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Fish Out of Water:

A Guide to Global Warming and Pacific Northwest Rivers

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A Guide to Global Warming and Pacific Northwest Rivers

March 2005

Prepared by:
Patty Glick, Climate Change Specialist,
National Wildlife Federation

Larry J. Schweiger,
President and Chief Executive Officer,
National Wildlife Federation

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Front Cover Photo:
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Table of Contents

Foreword

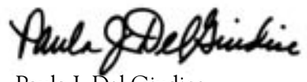
The great rivers of the Pacific Northwest (Washington, Oregon, and Idaho) and the wild salmon and steelhead that inhabit them truly are an American treasure. For some people, nothing beats the thrill of reeling in a 20-pound steelhead on the Rogue; for others, the serenity of watching the cool, clear water tumble through the Columbia River Gorge is spiritual. Celebrating the sight of healthy populations of sockeye returning to the Salmon River to spawn reminds us that the benefits these rivers bestow upon us all are priceless.

Unfortunately, the diminishing vitality of the Pacific Northwest's salmon and steelhead runs is a wake-up call and foretells the trouble facing our watersheds and the people and wildlife they support. We have damaged or altered the natural function of many of our rivers so severely that their natural inhabitants are struggling to survive. Many stocks of salmon and steelhead either are extinct or so depleted that they are near extinction.

At the same time we have taken the rivers away from fish to build cities, grow crops, transport products, and generate power, humans have added billions of tons of carbon dioxide and other heat-trapping gases to the Earth's atmosphere from power plants, motor vehicles, and other sources, resulting in a global warming trend that could devastate the region's already-fragile watersheds and fisheries.

Despite these dire circumstances, all hope is not lost. We can and must reverse this trend, so that our children and grandchildren can experience the rich natural heritage that the great rivers of the Pacific Northwest provide. First, we must restore as much of the natural function of our rivers as possible. Removing unnecessary and harmful dams and improving water quality will ensure that salmon and steelhead have the best chance of adapting to our warming environment caused by too much global-warming pollution. We must plan ahead and manage our rivers and our fisheries in ways that compensate for the loss of habitat that already is occurring.

But these strategies alone are not enough. We must all do our part today to reduce the pollution causing global warming and lessen its impact down the road. If we do not, we risk losing the fish that for centuries have defined one of the most beautiful and bountiful places in the United States. This report is meant to describe the challenge global warming poses for many of the Pacific Northwest's rivers. I hope you will join the National Wildlife Federation in our efforts to address global warming head on and change the forecast for the Northwest's rivers and fish.



Paula J. Del Giudice
Director, Western Natural Resource Center
National Wildlife Federation

Executive Summary

The Pacific Northwest is a place rich in history, tradition, and natural beauty. Its mere mention evokes images of snow-capped mountains, stately evergreens, rocky coasts, and scenic rivers. Perhaps no icon represents the region's ecological heritage more than wild salmon. Their continuing decline has galvanized citizens around numerous efforts to protect them for generations to come. But the job is not done. In addition to ongoing problems of habitat loss, deforestation, and other destructive activities, human-enhanced global warming looms as a serious threat to the region's salmon and other cold-water fish – and the economic, cultural, and ecological systems they sustain.

The Threat of Global Warming

An overwhelming majority of the world's scientists agree that human activities, particularly the burning of fossil fuels such as coal, oil, and gas in power plants, factories, and cars, have been causing excessive amounts of carbon dioxide and other gases to build up in the atmosphere. As a result, the Earth's atmosphere is rapidly heating up. This global warming is doing more than raising the Earth's average surface temperature. It is disrupting the planet's climate system, changing regional temperatures, causing sea levels to rise, and shifting rain and snowfall patterns around the world and across the United States, including the Pacific Northwest.

Like many regions, the northwestern United States is already beginning to feel the effects of global warming. Temperatures in the region have increased 1.5 degrees Fahrenheit (0.83 degrees Celsius) on average during the 20th century, and average annual precipitation has increased by 14 percent. In addition, the dates of peak snow accumulation and snowmelt-derived streamflow across the Pacific Northwest have shifted by 10 to 30 days earlier since the mid-1900s, and average snowpack has decreased 11 percent over the same period.

Scientists project that, without a significant reduction in the pollution that is contributing to global warming, the Pacific Northwest could face even less winter snow accumulation, earlier peak spring streamflows, lower summer streamflows, and elevated stream temperatures — all within just a few decades. Given the region's dependence on snowpack as the primary source of inflow to its surface water supplies, global warming is likely to dramatically alter the Pacific Northwest's rivers.

These potential changes do not bode well for cold-water fish like salmon, steelhead, and trout — particularly those in rivers and streams that are also degraded due to dams, loss of riparian vegetation, water diversions, and other problems. Human activities already have pushed many stocks to the brink of extinction. With the added stress of global warming, the result could be devastating.

Global Warming and Cold-water Fish

Higher Water Temperatures

Water temperatures are among the most important factors affecting the health of cold-water fish. When streams get too warm, the fish can experience slower growth rates, lower oxygen levels in the water, and greater susceptibility to toxins, parasites, and disease. Ultimately, if water temperatures stay too warm for too long, the river may no longer provide suitable habitat for cold-water fish. In general, areas where the average daily air temperature in the warmest summer months is greater than 69.8° F (21° C) have been found to be the "thermal limit" for most adult salmon, steelhead, and trout species.

Analysis conducted for the National Wildlife Federation by scientists at the University of Washington shows that a 3° F (1.7° C) rise in average August temperatures in the region could cause up to 20 percent of the streams in the Columbia River Basin and coastal watersheds of Washington and Oregon to become too warm for salmon, steelhead, and trout. Based on recent global warming projections, a 3° F rise in temperature is plausible by 2040.

Altered Streamflows

Earlier peak spring flows and lower-than-normal summer flows can make it more difficult for adult fish returning from the ocean at their usual time to negotiate obstacles such as falls as they navigate upstream to spawn. These changes can also hinder the ability of juvenile fish to make it to the ocean. Excessively high flows in winter, which can result from rapid melting of snowpack or increased rainfall, can cause "scouring" events, in which the gravel beds that salmon and other fish use as nesting sites wash away. Too little water after spawning can harm their eggs as well.

Streamflow projections for the region suggest that these types of flow conditions could become much more prevalent in the future. The Snake River at Hells Canyon Dam in Idaho, for example, could see a 10 to 15 percent decrease in average July-September streamflows by 2040, as compared to the long-term observed (naturalized) monthly annual flow for the period 1950 to 1989. In addition, the dates of peak spring snowmelt could shift, on average, up to one month earlier. Analyses conducted for a number of other snowmelt-dominated rivers in the region show similar results.

Ten Rivers at Risk

Rivers that are already facing too-high temperatures, altered streamflows, and other problems due to human activities are likely to be at greatest risk from global warming in the coming decades if they remain degraded. The Columbia, Snohomish, Snoqualmie, Skykomish, and Yakima rivers in Washington; the Snake River in Washington and Idaho; and the Deschutes, John Day, Klamath, and Rogue rivers in Oregon all face serious troubles due to the combined threats of global warming and other man-made problems. As home to the majority of the region's threatened and endangered salmon, steelhead, and trout, the plight of these rivers sounds an alarm bell. What is bad for fish will be bad for other wildlife — and people, too, from fewer opportunities for fishing to less-reliable hydropower and diminished irrigation.

TEN RIVERS AT RISK

- Columbia
- Snohomish
- Snoqualmie
- Skykomish
- Yakima
- Snake
- Deschutes
- John Day
- Klamath
- Rogue

With a longer-term vision and a recognition that solutions are within reach, America will succeed in protecting the fish, wildlife, and natural heritage of the Pacific Northwest.

Changing the Forecast for Rivers and Fish in the Pacific Northwest — A Plan of Action

Fortunately, solutions to these many problems exist. Many of the conservation strategies that help the cold-water fish of the Pacific Northwest today will also help them become more resilient to the global warming already occurring. This means redoubling efforts to restore the most degraded rivers and bring wild salmon, steelhead, and trout back to healthy populations by removing unnecessary and harmful dams, restoring riparian areas, protecting and restoring instream flows, and preserving the genetic diversity among species.

It also means ensuring that currently healthy rivers remain that way, as it is much harder to restore natural systems than to prevent their decline in the first place. Relatively pristine rivers (or parts of rivers), such as the Queets, Hoh, and upper Skagit rivers in Washington; the Sandy River in Oregon; and the Salmon River in Idaho, offer some of the best remaining refuge for fish and wildlife while the region works to restore lost or damaged habitat.

In addition, taking global warming and associated Northwest climate change into consideration in long-term resource management plans will improve the ability to meet the needs of fish in the future and still ensure that other activities are provided for when water resources are scarce. Finally, the region and nation must act to minimize the impact of global warming altogether by reducing the pollution that is causing it. A number of actions will make a difference, including:

- Strengthening state and federal policies and programs to promote energy efficiency, non-hydro renewable energy, and cleaner transportation options;
- Encouraging activities to absorb and store excess carbon through sound management and restoration of wetlands, grasslands, forests, and agricultural lands;
- Setting specific limits on the nation's global warming pollution; *and*
- Reengaging in international cooperation on global warming.

People can also make a difference by improving the energy efficiency of their homes; using cleaner, more efficient modes of transportation; and volunteering with local conservation groups to help restore degraded streams.

With a longer-term vision and a recognition that solutions are within reach, America will succeed in protecting the fish, wildlife, and natural heritage of the Pacific Northwest, and ensure that the economic opportunities, cultural values, and outdoor traditions they support will endure for generations to come.

Introduction

A Natural Heritage of Rivers and Fish in the Pacific Northwest

Salmon, steelhead, and trout (collectively called "salmonids") in the Pacific Northwest states of Washington, Oregon, and Idaho are the foundation of a healthy environment and a revered way of life. The presence of wild salmonids is a true indicator of the health of the region's lakes, rivers, and estuaries. The fish are an important part of the region's ecosystems, providing a critical food source for animals of all kinds — from tiny invertebrates to bald eagles and grizzly bears.

For the people who call the Pacific Northwest home, wild salmonids are a fundamental part of their ecological, economic, and cultural heritage. They sustain the spiritual and physical well-being of the region's Native American tribes. They support recreational and commercial fishing industries that contribute billions of dollars to the regional economy each year. And they provide a piece of the natural world for people to pass on from one generation to the next.

It is because of this strong tie between people and fish that the Pacific Northwest has become a model for conservation. Today, many salmon, steelhead, and trout stocks (unique populations) throughout the Northwest are considered unhealthy, and several have been listed as threatened or endangered under the Endangered Species Act.[1] Scientists estimate that at least 100 stocks of salmon and related species in the region are extinct, and more than 200 stocks are at moderate to high risk.[2]

Pacific Northwest Rivers: A "Blue Ribbon" Legacy

Among the many outdoor activities the region supports, recreational fishing in the Pacific Northwest has a particularly strong tradition. From the time when pioneer sportsmen such as Syd Glasso, Ralph Wahl, and Ken McLeod first cast their flies in the region's rivers, the Pacific Northwest has evolved into a world-class destination for anglers. Historical accounts speak of streams teeming with spawning salmon, and rivers such as the Deschutes in Oregon and the Skagit in Washington have earned true "blue ribbon" status for salmon and steelhead fishing.

