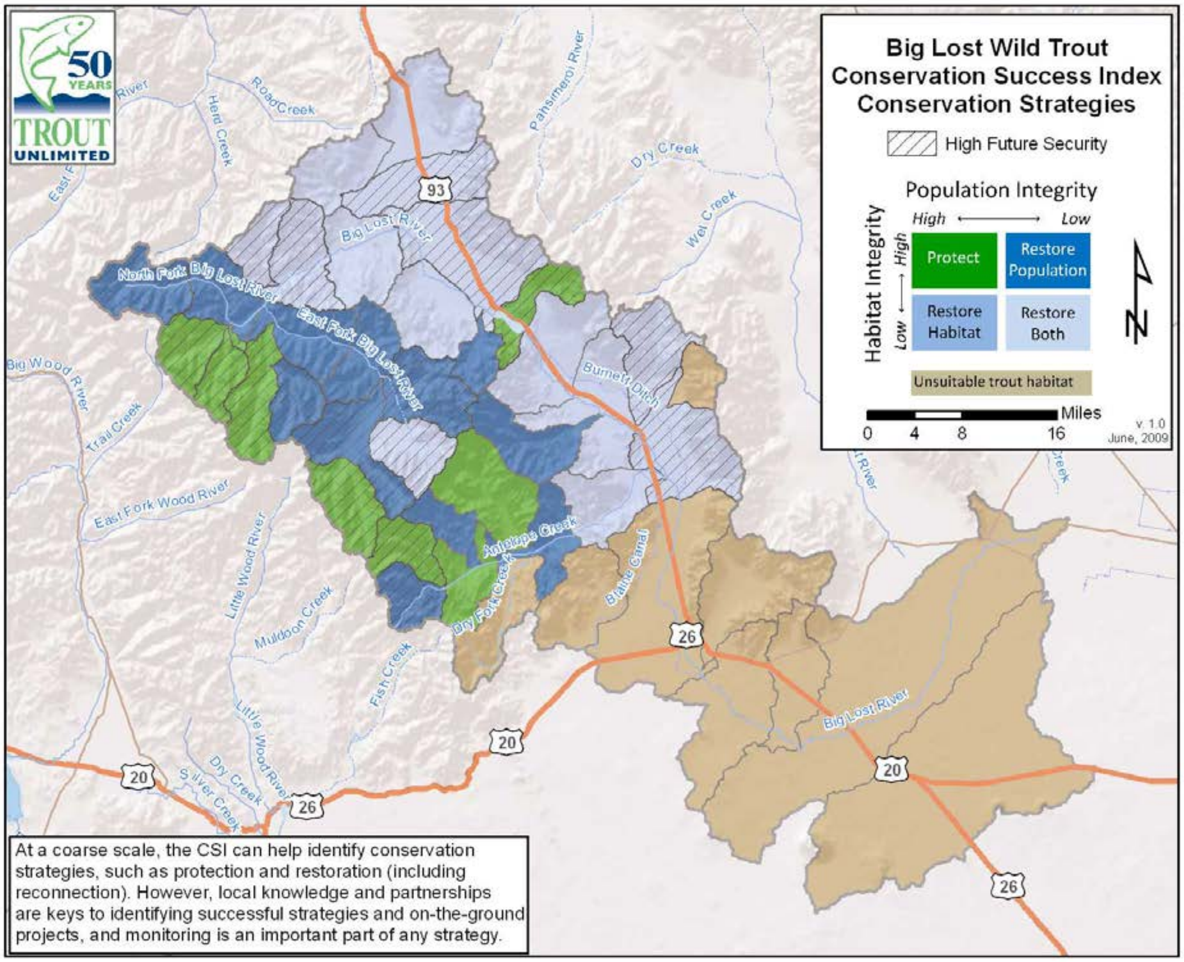

50 YEARS
TROUT UNLIMITED
Big Lost Wild Trout
Conservation Success Index
Climate Change Analysis
Wildfire Risk
Low
Moderate
High
Miles
0 4 8 16
v. 1.0 June, 2009
Big Lost River
North Fork Big Lost River
East Fork Big Lost River
Burnett Ditch
Antelope Creek
Dry Fork Creek
Blaine Canal
Little Lost River
Birch Creek
Mud Creek
Dry Creek
Wet Creek
Pahsimeroi River
Road Creek
Herd Creek
Big Wood River
Trail Creek
East Fork Wood River
Little Wood River
Muldoon Creek
Fish Creek
93
26
20



