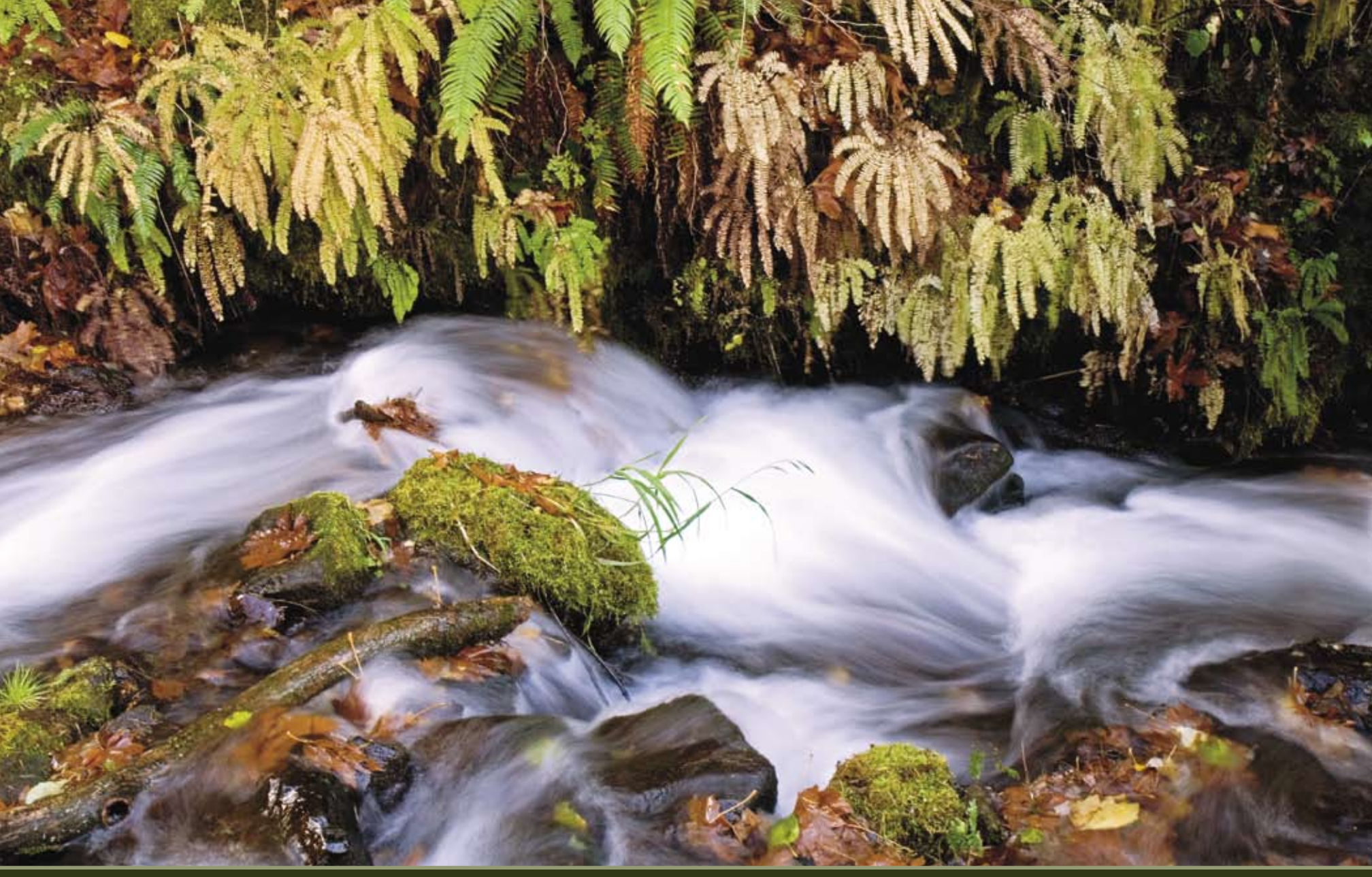


2008 Science Accomplishments of the Pacific Northwest Research Station

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.

Contents

Columbia Gorge; © Miles Hemstrom

THE SETTING

Broken Top Mountain, Oregon; © Miles Hemstrom

Pacific Northwest Research Station: The Setting

Experimental Areas

1. Bonanza Creek Experimental Forest
2. Caribou-Poker Creeks Research Watershed
3. Young's Bay Experimental Forest
4. Maybeso Experimental Forest
5. Entiat Experimental Forest
6. Wind River Experimental Forest
7. Cascade Head Experimental Forest
8. Starkey Experimental Forest and Range
9. H.J. Andrews Experimental Forest
10. Pringle Falls Experimental Forest
11. South Umpqua Experimental Forest

Laboratories and Centers

Alaska Wood Utilization and Development Center (Sitka)
Anchorage Forestry Sciences Laboratory
Boreal Ecology Cooperative Research Unit (Fairbanks)
Corvallis Forestry Sciences Laboratory
Juneau Forestry Sciences Laboratory
La Grande Forestry and Range Sciences Laboratory
Olympia Forestry Sciences Laboratory
Pacific Wildland Fire Sciences Laboratory (Seattle)
Portland Forestry Sciences Laboratory
Wenatchee Forestry Sciences Laboratory
Western Wildland Environmental Threat Assessment Center (Prineville)

- 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
- Pacific Northwest Research Station is one of five research stations in the U.S. Department of Agriculture, Forest Service
- 421 employees (285 permanent, 136 temporary)

A MESSAGE FROM THE STATION DIRECTOR

Deschutes River, Oregon;
© Miles Hemstrom

The Pacific Northwest (PNW) Research Station delivers high-quality science useful for addressing pressing land management issues. Our success is based on the hard work of many: our scientists, technicians, administrative support staff, and partners. Many retirees continue to volunteer their time and expertise to the station, and their dedication contributes to our success. We now have 17 emeritus scientists, and in the past 2 years I've been proud to appoint our first two women to the program.

Over the years, the station's research has delved deeply into many topics. Before climate change and carbon storage became part of the everyday vocabulary, we had scientists investigating these and other related topics. Now we are in the position to provide science-based tools to help land managers strategize for a changing climate. This year we worked with the National Forest System to disseminate this information to forest managers by hosting several climate-change short courses. We also launched the Climate Change Resource Center Web site as a clearing house for climate-related research by Forest Service scientists in the Western United States. I am very pleased that we were able to help the Olympic and Wenatchee National Forests incorporate climate mitigation strategies into their forest plans.

Water is another topic of increasing public interest that many of our scientists have been studying for years through the lens of their respective disciplines. We continue to deliver science and tools to facilitate management of this valuable resource and its associated aquatic life and riparian systems. Washington's Entiat Watershed Planning Unit, for example, is developing future water storage options and allocation plans based on one of our studies. Also of note, when developing and evaluating options for their new management plan in Oregon, the Bureau of Land Management used a PNW landslide model that enables land managers to identify and prioritize landslide sites with a high probability of affecting a fish-bearing stream either positively or negatively.

Tim LeBarge

Station Director Bov B. Eav

The station also explores areas of new research. For example, we work with partners in the Northwest to establish an urban forest long-term research center in Seattle. Meanwhile in Portland, a study was done to determine the economic benefits provided by the city's street trees. I anticipate that urban forest research will complement our long-standing research areas. Climate change and river health are just a few management issues that don't stop at the city limits or forest edge.

This report notes the variety of ways we share information with others. This year our scientists published 360 publications—of which 176 were journal articles and 42 were books or book chapters. We continue to extend our presence on the Web, in many cases with content unique to that medium, such as online tutorials or multimedia presentations. Communicating directly with our clients remains a valued tradition, and last year about 6,000 people attended symposia, workshops, field tours, and conservation education events sponsored by the station.

The coming year promises to be one marked by change. I am optimistic about our ability to seize new opportunities while remaining a pillar of scientific integrity.

Bov B. Eav
Station Director

Mount Hood, Oregon; © Miles Hemstrom

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

Key Findings

- Temperature increases projected over the next three decades are likely to cause water volume in seasonal snowpacks to decline to one-third of current levels and melt several weeks earlier in the interior Columbia basin.
- Dissolved organic carbon fluxes from coastal temperate rain forest watersheds in southeast Alaska are the highest reported rates in the world.
- Evapotranspiration in riparian forests plays a key role in regulating daily fluctuations in streamflow in small watersheds during late summer.
- Response to removal of Marmot Dam on the Sandy River in Oregon indicates that, under the right circumstances, dam removal can be an effective strategy for restoring ecosystems.
- Changes in stream temperature are accompanied by species-specific changes in macroinvertebrate size and life history.
- The Biscuit Fire burned more topsoil than expected; loss of carbon and nitrogen in the soil decreased site productivity.
- Lichens indicate patterns of biodiversity, air quality, and climate.
- Height-related trends in leaf hydraulic efficiency may limit growth of tall Douglas-fir trees.
- An Alaska study finds timing of warmer temperatures determines whether rate of tree growth increases or decreases.
- Compounds in the heartwood of certain western conifers exhibit strong antimicrobial activity toward *Phytophthora ramorum*, the pathogen that causes sudden oak death.
- Scientists develop cost-effective methods for genome sequencing to reveal adaptive variation and aid in conservation genetics applications.
- A whole-landscape management strategy may best promote recovery of habitat for the threatened northern spotted owl in dry forests.
- Interactions among environmental threats, such as climate change and invasive species, are key drivers that threaten western wildlands.