According to the U.S. Fish and Wildlife Service (FWS), nearly two million people flock to the clean, cold rivers and lakes in Washington, Oregon, and Idaho each year to fish for salmon, steelhead, and trout. In 2001, these anglers spent $1.76 billion on equipment, travel costs, and other fishing-related goods and services, supporting tens of thousands of jobs.[3]

Throughout this report, some of the region's well-known outdoor writers share their stories of what the great rivers of the Pacific Northwest mean to them – sentiments no doubt shared by all who have experienced the rivers' glory and are concerned about their demise.

Woman fishing in an Oregon stream. *Source: Natural Resources Conservation Service (NRCS)*

To date, the biggest factors that have contributed to the decline of wild salmonids include: the construction of dams for hydroelectric power, flood control, and barge transportation; habitat destruction from logging, grazing, and development; water diversions for agricultural, urban, and industrial uses; historic overfishing; and poorly managed hatcheries. While many of these activities have brought important economic opportunities to the region, they have often come at the expense of fish and wildlife and the overall health of the region's ecosystems. Dams in the Columbia River system, for example, have played a major role in the decline of the region's wild salmon, and they may well have been the driving factor in the extinction of wild coho salmon in the Snake River.[4]

Fish ladder on a stream in Washington.
Source: Washington Department of Fish and Wildlife

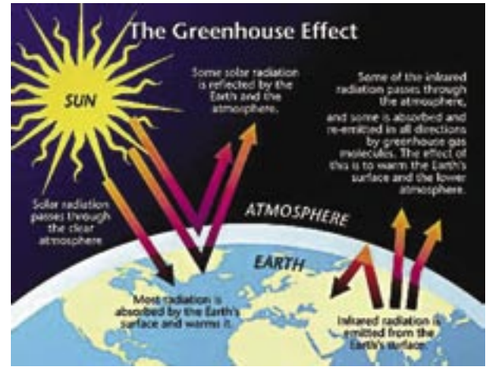
The loss of wild salmon, steelhead, and trout has bolstered a significant management and recovery effort, as stakeholders strive to protect critical habitat for the fish while at the same time support the demands of a growing human population. Federal and state agencies, Native American tribes, conservation organizations, sportsmen's groups, and other concerned citizens have struggled to help prevent further extinctions by restricting commercial, tribal, and recreational fishing; augmenting populations with hatchery-raised fish; and developing technological "fixes" such as building fish ladders and barging fish around dams.

Yet, despite these efforts, the abundance, diversity, and distribution of wild salmonids in the Pacific Northwest are still considerably lower than historic highs, and the trends continue downward.[5] As fisheries biologist Jim Lichatowich wrote in 1999, "Fundamentally, the salmon's decline has been the consequence of a vision based on flawed assumptions and unchallenged myths. ...We assumed we could control the biological productivity of salmon and 'improve' upon natural processes that we didn't even try to understand. We assumed we could have salmon without rivers."[6]

A growing recognition that much more is needed to protect the region's wild fish has led resource managers, conservationists, and other stakeholders to call for strategies not just to stop the decline in wild fish populations, but to restore habitat and healthy ecosystems.[7] For Pacific Northwest salmon, steelhead, and trout, that means restoring and protecting the region's rivers to ensure a consistent supply of cold, clean water. It means ensuring reliable streamflows and obstacle-free passageways to allow adult fish to swim up rivers to spawn and help young fish make it to the ocean. It also means preserving genetic diversity, which maximizes species' ability to adapt to and survive in varying environments.

Ultimately, success will require a more holistic, forward-looking approach to conservation — one that goes beyond prescribing treatments for current ills and incorporates measures to prepare for those threats that loom in the future. With the very real problem of global warming in that future, it is clear that this approach is needed now more than ever. Failure to address the threat of global warming would mean that the Pacific Northwest could face even greater challenges in the coming decades, from reductions in water resources and changes in river flows to shifts in ocean conditions, all of which can significantly affect the region's fish — with potentially irreversible consequences. It is the combination of global warming and other human-induced problems, in particular, that could push already-threatened stocks to extinction.[8]

The loss of wild salmonids means much more than diminished opportunities for fishing. The condition of the fish is nature's warning sign that the health and resiliency of the region's ecological systems are at risk, as are the people, fish, and wildlife that depend on them.



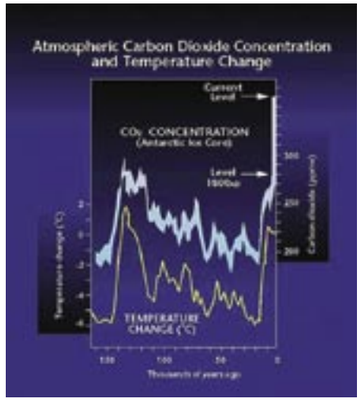
Source: U.S. Global Change Research Program

The Threat of Global Warming

Global warming is real and is happening today. Since the beginning of the Industrial Revolution in the mid-1700s, humans have been burning fossil fuels such as coal, oil, and gas in power plants, factories, and cars, sending tremendous amounts of heat-trapping "greenhouse gases" such as carbon dioxide into the air. Additionally, human activities have destroyed vast areas of forests, wetlands, and other natural systems, reducing the planet's natural ability to absorb excess carbon. As a result, carbon dioxide and other important trace gases are rapidly building up in the atmosphere, overloading the natural blanket of gases that help maintain the Earth's surface temperature.

While there are a number of factors that affect the Earth's climate, scientists know from looking back at long-term fluctuations in the planet's climate system that the level of carbon dioxide in the atmosphere plays a significant role. When the atmospheric concentration of carbon dioxide has gone up, so has the average global temperature. When carbon dioxide has gone down, the temperature has gone down as well. Generally, though, the carbon dioxide level has remained in a somewhat stable equilibrium, fluctuating between 180 parts per million (ppm) and 280 ppm over periods of thousands of years.

What has scientists concerned today is the high rate at which carbon dioxide has increased over the past 150 years. The current concentration of carbon dioxide in our atmosphere of 370 ppm is higher than at any time during the past 420,000 years, and is directly linked to human activities.[9] Consequently, the average global temperature has risen more than 1°F during the past century — a rate of change that far exceeds anything the Earth and the life it supports have experienced in at least the past 10,000 years.



Source: The Woods Hole Research Center

Without significant action to reduce global warming pollution, scientists project that the temperature change the planet will experience this century could be as much as 10 times more severe, rising 2.5 to 10.4° F (1.4 to 5.8° C).[10] While this may not seem like much, the average global temperature difference between the peak of the last ice age some 25,000 years ago and today's climate is only 9° F. With global warming, the global temperature could increase further by a similar amount in just a matter of decades. Already, the 20th century was the warmest in the last 1,000 years, and the World Meteorological Organization reports that the past 10 years (1995-2004), with the exception of 1996, are among the warmest years on record.[11]

Global warming means far more than hotter weather. As the atmosphere heats up, local climate systems are being altered in ways that directly affect forests, lakes, prairies, rivers, wetlands, and other habitats as well as the fish and wildlife that depend on them. Average water temperatures are becoming warmer, precipitation patterns are changing, and extreme weather emergencies such as droughts and floods are becoming more frequent and more severe.[12] In addition, thermal expansion of the oceans combined with melting glaciers and polar ice caps are causing global sea levels to rise at an unprecedented pace.

There is growing concern that the accelerating pace of change may put alarming numbers of species on the path to extinction.[13] A study published in January 2004 in the prestigious scientific journal *Nature* concluded that as many as a third of species in some regions could be "committed to extinction" due to global warming within the next 50 years if we fail to act now to reduce the pollution that is causing it.[14] At a minimum, global warming threatens to vastly change the natural world if it is left unchecked.

Global Warming and the Pacific Northwest

Like many regions, the Pacific Northwest is already beginning to feel the effects of global warming. Regional temperatures increased 1.5° F (0.83° C) on average during the 20th century, a rate slightly higher than the global average; and annual precipitation has increased by an average of 2.9 inches (14 percent).[15]

In addition, the dates of peak snow accumulation and snowmelt-derived streamflow across the region have shifted by 10 to 30 days earlier since the mid-1900s, and snowpack has decreased 11 percent over the same period.[16] Some locations in the Cascades have already seen a 30 to 60 percent decline in springtime snow water equivalent (the amount of water contained within snowpack) since 1950, particularly at lower elevations. This has contributed to a significant loss of summer water availability in sensitive areas.

According to researchers at the University of Washington's Climate Impacts Group, an interdisciplinary team of climate scientists, hydrologists, and other experts studying the impacts of climate variability and global warming on the Pacific Northwest, average annual temperatures in the region could rise by an additional 0.9 to 4.7° F (0.5 to 2.6° C) by the 2020s and 2.7 to 5.8° F (1.5 to 3.2° C) by the 2040s,* contributing to higher stream and estuary temperatures as well.[17] Precipitation is also projected to increase, particularly in winter months, although it is more likely to fall as rain than snow.

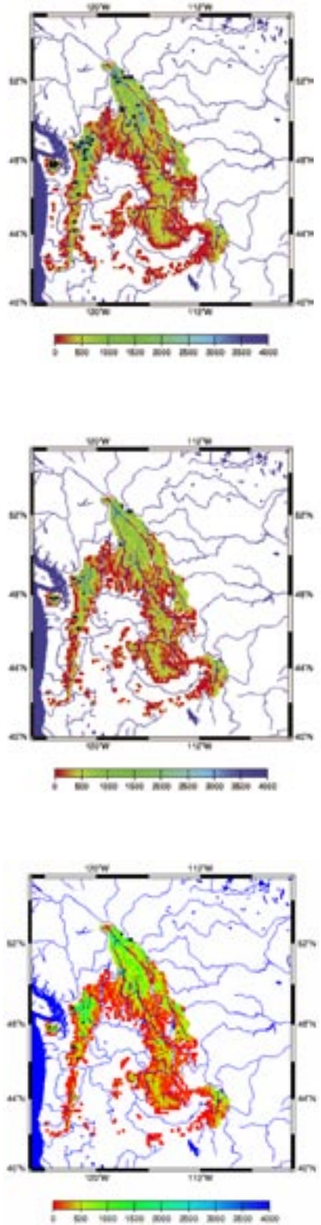
Comparison of South Cascade Glacier, Washington, in 1928 (top) and 2000 (bottom).
Source: U.S. Geological Survey

Overall, the scientists believe that these factors will cause a substantial decline in snow accumulation in the region — especially the warmer parts of the Northwest (the west slopes of the Cascades, the Olympics, and the coastal range) — in the coming decades. With continued warming, the Pacific Northwest could see an additional 50 percent decline in average snowpack in the next 45 to 75 years, significantly reducing the primary source of water for the region during dry summer months.

Global warming is also projected to hasten the retreat of many of the region's glaciers, which provide a regular and dependable source of water to some of the Northwest's major rivers in late summer and fall. Rapid glacier retreat can also contribute to significant siltation problems downstream. Most of Washington's 950 glaciers are receding rapidly, and several have disappeared in the past few decades.[18] Similar trends are occurring on other glaciers throughout the region.

The bottom line is that, left unchecked, global warming will dramatically alter the Pacific Northwest's rivers. Problems could include more winter flooding, earlier spring snowmelt, earlier peak streamflows, lower summer streamflows, and higher water temperatures.[19] For the region's wild salmonids, the impact of these changes could be overwhelming.

*Based on an average of eight global climate models driven by an increase in equivalent CO_2 of 1percent per year. Benchmarked to the decade of the 1990s. *Source: http://www.cses.washington.edu/cig/fpt/ccscenarios.*



Simulated Pacific Northwest
April 1 average snowwater equivalent
for the current climate (1950-99) (top), the 2020s (middle), and the 2040s (bottom) under mean climate scenario. *Source: P. Mote, et al., "Preparing for climate change: the water, salmon, and forests of the Pacific Northwest,"* Climate Change 61.1/2 (2003): 45–88.

