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Trout in Trouble

The Impacts of Global Warming on Trout in the Interior West

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About MT TU

Trout Unlimited's mission is to conserve, protect and restore the nation's coldwater fisheries and their habitats. The organization has 150,000 members and 500 volunteer-based chapters spread across the United States and Canada. The Montana Council of Trout Unlimited represents the 3,000 members and 12 chapters of TU in Montana.

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Foreword

In the middle of a prolonged drought, our local weather forecaster was exulting over more blue sky and hot temperatures. The headlines in state newspapers proclaimed that the recent local construction boom is great and exciting news for the Montana's economy, but there are some trout streams I can no longer find because they now run under new shopping malls and parking lots.

And yes, I'm lucky. I live, work, and chase wild trout in Yellowstone country, which many refer to as "the trout heart of America." But even this place is not exempt from the changes occurring across the West. Over the past 30 years, Yellowstone country has felt all of the predicted impacts of global warming—increased occurrence of fire, decreased winter snowpack, high summer temperatures, and retreating alpine glaciers. The journal *Science* earlier this year reported that our warming climate is the primary source of the decline in snowpack, which is our natural water storage system and the primary source of water in many regions. A healthy winter snow pack, which melts slowly throughout the summer season, feeds our rivers and streams, allowing them to maintain cool flows throughout the warm summer months. For cold-water fish species like trout, it is the safety valve that gets them through the warmest times of the year.

The stark reality is that if nothing is done to reduce greenhouse gas emissions, the primary culprit behind global warming, trout habitat in the western United States could be reduced by 50 percent—and even more in some locations.

Taking effective action to reduce the causes of global warming must start now, and anglers should be at the forefront of those efforts. Individually there are many things we can do to reduce our impact on global warming. And collectively, leading by example, we have the ability to make a huge difference. We must encourage and demand local and state leadership on reducing global warming emissions at a time when the federal government is irresolute on this critical issue.

Izaak Walton, author of *The Compleat Angler* and considered by many as the father of modern trout fishing, noted, "Rivers and the inhabitants of the watery elements are made for wise men to contemplate and for fools to pass by without consideration." If you love wild trout, clean, cool water, and wild places, you must learn to speak more loudly, more clearly, and more frequently to protect and preserve a healthy environment for our kids, grandkids, and all future generations of trout anglers.

Craig Mathews
Owner & Operator, Blue Ribbon Flies
Co-founder, 1% for the Planet
West Yellowstone, Montana

Executive Summary

Global warming is the single greatest threat to the survival of trout in America's interior West. If nothing is done to reduce human-produced greenhouse gas emissions—the primary culprit behind global warming—trout habitat throughout the Rocky Mountain region could be reduced by 50 percent or more by the end of the century.[1] The loss of habitat would bring fewer opportunities for anglers to enjoy sportfishing, resulting in serious economic consequences for those who depend on fishing, recreation, and tourism activity for their livelihoods. Although we are already seeing declines in trout populations and habitat throughout the West, it is not too late to avoid the most serious impacts of global warming on this important coldwater fish.

The unimpeded impacts of global warming on trout in the interior will be so sweeping that few populations will go untouched. Rivers like the Upper North Platte, the Green, the upper Colorado, the Fraser, the Provo, the Firehole, and the Gila—hallowed waters for trout anglers—will be dramatically altered by global warming. The famous recreational trout fishery on the Bighorn River in Montana, for example, has struggled in recent years due to drought, declining reservoir levels, record-setting high temperatures, and reduced snowpack—all common impacts of global warming. Even tailwater fisheries once thought immune to warming due to their location below immense dams that discharge cold water from far below the surface will be affected.

And the impacts of global warming will reach far beyond the magnificent trout, profoundly affecting economies throughout the region. Trout fishing has become integral to local and state economies in the interior West. In Colorado alone, sportfishing in 2002 had a total economic impact of more than $800 million and supported nearly 11,000 jobs.[2] In Montana, with its relatively small population of 950,000 people, angling generates nearly $300 million per year.[3] With each percentage decline in trout populations and stream miles occupied by

Fly fishing on the Arkansas River in Colorado.

trout—or reduction in the opportunity to fish due to fishing closures or fire—there could be a corresponding loss in jobs and income for the region.

Global Warming Will Cause Serious Damage to Trout Habitat

Native trout have existed in much of the interior West since the Pleistocene Era—the time of the great ice ages. The loss of these trout because of human-caused global warming would be a tremendous loss to the region and a harbinger of future trouble. Trout are viewed by many as an indicator of healthy river ecosystems. Their inability to survive due to environmental conditions could be a glimpse of the challenges that lay ahead for humans in places like the West.

Global warming is already changing the climate and affecting trout populations throughout the West. In some locations where the trout populations are particularly vulnerable, suitable habitat for trout could decline by 70 percent or more over the next 50 to 100 years.[4]

Trout are viewed by many as an indicator of healthy river ecosystems. Their inability to survive due to environmental conditions could be a glimpse of the challenges that lay ahead for humans in places like the West.

We Can Act Now to Save Trout

It is not too late to avoid the most severe projected impacts of global warming on trout and their habitat. We must act now to reduce our emissions of global warming pollution and adopt other policies that appropriately value healthy rivers, lakes, and streams. For trout to endure in the interior American West, anglers must consider the impacts of global warming and help lead the effort to save this treasured resource.

On the national level, strong federal action to reduce emissions of global warming pollutants at least 80 percent below current levels by the year 2050 is a necessary step to limit warming below dangerous levels, and to give businesses the certainty they need to plan large capital and investment projects. In the West, states should adopt their own binding policies to reduce emissions in a similar fashion. This challenge can be met through improvements in building, vehicle, and industrial efficiency; increased investment in renewable energy and low carbon fuel; and deployment of technologies to capture and store carbon emissions.

Cutthroat trout in Henry's Lake, Idaho.

Solving global warming can be done, and it can be done with little or no harm to our economy. A recent study by the respected consulting firm McKinsey & Company made this point,[5] as did a more recent study by the International Monetary Fund.[6] With its abundance of solar, wind, and geothermal energy potential, the western United States is uniquely suited to be a major player in a clean energy economy, bringing tremendous economic development to the region, helping to avoid the most dangerous effects of human-caused global warming, and preserving the West we know and love.

CHAPTER 1

A Changing Climate and Human Actions Pose Challenges for Trout

In the summer of 2007, the unthinkable happened in the world of trout and trout fishing. Ranked as one of the best dry fly fishing rivers in the West, the Firehole River in Yellowstone National Park has for years been a prime destination for serious anglers heading to the West. It is truly a one-of-a-kind river—the only place in the world where one can fish for brown and rainbow trout in the shadow of geysers, under the watchful eye of passing bison. But on a hot July day, with air temperatures exceeding 90 degrees Fahrenheit—a condition that occurred frequently that summer—the Firehole's trout found themselves in an environment suddenly inhospitable. Stifling temperatures brought reduced levels of dissolved oxygen in the water. For as many as 1,000 trout there was no sanctuary. The fish slowly turned belly-up and then drifted down the river. The fish kill would become the largest in the 135-year history of Yellowstone Park.[1]

Those familiar with the Firehole River attributed the fish kill to unnaturally high water temperatures, one of the indicators of a warming climate. In fact, July 2007 was the hottest July ever recorded in nearby Montana. Biologists, climatologists, and other members of the scientific community believe that the increased frequency in the past 20 years of hot and dry summers and warm winters in the West reflect an overall change in the world's climate.

What occurred on the Firehole River last summer is indicative of a growing problem that is appearing more frequently in trout streams throughout the American West. In Colorado, Wyoming, Utah, New Mexico, and other western states, record high air temperatures coupled with drought and reduced snowpacks are taking a toll on trout populations, including those of some of the nation's best known fishing destinations.

Scientists project that for trout and other cold-water aquatic species, the combined effects of a 1.5 degree Fahrenheit increase in average air temperatures could result in a 7 to 16 percent loss of trout habitat in the continental United States. And a 4.8 degree Fahrenheit increase could reduce habitat by a staggering 42 to 54 percent.

Big Horn River, Montana

BIG SKY FISHING (WWW.BIGSKYFISHING.COM)

Green River, Wyoming

MARK CONLIN/LARRY ULRICH STOCK (WWW.LARRYULRICH.COM)

Big Hole River, Montana

BIG SKY FISHING (WWW.BIGSKYFISHING.COM)

Summer fishing closures are becoming commonplace on trout streams throughout the West as state fishery officials attempt to reduce the impact angling, including catch-and-release techniques, poses to fish when streams are inordinately warm. By the end of July 2007, for instance, Yellowstone Park had closed 232 miles of 17 streams during the afternoon, a time of day when water temperatures increase.[2]

The Reality of Global Warming

Global warming and its negative impacts are a reality—with particular consequences for the American West. The observed changes in our climate are the result of an imbalance in the natural process referred to as the greenhouse effect. When heat-trapping gases such as carbon dioxide and methane, which are naturally occurring and also generated by human activities, accumulate in the atmosphere they prevent some of the heat from solar radiation from escaping into space. Some trapped heat is necessary—and indeed what makes the earth habitable. Increased concentrations of greenhouse gases caused by human activities such as burning of fossil fuels, however, are trapping increased amounts of heat in our lower atmosphere and causing our planet to warm rapidly.

More Rapid Warming in the West

2003 to 2007 5-Year Average Temperatures Compared to 20th Century Averages

Planet	+1.0°F
Western United States	+1.7°F
Colorado River Basin	+2.2°F
Arizona	+2.2°F
California	+1.1°F
Colorado	+1.9°F
Idaho	+1.8°F
Montana	+2.1°F
Nevada	+1.7°F
New Mexico	+1.3°F
Oregon	+1.4°F
Utah	+2.1°F
Washington	+1.4°F
Wyoming	+2.0°F

Data from the National Oceanic and Atmospheric Administration's climate division series. Analysis by the Rocky Mountain Climate Organization.

