
2005
SCIENCE ACCOMPLISHMENTS
OF THE PACIFIC NORTHWEST RESEARCH STATION

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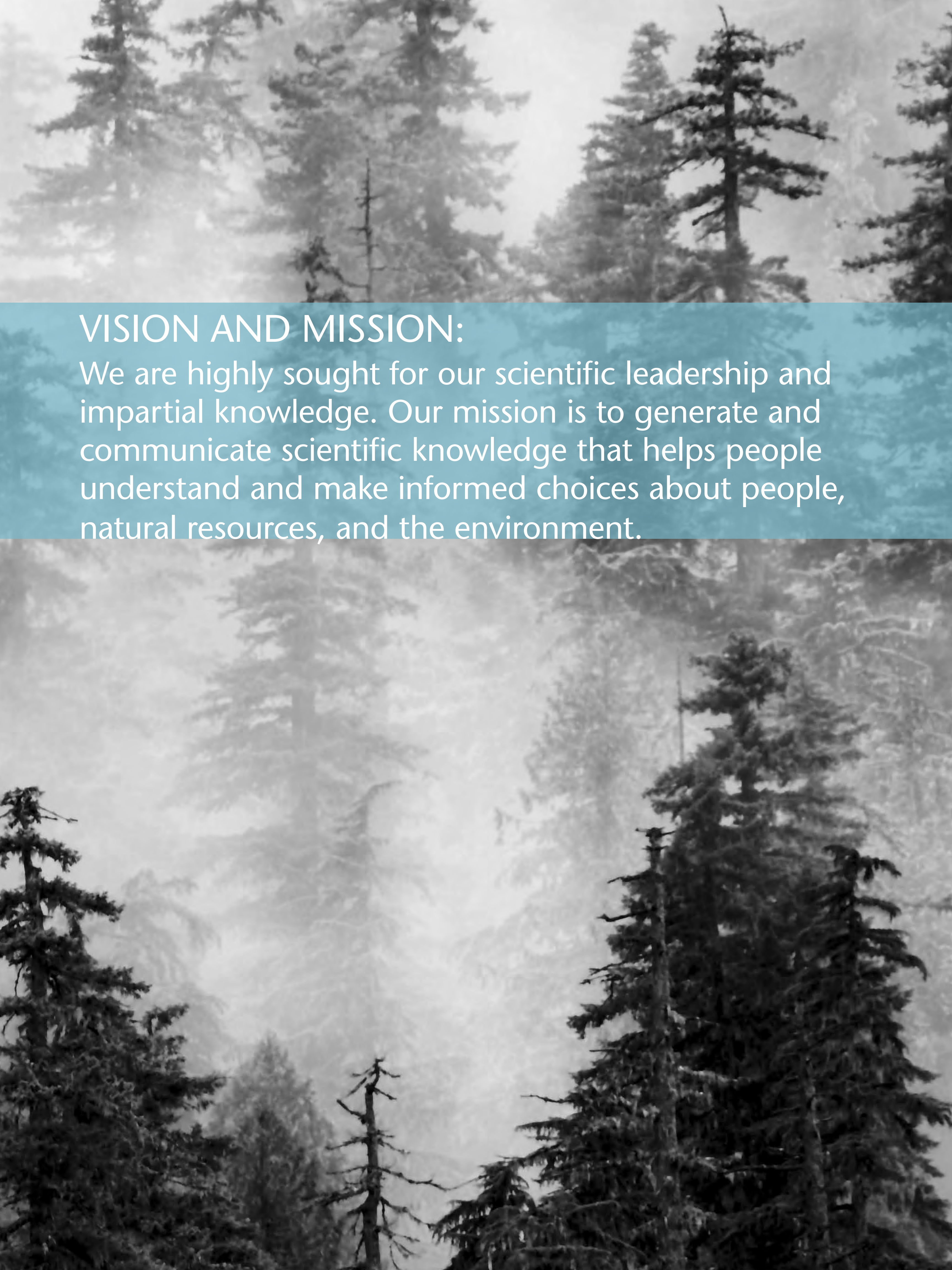
Cover photograph: Steve Wondzell



VISION AND MISSION:

We are highly sought for our scientific leadership and impartial knowledge. Our mission is to generate and communicate scientific knowledge that helps people understand and make informed choices about people, natural resources, and the environment.