Global Warming and Cold-water Fish

Salmon, steelhead, and trout have lived in the Pacific Northwest for millions of years. Over time, they have evolved and adapted to the region's environment, and they have developed specific habitat requirements: they need well-connected rivers and reliable streamflows, and, as "cold-water" fish, they need clean, cold water.

The Importance of Temperature and Streamflows

Bull trout in a Washington stream.
Source: Washington Department of Fish and Wildlife

Water temperatures are among the most important factors affecting the health and distribution of salmonids.[20] While the specific optimum temperatures vary somewhat depending on the particular species, its life stage, and the season, the average optimum range for most juvenile and adult salmonids in the region is 55 to 64° F (12.8 to 17.8° C).[21]

Changes in temperatures away from optimal conditions can influence cold-water fish in each of their life stages.[22] Scientific evidence shows that even a small increase in temperatures (just a few degrees) above their optimum ranges can begin to affect salmonids in a number of ways, including changing migration timing, reducing growth rates, reducing the supply of available oxygen in the water, and increasing susceptibility of fish to toxins, parasites, and disease.[23] Higher stream temperatures can also contribute to a reduction in salmonids' preferred foods, including mayfly, caddisfly, and stonefly nymphs.[24]

Because the fish seek out stream habitat that is in their preferred temperature range, the geographic distribution of salmonids tends to match rivers that are within those optimum temperatures.[25] In general, they won't be found in places where river temperatures are outside of that optimum range for an extended period of time. For most adult salmon, steelhead, and trout species, areas where the average daily air temperature in the warmest summer months is greater than 69.8° F (21° C) have been found to be at that "thermal limit."[26] This is based on evidence that air and water temperatures are correlated, particularly when the air temperatures remain at a certain level over time periods of a week or longer.[27] If salmonids are exposed to water temperatures at or above 71.6° F (22° C) over several days, they can die.[28]

As different species and stocks have developed over time, they have also acquired specific migratory and spawning behavior that corresponds with variations in streamflows. For example, "summer" chinook salmon are so named because they have historically relied on sufficient streamflows from June through August to reach their spawning grounds in the upper reaches and headwaters of the region's rivers.

Earlier peak spring flows and lower-than-normal summer flows can make it more difficult for adult fish returning from the ocean at their usual time to negotiate obstacles such as falls as they navigate upstream to spawn.[29] These changes can also hinder the ability of juvenile fish to make it to the ocean. Excessively high flows in winter, which can result from rapid melting or increased rainfall, can cause "scouring" events, in which the gravel beds that salmonids use as nesting sites wash away.[30] Too little water after spawning can also harm salmonids' eggs.

In addition, there is a direct relationship between streamflows and water temperatures. For example, lower-than-normal streamflows in warmer summer months can cause a decline in the number of deep water pools that remain cool when air temperatures rise.[31]

Generalized Timing of Stream Migration for Pacific NW Salmon, Steelhead, and Trout

Species/Run	Adults Return to Streams from Ocean	Young Migrate Downstream
Coho	October -January	March - July (2nd year)
Chum	September - January	Shortly after young leave gravel
Chinook		
Spring Run	January - July	March - July (2nd yr.)
Summer Run	June - mid-August	Spring (2nd yr.)
Fall Run	August - March	April - June (2nd yr.)
Cutthroat (Coastal-Sea Run)	July - December	March - June (2nd - 4th yr.)
Pink	July - October	December - May
Sockeye	July - August	April - June (2nd - 4th yr.)
Steelhead		
Winter Run	November - June	March - June (2nd - 5th yr.)
Spring Run	February - June	Spring/Summer (3rd - 4th yr.)
Summer Run	June - October (Columbia) April - November (Coastal)	March - June (3rd - 5th yr.) March - June (2nd - 5th yr.)

Source: Pacific States Marine Fisheries Commission, "Where Are the Salmon, When? Generalized Life History Patterns of Salmon, Steelhead, and Trout in the Pacific Northwest" http://www.streamnet.org/pub-ed/ff/fact-sheets/salmtbl.html (updated October 10, 2001)

Humans Are Altering the Balance

Historically, wild salmonids have evolved to deal with some variability in temperatures and streamflows. When natural streams and riparian areas are intact, the fish can find refuge in cool pools on hot summer days. When populations are abundant, stocks can usually survive periodic droughts or other extreme events in sufficient numbers to bounce back. However, their flexibility does have its limits. For instance, once salmon have returned to rivers from the ocean, they have a limited time period (typically a few weeks) to migrate upstream to spawn. Any delay, such as if streamflows are too low or water temperatures too high, places them at greater risk of pre-spawning mortality or having to spawn in a less-favorable location.[32] Furthermore, human activities have been changing river habitat so rapidly and so broadly that they are pushing the region's salmonids beyond their range of tolerance.

Ice Harbor Dam, Snake River, Washington.
Source: U.S. Army Corps of Engineers

A number of human activities have already altered natural streamflow patterns and river temperatures throughout the Pacific Northwest.[33] Groundwater withdrawals and water diversions for irrigation, urban consumption, and hydroelectric power production have reduced total annual streamflows and lessened the seasonal variability of flows in a number of the region's rivers. Among other things, shifting the patterns away from the more natural conditions, in which 75 percent of the annual streamflows were in the summer months, and toward conditions in which flows are divided relatively equally between winter and summer has allowed for more reliable hydroelectric power production year round. But it has also reduced available water supplies in summer, when demands for irrigation are the highest.[34] As a result, river flows are already frequently suboptimal during the times when salmon and other fish need them for spawning and migration.[35]

Many of these activities have also contributed to higher-than-normal stream temperatures. For example, the surface water in reservoirs behind dams can get too warm when air temperatures rise, particularly during times of year when water volumes are low.[36] The release of warm reservoir water through the dams can also contribute to higher temperatures downstream. Deposition of sediments from logging, agricultural activities, and development has made many rivers wider and shallower, enabling them to heat up more easily. Warm wastewater discharges from industrial and municipal sources along the rivers have increased temperatures downstream. In addition, the clearing of trees and other vegetation along riparian areas has eliminated shade that helps keep nearby stream temperatures cooler.

Today, unnaturally high temperatures are the single greatest reason for listing the region's rivers and other water bodies as "impaired" under the Clean Water Act, placing the impetus on government agencies and tribes to develop strategies to alleviate the problem.[37] With the potential for global warming to contribute to even higher average temperatures and altered streamflows in the region, it is all the more important for stakeholders to develop effective strategies to reduce the localized stressors that are contributing to these problems — as well as to support meaningful strategies to mitigate global warming.

A Possible Scenario for the Future: Lost Habitat, Fewer Fish

Scientists studying the potential effects of global warming on cold-water fish have found that higher average temperatures and altered streamflows in the coming decades could significantly reduce viable habitat for fish across the United States. For example, researchers at the University of Wyoming estimate that a 5.4° F (3° C) increase in average July air temperatures could eliminate 50 percent of currently viable trout stream habitat in the Rocky Mountain region.[38] A temperature rise of this magnitude is well within the range of recent future climate scenarios for the end of this century.

This analysis is based on evidence that trout and other salmonids in the region are either absent or very rare in areas where the average July air temperatures exceed 71.6° F (22° C). By comparing the historic patterns of average July temperatures across the region with how those patterns might look under various scenarios of global warming, the scientists found that many more areas would likely exceed the 22° C threshold in the future, reducing the thermally suitable habitat for the fish.

A similar study by the U.S. Environmental Protection Agency (EPA) projects a 50 to 100 percent reduction in cold-water fish habitat in a number of New England, Great Lakes, and western states with a 4.5° F (2.5° C) increase in average stream temperatures.[39] Research by Defenders of Wildlife and the Natural Resources Defense Council estimates that an increase in average summer water temperatures of 4.5 to 11° F (2.5 to 6° C) could eliminate 21 to 42 percent of stream habitat for the nation's trout and salmon species.[40] Again, temperature increases of these magnitudes are well within the ranges of climate warming projected for the decade of the 2090s.

In addition, a study of potential changes in water temperatures and streamflows in the Appalachian region of the eastern United States found that global warming could contribute to a significant decline in the abundance and habitat of resident trout species.[41] Among other things, the region could face a 61 percent decrease in abundance and 90 percent loss of habitat of brook trout in headwater streams, which are critical refuges for native brook trout populations.

Examples of Pacific Northwest Rivers Recently Listed as "Impaired" Under the Clean Water Act Because of Temperature Problems

Washington
Chehalis, Columbia, Green, Humptulips, Naches, Nooksack, Palouse, Sammamish, Skykomish, Snake, Snohomish, Snoqualmie, Spokane, Tucannon, Walla Walla, Wenatchee, Yakima.

Oregon
Alsea, Columbia, Coos, Coquille, Crooked, Deschutes, Grande Ronde, John Day, Klamath, Illinois, Owyhee, Rogue, Sandy, Santiam, Siuslaw, Sprague, Umatilla, Umpqua, Willamette.

Idaho
Big Lost, Clearwater, Owyhee, Payette, Potlatch, Saint Maries, Salmon, Snake.

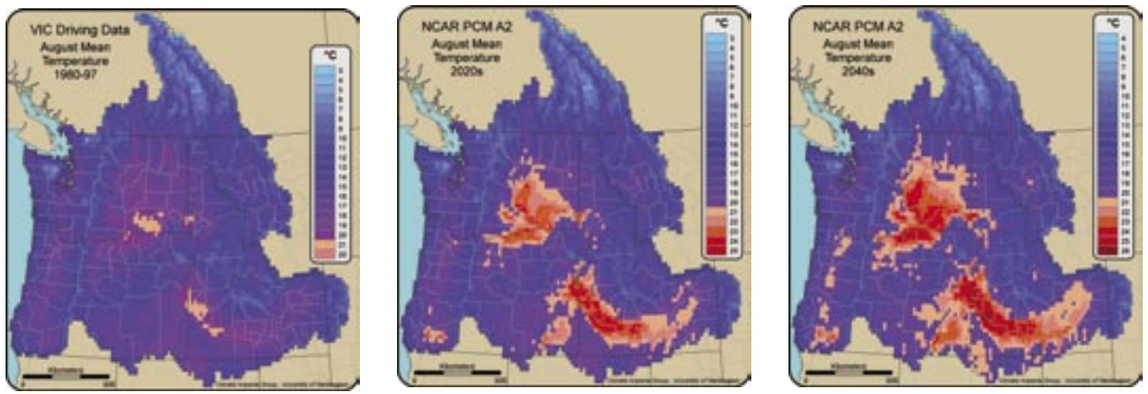
Source: U.S. EPA 1998 Section 303(d) Lists for Washington, Oregon, and Idaho (Seattle,WA: U.S. EPA Region 10)

Evidence of Change

Global warming may already be affecting rivers and fish in some regions. Canada's Fraser River, for example, experienced a significant increase in average stream temperatures during the latter half of the 20th century. During the period 1953 to 1998, the average temperature in the river rose 2° F (1.1° C).[42] This has been particularly problematic for fish returning to spawn in the summer. Since the early 1990s, some runs have lost more than 50 percent of fish returning to spawn in the years with warmer river temperatures.[43] 2004 was the worst year in 50 years for summer sockeye runs, with fewer than 10,000 of the expected 90,000 sockeye reaching their spawning grounds.[44] Since the Fraser River has remained largely undisturbed by dams and other stressors, scientists believe that changes in local climate associated with global warming could be the primary cause of the decline in sockey salmon.[45]

Research also indicates that an increase in average summer stream temperatures in the Yukon River drainage over the past few decades has weakened the health of chinook salmon.[46] By 1985, a parasite called *Ichthyophonus* started emerging in the river's fish and their associated health problems have grown progressively worse each year. The parasite has diminished the quality of fish caught by subsistence fishermen, and it has led to a significant increase in chinook salmon mortality. Scientists believe that the warmer river has reduced the ability of salmon to fight off the disease.