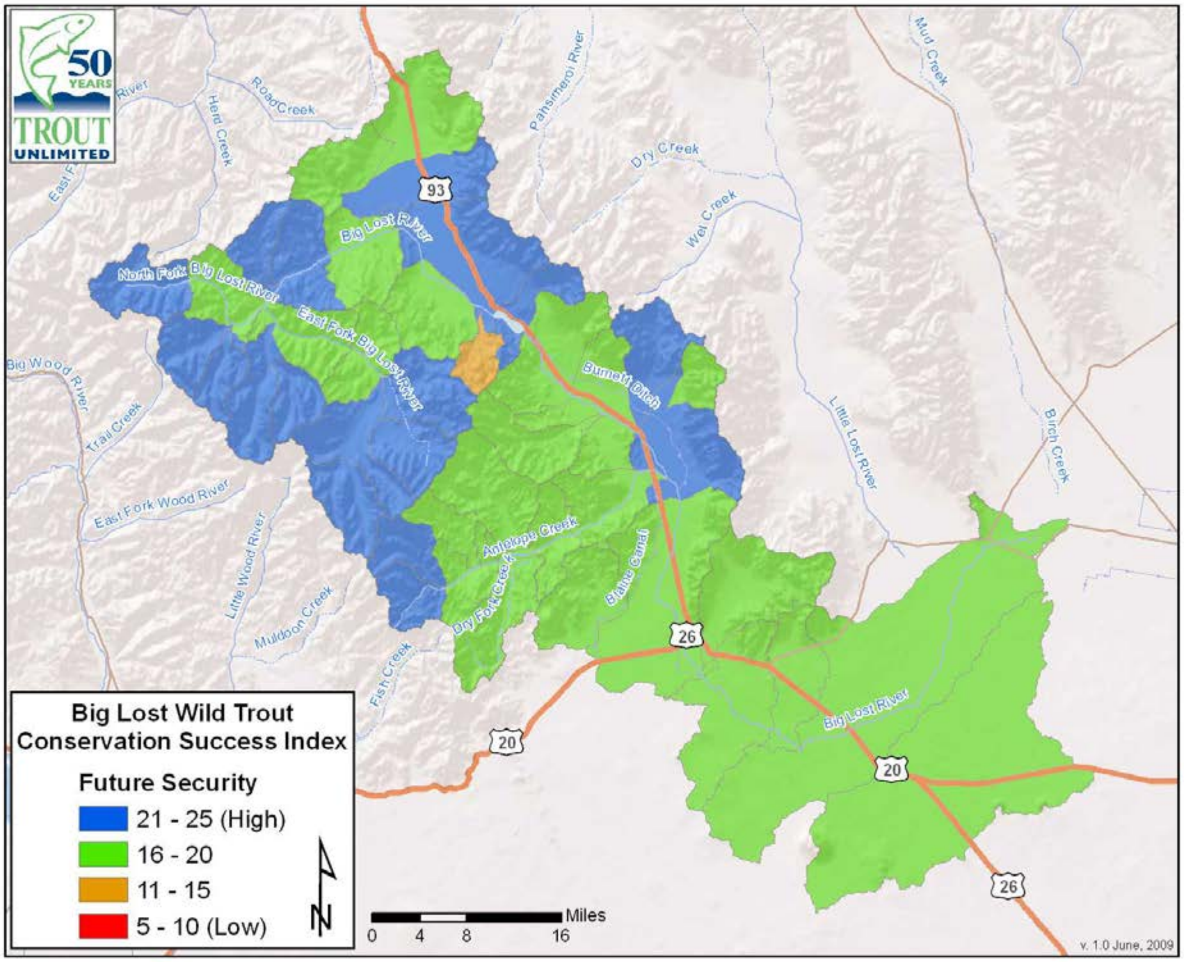
50 YEARS
TROUT UNLIMITED
Big Lost Wild Trout
Conservation Success Index
Climate Change Analysis
Winter Flooding Risk
Low
Moderate
High
Miles
0 4 8 16
v. 1.0 June, 2009
Big Lost River
North Fork Big Lost River
East Fork Big Lost River
Burnett Ditch
Antelope Creek
Dry Fork Creek
Blaine Canal
Little Lost River
Birch Creek
Mud Creek
Pahsimeroi River
Dry Creek
Wet Creek
Road Creek
Herd Creek
Big Wood River
Trail Creek
East Fork Wood River
Little Wood River
Muldoon Creek
Fish Creek
93
26
20

