

2013 Science Accomplishments



PACIFIC NORTHWEST RESEARCH STATION

Vision and Mission

The Pacific Northwest Research Station is a leader in the scientific study of natural resources. We generate and communicate impartial knowledge to help people understand and make informed choices about natural resource management and sustainability.



Ellen Eberhardt

Station scientists prepare for a research prescribed fire at Joint Base Lewis-McChord, Washington.

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Technicians with the Forest Inventory and Analysis team set a course to their next plot.





A Message From the Station Director

2013 was a good year. Since I arrived last January, I've spent a lot of time listening to employees and partners. I've enjoyed visiting our laboratories throughout the region and developing a sense of the work that is underway. As Forest Service Research and Development, we have an important mission to uphold. A key piece of carrying out our mission is communicating our research results so that they can be applied toward sustainably managing our Nation's natural resources. We want to provide the best available science to land managers—especially those working on the national forests of Alaska, Oregon, and Washington.

To position the station for the future, we are developing a new strategic plan. I asked employees and stakeholders to help shape our core values and priorities for the next 5 to 10 years. Among other goals, we are emphasizing a quick response to information needs by national forests in the Pacific Northwest. Currently, we are working closely with national forests and conservation collaboratives to produce science that can be used to increase the pace and scale of restoration of forests on the east side of the Cascade Range.

Station scientists are conducting a variety of research projects to help accomplish this goal. One need is to efficiently reduce fuels build-up in east-side forests. Prescribed burns are one option, but land managers wanted to know



Robert Mangold

Tim LeBarge

if the timing of the burn would affect the growth of ponderosa pine. Our scientists found that repeated prescribed burning in the fall or spring does not affect ponderosa pine growth in the Blue Mountains region.

To safely reduce fuels, land managers need to know the amount and type of fuels present. To help with this, station scientists mapped fuelbeds in north-

eastern Oregon and compiled a handbook that included fuelbed descriptions and fire behavior predictions. They shared this information and provided training at a workshop with resource managers from the Forest Service and Bureau of Land Management.

Along with ecological components, accelerated forest restoration in eastern Oregon and Washington has a social component. Station social scientists are developing a protocol for public engagement. The intent is to build a pathway for future collaboration and engagement.

As climate change triggers further changes in our environment, communicating new findings to those who manage working lands is critical. Reduced snowmelt, drought, more frequent fires, and higher temperatures are some of the challenges already facing Pacific Northwest landowners. This is why the Secretary of Agriculture created seven climate hubs around

the country. We are honored to host the Northwest Regional Climate Hub at our Corvallis Forestry Sciences Laboratory. We will be working with the USDA Agricultural Research Service and Natural Resources Conservation Service, and with many other partners, to gather and disseminate information that forest landowners, farmers, and ranchers can use to adapt and adjust their resource management as the climate changes.

Working with partners has been, and continues to be, instrumental in how we accomplish our work. We distributed 22 percent of our total funds to cooperators in 2013, a 4-percent increase from 2012, despite a drop in incoming funds. I appreciate the work and commitment to high-quality science by our scientists, support staff, volunteers, university partners, and collaborators at other federal, state, tribal, and nongovernmental organizations.

The station has many strengths—particularly in our scientists and support staff. I want to make the Pacific Northwest Research Station a great place to work, where employees can thrive and meet their full career potential. In the coming years I will focus on providing a work environment where this is possible.

Stay in touch and work safely.

Sincerely,

A handwritten signature in black ink that reads "Rob".

Station Director Robert Mangold



A field trip to the Olympic Habitat Development Study on the Olympic National Forest, Washington.



Metlako Falls, Columbia River Gorge National Scenic Area, Oregon.



6 Installation of a house post honoring the Tlingit People at the entrance to the new Forestry Sciences Laboratory in Juneau, Alaska.

PNW Research Station: The Setting

● 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)

- ▶ The Pacific Northwest Research Station is one of seven research units in the U.S. Department of Agriculture, Forest Service
- ▶ Headquarters are in Portland, Oregon
- ▶ 11 laboratories and research centers in Alaska, Oregon, and Washington
- ▶ 12 active experimental areas (forests, ranges, and watersheds)
- ▶ Research is conducted in more than 20 research natural areas
- ▶ 317 employees (271 permanent and 46 temporary)



● Experimental Areas

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



Finances and Workforce

Two sources of funding support the workforce of the Pacific Northwest (PNW) Research Station: federal appropriations, which contributed 82 percent of the funds in fiscal year 2013, and direct client support, which comes from organizations in need of scientific information.

The numbers below are for the fiscal year **October 1, 2012, to September 30, 2013**:

Incoming funding

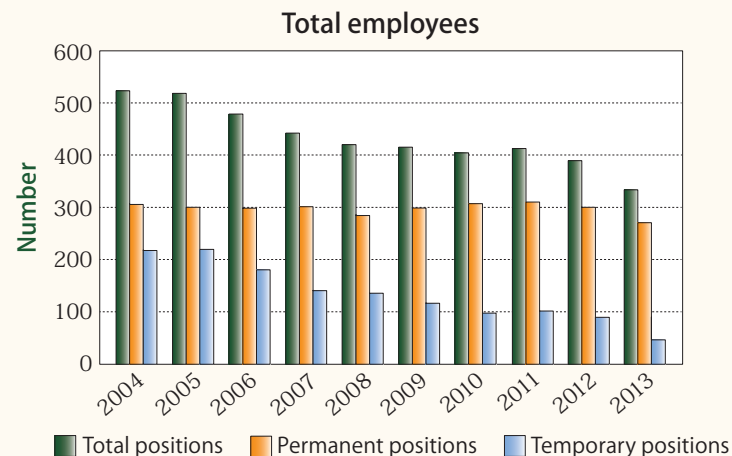
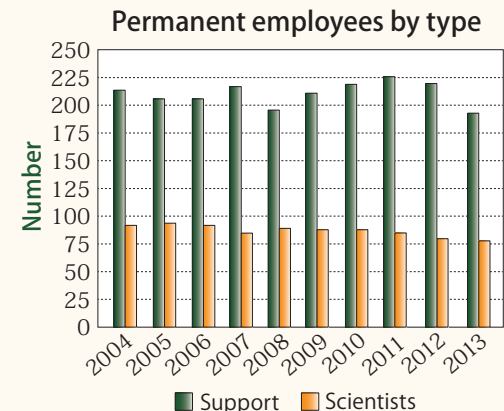
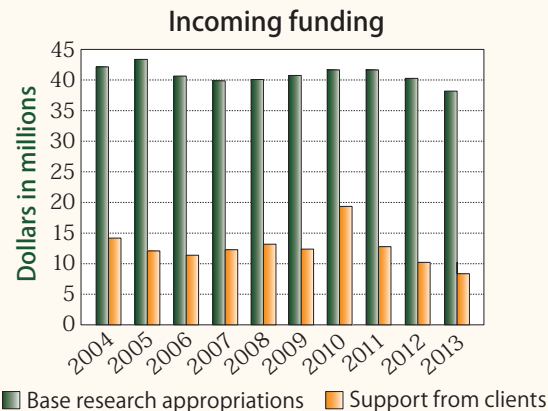
- ▶ Base research appropriations: \$38.2 million (82%)
- ▶ Client support: \$8.4 million (18%)
- ▶ Total funding: \$46.6 million

Distribution of funds

- ▶ Permanent employee cost: \$30.2 million (65%)
- ▶ Support and operations: \$6.1 million (13%)
- ▶ Distributed to cooperators: \$10.3 million (22%)
- ▶ Of the \$10.3 million to cooperators, 91% went to educational institutions

Workforce statistics

- ▶ Total station workforce: 317 employees
- ▶ Permanent workforce: 271 employees
- ▶ Of the permanent workforce, 78 employees (28%) are scientists
- ▶ Temporary workforce: 46 employees



Funding Partners in 2013

Cooperators Who Received Funding From the PNW Research Station for Studies

Educational Institutions

Colorado State University
Michigan Tech University
Mississippi State University
Northern Arizona University
Oregon State University
Portland State University
Stanford University
University of Minnesota
University of Alaska
University of Guam
University of Hawaii
University of Idaho
University of New England
University of Oregon

University of Redlands
University of Washington
Virginia Polytechnic Institute
Washington State University
Western Washington University
Willamette University

Nonprofit Organizations

Cascadia Conservation District
Earth Economics
Earth Systems Institute
Forterra NW
San Diego Zoological Society
Student Conservation Association, Inc.
Sustainable Northwest

Western Forestry and Conservation Association
Woodland Park Zoological Society
World Forestry Center

Other Federal Agencies

Department of the Interior, Geological Survey
Department of Health and Human Services
National Aeronautics and Space Administration,
Goddard Space Flight Center

Private Industry and Associations

Conservation Biology Institute

State Agencies

Oregon Department of Fish and Wildlife

Clients Who Provided Funding to the PNW Research Station for Studies

Educational Institutions

Oregon State University
University of Oregon

Municipal Governments

Seattle City Light

Nonprofit Organizations

National Fish and Wildlife Federation
The Nature Conservancy

Other Federal Agencies

Department of Agriculture, Animal
and Plant Health Inspection Service

Department of Agriculture, National
Institute of Food and Agriculture
Department of Defense, Army Corps of
Engineers Institute for Water Resources
Department of the Interior, Bureau of
Land Management
Department of the Interior, Geological Survey
Department of the Interior, National
Park Service, Mount Rainer National Park
Department of the Interior, Fish and
Wildlife Service
National Aeronautics and Space
Administration, Goddard Space Flight Center

Private Industry

Eco Logical Research, Inc.

State Agencies

Alaska Department of Fish and Game
Oregon State Marine Board
Washington State Department of Natural Resources
Washington State Parks and Recreation Commission

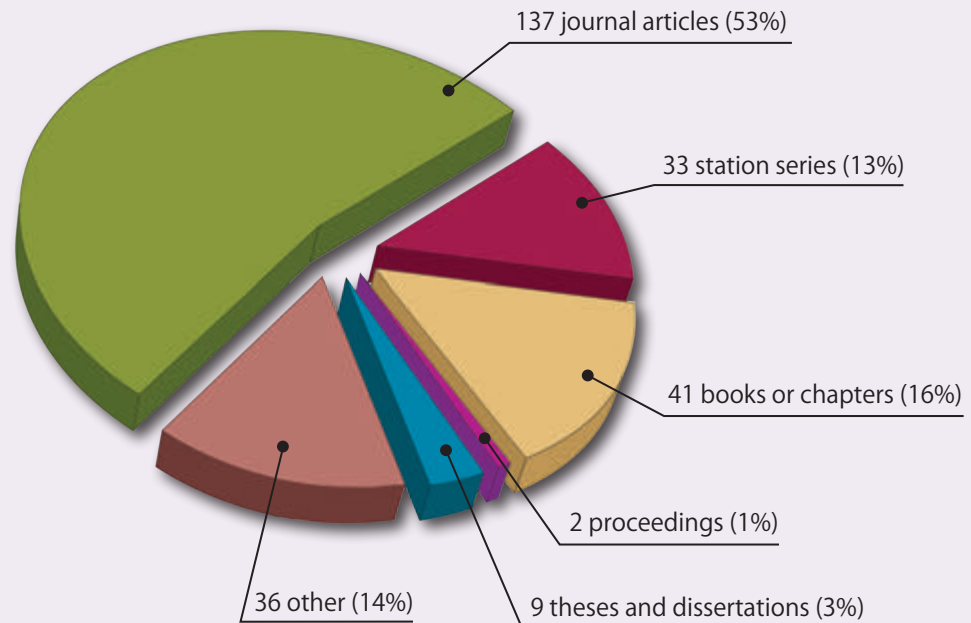
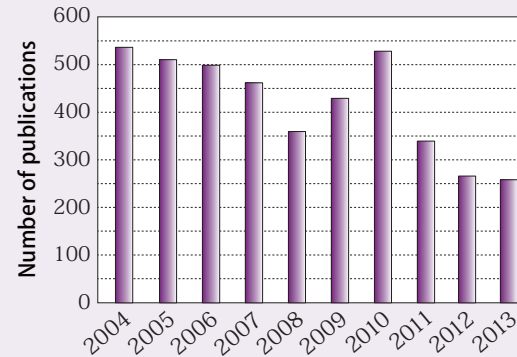
Sharing What We've Learned

The station produced 258 publications in fiscal year 2013. This includes station series reports, journal articles, books or book chapters, theses and dissertations, and other products.