Follow the for more information about these key findings.

Less water volume and earlier melts projected for snowpack

Much of the interior Columbia River basin depends on snowpack for its supply of clean water. In this semiarid environment, competition for water can be particularly intense during the late summer and early fall. Scientists modeled snow accumulation and melt to forecast the effects of increasing temperatures on availability of water from the snowpack.

Outcome: *Watershed planners are using projections about water supply to plan ahead for anticipated shortages.*

Results indicate that within the next 30 years, the volume of water contained in snowpack will shrink to one-third of its current level, and the dry season will likely lengthen by several weeks.

During the extended dry season, water temperatures can be expected to increase as streamflows decrease below current levels. These effects are likely to have profound implications for land management agencies, communities, and aquatic species such as threatened salmon. Washington's Entiat Watershed Planning Unit is using these findings to develop future water storage options and allocation plans.

Contact: Richard D. Woodsmith, rwoodsmith@fs.fed.us, Aquatic and Land Interactions Program

Partners: Oregon State University, USDA Forest Service Okanogan-Wenatchee National Forest

Rick Edwards

A field crew gathers water samples to determine the amount of dissolved carbon cycling through a watershed in southeast Alaska.

Scientists quantify carbon fluxes in southeast Alaska

Coastal temperate rain forests sequester large amounts of carbon because cool, wet conditions inhibit decomposition. They are also sources of carbon. The Tongass National Forest exports as much dissolved organic carbon per year in water as would be removed through harvesting 1.6 million board feet of timber—enough to frame 100,000 homes. Much of this carbon is transferred to aquatic systems where it likely plays a key role supporting production of species such as salmon, shrimp, crab, and others. What isn't incorporated into aquatic food webs enters long-term storage within the marine system.

As the climate warms, the rate at which carbon is released from the soils of coastal temperate rain forests could increase. Station scientists continue to measure rates and controls of major fluxes to better understand the carbon cycle and the interplay between terrestrial and aquatic systems. This information will be used to develop forest carbon management strategies and be applied to regional and national carbon sequestration goals.

Contact: Rick Edwards, rtedwards@fs.fed.us, Aquatic and Land Interactions Program; David D'Amore, ddamore@fs.fed.us, Resource Management and Productivity Program

Partners: University of Alaska Southeast, U.S. Cooperative State Research, Education, and Extension Service

Glacier-fed watersheds differ from those without glaciers and have climate change implications

Watersheds in southeast Alaska will be significantly altered as the climate warms. Currently, 86 percent of the water discharged from the Tongass National Forest comes from large continental watersheds containing glaciers and permanent snowfields. The seasonality of discharge, chemistry, and temperature of glacial rivers is very different from nonglacial rivers in the Tongass. As warming continues, the loss of glacial inputs and changes in the timing of runoff related to changes in snowpack and snow-to-rain ratios will dramatically affect stream habitats and the annual pattern of carbon and nutrient inputs to the marine system.

Watersheds that do not contain glaciers exhibit two peaks annually, a spring snowmelt peak and a fall peak. As the snow line rises, discharge will begin to track precipitation, as is observed in the lowest watersheds, and the spring melt peak will disappear. These changes in annual hydrology will interact with nutrient cycles to change the shape and productivity of river habitats.

Rick Edwards

Warmer temperatures will lead to changes in watersheds currently fed by glaciers.

This research is leading to better modeling of present and changing hydrology of Alaska's streams. Improved models of future runoff will help managers design stream restoration and fish enhancement projects and be used to model potential fish distribution under various climate scenarios.

Contact: Rick Edwards, rtedwards@fs.fed.us, Aquatic and Land Interactions Program; Dave D'Amore, ddamore@fs.fed.us, Resource Management and Productivity Program

Partners: University of Alaska Southeast, U.S. Cooperative State Research, Education, and Extension Service

Moose shape the flood plains of interior Alaska

What moose choose to eat plays a major role in the large-scale, landscape pattern of flood-plain plant communities and within-stand dynamics and element cycling in interior Alaska. Moose herbivory greatly decreased the aboveground biomass and age structure of willow and increased the biomass and density of later successional species, such as alder and balsam poplar. Moose herbivory also greatly increased the rates of carbon and nitrogen input to the soil and the subsequent cycling of those nutrients. At the landscape scale, however, the interactive effects among herbivory, erosion, and deposition of flood-plain soils can change large-scale landscape patterns in major ways that cannot be predicted on the basis of a single factor.

Outcome: *U.S. Fish and Wildlife Service uses findings to test predicted patterns of moose use of the landscape.*

These findings are being used to predict early succession flood-plain dynamics on other river systems of interior Alaska. The U.S. Fish and Wildlife Service, Yukon Flats National Wildlife Refuge, is currently testing the predicted patterns along the Yukon River with an interest in both plant community structure and potential implications for moose habitat quality and long-term moose-habitat interactions.

Thomas Hanley

A researcher examines the effects of moose herbivory in interior Alaska.

Contact: Thomas A. Hanley, thanley@fs.fed.us, Ecosystem Processes Program

Partners: Bonanza Creek Long-Term Ecological Research Program; University of Alaska Fairbanks; U.S. Fish and Wildlife Service, Yukon Flats National Wildlife Refuge

Riparian forests regulate stream flow through evapotranspiration

Scientists found that riparian forests are the primary location of lost streamflow from evapotranspiration in late summer in small watersheds. A study in the H.J. Andrews Experimental Forest explains how daily fluctuations in discharge were generated and why. Observations of daily fluctuations showed that the time lag between maximum evapotranspiration demand and minimum discharge increased, and the amplitude in daily fluctuations decreased as streamflow decreased.

Recently there has been renewed interest in using land management to "harvest" water, especially to augment streamflow during seasonal droughts. This research indicates that vegetation management on upland portions of watersheds may increase total annual water yield, but efforts specifically designed to enhance low-flow discharge in summer would have to concentrate vegetation management efforts in riparian areas.

Also, water quality in many streams is often limited during the summer when low flows combined with high air temperatures raise water temperature, lower dissolved oxygen, and increase concentration of pollutants. This research highlights naturally occurring signals that could be used to improve understanding of watershed processes and help inform management designed to protect or improve water quality.

Contact: Steve Wondzell, swondzell@fs.fed.us, Aquatic and Land Interactions Program

Partners: Montana State University, Pennsylvania State University, U.S. Geological Survey

Bridal Veil Falls, Columbia Gorge, Oregon.

Sandy River responds well to Marmot Dam removal

Removing dams that are outdated, unsafe, or pose significant economic or environmental costs has emerged in the last 10 years as a major river restoration strategy. The removal of the 45-foot-high Marmot Dam on Oregon's Sandy River in 2007 was the largest sediment release accompanying any dam removal to date and provided an unprecedented scientific opportunity to predict, monitor, and evaluate how a large energetic river "digests" a mammoth meal of sediment.

Scientists found that an energetic river can efficiently incise and remove very large volumes of unconsolidated stored sediment, even under very modest flows. Most of the channel changes occurred upstream of a bedrock gorge, with only limited changes downstream. The Marmot dam removal clearly demonstrates that under the right set of circumstances, dam removal can be an effective strategy for restoring ecosystem function and connectivity to large rivers, and improving conditions for threatened and endangered species.

Salmon River, Oregon; © Miles Hemstrom ▶

Under the right circumstances,
dam removal can help restore ecosystems.

Gordon Grant

The Marmot Dam on the Sandy River in Oregon was breached on October 19, 2007, to improve habitat for salmon and steelhead.

The results from this project will guide future dam removals for the next decade. It is also a superb example of meshing an engineering challenge with a scientific opportunity to deliver understanding for future use, all within the framework of a dynamic and open public process.

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

Partners: Graham Mathews and Associates, Johns Hopkins University, National Center for Earth-Surface Dynamics, National Science Foundation, Oregon State University, Portland General Electric, Stillwater Sciences, University of Oregon, U.S. Geological Survey

Small streams are important sites for nitrogen uptake and processing

Nitrogen is an essential element for life, and historically the Pacific Northwest has had a limited supply. Humans have increased the supply through fossil-fuel combustion and fertilizers. Some of this excess is taken up by soils, but much enters aquatic ecosystems where it can be transported far downstream, potentially leading to noxious algal blooms and oxygen-starved estuaries.