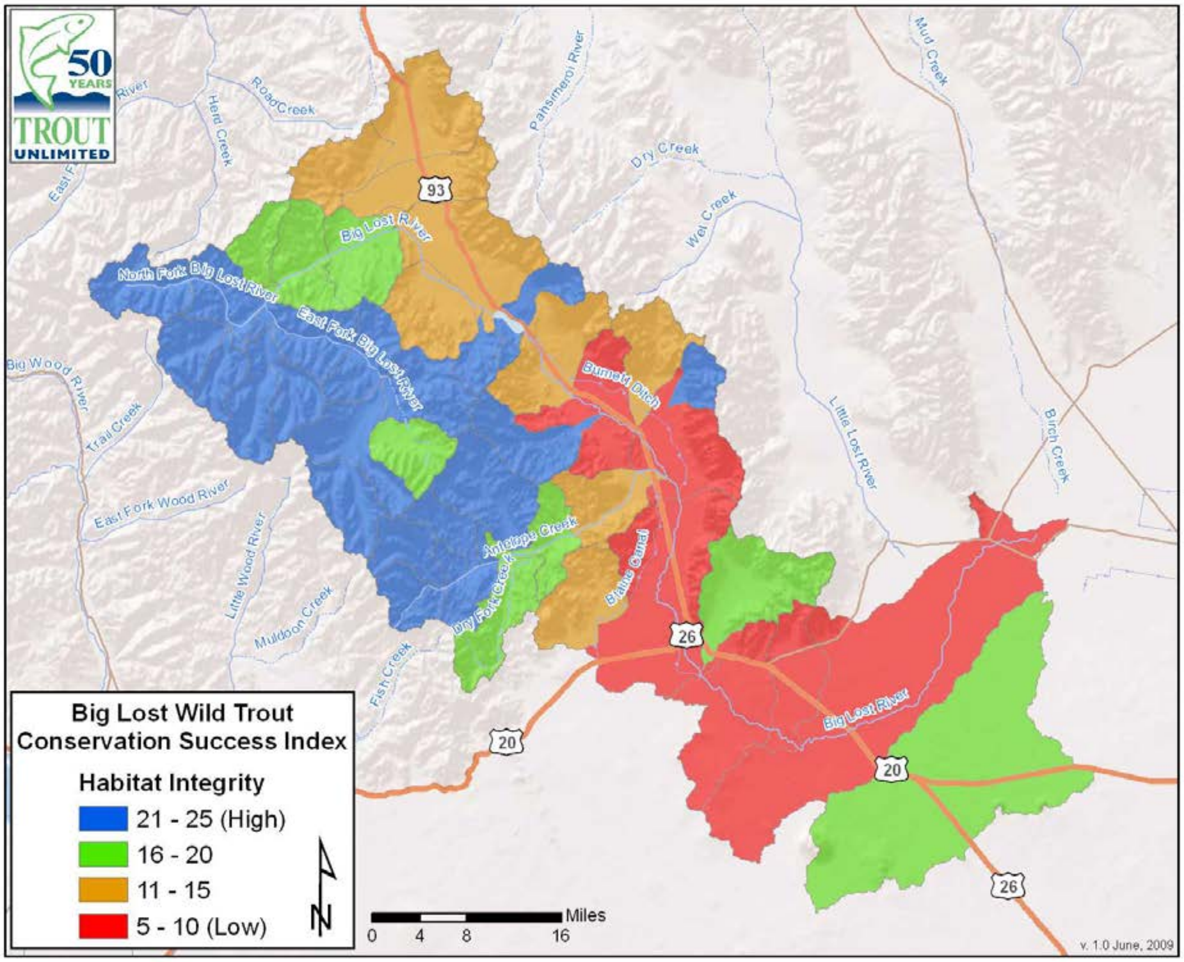


50 YEARS
TROUT UNLIMITED
Big Lost Wild Trout
Conservation Success Index
Climate Change Analysis
Summer Temperature Risk
Low
Moderate
High
Miles
0
4
8
16
v. 1.0 June, 2009
Big Lost River
North Fork Big Lost River
East Fork Big Lost River
Antelope Creek
Dry Fork Creek
Burnett Ditch
Blaine Canal
Little Lost River
Birch Creek
Mud Creek
Dry Creek
Wet Creek
Pahsimeroi River
Road Creek
Herd Creek
Big Wood River
Trail Creek
East Fork Wood River
Little Wood River
Muldoon Creek
Fish Creek
93
26
20

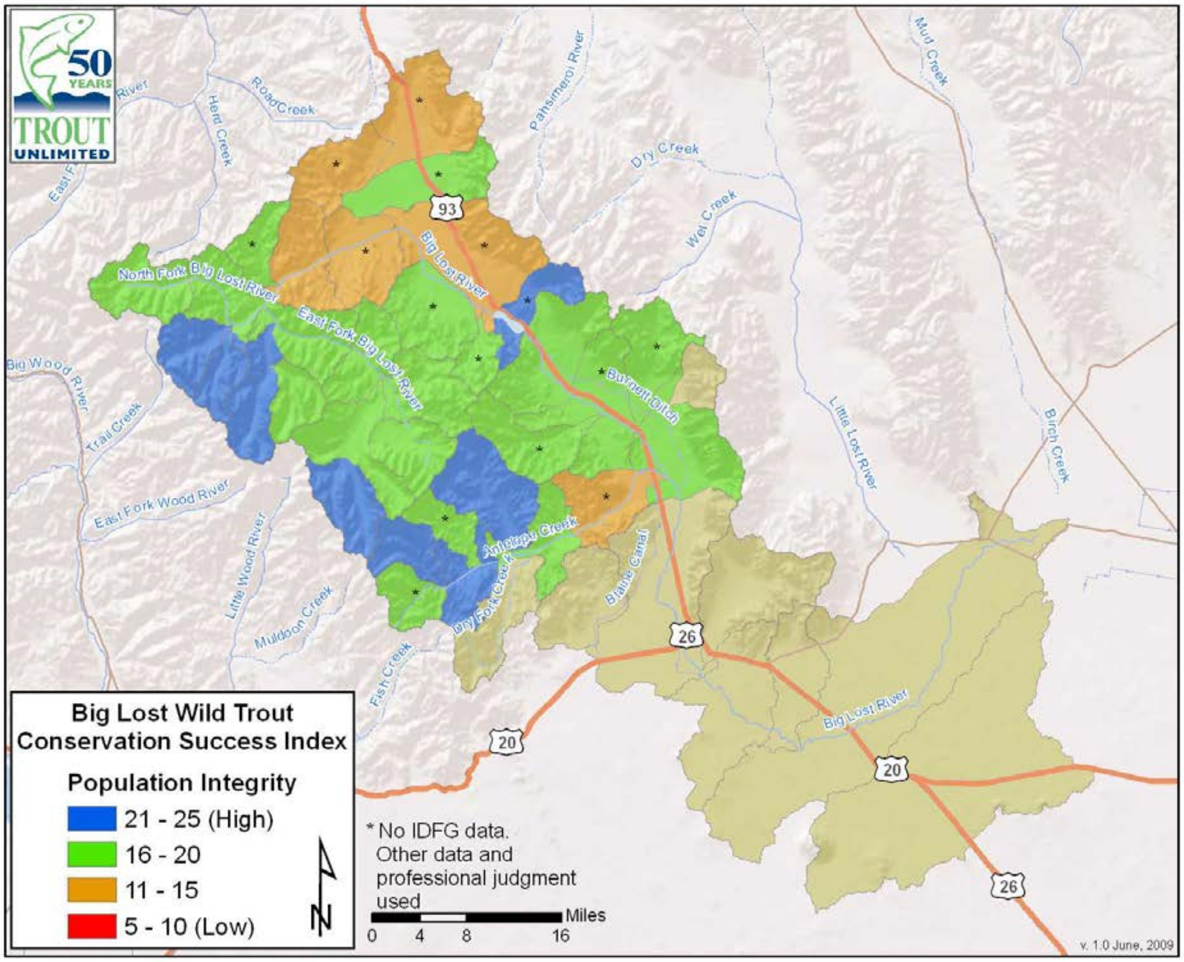



At a coarse scale, the CSI can help identify conservation strategies, such as protection and restoration (including reconnection). However, local knowledge and partnerships are keys to identifying successful strategies and on-the-ground projects, and monitoring is an important part of any strategy.