Frank Vanni

A MESSAGE FROM THE PNW EXECUTIVE TEAM

In 2005, we celebrated a century of service for the Forest Service. The Pacific Northwest (PNW) Research Station is proud to contribute its service particularly at this juncture in history where we have a strong historical legacy of scientific knowledge that has allowed us to begin to understand just how complex forests and range lands are and how much they mean to people.

Last year we met a major milestone for perhaps one of the largest scale policy decisions to which we have contributed information: the Northwest Forest Plan. In April 2005, we shared science information on the monitoring and implementation of this plan during a conference attended by over 500 people. Twelve reports on the information discussed at this conference are being published in 2005 and 2006.

Another important accomplishment in 2005 was a series of meetings where we launched significant partnerships to address the critical issues we face in fire and fuels in the Northwest. New products to meet manager needs include a “consumer’s guide” synthesis of tools and models for fuel and vegetation treatments, a series of fuel treatment fact sheets, strategies to address fire risk in old forests, better integration among existing models, and techniques to meet postfire restoration needs.

In 2005, we contributed scientific concepts and other information about critical fish habitat, which is now being used by managers and regulators as they design management actions and monitor treatments from the Pacific coast to the interior West headwaters in Oregon and Washington.

As an Executive Team, we have the honor to work with scientists and others who have dedicated their careers to serving people through generating and communicating scientific knowledge. This accomplishment report provides a snapshot of this service for 2005. We look forward to continued service in years to come as we work with our many partners toward improved knowledge and informed choices.

PNW EXECUTIVE TEAM

February 2006

PNW RESEARCH STATION: THE SETTING

- 11 laboratories and centers in Alaska, Oregon, and Washington
- 11 active experimental areas (watershed, range, and experimental forests)
- Research also conducted in more than 20 research natural areas (RNAs)
- Headquarters in Portland, Oregon
- PNW is 1 of 5 research stations in the U.S. Department of Agriculture, Forest Service
- 519 employees (300 permanent, 219 temporary)

GOAL ACCOMPLISHMENTS

TOM IRACI

GOAL 1: Develop a fundamental understanding of ecological, social, and economic systems and their interactions

KEY FINDINGS

- Over the past 300 years, the Northwestern United States has had 10 distinct climate periods, with 3 of those being unique regimes that stood out from the background climate. These climate-switching episodes can have important consequences for ecosystems.
- The deep groundwater system of the high Cascade Range may buffer the hydrological effects of climate variability, but streams from the western Cascade Range are likely to have dramatically reduced summer streamflows under a warmer climate.
- Tourist numbers in southeast Alaska tripled from 1990 to 2004, with visible effects on local lifestyles, livelihoods, and resident relations with natural resources. As tourism increased, local leaders began to negotiate control of the process with outside corporations.
- In the dry, mixed-conifer forests of the inland Northwest, changes in forest structure and composition over the last 200 years have brought about changes in the pattern, distribution, frequency, and severity of disturbances, especially fires.
- Marbled murrelets travel widely between their foraging and nesting sites. Murrelets that nested in Washington's Olympic National Park were found foraging off the coast of Vancouver Island, and birds foraging off the Olympic Peninsula coast were nesting on Vancouver Island.
- Although trees' deep roots have access to water in dry periods, their ability to take up that water successfully depends on their shallow roots, which work in conjunction with leaf stomata to limit water loss.

ACCOMPLISHMENTS

Scientists characterize climate regime switching for past 300 years in the Northwest

A region can undergo periods of climate switching—episodes ranging from a few years to decades when its climate may differ significantly from its normal, or background climate. This climate switching can be initiated and sustained by shifting ocean and atmosphere conditions and can generate important changes in ecosystem patterns or processes, such as increasing fire frequency or the duration of pest outbreaks.