Observed and Projected August Monthly Mean Surface Temperatures in the Pacific Northwest (Columbia River Basin and coastal watersheds of Washington and Oregon)



This analysis assumes that areas where average August temperatures are less than 69.8° F (21° C) (shaded in blue and purple) reflect the present-day distribution of salmonids in the Columbia River Basin (disregarding other habitat determining/limiting factors). The left-hand panel shows observed August temperatures for 1980-97. Temperatures in the other two panels are based on future climate scenarios simulated by the National Center for Atmospheric Research's Parallel Climate Model (NCAR-PCM) with greenhouse gas emissions scenario "A2." This particular model is considered to have a relatively insensitive response to increased concentrations of greenhouse gases, and yields a regionally averaged warming of approximately 2.5° F (1.4° C) for the Pacific Northwest by the 2020s (middle panel) and 3° F (1.7° C) for the region by the 2040s (right-hand panel).

Source: Dr. Nathan Mantua and Robert Nordheim, Climate Impacts Group, University of Washington, 2005

Ocean Conditions and Anadromous Fish

Many of the wild salmonids in the Pacific Northwest are anadromous fish, which means that they are born in freshwater rivers, migrate to the ocean where they spend their adult lives, then return to their natal rivers to spawn. For these fish, changes in ocean conditions and estuaries (places where rivers meet the sea) can have a significant effect on their health and abundance. Scientists have been able to determine just how sensitive salmonids are to variations in climate by studying how natural cyclical ocean conditions have affected them from year to year and decade to decade.[47]

The El Niño/Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) cycles, in particular, influence fish in a number of ways. Among other things, they play an important role in determining ocean temperatures and food availability in the North Pacific. During El Niño and/or warm-phase PDO, higher Pacific Ocean temperatures and changes in wind patterns can reduce the upwelling of nutrients from the ocean floor, affecting the entire ocean food web. Ultimately, this can lead to a reduction in the abundance of anadromous species such as chinook and coho salmon, which spend much of their lives in the ocean before returning to Northwest streams to spawn. Historically, these cycles also tend to influence the Pacific Northwest's climate. El Niño and warm-phase PDO are often associated with warmer, drier conditions; below-average snowpack and streamflow; and below-average salmon survival. La Niña and cold-phase PDO tend to have the opposite effect.

Improved understanding and forecasting of ENSO and PDO events have enabled resource managers to become more proactive in managing salmon from year to year by helping them identify whether conditions will be "favorable" or "unfavorable." If an El Niño year is predicted, for example, managers might assume that run sizes will be reduced due to fewer fish surviving in the ocean, prompting them to implement strategies such as limiting fishing harvests to protect the fish.

Although it is still unclear exactly how global warming will affect overall ocean conditions in the future, several studies project that global warming will lead to more prevalent El Niño and/or Warm-phase PDO events.[48] According to the Intergovernmental Panel on Climate Change, "Warm episodes of the El Niño-Southern Oscillation phenomenon have been more frequent, persistent, and intense since the mid-1970s compared with the previous 100 years."[49]

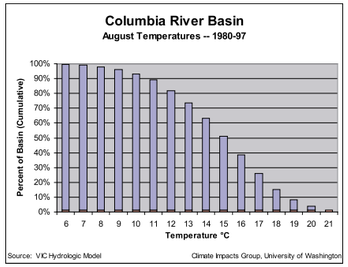
Global warming is also likely to affect the region's estuaries by contributing to a rise in sea level. Scientists project that the average global sea level will rise an additional 3.5 to 34.6 inches by 2100.[50] This could cause significant inundation of lowlying areas such as the southern portion of Puget Sound, which is already sinking due to land subsidence by about 0.8 inch per year. Because these areas are critical habitat for salmonids as they make the transition between their river and ocean life stages, sea level rise could have a major impact on the fish.

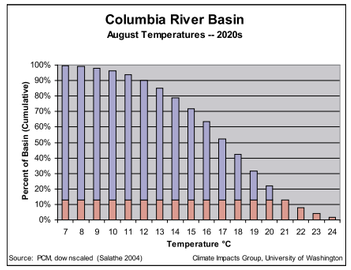
With likely changes due to global warming on the horizon for both oceans and rivers, the Pacific Northwest's anadromous fish will face the effects throughout their life cycle.

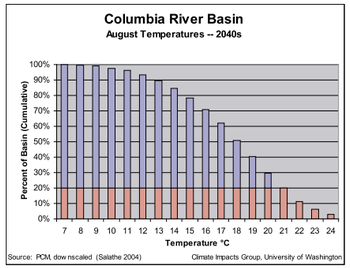
What could global warming mean for the future of salmon, steelhead, and trout in Pacific Northwest rivers?

As home to some of the most significant habitat for anadromous salmonids in the nation, the Pacific Northwest is truly in the hot seat in terms of what global warming could mean for the future of these fish. A study of climate change impacts on Yakima River spring chinook suggests that a warmer and drier climate could reduce their productivity by as much as 50 to 60 percent by increasing the mortality among adult fish returning to spawn and reducing the ability of smolts to successfully migrate downriver.[51] Other studies project similar impacts for salmonids throughout the interior Columbia River Basin.[52]

Analysis conducted for the National Wildlife Federation by scientists at the Climate Impacts Group shows that a 3° F (1.7° C) rise in average August temperatures in the region could cause 20 percent of the Columbia River Basin and coastal watersheds of Washington and Oregon to exceed the 69.8° F (21° C) temperature threshold for salmonids. Based on recent global warming scenarios for the future, such a warming is plausible by 2040. Assuming a direct correlation between air and stream temperatures, this means that 20 percent of the region's streams that have historically been suitable habitat for the fish would likely become too warm. If streams in the region continue to be degraded by other factors, the impact will likely be even greater.







Cumulative percent of the Pacific Northwest (for the Columbia Basin and coastal Washington and Oregon watersheds) with August mean temperatures exceeding specified temperature thresholds

In the period 1980-97, 100 percent of the region had August mean temperatures greater than 42.8° F (6° C), but less than two percent of the region had August mean temperatures greater than 69.8° F (21° C). In contrast, the 2020s climate scenario shows about 12 percent of the region having August mean temperatures exceeding 69.8° F (21° C), while in the 2040s about 20 percent of the region's temperatures exceed 69.8° F (21° C). In each panel, the percentage of the region with temperatures greater than 69.8° F (21° C) is shaded in red.

Source: Dr. Nathan Mantua and Robert Nordheim, Climate Impacts Group, University of Washington, 2005

THE DESCHUTES RIVER

©2005 by Pat Wray

The author, Pat Wray, on the Deschutes. *Source: Pat Wray*

In some ways, rivers are like people. They start out fresh and pure, jumping over rocks and sparkling around every obstacle. Then gradually, time and river miles wear on them. They cease the joyous leaping of youth. Their bright sparkles turn to froth. They are, figuratively as well as literally, going downhill. Only a few people, and even fewer rivers, manage to remain vibrant and energetic throughout their lives. Their ability to do so depends on their foundation, and whether or not they have friends to help them through the hard times.

The Deschutes River's foundation is porous soil over fractured volcanic rock and multiple aquifers. In effect, the Deschutes sits atop a sponge, which soaks up water in the wet years and dispenses it with remarkable consistency of flow and temperature.

As the Deschutes makes its way from the central Cascades toward the Columbia, it faces almost every crisis that can befall a river, and still emerges pristine, or very close to it – with a little help from its friends.

It flows through the center of Bend, a city of nearly 60,000, where more than 95 percent of its water is removed for irrigation. But it reconstitutes itself with downstream tributaries and countless springs fed from the volcanic sponge below.

It hosts thousands of jet boaters, fishermen, rafters, swimmers, campers, hunters and wildlife viewers and yet careful, conservative regulations keep conflicts to a minimum and protect the river and its resources.

The Deschutes has been dammed multiple times but prudent water releases generate downstream flows beneficial to fish, wildlife and the millions of other organisms. Emphasis on the fish, for it is impossible to think about the Deschutes River without thinking about spring and fall Chinook, bull trout, summer steelhead and of course, Deschutes River redsides. Redsides are a strain of rainbow trout famous for their size, power, rich coloration and belligerent attitude, as well as for their numbers. More than 1,800 adult trout per river mile are found in parts of the lower river.

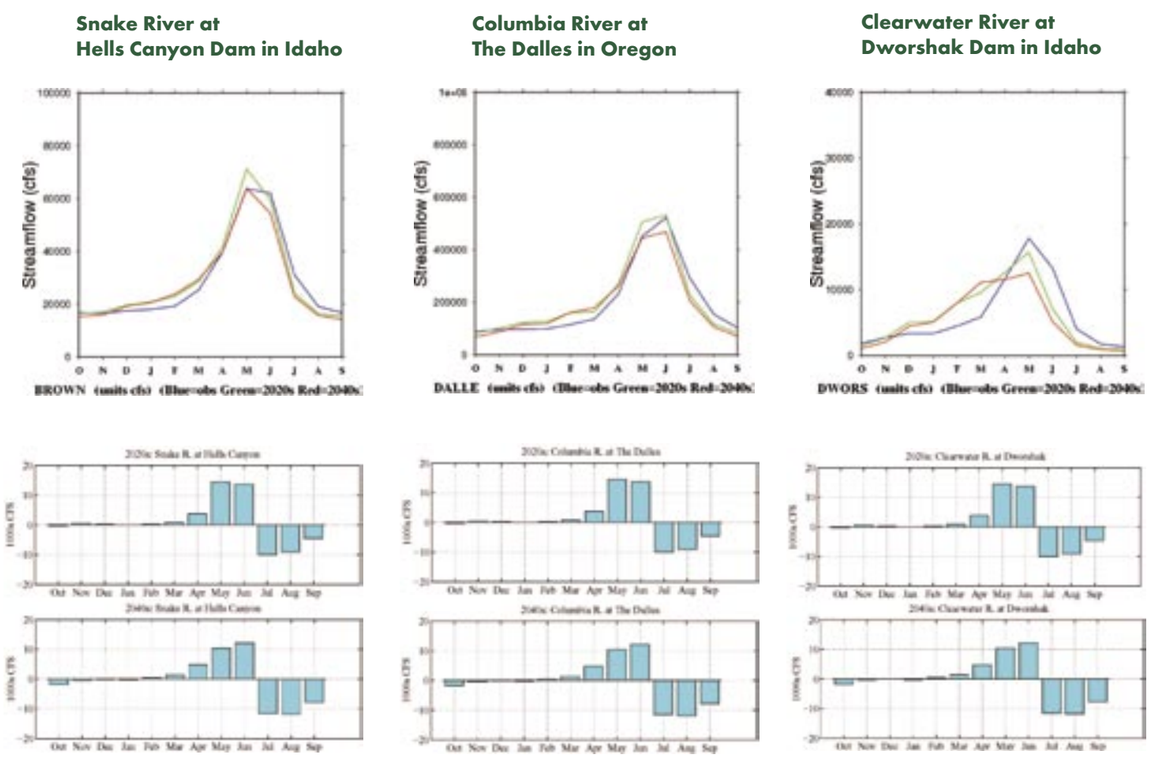
Fishermen from all over the world have embraced those fish, just as they have the river itself. Even though regulations allow anglers to keep two trout per day, surveys indicate less than one percent of those caught are actually kept.