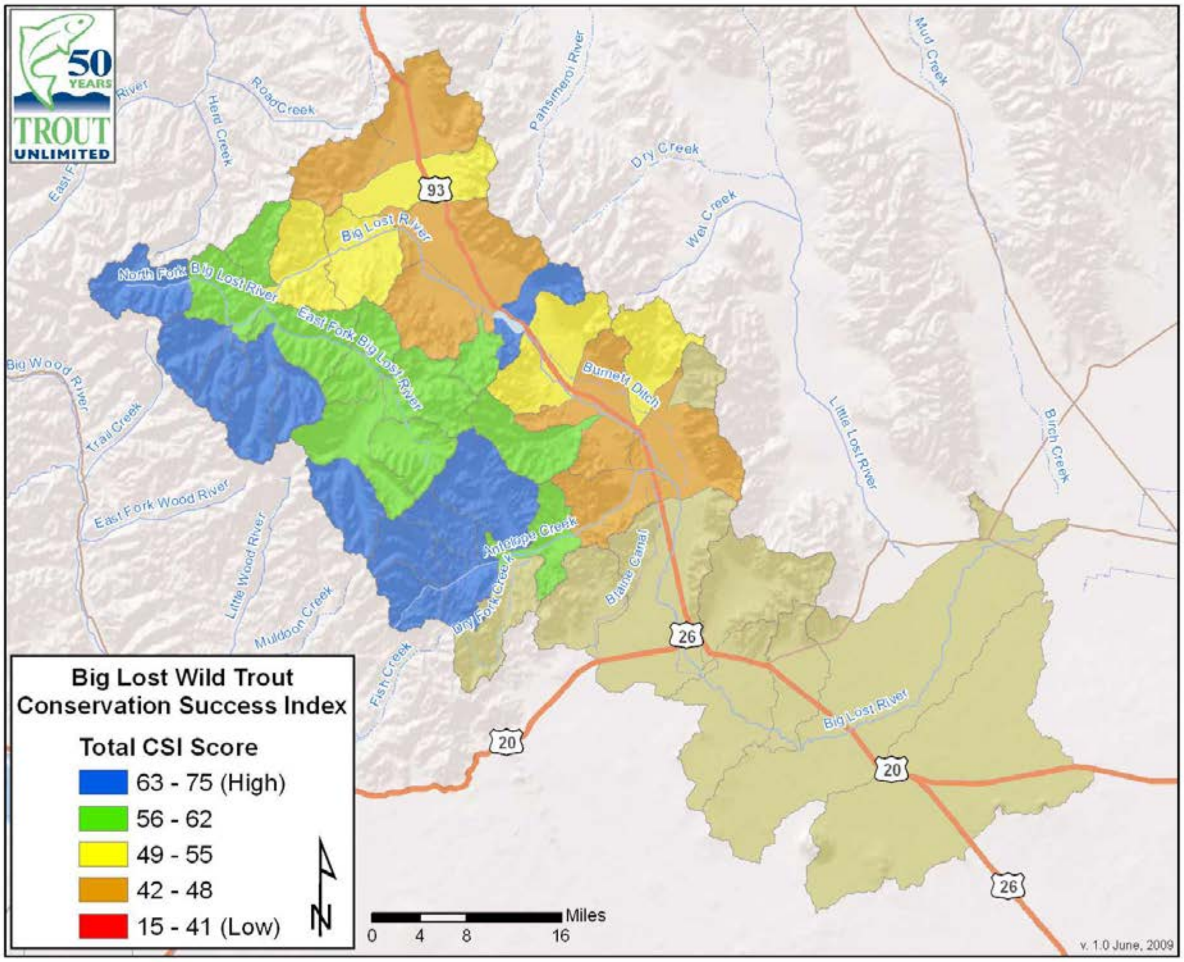

50 YEARS
TROUT UNLIMITED
Big Lost Wild Trout
Conservation Success Index
Future Security
21 - 25 (High)
16 - 20
11 - 15
5 - 10 (Low)
Miles
0 4 8 16
v. 1.0 June, 2009
Big Lost River
North Fork Big Lost River
East Fork Big Lost River
Burnett Ditch
Antelope Creek
Dry Fork Creek
Blaine Canal
Little Lost River
Birch Creek
Big Wood River
Trail Creek
East Fork Wood River
Little Wood River
Muldoon Creek
Fish Creek
Pahsimeroi River
Dry Creek
Wet Creek
Mud Creek
Road Creek
Herd Creek
93
26
20