Over the past 50 years, the average global temperature has increased at a rate that has not occurred for hundreds of thousands of years,[3] with 11 of the 12 warmest years on record occurring in the past 12 years.[4] The Nobel Prize–winning Intergovernmental Panel on Climate Change (IPCC) and other scientists—including the National Academy of Sciences and the American Meteorological Society—believe that heat-trapping pollution is primarily responsible for changes in climate patterns across the globe.

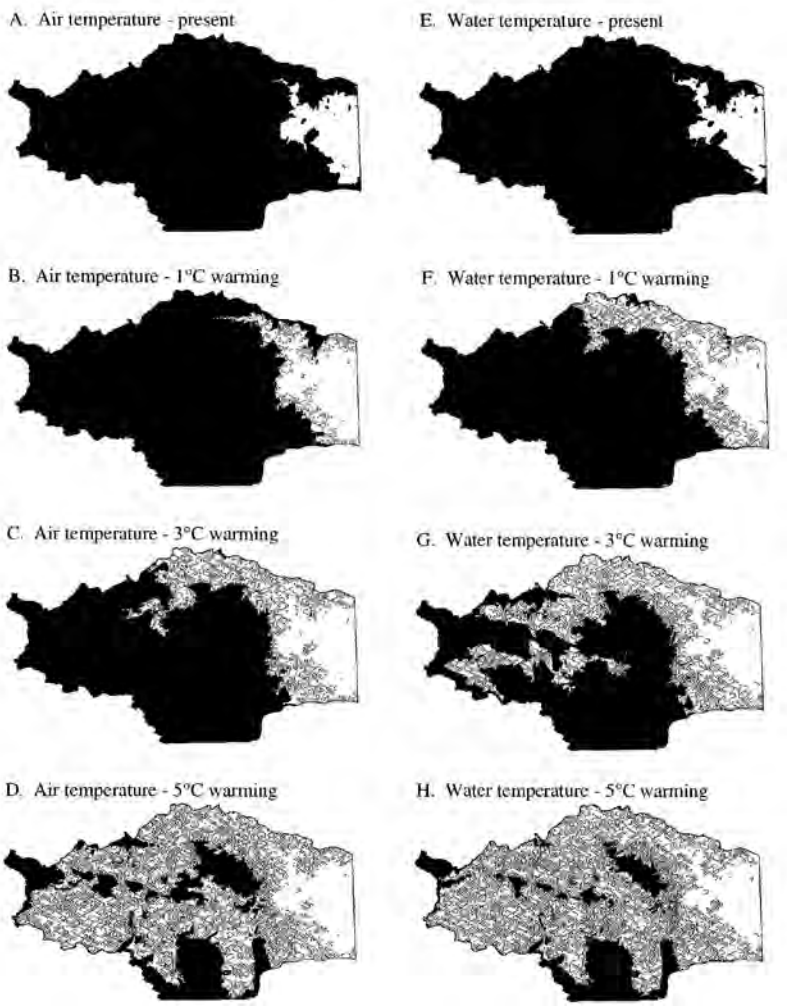
The greatest source of human-caused global warming pollution is the large amount of carbon dioxide produced from the burning of carbon-based fuels such as coal, oil, and natural gas. The debate over global warming, therefore, often pits carbon-based industries such as oil and coal companies—and their powerful lobbyists—against conservationists and others who believe that the United States must lead the effort to reduce the amount of carbon dioxide that all nations emit. Recently, however, many energy and other companies have acknowledged the need to curb global warming and have called on Congress to rapidly enact comprehensive legislation to reduce emissions by 60 to 80 percent from their current levels by mid-century.[5]

Global Warming Is Hitting the West Hard

Climate models predicting future temperature trends and weather patterns are showing continued hot and dry weather well into the future. During the 20th century, the average annual temperature in the western United States rose by 1.7 degrees Fahrenheit, which is 70 percent more warming than the planet as a whole during the same time period.[6] Global climate models show that average annual temperatures could increase anywhere from 3 to 10 degrees Fahrenheit during the next hundred years if nothing is done to reduce carbon dioxide emissions,[7] the primary cause of global warming. Regional average temperatures could be even higher, especially in higher latitudes where scientists predict the most dramatic climate changes will occur.[8]

For more information about the impacts of global warming in the West, visit www.nrdc.org/policy to read the March 2008 report *Hotter and Drier: The West's Changed Climate.*

Potential Habitat Loss for Cold-Water Fish in the North Platte River



COURTESY OF FRANK RAHEL AND *LIMNOLOGY AND OCEANOGRAPHY*

Loss of habitat for cold water fish in the North Platte River drainage. Areas that are thermally unsuitable at present are shown in white; areas that would be lost with a given temperature increase are shown stippled. Areas that would remain thermally suitable after a given temperature increase are black. A-D: Habitat loss based on use of summer air temperature to define thermal limits. E-H: Habitat loss based on use of summer water temperatures to define thermal limits.

The multiple environmental impacts due to a predicted 3 to 10 degree Fahrenheit temperature increase will be devastating for trout in the interior West. Scientists project that for trout and other cold-water aquatic species, the combined effects of a 1.5 degree Fahrenheit increase in average air temperatures could result in a 7 to 16 percent loss of trout habitat in the continental United States.[9] And a 4.8 degree Fahrenheit increase could reduce habitat by a staggering 42 to 54 percent.[10] A University of Wyoming study that looked at the impact of temperature increases on cold-water fish in the North Platte River drainage on the eastern slopes of Rocky Mountains also found that a temperature increase of 1.8 to 9 degrees Fahrenheit could result in a loss of 7 to 76 percent of habitat in that region.[11] For all who admire and care about wild trout, these figures are undeniably dire.

Unfortunately, the potential negative impacts of global warming go beyond increases in air temperatures. Scientists predict the warming climate will lead to changes in natural supply of water to western rivers, lakes, and streams. Global warming will increase the likelihood of drought in many locations and lead to more precipitation falling in the form of rain instead of snow, which will dramatically affect snowpack levels. Snowpack serves as a crucial water storage system for most of the West, providing a steady flow of water through the warmer months as accumulated snow melts, maintaining flows in streams and rivers and supplying water for irrigation and cities. Even if overall precipitation levels remained constant, warmer temperatures—and more rain and less snow—will lead to more evaporation and less water reaching rivers and streams, in turn reducing the presence of the cool, oxygen-rich water that trout depend on.

Competition for Water Resources Endangers Trout

Global warming is bringing increased drought conditions in the arid West, escalating competition for already-scarce water resources. The settling and development of the West, including meeting the needs of a growing population and the industries upon which many of these people depend—namely agriculture, mining, and energy development—has brought significant changes for the hydrology of the region. Rivers have been dammed, canals dug, and irrigation structures created. And in many cases, sections of rivers and even entire streams are sucked dry. Trout have also experienced habitat loss due to excessive road building, logging, and irresponsible all-terrain vehicle use and energy development.

The partitioning and diversion of water resources—long a feature of the West—will likely increase in the face of global warming, further reducing the ability of trout and other cold-water species to move freely within a larger watershed and seek sanctuary from the effects of climate change. Dams, canals that intersect streams, irrigation diversions that cause streambeds to go dry, and even low water levels that heat up during summer to lethal levels, can be barriers to trout movement. Fewer remaining cool refuges will result in less habitat and fewer trout overall.

Trout streams and rivers in the interior West also face challenges created by excessive groundwater pumping. Residential and agricultural wells are springing up at a rapid pace throughout the region in response to population growth. Lightly regulated throughout much of the West, groundwater wells siphon water away from streams and rivers, placing further stress upon trout habitat.

Recent Court Decision Puts Trout Habitat in Jeopardy

Added to the challenges to survival facing trout is a recent Supreme Court decision that weakened the Clean Water Act by making waters that are critically important to trout and trout habitat, including wetlands and intermittent streams, vulnerable to development and destruction. An estimated 20 million acres of wetlands and as much as 60 percent of stream miles that do not flow year round are threatened due to the decision. Fortunately, members of Congress are attempting to pass legislation to protect these critical areas.[12]

Exploration and extraction of carbon dioxide–rich fuels—including natural gas and coalbed methane—has further undermined habitat preservation for trout throughout the West. Vast quantities of groundwater are extracted in the process of capturing coalbed methane, with the water then dumped into waterways, including rivers and streams. This groundwater extraction holds the potential to affect surface water flows, as the two are connected. But more importantly, the extracted water is often high in salts and, when dumped, can impact water quality in trout streams. In addition, fragile populations of native Colorado River cutthroat trout, such as those on Colorado's Roan Plateau, face the likelihood of the release of industrial toxins into the streams they inhabit, as well as the potential for stream-choking erosion due to road building and drilling site work.[13]

CHAPTER 2

Impacts of Global Warming Endanger Trout and Their Habitat

Many scientists believe that trout in the interior West are particularly vulnerable to climate change because they live in environments already made fragile by human impacts. And now global warming poses larger, more profound, landscape-scale impacts that include drought, reduced snowpack, increased stream temperatures, invasive species proliferation, and fire.

Diminished Snowpack Reduces Needed Water Flows

Among the negative impacts of global warming, its effects on snowpack are among the most troubling. In the interior West, high-elevation snowpack serves as a natural water storage system, and in some regions it is the primary source of water. Western snowpacks melt slowly through spring and into early summer, releasing water gradually to the streams and the groundwater systems they charge. Snowpack then builds back up in the late fall and winter to produce water for the subsequent year.

Most populations of native trout in the West have evolved around this water cycle, timing spawning or movement to rearing and foraging areas with the rise and fall of streams caused by spring melting of snowpack. Healthy snowpacks that melt gradually enable streams to maintain flows and cool temperatures well into the hot summer months, allowing coldwater fish such as trout to survive.

