





Weathering the Change

Helping Trout in the West
Survive the Impacts of
Global Warming

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Rising temperatures. Sweeping forest fires.
Prolonged drought. Increased storm severity.
The environment is changing, and nowhere are



these changes more evident than in the West.

When asked to name the culprit, scientists and meteorologists from interests as diverse as NASA and The Weather Channel usually respond with two words: global warming. By now, it would be hard to find anyone who hasn't heard of this phenomenon and its alarming consequences. Although there is still some debate about just how hot it will get and how severe the consequences will be, the overwhelming majority of experts agree that global warming is real (see sidebar on page 20).

What will this mean for coldwater species like trout and salmon? Although the severity of some changes will be hard to predict, we're likely to see higher stream temperatures and more intense disturbances like the ones listed above.

The good news is that the kinds of restoration projects that are undertaken now can make a big difference in the quality of tomorrow's fisheries—even in the face of climate change. For instance, knowing that fish will need coldwater refuges, we can focus on restoring deep pools and valley-bottom stream segments, and reconnecting flows from headwaters to downstream reaches. Recognizing that we're likely to see more frequent, higher intensity storms, we can restore riparian areas as stream buffers, and reconnect rivers with their floodplains.

In the pages that follow, we've identified a few restoration strategies

that will be particularly important during an era of climate change. We hope these recommendations will prove useful to chapters deciding how to prioritize local projects in the years ahead.

But first, the bad news: how hot will it get?

Projections and climate models predict that average annual temperature levels will increase anywhere from 2 to 9 degrees Fahrenheit (all temperature measures were converted from Celsius to Fahrenheit for this article) over the next 100 years. That will come on top of the 1-degree average annual temperature increase the United States has experienced since 1900.

To put these numbers in perspective, a study prepared in 2002 for the Pew Center on Global Climate Change predicted that a 1.5-degree increase in air temperature in the Rocky Mountain region could reduce suitable stream habitat for trout by 7 to 16 percent. A 4.8-degree increase could reduce habitat by a staggering 42 to 54 percent. According to another model created by researchers from the Oak Ridge National Laboratory, water temperature increases of just 3 to 3.5 degrees would render the lower reaches of most streams in California's Sierra Nevada region uninhabitable for brown and rainbow trout. The fish would be forced to retreat to higher elevations to survive.

Unfortunately, the fallout from global warming doesn't stop with increased water temperatures. In the mountainous regions of the West, high elevation snowpack serves as a natural water storage system, slowly releasing water into streams and groundwater in the spring and summer, and recharging in the fall and winter.

Climate change has the potential to alter this cycle dramatically by reducing the amount of snowpack that exists to feed the river. As air temperatures warm, the snowpack would likely develop later and melt earlier, causing peak runoff to come earlier in the winter and spring. By summer, we would likely see decreased stream flows and reduced groundwater levels.

Some experts predict more precipitation in the West, but in the form of rain, not snow. This additional rain could speed melting of the snowpack, making winter floods even more likely. These floods could cause a decrease in fall-spawning trout populations by scouring the trout's spawning redds.

The changes also have implications for the drinking water supply in fast-growing cities in the West and Southwest, where competition for water has accelerated rapidly. "Increased populations increase pressure on rivers," says Melinda Kassen, who has seen this truism play out first-hand in her role as director of TU's

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The State of Science of Global Warming

By Dr. Tad Anderson University of Washington, Department of Atmospheric Sciences

The theory of human-induced global warming is based on physical principles formulated more than 100 years ago. Because carbon dioxide and other greenhouse gases are known to be increasing in the atmosphere, this theory has been the subject of intense scrutiny by the scientific community for the past two decades. During this time period, the evidence that warming is occurring and that it is due to human activity has become convincing to the great majority of scientists studying the problem.

Understanding of the greenhouse effect and its impact on the Earth's temperature goes back to the 19th century. British scientist John Tyndall explained the effect beautifully in 1862 when he wrote, "As a dam built across a river causes a local deepening of the stream, so our atmosphere, thrown as a barrier across the terrestrial rays, produces a local heightening of the temperature at the Earth's surface."