- ▶ **103,368** hard copies of station publications distributed
- ▶ **25,830** electronic publication downloads for the station's Web site and Treesearch (www.treesearch.fs.fed.us)
- ▶ **4,336** station publications available online via the station's website and Treesearch
- ▶ **11** issues of *PNW Science Findings* published, about 8,000 copies of each issue distributed or downloaded

Web Visitors

- ▶ Total number of visits: **105,445**
- ▶ Total number of unique visitors: **67,516**
- ▶ Total number of page views: **210,368**
- ▶ Percentage of new visitors: **61.84%**



Our Most Popular Publications

All of the station's publications are available online. The station's top 10 most frequently downloaded publications are listed below. Some of these publications are decades old but still relevant today.

1. Effects of climatic variability and change on forest ecosystems: a comprehensive science synthesis for the U.S. (2012; PNW-GTR-870)
2. Natural vegetation of Oregon and Washington (1973; PNW-GTR-008)
3. Tangled trends for temperate rain forests as temperatures tick up (2013; Science Findings 149)
4. Adaptation: Planning for climate change and its effects on federal lands (2013; Science Findings 148)
5. Production, prices, employment, and trade in Northwest forest industries, all quarters 2011 (2012; PNW-RB-264)
6. Ecology and management of commercially harvested chanterelle mushrooms (2003; PNW-GTR-576)
7. Adaptive management of natural resources: theory, concepts, and management institutions (2005; PNW-GTR-654)
8. Responding to climate change in national forests: a guidebook for developing adaptation options (2011; PNW-GTR-855)
9. FRAGSTATS: spatial pattern analysis program for quantifying landscape structure (1995; PNW-GTR-351)
10. Ecosystems, their properties, goods, and services (2007; Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change)

Twitter

During fiscal year 2013, the station's Twitter account increased to 928 followers—up from 766 in 2012. Reporters, natural resource professionals, and nonprofit groups comprise the majority of subscribers, who receive instant electronic alerts (tweets) to station news releases, new publications, and other information.

RSS Feeds

Readers can receive alerts about new publications by subscribing to a Really Simple Syndication (RSS) feed at www.fs.fed.us/pnw/RSS/index.shtml.



Symposia, Workshops, and Tours

The station sponsors learning events each year, often in partnership with other agencies, organizations, and universities. A few events are highlighted below.

In 2013:

~1,500 people participated in symposia, workshops, and webinars sponsored by the station.

~1,000 people went on field trips led by station researchers.

~1,380 people participated in conservation education activities sponsored by the station.

Air Resource Advisor Workshop: Fifteen Air Resource Advisors from across the Nation attended a workshop in Seattle. Participants were taught how to use, understand, and interpret smoke dispersion and trajectory models; setup and operate monitoring equipment used on wildfires; and communicate with the Incident Management Team (IMT) and state and local officials. Air Resource Advisors are new members of the IMT who provide information on smoke dispersion and effects, collect data, and serve as liaisons.

Blue Mountains Elk Habitat Modeling Workshop: Station scientists and key partners presented revised versions of newly developed models that predict and map elk nutritional resources and habitat use in the Blue Mountains of eastern Oregon and Washington. The 2-day Pendleton,

Oregon, workshop provided 90 participants with hands-on opportunities to apply the models using their own data.

Blue River Environmental Writers Gathering:

This biannual gathering of about 20 writers from the Pacific Northwest is an important event that helps build the arts and humanities program at H.J. Andrews Experimental Forest in Oregon.

Eastern Oregon University Workshop: A 2-day workshop at Eastern Oregon University highlighted natural resource issues and discussed current challenges in resource management. Thirty-five participants from agricultural and ranching industries attended.

Forest Inventory and Analysis (FIA) Client Meeting and Data Workshop: PNW-FIA organized a forum with 60 regional stakeholders in Anchorage, Alaska, to share current research activities using FIA data, provide information and updates, and obtain feedback from partners to improve the program. The program also hosted a hands-on workshop that taught 24 participants how to analyze and summarize FIA data using PNW-FIADB, a user-friendly database.

H.J. Andrews Day: More than 120 people attended the annual day-long tour of H.J. Andrews Experimental Forest to learn about current and past research. Participants included scientists, students, federal, state, and utility managers, and the general public.

NOVUS Research Coordination Network

Meeting: Researchers from around the world attended this meeting at H.J. Andrews Experimental Forest as part of an effort to unify records of disturbance and ecosystem response at multiple time scales. The experimental forest was chosen to host this meeting and provide a field trip for its productive research history on this topic.

NW Climate Science Center Boot Camp:

This week-long program at H.J. Andrews Experimental Forest provided training to graduate students from universities in Oregon, Washington, and Idaho who are researching climate and ecosystem responses to climate change.

Olympic Habitat Development Study Tours:

Station scientists led two 1-day tours of the Olympic Habitat Development Study in Washington, with 12 participants learning about variable-density thinning and accelerating the development of old-growth characteristics.

Silviculture Options Study Field Tour:

A dozen members of the Washington Forest Farmers Association learned about the Silviculture Options Study on Capitol State Forest in Olympia, Washington. The 15-year-old project demonstrates results from different approaches to harvesting and regenerating Douglas-fir trees.