Pressures are growing on the Deschutes, but people who love the river have taken steps to counteract them. Those steps help ensure water clean enough to support the renowned stonefly hatch every spring. They guarantee the campsites are accessible but not overwhelmed. They make certain the list of watchable wildlife remains virtually unlimited.

Rivers are not so similar to people that they can smile. But if they could, it might look like this very typical scene: A fisherman is hooked to a steelhead cartwheeling out of bright, dancing water. Mule deer are grazing on the opposite bank while bighorn sheep explore the rocks above. And enveloping them all, the siren song of chukars floats on the clear background symphony of a clean, flowing Deschutes River.

Pat Wray, a former Marine helicopter pilot and Oregon Department of Fish and Wildlife Information Officer, is a freelance writer and author of *A Chukar Hunter's Companion*. Wray and his wife Debbie live with their three hunting dogs in Corvallis, Oregon.

Projected changes in temperatures and precipitation patterns associated with global warming could also lead to a significant shift in the timing and volume of streamflows in a number of the region's snowmelt-fed rivers. The Snake River at Hells Canyon Dam in Idaho, for example, could see a 10 to 15 percent decrease in average July to September streamflows by 2040, as compared to the long-term observed (naturalized) monthly annual flow for the period 1950 to 1989. In addition, the dates of peak spring snowmelt could shift up to one month earlier, on average. Analyses that hydrologists with the Climate Impacts Group have conducted for a number of other snowmelt-dominated rivers in the region (including the Columbia River at The Dalles in Oregon and the Clearwater River at Dworshak Dam in Idaho, as shown in the following graphs) show similar results .



Comparison between long-term observed monthly annual flow for the period 1950-89 with projected climate change flows for the decade of the 2020s and 2040s at three sites in the Columbia/Snake Basin

Source: A.K. Snover, A.F. Hamlet, and D.P. Lettenmaier, "Climate Change Scenarios for Water Planning Studies: Pilot Applications in the Pacific Northwest," Bulletin of the American Meteorological Society, Vol. 84(11), 2003: 1513–18.

Figure A

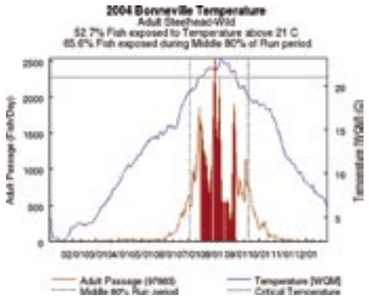


Figure B

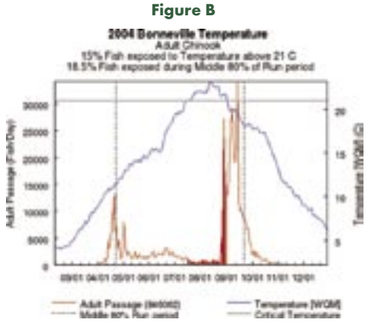
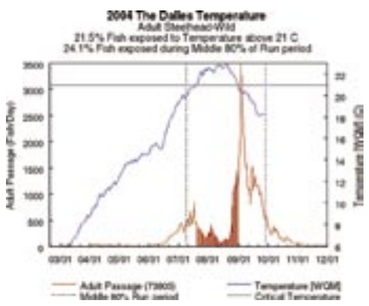


Figure C



Source: Columbia Basin Research, University of Washington

Fish kill in the Klamath River Basin, 2002. *Source: Earthjustice*

These changes would likely have a significant impact on species that rely on adequate summer flows and optimal temperatures for migration and spawning, particularly where streams are already warmer than normal.[53] For example, Figure A shows the timing of wild adult steelhead in the Columbia River at Bonneville Dam in 2004; 65.6 percent of the fish were exposed to temperatures above 69.8° F (21° C) during the middle 80 percent of the run period. Similarly, 18.5 percent of adult chinook were exposed to the 21° C threshold at the same site (Figure B), as were 24.1 percent of wild steelhead at The Dalles (Figure C). If the number of days with temperatures above 69.8° F (21° C) were to increase even slightly during these peak migration times, many more fish could be exposed to adverse conditions or forced to wait until conditions became more favorable.[54]

The rapid rate at which global warming–induced changes in habitat are likely to occur — as well as the fact that other stressors have substantially reduced the resiliency of many stocks — casts doubt on whether the majority of the region's salmonids will be able to adapt to these changes over the longer term. Ultimately, it is a combination of human-induced problems that threatens the future of the region's rivers and the fish, wildlife, and people they sustain.

The unprecedented fish kill in the lower Klamath River Basin in California in 2002 is a profound example of the challenges the region may face from these cumulative problems. Extensive water diversions for irrigation in southern Oregon during a severe drought led to the loss of more than 33,000 fall chinook and other salmonids downstream, where reduced river flows and warm water temperatures made the fish more susceptible to disease.[55]

All too often, when water resources are scarce, the needs of fish get the short end of the stick — as do the anglers, commercial fishermen, Native American tribes, and other stakeholders that depend on them. The additional stressors associated with global warming will likely mean that more wild salmon, steelhead, and trout in the Pacific Northwest will decline without a more concerted effort to address these multiple threats.[56]

Ten Rivers at Risk

Rivers that are already facing too-high temperatures, altered streamflows, and other problems due to human activities are likely to be at greatest risk from global warming in the coming decades if they remain degraded. The plight of these rivers, home to the majority of the region's threatened and endangered salmonids, should serve as an alarm bell.

Source: National Wildlife Federation and www.streamnet.org

Columbia and Snake Rivers

The Columbia and Snake are two of the Pacific Northwest's "flagship" rivers — they are also among the most unhealthy. Historically, these rivers were home to some of the most abundant wild salmon runs on Earth. Now, the majority of the rivers' salmon are hatchery-reared, and many stocks are currently listed as threatened or endangered under the Endangered Species Act.[57]

The Columbia River, which is the most hydroelectrically developed river system in the world, has seen a steady decline in its salmon and steelhead populations over the past century. Throughout the Columbia and Snake River system, an estimated 55 percent of the total area and 33 percent of the total stream miles are no longer accessible to anadromous salmonids because of dams.[58] In addition to obstructing fish passage, dams have also contributed to altered streamflows and warmer water temperatures, particularly in summer.[59] The four main dams in the lower Snake River, for example, have been identified as the primary factor in the decline of several stocks of anadromous salmonids.[60] Today, Snake River coho salmon are extinct, and sockeye, chinook, and steelhead are listed as threatened or endangered. Additional decreases in flows or increases in water temperature due to global warming would likely further reduce survival rates.[61]

Snohomish River Basin (including Snohomish, Skykomish, and Snoqualmie Rivers)

The Snohomish River watershed is the second largest river basin draining into Puget Sound, and it remains one of the primary salmon producers in the region. The three major rivers in the basin are the Snohomish, the Skykomish, and the Snoqualmie Rivers, which host significant runs of coho, chinook, chum, and pink salmon; steelhead trout, bull trout, and other resident trout species.[62] A large portion of the Snohomish River watershed drains high-elevation areas of the Cascades, and spring and early summer snowmelt strongly influences streamflow patterns in the basin, making its rivers — and the fish that inhabit them — vulnerable to global warming.[63] There are currently three stocks in the basin listed as threatened, including Skykomish chinook, Snoqualmie chinook, and Snohomish bull trout/Dolly Varden.

The Yakima River. *Source: Pacific Northwest National Laboratory*

Yakima River

The Yakima River in Washington was historically one of the top production areas in the Columbia River Basin for anadromous salmonids.[64] Currently, the river supports spring and fall chinook, coho, summer steelhead, and bull trout. It is also considered by some to be one of the best year-round trout fisheries in the Northwest.[65] However, the Yakima faces considerable pressure on water for irrigation, and degraded habitat has caused historically numerous stocks of summer chinook and anadromous sockeye to disappear. A number of other species, including summer steelhead and bull trout/Dolly Varden, are currently listed as threatened. Continued pressures could place other fish at risk as well.

Deschutes River

The Deschutes River in Oregon is one of the region's most popular fisheries for trout and summer steelhead.[66] It is particularly renowned for its wild rainbow trout, which are often called "redsides" because of their unusually prominent red stripe. Like the Yakima, however, its spring and summer flows are usually severely reduced by drawdowns for irrigation, and the river has consistently been listed as "impaired" from high temperatures due to low water and deforestation of riparian areas. Dam development has also disconnected resident trout populations and has completely restricted the ability of wild steelhead, chinook, and sockeye to spawn in the upper reaches of the river.

John Day River

The John Day is one of Oregon's longest rivers, and it is one of the few rivers in the region that have remained dam-free. The John Day is considered to be a first-rate fishery for steelhead and spring chinook salmon. However, much of the river has been degraded from extensive logging, irrigation withdrawals, road building, grazing, and mining — problems that have collectively made parts of the river shallower, wider, and warmer.[67] A number of public and private efforts to restore the John Day have been under way in recent years, and continued restoration and conservation work, such as reestablishing vegetation in riparian areas and promoting more efficient irrigation to restore instream flows, will be important in helping reduce the river's vulnerability to global warming.

The John Day River. *Source: NRCS*

Klamath River

At one time, the Klamath River was the nation's third most productive salmon and steelhead river, supporting thriving recreational and commercial fishing industries and providing important cultural and economic resources for Native Americans.[68] The Klamath Basin's expansive wetlands also served as habitat for a vast array of waterfowl and other wildlife. Today, much of the region's natural habitat is gone, largely due to agricultural conversion. Fall chinook have declined to less than 8 percent of historic numbers, and coho have declined to just 1 to 2 percent of historic numbers, prompting their listing as endangered. Continued demands on water for irrigation and other uses have plagued the Klamath in recent years, and pressures will likely grow with global warming.

Rogue River

The nearby Rogue River in Oregon is one of the Pacific Northwest's richest streams, supporting large numbers of genetically diverse spring and fall chinook, coho salmon, summer and winter steelhead, trout, and other fish. Anadromous fish enter the river every month of the year.[69] The Rogue has long held a reputation as one of the region's top rivers for steelhead fishing — there are even exclusive fly patterns that carry its name. However, the Rogue River faces continuing pressures from timber harvesting and increasing demand for water, and all of the river's anadromous stocks are listed or being considered for listing.[70] With the added threat of global warming, the Rogue's wild fish could see a significant decline in viable habitat.

WILD AT HEART

©2005 by Don Roberts

Even though the Columbia River reigns as the indisputable matriarch of all watersheds in the Pacific Northwest, don't expect anything resembling a motherly embrace. She's too moody and dangerous for that, way too big and powerful to get your arms around. That said, I must admit to an inexorable attraction to and abiding affection for this mighty and inscrutable flow.

Part of my affinity for the Columbia, of course, can be explained by my pretensions – some would say hopeless obsessions – as an angler. The Columbia River drains a 259,000-square-mile basin that encompasses seven states [Oregon, Washington, Idaho, Montana, Nevada, Wyoming and Utah], reaching into long spurs of the Rockies and extending hundreds of miles north into British Columbia. All along the way tributary streams, some large, some small, braid themselves into the single overarching flow of the Columbia. The Spokane, the Snake, the Yakima, the Walla Walla, the Deschutes, the Klickitat, the Wind, the Sandy, the Willamette. And dozens of others. But here's the clincher – the magic, if you will: all of these tributaries are conjoined by their vital role as birthing grounds, as nursery waters for salmon ascending the Columbia. Think of the Columbia, indeed think of the Northwest, and salmon come to mind.