Station scientists found that river networks, particularly small streams, can remove and retain some of this excess nitrogen, but their effectiveness is partly determined by surrounding land use. Across a range of land-use types (forest, agriculture, urban), the ability of small streams to process nitrate declined as ambient nitrate concentrations increased.

The results from these short-term studies are being combined with results from 40-year studies of nutrient export in the H.J. Andrews Experimental Forest. These findings provide guidelines for restoring and maintaining ecosystem functions.

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

Partners: Oregon State University, Lotic Intersite Nutrient Experiment

New technique identifies sources of soil and stream productivity

Scientists have identified a type of dissolved organic material that is easily digested by stream micro-organisms by using a novel modeling technique known

Rick Edwards

A wetland in southeast Alaska.

as parallel factor analysis (PARAFAC). This "labile" organic matter is exported from wetlands and carried downstream. It is generally accepted that soils provide important ecosystem services in the maintenance of terrestrial and aquatic biological systems, but it is difficult to identify the source of this easily degraded material that sustains primary production in soils and streams. The PARAFAC analysis can be used to determine if the type of organic material in watersheds is usable by stream microorganisms, an indicator of proper ecosystem function. Until now, it has been difficult to evaluate management impacts on terrestrial and aquatic systems at this fundamental level. The development of this technique is an important advance, enabling scientists to evaluate soil quality and wetland functions in the coastal temperate rain forest of southeast Alaska.

Contact: David D'Amore, ddamore@fs.fed.us, Resource Management and Productivity Program

Partners: University of Alaska-Fairbanks, University of Alaska-Southeast

Changes in stream temperatures are species-specific

Stream temperature is a major influence on aquatic insect emergence, affecting maturation rates, body size, and fecundity. In laboratory experiments, scientists examined the effects of three thermal regimes on emergence timing and adult body size of three species of common stream macroinvertebrates.

© Miles Hemstrom

For one species in the warmest treatment, scientists observed a shift in timing of emergence of males by 23 days before the females from the same treatment and before individuals of either sex from the other temperatures. A second species showed no change in timing of emergence or size of adults when temperature was elevated, and a third species showed smaller size of adults at higher temperatures.

These findings suggest that subtle changes in thermal regimes, such as those associated with land management or climate change, may have effects on aquatic insect maturation and adult body size that are species-specific. These effects could have repercussions throughout the stream food web.

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

Partners: Oregon Department of Fish and Wildlife, Oregon Department of Forestry, Oregon State University, Watershed Research Cooperative, Weyerhaeuser Company

Trout in Spirit Lake have unusual adaptations

As the closest and largest lake adjacent to Mount St. Helens, Spirit Lake underwent extensive changes during the 1980 eruption. It was transformed from a relatively pristine cold-water mountain lake to a larger, shallower lake containing a warm microbial broth in which no air-breathing organisms survived, including fish. The lake gradually returned to conditions that supported flora and fauna more typical of the Cascade Range over the next decade, but the first trout was not captured until 1993. The rainbow trout population has expanded rapidly, and the fish are exhibiting exceptional growth rates and unusual life histories. They grow fast, have unusual spawning characteristics, and die young, in marked contrast to trout in most mountain lakes.

Outcome: *Chilean scientists look to recovery of Spirit Lake for clues about possible recovery of lakes near currently erupting Chaiten Volcano.*

Rainbow trout.

The unusual adaptations of Spirit Lake trout to the volcanic environment have piqued international scientific interest. For example, scientists in Chile are seeking to extend lessons learned at Spirit Lake to lakes near the currently erupting Chaiten Volcano.

Contact: Charlie Crisafulli, ccrisafulli@fs.fed.us, Aquatic and Land Interactions Program

Partners: University of Washington, U.S. Geological Survey, Washington Department of Fish and Wildlife, Wild Fish Conservancy

Historical forest conditions supported a range of fire severities

To EFFECTIVELY use fire as a land management tool, it is helpful to know the typical severity of historical fires in the area. In this study, scientists found that the suite of forest structural conditions and patch sizes supporting native fire regimes of mixed-conifer forests was broader than was formerly recognized.

After analyzing aerial photos from the early 1900s of unharvested forest on about 750,000 acres in eastern Washington, scientists found that mixed-severity fires were most prevalent, regardless of forest type. The structure of mixed-conifer patches in the eastern Washington Cascades, in particular, was formed by a mix of fire severities. In moist mixed conifers, stand-replacement fire effects were more widespread than surface fire effects, whereas in dry mixed conifers, surface fire effects were more widespread by nearly 2 to 1. The relatively low abundance of old, parklike or similar forest patches in comparison with the abundance of young and intermediate-aged patches, and evidence of partial-stand and stand-replacing fires suggested that variable fire severity and nonequilibrium patch dynamics were primarily at work.

This suggests that some of the contemporary effects from wildfires may better meet management objectives than once thought, particularly when the objective is to create patch conditions achieved through low- and mixed-severity fires.

Tom Iraci

Forest structure is one variable that influences fire severity.

Contact: Paul Hessburg, phessburg@fs.fed.us, Managing Disturbance Regimes Program

Partners: USDA Forest Service Intermountain, Northern, and Pacific Northwest Regions; USDI Bureau of Land Management

Central Oregon's sandy loam soils tolerant to postfire logging

LOGGING ACTIVITIES can compact the soil, reducing its pore size and decreasing oxygen availability and movement of water and nutrients to tree roots. To alleviate compaction, land managers may fracture the subsoil, a practice known as subsoiling.

In this study, scientists examined the effects of compaction and subsoiling after postfire logging on the soil microbes in a mixed-conifer forest in central Oregon.

These bacteria and fungi are a key component of forest ecosystems. They perform the complex biological and chemical processes that render essential nutrients available for the healthy growth of forests. They are essential to maintaining soil health and long-term productivity.

Scientists found differences among stands with respect to relative bacterial species abundance, but no difference among treatments. The cumulative number of bacterial species and fungal species did not differ significantly among the compacted soil, subsoiled, or fire-only treatments. Over multiple sampling seasons, however, slightly more bacterial and fungal species were found in the compacted soil treatment.

These findings suggest that microbial communities in the sandy loam soils in this study were generally tolerant of postfire harvest disturbance.

Contact: Jane Smith, jsmith01@fs.fed.us, Ecosystem Processes Program

Partners: Oregon State University, USDA Forest Service Deschutes National Forest

Sarah Beldin

Researchers study the effects of postfire logging on soil health on the Deschutes National Forest.

Intense wildfire alters forest soil

For the first time, scientists were able to directly measure the effects of hot wildfire on forest soils. The 2002 Biscuit Fire burned about half of twenty-seven 15-acre study plots east of Gold Beach, Oregon, established before the fire.

The fire burned at temperatures over 1,300 °F, as evidenced by the melted aluminum tags across the research plots—this is more than twice as hot as typical prescribed fires. Loss of topsoil and combustion of organic material were higher than most previous estimates. More than 10 tons per acre of carbon and 450 to 620 pounds per acre of nitrogen were lost, and nearly 60 percent of this came from the mineral topsoil below the organic layer.

The loss of topsoil and soil carbon can negatively affect a range of processes including nutrient retention and water infiltration. To replace the documented amount of lost nitrogen would require nitrogen-fixing plants to dominate the forest for decades.

This study illustrates the dramatic effects of intense wildfire on soil nutrients and resulting site productivity. Understanding how fire can alter the available nutrients and thus change the productivity

of a site is essential when undertaking reforestation efforts and projecting future stand development. Also, a forest that grows slower after an intense wildfire than it did before will have reduced rates of carbon sequestration.

Contact: Bernard Bormann, bbormann@fs.fed.us, Ecosystem Processes Program

Partners: Oregon State University, Western Washington University

Scientists estimate carbon emission from Biscuit Fire

How much stored carbon did the 2002 Biscuit Fire release? To answer this question, scientists estimated the amount of carbon in 24 separate fuel "pools" by using prefire data from areas later burned by the Biscuit Fire in southern Oregon. They then used postfire estimates to check combustion factors for the various pools of carbon and estimated 2.9 to 3.5 terragrams of carbon were emitted during the fire. This is about 16 times the annual net ecosystem production of this landscape before the wildfire.

Few studies have attempted to empirically quantify wildfire-induced carbon exchange between terrestrial vegetation and the atmosphere. This study may lead to further use of pre- and postfire data to determine the carbon outputs to the atmosphere from large wildfires. As more pre- and postfire pairs of plots are measured, a better estimate of the carbon released may be modeled.

