

Healing Troubled Waters

**PREPARING TROUT
AND SALMON HABITAT
FOR A CHANGING CLIMATE**

A REPORT BY
TROUT UNLIMITED
ARLINGTON, VA
OCTOBER 2007



Our planet is facing a time of unprecedented environmental change—

*“I say the debate is over.
We know the science.
We see the threats and the
time for action is now.”*

—ARNOLD SCHWARZENEGGER,
CALIFORNIA GOVERNOR, 2006

the warming of the earth’s surface is predicted to dramatically affect fish and wildlife, and water resources. Climate change has already begun, and the rapid pace of change greatly threatens trout and salmon in the United States. A litany of

scientific evidence demonstrates that our atmosphere is warming and the climate is changing due to the buildup of carbon dioxide, methane and nitrous oxide, or greenhouse gases. Carbon dioxide is at its highest concentration in the earth’s atmosphere in the past 400,000 years,¹ having risen 30% since the late 1800s², and is increasing at the fastest rate in history.³ Global temperatures have risen on average more than 1°F over the last century, and scientists project that temperatures will increase anywhere from 2 to 10°F over the next 100 years.⁴ Eleven of the last 12 years rank among the 12 warmest years on earth since 1850.⁵

Around the world, evidence of the warming climate can be seen in many ways—glaciers are melting faster, the Arctic’s permafrost is disappearing,⁶ and sea levels are rising. Ocean temperatures are increasing, snowmelt is occurring earlier and rainfall patterns are shifting. There are increases in drought and the intensity of wildfires, and diseases and pests are spreading. All of these changes in the natural world provide evidence that our planet is warming.⁷ These changes pose direct threats to the long term well-being of trout and salmon.

BELOW:
Large portions of suitable trout habitat are predicted to disappear in the next century due to rising water temperatures.

REDUCTION IN TROUT HABITAT

Modeling a Projected 3°C Increase in Average July Air Temperature

- Thermally Suitable Trout Habitat
- Thermally Marginal Trout Habitat
- Thermally Unsuitable Trout Habitat
- State Boundary

EASTERN BROOK TROUT



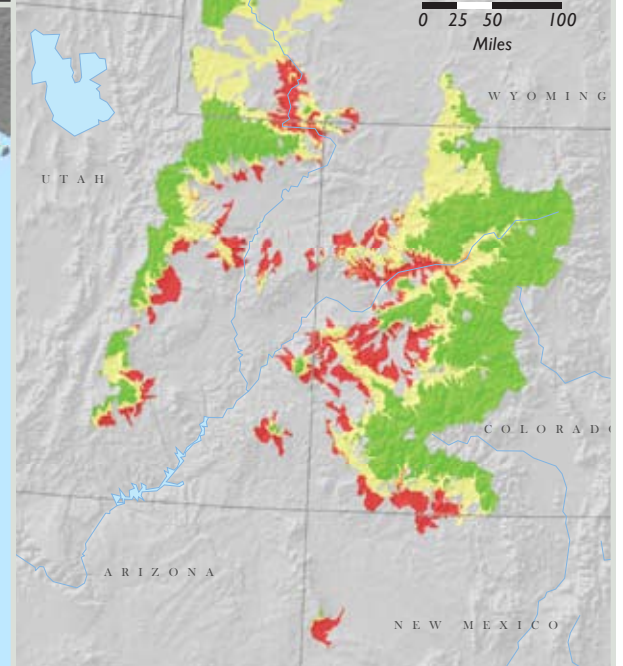
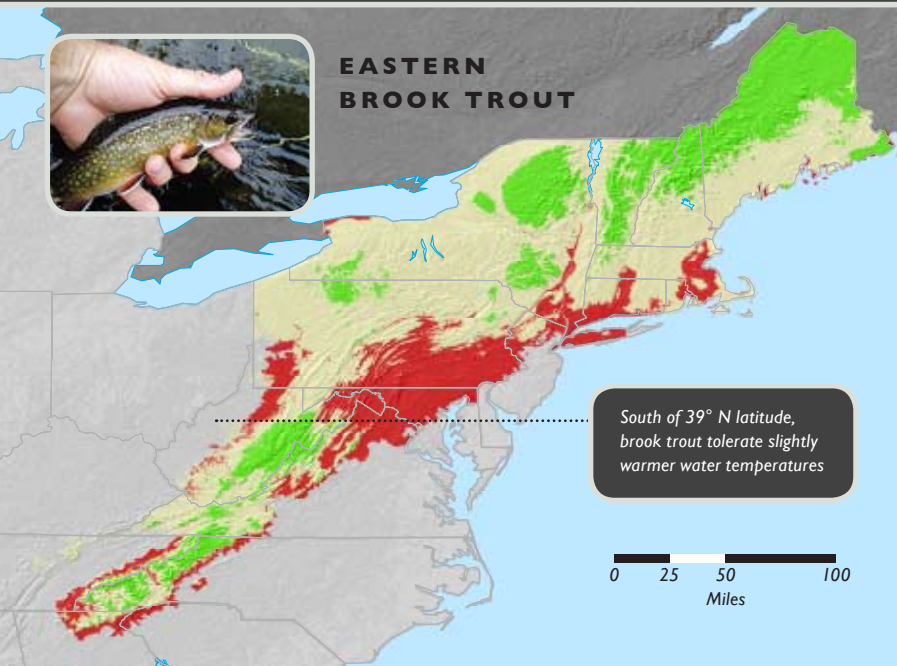
South of 39° N latitude, brook trout tolerate slightly warmer water temperatures