One of my favorite places to fish is on a stretch of water that explorers Lewis and Clark called the "Great Shoot," because this is where the river literally battered its way through the backbone of the Rockies. Due to the construction of Bonneville Dam, a monumental federal jobs project completed in 1938 – an occasion heralded, with nary a hint of irony, by the Woody Guthrie song "Roll On, Columbia, Roll On"– the insane turbulence and roar of the river was muted, transformed into something more closely resembling the purr of a pussycat. I like to anchor my boat downstream from Bonneville, at a vantage point where I can watch the sun crest the 3,000-foot basalt bluffs of the Columbia River Gorge and penetrate shrouds of fog clinging to sentinels of Douglas fir and lower-lying cottonwoods, and gradually set aglow abstract murals of ochre and amber lichens on lava rock walls and dapple the feathery fronds of emerald-green maidenhead ferns.

By standing squarely upright in the stern of the boat you can feel the throb of the river passing underneath and know that there's the distinct possibility of salmon finning in the dark currents below. On any given day throughout the year it could be one of several different stocks or species of salmon. And if not salmon, it could be walleye, or smallmouth bass, or sturgeon – a fish whose ancient whiskered snout, unearthly size and seriously knobby spine conjures up images of the primordial ooze. Then there's steelhead trout, god bless their silver hides, the most enigmatic and compelling species of all. Why does this peculiar genetic strain of rainbow trout shun the trout lifestyle, forsaking the comfort and sanctuary of mountain lair in order to venture into the blue void of the Pacific? Why scurry from sweet-water upland to saltwater abyss? And back again?

All I know is that steelhead are so luminous and lovely that each time I land one I'm tempted to plant a kiss on each cheek. *Mmwaa...mmwaa.*

Depending upon what fish you pursue and, therefore, what part of the Columbia you concentrate your efforts, you'll be confronted with diverse ecological backdrops – a landscape sere, windswept and raw at one end of the mainstem Columbia and dependably damp, lush and verdant at the other end of the river. While fishing in the Gorge – a place so drop-dead gorgeous Congress declared it a National Scenic Area in 1986 – I am always startled when the doglike heads of seals pop up in the foam behind the boat, chasing salmon as they did centuries ago when they competed with naked tribesmen for the pink-fleshed bounty.

There's human "wildlife" to contend with as well: the jostle of other sport-fishing vessels, sailboats, motor yachts, water skiers, windsurfers, kite-boarders, steamboat tours and the constant threatening incursion of massive, unwieldy barges. It's an oddly pleasurable melee, but also a sober reminder that the Columbia River Basin bears the dubious distinction of being one of the most manipulated – dammed, dredged, diverted and developed – watersheds on earth.

Yet despite all, despite the continued desecration, despite my fears that future insults could prove fatal, the Columbia River remains wild at heart. And the salmon keep coming back.

Don Roberts is a contributor to numerous outdoor publications. His writing and photography pursuits have taken him all over North America and angling destinations abroad. But he makes his base camp in Portland, Oregon, about halfway between the cool blue Pacific and the rich green flow of the Deschutes River – one of the major salmon/steelhead arterials draining into the Columbia.

The author, Don Roberts, on the Columbia River. *Source: Don Roberts*

Five Rivers to Watch

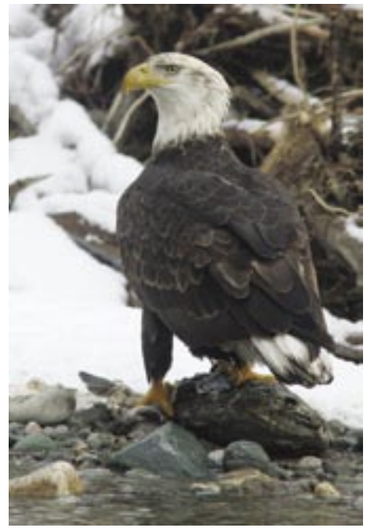
Although many of the Pacific Northwest's rivers face serious challenges, it is still possible to find relatively pristine, untouched rivers reminiscent of the past. Currently, these rivers provide the best opportunity to protect the last remaining refuges for fish and wildlife while the region works to restore habitat that has been degraded. However, ensuring that the rivers remain protected will require a longer-term vision that also recognizes the need to curb global warming. Several of these rivers have experienced impairments due to high temperatures despite their otherwise pristine state. Furthermore, their dependence on glaciers for water places some of them at significant risk over the long term as glaciers continue to recede.

Skagit River

The upper reaches of the Skagit River in Washington have remained largely intact, providing an important habitat for wild salmonids. It is the only river in the state that still holds native populations of all five Pacific salmon species, as well as bull trout, steelhead, and sea-run cutthroat trout.[71] However, high stream temperatures and other problems in lower reaches of the Skagit River are cause for concern, particularly for threatened Puget Sound chinook salmon.[72] Moreover, because the Skagit River depends on glaciers as a significant source of water, continued global warming could place the upper river at risk as well. The glaciers that feed the basin have lost 44 percent of their mass in the last 150 years, and that pace is increasing.[73] South Cascade Glacier, for example, has been shrinking at such a rapid pace over the past three decades that scientists predict it could melt away completely within a century.[74]

Hoh and Queets Rivers

The Hoh and Queets are among the most scenic and accessible rivers on Washington's Olympic Peninsula. They are particularly popular among anglers for their winter steelhead, but they also host fishable runs of summer steelhead, along with chinook and coho salmon and sea-run cutthroat trout.[75] Both rivers depend on a combination of glaciers, snowmelt, and rainfall for their water, and they are among the few remaining unobstructed rivers in the region. As a result, they are considered to be among the strongest holdouts of favorable habitat for wild fish. However, the rivers are vulnerable to low summer flows during periods of drought, and warmer-than-normal water temperatures associated with low-flow periods rank as one of the biggest limiting factors for salmon production.[76]



The Skagit River is one of the key wintering areas for bald eagles in the Pacific Northwest. *Source: Washington Department of Fish and Wildlife, Paul Bannick*

Salmon spawning.
Source: U.S. Fish and Wildlife Service (FWS)

Sandy River

Even though it is in close proximity to major urban areas, the Sandy River in Oregon still provides considerable habitat for wild spring and fall chinook salmon, coho salmon, summer and winter steelhead, and cutthroat and rainbow trout.[77] Among anglers, it is a particularly popular river for year-round steelhead fishing. Since the river is largely glacier-fed from four glaciers on Mt. Hood, it has a relatively consistent supply of water, making it an important refuge in the Columbia River Basin for threatened and endangered salmonids. However, like most of the region's rivers, the Sandy has its share of problems from culverts and dikes, logging, road building, and pollution. And over the longterm, loss of glaciers due to global warming could pose a serious threat to its late-summer water supply.

Salmon River

The Salmon River in Idaho is the longest free-flowing river within one state in the lower 48. Long-renowned for the recreational opportunities it provides, the Salmon has also remained one of the least-degraded rivers in the region. It continues to be a top destination for sportfishing, including chinook salmon, sockeye salmon, steelhead, cutthroat trout, bull trout, and rainbow trout. Because it is relatively undisturbed, the Salmon River has served as a model to determine the effects of climate-related variables on water quality and species in isolation from other stressors.[78] Despite its pristine state, however, high temperatures have been identified as a habitat limiting factor for salmonids in parts of the Salmon River Basin in recent years, and trends suggest that human-induced global warming may play a significant role in the degradation of the basin's water quality in the future.

THE SALMON RIVER

Idaho's Salmon River is born in the Sawtooth and White Cloud Mountains. It murmurs northeast around the Salmon River Mountains, recruiting rivers like the Pahsimeroi and the Lemhi as it builds body and muscle from the Beaverhead and Bitterroot ranges. But it doesn't find its size and pace until cornering west into the 98-mile, headlong plunge through the River of No Return Wilderness where it embraces its North, Middle and South Forks. On the 400-mile turbulent journey to the Snake River, the Salmon takes water from 14,000 square miles of the heart of Idaho.

This enduring ribbon of life is America's longest undammed river in the Lower 48. It still does what rivers are supposed to do: take water from the mountains and bring salmon back to them. The Nez Perce named it *Natsoh Koos* chinook-salmon-water. The Shoshone called it *Agaimpaa* big-fish-water. A quarter of the 16 million salmon that once returned annually to the entire Columbia River came to this river.

On September 8, 2001, my wife and I were leading our pack string along the River on our annual elk-hunting pilgrimage. As I alternately watched the horses behind me and the rushing water beside me, I didn't know that in three days events thousands of miles away would occur which would focus our nation's attention away from rivers, mountains and the natural world. I wasn't thinking about world events; I wasn't even thinking about elk. I was thinking about salmon. It is impossible to be near the Salmon River without thinking about the remarkable creatures for which it was named.

We would ride for two days out of this canyon and over a 7,000-foot-high divide where we would descend into a remote basin. Here, on the morning of September 11, 2001, while events would ignite a global crisis two thousand miles away, we would sit on our horses deep in the River's cradle and watch salmon spawn.

In the following weeks the only news we would read would be left by elk, deer, cougar, moose and bear. The only flags we would see would be saplings stripped by rutting bull elk. We would hunt timbered ridges and valleys, listen to wolves howl and wonder at the gentle antics of spruce grouse. We would pack our winter's elk meat from deep, timbered basins and breathe air so quiet that the bark of pine squirrels would ring like crystal. And at night we would listen to the splash of salmon and wonder at their ability to survive against the odds outside of this river.

We wouldn't know about the deeds of others. We wouldn't think about religious and ethnic divisions, nor consider the bitter soil of poverty, desperation and oppression that germinates hatred, extremism and war.

Our thoughts would be only on the rhythm of the River, the life-giving miracle of moving water and the thousands of salmon-filled years cradled in the memory of these mountains.

Scott Stouder has been a freelance writer and is the Western Field Coordinator for Trout Unlimited, focusing on protecting the last remaining roadless country in the United States. He is an avid hunter, angler, and wilderness enthusiast as well as being an Advisory Board member of Backcountry Hunters and Anglers. He lives near Riggings, Idaho.

Here, on the morning of September 11, 2001, while events would ignite a global crisis two thousand miles away, we would sit on our horses deep in the River's cradle and watch salmon spawn.

The author, Scott Stouder, with pack string along the Salmon River. *Source: Scott Stouder*

Changing the Forecast for Rivers and Fish in the Pacific Northwest – A Plan of Action

The great rivers of the Pacific Northwest are true symbols of the connection between people and the natural world. Yet, for too long, humans have disregarded that connection and allowed short-term needs to transcend the region's long-term ecological and economic well-being.

As habitat for fish and other wildlife; resources for energy, transportation, commercial fisheries and agriculture and an essential part of the region's outdoor traditions, the great rivers of the Pacific Northwest are true symbols of the connection between people and the natural world. Yet, for too long, humans have disregarded that connection and allowed short-term needs to transcend the region's long-term ecological and economic well-being.

The continuing decline of wild salmon, steelhead, and trout is a sign that the region's rivers are in trouble, despite a concerted effort to tackle the problems confronting them. In general, strategies to protect the fish have been reactive rather than proactive, focusing on problems once they have become critical rather than looking at the problems and their solutions from a more holistic, long-term perspective — an approach that is all the more important in the face of global warming.