Contact: David Azuma, dazuma@fs.fed.us, Forest Inventory and Analysis Program

Partners: Oregon State University

Cecile Shohet

Burning during the 2002 Biscuit Fire was so intense in some areas that topsoil was degraded and lost, likely reducing long-term site productivity.

Lichens indicate patterns of biodiversity, air quality, and climate

Scientists found that lichen communities indicate key patterns in air quality, climate, and biodiversity in forests of Washington, Oregon, and California. Increases in atmospheric nitrogen are causing a shift in lichen species composition in many parts of the Pacific Northwest. Lichen community

Hypogymnia imshaugii, *by Sarah Jovan* ▶

Shifts in lichen communities in many parts of the Pacific Northwest suggest that several species will be highly sensitive to climate change.

Sarah Jovan

Nitrophytes are weed-like lichens that thrive in polluted habitat.

composition in the region is also closely patterned on temperature and moisture conditions in the forest interior. The current arrangement of lichen communities suggests several species will be highly sensitive to climate change. Shifting lichen distributions will provide early warning of shifting climate in a region and help forecast how plant communities will respond.

These baseline assessments help natural resource managers identify forests at high risk of degradation from poor air quality as well as areas of high biodiversity and conservation importance.

Contact: Sarah Jovan, sjovan@fs.fed.us, Forest Inventory and Analysis Program

Partners: Oregon State University

Nitrogen oxide fluxes from coastal Douglas-fir plantations identified

Moist coastal forests of the Pacific Northwest often have more available soil nitrogen than inland forests. High soil nitrogen, when combined with adequate soil moisture and warm temperatures, may create ideal conditions for producing and releasing nitrous oxide (N_2O), a powerful greenhouse gas, and nitric oxide (NO), a precursor to tropospheric ozone, one component of smog. Given their potential impacts on climate, it is important to understand the factors contributing to nitrogen oxide fluxes in these forests.

Station scientists found that nitrogen oxide fluxes were dominated largely by NO, and fluxes of N_2O were relatively low from coastal Douglas-fir plantations. The NO fluxes increased with nitrogen availability and temperature when soils were relatively dry. However N_2O fluxes were relatively insensitive to changes in temperature, soil moisture, and nitrogen availability, suggesting that these forest plantations may not become significant sources of this greenhouse gas, given expected near-term climate changes.

Contact: Heather Erickson, herickson@fs.fed.us, Focused Science Delivery Program

As Douglas-fir get taller, growth is limited by changes in leaf function

Height-related changes in leaf function may affect tree growth and forest productivity because leaf stomata are responsible for maximizing photosynthetic carbon gains while simultaneously limiting transpiration to avoid damaging levels of dehydration. The xylem of Douglas-fir needles undergoes structural changes with

John Laurence

Douglas-fir compromise growth to maintain photosynthetic abilities.

increasing tree height that make the needles less vulnerable to hydraulic failure caused by entry of gas bubbles or emboli. This increased hydraulic safety is associated with a reduction in the hydraulic efficiency of the needles, causing them to act as hydraulic bottlenecks. Although this syndrome is likely to result in the maintenance of photosynthesis under conditions of greater foliar water stress, it is also likely to result in increased stomatal restriction of transpiration and carbon dioxide uptake in taller trees while gas exchange is occurring in

this foliage, thus contributing to height-related reductions in tree growth.

These findings are fundamental to understanding how trees cope physiologically with increases in water stress and timing of tree growth in different sites and environments. Basic physiological information informs models used to project the effects of climate change on tree growth and ability to adapt to stresses of a changing environment.

Contact: David Woodruff, dwoodruff@fs.fed.us, Ecosystem Processes Program

Partner: Oregon State University

Tree growth response to climate warming depends on timing

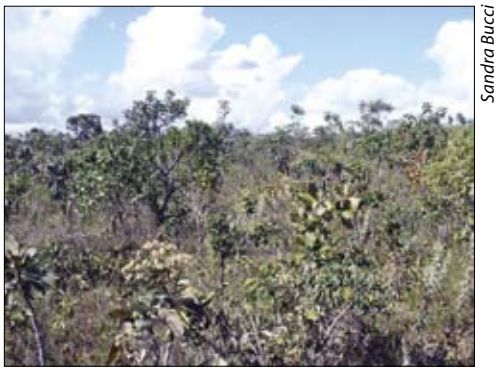
Trees growing at treeline at high latitudes are generally thought to be limited by available warmth, and most studies on treeline report tree growth increases with warmer temperatures. However, population-wide responses of treeline trees to climate remain largely unexamined.

To fill this knowledge gap, researchers systematically sampled 1,558 white spruce trees at 13 treeline sites in the Brooks Range and Alaska Range. Both positive and negative growth responses to climate warming were found. These opposing growth responses were found at all sampled sites, although their relative proportion differed between sites and there was no clear relationship with landscape position.

Without accounting for these opposite responses and temperature thresholds, climate reconstructions based on ring width will miscalibrate past climate, and biogeochemical and dynamic vegetation models will overestimate carbon uptake and treeline advance under future warming scenarios.

Contact: Harold Zald, harold.zald@oregonstate.edu, formerly with the Forest Inventory and Analysis Program

Partners: Oregon State University



Sandra Bucci

Vast areas in central Brazil are covered by this type of tropical savanna known as cerrado.

Dry season has little effect on tree transpiration in tropical savanna

Tropical savannas in Brazil are characterized by large variations in tree density over short distances. As expected, stand-level water loss to the air increased with increasing abundance and coverage of trees. Surprisingly though, tree transpiration showed little seasonality despite a 5-month dry season. Stability of transpiration is attained via reduced leaf stomatal opening that balances the higher evaporative demand during the dry season, and a deep rooting habit that ensures a reliable supply of water year-round.

Scientists are using these findings to better understand the mechanisms that are important in modeling the effects of changing climate.

Contact: Rick Meinzer, fmeinzer@fs.fed.us, Ecosystem Processes Program

Partners: Universidad de Buenos Aires, Argentina; Universidade de Brasilia, Brazil; University of Miami, Florida

Sapwood water storage helps protect trees against catastrophic xylem failure

Water stored in living and dead sapwood tissue can be released into the transpiration stream where it buffers changes that can provoke formation of air emboli and consequent loss of water transport capacity in the tree. Studies conducted on tropical trees in Panama showed that species with higher sapwood water storage capacity experienced smaller daily fluctuations in xylem tension than species with lower sapwood water storage capacity and did not allocate as much of their carbon resources to producing embolism-resistant xylem. These relationships are being explored in Pacific Northwest conifers to better understand how they transport sapwood water along gradients of increasing aridity and summer drought.

Paula Campanello

Researchers use the Smithsonian Tropical Research Institute canopy crane in the Parque Natural Metropolitano near Panama City to measure the photosynthetic capacity of the canopy foliage.

Understanding the fundamental physiology of tree species is critical to predicting growth and vigor under variable conditions. The findings are being used by tree physiologists and groups modeling tree species distribution and performance under different climate scenarios.

Contact: Rick Meinzer, fmeinzer@fs.fed.us. Ecosystem Processes Program

Partners: Universidad de Buenos Aires, Argentina; University of Miami, Florida

Compounds in heartwood may slow spread of sudden oak death

From the public land manager to the homeowner with an oak tree in the front yard, people are looking for ways to limit the spread of *Phytophthora ramorum*, the pathogen that causes sudden oak death.

To address this need, scientists tested the antimicrobial activity in extracts from the heartwood of seven conifers and identified their volatile constituents. They found that extracts from the heartwood of incense-cedar and western redcedar were the strongest inhibitors of pathogen growth.

Outcome: *Scientists identify chemical compounds with potential to increase resistance to sudden oak death.*

A field trial in California showed that heartwood chips from western redcedar placed on the forest floor for 4 months under a host tree with symptoms of sudden

Rick Kelsey

Wood chips from the heartwood of western redcedar appear to slow the spread of pathogen.

oak death significantly limited the accumulation of *P. ramorum* DNA in the litter layer. Heartwood chips or shavings from conifers with strong antimicrobial activity toward this pathogen might be useful in slowing its spread as part of an integrated pest management program.

Also, scientists identified several individual chemicals in the heartwood extracts with potent antimicrobial activity that potentially may be used in products such as foliar sprays to increase resistance against *P. ramorum*.

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Partners: Agricultural Research Service, USDA Forest Service Pacific Southwest Research Station, Oregon State University

Scientists develop cost-effective methods for genome sequencing

Vast improvements in DNA sequencing offer unprecedented insight into the connection between genomes and phenotypes—that is, the interactions between an organism's hereditary genetic information and its observable characteristics that may be shaped by its environment. Nevertheless, current sequencing methods emphasize sequencing "depth" (e.g., a genome from one individual) over "breadth" (part of a genome from hundreds of individuals), making them poorly suited to population studies.