Using 300 years of tree-ring data, scientists evaluated the recent (from 1675 to 1978) climate of the Northwestern United States by determining past periods of above- and below-average drought. Using these data, they characterized the region's historical background climate and then identified anomalies—periods in which the region experienced abnormally dry or wet events. Their analysis revealed 10 distinct climate periods and 3 unique climatic regimes or signals that stood out from the background climate. Five of the 10 periods, representing about 80 percent of the time, were marked by mild and equitable moisture conditions, representing the Northwest's background climate. The remaining periods were anomalies: two displayed switching between severe and extreme dry and wet episodes; another two displayed switching between more moderate dry and wet episodes; and one exhibited no switching at all, but was marked by persistent, yet mild to moderate, drought. This latter period was how the Northwest experienced the "dust bowl" of the 1930s.

Tom Iraci

Using tree-ring data, scientists have built a timeline of droughts and wet cycles over the past 300 years in the Pacific Northwest.

Knowledge of the Northwest's recent historical climate is helping to examine the role of past climate in historical ecosystems. Linking historical climate to particular ecosystem patterns and processes also helps predict future ecosystem changes by providing evidence of the types of interactions that may occur.

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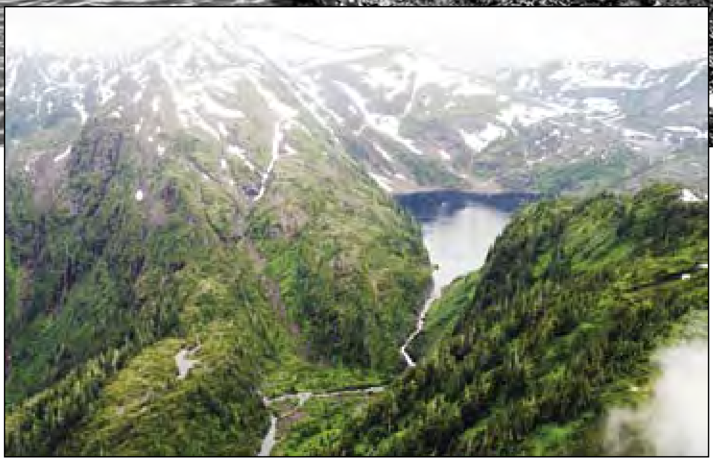
Partner: University of Arizona



Research reveals associations between climate and fire season severity

Scientists have documented associations between fire and climate variability. Both historical and contemporary records of fire show that in seasons, years, and decades experiencing above-average drought and temperatures, there have been dramatic increases in fire and area burned. Using these relationships, scientists estimated that significant increases in area burned would occur across the Western United States in the next century in direct response to global warming trends. Unusually dry or hot periods associated with periodic weather patterns may produce especially severe wildfires.

This research informs long-term planning for fire and fuels management by demonstrating that fire extent will be controlled most by regional climate and less by fuel accumulations.

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Partners: University of Guelph (Ontario, Canada), University of Washington, West Virginia University

Modified definition of El Niño could lead to improved seasonal weather forecasts

El Niño refers to a recurring oceanic-atmospheric phenomenon in which the temperature of Pacific Ocean surface waters increases. The result is a host of potentially devastating worldwide weather anomalies, such as flooding and changes in temperature and precipitation. Although scientists agree that 11 El Niño events have occurred since 1950, no consensus has been reached on an official definition of El Niño.

Recently the National Oceanic and Atmospheric Administration (NOAA) introduced a new definition that outlines surface water temperature increase and duration criteria for classifying El Niño events. This new definition is based on temperature anomalies of the central Pacific Ocean, however, and does not factor in conditions of the eastern Pacific Ocean, near the international dateline. The extreme weather resulting from these two types of El Niño events is substantially different. Collaborative research conducted by Station and NOAA scientists has revealed that a modification of the new definition, separating El Niño events into two classes—"conventional" and "dateline" events—will allow for significantly improved seasonal weather forecasts during El Niño events. Seasonal forecasts are relevant for anticipating droughts, firefighting needs, and so forth.

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Partners: USDC National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory

Assessments indicate Alaska's ecosystems may be in for change

Scientists used the Dynamic Global Vegetation Model MC1 to study potential future climate conditions on the interactions among climate, fire, and ecosystems in Alaska. The MC1 model forecasts the impacts of climate scenarios, such as those associated with global warming, on vegetation and fire disturbance.