For much of the past half century, average snowpack levels in the West have been less than the historical average.[1] Further, the snowpack that does exist is now melting faster. Recent studies have shown that since the late 1940s, overall spring snowmelt in much of the West has been occurring sooner.[2] In some locations in the West it is running off 20 to 30 days earlier than normal.[3] The increase in spring snowmelt is caused by a number of factors, including higher spring temperatures (causing melting and evaporation) and more occurrences of rain rather than snow falling on the accumulated snow (speeding up melting).

A study published by the journal *Science* in early 2008 examined all possible causes for the American West's dramatic decline in snowpack. While the study considered natural variations in temperature and precipitation, as well as the potential effect of global volcanic activity, it concluded definitively that human-caused global warming is a primary culprit in snowpack decline.[4]

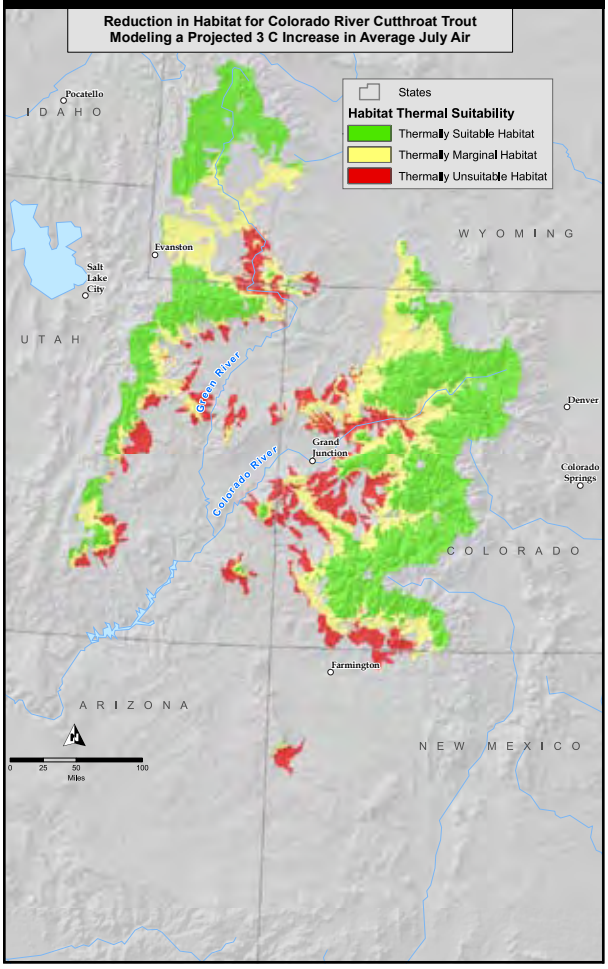
For additional analysis of the impacts of global warming on cold-water species such as salmon and trout—and approaches for increasing their resistance and resilience to climate change—read the October 2007 Trout Unlimited report entitled *Healing Troubled Waters: Preparing Trout and Salmon Habitat for a Changing Climate*. The report and other useful materials are available at www.tu.org/climatechange.

A study published in the Transactions of the American Fisheries Society in 1999 created a model to project other likely impacts of climate change on trout in streams in California's Sierra Nevada Mountains. The study found that the combined effects on trout of increased water temperatures and altered runoff due to reduced or rapidly depleted

snowpack could be severe. Assuming a 3.6 degree Fahrenheit increase in water temperature, the model predicted that both brown and rainbow trout would no longer be able to inhabit the lower reaches of most streams.[5]

The impacts extend beyond higher stream temperatures. Many trout species have evolved to time their spawning behavior around snowpack melt.[6] The above-mentioned study also predicted that populations of fall-spawning brown trout would decrease. Winter floods resulting from early melt of snowpack or triggered by more frequent rain-on-snow events, both caused by higher winter temperatures, would be severe enough to scour incubating eggs from the spawning nests of brown trout. This scenario—with its combination of higher stream temperatures and spring flooding—will likely occur throughout the West, especially if steps are not taken to reduce the rate of global warming.[7]

Increased Temperatures Threaten Habitat for Colorado Cutthroat Trout



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Increased Temperatures Make Streams and Rivers Uninhabitable

As ectotherms—or cold-blooded animals—trout depend on their environment to regulate their body temperatures. Water temperatures in the range of 50 to 63 degrees Fahrenheit are generally ideal for most trout to breathe, feed, metabolize food, evade predators, and spawn (cool water is essential to trigger spawning activity and incubate eggs).[8] Cooler water generally contains higher concentrations of dissolved oxygen, which is important for trout respiration, and for development of embryos in the eggs they deposit in streambeds. Most trout species begin experiencing physical problems when stream temperatures reach the high 60s. While species such as brown and rainbow trout can tolerate slightly higher temperatures, particularly if high levels of dissolved oxygen are present in the water, most species cannot. Lethal ranges begin to occur in the mid-70s.

Unless steps are taken to curb greenhouse gas emissions, scientists predict that average temperatures in the western United States could rise 3 to 10 degrees Fahrenheit by the end of the century—on top of the 1.7 degrees increase that has already occurred.[9] They have also noted that the frequency and magnitude of extreme weather events will increase, especially extremes of heat and drought. Those higher air temperatures are problematic for trout in the interior West, especially those already living at the upper end of their natural thermal range.

A study published in the *Journal of Environmental Engineering* in 2005 examined the complex relationship between air temperatures and stream temperatures. The majority of streams in the study showed that water temperature increased approximately 1 to 1.2 degrees Fahrenheit for every 1.8 degrees Fahrenheit increase in air temperature. The study further indicated that surface water temperature in many streams will increase dramatically (3.6 to 5.4 degrees Fahrenheit) if air temperatures increase 5.4 to 9 degrees Fahrenheit, one of the upper-end warming predictions made using current climate models.[10]

The study's authors also noted that in streams currently displaying low dissolved oxygen concentrations, an increase in summer stream temperatures could cause levels to fall into a critically low range, threatening the health of many aquatic species, including trout and food sources, such as aquatic insects upon which they rely.

In many streams and rivers in the West, trout are already living at the upper end of their natural thermal range. This means that a slight warming of stream temperatures of only a couple of degrees could render those streams uninhabitable. Drought could further complicate conditions by lowering streams flows. Lower streamflows generally produce shallow water, which warms more quickly in the daytime heat and provides for fewer deep, cool pools and runs into which trout can escape.

The Yampa River: Disaster Barely Averted

In July 2007, Colorado's Yampa River became a case study for the kinds of threats to trout that could become more common due to global warming and higher temperatures. With high air temperatures and river flows down to 20 percent of normal, state officials instituted a fishing closure on a section of the river. By the end of the month, water temperatures approached 79 degrees Fahrenheit, dissolved oxygen levels plummeted, and fish were at the limits of survival. Fortunately for the Yampa and its population of brown, rainbow, cutthroat, and brook trout, rains and cooler temperatures followed in August, helping remedy the crisis. But with global warming leading to hotter and drier conditions, serious fish kills could occur the next time temperatures rise.[11]

While global warming presents a greater threat to fish living in river and stream habitats, trout lakes are not exempt from the challenges of higher air and water temperatures. One study found that global warming could reduce overall suitable habitat for cold-water fish across the continental United States by 45 percent.[12] In lakes, higher temperatures can result in an increased proliferation of nuisance algae, which can reduce oxygen levels over time. Shallow lakes will be susceptible to warming water temperatures, making them unsuitable for cold-water species like trout. Even deep, higher-elevation lakes could be compromised. Deeper sections of lakes sometimes have lower dissolved oxygen levels because they are not fed by oxygen rich springs, aerated by wind action, or vertical circulation of the water column. Under these circumstances, when the surface of a lake warms significantly due to higher air temperatures, trout will have difficulty finding a layer of cold, oxygenated water.

Proliferation of Diseases and Invasive Species Pose Threat

One of the most serious threats facing trout in the West in recent years is a battle with whirling disease, a potentially fatal parasitic infection that attacks juvenile trout and salmon and thrives in warmer and low-flow water conditions. Rainbow trout and cutthroat trout are especially susceptible. Native to Europe, whirling disease was first observed in the United States in the 1956. Today it exists in streams throughout the interior West.[13]

Research conducted in 1997 in Montana on the Missouri River and Little Prickly Pear Creek, an important spawning tributary, concluded that the parasite that causes whirling disease thrives in stream temperatures that range between 50 and 60 degrees Fahrenheit; infection rates drop dramatically when temperatures fall below 50 degrees, a range common to healthy upper elevation trout streams, especially those that are nurseries for young fish.[14] Further, a common aquatic worm that is the essential alternate host for the two-stage whirling disease parasite thrives in the sediment- and