50 YEARS
TROUT UNLIMITED
Big Lost Wild Trout
Conservation Success Index
Habitat Integrity
21 - 25 (High)
16 - 20
11 - 15
5 - 10 (Low)
N
Miles
0 4 8 16
v. 1.0 June, 2009
Big Lost River
North Fork Big Lost River
East Fork Big Lost River
Burnett Ditch
Antelope Creek
Dry Fork Creek
Blaine Canal
Little Lost River
Birch Creek
Mud Creek
Pahsimeroi River
Dry Creek
Wet Creek
Road Creek
Herd Creek
Big Wood River
Trail Creek
East Fork Wood River
Little Wood River
Muldoon Creek
Fish Creek
93
26
20



50 YEARS
TROUT UNLIMITED
Big Lost Wild Trout
Conservation Success Index
Population Integrity
21 - 25 (High)
16 - 20
11 - 15
5 - 10 (Low)
* No IDFG data. Other data and professional judgment used
N
0 4 8 16 Miles
v. 1.0 June, 2009
North Fork Big Lost River
East Fork Big Lost River
Big Lost River
Burnett Ditch
Antelope Creek
Dry Fork Creek
Blaine Canal
Big Wood River
Trail Creek
East Fork Wood River
Little Wood River
Muldoon Creek
Fish Creek
Herd Creek
Road Creek
Pahsimeroi River
Dry Creek
Wet Creek
Mud Creek
Little Lost River
Birch Creek
93
26
20


Big Lost Wild Trout
Conservation Success Index
Total CSI Score
63 - 75 (High)
56 - 62
49 - 55
42 - 48
15 - 41 (Low)
Miles
0 4 8 16
v. 1.0 June, 2009
50 YEARS
TROUT UNLIMITED
Big Lost River
North Fork Big Lost River
East Fork Big Lost River
Burnett Ditch
Antelope Creek
Dry Fork Creek
Blaine Canal
Little Lost River
Birch Creek
Mud Creek
Dry Creek
Wet Creek
Pahsimeroi River
Road Creek
Herd Creek
Big Wood River
Trail Creek
East Fork Wood River
Little Wood River
Muldoon Creek
Fish Creek
93
26
20

v. 1  June 2009

# Conservation Success Index:
# Wild Trout in the Big Lost River basin:
# Subwatershed Scoring and Rule Set

**Introduction**:

The CSI is an aggregate index typically comprised of four different component groups: Range-wide Condition; Population Integrity; Habitat Integrity; and Future Security.  However, for non-native wild trout there is no historical range, and, therefore, there is no Range-wide Condition group of indicators in a CSI developed for wild trout.  Only Population Integrity, Habitat Integrity, and Future Security groups are used.  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 condition within the current distribution of wild trout.

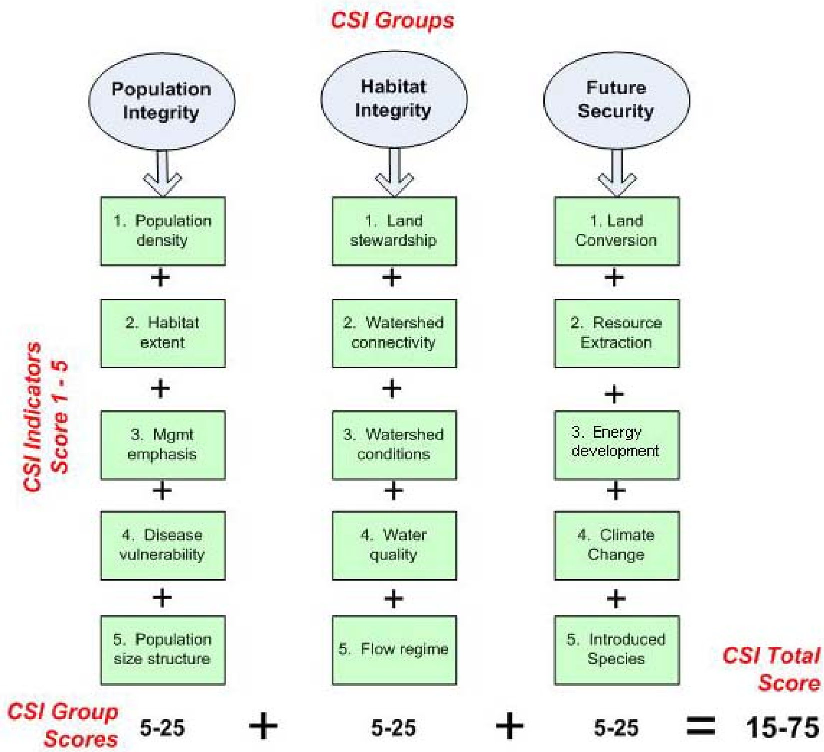



Figure 1. For a wild trout CSI, each subwatershed is scored from 1 to 5 using 15 indicators within three main groups.  Indicator scores are added per group to obtain an overall group score. Group scores are then added to obtain a composite CSI score for each subwatershed.

CSI Groups and Indicators

The CSI for wild trout consists of three main groups of indicators:

1. Population integrity
2. Habitat integrity
3. Future security

Below is an overview of each CSI group and the indicators within each group. Each section contains the indicator scoring rules, the rational for the indicator, and the data sources used for the indicator.

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

**Overview**:

1. Population density
2. Habitat extent
3. Management emphasis
4. Disease vulnerability
5. Population size structure

**Indicator**: 1. Population density.

**Indicator Scoring**:

| Fish / mile | Trophy-designated stream miles | CSI Score |
|---|---|---|
| 0 | | 1 |
| 1 – 50 | | 2 |
| 51 - 150 | 1 - 5 | 3 |
| 151 - 400 | 5 - 10 | 4 |
| >400 | >10 | 5 |

Score for highest

**Explanation**: Adult population density within each subwatershed. When multiple populations were present within a subwatershed, population density was calculated as the mean density across sample sites. Blue, red, or yellow ribbon or gold medal designations are awarded to exceptionally productive streams and lakes.