To address this need, station geneticists developed cost-effective methods to sequence DNA for population-level studies. Using this "multiplex sequencing-by-synthesis" approach, it is possible to simultaneously sequence 150 chloroplast genomes (plants), 1,100 mitochondrial genomes (animals), or 10,000 genes from an individual in a single sequencing run.

Station geneticists are using these methods to characterize genetic diversity in threatened species, such as the Torrey pine, and to evaluate gene flow in native and managed stands of conifers. They are also using them to examine historical migration in pine species, the role of mutation on adaptation to climate in conifers, host and pathogen interactions, and to categorize taxonomically challenging species based on genetic similarities.

Contact: Richard Cronn, rcronn@fs.fed.us, Resource Management and Productivity Program

Partners: Oregon State University, Santa Clara University, Universidad Nacional Autónoma de México

Dispersed housing development associated with amenity migration affects ecological processes, alters social norms

When large numbers of immigrants move to a community, competing claims may arise over appropriate uses and meanings of the landscapes. Particularly in the Western United States, dispersed housing development, often a result of amenity migration, leads to a physical transformation of the landscape, affecting a variety of ecological and social processes. Forest fragmentation, changes in wildlife migration patterns, alterations in riparian systems, and challenges

Rhonda Mazza

Lee Cerveny

Tourism brings change to coastal Alaska communities.

related to wildland fire management have all been found to increase as immigrants build houses in remote rural areas. Sometimes recreational patterns are altered, which can mean less access to private lands and a variety of management challenges for nearby public lands.

Contact: Linda Kruger, lkruger@fs.fed.us, Human and Natural Resources Interactions Program

Partners: West Virginia University

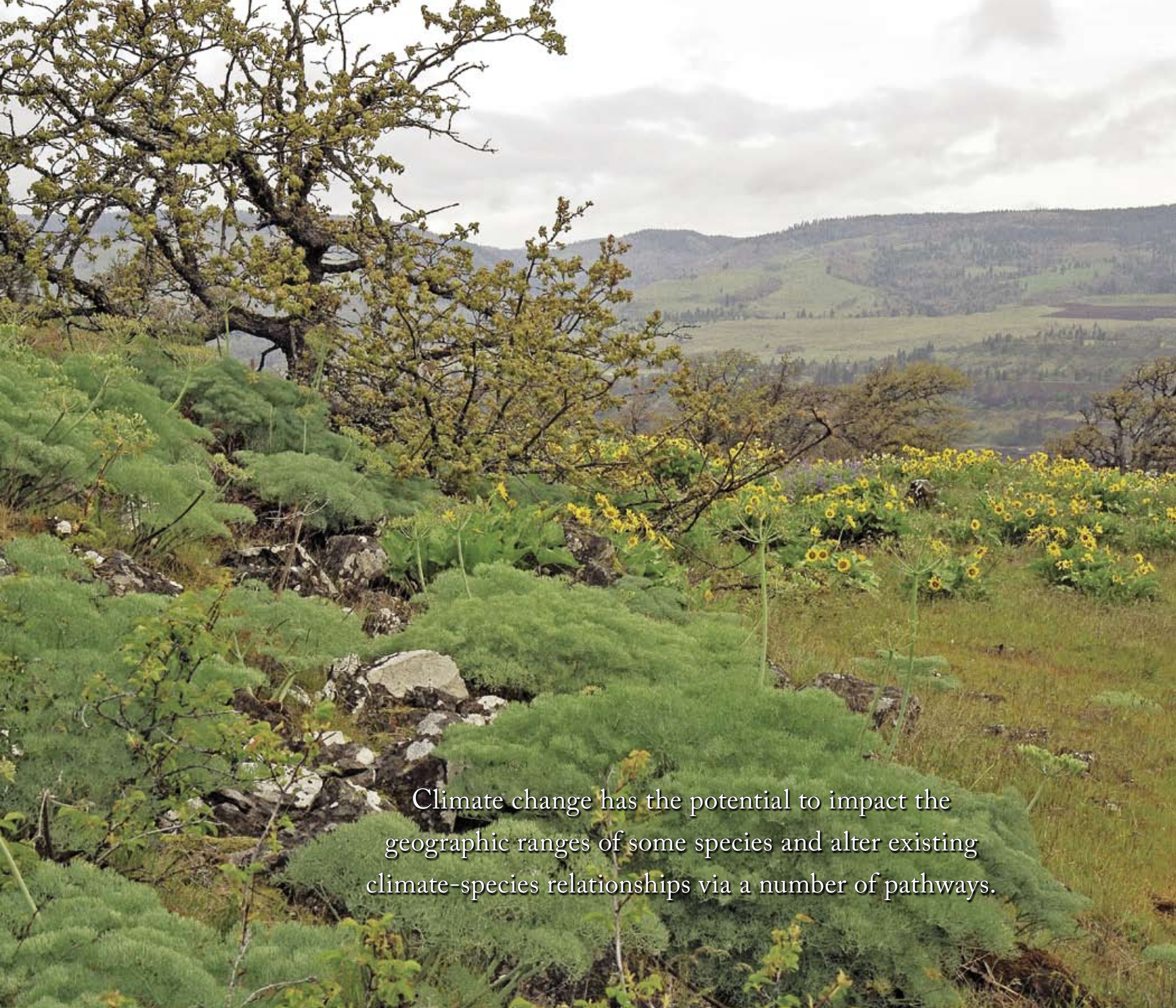
Tourism affects resident interactions with natural and social environment

In coastal Alaska, growth of the tourism industry affects the ways rural residents interact with their natural and social environment. Those whose livelihood or lifestyle depends on unfettered access to natural resources (e.g., fishing, subsistence) and special places found they had to share their use with tourist groups at certain times. Those whose quality of life is determined by a slower pace and small-town values were wary of the arrival of visitors and changes in the rhythm of community life during peak season. Rural residents struggled to adapt to these changes while recognizing the significant economic benefits tourism provides. Uncertainty about the pace and nature of tourism development were widely shared among tourism proponents and skeptics alike.

These findings are the culmination of 4 years of ethnographic research in which 213 indepth interviews were conducted at three sites. Greater understanding of the complex ways tourism affects stakeholders and social groups in coastal Alaska may help regional tourism planners.

Contact: Lee K. Cerveny, lcerveny@fs.fed.us, Human and Natural Resources Interactions Program

Rowena State Park, Oregon; © Miles Hemstrom ▶



Climate change has the potential to impact the geographic ranges of some species and alter existing climate-species relationships via a number of pathways.

Tom Iraci

Habitat lost to wildfire is one issue that points to the benefits of adopting a landscape approach in the recovery strategy for the northern spotted owl.

Restoring spotted owl habitat may take landscape approach

The threatened northern spotted owl continues to decline despite 15 years of intense management effort. One significant threat continues to be the loss of habitat in dry forests from wildfire. Habitat gain and loss from uncharacteristic fire disturbance regimes has been extensively documented by station scientists. Their research has documented landscape dynamics, owl prey demography, and conflicts with competitive barred owls that are directly relevant to recovery plans for the northern spotted owl.

Outcome: *Northern spotted owl recovery plan shifts approach based on new information.*

This information was central in shifting the recovery strategy for northern spotted owl habitat from a species-oriented reserve strategy to a whole-landscape strategy.

Contact: John Lehmkuhl, jlehmkuhl@fs.fed.us, Managing Disturbance Regimes Program

Partners: Sustainable Ecosystems Institute, University of Washington, USDA Forest Service Pacific Northwest Region, USDI Fish and Wildlife Service

Interaction between climate change and invasive species may intensify threats

Exotic and native invasive species are among the most serious threats facing western wildlands. Land managers have traditionally relied on observations and lessons from the past to help plan for the future. However, environmental conditions are changing, and significant changes are predicted for the future.

Working with partners and cooperators, scientists developed a set of rapid threat assessments, syntheses, and modeling projects that focused on the interaction of climate change and invasive exotic and native species on wildland resources in the Western United States.

This work demonstrates that climate change has the potential to impact the geographic ranges of some species and alter existing climate-species relationships via a number of pathways. As a result, many species likely will be able to disperse into novel climate regions and expand their ranges or increase their populations within existing locations.