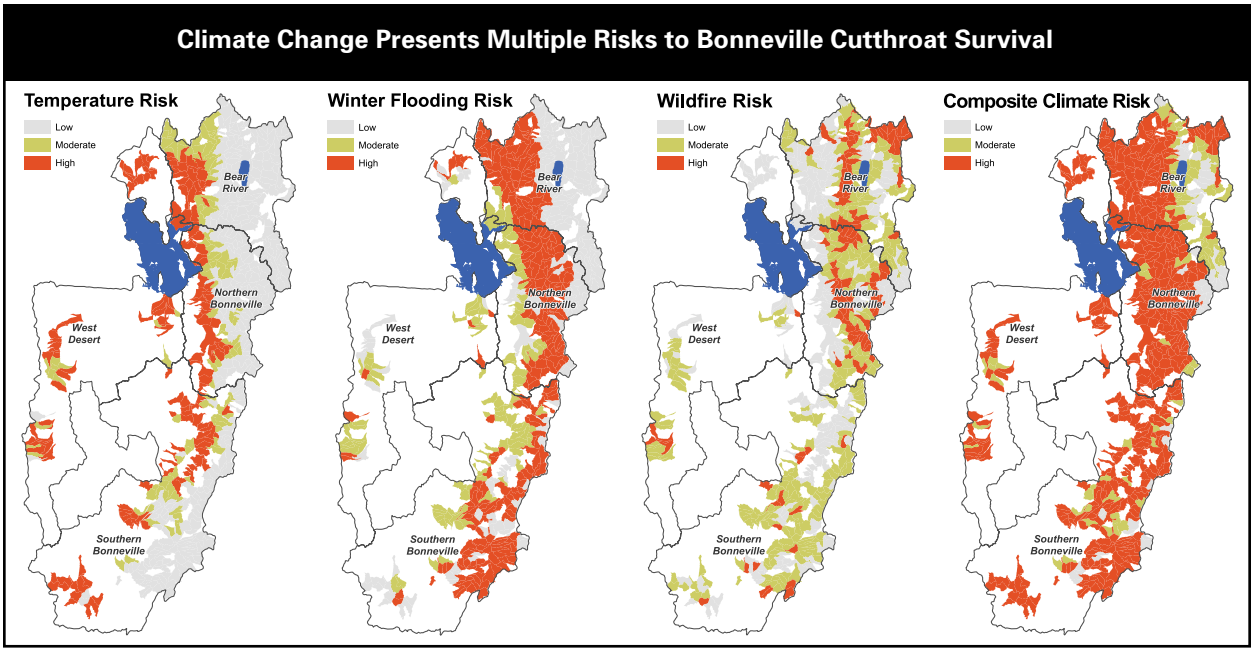
nutrient-rich streambeds that build up when diminished snowpacks lead to lower spring runoff flows.[15] By providing an environment hospitable to invasive species such as the parasitic spores that cause whirling disease, global warming has the potential to directly reduce trout populations.

Among other biological threats to trout, scientists in New Zealand theorized in a 2004 study that the recent proliferation of the single-cell alga *Didymosphenia* in many of the West's trout streams might be due to increased exposure to ultraviolet radiation brought on by warmer winters and reduced flows.[16] *Didymosphenia*, also referred to as didymo, or rock snot, can completely cover a streambed, diminishing macro invertebrate populations that are the primary food source for trout. In recent years, the prevalence of nuisance blooms associated with didymo have expanded throughout the western United States in rivers and streams in Colorado, Montana, New Mexico, and elsewhere.

In addition to an increase of invasive species like whirling disease and didymo, higher stream temperatures likely will favor fish species not native to the West's coldest waters. For example, slightly warmer stream temperatures could allow brown and brook trout, which are not native to the interior West, to move into some stream sections currently occupied by native cutthroat trout, which prefer colder streams. Higher stream temperatures also create opportunities for introduced populations of warm- and cool-water species such as bass or walleye to either out-compete or prey on trout, rendering it even more difficult for cold-water fish types to survive.

More Frequent and Larger Fires Threaten Trout Habitat

Drier climates in the interior West will also increase the potential for larger and hotter wildfires. While fire has always been a natural and important part of the West's climatic landscape—and native species of trout and salmon have evolved with it—studies have shown that earlier spring snowmelt and hotter, drier summers have resulted in an increase in the number, size, and duration of wildfires in the region.[17]



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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.

Some large fires can have a serious impact on trout habitat. Fire can destroy streamside growth, including trees that provide shade and cool water in summer or maintain thermal cover that prevents harmful "anchor ice" buildup on streambeds in winter. Anchor ice, which forms on stream bottoms when streams have little streamside vegetation and are exposed to lengthy freezes, can reduce available winter habitat for trout, reducing the number of trout a stream can support.

Fire can also lead to increased erosion. Often triggered by snowmelt or hard rains on top of raw, burned landscapes, erosion can wash large amounts of sediment into streams, choking spawning gravels and filling up pools that trout use to escape predators. Rain or snowmelt on burned landscapes that are zigzagged with logging roads can cause roads to cave into streams, or create torrents that plug culverts with debris, which in turn fail and cause severe erosion and streambank damage.

Researchers at the Scripps Institution of Oceanography and the University of Arizona examined 34 years of forest fire reports in 11 western states. They found that the number of fires has increased in size and severity since 1987, corresponding to increasing average spring and summer temperatures in the region. The study found that the greatest increase in forest fires was in the northern Rockies, in the mountains around Yellowstone National Park, and in Montana and Idaho's Bitterroot Range at elevations between 6,000 and 8,000 feet. The researchers observed that in these regions, melting snowpack plays a key role in determining forest fire risk.[18]

Warming temperatures have also accelerated the spread and winter survival of forest insects such as bark beetles and budworms. In many areas of the interior West, bark beetles have recently decimated large tracts of lodgepole pine. The infestations have left behind vast acreages of dead trees, further increasing the likelihood of extremely volatile forest fires. With projections of even higher air temperatures as a result of global warming, coupled with more frequent drought, the prospect for more frequent and larger fires is likely throughout the interior West.

Though western trout have evolved around fire, populations of many species native to the region have diminished so dramatically in number, and become so fragmented and scattered, that they are now susceptible to localized fire-caused impacts. Today, some of the most vulnerable populations of trout in the West are those that once adapted reasonably well to fire events. Now, however, their populations are so reduced and fragmented that they have lost much of their resiliency and are more susceptible to fire. Such populations include New Mexico's Gila trout and Utah's Bonneville cutthroat, two native fish that teeter on the edge of extinction and have had local populations harmed by recent fires.[19]

Global Warming Causes Loss of Needed Genetic Diversity

Genetic diversity is important for all species, including trout, as it is the inherited means by which they are often able to confront long-term challenges to their survival. Because behavioral traits essential to survival are often expressed in a fish's genetic material, it is important to ensure that within populations of a species as much diversity as possible is conserved. This diversity helps ensure there are always individuals or groups in a population that are resilient to the things nature presents, including natural droughts, predators, diseases, and landscape-altering events such as fire.

Today, the populations of all native species of trout in the West are just a fraction of what they once were historically. Many individual populations are now fragmented across large areas, resulting in genetic isolation. While maintaining or restoring connectivity among populations is important to ensure continued genetic diversity, global warming threatens genetic diversity because it threatens to further isolate populations of native trout by making much of their existing habitat unsustainable.

The experience of the bull trout is illustrative of the dangers of fragmentation and isolation. Currently listed as threatened under the federal Endangered Species Act, bull trout inhabit high-elevation tributaries, large rivers and some lakes in the West. At one time, the fish could be found from Washington and western Montana to northern Nevada and California, but their populations have been reduced considerably due to increased water temperatures, poor water quality, low flows, as well as hybridization, predation, and competition from introduced species such as brook trout and lake trout.[20] Under certain upper-level warming projections, remaining habitat for bull trout in Montana, Idaho, and eastern Oregon and Washington would diminish significantly—by as much as 27 to 99 percent. If that were to occur, the fish would remain in only a few high-elevation strongholds, becoming functionally extinct because the populations would be too small and isolated to guarantee ample genetic flow.[21]

CHAPTER 3

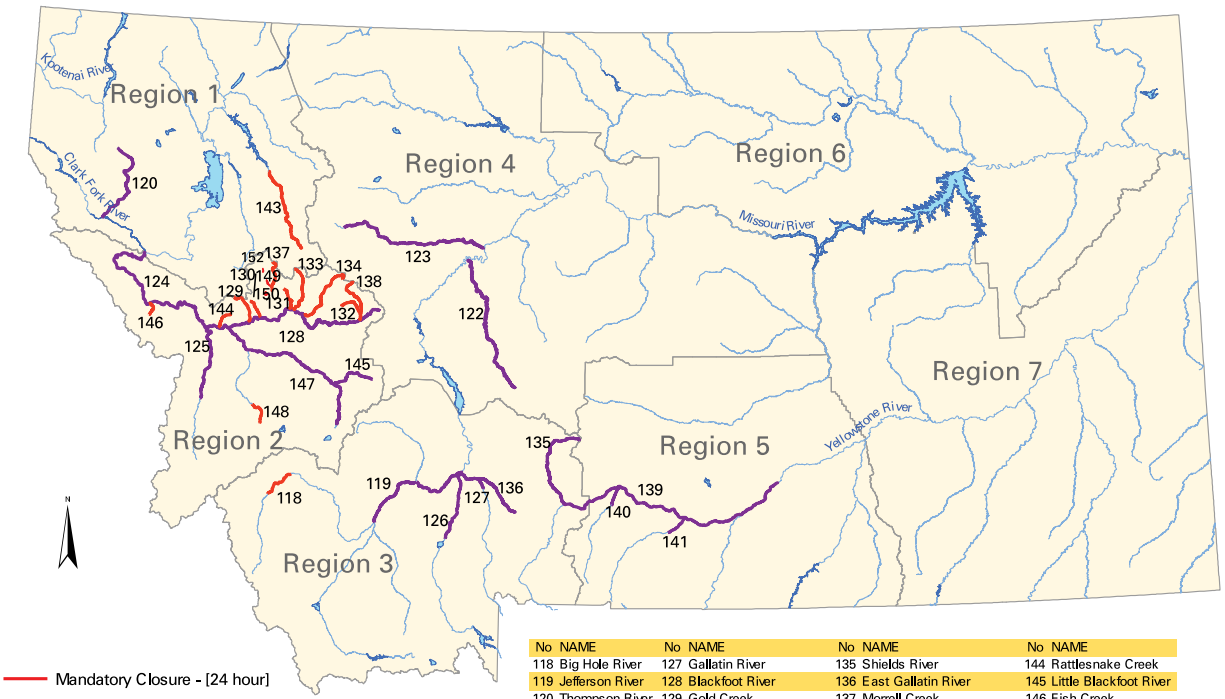
Declining Trout Populations Hurt Western Economies

Sportfishing in the United States is a huge industry, driven by 40 million anglers generating $45 billion in retail sales. With the West being the epicenter of trout fishing in the United States, fishing is big business there as well, pumping hundreds of millions of dollars into state economies throughout the region. Further, the attraction of having high-quality trout angling nearby has been a magnet for entrepreneurs to invest in new businesses in the region. Thus, if global warming reduces trout populations, it could cause broad, deep, and hard-felt impacts on the economies of western states. Tourism spending and small-business growth, as well as jobs and tax revenue, could diminish.