Certainly, there will not be wild salmonids in the future if they disappear today, which underscores the importance of current protections provided to the fish and fish habitat under laws such as the Endangered Species Act and the Clean Water Act. At the same time, however, current conservation efforts could be futile if they do not also address the threat of global warming. In fact, it is the combination of global warming and other anthropogenic stressors that could well push already-threatened salmonids to extinction.[79]

Fortunately, solutions to these many problems exist. Many of the conservation strategies that help these fish today, such as removing unnecessary and harmful dams, promoting more efficient use of energy and water resources, restoring and protecting instream flows, and preserving genetic diversity among species, will also help them become more resilient to the global warming that is already occurring. In addition, taking global warming and associated climate change into consideration in long-term resource management plans will improve the ability to meet the needs of fish in the future and still ensure that other activities are provided for when water resources are scarce.

Finally, it is possible to minimize the impact of global warming altogether by reducing the pollution that is causing it — but policymakers must begin to take meaningful action today, because every ton of global warming pollution that is emitted stays in the atmosphere and continues to warm the planet for more than 100 years. Delaying action will make it more difficult and costly to achieve the significant reductions in emissions of carbon dioxide and other heat-trapping gases necessary to successfully curb global warming. Numerous studies show that we can lower global warming pollution using readily available technologies to improve energy efficiency and generate electricity with clean, environmentally sustainable resources, while at the same time spur innovation and promote an emerging market for new alternatives.

Recommendations

1. Implement a more holistic, long-term strategy to protect and restore healthy rivers and fish.

To protect the Pacific Northwest's wild salmon, steelhead, and trout now and for the future, the region must implement a strategy that focuses not just on policies to prevent further declines, but on efforts to bring populations back to historic levels of abundance and diversity and provide them with the more natural streams that they need for long-term survival.[80] Specifically, such a strategy should strive to restore free-flowing rivers and estuaries throughout the Pacific Northwest, protect areas with the best remaining habitat, and reform fisheries management to encourage greater use of real-time monitoring and seasonal streamflow projections as well as maintain the genetic diversity of fish.

Sportfishing the Columbia River on opening day.
Source: Washington Department of Fish and Wildlife

Restore Rivers and Estuaries

Stakeholders in the region must redouble efforts to reduce current pressures on rivers, including those activities that have been contributing to high water temperatures and altered streamflows. Such strategies should go beyond mitigating problems once they have occurred and focus more intently on reducing the fundamental causes of the problems, as well as coordinating efforts to ensure that a solution for one problem does not end up exacerbating another. For example, efforts to meet "flow targets" established by state and federal agencies to assist with salmon recovery efforts could cause downstream temperatures to rise if the water being used to augment flows comes from a reservoir with water that is warmer than that of the river and its tributaries.[81] States and tribes may also find it difficult to meet new Clean Water Act criteria for stream temperatures without adequately addressing "non-point" sources of warming, such as water diversions, land-use practices, and other activities that contribute to higher temperatures by altering streamflows or affecting the structure of stream channels or riparian areas.

On the whole, the best way to reduce these collective problems is to restore and protect more natural conditions of rivers, including instream flows, wherever possible. At a minimum, decision makers should move forward with plans to remove unnecessary and harmful barriers, such as the four dams on the lower Snake River. Partially removing these dams alone would help restore 140 miles of free-flowing river, reducing added pressures on temperatures and streamflows and enabling wild salmon and steelhead to return to their historic spawning grounds.[82] Studies show that it is possible to provide stakeholders in the region

Studies show that it is possible to provide stakeholders in the region with alternative resources for power, transportation, and irrigation and save the millions of dollars that it currently costs to barge salmon around the [four lower Snake River] dams.

with alternative resources for power, transportation, and irrigation and save the millions of dollars that it currently costs to barge salmon around the dams.[83]

For example, a study by RAND Science and Technology shows that current energy production from the lower Snake River dams could easily be replaced with low-cost energy-efficiency measures, resulting in nearly 15,000 new jobs for the region and setting the stage for even greater investments in efficiency over the longer term.[84] In addition, the return of wild salmon and steelhead to the river system would provide opportunities for increased revenues from activities such as sportfishing, which could generate an estimated $293 million to $452 million a year.[85]

Restoring the region's estuaries, many of which have been damaged or destroyed due to development, pollution, siltation, and loss of water upstream, will also be an important step toward long-term health of the region's fish. To be effective, however, such efforts must incorporate the potential impact of global warming, such as a rising sea level, so that any short-term successes are not ultimately lost to problems such as coastal erosion and inundation. Designating coastal buffers and eliminating intensive agricultural practices in flood-prone areas would provide a more intelligent and flexible approach to managing coastal resource systems than structural approaches by enabling wetlands and other estuarine habitat to ebb and flow when necessary.

Save the Best Remaining Habitat

The region must also strive to protect the rivers (or parts of rivers) that currently provide the best remaining habitat for wild fish — places like the upper Skagit in Washington, the Sandy River in Oregon, and the Middle Fork of the Salmon River in Idaho.[86] As refuges from the ongoing pressures of water withdrawals, dams, and other problems, these areas offer the greatest hope for preventing further decline of salmonids as the region progresses toward longer-term restoration and global-warming mitigation goals. This should include protecting parks and wilderness, preserving roadless areas, and improving forestry and farming practices to minimize their impact on the rivers.

Reform Fisheries Management

In addition to protecting habitat, fisheries managers should rely more often on real-time monitoring, as opposed to preseason run-size predictions, to help determine short-term harvest limits.[87] Where projections are warranted, they should incorporate potential seasonal streamflow conditions and other climatic variables to better anticipate potential stresses on abundance.[88] They should also work to revise hatchery programs to ensure that they do not damage genetic diversity or viability of wild salmonids, which are better able to adapt to changing environmental conditions.[89] While hatcheries can bolster fish numbers and provide more opportunities for commercial and recreational fishing, raising captive-bred fish was never intended as a substitute for protecting wild salmon and the habitat they and many other species need to survive. Poorly managed hatcheries ultimately harm wild fish and other wildlife in the region by contributing to genetic interbreeding, reducing disease resistance, and causing competition for food and habitat.[90]

2. Incorporate global warming in water resource management and planning.

Even without global warming, the Pacific Northwest will face increasing pressures for water in the coming decades as the human population grows. With global warming expected to contribute to reductions in available water supplies, conflicts among users will likely escalate. Anticipating those changes today by taking global warming and associated climate change into consideration in long-term water resource management plans would enhance the region's ability to meet the needs of fish and ensure that other activities are provided for when water resources are scarce. This should include actions to increase water-use efficiency and conservation among major users such as cities and farms, and encourage greater use of seasonal and longer-term projections for streamflows in water management decisions to more proactively protect and restore instream flows for fish habitat.

Increase Water Efficiency and Conservation

Promoting greater use of efficient technologies and water conservation practices can go a long way toward protecting water resources, particularly during droughts and other periods when water supplies are scarce. Individual actions like fixing leaks, converting to water-efficient faucets and showerheads, and turning on the tap only when you need it can provide significant water savings at little or no cost to consumers.

However, with water resources likely to become increasingly scarce in the future, state and local governments should also consider more long-term investments in water management programs and infrastructure that will greatly reduce the amount of water needed for households, farms, and other consumptive uses and ensure that more water is available for fish and wildlife. For example, expanding water-use metering programs can help consumers and managers determine the actual amount of water usage and improve compliance with any necessary restrictions.[91]

Using drip irrigation instead of sprinklers in the garden can save water. *Source: NRCS*

In the Pacific Northwest, greater reliance on energy efficiency and clean, renewable energy resources would not only help reduce the need for electricity produced from hydroelectric dams, but it would provide the region with opportunities to meet future energy needs without contributing to global warming pollution.

Use Longer-term, Climate-based Forecasts

In response to the growing concern about water in the region, the Climate Impacts Group has initiated a stakeholder-driven process with public and private entities throughout the Pacific Northwest to raise awareness of the impact of global warming on the region's water resources and identify solutions. As part of this process, the Group is providing resource managers with tools so they can project potential changes in streamflows and other factors on a more seasonal and long-term basis, rather than rely too heavily on historic trends.[92] Such information can enable municipal water agencies and other relevant decision makers to more proactively implement contingency plans such as voluntary water-use restrictions and increasing reservoir stores when drought conditions are forecasted, providing a greater chance that there will still be enough water in the rivers for fish.

Resource managers must also give greater consideration to likely changes in water resources on a longer-term, basin-wide level when evaluating any applications for new water withdrawals. However, despite increasing attention to the region's water resource issues, there are a number of institutional barriers that hinder the use of these more forward-looking approaches, particularly on a regional basis such as in the Columbia River Basin.[93] Lack of coordination and cooperation among the many stakeholders involved in managing the region's rivers and inequities in allocating scarce water to meet competing needs make it much more difficult for effective decisions to be made. Moreover, many institutions and policies actually promote increased use of water, such as the "use-it-or-lose-it" provisions in Western Water Law.[94] Addressing these barriers should be a priority in the coming months in order to open the door for more prudent management of the region's water.

3. Minimize the threat of global warming by reducing greenhouse gas emissions.

The region and nation must be part of the solution to curb global warming altogether by reducing the pollution that is causing it. There are a number of actions that will make a difference, including strengthening state and federal policies and programs to promote energy efficiency, non-hydro renewable energy, and cleaner transportation options; encouraging protection and restoration of natural habitats (grasslands, wetlands, forests) that have a net use of carbon dioxide (often called carbon sequestration); setting specific limits on the nation's global warming pollution; and reengaging in international cooperation on global warming.

A SKAGIT RIVER ESSAY

It came like a burst of storm terror. The eagle was nowhere and suddenly it's everywhere – around my head, in my face, wings whooshing, flapping, slapping river air, clawing for altitude. Concussive waves of pounding flight feathers whomped against my ears, and my eyes filled with unfocused brown. It was too late to duck by the time I did.

Thirty years since and the kinetic etching of that incongruous near-collision is still vivid enough to perk adrenaline every time, without fail, when I cross the Rockport highway bridge and make the turn upstream along Washington's Skagit River. This powerful, broad flow is a pedestal river, host to American presidents and European royalty, electrifier of Seattle, and spawner of 70-pound king salmon. It carries the color and silt of alpine glaciers that leak ice water from leftover chunks of the Cordilleran ice sheet.

It's a most embarrassing place to be run over by a bird.

This powerful, broad flow is a pedestal river, host to American presidents and European royalty, electrifier of Seattle, and spawner of 70-pound king salmon.

The near-collision was an accident, an alignment of magnificent coincidence that for the eagle probably meant nothing. For me, a 26-year-old, freshly fled from a birthright of Midwest soybean fields, gypsying West searching for new, it became an epiphany ... and roots.

Certainly, it was an accidental collision of predators: one inexperienced and lumbering up from the river, the other skilled and flying down from who knows where — both looking for a vantage point, both cresting the cutbank from opposite directions arriving at the precise spot in an exact millisecond.

Tracks were stitched across the sandy bank: black-tailed deer, coyotes picking through shredded carcasses of spawned-out chum salmon, and the splayed outline of red-breasted merganser fans pressed into the damp at the waterline.