The greenhouse effect occurs when human-generated and naturally occurring gases like carbon dioxide, water vapor, methane and chlorofluorocarbons accumulate in the atmosphere and trap the "terrestrial rays" Tyndall referred to—today more commonly known as infrared radiation, or more simply, the heat that is radiated to space. Trapped heat in the atmosphere helps to keep the Earth warm and livable. But too much of this trapped heat, caused by an increase in the concentration of greenhouse gases, creates global warming.

What is the nature of the evidence that global warming is taking place? The most commonly cited data comes from tens of thousands of weather-station thermometers which, taken together, show an increase in globally averaged surface temperature of approximately 1 degree Fahrenheit over

the 20th century. But there are many independent lines of evidence as well, including satellite measurements showing warming of the lower atmosphere, the observed retreat of mountain glaciers around the world, the increase in sea level, the increase in heat content of the global oceans, reductions in winter snow cover and the pole-ward migration of a large number of plant and animal species.

But is *human-induced* warming actually occurring? The past two decades of intensive study have seen a dramatic evolution in confidence that it is. Using climate models, scientists have shown that warming in the 20th century cannot be reproduced by simulations that

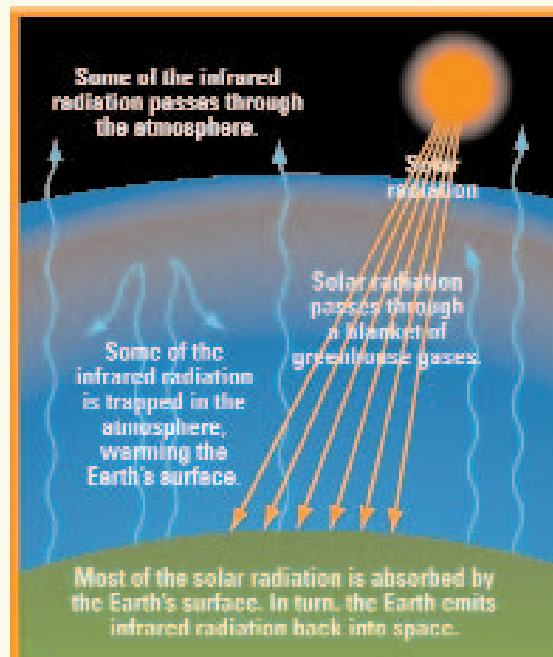
exceeds any other warming events over the past thousand years.

Reports published over the last decade by The Intergovernmental Panel on Climate Change (IPCC) document the evolution of thinking within the scientific community. In 1990, an IPCC report stated that global warming is, "of the same magnitude as natural climate variability." By 2001, the report noted that, "An increasing body of observations gives a collective picture of a warming world and other changes to the climate system. . . There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."

In 2001, President Bush convened a panel of the U.S. National Academy of Sciences to carefully scrutinize the IPCC report for signs of bias or inaccuracy. The panel concluded that the IPCC attribution of the recent warming to human-caused increases in greenhouse gases "accurately reflects the current thinking of the scientific community on this issue."

There is no question that human-induced emissions of greenhouse gases, primarily carbon dioxide, have the potential to alter the global climate and it is now apparent, from the changes we see all around us, that they are. As the American Meteorological Society noted as far back as 1990,

"Observations do reveal unmistakable changes in the composition of the atmosphere that can be traced—without ambiguity—to human activities. The theory of how these greenhouse gases directly influence the earth's energy balance is not controversial. If no other factors counter their influence, increases in their concentration will lead to global warming."



only include natural factors such as emissions from volcanoes and solar activity. However, it can be reproduced when the simulations include the effects of human-emitted greenhouse gases. In addition, evidence from efforts to reconstruct global temperatures in the distant past using tree rings, ice-cores, and other proxies indicate a likelihood that warming in the 20th century



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Colorado Water Project. “Climate change means less of the snow that gives our rivers their cold spring pulse. Our system is built around storing those spring high flows—or using them to flush contaminants out of the river.”

Kassen sums up the situation for the West simply: “The combination of more people and dry weather—regardless of whether the cause is a periodic drought or climate change—will require a change in the way people store and use water, especially if we want the fish to survive.”