In the West, many local economies have sprung up around healthy, flowing trout streams. In Colorado alone, sportfishing in 2002 had a total economic impact of more than $800 million and supported nearly 11,000 jobs.[1] In Montana, with its relatively small population of 950,000 people, angling generates nearly $300 million per year, most of which comes from in-state and out-of-state trout anglers.[2] In Wyoming, a 2005 study examined the income and employment contribution of the reach of the upper Snake River from Jackson Hole to the confluence of the Henry's Fork, including the Henry's Fork, and found huge benefits from that fishery to the local economy. Estimating the net economic value of anglers, boaters, and other visitors to the river, the study determined that fishing and boating on the Upper Snake River has created 1,460 jobs, and produced $46 million in annual income. Outfitters, hotel and motel owners, restaurant owners, employees, and communities near river systems all benefit economically from healthy trout habitats.[3]

Global warming and its impacts pose tremendous challenges to the region's sportfishing industry—a fact increasingly recognized by states in the region. A 2005 report by a group of New Mexico state agencies identified the threat of global warming to that state's tourism industry. They concluded that global warming will likely increase the frequency and duration of forest closures because of wildfire hazards, and that projected trout habitat will be dramatically reduced because of warmer stream temperatures. They also noted that reduced opportunities in these and other forms of outdoor recreation, "will not only impact the quality of life for New Mexicans, but will likely harm the state's economy because outdoor activities are a major attraction to tourists."[4] During recent major fires in Colorado, visitor numbers fell by 40 percent in some areas of the state and reservations at state campgrounds dropped 30 percent, directly impacting those at the local level who cater to anglers and other tourists.[5]

Montana Fishing Closures and Restrictions on August 14, 2007



No	NAME	No	NAME	No	NAME	No	NAME
118	Big Hole River	127	Gallatin River	135	Shields River	144	Rattlesnake Creek
119	Jefferson River	128	Blackfoot River	136	East Gallatin River	145	Little Blackfoot River
120	Thompson River	129	Gold Creek	137	Morrell Creek	146	Fish Creek
122	Smith River	130	Belmont Creek	138	Landers Fork	147	Clark Fork River
123	Sun River	131	Cottonwood Creek	139	Yellowstone River	148	Rock Creek
124	Clark Fork River	132	Copper Creek	140	Boulder River	149	Seely Lake
125	Bitterroot River	133	Monture Creek	141	Stillwater River	150	Placid Lake
126	Madison River	134	North Fork Blackfoot R.	143	South Fork Flathead River	152	Lake Inez

Mandatory Closure - [24 hour]
Mandatory Closure - 2 PM to Midnight
Lake Mandatory Closure - 24 hours
Streams
FWP Region

*Map is updated as new closures are posted.
Refer to http://fwp.mt.gov/fishing/guide/waterclosure.aspx for a current list of all active closures.
Rev.15

0 12.5 25 50 75 100 Miles

Montana Fish, Wildlife & Parks

MAP COURTESY OF THE MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS

Drought-Related Fishing Closures in Montana, 2001 to 2007

REGION	2001	2002	2003	2004	2005	2006	2007
1	1			1	1		3
2	5		14			9	23
3	45	5	4	3	4	5	10
4	6	1	1		2	3	3
5	3		2		1		4
6					1		
7					1		
Total	60	6	21	4	10	17	43

DATA PROVIDED BY THE MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS

CHAPTER 4

Montana's Big Blackfoot River: A Model for Conservation

With headwaters on the Continental Divide, the Big Blackfoot River in western Montana has long been a vital trout fishery. In addition to its main-stem population of wild rainbow and brown trout, its tributaries provide crucial spawning and rearing habitat for rare native bull trout and westslope cutthroat trout. By the 1980s, however, the Blackfoot was typical of many struggling western rivers. Mining and agricultural and logging practices had degraded water quality and habitat, reducing the river's ability to sustain healthy trout populations. The result was a decline in the quality of the fishery, and with it a downturn in the angling opportunities the river could provide.

The Blackfoot provides an example of how diverse interests can work together to benefit not only a struggling trout fishery, but also the people and important values that exist around a river. It serves as an example of what—in addition to reducing greenhouse gas emissions—can be done to protect trout fisheries throughout the West.

An Organized Approach to Restoration

In the late 1980s, landowners and conservationists formed a local Trout Unlimited (TU) chapter to work at restoring this once great river. By the early 1990s, the chapter was engaged in dozens of habitat restoration projects aimed at improving trout populations. And the fish started to respond. Seeking to expand their efforts by ensuring that public agencies and landowners became larger partners in a basin-wide restoration effort, TU members worked with state and federal agencies to form a watershed group that brought in additional partners. This organization became the Blackfoot Challenge, which has since grown into a landscape-based partnership that includes private citizens, old and new ranchers, federal and state agencies, and conservation groups.

Along with dedicated volunteers of the Big Blackfoot Chapter of TU, the Blackfoot Challenge has helped improve the Blackfoot's trout fishery, as well as overall watershed health. This work includes restoration efforts on 51 tributaries, including 50 miles of stream-channel restoration and 80 miles of riparian improvement. Additional fish habitat improvements include elimination of human-caused barriers to fish movement, such as irrigation structures affecting 500 miles of stream, and the installation of 19 fish screens on irrigation diversions.[1] Large-scale landscape protections have also been put in place, including 95,000 acres of private lands placed under perpetual conservation easements. These protected acres are in addition to thousands more previously protected by federal and state agencies, as well as private land trusts.[2]

CREDIT: BIG SKY FISHING (WWW.BIGSKYFISHING.COM)

The Blackfoot River traverses mountains and forests near Whitaker Bridge in west central Montana.

A River Rebounding

The combination of habitat enhancement and flow improvements has brought significant positive impacts for trout populations. Bull trout redd (spawning nest) surveys in two of the majority tributaries to the Blackfoot have increased from a combined 18 redds in 1989 to 170 redds in 2001. Westslope cutthroat trout populations have increased tenfold in portions of some restored tributary streams.[3] Still, due to lingering drought, research on fish surveys in recent years indicate these impressive gains are in peril because of low flows and high stream temperatures—indicating that there should be no letup in these efforts.

One of the more impressive success stories of the Blackfoot Challenge has been its cooperative work among all stakeholders to help save trout in the face of low summer flows and high temperatures caused by a warming climate. The Blackfoot Challenge manages a voluntary drought management plan for the watershed under which snowpack and streamflows are tracked. When certain flow and temperature triggers are hit on different reaches of the Blackfoot River, irrigators are asked to reduce their water withdrawals and anglers are asked not to fish.

Success Through Collaboration and Cooperation

The success of the plan depends on the voluntary involvement of fishing outfitters, anglers, irrigators, local businesses, homeowners, and government agencies—all of whom are asked to contribute to the effort or to sacrifice a little so that no one interest suffers when water is short. For the past seven years, the plan has triggered reductions in irrigation withdrawals, angling bans on important tributaries, and fishing restrictions on the Blackfoot—all of which have combined to lessen the impacts of drought, reduced snowpack, and higher air temperatures on the river's trout.

The guiding principles of the efforts in the Blackfoot watershed are cooperation, trust, and consensus. The work requires constant adjustment, patience, and dedication. The successes in the Blackfoot watershed do not diminish the importance of reducing global warming emissions in order to ensure the survival of the majority of trout in the West, but the work in that single area does offer a guide—and hope—for trout and trout anglers throughout the West.

CHAPTER 5

Conclusion and Recommendations

The evidence is clear: global warming and its negative impacts on our climate is largely a human-caused problem that will increasingly harm trout populations throughout the interior West. But it is also within our power to reduce significantly the activities contributing to global warming pollution. Policies designed to slow, stop, and reverse emissions of global warming pollution are most needed at the federal level, but cities, states, and regions must act as well. Taking important steps to reduce emissions, support alternative energy sources, promote intelligent water use, and reduce impacts on local trout habitats can all help avoid catastrophic problems for trout, the environment, and ourselves.

Combating Global Warming

The good news is that solving global warming can be done, and it can be done with little or no harm to our economy. Recent studies conducted by the respected consulting firm McKinsey & Company and by the International Monetary Fund make this point clear. And with its abundance of solar, wind, and geothermal energy potential, the western United States is uniquely suited to be a major player in a clean energy economy that could bring tremendous economic development to the region.

Comprehensive Federal Action Is Needed

A growing chorus of leaders across the spectrum are calling for immediate action to reduce the lasting and potentially irreversible effects of global warming. In June 2008, a majority of Senators supported moving forward with "America's Climate Security Act" (S. 3036), also referred to as the Lieberman-Warner bill. In 2009, Congress will consider a variety of new global warming bills. We urge senators from Western states to support a bill that is at least as strong as the bipartisan Lieberman-Warner bill.

PHOTO COURTESY OF LANCESCHELVAN.COM

Regional Initiatives Are Part of the Solution

While federal action is crucial to combating global warming, state officials should also act now to stop global warming. To date, the governors of Arizona, California, Montana, New Mexico, Oregon, Utah, and Washington have signed the Western Climate Initiative (WCI), an agreement to reduce global warming pollution through a market-based system. Governors of these states, and others that join the Western Regional Climate Initiative, should insist that a range of comprehensive policies be implemented to ensure the WCI's targets of reducing carbon emissions 15 percent below 2005 levels by 2020 are achieved either on or ahead of schedule. Additionally, the WCI states must agree to the firm target of reducing emissions of global warming pollution at least 80 percent below current levels by mid-century.