0 25 50 100 Miles

COLORADO RIVER CUTTHROAT



0 25 50 100 Miles



Trout and Salmon: New Challenges to Survival

Trout and salmon are especially vulnerable to climate change and global warming because they are dependent on an abundance of clear, cold water. As coldwater habitats warm, rising temperatures will have negative impacts on a variety of life history phases—from eggs to juveniles to adults.

Trout and salmon already face pressures because of reduced habitats and population losses. Roads, dams, and diversions of water for municipal and agricultural purposes have fragmented stream habitats. Remaining habitats often are degraded by mining, livestock grazing, timber harvest or other land uses. Also, non-native and hatchery fish are compromising native gene pools.

Adding climate change to these stressors increases the likelihood that populations will be pushed to the brink of extinction. Unless immediate action is taken to restore habitats and increase populations, it is likely that trout and salmon will be eliminated from large areas. For example, U.S. Forest Service scientists predict that over half of the wild trout populations will likely disappear from the southern Appalachian Mountains because of the effects of warming stream temperatures.⁸ Losses of western trout populations may exceed 60% in certain regions,⁹ with potential losses of migratory bull trout as high as 90%.¹⁰

Models of Pacific Northwest salmon populations predict losses of 20–40% by the year 2050 because of the effects of climate change.¹¹ In California, where high temperature and water availability already pose a significant source of stress, greater declines are likely. For salmon and steelhead, these predictions may be best case scenarios because the underlying models focus on freshwater conditions and do not consider the complexities of ocean environments.

There are already indications of rising water temperatures around the country. For example, scientists have documented increases in algae and zooplankton abundance in high-latitude and high-altitude lakes that only occur when water gets warmer. Fish in rivers are extending their ranges northward and migrating earlier, to waters that were previously colder than the fish could tolerate.¹² One study documented that mayflies, and other aquatic insects that trout rely on for food, are emerging earlier and at smaller sizes in Rocky Mountain streams because of warmer stream flows and earlier peak runoff.¹³ As the delicate balance of the food web changes, smaller insects produce fewer offspring, and as a result, less food is available for trout.

Local effects of a changing climate will vary in intensity and duration because of differences in habitat quality, distance from coastal areas, elevation and topography of the watershed.¹⁴ Scientists predict that there will be an increase in the severity and frequency of droughts and floods.¹⁵ Increasing human demand for water will place additional stresses on watersheds and will amplify the negative impacts of climate change on fish populations.

Many fish diseases and parasites that currently are limited by cold waters may expand their distribution and become more virulent as waters warm.¹⁶ Fish populations that are struggling to survive in already stressful environments may become increasingly susceptible to disease.¹⁷ In addition, municipal and agricultural demands for water are likely to increase, particularly in the arid American West and Southwest, as summer rainfall decreases and droughts become more severe.¹⁸ Decreased groundwater and surface water will further stress aquatic ecosystems and human communities.¹⁹

“At continental, regional and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones.”

