Healing Troubled Waters

PREPARING TROUT AND SALMON HABITAT FOR A CHANGING CLIMATE

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TROUT UNLIMITED

**** DRAFT RELEASE ****
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Our planet is facing a time of unprecedented environmental change—

the warming of the earth's surface is predicted to dramatically affect human society, and fish and wildlife, and water resources. A litany of scientific evidence demonstrates that due to the buildup of carbon dioxide, methane and nitrous oxide, or greenhouse gases, as they are called, our atmosphere is warming and that the global climate is changing at a rapid pace. 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 1800s,[2] and 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 twelve years rank among the twelve warmest years since 1850.[5]

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

—CALIFORNIA GOVERNOR SCHWARZENEGGER, 2006

Around the world, evidence of the warming climate can be seen in many ways—glaciers are melting faster, affecting species who live in those environments; there is a decline in the Arctic's permafrost,[6] and sea levels are rising. Ocean temperatures are increasing, snowmelt is occurring earlier than ever before and the amount of rainfall is changing. 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.

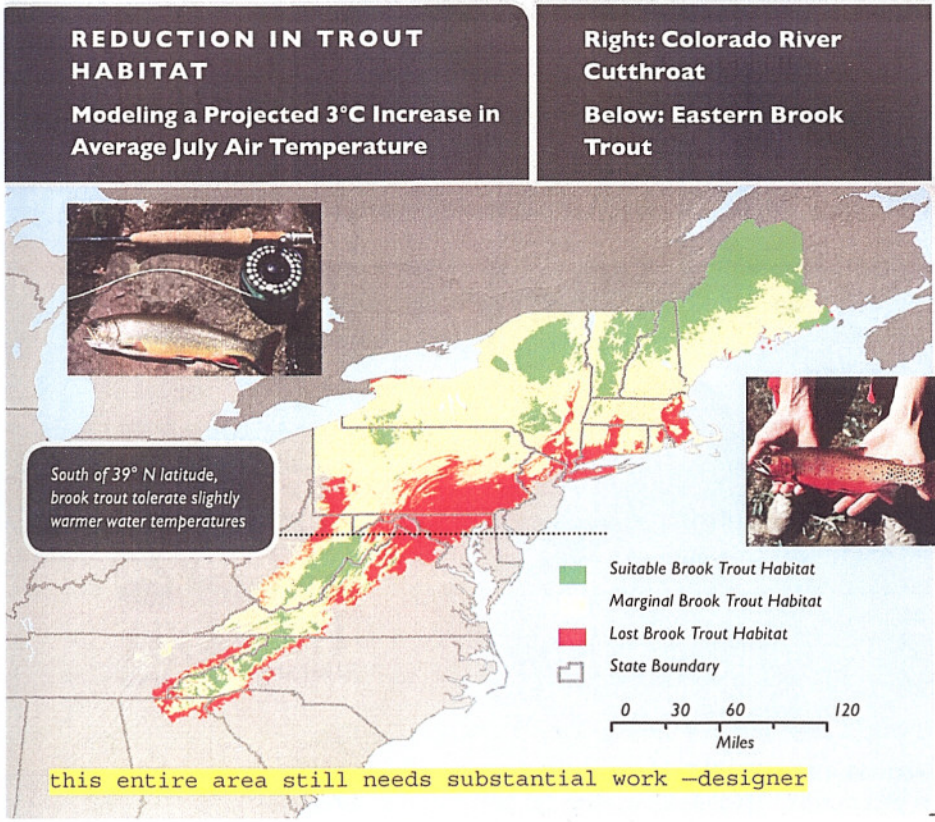
BELOW:
Large portions of trout habitat are predicted to disappear in the next century due to rising water temperatures.