Of course, humans do have the capacity to adapt to changing conditions in their environment. We can

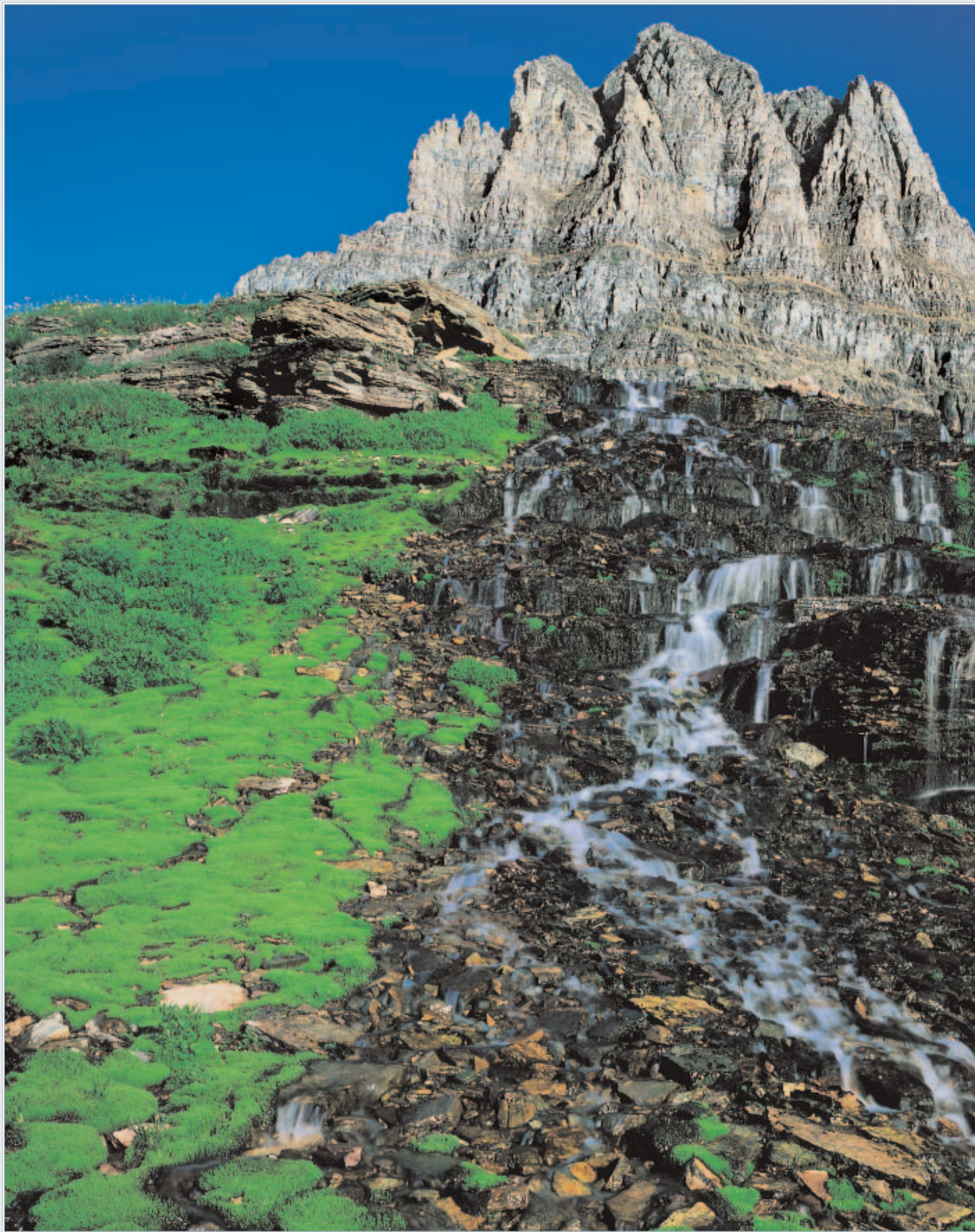
replace our blue-grass lawns, install more efficient irrigation systems, reduce our greenhouse gas emissions. Our ability to change is perhaps the most important factor in all the projections related to global warming.

Experts generally believe temperatures will go up slowly, reaching peak levels roughly 100 years from now. This gradual increase buys a little time for temperature-sensitive species like trout. “We don’t have to get all the work done today,” says Stan Bradshaw of TU’s Montana Water Project, which has been actively engaged in helping create buffers to protect trout from the impacts of changing temperature levels. “But we should begin thinking in larger terms.”