Investments in Alternative Energy Sources Are Overdue

Elected officials should also work on securing larger investments in alternative energy sources such as wind, solar, geothermal, and energy efficiency to reduce the nation's—and eventually the world's—dependence on fossil fuels. The cost of inaction for trout, angling, and the culture and economies that depend on this treasured western resource will be significant. Avoiding this cost will require elected officials to make tough, forward-thinking decisions. The sooner and the more decisively we act to usher in the next generations of buildings, vehicles, fuels and energy, the greater our chances will be of avoiding the most dangerous effects of human-caused global warming and preserving the West we know and love.

Promoting Intelligent Water Use

The high demand for water in the west—and the competition that ensues—often complicates trout conservation efforts in the region. In many western states, municipal and public demand for water is outpacing locally available water resources, leading cities to build pipelines and tunnels to bring in water from far away, often from the headwaters of a river—the same headwaters trout need to help them survive in a warming climate.

Improving Federal and State Laws

Federal and state lawmakers must seriously consider how water is currently used in the West and pass legislation supporting sustainable water use. Laws and regulations governing water use, and water infrastructure such as large dams and other federal water projects, must be updated to respond to the challenges and opportunities of the 21st century. Such policies should take an integrated approach to water management in the face of a warming climate and fish and wildlife conservation in the face of declining water resources. Existing state laws that make it difficult, if not impossible, to protect trout must be changed.

For example, many states do not define protecting trout habitat as a beneficial use of water despite the huge financial benefits trout fishing brings to the West. If farmers or ranchers want to leave some of their irrigation water in-stream to help protect trout, they can lose their legal water right. It is time to modernize water laws and allow for trout conservation to become a priority.

City and local officials should implement smart policies that reduce overall water demand. These policies could include ensuring that household and industrial use is metered, and that water rates reward conservation. City officials should also examine ways wastewater at city treatment plants can be reused for industrial, municipal, household, or irrigation uses and promote voluntary programs or ordinances that encourage landscaping that requires little water.

Restoring and Protecting Local Trout Habitat

Working together, local government, watershed groups, and preservation organizations like the local Trout Unlimited chapter can restore degraded rivers and streams and buffer the impacts of global warming on trout by:

- Encouraging water managers to help improve water quality by reducing the runoff of pollutants—including high-temperature runoff—into trout streams and rivers.

- Advocating for increased protections for trout habitat from new roads, residential development along streams, harmful grazing practices, energy development, logging, and irresponsible all-terrain vehicle use, especially in the headwaters of trout streams.

What Individuals Can Do

To Combat Global Warming

When making lifestyle decisions you have the power to make choices that contribute either to the problem of global warming or its solution. Planting a tree, buying a fuel-efficient car or truck, driving less, getting an energy audit for your home, buying efficient appliances and lighting can all save energy and reduce emission of global warming pollution. It is estimated that if every household in the United States replaced one regular light bulb with an energy-saving model, the result would be the same as taking 6.3 million cars off the road.

Further, your choices can boost demand for more efficient products and send a signal to manufacturers that efficiency matters. Go to www.nrdc.org/globalwarming/gsteps.asp to learn what else you can do to make your own contribution toward reducing global warming.

To Reduce Demand for Water

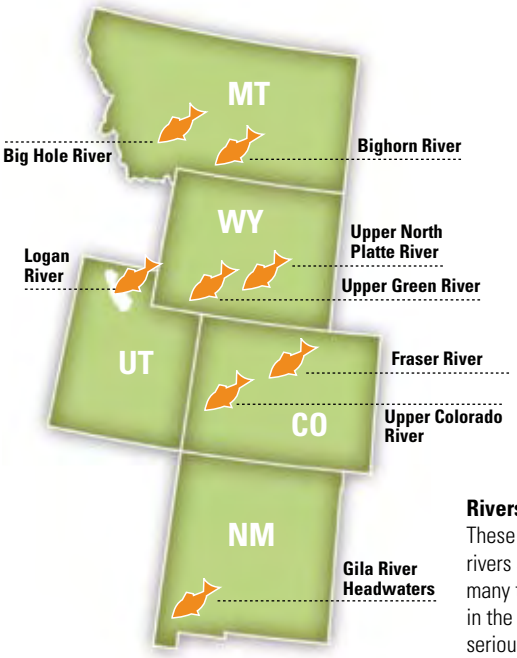
You can do your part to conserve water by installing water-saving devices throughout your home. Also consider encouraging the installation of similar devices at your office, school, and house of worship where the water and cost savings could be even greater.

To Reduce Your Impact on Trout While Fishing

First, and most important, respect fishing closures. Closures are put into place to help trout survive high stream temperatures caused by drought, water use, and high air temperature. Even when stream closures are not in place, there are a few things you should do if fishing when streamflows are low and temperatures warm: fish in the morning hours when temperatures are cooler, limit the length of time you play a fish, use barbless hooks, minimize the fish's exposure to the air, and release the fish as quickly as possible. Alternatively, you can fish high-elevation streams and lakes that remain cool in summer.

Case Studies: Rivers in Focus

Upper Colorado River
Location: Colorado
Trout at risk: Rainbow trout, brown trout
Worst global warming threats: Altered snowpack, invasive species proliferation



Rivers in Focus
These eight treasured rivers are among the many trout fisheries in the West that face serious threats from global warming.

Upper Colorado River, Colorado

In the West, the Colorado River is representative of the best recreational opportunities the region has to offer. Colorado's most famous river, big and bold, it is the one stretch of water people often think of when they consider what a western river is supposed to be.

The upper Colorado River in Colorado is a spectacular trout fishery. Beginning high in the Rockies in north central Colorado, the river tumbles steeply down until it meets the Fraser River. For roughly 20 miles downstream from the Fraser, the reach has been designated blue ribbon trout waters by the State of Colorado. It offers some of the best fly-fishing in the state for wild trout. Rainbows and large brown trout are commonly found amidst its deep pools, long riffles, and boulder-strewn runs.

In recent years, the Colorado River has received a lot of attention because low flows have impacted water storage levels in its massive downstream reservoirs like Lake Powell and Lake Mead, creating questions over whether those reservoirs will ever again fill to capacity. That dilemma has its roots, in part, in the upper reaches of the river in Colorado. Drought, reduced snowpack, and early snowpack depletion, coupled with water withdrawals for human and agricultural consumption, have all played a part in impacting normal flows on the Colorado River. These altered flows hold potential negative impacts for the Colorado River's famous trout fishery—consequences that could become far greater as the impacts of global warming continue to increase.

Climate statistics and flow data tell the story of a region struggling with the impacts of global warming. Since 1998, the Colorado River basin has seen below-average snowpack for 8 out of 10 years.[1] The average annual streamflow in the central Rocky Mountains over the last century has decreased by about 2 percent per decade, and since 1950, stream discharge in the Colorado River basin has similarly decreased.[2] The average air temperature in Colorado was 1.9 degrees Fahrenheit warmer from 2003 to 2007 than the average for the period from 1901 to 2000.[3]

Recent droughts in Colorado, coupled with reduced snowpack and quick melting of snowpack, have had a direct impact on river flows throughout the state, including its namesake. The span of time from 2000 through 2004 was the first period since modern recordkeeping began in 1922 in which there were five consecutive years of below-average flow in the Colorado River.[4]

Climate modeling projections for Rocky Mountain National Park predict continued earlier spring runoff, lower flows from late spring to fall, decreased snowpack, and decreased soil moisture. These impacts are expected to result in longer

and drier summers. For trout and trout anglers who value the Colorado River, especially the fishery on its upper reaches, this should be cause for serious concern.

The proliferation of whirling disease on the Colorado River is yet another reason anglers should be concerned by the prospects of global warming. Whirling disease has long plagued the Colorado River, but increased air temperatures and reduced snowpack will result in higher stream temperatures and increased siltation, which in turn could increase the opportunities for the parasite that causes whirling disease to thrive and infect trout.

The potential for fire due to global warming also threatens to negatively impact the Colorado River fishery and to diminish the economic activity fueled by the river. A Colorado State University analysis of the impacts of climate change on Rocky Mountain National Park determined that, under predicted climatic changes, fire frequency and extent is expected to increase substantially.[5] Recent fires and fire conditions in Colorado have already impacted tourism, including angler visits and expenditures.[6] For upper Colorado River counties like Grand, Eagle, and Garfield, which receive roughly $70 million in annual economic activity due to fishing, the potential impact could be large.[7]

Fraser River
Location: Colorado
Trout at risk: Rainbow trout, brown trout, Colorado River cutthroat
Worst global warming threats: Altered snowpack, high air temperatures
Complicating factors: Transbasin diversions further reducing flows on the river

Fraser River, Colorado

The Fraser River and its trout have long made their mark in American history. Herbert Hoover fished there. During his presidency in the 1950s, Dwight Eisenhower regularly traveled to the Fraser River and its tributary St. Louis Creek to fish for trout. Eisenhower traveled there so often, in fact, that the nearby ranch where he would stay became known as the Western White House.

The Fraser continues its distinct history as one of only three remaining major tributaries to the Colorado River that does not have a dam. The river begins on the west side of Berthoud Pass in the Rocky Mountains, then flows north a mere 28 miles before joining the Colorado River at Granby, Colorado. Along the way, it picks up many smaller streams, passes through the towns of Winter Park and Fraser, and runs through a steep canyon that has received a special Wild Trout Water designation from the State of Colorado. The Fraser's pools and runs are home to rainbow and brown trout, as well as an occasional cutthroat that will come into the mainstream from one of the small tributaries.