**Rationale**: Small, low density populations, particularly those below an effective size of 500 individuals, are more vulnerable to extirpation[1].

**Data Sources**: Trout densities from a 2007 Big Lost fishery survey by Idaho Department of Fish and Game were used to compute mean trout density for each subwatershed[2]. Trout densities for subwatersheds not sampled were scored based on professional judgment based on adjacent subwatershed density, location of subwatershed in the basin, and data from Idaho Department of Environmental Quality BURP[3].

**Indicator**: 2. Habitat extent.

**Indicator Scoring**:

| Connectivity | CSI Score |
|---|---|
| < 6.2 mi (10 km) connected habitat | 1 |
| 6.2 – 12.4 mi (10-20 km) connected habitat | 2 |
| 12.4 – 18.6 mi (20-30 km) connected habitat | 3 |
| 18.6 – 31.3 mi (30-50 km) connected habitat | 4 |
| > 31.3 mi (50 km) connected habitat | 5 |

**Explanation**: Habitat connectivity is the amount of connected perennial stream habitat available to the population.

**Rationale**: Populations with less available habitat are more vulnerable to extirpation[4] as a result of small, localized disturbances.

**Data Sources**: Connectivity was based on the connectedness of perennial streams in the National Hydrography Dataset Plus[5]. Barriers to fish passage recently identified by Gregory Aquatics[6;7] were used to disconnect streams at barrier locations; barriers reflected fish passage work completed in 2008 (J. Gregory, Gregory Aquatics, pers. comm.). Each continuous section of stream was scored, and subwatersheds scores were a length weighted average of scores for each connected section.

**Indicator**: 3. Management emphasis.

**Indicator Scoring**:

| Management emphasis in subwatershed | CSI Score |
|---|---|
| Hatchery dependent (no natural reproduction) | 1 |
| Hatchery supported (some natural reproduction) | 2 |
| Wild trout fishery (self-sustaining), diploid stocked | 3 |
| Wild trout fishery (self-sustaining), triploid stocked | 4 |
| Wild trout fishery (self-sustaining), no stocking | 5 |

**Explanation**: Management emphasis for wild trout in the subwatershed.

**Rationale**: A wild trout fishery that is self-sustaining through natural reproduction reflects quality trout habitat. Although triploid trout are stocked to provide recreational opportunities for anglers, there is the potential for stocked fish to compete with wild fish for food and space, reduce growth[8], and result in lower fitness[9]. Wild trout populations sustained by stocking have lower integrity, and populations existing solely as a result of stocking have low integrity.

**Data Sources**: Subwatersheds were scored based on Idaho Department of Fish and Game stocking records for 2008 (http://fishandgame.idaho.gov/apps/stocking/). Snake River fine-spotted cutthroat trout were stocked into the North Fork and West Fork, and triploid rainbow trout were stocked into Mackay Reservoir, East Fork, and Wildhorse Creek.

**Indicator:** 4. Disease vulnerability.

**Indicator Scoring**:

| Disease Vulnerability | CSI Score |
|---|---|
| Disease/pathogens present in target species | 1 |
| Disease/pathogens in habitat but not target fish | 2 |
| None present but proximity <10 km | 3 |
| None present but proximity >10 km | 4 |
| No diseases/pathogens present | 5 |

**Explanation**: The risk of populations in each subwatershed 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**: The presence of whirling disease was determined using data reported by Szumlyo[10]. When data were not available for a subwatershed, whirling disease was assumed to be present in the habitat of the mainstem Big Lost River and tributary subwatersheds were scored based on their proximity to subwatersheds with whirling disease present.

**Indicator**: 5. Population size structure.

**Indicator Scoring**:

| Juvenile:Adult Ratio | CSI Score |
|---|---|
| <0.25, or >15 | 1 |
| | 2 |
| 0.25-1, or 5-15 | 3 |
| | 4 |
| 1-5 | 5 |

**Explanation**: Population size structure indicates the relative number of young fish to adult fish. The juvenile:adult ratio is the number of juvenile divided by the number of adult fish. The length of fish used to define juveniles and adults varies by species.

**Rationale**: Low ratios indicate poor reproduction, poor recruitment, or the effect of stocking large fish. High ratios indicate excessive reproduction or low survival of adults[11].

**Data sources**: Trout densities from 2007 Big Lost fishery survey by Idaho Department of Fish and Game were used to compute size structure of all trout for each subwatershed[2]; Densities of all trout and trout >150mm from Table 1 of Garren[2] were used to compute ratios. Trout population size structure for subwatersheds not sampled were scored using professional judgment based on trout density and location subwatershed in the basin.

***Habitat Integrity****: Indicators for the integrity of aquatic habitats.*

**Overview**:

1. Land stewardship
2. Watershed connectivity
3. Watershed conditions
4. Water quality
5. Flow regime

**Indicator**: 1. Land stewardship.

**Indicator Scoring**:

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

*If subwatershed is non-trout habitat then scores are based only on subwatershed protection: <25% =1; 25 – 50%=3; >50%=5.

**Explanation**: The percent of perennial 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, other 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[12] and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset[13].