Using projections generated by MC1, scientists found that by the end of the 21st century, 75 to 90 percent of the area simulated as tundra over recent decades may be replaced by boreal and temperate forest. Under future climate change scenarios, both carbon emissions from fire and total area burned increase significantly. The model also projects that as the temperature increases, Alaska ecosystems will reabsorb increasingly less carbon released from fires, to the point where the state actually becomes a carbon source near the end of the 21st century. Under the current climate, Alaska's boreal forests are a carbon "sink." Because boreal forests contain a large percentage of the world's terrestrial carbon, Alaska's boreal forests play a key role in the global carbon cycle.

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Partner: Oregon State University

Deep groundwater can buffer hydrologic impacts of climate variability in western Oregon

In the Western United States, city water supplies and the summer streamflows they come from are highly dependent on winter snowpacks. A growing number of studies predict, however, that climate change will lead to significant reductions in the region's snowpacks and, subsequently, its streamflows.

Scientists drew on their previous research on the High and Western Cascade geologic provinces of Oregon to study the possible effects of a warmer climate on streamflow. In the younger High Cascades province, deeper groundwater springs maintain higher and more consistent summer streamflow volumes than occur in the Western Cascades province, which has shallower, subsurface springs. Using a hydroecological model, scientists tested the response of these distinct streamflow systems to warmer temperatures. They found that the deeper groundwater system of the High Cascades is likely to buffer the impact of rising temperature and associated changes in snow accumulation and melt. The Western Cascades province, however, showed dramatically reduced summer streamflows under a warmer climate.

These findings are being incorporated into a multiyear planning process conducted by the Eugene Water and Electric Board, a public water utility serving over 200,000 customers in Oregon. The findings are likely to be used by other cities and by forest managers.

Contact: Gordon Grant, ggrant@fs.fed.us, Ecosystem Processes Program

Partners: Eugene Water and Electric Board, Oregon State University, San Diego State University

Scientists trace the fate of nitrogen in streams

Nitrogen, an essential nutrient for plant growth, is often a limiting nutrient in the forested mountain streams of the Western United States. In agricultural and urban streams, high levels of nitrogen often occur because of fertilizer runoff and other human-caused inputs. Recent findings reveal new information on nitrogen dynamics in forest streams.

Scientists studied the fate of two forms of nitrogen—ammonium and nitrate—within forested streams to better understand the dynamics of nutrient fluxes in ecosystems. Using a naturally occurring isotope of nitrogen as a tracer, they found that half the ammonium was sequestered, or taken up, in the stream in the first 650 feet, while the rest was transformed into nitrate and exported downstream. Instream uptake occurred in all parts of the instream food web and by riparian plants, with a large portion of uptake by mosses, bryophytes, and biofilms on wood, rocks, and detritus. Only 2 to 5 percent of nitrate remained within a forested reach, and similar but small amounts were released back to the atmosphere

Gordon Grant

Under a warmer climate, deep-groundwater springs in the High Cascades province may buffer the effects of summer drought on water supply, but shallower springs in the Western Cascades province may have dramatically reduced summer streamflows.

through denitrification, a natural process whereby bacteria break down nitrates and nitrogen gas is released into the atmosphere. The majority of nitrate was transported long distances downstream. In surveys throughout stream networks, scientists found that forest structure and age are not good predictors of nitrate availability—old-growth forest streams can have high or low nitrate levels, and stream reaches in alder stands have high nitrate levels regardless of forest age.

Contact: Sherri Johnson, sherrijohnson@fs.fed.us, Ecosystem Processes Program

Partners: Oregon State University, Lotic Intersite Nitrogen Experiment

Invertebrates increase nutrient processing, respiration in hyporheic zones

Critical to the health of watersheds are hyporheic zones—areas in which underlying groundwater meets surface water. These zones filter stream water, provide habitat for salmon eggs and fry, and host a variety of organisms. Hyporheic-zone life includes bacteria that cycle nutrients critical for the aquatic food web, including marine-derived nutrients from the carcasses of spawning salmon.