Contact: Becky Kerns, bkerns@fs.fed.us, Western Wildland Environmental Threat Assessment Center

Partners: EnviroWise Design; ESSA Technologies Ltd.; GEO/Graphics, Inc.; Oregon State University; University of Arizona; University of Idaho; USDA Forest Service Forest Health Protection, Forest Health Technology Enterprise Team, National Forest System, and Western Bark Beetle Research Group; U.S. Geological Survey; Western Regional Pathologists

Imported bark beetle forms new fungal associations in China

The red turpentine bark beetle and the *Leptographium terebrantis* fungus and others in the same genera have a symbiotic relationship: the bark beetle provides the fungi with a place to live and transportation while the fungi play a critical role in the beetle's development and reproduction. The red turpentine bark beetle is native to the United States, and the combined effects of the fungi and this bark beetle on the various species of pine trees they inhabit are relatively benign.

About 10 years ago, the red turpentine bark beetle was introduced to China, most likely via a shipment of logs from the United States. Scientists have discovered that while in China, the bark beetle has formed new associations with different fungal species. Scientists in the United States, China, and South Africa are studying this to better understand the taxonomic positions of these fungi and their ability to incite disease. One concern is that red turpentine beetles that have formed Chinese fungal associates may be reintroduced to the United States and that their effect on trees may no longer be as benign.

Contact: Charles G. "Terry" Shaw, cgshaw @fs.fed.us, Western Wildland Environmental Threat Assessment Center

Partners: Nancy Gillette, USDA Forest Service Pacific Southwest Research Station; USDA Forest Service Forest Health Protection; University of Pretoria, South Africa

Northeastern Washington.

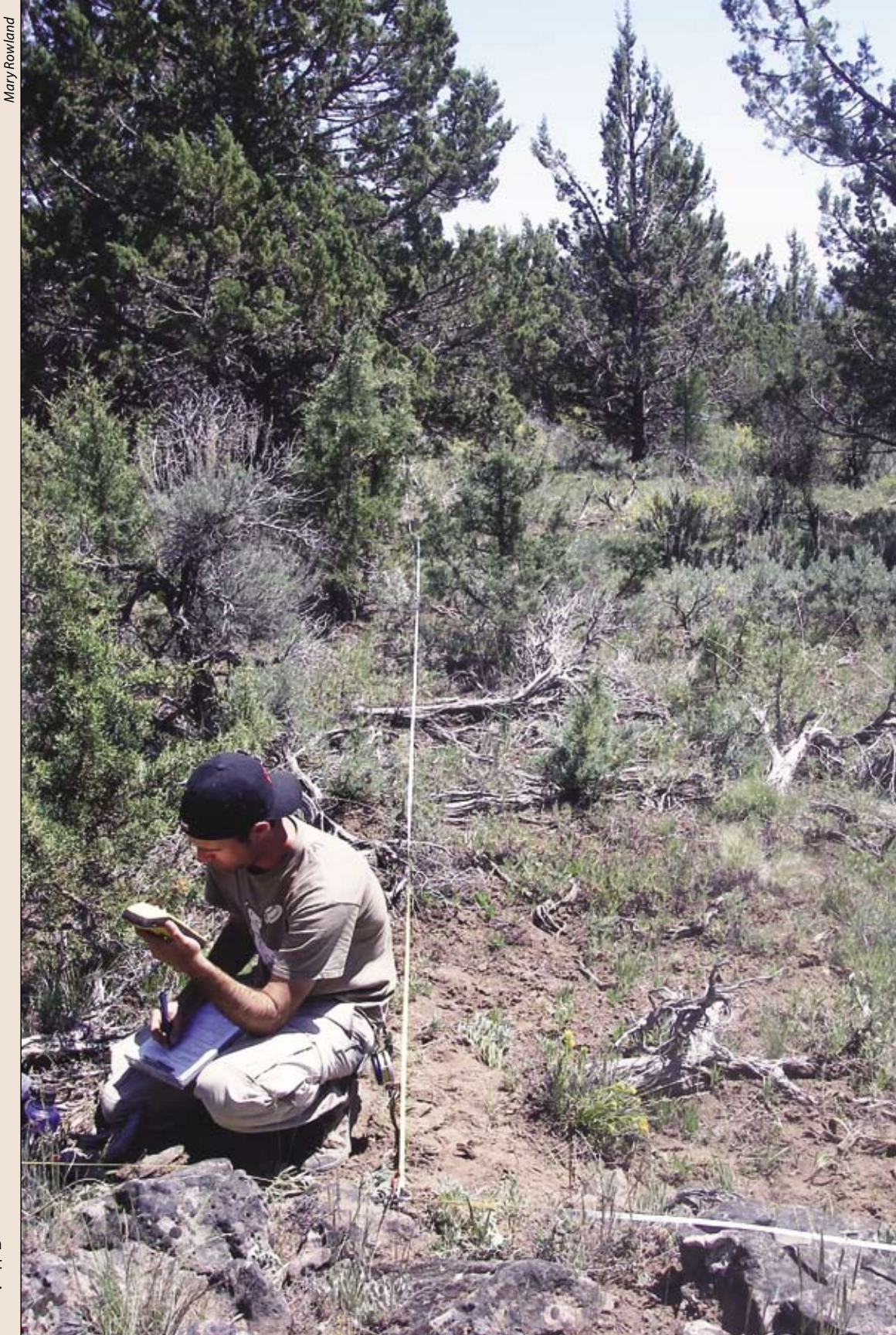
Near Gilchrist, Oregon; © Miles Hemstrom.

GOAL 2: Assess the status and trends of ecosystems and natural resources and their uses

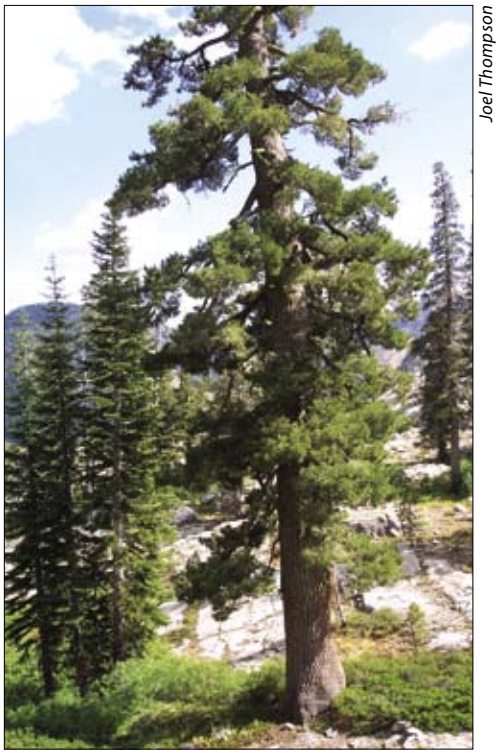
Key Findings

- Two reports highlight key findings from 2001–2005 inventory data across all forest land in California and Oregon. Topics include fuel loading, land use change, air quality, timber availability, climate change impacts, and much more.
- Models estimate carbon stocks and flux in California forests circa 1990.
- Live and dead tree biomass is below the historical range of variation in the Oregon Coast Range.
- Modeling of Canada lynx habitat in North America shows potential habitat loss in the United States and gains in Canada under various climate scenarios.
- Two-thirds of the global polar bear population is at risk of dying by 2050 if environmental conditions change as predicted.
- Numbers of juniper per acre have increased in the last 140 years, threatening sagebrush habitat in central Oregon.
- Street trees in Portland, Oregon, provide $1.1 billion in benefits, far outweighing their maintenance costs.

Mary Rowland



Collecting data from a sagebrush study plot near John Day, Oregon.



Joel Thompson

Annual data collected by field crew provides critical information about the status and health of the Nation's forests.

New 5-year reports summarize forest conditions in California and Oregon

Scientists summarized and interpreted basic information about the public and private forest land in California and Oregon. These reports establish a baseline against which future conditions can be compared and trends can be identified. These data can be used for the Forest Service's reporting on international criteria and indicators of sustainability. They can also be used for regional and state-level assessments of various topics including biomass, carbon flux, fuel loading, and fire risk; land use change; status and change in oak woodlands; air quality; timber availability; and the impacts of climate change.

Policymakers and practitioners have found the information yielded from state-specific equations for calculating carbon storage particularly useful. California policymakers are using this information as they develop the state's carbon policy.

These reports are the first to be published in response to a Congressional mandate in the 2002 Farm Bill. They are based on annual data gathered under the new, standardized national inventory method in which a portion of all plots in each state are measured each year.

Contacts: Glenn Christensen, gchristensen@fs.fed.us (California report); Joe Donnegan, jdonnegan@fs.fed.us (Oregon report), Forest Inventory and Analysis Program

Partners: Bureau of Business and Economic Research, California Department of Forestry and Fire, Oregon Department of Forestry, USDA Forest Service Pacific Northwest and Pacific Southwest Regions

Scientists find low regeneration levels for California's blue oak and valley oak

California's oak woodlands may not be sustainable. Scientists examined the latest 5 years of statewide data and found evidence that regeneration and recruitment among blue oak and valley oak may be insufficient for a stable population. They have been monitoring these species for 30 years and know that blue oak, valley oak, and coast live oak forest types have been characterized by low numbers of saplings during that time; however, better information is needed on growth and mortality to be able to project future population trends.