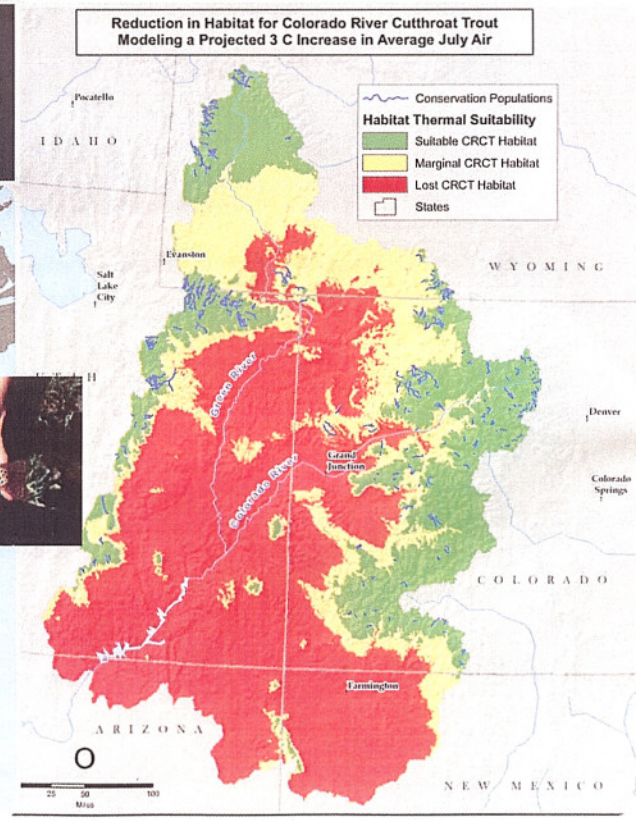
REDUCTION IN TROUT HABITAT

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

Right: Colorado River Cutthroat

Below: Eastern Brook Trout





Trout and Salmon: New Challenges to Survival

Trout and salmon are especially vulnerable to global warming because they are dependent on cold, clear water to survive. When coldwater habitats warm, these rising temperatures will have negative impacts for these fish—from eggs to adults.

Trout and salmon are already facing pressures, and their populations and habitats are threatened. Trout and salmon habitats are largely degraded—water quality is already compromised, a large percentage of their natural habitat has been converted to farm land, developed or impacted by mining and forestry. In addition, trout and salmon populations are isolated and a number of non-native species compete with trout and dilute their gene pools.

Adding climate change atop of all of these stressors will drive many of these trout and salmon populations to disappear. For example, U.S. Forest Service scientists have predicted that over half of wild trout populations are likely to be eliminated from the Appalachian Mountains because of the effects of global warming.[8] Losses of western trout populations may exceed 50% in certain regions[9], with potential losses of migratory bull trout as high as 90%.[10]

Most studies of Pacific Coast salmon predict losses of 20-40% by the year 2050 because of the effects of climate change.[11] In California, where temperatures already pose a significant source of stress for fisheries, greater declines are likely. These predictions could be the best case-scenario, because the underlying models focus on freshwater conditions and do not consider the complexity and uncertainty of changing ocean environments.

There are already indications of rising water temperatures in waters 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,[12] to waters that were previously colder than the fish could tolerate. One study documented that mayflies and other aquatic insects that trout and salmon rely on for food are emerging earlier in Rocky Mountain streams because of warmer stream flows and earlier peak runoff.[13] Trout are directly affected as the delicate balance of the food web changes—smaller insects produce fewer offspring which means less food, overall, for the fish.

The effects of a changing climate on watersheds may vary in intensity and duration across the country because of differences in habitat and landscape.[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. Although some regions could fare better than others, there is a clear need for concern.

Many diseases and parasites that are lethal to fish are limited by cold waters, and so their distribution and virulence may increase with climate change.[16] Fish populations that are struggling to survive in an already stressful environment 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, alike.[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

Bismarck, March 2007

Boise, July 2007

Denver, July 2005

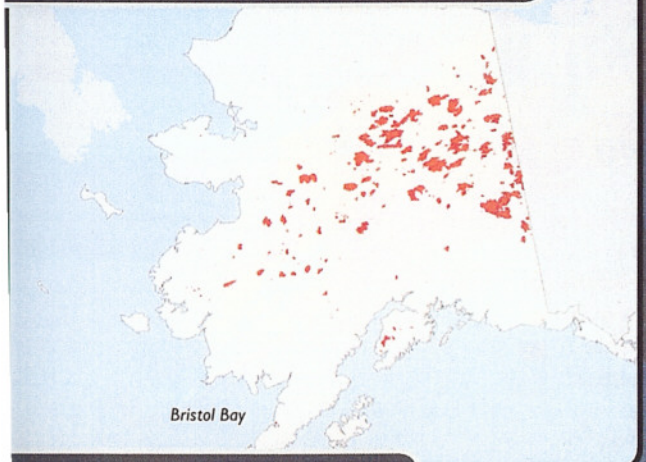
California, July 2006
Multiple Cities

Phoenix, Summer 2005

MORE FREQUENT AND MORE INTENSE WILDFIRES

Fire Perimeters 2000–July 2007

Texas, Summer 1998
Multiple Cities



THAWING SEA ICE AND PERMAFROST

CATASTROPHIC FLOODING

Major Flood Events 1990–Present

Photo: Richard Perry/ The New York Times/Redux

HOTTER SUMMER TEMPERATURES ACROSS MUCH OF THE U.S.