Interstitial invertebrates—those that live among a stream's sediment particles—can change the hyporheic zone's processes and affect how it stores nutrients, especially those from salmon carcasses. Scientists studied invertebrates' effects on salmon-derived nitrogen and carbon by creating large mesocosms, models that replicate the stream environment. Scientists found that invertebrates more than doubled the rate of nitrogen uptake and, in combination with fish, had the highest average rates of respiration. Thus scientists concluded that invertebrates increase the rates of nutrient processing from salmon carcasses and respiration in hyporheic zones. These findings are relevant to the management of salmon carcasses in streams and actions intended to augment nutrient additions to streams by adding fish carcasses or fertilizers.

Contact: Richard Edwards, rtedwards@fs.fed.us, Aquatic and Land Interactions Program

Partners: University of Wyoming

Pete Bisson

Uncertainty about salmon run sizes and other factors make it difficult to know if current fishing regulations adequately protect threatened species of salmon.

Effects of fishing on threatened salmonids not completely understood

Despite reductions in the harvest of salmonids (salmon and steelhead) in the Columbia River and its tributaries, many questions remain about the role current fishing seasons and catch limits have on the recovery of species listed under the Endangered Species Act.

Members of the Independent Scientific Advisory Board investigated salmon harvesting practices and found that insufficient data exist to determine the effects of fishing on individual salmonid populations. The board also concluded that inherent uncertainty, like run size predictions or actual harvest levels, is not factored into most management plans. These conclusions will be used to target specific data gaps for future funding through the Northwest Power and Conservation Council.

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Partners: Northwest Fisheries Science Center, Northwest Power and Conservation Council, USDC National Oceanic and Atmospheric Administration Fisheries

Salmonid foraging behavior helps predict carrying capacity

Scientists monitored the foraging behavior and interactions of salmonids (salmon and steelhead) in a variety of streams in the interior Columbia River basin in Washington. They found that salmonid species differ in the size of their foraging groups, suggesting that both food intake (how much they eat) and the aggressive interactions between individuals and species (how much they compete) will affect how a stream's productivity influences salmonid population size. Scientists found, for example, that in streams where wild steelhead trout exist alongside hatchery-derived coho salmon, steelhead foraging was reduced.

These findings can be used by land managers, whose actions can influence stream productivity, and by fisheries managers who control releases of hatchery fish and monitor the effects of invasive fish species on native, wild fish.