—INTERNATIONAL PANEL ON CLIMATE CHANGE, WORKING GROUP I SUMMARY FOR POLICYMAKERS, 2007

Warning Signs of a Changing Climate

ACCELERATING GLACIAL RETREAT

Boulder Glacier, Glacier National Park



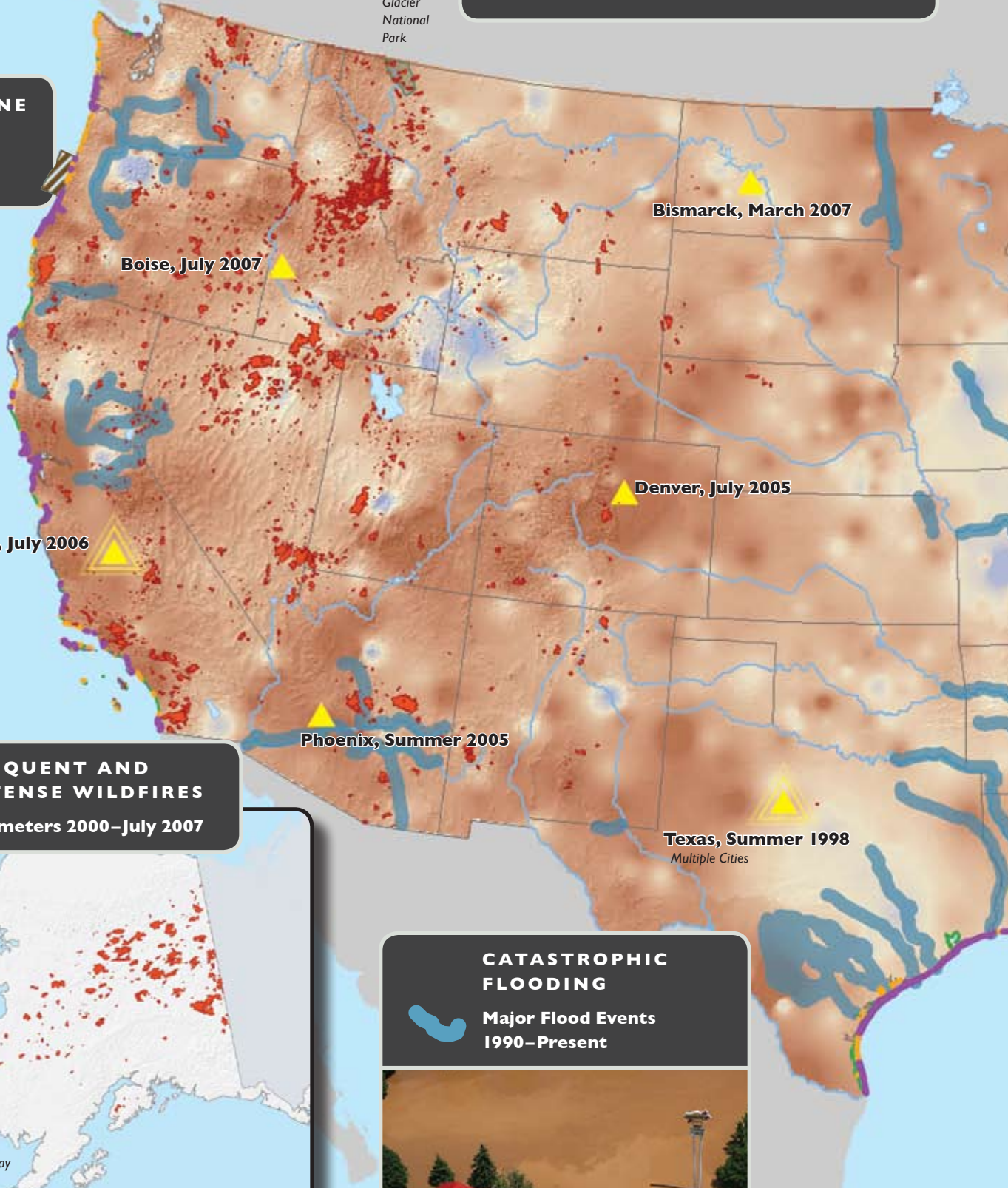
George Grant photo courtesy of Glacier National Park Archives



Jerry DeSanto photo

Glacier National Park

DEAD ZONE OFF THE OREGON COAST



California, July 2006
Multiple Cities

Boise, July 2007

Bismarck, March 2007

Denver, July 2005

Phoenix, Summer 2005

Texas, Summer 1998
Multiple Cities

MORE FREQUENT AND MORE INTENSE WILDFIRES

Fire Perimeters 2000–July 2007

CATASTROPHIC FLOODING

Major Flood Events 1990–Present

THAWING SEA ICE AND PERMAFROST



Photo: Richard Perry/
The New York Times/Redux

Bristol Bay

HOTTER SUMMER TEMPERATURES ACROSS MUCH OF THE U.S.