One might reason that a small free-flowing river that begins high in the snowfields of the Rocky Mountains would enjoy a natural buffer against the impacts of global warming. Unfortunately, that is not the case for the Fraser or its population of trout. The Fraser River of today is not the Fraser of America's presidents. A large quantity of the river and in its headwaters have been diverted through tunnels to help quench the thirst of the rapidly growing population along Colorado's Front Range, including Denver. These diversions collect and convey water from the river and its tributaries and move it through the massive Moffat tunnel. More than 60 percent of the flows that were historically destined for the Fraser and its trout are shipped to the Front Range.[8] Due to these trans-basin diversions, the Fraser River today frequently suffers from low flows and high water temperatures, particularly in the late summer months. As a result, its trout often suffer.

It is estimated that approximately 70 percent of the Fraser's annual streamflow comes from the upper elevation snowmelt that usually occurs in May, June, and July.[9] If that snowpack is reduced, or melts off earlier (as has been the case in recent years), and air temperatures increase even more (they've already increased 3.1 degrees Fahrenheit over the last 100 years) and drought becomes more frequent, the combination could be fatal for both the river and its trout.[10] Low flows will also increase the likelihood of increased sediment, a problem with which the river already struggles, impacting not only water quality but also the invertebrates trout depend upon as a food source.

To make matters worse for the Fraser and its historic trout fishery, the City of Denver has been considering the possibility of increasing its diversions from the river.[11] If that occurs, not only would the Fraser suffer further and become even more vulnerable to global warming, but the upper Colorado River's gold medal trout waters, which begin at its confluence with the Fraser, would also be seriously impacted.

Big Hole River
Location: Montana
Trout at risk: Brown trout, rainbow trout, brook trout, westslope cutthroat
Other coldwater fish of concern: The river also contains the last remaining population of native fluvial grayling in the lower 48 states
Worst global warming threats: Altered snowpack, high air temperatures

Big Hole River, Montana

A famous trout fishery, and one of the last of a handful of free-flowing rivers in the West, the Big Hole is considered by many to be Montana's most beautiful river. It begins in the Beaverhead Mountains as the outlet of Skinner Lake, and then flows for 155 miles before emptying into the Jefferson River near Twin Bridges, Montana.

Known worldwide as an incredibly diverse fishery, the Big Hole is home to wild populations of rainbow, brown, cutthroat, and brook trout. The river has been considered one of the nation's most vibrant fishing destinations and is referred to as "Montana's last best river."

While the Big Hole is well known for its populations of wild trout, it also contains the last population of native stream-dwelling, or fluvial, arctic grayling in the lower 48 states. The fluvial grayling is a member of the trout family. Its most distinguishing feature is its large dorsal fin. Although a candidate for listing under the federal Endangered Species Act,[12] the federal government has thus far refused to list the fish, a decision that has been widely criticized.[13]

Still, ask anyone in Montana which trout fishing river system will likely feel the greatest impacts due to global warming, and many will cite the Big Hole. The health of the Big Hole, like other free-flowing rivers in the interior West, depends heavily upon snowpack. The river is almost completely dependent on snowpack-based runoff from the Beaverhead, Pioneer, and Anaconda Mountains.

The ongoing 10-year drought in Montana—coupled with decreased snowpack, earlier snowmelt, and air temperatures that were 2.1 degrees Fahrenheit warmer from 2003 to 2007 than the average for the period from 1901 to 2000—has decreased flows on the Big Hole and increased its water temperatures.[14] Irrigation withdrawals from the river have further compounded the problem of low flows.

Records compiled by the U.S. Geological Survey have revealed that the Big Hole historically enjoyed healthy fish-sustaining flows. In recent years, though, spring and summer flows on the river have at times dropped dramatically. In the summer of 2007, near Wisdom, Montana, flows on that section of the river were a mere 13 percent of median flow—far less than levels fisheries experts have determined necessary for minimum survival conditions for the river's cold-water fish.[15]

A voluntary drought management plan was established on the Big Hole in 1997, and as a result the river has seen mandatory fishing closures on many of its reaches during the past nine summers. In some reaches, closures have been put in place every summer to help protect its resident trout and grayling from stress caused by fishing.[16]

The current problems experienced by the Big Hole—low flows and high temperatures brought on by drought, reduced snowpack, and irrigation withdrawals—could be compounded dramatically by further warming and climate changes. The river's trout face a great deal of uncertainty if stream conditions continue to deteriorate. Recent stream surveys have shown decreased populations of spawning-age grayling—less than 30 per mile on some reaches of the river—which biologists attribute to low flows in the spring when the fish traditionally spawn, as well as diminished water in summer when temperatures are high. And according to a 2005 environmental assessment by the State of Montana,

populations of brown and rainbow trout have also decreased significantly on portions of the river due to drought and increased stream temperatures. [17]

For the angling industry in the region, any negative impact on the Big Hole will be widely felt. According to a survey conducted by the Institute for Tourism and Recreation Research, in 2001 and 2002, nonresident tourists spent more than $25 million, including $1.4 million on outfitters, in Beaverhead County, which includes most of the Big Hole River. The survey also concluded that 17 percent of those surveyed identified fishing as the primary attraction in the county.[18]

Big Horn River
Location: Montana
Trout at risk: Brown trout, rainbow trout
Worst global warming threats: Drought and altered snowpack
Complicating factors: A tailwater, the Bighorn River's trout population is dependent on the Bureau of Reclamation's operation of the Bighorn reservoir

Bighorn River, Montana

One of the most famous trout fishing destinations in the world, the Bighorn River in Montana has in the past been synonymous with large populations of big trout. The fishery has been so robust that fish counts during the 1980s found as many as 11,000 wild rainbow and brown trout per mile in the tailwater section of the river.[19]

The construction of Yellowtail Dam and the Bighorn Reservoir near Fort Smith in 1965 created the famous tailwater fishery. And while one might think that the existence of the reservoir—which backs up more than 70 miles of water into canyons hundreds of feet deep—would make the cold-water fishery below the dam impervious to the impacts of global warming, the opposite could be true.

Prolonged drought and reduced snowpack, two of the more commonly predicted features of global warming, have caused reservoir elevations in recent years to drop to some of the lowest levels since the dam was built. In the fall of 2007, the U.S. Bureau of Reclamation reported that inflows to Bighorn Reservoir had fallen to 54 percent of average. That announcement confirmed that yearly inflows into the lake had fallen below normal for seven years.[20] At times reservoir levels have fallen so low that some boat launches on the lake have become unusable. Not coincidentally, data from the U.S. Western Regional Climate Center showed that Montana recorded its hottest July ever in 2007.[21]

For the fabled 13-mile trout fishery below the reservoir, reduced inflows into the reservoir have meant bad news. The Bureau of Reclamation reduced flows down the river in 2007 to as low as 1,500 cubic feet per second to help raise reservoir levels. Those releases were well below the 2,500 cubic feet per second that fisheries experts believe is necessary, in the long term, to sustain healthy trout populations. State of Montana officials have estimated that reduced flows on the river due to drought and reduced snowpack have decreased populations of brown trout on the river from 9,000 per mile in 1997 to around 2,000 today.[22]

The operation of the reservoir and the amount of water the Bureau of Reclamation releases down the river have resulted in a growing dispute between the States of Montana

and Wyoming. Reservoir users and promoters in Lovell, Wyoming, want the operators of the dam to reduce flows out of the reservoir to help keep lake levels higher, ensuring that boat ramps at a nearby marina are touching water and thereby encouraging development of a tourism economy. Trout anglers and other river advocates want outflows to be maintained at levels necessary to protect trout habitat in the tailwater reach, as well as the $30 million in annual economic activity the fishery brings to local communities such as Fort Smith, Montana. It has been estimated that between 70,000 and 90,000 angler days are spent annually on the trout waters below the reservoir.[23]

The debate over how to balance competing water uses associated with Bighorn Reservoir and the Bighorn River trout fishery provides a glimpse at what a future under global warming holds, not only for that particular tailwater fishery, but similar fisheries throughout the interior West. Drought, reduced snowpack, higher air temperatures, and competing demands for a dwindling supply of water due to over-allocation will mean that tailwater fisheries such as the Bighorn River will continue to face serious—and possibly even greater—challenges into the future.

Gila River Headwaters
Location: New Mexico
Trout at risk: Gila trout
Worst global warming threats: Fire, drought, increased air temperatures

Gila River Headwaters, New Mexico

Fire has always been a feature of the southwestern United States, particularly during periods of large-scale, persistent drought. But nearly a century of fire suppression, coupled with a bark beetle invasion (exacerbated by a warmer climate) and hotter and drier conditions brought on by global warming, have created the potential for massive fires in the region that will have major impacts on ecosystems and trout populations throughout the state of New Mexico.[24] Temperatures in New Mexico were 1.3 degrees Fahrenheit hotter from 2003 to 2007 than the average for the previous 100 years.[25]

Nowhere in New Mexico are trout more threatened by global warming and fire than in the headwaters of the Gila River, home to some of the last remaining populations of Gila trout. Small shallow streams such as South Diamond Creek, Upper White Creek, Lower Little Creek, Black Canyon, and Main Diamond Creek provide a refuge for this magnificent iridescent gold- and copper-colored fish.

The Gila River rises in the Elk Mountains in southwestern New Mexico. From there, it flows west through desert lands into Arizona. From a distance, as it winds through a formidable landscape, the Gila does not look as though it could ever support cold-water fish such as trout. But at one time, the Gila trout occupied much of the river system and its adjacent drainages.

By the 1950s, hybridization with non-native trout, poor land-use practices, pollution, and water withdrawals had raised water temperatures and reduced the Gila trout's range to only five streams in the Gila River's headwaters in New Mexico.[26] This habitat encompassed a mere 20 miles, compared to the 600 miles the fish had historically occupied in the region prior to the turn of the century.[27]

When the Gila trout was listed as endangered under the Endangered Species Act its population had dwindled to fewer than 10,000 fish.[28] While the Gila trout's endangered listing was recently upgraded to threatened, and it can now be fished for under strict catch-and-release guidelines on certain streams, its survival is still tenuous, particularly in the face of climate change–driven wildfire.