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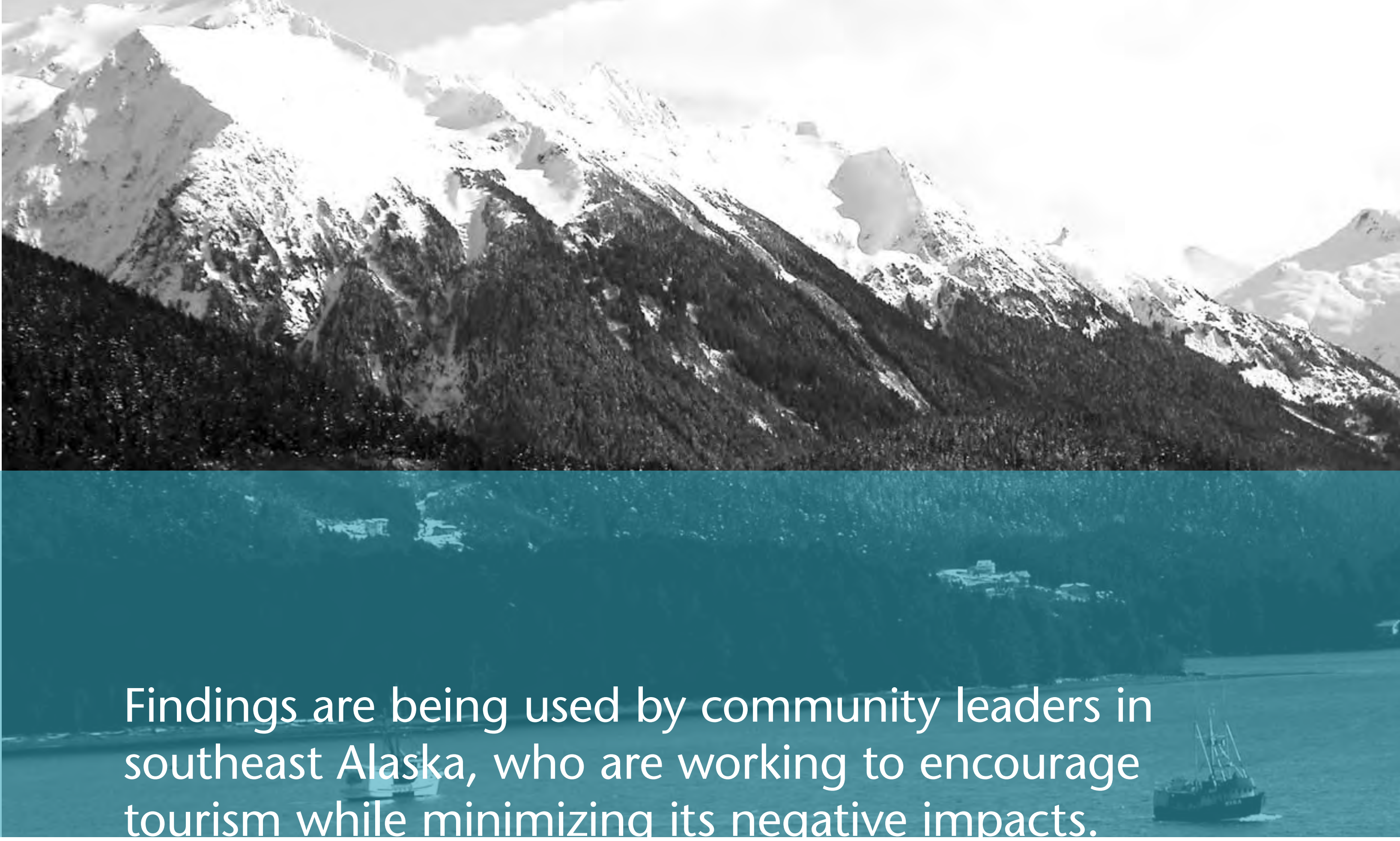
Partners: USDA Forest Service, Okanogan-Wenatchee National Forest; USDC National Oceanic and Atmospheric Administration Fisheries; Washington Department of Fish and Wildlife; Yakama Nation

Salmonids use high-gradient, headwater streams in southeast Alaska

A stream's gradient, or underwater slope, is an important characteristic related to waterflow, sediment load, and fish habitat. In Pacific Northwest forests, headwater streams frequently are small and high gradient and can make up as much as 80 percent of stream network miles. Large wood in these streams can create steps that break the stream into a series of low- and high-gradient sections and pools that retain sediment, sustain populations of invertebrate food species, and serve as salmonid habitat.



Findings are being used by community leaders in southeast Alaska, who are working to encourage tourism while minimizing its negative impacts.

Scientists found that in high-gradient, headwater streams in southeast Alaska, the gradient influenced the distribution of species. Dolly Varden, for example, were the dominant species in moderate and high-gradient zones, whereas juvenile coho salmon were the dominant species in low-gradient zones. Small numbers of steelhead were present in spring and fall. Overall, scientists found that the abundance of all of these species decreased as the gradient increased. Scientists determined that salmonids do use high-gradient reaches when the reaches are accessible and habitat is present.

These findings document the upstream limits of fish habitat in southeast Alaska and demonstrate the importance of connectivity of all parts of stream networks. The findings are relevant in planning culvert replacements that ensure fish passage and managing headwater streams.

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Procedures developed to measure change in Alaska flood-plain-type streams

Southeast Alaska's flood-plain-type streams are constantly in flux, responding to frequent changes in precipitation and sediment supply. This dynamic environment provides high-quality habitat for a variety of aquatic species. Scientists developed monitoring procedures for measuring change in flood-plain channel habitat in southeastern Alaska. Using the procedures, personnel can analyze change in channel conditions and develop conclusions on how land use practices are affecting channels. These procedures allow channel condition to be objectively and precisely measured to quantify changes over time—critical to assessing the effectiveness of fish and riparian standards and guidelines.

These procedures are being used in the development of monitoring protocols for Alaska's Tongass National Forest. They are being considered in the development of monitoring protocols for the broader Pacific Northwest region.