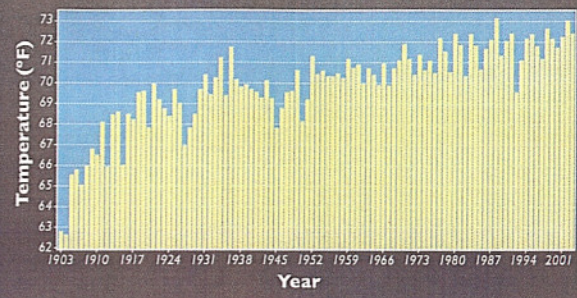
Change in Average Summer Temperature by Area, 1903–2003

-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.



Chicago, July 1999

New York City, July 1999

Little Rock, June 1998

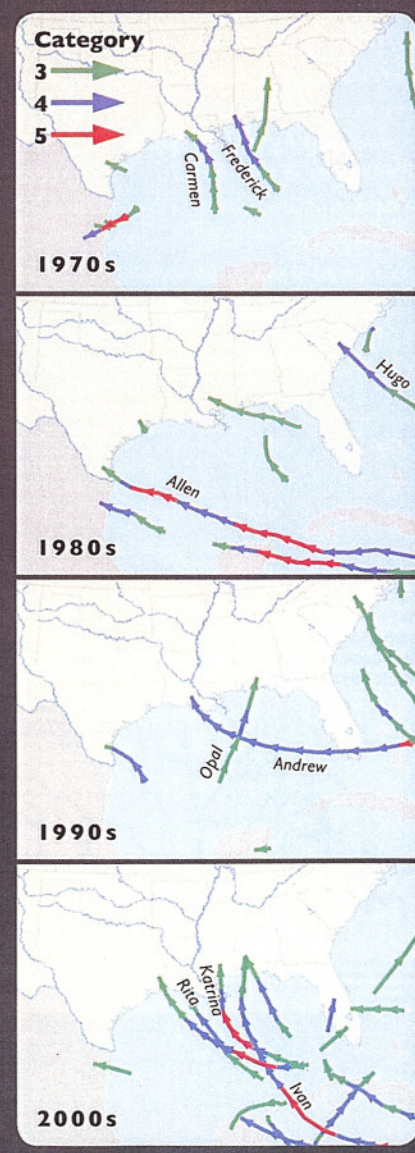
Melbourne, June 1998

OTHER IMPACTS:

Fishing Closures on Low Rivers

Increased Forest Insect Pests

INCREASED OCCURENCE OF MAJOR HURRICANES



COASTLINES AT RISK TO RISING SEA LEVEL

Coastal Vulnerability Index

- Low
- Moderate
- High
- Very High

CONSERVATION GEOGRAPHY

Protect–Reconnect–Restore

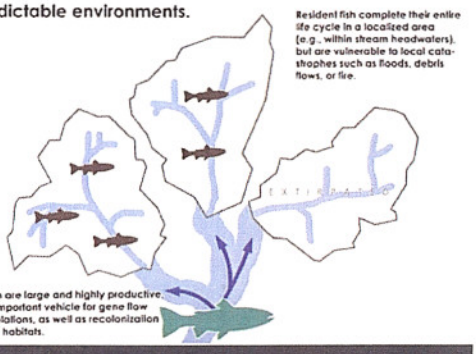
An approach to helping trout and salmon build resistance and resilience to climate change.

CONNECTIVITY AND RECOLONIZING HABITAT

For many species of inland trout, headwater habitats currently support the last remaining populations because lower elevation habitats in the more populated valleys have become degraded from land use changes, elevated temperatures, chronic water withdrawals, and non-native species introductions.[23] These smaller headwaters are often hit the hardest by natural catastrophes like large floods, wildfires, and droughts, events that are all predicted to increase with a changing climate. When streams throughout a watershed are physically connected to one another, surviving fish from downstream quickly move upstream to "reseed" these waters as they recover. If streams, however, are segmented by physical barriers like culverts or dams or are dominated by non-native fish, these natural catastrophic events can wipe out small isolated populations because native fish elsewhere in the watershed have no opportunity to migrate upstream and naturally recolonize these waters.

Maintaining different life histories (migrant and resident) c take advantage of diffe and deal better with var unpredictable environments.

[FPO]



Road-building, oil and gas drilling, and other development degrade water quality and diminish fish habitat in high-elevation lands.