Starkey Tours: Sixty members of the Society of American Foresters Oregon Chapter toured the Starkey Experimental Forest and Range in eastern Oregon to learn more about long-term ungulate research at the site. Visitors to the site in 2013 also included 30 Eastern Oregon University wildlife students, 30 Union Primary school students, two dozen Central Oregon Community College students, and 70 key partners.

Stream Sediment Symposium: The station cosponsored this event at Oregon State University in Corvallis, which brought together leading researchers to discuss knowledge of in-stream sediment. One hundred and fifty participants attended onsite, and more than 80 watched online via a livestream video.

Tours at the Thornton T. Munger Research Natural Area: Outreach tours at the Thornton T. Munger Research Natural Area adjacent to the Wind River Experimental Forest included about 30 University of Washington's Ecosystem Science and Resource Management students, 10 Concordia University students, 30 enrollees of the World Forestry Center's International

Educators Institute Workshop, and nearly two dozen university and federal agency researchers. Participants learned about ongoing projects and helped install research equipment.

Conservation Education

Station scientists make time to share their expert knowledge with students and their teachers through programs ranging from classroom activities to week-long field camps. A few activities from 2013 are highlighted below.

Alaska Field Exploration: A social scientist led groups of Alaska teachers on an exploration of southeast Alaska's coastal temperate rain forest as part of the Pedagogy of Place Institute, based at the University of Alaska Southeast in Juneau. The 3-day workshop at this professional development institute for K-12 teachers incorporated local Tlingit culture bearers as speakers and field trip co-leaders.

Amphibian Monitoring: The station taught 50 high school freshmen and sophomores about



Students with the Inner City Youth Institute prepare for a kayaking trip on the Willamette River , Oregon.

local amphibian species and then helped them to sample for the animals in two ponds located on the 120-acre campus of Clark Agricultural, Sciences, and Environmental Education High School, in Brush Prairie, Washington.

Endangered Species Panel: Station scientists served as expert panelists who provided guidance and feedback to about 30 eighth-grade student researchers from Oregon's Jane Goodall Elementary and Middle School. The students worked on research projects on topics ranging from Oregon amphibians to marine species.

Forests Inside Out! In its fifth year, the PNW partnership with the nonprofit World Forestry Center conducted Forests Inside Out! This summer conservation education program is a series of 2-day immersive and unforgettable indoor and outdoor experiences for 400+ children ages 6 to 10 and family members from diverse and underserved communities in the greater Portland metropolitan area. The program promotes active, healthy outdoor lifestyles for young children and their families and creates positive and direct associations with urban forests, natural areas, and national forests. Eight high school and college-age students from the Portland area were hired to act as mentors for the program.

Inner City Youth Institute: The Inner City Youth Institute (ICYI) encourages underrepresented youths to pursue higher education and careers in the natural resource and environmental fields. ICYI participated in a natural resources

career fair held at Mount Hood Community College and sponsored forest ecology programs in Portland inner city high schools and a summer camp for Portland high school students. The 2013 week-long camp began at Oregon State University, where participants stayed in the dorms, explored campus, and participated in team-building exercises. The teens headed for the coast and met with a PNW scientist to collect survey data for future elevation mapping analyses, and then camped out at Cape Perpetua State Park, met with interpretive rangers from the Siuslaw National Forest, toured the Oregon Dunes National Recreation Area, visited the Oregon Aquarium, and sailed in a 64-foot sailing research vessel, *Ocean Watch*, off the coast of Newport. The camp concluded with student presentations to parents and sponsoring agency representatives. ICYI is a partnership between the Forest Service (Pacific Northwest Region and PNW), Oregon State University's 4-H program, and the Bureau of Land Management. About 200 students participated in ICYI programs.

Mount St. Helens Outreach: Two hundred students from five high schools across Washington state participated in a terrestrial and aquatic ecology curricula based on lessons from 32 years of research on the Mount St. Helens volcano. The students were introduced to concepts, terminology, and theories of disturbance ecology.

Oregon Natural Resources Education Program:

A workshop at Oregon State University provided more than 50 primary and secondary education students with an introduction to natural resource issues and management.

Science Fairs: Station scientists participated as judges in the 2013 Washington State Science and Engineering Fair. Judges interacted with many middle school and high school students who had exhibits at the fair and offered feedback on how the students could improve their science projects. The station also sponsored an "Outstanding Natural Resource Science Award" and an "Outstanding Statistical Thinking Award" and taught a teacher workshop. Station employees also judged entries to the Oregon State Science Fair held in Portland and sponsored a natural resource science award.

Trout International: Station scientists led an international fish education project connecting students in Oregon and Northern Ireland in the experience of raising and releasing native trout. Each school day, students in both countries monitored the condition of the trout hatching tanks and recorded their observations. They also designed special projects around the hatching experience, including keeping essay diaries of the developing fry. The project culminated for the students in the spring, when each classroom took a field trip to release their fry into a pond or stream. More than 200 students participated in the 10-week experience.

Communities

The health of our Nation's natural resources reflects the long-term health of our communities—both rural and urban. 🌀 Station scientists study the connections between forests and people from social and economic perspectives. 🌀 Their findings are used by cities, public health officials, rural development councils, federal and state land managers, and others to strengthen and enhance communities and help people benefit from trees and forests.



Andrew Gray

County sign highlights local resources.



Melissa Poe

Seattle's Belltown P-Patch community gardens.

Highlights in 2013

- ▶ Scientists map human connections to forests so that land managers can better anticipate how changes to access in other jurisdictions may affect their own management unit.
- ▶ Washington's Green-Duwamish Watershed joins Urban Waters Federal Partnership Network. Key efforts include salmon recovery, environmental justice initiatives, and creating jobs.
- ▶ Research finds a link between trees and human health.
- ▶ Resource-use land area declines in Washington state while rural housing density increases over 30 years.
- ▶ Study in eastern Oregon finds that 70 percent of surveyed landowners were concerned about invasive plants, and 46 percent had treated invasives on their land.



Workshop participants map priority areas as part of the Human Ecology Mapping project.