Oak sustainability is of interest to many Californians, and several pieces of recent legislation focus on oak conservation. Loss of California oaks has a social impact

Tara Barrett

Many oak woodlands in California have few seedlings or saplings present.

disproportionate to the area on which it occurs because oak woodlands are found in the high-visibility areas where people live, work, and play.

Contact: Tara M. Barrett, tbarrett@fs.fed.us, Forest Inventory and Analysis Program

Partners: California Department of Forestry, University of California Integrated Hardwood Range Management Program

Airborne laser scanner used to characterize forests on Kenai Peninsula

The Alaska forest inventory program is charged with inventorying extensive and remote areas of forest where it is often prohibitively expensive to establish plots at an adequate sampling intensity to meet target levels of precision. Using an airborne laser scanner may be an efficient and cost-effective way to accomplish this task.

Scientists tested its accuracy by using light detection and ranging (LIDAR) data to estimate forest stand size, land cover type, and forest density at 32 plots across Alaska's Kenai Peninsula. Height, area, and species type of individual trees were derived from the three-dimensional LIDAR point cloud, LIDAR-based canopy height models, and LIDAR return intensity information. A quantitative comparison of the LIDAR and field-based condition classifications at the subplot centers indicates that LIDAR has potential as a useful sampling tool in an operational forest inventory program.

Pete Bisson

Spider Lake, Olympic National Forest

Contact: Hans Andersen, handersen@fs.fed.us, Forest Inventory and Analysis Program

Partners: University of Washington

Individual tree species can be identified using LIDAR technology

Scientists tested the ability of airborne laser scanners to produce data allowing them to identify the species of individual trees. These light detection and ranging (LIDAR) data were collected in Seattle's Washington Park Arboretum at two times of year: when trees had leaves and when they did not. For this purpose, scientists found LIDAR data were more useful for species discrimination when collected from trees with no leaves.

Also, scientists found that the intensity values of the LIDAR data for different species were related not only to reflective properties at a particular wavelength, but also to a presence or absence of foliage and the arrangement of foliage and branches within individual tree crowns.

The use of airborne laser scanning data has the potential to significantly increase the efficiency of forest inventory, especially in remote regions such as interior Alaska. If LIDAR can provide both structure and species information, the utility and value of the technology for forest inventory applications will be significantly increased.

Contact: Hans Andersen, handersen@fs.fed.us, Forest Inventory and Analysis Program

Partner: University of Washington

Historical evidence suggests that forests of the Oregon Coast Range could be managed to sequester more carbon than they do now.

Scientists model carbon stores and flux in California forests

California wants to lower its greenhouse gas emissions to 1990 levels by 2020. As part of this process, the legislature mandated a state-wide greenhouse gas inventory. In support, PNW scientists modeled estimates of forest carbon stores and flux for California circa 1990. They estimated annual carbon flux on the 7.97 million acres of timberlands outside of national forests at 2.9 terragrams per year. With continuing annual inventories, the Forest Inventory and Analysis Program will provide future monitoring data on carbon flux across all forest land ownerships, productivity classes, and reserve statuses, as well as providing the basis for understanding the dynamics of carbon transfers from live trees to wood products, bioenergy, or atmospheric emissions via fire.

Outcome: *California legislature and other state agencies use carbon estimates to develop policy.*

The legislature used this information in the California Assembly Bill 32 framework for carbon monitoring and emissions reduction. Other clients, such as California Air Resources Board, the Fire and Resource Assessment Program of CALFIRE, the California Board of Forestry, and the California Climate Action Registry Forestry subgroup have used this information to generate options for intensified monitoring activity that would deliver sufficiently precise estimates of carbon flux to support policy development and carbon trading frameworks.

Contact: Jeremy Fried, jsfried@fs.fed.us, Forest Inventory and Analysis Program

Partners: California Climate Action Registry, USDA Forest Service Pacific Southwest Research Station

John Laurence

Biomass in Oregon Coast Range is lower than in the past

Scientists examined the historical variation in live and dead tree biomass under the historical disturbance regime of the Oregon Coast Range. They found that current amounts of live and dead biomass are much lower than what occurred in this region before the high-intensity wildfires of the early settlement period and intensive timber management of the 20th century.

This means these forests could probably sequester more carbon. This assessment provides the basis for understanding carbon management across a mixed-ownership landscape and is the first study to estimate the range of variation in terms of live and dead biomass.

Contact: Thomas A. Spies, tspies@fs.fed.us, Ecosystem Processes Program

Partners: Oregon State University, South Dakota State University

Carbon dynamics can be evaluated with inventory plots and satellite imagery

Forests are both a sink and a source of carbon. Quantifying the direction and amount of change in forest carbon storage is necessary to evaluate the contribution of forests to global warming.

Scientists combined data gathered from inventory plots in western Oregon in the mid-1990s and mid-2000s with Landsat satellite images taken in 2-year intervals, stand age maps, and models of carbon accumulation as forests age. They compared changes in carbon estimated from maps, images, and a model with inventory results at both plot and landscape scales. The model overestimated carbon amounts at the plot and landscape scales for both inventory periods, but the change in forest carbon estimated by the model was well within the standard error of the inventory estimates—which indicated a 7-percent increase during the period. Further analysis indicated that the satellite imagery may have detected short-term changes in rates of harvest or development patterns that were not obvious in the inventory data. Landsat imagery has been collected since 1972. This study illustrates the potential in using satellite

◀ *Oregon coast, by Tom iraci*

imagery and models to estimate forest areas that were not measured accurately before 1990 or to project future changes.

Contact: Andrew N. Gray, agray01@fs.fed.us, Forest Inventory and Analysis Program

Partners: Oregon State University, Western Washington University

Lynx likely to lose habitat in United States, may gain it in Canada

Scientists simulated the responses of terrestrial ecosystems in North America to the historical climate and nine future climate scenarios on a 5-minute-resolution spatial grid using MC1, a dynamic general vegetation model. The model simulations were part of a joint project with The Nature Conservancy and the U.S. Forest Service investigating potential impacts of climate change on the habitat of the endangered Canada lynx. The simulations show extensive loss of lynx habitat in the conterminous United States and potential habitat expansion in Canada under all of the future climate scenarios.

Outcome: *The Nature Conservancy uses model simulations to focus conservation efforts for Canada lynx.*

The climate data sets have been shared with the Remote Sensing Application Center and other research groups upon request.

Contact: Ron Neilson, rneilson@fs.fed.us, Managing Disturbance Regimes Program

Partners: Oregon State University, The Nature Conservancy

Keith Aubry

Wolverines use spring snow to build their dens.

Spring snow cover defines the bioclimatic niche of the wolverine

Wolverines need spring snow cover to build dens where they raise their young, but recent research reveals that they also need this habitat component for other aspects of their life history. Scientists discovered this by developing a satellite-based image of persistent snow cover from 24 April to 15 May and found strong concordance with an expert-based map of wolverine distribution. They found more than 99 percent of 553 wolverine reproductive dens in Scandinavia and North America occurred within the spring snow cover, as did 88 percent of wolverine telemetry relocations from eight recent wolverine studies in western North America.

This layer of spring snow provides a spatially explicit habitat model for the wolverine that can be used to test hypotheses about population connectivity, movement corridors, and genetic relatedness. Scientists can also use this model to predict the potential effects of climate change on the geographic extent and connectivity of wolverine habitat, and identify future refugia where conservation efforts are likely to be most effective.

Contact: Keith B. Aubry, kaubry@fs.fed.us, Ecosystem Processes Program

Partners: Alaska Department of Fish and Game, B.C. Ministry of the Environment, Columbia Basin Fish and Wildlife Compensation Program, Northern Rockies Conservation Cooperative, Norwegian Institute for Nature Research, Swedish University of Agricultural Sciences, The Nature Conservancy, The Wolverine Foundation, USDA Forest Service Rocky Mountain Research Station, Wildlife Conservation Society Wildlife Research and Management

Two-thirds of global polar bear population at risk by 2050

A station scientist developed models, in close coordination with a leading polar bear biologist from the U.S. Geological Survey (USGS), of polar bear carrying capacity and population response to historical, current, and future human stressors, environmental conditions, and habitat states under climate change scenarios. Arctic sea ice is projected to melt at an accelerated rate, and study results suggest a high probability that two-thirds of the current global polar bear population may face great reductions or local extirpations by mid-century. This work was used by the U.S. Fish and Wildlife Service and U.S. Department of the Interior in their decision to list the polar bear as a threatened species.