Change in Average Summer Temperature by Area, 1903-2003

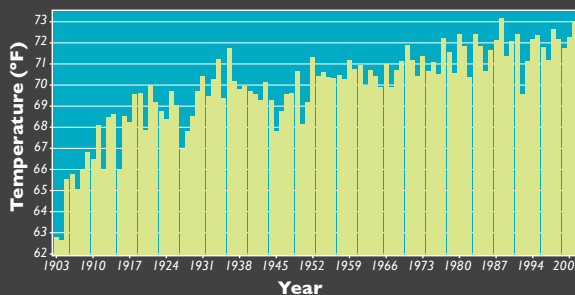
-18% No Change +20%



Record Heat and Related Deaths Make Headlines

Average Summer Temperature, 1903-2003

Based on approximately 1,000 weather stations covering the U.S.

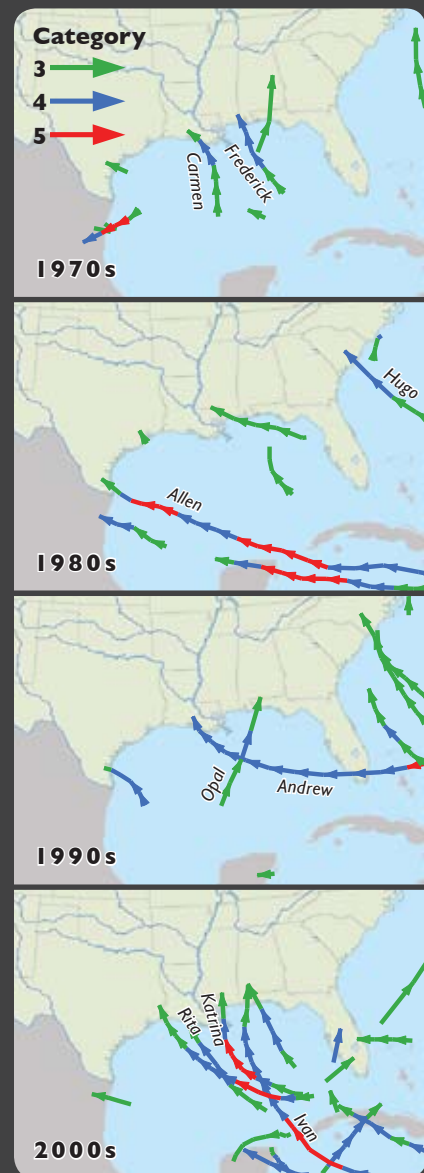


OTHER IMPACTS:

Fishing Closures on Low Flow Rivers

Increased Forest Insect Pests

INCREASED OCCURRENCE OF MAJOR HURRICANES



COASTLINES AT RISK TO RISING SEA LEVEL

Coastal Vulnerability Index

- Low
- Moderate
- High
- Very High



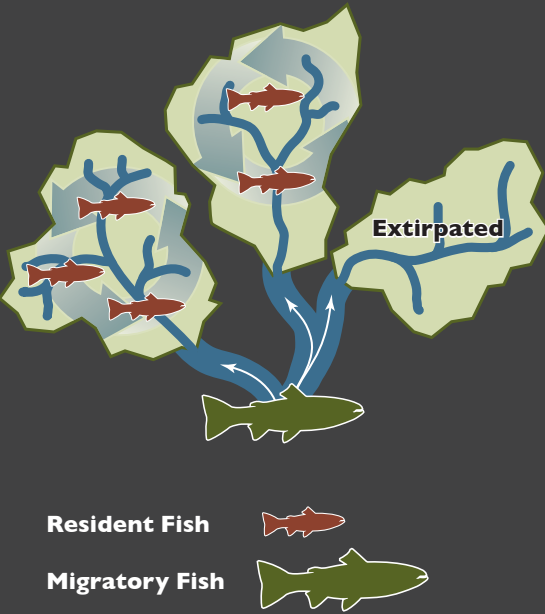
CONSERVATION
GEOGRAPHY

Protect–Reconnect–Restore

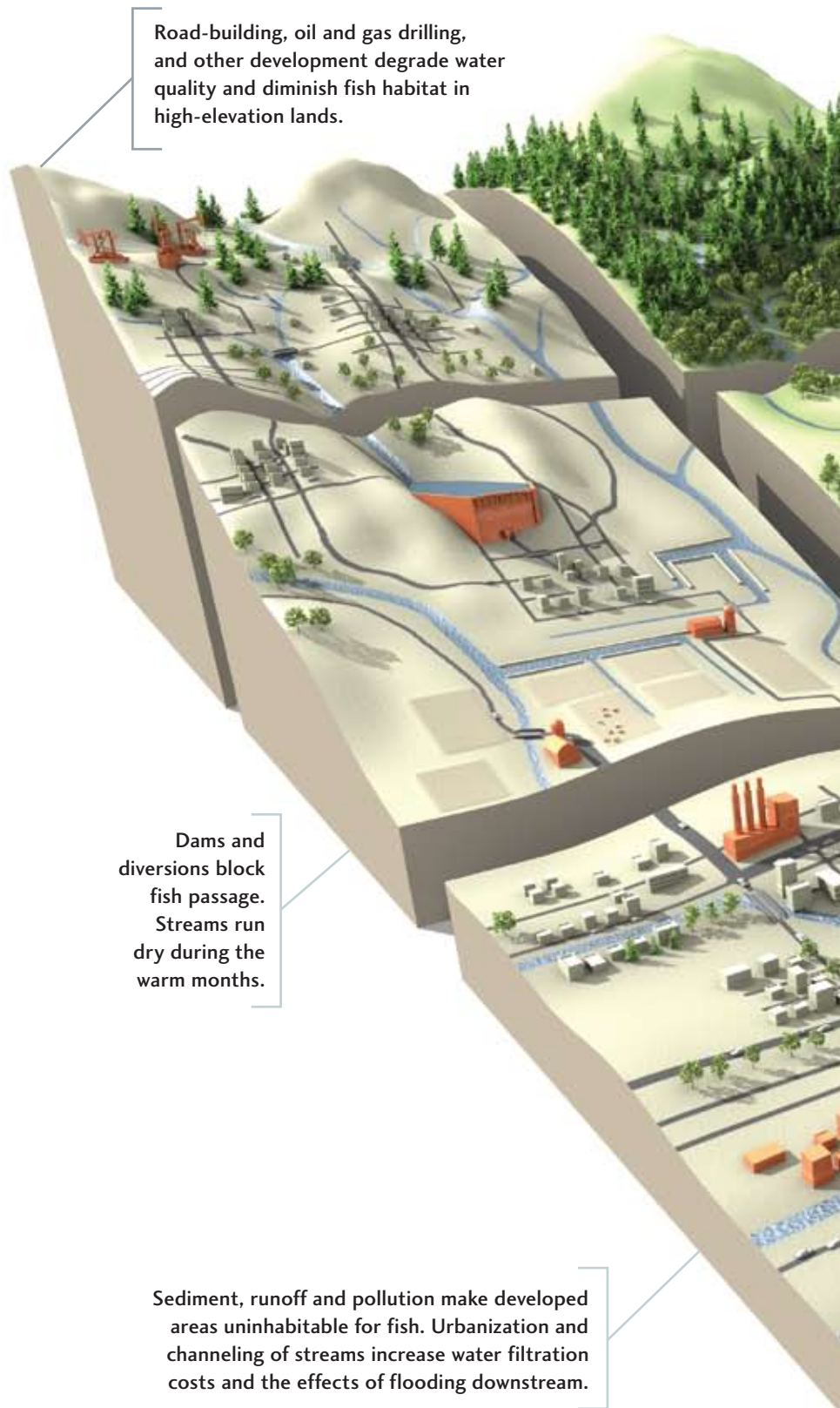
An approach to helping trout and salmon build resistance and resilience to climate change.

CONNECTIVITY AND RECOLONIZING HABITAT

For many species of inland trout, headwater habitats currently support the last remaining populations. Lower elevation habitats in the more populated valleys historically produced large, migratory fish, but have become degraded from land use changes, elevated temperatures, chronic water withdrawals, and non-native species introductions.²⁰ They are also segmented by physical barriers like culverts and dams.



Smaller headwaters are often hit hardest by natural catastrophes like floods, wildfires, and droughts, events that are predicted to increase with a changing climate. When streams throughout a watershed are physically connected to one another, surviving fish from downstream habitats quickly move upstream to “reseed” these waters as they recover. With the loss of larger, migratory fish and the inability of downstream populations to recolonize habitat, naturally occurring catastrophic events can extirpate, or wipe out, these small, native fish populations.