Unique, interactive mapping project reveals human ties to landscape

Mapping human connections on and off a forest helps land managers better anticipate how changes to access in other jurisdictions affect their own management unit. This knowledge can initiate discussions with other government agencies, private landowners, and resource partners working in collaboration for “all-lands” conservation.

The Human Ecology Mapping Project is a multiyear study to understand and map human activities and values in the forests of Washington's Olympic Peninsula. Using a Web-based mapping tool and a series of community workshops, the project identified and displayed the diversity of recreational, cultural, historical, and economic connections

held by agencies, tribes, resource users, and residents. The maps were digitized and analyzed with GIS (geographic information system) tools to reveal existing patterns, such as high-intensity sites, areas of overlapping use, and treasured places with barriers to access. These sociocultural data layers can be integrated with biophysical data layers for use in planning. By understanding changing patterns of resource use and human activity area-wide, national forest planners can make informed decisions about their own management unit.

Contact: Lee Cervený, lcervený@fs.fed.us

Partners: Institute for Culture and Ecology, Northwest Sustainability Institute, Puget Sound Institute

Washington's Green-Duwamish Watershed joins Urban Waters Federal Partnership Network

The Green-Duwamish River Watershed is home to some of the most economically and ethnically diverse neighborhoods in the Nation. Recent GIS mapping efforts confirm that the urban forest canopy and a range of other determinants of equity are unevenly distributed in the watershed, resulting in affluent residents enjoying greater amenities than lower income residents. Established in 2013, the Green-Duwamish Urban Waters Federal Partnership is helping scale these findings and implications, bringing

together a common framework for federal, tribal, state, regional, and local agencies in their effort to design protection and recovery projects.

The Green-Duwamish Urban Waters Federal Partnership establishes ties with civic and nongovernmental organizations such as Community Coalition for Environmental Justice and the Duwamish River Cleanup Coalition to understand their environmental justice concerns. The partnership serves as a coordinating mechanism for many existing stewardship groups, agencies, and other organizations such as the Puget Sound Federal Caucus, the Green Cities Research Alliance, and the Water Resources Inventory Area. Efforts focus on salmon recovery and connecting ongoing environmental justice initiatives to provide residents with skills, and protect human health, with the added goal of creating local jobs.

Contact: Dale Blahna, dblahna@fs.fed.us

Partners: Duwamish River Cleanup Coalition; Earth Economics; Forterra; King County; NOAA; U.S. Environmental Protection Agency; USDA Natural Resources Conservation Service, State and Private Forestry, Urban and Community Forestry; University of Washington; U.S. Fish and Wildlife Service, Geological Survey; Watershed Ecosystem Forum; Washington State Department of Natural Resources Urban and Community Forestry



A community garden in the Seattle metropolitan area.

Urban foraging helps residents connect with nature and supports broader goals of environmental justice

The city of Seattle and many partners are undertaking stewardship activities to support urban natural spaces and sustainability. One popular way people interact with urban

Project promotes integrating local knowledge and diverse values into urban ecosystem planning.

nature is through the gathering of edible plants and mushrooms. Little is known about

what people are gathering and how these plants are used, the ecological impact of foraging, the characteristics of gatherers, and the social and economic importance of the activity for diverse populations. This project fills some of those knowledge gaps and promotes the integration of local ecological knowledge and values of diverse ethnic groups into urban ecosystem planning and management in the Seattle area.

Contact: Susan Charnley, scharnley@fs.fed.us

Partners: Institute for Culture and Ecology, Ursinus College, USDA Forest Service Northern Research Station



Mountain to Sound Greenway Trust

Urban trees improve the quality of life for city dwellers.

Loss of trees to invasive insect associated with negative impact on human health across 15 states

Since 2002, the emerald ash borer has killed 100 million ash trees across the Midwestern United States. Scientists explored the impact of losing these urban trees on human health.

Trees can be part of a city's public health infrastructure.

This is the first study to use a natural experimental design to look at the public health

benefits of trees. The beetle invasion spreads over space and time, enabling researchers to weed out other possibly confounding influences

on human health outcomes. They found that the deaths of these trees were associated with increased death rates in humans through cardiovascular and lower respiratory mortality. Specifically, the emerald ash borer is associated with more than 6,000 additional lower respiratory deaths, and over 15,000 additional cardiovascular deaths in counties with infestations.

This study has raised awareness that trees can be considered part of a city's public health infrastructure. And, planting trees is something cities can do fairly easily. The Arbor Day Foundation has acknowledged the importance of these study findings and has used them in

campaigns to spread the word about the value of trees.

Contact: Geoffrey Donovan, gdonovan@fs.fed.us

Partners: Drexel University, National Institute of Standards and Technology, USDA Forest Service Southern Research Station and Northern Research Station

Resource-use land area declines in Washington state while rural housing density increases over 30 years

Changes in human land use patterns have wide-ranging social, economic, and ecological implications. Station scientists and partners assessed changes in land use and housing

A football-field-sized area of nonfederal forest land is lost every 42 minutes in western Washington.

density across Washington between 1976 and 2006.

They found that the population in Washington increased by 2.5 million people, leading to the

conversion of 1.16 million acres of forest and agricultural land to residential and urban land uses. Nonfederal forest lands in western Washington declined 4.7 percent over 30 years (an annual rate of 0.2 percent—the equivalent of losing a football-field-sized area every 42 minutes). Agricultural lands in western Washington declined at a rate of 0.7 percent per year, for a net loss of 22 percent over 30 years. Housing density on these resource lands also increased, particularly around agricultural areas. Low-density residential lands increased

substantially, more than doubling over 30 years in eastern Washington.

The loss of nonfederal forest land in Washington to development could represent a significant impact on resource availability, including timber production as well as wildlife habitat. Increased density of houses in and near resource lands can also affect the land's resource production and habitat quality. It also makes it more difficult to fight wildfire. Providing comprehensive, consistent information on the type and location of land use changes in Washington enables assess-

ment of desirable and undesirable impacts and provides a foundation for future assessments and comparison to development in neighboring states.