Dams and diversions block fish passage. Streams run dry during the warm months.

Sediment, runoff and pollution make developed areas uninhabitable for fish. Urbanization and channeling of streams increase water filtration costs and the effects of flooding downstream.

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.

BRYAN CHRISTIE DESIGN

Helping Trout and Salmon Survive Climate Change

The effects of global warming will further stress stream systems and watersheds that have already been pushed to their limits by competition with non-native or hatchery fish, disease, increased water extraction, or impacts from mining, grazing, and unsustainable timber harvests.

But, trout and salmon are resilient. They have survived and adapted to many fluctuations in climate and environment over thousands of years. 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.

In an era of a changing climate, trout and salmon populations will require our help to build resistance and resilience to climate change. Resistance refers to the ability to withstand environmental change, and resilience is the ability to rebound after environmental disturbance. 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, and perhaps most importantly, significant effort must be made to sustain on the ground improvements to trout and salmon habitats by engaging local communities, state and federal agencies, conservation organizations, and industry groups in the recovery of the lands and waters that sustain us all.

By working collaboratively at a landscape scale on a focused effort to protect, reconnect, and restore fisheries and fish habitat, state and federal agencies, local communities and non-profit organizations can help keep aquatic systems from ecological collapse.

In order to strengthen the resistance and resilience of trout, the following steps must be taken:

BELOW:
Installation of this fish ladder at an agricultural diversion weir reconnects stream habitat for Bonneville Cutthroat trout in Utah.

ABOVE:
Installing woody debris in downstream regions of spawning tributaries to the Russian River helps restore habitat for juvenile coho salmon and steelhead in California.

Protect

1. Protect Remaining Central 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.

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.

Maintaining 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.[20]

Reconnect

2. Reconnect High Quality Habitats to Other Areas by Removing Barriers to Migration and Improving River Flows. 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 only valuable when they are connected to one another. Dams, culverts and other barriers that restrict fish from moving up and down the watershed can reduce overall fish population and compromise genetic integrity.[21] Restoring connectivity within and among watersheds by removing obsolete and unneeded barriers that block fish movement will facilitate the recovery of the migratory forms of fish within a population, and increase the likelihood of fish finding suitable habitat conditions. Similarly, creating incentives to leave water instream will help to recover more natural river flows.

Restore

3. Restore Entire Watersheds, not Just Individual Streams and Rivers. Identify and reconnect important stream systems that have been disconnected by dams, culverts, water diversions and other dewatering processes. By restoring streams and floodplains to a healthy, more natural state, fish will have a greater opportunity to withstand the impacts of floods, increased fire, and droughts.

- Control Non-native Species and Hatchery Fish: The presence of non-native species or hatchery fish may increase the vulnerability of native fish to climate change. Non-native fish not only compete for food and habitat, but they may thrive in warmer 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.

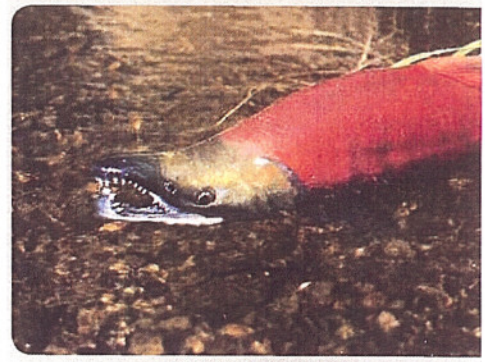
- Restore trout populations. Small, fragmented trout populations are at larger risk of extinction, while larger populations will be better able to survive.[24] Populations that exist in larger geographic areas will be more resistant to local extinction. Restoring diverse habitat to increase trout population size and a range of age classes will make populations more resilient to climate change.

Sustain

4: Sustain Conservation and Recovery Efforts. In one generation, America has evolved from a nation where 60 percent lived in a rural society to where 80 percent of Americans now live in cities or suburbs. This trend has diminished our connection to the natural world. Climate change provides an important opportunity to remind us that we are still dependent as a society on the health of our natural resources. Engaging communities in restoration activities such as energy conservation, tree planting, open space preservation, community planning will markedly improve the likelihood of survival for trout and salmon through global warming. As a result, it will also improve the quality of life for Americans and reconnect communities to the lands and waters that sustain them.

- Monitoring and Evaluation: 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. Additional analysis will be needed to ensure that restoration work is achieving intended goals.