I was face-down in the wild tracks and wet sand of a uniquely Northwest diorama cradling a yellow-orange steelhead rod, belly into a low spot of eroded bottomland. On each side beyond the river were vertical walls, most of them more than a mile high. Dark green and gray and shot through with silver mists, the walls rose from the river through snowlines into whiteness and punched into banked overcast. Not far upriver, those walls pressed to the very edge of the river, and overhung the highway. They thundered with waterfalls and rolled into folds where mountain goats, cougars and the rumor of remnant grizzlies lived.

When I looked, the eagle was long gone, folded into a crowd of look-alike eagles that swept upstream and down in singles and groups of twos and threes, hunting for used-up chums, ignoring the bipedal transient with the dirty fish vest.

I remember thinking, praying actually, "Gawd I hope that bird didn't scare my steelhead!"

Wet splatters of snow began to fall.

My steelhead? A strangely proprietary reference, "my steelhead."

I walked to the waterline and a few feet further. Skagit water swept around my booted legs; powerful, deep, swirling downstream, deceptively quiet. The flow became a dark ribbon twisting into a twilight of muted grays. The snow fell harder, a soggy, thick flop that splattered on the land and crashed into the water. Upstream were ice-age glaciers and young rugged mountains, wilderness areas and a triad of power dams, a national park and clear-cut logging. Downstream were river guides and salmon hatcheries, tulip fields, and dairy cows, gillnets and politics.

The lure struck the water quartering upstream, and sank to the stones, ticking downstream slightly slower than the current. I tightened up on the line, worked my fingers into the rod cork, and settled in.

"My steelhead."

Terry Sheely is an award-winning full-time writer/photographer specializing in outdoor recreation, wildlife, and conservation subjects. He lives on a lake at the edge of the Cascade Mountains near Black Diamond, Washington, and is an unapologetic river fanatic and steelhead angler.

The author, Terry Sheely, on the Skagit River. *Source: Terry Sheely*

Source: Renewable Northwest Project

Increase the Use of Energy Efficiency and Renewable Energy Resources

Increasing the energy efficiency of homes, offices, motor vehicles, and factories is not only environmentally wise and technologically feasible; it also represents significant economic savings for households and businesses. For example, research shows that implementing stronger state and federal efficiency standards for air conditioners and appliances and improving energy efficiency in buildings over the next 20 years could lead to a 10 to 30 percent reduction in U.S. carbon emissions compared to business as usual.[95]

Abundant, clean, and reliable energy sources such as the sun and wind also have tremendous potential to help reduce the region's and nation's use of fossil fuels. Thanks in part to federal programs, the cost of renewable energy has fallen dramatically, and use of these technologies continues to grow. Properly sited and designed wind energy projects, for example, have the potential to generate enough electricity to meet the needs of more than 10 million homes and prevent as much as 100 million metric tons of carbon dioxide emissions by 2010.[96] With policies such as production tax credits and state and national renewables portfolio standards, the United States could achieve a goal of having 20 percent of its electricity produced from renewable sources by 2020, creating hundreds of thousands of jobs in the process.[97]

In the Pacific Northwest, greater reliance on energy efficiency and clean, renewable energy resources would not only help reduce the need for electricity produced from hydroelectric dams, but it would provide the region with opportunities to meet future energy needs without contributing to global warming pollution. According to a recent study by the Tellus Institute, the Pacific Northwest can significantly improve energy efficiency in buildings and factories and produce enough electricity from increasingly affordable resources such as wind to meet new demand over the next 20 years (as well as replace the power currently generated from the four lower Snake River dams).[98] Doing so would prevent adding 16 million metric tons of additional carbon dioxide into the atmosphere which would happen if the region instead were to meet that electricity demand with natural gas.

At a regional level, the Bonneville Power Administration (BPA) must take a leadership role by diversifying its energy mix to include a greater percentage of non-hydro renewable energy sources. This would improve BPA's ability to meet fish conservation obligations as well as serve to stabilize energy prices and improve reliability of electricity production in the short- and long-run.

Improve the Energy Outlook for Transportation

Another critical step for the region and nation to take is the implementation of a meaningful strategy to reduce energy use in the transportation sector. Transportation accounts for the greatest portion of carbon dioxide emissions in the Pacific Northwest, and the sector's share of total emissions is expected to continue growing in the coming decades without significant action to address the problem.[99] In addition to contributing to global warming pollution, the increasing reliance on cars and trucks has worsened congestion problems and urban air pollution and led to loss of green space and wildlife habitat.

America can save more than one million barrels of oil and reduce at least 400 thousand tons of carbon dioxide emissions every day just by raising Corporate Average Fuel Economy (CAFE) standards for sport utility vehicles, pickups, and minivans from the current low of 20.7 miles per gallon (mpg) to 27.5 mpg. A 2001 National Academy of Sciences report concluded that technologies are readily available to all car companies to significantly improve fuel economy without sacrificing vehicle performance, affordability, and safety.[100]

Federal and state governments can also provide greater incentives to increase the use of cleaner fuels and vehicles such as the new electric/gasoline hybrids, which are increasingly available to consumers. California has taken this a step further by enacting a law to limit the amount of global warming pollution from motor vehicles, beginning with the 2009 model year.[101] Under the U.S. Clean Air Act, other states can elect to adopt California's standards, which makes it possible for similar legislation across the country.

Communities can also decrease reliance on individual automobiles altogether by reeling in suburban sprawl, reducing the distances between where people work, shop, and live. Curbing sprawl will not only save energy, but it will help save green space and habitat for fish and wildlife. According to the National Governors' Association, local and state governments can use a variety of strategies, such as creating incentives to increase public transit use, promoting bicycle- and pedestrian-friendly options, and linking transportation funding to effective growth management strategies.[102]

The recently adopted West Coast Governors' Climate Change Initiative provides an important opportunity for the region to forward these and other actions to combat global warming. In September 2003, the governors of Washington, Oregon, and California committed to the development of a regionwide strategy to reduce their global warming pollution. While the West

Using homegrown biodiesel fuel, made from vegetable oil, in its buses helps King County Metro Transit reduce its global warming pollution.
Source: Seattle City Light/King County

Coast initiative does not yet have specific targets and timetables, other states are showing that this type of regional plan can provide an opportunity to establish ambitious-yet-achievable goals. For example, the recently established New England Governors/Eastern Canada Premiers Climate Change Initiative seeks to reduce regional emissions to 1990 levels by 2010, and by at least 10 percent below 1990 levels by 2020.

Streambank stabilization project along Dogfish Creek, Washington, showing root wads and plantings. Source: NRCS

Encourage Carbon Sequestration Through Sound Management and Restoration of Grasslands, Wetlands, Forests, and Agricultural Lands

The primary emphasis on curbing global warming must be on reducing emissions of carbon dioxide from burning fossil fuels. However, strategies to protect and enhance the ability of grasslands, wetlands, and other natural systems to absorb and store carbon from carbon dioxide in the air can play a role in slowing the growth in emissions. Properly designed projects can also provide additional benefits such as habitat for wildlife and economic opportunities for farmers.

Offsetting industrial carbon emissions by investing in projects to reforest riparian areas in the Pacific Northwest could provide stakeholders with an option to meet organizational or regional emissions-reduction targets in the short term, as well as help restore fish habitat by reducing erosion and providing shade for rivers. Researchers estimate that a number of forest management activities in the Pacific Northwest, including reforesting previously deforested land, lengthening harvest rotations, and replacing marginal croplands with trees, could enable the region to store as much as 9.4 million tons of carbon over the next five decades.[103]

Furthermore, studies suggest that restoring riparian vegetation and channel widths to their natural state could significantly reduce mean maximum water temperatures in summer months, which could help the region meet critical water quality standards.[104] Much of the remaining cool water habitat for chinook, steelhead, bull trout, and cutthroat trout in the Columbia Basin (or areas that contribute to cool water downstream) is on U.S. Forest Service lands, which points to opportunities to improve the outlook through more ecologically sound forest management.[105]

Set Specific National Limits on Global Warming Pollution

The United States has the technology and know-how to lead the world in environmental solutions while creating good-paying jobs here at home and strengthening America's economy. The best way to channel the ingenuity of America's industry toward confronting global warming is to establish specific national limits on U.S. global warming pollution.

A sensible first step would require power plants, oil companies, and other major sources to collectively stop their emissions of greenhouse gas emissions from growing. Using an emissions trading system similar to that developed for acid rain pollution under the Clean Air Act would permit each business to make its own decisions on the best way to meet the goals of the program. Companies that want to increase emissions can purchase emission credits from other companies that have reduced emissions beyond the program's goals. Although the initial goal of stabilizing pollution levels may be modest, it is important to get started now and put the nation on a path to a more sustainable energy future.

A market-based emissions trading system that establishes concrete limits on pollution will provide needed incentives to American industry to innovate and respond to the challenges of global warming. It will spur manufacturing jobs by retooling American industry and encouraging innovation that will help U.S. industry be a leader in the large global market for energy technologies over the next 20 years. According to the President's Committee of Advisors on Science and Technology in 1999, "U.S. firms would greatly benefit from investments in [clean energy technology], helping them capture much of the $10 trillion which will be spent worldwide for energy supply technologies over the next 20 years."[106] Moreover, researchers at the Tellus Institute estimate that a proposal to halt the growth in U.S. global warming pollution levels would lead to net consumer savings of $30 billion annually by the year 2020 by spurring innovation and energy bill savings.[107]

Given the United States' role as the largest emitter of greenhouse gases, U.S. leadership on global warming is critical to building international support for the deeper global reductions that will be needed in the decades ahead.

Five Things You Can Do at Home to Combat Global Warming and Protect the Pacific Northwest's Rivers

1. Conserve water by turning on the tap only when you need it and converting to water-efficient faucets and shower heads.

2. Improve the overall energy efficiency of your home through actions such as improving insulation, reducing unnecessary energy usage, replacing the most frequently used light bulbs in your home with energy-saving compact fluorescent bulbs, and other means.

3. Meet your transportation requirements by considering the cleanest, most efficient automotive model, such as a hybrid vehicle, that suits your needs; use public transportation when possible; and regularly check your car's tire pressure – poorly inflated tires waste gas and cause extra pollution.

4. Volunteer with a local conservation group to help restore rivers and other habitats, including replanting native trees.

5. Contact your representatives in Congress and encourage government to enact policies that reduce global warming pollution and promote a clean, sustainable energy future.

Reengage in International Cooperation on Global Warming

Ultimately, the U.S. government must reengage in the international process to implement a worldwide solution to global warming. To date, 141 other nations have taken an important step forward by ratifying the Kyoto Protocol, which requires them to reduce their collective greenhouse gas emissions to 5.2 percent below 1990 levels by the year 2012. While the United States abandoned its support for the treaty in 2001, there is still an important opportunity for the nation to participate in the development of further international commitments.

As the world's richest nation and number-one contributor to the global warming problem, America has a responsibility to do its share. Moreover, the United States has the technology and know-how to help other countries cut their own emissions, which places the nation in an excellent position to lead the international market for clean energy.[108]

Sockeye salmon. *Source: Scott Church*

With the right investments, people can change the forecast for the wild salmon, steelhead, and trout that epitomize the Pacific Northwest and ensure that their children and grandchildren will have the same opportunities to benefit from and enjoy the natural world that they have grown to know and love.

Sources for More Information

National Wildlife Federation
www.nwf.org/globalwarming

Climate Impacts Group,
University of Washington
www.cses.washington.edu/cig/

Save Our Wild Salmon
www.wildsalmon.org

Climate Solutions
www.climatesolutions.org

Northwest Energy Coalition
www.nwenergy.org

Transportation Choices Coalition
www.transportationchoices.org

West Coast Governors'
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www.ef.org/westcoastclimate/

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