Contact: Andrew Gray, agray01@fs.fed.us

Partners: Oregon Department of Forestry, USDA Forest Service Forest Health Monitoring Program

Citation: Gray, A.N.; Azuma, D.L.; Lettman, G.J.; Thompson, J.L.; McKay, N. 2013. Changes in land use and housing on resource lands in Washington state, 1976–2006. Gen. Tech. Rep. PNW-GTR-881. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 51 p. <http://www.treeseearch.fs.fed.us/pubs/42975>



Andrew Gray

An agricultural area near Sequim, Washington, with recent housing developments on previous agricultural and forest resource lands.

Landowner efforts to mitigate invasive plants are linked to awareness

Station scientists investigated perception of risk among nonindustrial private forest owners in Oregon's ponderosa pine zone regarding invasive plants. They found that 70 percent of surveyed landowners were concerned about invasive plants, and 46 percent had treated invasives on their land.

Owners' perceptions of invasive plant risks fell along a spectrum, ranging from a lack of awareness or concern, to the view that invasive plant infestations have discrete causes and controllable consequences, to the perception that incursions by invasive plants have diffuse causes and uncontrollable effects. Awareness or concern about invasive plant species were predictors of whether owners treat their parcels to control invasive plants. Holding wildlife habitat or biodiversity as an important forest management goal was also a predictor of whether owners treated their parcels to control invasive plants. Some owners were sensitive to the risks of invasive plant infestations from nearby properties, and a surprisingly high percentage of respondents had cooperated with others in forest management activities previously.

These findings suggest three promising approaches to increasing the frequency of invasive plant mitigation by private forest land owners: (1) raise awareness and concern about invasive plants and their impacts on forest management goals that owners care about,

Tom Iraci



A Forest Service volunteer helps remove knapweed, a noxious weed in the Columbia River basin.

(2) provide assistance to help owners mitigate invasive plants that they feel unable to control, and (3) engage owners in coordinated efforts across ownership boundaries to address invasive plant risks.

Contact: Paige Fischer, paigefischer@fs.fed.us

Community education programs for improving wildfire preparedness are effective

A desire to help communities improve their level of preparedness for wildfire has led to diverse educational campaigns and approaches. These campaigns have been difficult to document and assess. Researchers explored measures of success for 15 communities in the United States that undertook efforts to reduce their wildfire risk. These case studies suggest that a variety of strategies can be used to increase learning and bring about change.

This information can help move environmental education research from the traditional context of measuring individual gains to measuring community impacts. Agency staff could use strategies based on this work to devise educational activities that enhance information exchange and build social capital.

Contact: Linda Kruger, lkruger@fs.fed.us

Partners: Southern Oregon University, University of Florida, University of Minnesota, USDA Forest Service Northern Research Station

Citation: Monroe, M.C.; Agrawal, S.; Jakes, P.; Kruger, L.E.; Nelson, K.C.; Sturtevant, V. 2013. Identifying indicators of behavior change: insights from wildfire education programs. *Journal of Environmental Education*. 44: 180–194.

Fuels, Fire, and Smoke

Our understanding of fire and its role in nature has grown more nuanced over the past century. 🌀 Fire plays a key role in many ecosystems, and without it, the forest can become unbalanced. The question now is how to reintroduce fire to landscapes where it has long been excluded—so that benefits of fire are gained as costs are minimized. 🌀 Fire-related research at the station provides science-based knowledge and tools so that land managers and fire professionals can reduce fuels and minimize overall risk to property and human health.



Researchers prepare to launch a balloon into a smoke plume to measure emissions during an operational-scale fire at Eglin Air Force Base, Florida.

Roger Otmar



Ignition of a 200-hectare forested burn block at Eglin Air Force Base.

Roger Otmar

Highlights in 2013

- ▶ Operational-scale fire experiments at Eglin Air Force Base, Florida, provides information on fuels, meteorology, fire behavior, heat balance, smoke, and fire effects. Discovery Channel covered the event.
- ▶ New guide synthesizes research on fuel management in dry mixed-conifer forests of the northern Rocky Mountains, Cascade Range, Klamath Mountains, northern California, and Utah.
- ▶ New fuel consumption models developed for smoke management in shrub-dominated ecosystem.
- ▶ New tool maps a community's expected risk from fire and embers during fire; potential to improve firefighter safety and prevent damage.
- ▶ Fuel treatments reduce carbon storage compared to periodic wildfire but ensure smaller pulses of carbon emission.

Roger Ottmar



The RxCADRE-prescribed burns are yielding a comprehensive data set of fire behavior, fire effects, and smoke chemistry and dynamics. This information will be used to test, evaluate, and validate next-generation fire models.

Novel integrated fire experiment conducted at Eglin Air Force Base, Florida

Three operational-scale fires (200 to 400 ha) and six fine scale (100- by 200-meter blocks) replicate units at Eglin Air Force Base, Florida, were ignited in fall 2012, allowing researchers to conduct simultaneous experiments on fuels, meteorology, fire behavior, heat balance, smoke, and fire effects. A grass or grass/shrub fuelbed

dominated eight of the research blocks while one operational block was a managed southern pine forest.

This prescribed Fire Combustion and Atmospheric Dynamics Research Experiment (RxCADRE), involving 90 scientists and technicians, will provide a high-quality, integrated fire data set for testing, evaluation, and validating next-generation fire models. The project targeted critical data needs outlined by members of the fire modeling community.

All data collected and accompanying meta-data is being uploaded into the Forest Service Research and Development archival repository and will be available to scientists around the world by September 30, 2014. The Discovery Channel Canada gathered footage and broadcast a 6-minute segment. The *International Journal of Wildfire* has agreed to sponsor a special issue, scheduled for 2014, with 10 articles dedicated to the RxCADRE project.