BELOW:
One of the more striking examples of the importance of genetic diversity was described in Bristol Bay, Alaska, where a large number of sockeye salmon stocks from various 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.[22]



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

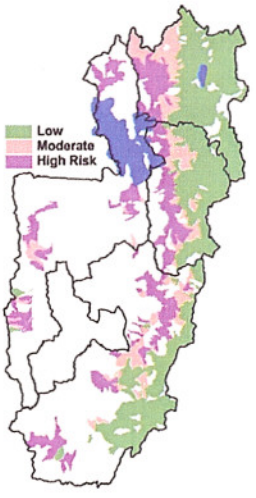
How the CSI Provides a Strategic Approach to Dealing With the Climate Crisis

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 to accomplish this task.

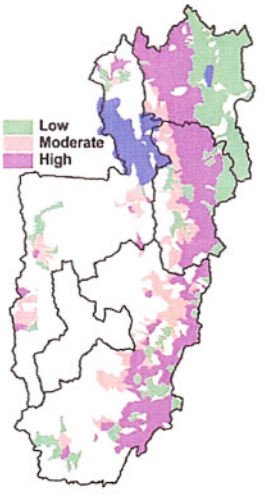
Bonneville cutthroat trout provide an example of likely climate change impacts. A variety of scientific information is combined to examine impacts that will affect trout populations in each subwatershed, which are stream drainages of about 20,000 to 30,000 acres. This information is used to model the 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.

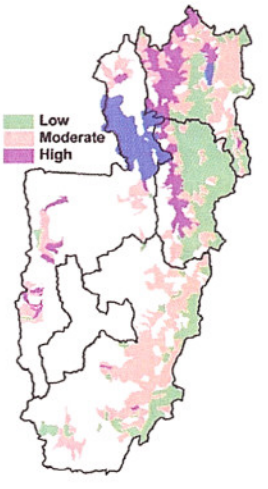
TEMPERATURE RISK



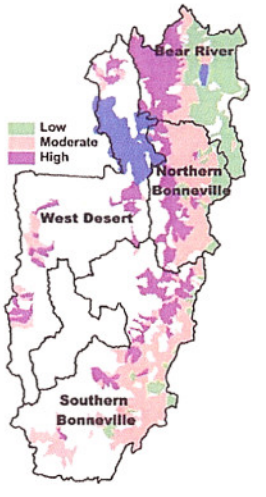
WINTER FLOODING RISK



WILDFIRE RISK



COMBINED CLIMATE RISK



For Bonneville cutthroat trout, the best remaining populations are in the Bear River and Northern Bonneville regions. Populations in the West Desert and Southern Bonneville regions already are stressed and fragmented. Climate change impacts will be moderate to high in much of the west and south regions inhabited by Bonneville cutthroat. In these areas, aggressive restoration efforts will be needed to maintain native cutthroat populations. In more northern portions of the range, habitats must be strongly protected. Impacts from climate change will be less here with the exception of increased wildfire risk. Maintaining large populations in well-connected stream systems is the best insurance against wildfire and other climate-related impacts in the Bear River and Northern Bonneville regions.

TEN STEPS TO PROTECTING TROUT AND SALMON FROM CLIMATE CHANGE

1. Protect the diversity of remaining native trout and salmon populations.
2. Restore the habitats that support various types of fish within a population.
3. Protect springs, headwaters and other sources of cold water.
4. Expand native plants and vegetation along streams and rivers.
5. Restore large woody debris and boulders in stream channels to create deeper pools.
6. Remove instream barriers like dams and culverts.
7. Restore instream flows that have been lost or reduced from irrigation, water withdrawals, hydropower or diversions.
8. Minimize 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 resistance and resiliency 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 among the health of our lands and waters and the well being of human communities.

Endnotes

1 Climate Impacts Group 2004

2 IPCC Working Group 1 2007

3 IPCC Working Group 1 2007

4 Climate Impacts Group 2004

5 IPCC Working Group 1 2007; Poff et al 2002

6 IPPC Working Group 2 2007

7 IPPC Working Group 1 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 Reiman et al, in review

11 O'Neal 2002

12 IPPC 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

17 Richter and Kolmes 2005

18 National Assessment Synthesis Team 2000

19 IPPC Working Group 2 2007; National Assessment Synthesis Team 2000

20 E.O. Wilson, 1994

21 Rieman and Dunham 2000; Fausch et al 2006

22 Hilborn et al. 2003

23 Dunham et al. 1997; Fausch et al. 2006; Rieman and Dunham 2000

24 Dunning et al. 1992; Hilderbrand and Kershner 2000; Rieman and Allendorf 2001