Outcome: *Federal agencies use these findings to inform their decision to list the polar bear as a threatened species.*

Contact: Bruce G. Marcot, bmarcot@fs.fed.us, Ecosystem Processes Program

Partners: Alaska Science Center, University of Wisconsin, U.S. Geological Survey, USDI Fish and Wildlife Service

Bruce Marcot

These polar bears at the Portland Zoo may be better off than their wild counterparts, if the climate warms as predicted.

Web site: Forest Carnivore Surveys in the Pacific States

Description:
This interactive Web site provides an archival and retrieval system for occurrence data on forest carnivores in Washington, Oregon, and California. Data were obtained during standardized surveys using remote cameras or trackplate boxes. The Web site also contains all verifiable records for the Canada lynx, wolverine, fisher, coastal populations of marten, and mountain red fox. These five forest carnivores are of greatest conservation concern in the region.

Use:
The first step toward conserving forest carnivores is to accurately map their geographic distributions and evaluate the extent to which current and historical ranges may differ.

Prior to this Web site, the compilation of verifiable occurrence records for conservation purposes was done by hand on an ad-hoc basis, and resulting data were not maintained in a permanent archive. It was very challenging to avoid duplicating survey efforts or to prioritize the locations of future surveys. The results of surveys conducted by different agencies or groups are archived in perpetuity and may be combined and compared on a regional basis. This Web site is an essential tool for any public or private biologist working to conserve forest carnivores in the Pacific States.

Partner:
USDA Forest Service Geospatial Services and Technology Center

How to get it:
http://maps.fs.fed.us/carnivore/Modules/application/home.html

Contact:
Keith B. Aubry, kaubry@fs.fed.us
Ecosystem Processes Program

Effects of budworm outbreak analyzed for private lands in eastern Oregon

Between 1980 and 1994, eastern Oregon was plagued by a severe outbreak of western spruce budworm. The budworm eats new growth of coniferous trees, thus weakening or killing the tree. Researchers estimated the effects of the outbreak on private forest land in eastern Oregon and found a 10-percent growth reduction resulting from defoliation. Tree mortality was estimated to have doubled in the 5-year period 1987–1992, compared to the 10-year period 1977–1987 for Douglas-fir, grand fir, and white fir. The ponderosa/lodgepole pine group did not show this difference.

Outcome: *Oregon Department of Forestry uses study to brief governor about extent of budworm damage.*

David McComb, U.S. Forest Service, Bugwood. org

Budworm larvae.

The Oregon Department of Forestry used these findings to brief the governor about the extent of budworm damage in eastern Oregon. This information also will be useful when land managers consider options to address future outbreaks.

Contact: David Azuma, dazuma@fs.fed.us, Forest Inventory and Analysis Program

Partners: Oregon Department of Forestry

Case studies identify factors leading to development on private forests

Approximately 1 million acres of forest are converted to more developed uses annually. Recent research found that 44 million acres of private forest are projected to be affected by residential development in the coming decades. In a followup study, station scientists examined commonalities and differences in land development patterns in northwest Washington, southern Maine, and northern Georgia.

Commonalities in conditions and trends across the three regions include a changing forest ownership, proximity to large metropolitan areas, and the influence of historical settlement patterns and transportation networks on residential development. Differences in factors influencing residential development among the study areas include the influence of seasonal home development, the land use planning systems in place, and the effect of topography.

Contact: Eric White, emwhite@fs.fed.us, Human and Natural Resources Interactions Program

Partners: USDA Forest Service State and Private Forestry, Cooperative Forestry

Rhonda Mazza

A new housing development adjacent to private forest land near Damascus, Oregon.

Encroaching juniper threaten sagebrush habitat

Sagebrush and other native shrublands in the Western United States are threatened by encroaching pinyon-juniper woodlands. In this study, scientists applied a pinyon-juniper risk model to the John Day province in central Oregon. They found that 140 years ago, prior to settlement by Euro-Americans, western juniper were scattered across the landscape with up to 7 trees per acre. Current densities of juniper younger than 140 years are much greater, ranging from 30 to 185 trees per acre, indicating most junipers in the study area were established postsettlement.

Canopy cover of sagebrush was lower in areas where the juniper canopy cover was most dense, a finding reported elsewhere. Low sagebrush and mountain big sagebrush communities in central Oregon may have the highest risk of future woodland encroachment. Juniper densities were greatest in the 1- to 3-foot-tall size class within these sites, suggesting relatively recent tree establishment but future growth and infilling.

Maps derived from this model will help land managers anticipate the magnitude and spatial patterns of potential sagebrush habitat loss from encroaching juniper woodlands.

Contact: Mary Rowland, mrowland@fs.fed.us, Managing Disturbance Regimes Program

Partners: USDA Forest Service Rocky Mountain Research Station, Remote Sensing Applications Center, Washington office, and Western Wildland Environmental Threat Assessment Center

Mary Rowland

Juniper densities have increased since Euro-Americans first settled in Oregon.

Forest biomass mapped for conterminous United States, Alaska, and Puerto Rico

Scientists mapped the distribution of biomass across the conterminous United States, Alaska, and Puerto Rico. The map is based on a spatially explicit data set of aboveground, live forest biomass complied from the national Forest Inventory and Analysis Program. Map-based estimates of forest area and forest biomass compared well with traditional plot-based estimates for individual states.

The map was produced by using moderate-resolution geospatial data. It can be used to direct future efforts using higher resolution geospatial data and further ground reference. Subsequent maps also can be used to illustrate gross changes in forest biomass distribution.

Contact: Kenneth Winterberger, kwinterberger @fs.fed.us, Forest Inventory and Analysis Program

Partners: USDA Forest Service International Institute of Tropical Forestry, Northeastern Research Station, North Central Research Station, Remote Sensing Application Center, Rocky Mountain Research Station, and Southern Research Station

Atlas maps current and potential distribution of Mexican bark beetle

Bark beetles belonging to the genus *Dendroctonus* are a wide-ranging and important disturbance agent in the pine forests of Mexico. As the climate changes, Mexican bark beetles may migrate north into U.S. forests, potentially causing widespread mortality. A new atlas maps the present and potential distribution for bark beetle species. The atlas also quantifies the frequency of specific pine-bark beetle associations found in historical collections and provides new information on the host specificity. Researchers created a beetle threat index and used it to map where beetle populations might have the largest impact on 25 native pine species.

The atlas can be used by researchers in a variety of biogeographical studies to further describe the distributions of bark beetle populations relative to their host species and their potential distribution under future climate scenarios. Managers can use the atlas to understand where bark beetles will likely have future impacts on pine forests in Mexico.

Contact: Alan Ager, aager@fs.fed.us, Western Wildland Environmental Threat Assessment Center, Jane L. Hayes, jlhayes@fs.fed.us, Managing Disturbance Regimes Program

Partner: Escuela Nacional de Ciencias Biológicas, México

Geoffrey Donovan

Portland's street trees are estimated to provide a $45 million benefit each year.

The benefits of street trees in Portland, Oregon, far outweigh their costs

Does the size or type of tree in front of a home influence the home's sale price? This study found that crown area within 100 feet of the house, and number of trees fronting the house were significant. When combined, these two variables add an average of $7,020 to the price of a house in Portland, which is equivalent to adding 106 finished square feet to a house. Extrapolating to the entire city, the total value of Portland's street trees is $1.1 billion. When converted to an annual value, this translates to a $45 million benefit annually. For comparison, the city of Portland estimates that the annual maintenance of Portland's street trees costs $4.6 million.

Outcome: *Cities of Portland, Tigard, and Gresham, Oregon, incorporate study findings into their urban forestry plans.*

In addition, these benefits spill over to neighboring houses—perhaps the most significant finding from the study. If home-owners have a tree outside their house, only about half the benefit goes to them. The remaining half spreads to

neighbors within 100 feet. Currently, homeowners bear all the costs of street tree maintenance. Because they do not receive all the benefits, individual homeowners are unlikely to plant enough trees to maximize Portland's urban tree potential.

This study was done in close collaboration with the city of Portland and has attracted interest from the Multnomah County Assessors' Office, State and Private Forestry, Oregon Urban and Community Forestry Program, and several local arborists and landscape architects. In addition, the cities of Tigard and Gresham, Oregon, have incorporated the study into their urban forestry plans. The study was also featured in the June issue of *Portland Monthly* and on Oregon Public Broadcasting.

Contact: Geoffrey Donovan, gdonovan@fs.fed.us, Human and Natural Resources Interactions Program

Partners: City of Portland Urban Forestry Program, National Institute of Standards

Continue to Part 2 (goals 3 and 4)

Mount Hood, Oregon.