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Partners: Department of Defense, Air Force, Eglin Air Force Base, Jackson Guard and Eglin Air Force Base Test Wing; Georgia Institute of Technology; NASA; San Jose State University; University of Alaska; University of Idaho; University of Montana; USDA Forest Service, Rocky Mountain Research Station, Southern Research Station, Northern Research Station, and Pacific Southwest Research Station; U.S. Environmental Protection Agency

More information:

<http://watch.discoverychannel.ca/#clip918742>

Scientists analyze approaches that link estimates of air quality and health impacts from smoke

Many U.S. state and tribal agencies and other countries use a visual range measurement to estimate short-term concentrations of particulate matter (PM) in the air. This PM concentration estimate is then linked to a public health warning scale to inform the public about potential health impacts from smoke from wildfire. This method is often used where monitoring data do not exist, such as in many rural areas.



Station scientists check an instrument for measuring smoke concentrations downwind from a research burn conducted at Eglin Air Force Base, Florida.

Concerns about the use of a human-sighted visual range, presence of pollutants other than smoke in the air, its usage in higher humidity environments, and the potential for public messaging conflicts at state and international

borders were voiced in many discussions within the National Wildfire Coordinating Group Smoke Committee. To explore these concerns, station scientists analyzed the approach and pinpointed its limitations. Because visual range/

PM/health impact approaches may differ by not only state or tribe but by country, this report is also the first published summary of national and international approaches to linking visual range, PM concentrations, and air quality health impact indices for wildfires.

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Partners: Joint Fire Sciences Program; National Wildfire Coordinating Group Smoke Committee; USDA Forest Service Fire and Aviation Management; USDI National Park Service, Fish and Wildlife Service

Guide to fuel-management practices published for dry mixed-conifer forests in the northwestern United States

Managers seek synthesized, scientifically sound knowledge to help them plan, implement, and monitor a successful fuel treatment program. They need to understand when treatments will

Interviews with land managers shape management guide.

be beneficial, the pros and cons of different treatment approaches in specific situations, how

to integrate fuel treatments with other resource planning and management objectives and constraints, and the economic challenges and opportunities of committing to a fuel treatment program. To meet this need, a new guide synthesizes research on fuel management in the ecologically complex dry mixed-conifer forests of the northern Rocky Mountains, Cascade Range, Klamath Mountains, northern California, and Utah.

This guide was targeted to meet manager needs, determined via extensive interviews, and differs from other syntheses. For example, the authors emphasize fuel treatment design in light of the full range of potential fire weather and behaviors, address other factors (e.g., climate change, disease, insect, snow, and wind) that modulate treatment effectiveness and longevity, recommend fuel treatment maintenance for these forests where regeneration and growth make for rapid ladder fuel development, and lay out a strong case for monitoring fuel treatment effectiveness over time. A unique component is

an analysis of current fire hazard, fuel treatment effectiveness, and economic evaluation of treatment options, based on Forest Inventory and Analysis data.

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Partners: Humboldt State University, USDA Forest Service Rocky Mountain Research Station, University of Montana

Citation: Jain, T.B.; Battaglia, M.A.; Han, H.-S. [et al.]. 2012. A comprehensive guide to fuel management practices for dry mixed conifer forests in the northwestern United States. Gen. Tech. Rep. RMRS-GTR-292. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 331 p.

<http://www.treesearch.fs.fed.us/pubs/42150>



Dry mixed-conifer forest in the Colville National Forest.

Andrew Gray



A technician ignites a controlled burn in pine flatwoods of the Apalachicola National Forest.

New fuel consumption models developed for smoke management in shrub-dominated ecosystem

Despite the many ecological benefits of prescribed fire, resulting smoke can degrade air quality, potentially impair visibility, and negatively affect human health and safety. Burning shrubs, such as sagebrush in the interior West and understory species associated with pine forest in the Southeast, can emit large amounts of smoke. These emissions are regulated by the federal Clean Air Act, so emissions measurements or estimates are necessary to manage air quality impacts. This means that accurate

estimates of fuel consumption in shrub-dominated ecosystems during prescribed fires are critical for managing terrestrial and atmospheric fire effects.

Station scientists conducted field measurements of prefire fuel characteristics, day-of-burn environmental conditions, and fuel consumption in shrub-dominated sites in the interior West (sagebrush) and southern Coastal Plain (pine flatwoods). Ecosystem- and season-specific statistical models for predicting fuel consumption from easily measured variables were developed that improve the ability of fuel, fire, and air quality managers

to accurately predict fuel consumption and emissions during prescribed fires. These models are being integrated into CONSUME, a software application used for estimating fuel consumption and emissions for smoke management planning and regulation.

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Partners: Department of Defense, Eglin Air Force Base; Florida State Parks, Pumpkin Hill Preserve State Park; The Nature Conservancy; USDA Forest Service, Apalachicola National Forest; USDI Bureau of Land Management, Cody (Wyo.), Rawlins (Wyo.), Burns (Ore.), Dillon (Mont.), and Lewistown (Mont.) Field Offices; USFWS Sheldon-Hart Mountain National Wildlife Refuge Complex and St. Marks National Wildlife Refuge; USDI National Park Service, Lava Beds National Monument

New photo series published for quantifying fuels

Researchers created a new photo series for quantifying natural fuels in eastern Oregon sagebrush-steppe and in northern spotted owl nesting habitat in the Pacific Northwest; and

Tools for fire managers in California, Oregon, and Washington.

grasslands, shrublands, oak-bay woodlands, and eucalyptus forests in the East Bay area of California.

The sites were photographed, inventoried, and compiled in field guides to assist land and fire managers who are planning and implementing management activities and managing wildland fires in Washington, Oregon, and California.

Tool

An enhanced CONUS-wide fuels map uses Fuel Characteristic Classification System (FCCS) and satellite imagery

Description:

This new product links mapped FCCS fuelbeds to estimates of dominant vegetation cover from satellite imagery (MODIS) to refine fuel-loading estimates at each point (pixel) on the map. By including observed vegetation cover, mapped output more accurately describes the actual fuels on the ground. This is critical for estimating fire effects, such as smoke exposure in local airsheds and air quality downwind, as well as carbon emissions that contribute to greenhouse gases. Regular updates using updated MODIS products (e.g., Vegetation Continuous Fields) will keep the data set current with ongoing application to fire, smoke, and carbon management.