One analysis found that, on average, fire that impacts the survival of Gila Trout has occurred every two years.[29] Due to its fragmented populations, wildfire is the most significant risk factor for the sustainability of the fish. Since 1989, wildfires and the resulting floods and ash flows they produce have annihilated populations of Gila trout on seven streams.[30]

Logan River
Location: Utah
Trout at risk: Brown trout and rainbow trout in the lower reaches, Bonneville cutthroat in the upper reaches
Worst global warming threats: Altered snowpack, higher air temperatures, drought, fire, invasive species proliferation

Logan River, Utah

When it comes to trout, trout fisheries, and global warming, Utah faces unique challenges. Its cold-water streams have always served as an oasis amidst an arid and semi-arid landscape. But this environment also makes those resources highly vulnerable to the impacts of a warmer and drier climate.

Climate models project that temperatures in Utah will increase at a rate greater than the average for the entire globe. The state is also expected to experience periods of prolonged drought and reduced and/or rapidly depleted snowpack. Certain areas will also see increased levels of precipitation in the form of rain that could potentially result in flooding.[31]

If global warming pollution is not curbed, average temperatures in Utah by the end of the century could be 7 or more degrees Fahrenheit higher than today. According to published reports, the average temperature in the state was 2.1 degrees Fahrenheit warmer from 2003 to 2007 than the average for the period from 1901 to 2000.[32]

Utah's Logan River, which begins in the Wasatch Mountains, is an example of a waterway that could potentially face severe consequences from global warming. The Logan is important not only for its historical status as one of the best trout streams in the intermountain region but also for the trout it contains. Its lower reaches are populated by stocked rainbow and brook trout, as well as wild brown trout. But the Logan's upper reaches and its headwaters and tributaries are home to a significant population of wild Bonneville cutthroat trout, the state fish of Utah.

In spite of once having thrived in numerous locations, by 1978 only six populations of Bonneville cutthroat trout were known to exist in Utah.[33] And while today those populations have expanded since 1978, the long-term survival of the fish remains in question. The Fish and Wildlife Service has initiated a status review of the Bonneville cutthroat trout to determine if the species is warranted for listing under the Endangered Species Act in any significant portion of its range.

Global warming presents a myriad of challenges for the Logan, and especially for its population of Bonneville cutthroat. Further reduced or earlier-melting snowpack will have a significant impact on the upper river and its tributaries, especially if combined with higher air temperatures and drought.[34] A preview of the potential impact took place from 2000 to 2004 when drought caused the river to suffer from higher temperatures and lower stream flows. Sampling showed that the abundance of cutthroat decreased at several locations on the river.[35]

Higher stream temperatures will not only compromise the ability of the fish to survive thermal stresses but could encourage more competition from brown trout as they move further upstream into the zones now dominated primarily by cutthroat. An increased incidence of fire, caused by drought and insect threats such as the bark beetle, and potentially the gypsy moth, is another likely threat.[36]

SCOTT SMITH (WWW.SCOTTSMITHPHOTO.COM)

Declining forest health, drought, and insect invasions have placed most of Utah's forests in the moderate- to high-risk category for catastrophic forest fire.[37] A fire in 2002 devastated populations of Bonneville cutthroat trout in several streams in the state when six inches of sediment and flash flooding inundated the stream channel.[38]

Instream invasive species is yet another climate change threat the Logan faces. Whirling disease exists in the river and has been carefully monitored since its appearance. Thus far, no significant trout population declines have occurred due to the disease.[39] But if mean stream temperatures increase to levels conducive to the parasite, that situation could easily change.

Upper Green River
Location: Wyoming
Trout at risk: Brown trout, rainbow trout, brook trout, Colorado River cutthroat
Worst global warming threats: Altered snowpack, drought
Complicating factors: A proposal to build a dam on the upper Green River would further complicate the ability of the river's population of trout to survive

Upper Green River, Wyoming

When you say "The Green," nearly every trout angler instantly knows what you're talking about. Without question, the Green River is one of the most popular recreational trout fisheries in the United States.

While the tailwater sections of this river, including the one below the Flaming Gorge Reservoir, receive a lot of attention, it is the upper Green River in Wyoming that is truly incredible. Home to rainbow, cutthroat, brown, and brook trout, it is a natural river that rolls through a stunning landscape of foothills, ranchland, sagebrush, and rich riparian habitat.

The headwaters of the Green in Wyoming, which help feed the entire river including its upper section, begins in the Wind River Range—the state's longest and highest mountain range. For anglers who value this fishery, that fact should be cause for concern because it relates to the potential impact of global warming upon the river. Air temperature increases, reduced snowpack, and drought have the potential to impact not just the upper Green but the entire river system.

Like all of Wyoming's rivers, the Green is snowpack dependent.[40] Historically, the Wind River Range has received precipitation levels between 40 and 60 inches annually, while the lower elevations in the region historically receive between seven and nine inches per year.[41] Roughly 70 percent of the runoff the Green River basin receives comes from snowpack.[42]

To understand what is happening in the Wind River Range in terms of global warming, one need only to look at its glaciers. The largest concentration of glaciers in the American Rockies exists in the Wind River Range.[43] Research shows that these glaciers shrank by more than a third between 1950 and 1999. The research also concluded that the melting of the glaciers was greater in the 1990s than in any other decade during the past 100 years.[44] To further complicate matters, over the last century, precipitation has decreased by up to 20 percent throughout the state.[45]

Retreating glaciers in the Wind River Range, reduced and/or more rapidly melting snowpack, higher air temperatures, and drought will potentially have huge ramifications for the Green River's trout. This combination of circumstances will not only reduce the amount of water flowing out of the mountains but will also cause an increase in water temperatures.

The ongoing drought—and air temperatures that were 2 degrees Fahrenheit warmer from 2003 to 2007 than the average for the period from 1901 to 2000—have already negatively impacted flows on the river.[46] In September of 2007, flows on the Green River near Pinedale were running at 198 cubic feet per second, 66 percent of the historical 73-year average of approximately 300 cubic feet per second.[47]

But the threats to the upper Green River and its important trout fishery go beyond the direct impacts of climate change; there are potential indirect impacts as well. In an effort to capture and retain more water in state partly in response to a warming climate, a proposal has been drawn up to place a dam on the upper main stem river to create a reservoir. In addition to flooding the river upstream, the dam would have other serious ramifications, including impeding the ability of cutthroat trout to migrate to important spawning tributaries. The proposed dam, in attempting to respond to problems created by global warming, would pose a substantial threat to trout and their habitat.

The impact of altered flows on the Green will extend beyond just its population of fish. There will also be economic ramifications for the fishing-related businesses and jobs that have developed around the river, especially on its upper reaches. Trout fishing has made a major, positive economic impact on the lodging industry, outfitters and guide services, and the service industry in communities such as Pinedale, Wyoming. Thus global warming will have negative impacts on the sustainability of the Green's waterways, the experience of those who love the outdoors, and the pocketbooks of those who depend on both.

Upper North Platte River
Location: Wyoming, Colorado
Trout at risk: Rainbow trout, brown trout, cutthroat trout
Worst global warming threats: Altered snowpack, higher air temperatures, drought

Upper North Platte River, Wyoming

The North Platte River has its beginnings in north central Colorado. It flows north into Wyoming through a valley bordered by the Medicine Bow Mountains on the east, and the Sierra Madre to the West. It then flows through east central Wyoming and out onto the Great Plains, where it joins the South Platte to become the Platte River before draining into the Missouri River in Nebraska.

The Platte is one of the most recognized river systems in the United States. Its stretches in Nebraska are noted as one of the nesting grounds for the Sandhill Crane. There, the river is wide and braided. But in Wyoming, it is a far different river, passing through steep mountain valleys, foothills, and ranch country.

For trout anglers, the North Platte in Wyoming is famous. The Miracle Mile and the Gray Reef Section of the river are some of the best loved and well known trout fisheries in the West. But for serious trout anglers, it is the upper North Platte that is truly worthy of recognition. It is a wild, freestone river, consisting of pocket water, runs, deep pools, and shallow riffles—classic trout water.

The river and its tributaries offer large numbers of trout, including browns, rainbows, and cutthroats. Its trout population densities range from 4,000 to 6,000 per mile. Its popularity as a trout fishing destination has been confirmed by the estimated $20 million that anglers spend annually in Carbon County, Wyoming, where the upper North Platte and its tributaries run.[48]

For these reasons and others, anglers should be concerned about the impact of global warming on the upper North Platte. Wyoming possesses an arid and semi-arid climate, and its water resources are considered highly sensitive to climate change. While precipitation ranges from six inches per year in the low basins to 70 to 90 inches a year in higher elevations, approximately 75 percent of the state receives less than 16 inches per year, making Wyoming the fifth driest state in the nation.[49] Wyoming is also getting hotter. The state was 2 degrees Fahrenheit warmer from 2003 to 2007 than the average for the period from 1901 to 2000.

Rivers such as the North Platte, especially that river's upper reaches, are heavily snowpack dependent. The wettest regions of Wyoming tend to be above 10,000 feet, and these snowpack zones comprise a mere 7 percent of the state's landmass.[50] With snowpack in Wyoming already running off 30 to 45 days sooner than normal, conditions have the potential to seriously alter the ability of the upper North Platte to continue its history as a rich trout fishery.[51]

One study by the University of Wyoming confirmed that, depending upon the temperature range increases under global warming–induced climate change, habitat loss and population fragmentation for cold-water fish in the North Platte River drainage could decline from 7 to a staggering 76 percent.[52]

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