**Indicator**: 2. Watershed connectivity.

**Indicator Scoring**:

| Number of stream/canal intersections | Current/historic subwatershed connectivity | 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 |

Score for worst case

Current/historic subbasin (4th level HUC) connectivity:

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

**Explanation**: The number of stream-canal intersections and reduction in historical connectivity in the subwatershed and subbasin. Connectivity is measured by determining the longest continuous section of stream habitat uninterrupted by man-made structures impassable by fish in the subwatershed and dividing that by the longest continuous section of historically connected stream habitat. Connectivity is also computed for the subbasin. Man-made barriers may include dams, water diversion structures, or human-caused dewatered stream segments that impede fish movement.

**Rationale**: Increased hydrologic connectivity provides more habitat area and better supports multiple life histories (e.g., fluvial, adfluvial), which increases the likelihood of persistence[4]. Diversions, when they do not directly inhibit fish passage, can represent false movement corridors, cause fish entrainment, and act as population sinks[14;15].

**Data Sources**: Connectivity was determined by comparing connectivity of the perennial stream network to the current connectivity of the stream network after fish barriers, from assessments by Gregory Aquatics[6;7], and dewatered sinks were taken into account. The barriers information was updated to reflect fish passage has recently been provided by the end of 2008 on the following barriers: Chilly Diversion; Darlington Diversion; Swauger Diversion; Blaine Diversion; 6X Diversion; and Antelope 2 Diversion (J. Gregory, Gregory Aquatics, pers. comm. 2008). Historical connectivity was assumed across the Chilly and Darlington sinks.

**Indicator**: 3. Watershed condition.

**Indicator Scoring**:

| Riparian Buffer (300 ft.) Vegetation | Land conversion | CSI Score |
|---|---|---|
| 0% | ≥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.

CSI Score downgraded 1 point if riparian vegetation in 300 ft. buffer is 0.1 to 10%

**Explanation**: The percentage of converted lands in the subwatershed and the density of roads. Percent riparian vegetation along the stream is determined within a 300 ft. buffer.

**Rationale**: Habitat conditions are the primary determinant of persistence for most populations[16]. Converted lands are known to degrade aquatic habitats[17;18]. Road density is computed for the subwatershed; roads are known to cause sediment-related impacts to stream habitat[19-21]. Lee et al.[20] 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. Percent riparian vegetation is a remotely sensed measure of riparian conditions[22] that is often related to aquatic habitat conditions[23], and 300 ft. is a useful buffer width in which to measure riparian vegetation[23].

**Data Sources**: Converted lands were determined using the National Land Cover Database[24], 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[25]. Riparian vegetation was determined using the National Land Cover Database[24], using Woody Wetlands, Emergent Herbaceous Wetlands, Deciduous Forest, Evergreen Forest, and Mixed Forest land cover classes. The National Hydrography Dataset Plus[5] was used to define the stream buffer.

**Indicator**: 4. Water quality.

**Indicator Scoring**:

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

Score for worst case.

**Explanation**: The presence of 303(d) impaired streams, percentage agricultural land, number of active mines, number of oil and gas wells, and miles of road within 150 ft of perennial streams in the subwatershed.

**Rationale**: Decreases in water quality, including reduced dissolved oxygen, increased turbidity, increased temperature, and the presence of pollutants, reduces habitat suitability for salmonids. Agricultural land can impact aquatic habitats by contributing nutrients and fine sediments, and depleting dissolved oxygen. Mining activity can deteriorate water quality through leachates and sediments. 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 Idaho Department of Environmental Quality data[28]. The National Land Cover Database[24] 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]. Oil and gas wells were determined using oil and gas wells compiled by Finn[30] for the West. Road density within a 150 ft buffer was computed using Integrated Road Transportation of Idaho data[25] and the National Hydrography Dataset Plus[5].

**Indicator**: 5. Flow regime.

**Indicator Scoring**:

| Number of dams | Percent of runoff diverted or withdrawn | 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, percent of natural runoff diverted or withdrawn, and acre-feet of reservoir storage per perennial stream mile.

**Rationale**: Natural flow regimes are critical to proper aquatic ecosystem function[31]. Dams, reservoirs, and canals alter flow regimes[32]. Reduced or altered flows reduce the capability of watersheds to support native biodiversity and salmonid populations.

**Data Sources**: The National Inventory of Dams[33] was the data source for dams and their storage capacity. Data on canals were obtained from the National Hydrography Dataset Plus[5]. The Idaho Department of Water Resources dam database did not have reservoir storage data and all dams not in the National Inventory of Dams database were on intermittent streams; hence, they were not used. Perennial streams were obtained from the National Hydrography Dataset Plus[5]. Percent runoff is calculated as the proportion of the predicted mean annual flow, estimated by Vogel et al.[34] and reported in the NHD Plus dataset[5], diverted by all upstream spring, stream, or groundwater diversions recorded in the Snake River Basin Adjudication[35].

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

**Overview**:

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

**Indicator**: 1. Land conversion.

**Indicator Scoring**:

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

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

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

**Data Sources**: Slope was computed from elevation data from the National Hydrography Dataset Plus[5]. Land cover was determined from the National Land Cover Database[24], 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 Integrated Road Transportation of Idaho data[25], 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.

**Explanation**: Percentage of subwatershed 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**:

**Data Sources**: Timber management potential identifies productive forest types using the existing vegetation type in the Landfire dataset.[39] The number of mining claims was determined using Bureau of Land Management data[40], 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[12] and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset[13].

**Indicator**: 3. Energy Development.

**Indicator Scoring**:

| Leases or reserves | New Dams 4$^{th}$ | New Dams 6$^{th}$ | CSI Score |
|---|---|---|---|
| 51-100% | ≥0 | ≥1 | 1 |

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

Score for worst case

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

**Rationale**: Increased resource development will increase road densities, modify natural hydrology, and increase the likelihood of pollution to aquatic systems. Changes in natural flow regimes associated with dams are likely to reduce habitat suitability for native salmonids and increase the likelihood of invasion by non-native species.[41] If lands are protected then the watersheds will be less likely to be developed.