Culverts can inhibit native trout like westslope cutthroat from accessing critical spawning habitat and cold water within a watershed.



Protect:

Backcountry land intact, improving water quality downstream and providing a stronghold for native fish and other species.

Reconnect:

Obsolete dams and diversions removed. Fish ladders and fish passage installed. Sufficient water left in stream, allowing fish to migrate through the river.

Restore:

Tree-shaded river reconnected to its floodplain. Grazing and development practices protect water quality. Industrial and agricultural pollution reduced.



BELOW:

One of the more striking examples of the importance of genetic diversity is found in Bristol Bay, Alaska.

Here, a large number of sockeye salmon stocks from different bay tributaries are varied enough in their life history diversity to buffer the overall population from annual changes in ocean conditions, ensuring large numbers of returning fish each year.²¹

Sockeye photo: University of Washington



ABOVE:

Installation of this fish ladder at an agricultural diversion dam reconnects stream habitat for Bonneville cutthroat trout in Utah.

Helping Trout and Salmon Survive Climate Change

The effects of a rapidly changing climate will further stress habitats and populations that already have been pushed to their limits by water extraction, land use changes, increased road density, and impacts from non-native fishes.

Fortunately, trout and salmon are resilient. They have adapted to many fluctuations in climate and environmental conditions during their long evolutionary history. As the last glaciers melted in North America over 10,000 years ago, these fish were able to migrate to the rivers and streams where they now live. Lakes formed and dried up, rivers expanded and contracted, and trout and salmon always found the cold water habitat they have needed to survive.

To help trout and salmon survive the effects of global warming, there needs to be an active and integrated effort to protect the best remaining fish habitats and populations, to reconnect fish habitats by removing instream barriers and reestablishing instream flows, and to restore vital main-stem river and streamside habitats. Finally, significant efforts must be made to sustain restoration on the ground by engaging local communities, state and federal agencies, conservation organizations, landowners, and industry groups in the recovery of the lands and waters where trout and salmon thrive.

By working collaboratively at a landscape scale on a focused effort to protect, reconnect, and restore fisheries and fish habitat, we can increase resistance and resilience to climate change and insure a future with healthy aquatic systems. In order to strengthen the resistance and resilience of trout, the following steps must be taken:

Protect

1. Protect Remaining Critical Habitat Areas. It is vital that remaining rivers and streams where salmon and trout live are protected. Well-protected headwater streams and lakes that provide high quality, cold water flows will be integral to maintaining suitable downstream conditions during periods of warming. Key watersheds that are roadless or otherwise minimally disturbed typically provide the most reliable sources of cold water.

- **Protect Healthy, Connected Habitat:** Fish need healthy, high quality habitat. This means that rivers and streams must be surrounded with healthy, natural vegetation. The watershed must be healthy as well—with the proper cycles of floods and flow.
- **Maintain Genetic Diversity of Native Fish Populations:** Higher levels of genetic diversity enable populations to better adapt to future environmental change. The predominance of certain characteristics in a population may provide that population with a higher likelihood of surviving and reproducing successfully through periods of extreme change.²²

Reconnect

2. Reconnect High Quality Habitats. Identify and reconnect important stream systems that have been physically disconnected by dams and culverts or that seasonally run dry from water diversions and other dewatering processes.

Trout and salmon need to be able to access a wide variety of habitats, from small headwater streams to deep river pools. These waterways are most valuable when they are connected to one another. Barriers that restrict fish from moving up and down the watershed can reduce overall fish populations and compromise their genetic integrity.²³

- **Remove or Modify Physical Barriers:** Dams, culverts and other blockages to fish movement that are obsolete or unneeded should be removed to facilitate the recovery of migratory fish within a population, and to increase the likelihood of fish finding suitable habitat conditions.
- **Return Water Flows to Streams:** Many streams periodically run dry because of inefficient irrigation and water withdrawals. Creating incentives to leave water in streams will help to recover more natural river flows and enable fish to find cold water and high quality habitats.

Restore

3. Restore Entire Watersheds, Not Just Individual Streams and Rivers.

Taking a broad geographical approach to identifying areas to improve water quality, streamside vegetation and instream habitat is critical to restoring the overall health of lower elevation, valley bottom streams and rivers. By restoring streams and floodplains to a healthy, more natural state, fish will be better able to withstand the impacts of rising temperatures, floods, fires, and droughts.