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Partners: USDA Forest Service, Alaska Region and Tongass National Forest

Tom Iraci

Visitors to Alaska tripled from 1990 to 2004, as Alaska was recognized internationally as a premier destination.

As tourism triples in southeast Alaska, local communities find unplanned effects

Tourism in southeast Alaska tripled from 1990 to 2004, with visible effects on local lifestyles, livelihoods, and resident relations with natural resources. Cruise ship passengers were about 75 percent of the 900,000-plus annual visitors, and the number of charter fishing boats multiplied tenfold. Many people who lost work in the timber or fishing industries have turned to tourism for economic survival, but tourism is having unplanned social and environmental impacts on Alaska communities.

Scientists studied the effects of tourism in three rural southeast Alaska communities, Haines, Craig, and Hoonah, which had different scales of tourism. They found that corporate investment in tourism escalated its growth, especially when combined with local initiatives such as construction of visitor facilities and transportation improvements. As tourism increased, however, local leaders began to negotiate control of the process with outside corporations. Tourism's effects differed based on visitor volume and the role of corporations. In Haines, a popular cruise ship destination, local people saw major, widespread changes in their natural and social environment. In Craig, where charter fishing lodges dominate the tourism landscape, the most significant effects were at popular fishing grounds, where residents now have to compete with tourists for limited resources. A new cruise ship attraction in Hoonah brought 66,000 visitors to this small Tlingit community, where residents now encounter tourists in culturally significant areas.

These findings are being used by community leaders, who are working to encourage tourism while minimizing its negative impacts; by agency managers, who are working with guides, outfitters, and communities to find environmentally sound and socially just opportunities; and by tourism companies working to have mutually beneficial operations in small communities.

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Partner: USDA Forest Service, Tongass National Forest

More information: Research Paper PNW-RP-566, 2005. *Tourism and Its Effects on Southeast Alaska Communities and Resources: Case Studies From Haines, Craig, and Hoonah, Alaska.* http://www.fs.fed.us/pnw/publications/pnw_rp566.

Questions raised about suitability of flying squirrels and voles as old-growth indicator species in Alaska

Southeast Alaska is noted for its especially high rate of mammalian endemism—meaning that many of its mammal species, such as the Prince of Wales flying squirrel and Wrangell Island red-backed vole, are found nowhere else in the world. These species' counterparts in the Pacific Northwest have habitat requirements that make them good indicators of old-growth forest condition.

To see if this were also true in southeast Alaska, scientists synthesized scientific knowledge on these species as well as four others listed in the Tongass Land Management Plan as proposed management indicator species. Scientists found that for most of these species, there were limitations in using them as indicator species on the Tongass. The flying squirrel was found not to be as closely linked to old-growth forest attributes and the vole not to be as sensitive to canopy removal as has been documented in the Pacific Northwest. Tongass managers will use this information to select management indicator species for forest planning, to guide management of second-growth stands to benefit flying squirrel and red-backed vole populations, and to develop protocols for monitoring endemic small mammals across southeast Alaska.

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Partners: USDA Forest Service, Alaska Region and Tongass National Forest

John Laurence

Scientists live-trap flying squirrels in southeast Alaska.

Environmental gradients control plant composition of black spruce forests

In Alaska's boreal interior, black spruce is the predominant tree species, spanning a wide range of habitat types. Scientists named and described three of the region's black spruce plant communities and five community subtypes and then correlated these communities with environmental gradients. The result is the first floristically based community classification for Alaska's boreal forest. It also is the first time a mineral soil pH gradient has been identified as an important driver in species composition in the boreal forest of Alaska. Scientists found that patterns in soil-carbon pools, terrestrial storage sites of carbon and prime habitat for black spruce, were highly correlated with differences in species composition among sites.

This information is being used by wetland and forest managers, scientists in the Long-Term Ecological Research (LTER) program for interior Alaska, and vegetation ecologists. Management of the soil carbon pool may be a particularly important issue in a warming climate.

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Partners: National Science Foundation; University of Alaska Fairbanks

Changes in forest structure and composition linked to changes in disturbances

Managers often look to a landscape's past for guidance in managing its future. For more than 10 years, scientists have studied the differences in forest vegetation patterns

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