**Data Sources**: **Data Sources**: Wind resources ("Good" and better) from Wind Powering America/National Renewable Energy Lab (NREL).[42] Coal leases are mineable types from the Coal Fields of the United States dataset.[43] Geothermal known and closed lease areas and oil and gas leases and agreements from BLM Geocommunicator. [*44] Potential dam sites are based on Idaho National Laboratory (INL) hydropower potential data[45]. Protected areas data were compiled from the ESRI, Tele Atlas North American / Geographic Data Technology dataset on protected areas[12] and the U.S. Department of Agriculture, Forest Service's National Inventoried Roadless Areas dataset[13].

**Indicator**: 4. Climate change.

**Indicator Scoring**:

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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.

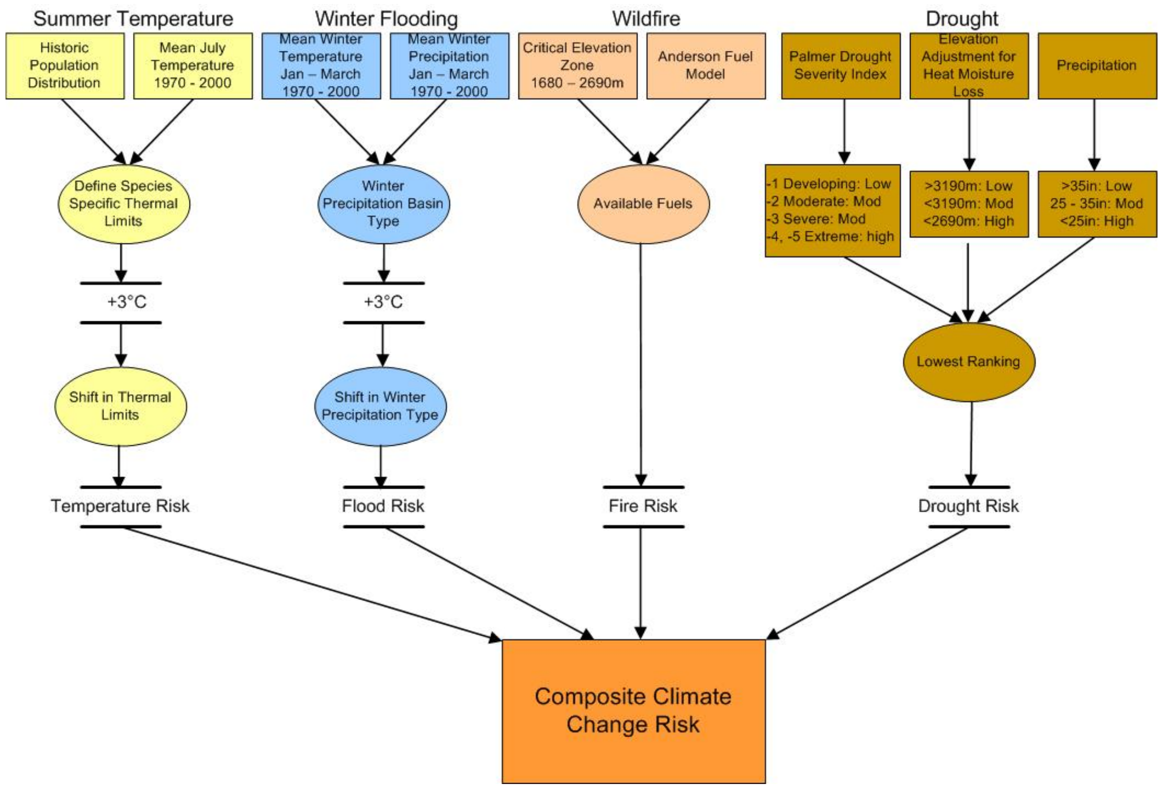
*Closed*: Not retired, just expired and may become available and open to resubmittal.

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

| 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.[46;47] 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.[48] Drought is expected to reduce water availability[49;50] and the availability of aquatic habitat. These risks are further discussed by Williams et al.[46]

**Data Sources**: Temperature and precipitation data were obtained from the PRISM Group.[51] Elevation data was obtained from the National Elevation Dataset,[52] and LANDFIRE data for the Anderson Fire Behavior Fuel Model 13[39] was used as input for wildfire risk. The Palmer Drought Severity Index was used for drought risk[53], but was adjusted for elevation (elevations above 2690 have lower risk[50]) and the deviation from mean annual precipitation (areas with more precipitation on average have lower risk).

**Indicator**: 5. Introduced species.

**Indicator Scoring**:

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

**Explanation**: The presence of introduced, injurious species in any stream reach connected to the subbasin and subwatershed (see Watershed Connectivity region group); also road density. Road density is the length of road per subwatershed, and represents the potential for future introduction of species not native to the basin.

**Rationale**: Introduced species are likely to reduce wild trout populations through predation, competition, hybridization, and the introduction of non-native parasites and pathogens.[54] In the absence of data on presence of non-native species, road density can be used as a surrogate for risk of introductions of injurious and invasive species by purpotrators.[55]

**Data Sources**: Gregory[56] reported no introduced species in the Big Lost River Basin that are injurious to wild trout populations. Roads were obtained from the Integrated Road Transportation of Idaho dataset[25].

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