- **Restore Habitat:** Reestablishing natural habitat diversity will support a range of age classes and make populations more resilient to climate change. Native populations that exist in headwaters and lower elevation habitats across large geographic areas will be more resistant to local extinction.²⁴
- **Restore Native Fish Populations:** More robust populations inhabiting larger, inter-connected stream systems are more resistant to catastrophic disturbances, such as drought and floods. Non-native species and hatchery fish can limit native fish populations and increase their vulnerability to climate change. Non-native fish compete with natives for food and habitat, and they often thrive in warmer and more polluted waters. Hatchery fish can interbreed with native populations and can weaken the gene pool that may ultimately provide fish with the ability to adapt and survive.

Sustain

4. Sustain Conservation and Recovery Efforts. In little more than a single generation, we have moved from a rural existence to life in sprawling suburbs and cities. This lifestyle change has diminished our connection to nature. Our youth has been most affected as electronics have largely replaced the outdoors as a source of enjoyment, resulting in what has become known as "nature-deficit disorder."²⁵ Climate change provides an important reminder that our society is still dependent on the health of our natural environment.

- **Engage Communities:** Activities such as energy conservation, tree planting, open space preservation, and water conservation will markedly improve the likelihood of trout and salmon survival into future generations. As a result, it will also improve the quality of life for Americans and reconnect communities to the lands and waters that sustain them.
- **Monitor and Evaluate:** Because many aspects of climate change are unpredictable, it is important to adequately fund monitoring programs in order to track and analyze changes in the health of fish populations and their environment. Additional analysis will be needed to insure that restoration work is achieving intended goals.

BELOW:
Installing woody debris in downstream tributaries of California's Russian River helps restore deep pool habitat that is essential for coho salmon and steelhead.



ABOVE:
Installing fencing to exclude livestock grazing helps restore water quality and spawning habitat for brook trout in West Virginia.

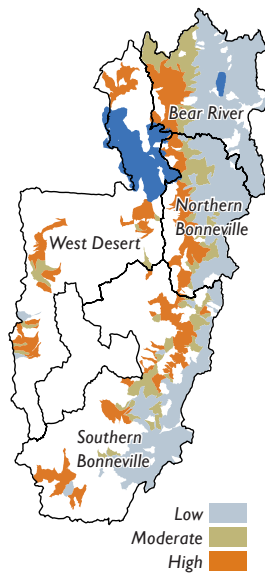
How the CSI Provides a Strategic Approach to Dealing With the Climate Crisis

To be effective in dealing with the climate crisis, it is important to know where the most severe impacts from climate change are likely to occur, where population strongholds exist, and therefore, where we should make our conservation investments. TU is using the Conservation Success Index (CSI) to accomplish this task.

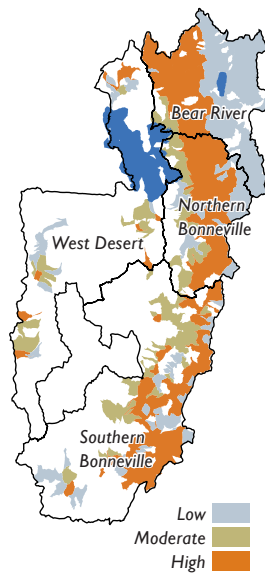
Bonneville cutthroat trout provide an example of likely climate change impacts. A variety of scientific information is combined to examine impacts that will affect trout populations in each subwatershed, which are stream drainages of about 20,000 to 30,000 acres. This information is used to model the climate change impacts that are likely to be most severe for native trout like the Bonneville cutthroat: increasing summer temperatures, increasing flood risk, and increasing wildfire risk.

Heat, flood, and fire have always been major factors in shaping ecosystems and the species they support, however, the magnitude, distribution, and timing of these events are changing. Increased stress from uncharacteristic patterns of extreme summer heat, winter flooding, and increased frequency and intensity of wildfires is projected to further reduce populations of native trout under a changing climate. The images below illustrate how these factors potentially increase the risk of lost habitat for currently occupied subwatersheds for the four separate management regions of Bonneville cutthroat trout.