This means establishing long-term strategies for restoration and water use to help trout populations survive and undertaking broad policy changes that will lead to a reduction in the human-created causes of global warming.

However slight it may be in the context of life on the planet, we have a cushion of time now to embark on the work necessary to ensure the survival of many trout populations. The next generation of anglers will thank us for taking action.

The following pages highlight several restoration strategies that may help minimize the impacts of global warming on trout and salmon fisheries.





Coldwater Conservation in a Changing Climate

Reconnect Entire Watersheds

As local stream conditions change, trout and salmon must be able to move within their watershed to find more suitable habitat. In eastern Nevada, restoring the Marys River and its tributaries provides extensive habitat and multiple options for Lahontan cutthroat trout within the drainage. If one portion of the drainage becomes unsuitable because of drought, flood or fire, a connected network of habitat will allow recolonization of the degraded habitat once conditions improve.

The key to connecting habitat is restoring flows, but this can be quite a challenge in the arid West, where irrigators, thirsty citizens and fish often compete for scarce water resources. TU's Western Water Project has pioneered the use of legal agreements like water leases and transfers to provide economic incentives to water rights holders for actions that restore flows.

On Montana's North Fork of the Blackfoot River, for instance, TU negotiated a water lease agreement with a farmer that supplied an additional 18.5 cubic feet of water per second on a severely dewatered portion of the river. In exchange, the organization replaced his irrigation canal, which leaked as much as 90 percent of the water diverted from the river, with a pump and pipes and a more efficient sprinkler irrigation system. Such leases have benefited key spawning streams for native cutthroat and bull trout on tributaries to the Yellowstone, Blackfoot and Missouri rivers.

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Coldwater Conservation in a Changing Climate

Maintain Genetic Diversity by Protecting Native Fish

Biologists believe that genetic diversity gives native fish populations an advantage over non-natives and hatchery fish in changing environments. In the Clark Fork and Blackfoot rivers, native cutthroats and bull trout have remained relatively stable or declined only moderately in the face of recent droughts, while non-native rainbow populations have crashed. Cutthroats also seem to have demonstrated an ability to adapt to chronically dewatered areas by altering the timing of their spawning runs.

In Alaska's Bristol Bay, sockeye salmon have managed to maintain large populations despite changing ocean conditions. A study authored by researchers at the University of Washington and published in the *Proceedings of the National Academy of Sciences* attributed this resilience to the fact that many different sockeye salmon stocks exist in various tributaries to the bay. These stocks provide significant natural variation in their life history requirements—or “biocomplexity”—to buffer the overall population from changes in ocean conditions. If trout, salmon and steelhead populations are diverse enough, some stocks may succumb but others will thrive, giving the species overall a far better chance of survival.

TU works with federal agencies like the Bureau of Land Management and the U.S. Forest Service to restore watersheds and research techniques for reintroducing native species and reconnecting fragmented habitats. Large-scale restoration efforts are underway for bull trout and anadromous salmon in Idaho's Pahsimeroi Basin and Apache trout in the White Mountains of Arizona. Meanwhile, to guide future restoration projects, TU is monitoring the response of local fish populations to barrier removal on watersheds in Utah, Wyoming and Idaho.



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Coldwater Conservation in a Changing Climate

Protect High- Quality Habitat

Roadless or relatively undisturbed watersheds provide good sources of cold water, which serves as a buffer against future changes in stream flows and temperatures. Protecting headwater streams and lakes will also help to preserve high-quality coldwater flows, in turn maintaining suitable downstream conditions.

TU's dedicated grassroots network has been protecting and restoring trout habitat for years, long before anyone was talking about global warming. Consider just one measure of its effectiveness: the organization's Embrace-A-Stream program, which makes small grants to local chapters for restoration projects, has invested nearly \$3 million in 779 local efforts over the past 30 years. These funds have leveraged another \$10 million for the projects from other sources.

Moreover, through its efforts to support sensible roadless area management on Forest Service lands, TU is a strong advocate for continued legislative and administrative protections for roadless areas throughout the West. The organization is also working to designate new wilderness areas in Oregon, Washington, California and Idaho. 🚧

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