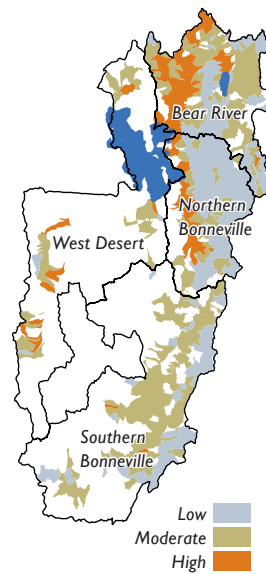
TEMPERATURE RISK



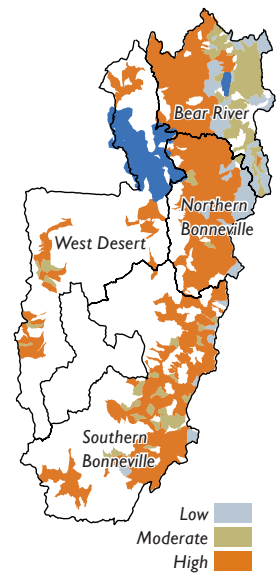
WINTER FLOODING RISK



WILDFIRE RISK



COMPOSITE CLIMATE RISK



The best remaining populations of Bonneville cutthroat trout are in the Bear River and Northern Bonneville regions in northern Utah, southern Idaho and southwestern Wyoming. Populations in the West Desert along the Nevada border and Southern Bonneville regions in southern Utah already are stressed and fragmented. Moderate to high climate change impacts throughout much of the range will necessitate aggressive restoration efforts

to maintain native cutthroat populations. The higher elevations along the eastern portion of the historic range provide thermally suitable habitat, but are at risk of increased flooding and wildfire. Protecting large populations that inhabit well-connected stream systems in the Bear River and Northern Bonneville regions is the best insurance against flooding, wildfire and other climate-related impacts.

TEN STEPS TO PROTECTING TROUT AND SALMON FROM CLIMATE CHANGE

- 1 Protect the diversity of remaining native trout and salmon populations.
- 2 Restore the natural range of life history strategies in trout populations, including migratory and lake-dwelling forms.
- 3 Protect springs, headwaters and other sources of cold water.
- 4 Restore riparian habitats—the native trees and vegetation along streams and rivers—to provide shade.
- 5 Restore large woody debris and boulders in stream channels to create deeper pools.
- 6 Remove instream barriers to fish movement, such as dams and poorly-designed culverts.
- 7 Restore instream flows that have been reduced by diversions for irrigation and other purposes.
- 8 Minimize existing sources of stress, such as pollution, overgrazing, and roads along streams.
- 9 Limit introductions of non-native fishes and control existing populations.
- 10 Monitor and evaluate habitats as they face climate change.

Conclusion

Unless immediate action is taken to restore resilience and resistance to climate change, many more of our native trout and salmon will be at serious risk of disappearing. By following a well-developed plan that protects, reconnects and restores habitat at watershed scales, Trout Unlimited and its partners can help trout and salmon populations survive the unknown implications of a changing climate. Equally important, in helping to recover trout and salmon, we also remind society of the inextricable link between the health of our lands and waters and the well being of human communities.



Endnotes

- 1 Climate Impacts Group 2004
- 2 IPCC Working Group I 2007
- 3 IPCC Working Group I 2007
- 4 Climate Impacts Group 2004
- 5 IPCC Working Group I 2007; Poff et al. 2002
- 6 IPCC Working Group 2 2007
- 7 IPCC Working Group I 2007; National Assessment Synthesis Team 2000
- 8 Flebbe et al. 2006
- 9 Keleher and Rahel 1996; Rahel et al. 1996; Rahel 2002; O'Neal 2002
- 10 Rieman et al. in review
- 11 Battin et al. 2007
- 12 IPCC Working Group 2 2007
- 13 Harper and Peckarsky 2006
- 14 Loukas and Quick 1999
- 15 National Assessment Synthesis Team 2000
- 16 Hari et al. 2006
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- 20 Dunham et al. 1997; Fausch et al. 2006; Rieman and Dunham 2000
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- 22 E.O. Wilson, 1994
- 23 Rieman and Dunham 2000; Fausch et al. 2006
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Suggested
WEBSITES AND READING
on climate change

Climate.org – A Project of the Climate Institute:
www.climate.org

Intergovernmental Panel on Climate
Change: www.ipcc.ch

US Climate Change Science
Program: www.climatechange.gov

The Pew Center on Global Climate Change:
www.pewclimate.org

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