Users:

This will be a key product for modelers of air quality and the carbon cycle. It will be useful for regulators creating emissions inventories (e.g., Environmental Protection Agency and the Western Regional Air Partnership) that can also provide inputs for Earth-system models (e.g., NASA and the National Center for Atmospheric Research).

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Partners:

Michigan Technological University, NASA, University of Washington



Clint Wright

A prescribed fire in sagebrush lands near Steens Mountain in southeast Oregon.

The field guides are published as two separate general technical reports by the Pacific Northwest Research Station. Data and images were also incorporated into the Digital Photo Series (<http://depts.washington.edu/nwfire/dps>), a Web-based tool for searching and viewing the content of all Natural Fuels Photo Series volumes.

Contact: Clint Wright, cwright@fs.fed.us

Partners: USDA Forest Service, Pacific Northwest Region, Fire and Aviation Management; USDI Bureau of Land Management, Oregon State Office; East Bay Regional Park District

Citations:

Wright, C.S.; Vihnanek, R.E.; Restaino, J.C.; Dvorak, J.E. 2012. Photo series for quantifying natural fuels. Volume XI: eastern Oregon sagebrush-steppe and spotted owl nesting habitat in the Pacific Northwest. Gen. Tech. Rep. PNW-GTR-878. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 85 p.

Wright, C.S.; Vihnanek, R.V. [In press]. Stereo photo series for quantifying natural fuels. Volume XIII: grasslands, shrublands, oak-bay woodlands, and eucalyptus forests in the East Bay of California. Gen. Tech. Rep. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Fuelbeds mapped in northeast Oregon

Scientists used the Fuel Characteristic Classification System (FCCS) to develop a set of past, current, and future fuelbeds for the Blue Mountains and other areas of northeastern

**Northwest Interagency
Coordination Center's
Predictive Service uses
FCCS fuelbeds.**

Oregon that include the Umatilla, Wallowa-Whitman, and Malheur National Forests and Bureau of Land

Management (BLM) land. They compiled a fuelbed pathway handbook of 11 fuelbed types, pathway schematics, fuelbed names and descriptions, fire behavior predictions, fire behavior fuel model assignments, and general photographs assigned to the fuelbeds. Fifty-five of the fuelbeds were matched to vegetation attributes from the Umatilla, Malheur, and Wallowa-Whitman National Forests data set and mapped for this area. In March 2013, a 1-day “hands-on” workshop was conducted with forest land managers on how to use the FCCS fuelbeds and associated fuelbed map.

Defining and mapping important fuelbeds will enable managers to better plan restoration and wildlife habitat projects and account for potential fire hazard, smoke from wildland fire, and carbon. Custom fuelbed handbook, fuelbed fire behavior outputs, fuelbed map, and fire behavior maps were shared with the Forest Service Pacific Northwest Region and BLM land managers.

Researchers compared model predictions to the actual postfire conditions for forest stands burned in the Cold Springs Fire in Washington.

The FCCS fuelbeds and associated fire behavior have been used for developing policy direction for other areas of northeastern Oregon.

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Partners: USDA Forest Service Pacific Northwest Region, Malheur, Umatilla, and Wallowa-Whitman National Forests; USDI Bureau of Land Management, Oregon Vale District

Fire behavior model performs more accurately when using actual weather data rather than default inputs

Resource managers regularly use computer models to help make wildfire management decisions. For example, the Fire and Fuels Extension of the Forest Vegetation Simulator (FFE-FVS) is widely relied upon to estimate forest fuel levels

before wildfires occur, as well as to guide silvicultural activities like reforestation and dead tree management after fires happen. Despite its widespread use, the accuracy of the model's outputs was not well tested. To remedy this, researchers compared the predictions of FFE-FVS to the actual postfire conditions for forests burned in the Cold Springs Fire in Washington. They found that its performance for estimating total surface fuels and tree mortality was better when using real weather data than when the default inputs were used. As such, using site-specific information over model default values could substantially improve the accuracy of FFE-FVS results.

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Partner: University of Washington

Julie Johnson





Karl Greer

Researchers created a scale for a community's expected risk from fire and embers.

risk from fire and embers during a WUI fire and allows users to predict the likely response of

individual buildings, based on details such as whether a wooden deck has been treated with fire retardant. Work like this offers a foundation for standard testing of WUI structure materials and field guidance for homeowners, community organizations, and fire officials for assessing WUI fire risks.

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Partners: Engineering Laboratory of the National Institute of Standards and Technology

Fuel treatments reduce carbon storage compared to periodic wildfire but ensure smaller pulses of carbon emission

Hazardous fuel treatments in dry western forests generally reduce carbon storage over time compared to periodic wildfires, but the treatments ensure smaller pulses of episodic carbon emissions while reducing the potential for large crown fires. This is a key finding from a comprehensive literature synthesis that analyzed how different types of fuel treatments affect carbon dynamics across a broad range of forest ecosystems.

In general, small but regular pulses of carbon emissions from fuel treatments

result in lower overall carbon storage than no treatments with or without wildfire. Type of treatment, periodicity of treatment, assumptions about carbon emissions, and specific forest type all affect long-term carbon storage relative to the effects of no treatment and periodic wildfires.

Periodic (every 20 to 40 years) hazardous fuel treatments result in lower forest carbon storage compared to no treatment. However, a regular treatment schedule ensures that carbon emissions over time are small and predictable compared to emissions caused by wildfire. Methods and assumptions used to calculate carbon budgets can have a significant effect on inferences about the effects of management actions.

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Roger Ottmar

A prescribed burn such as this one emits a relatively small carbon pulse.

New fire hazard exposure tool can improve firefighter safety and potentially prevent damage

The high cost of wildfire in the wildland-urban interface (WUI) provides a constant motivation to improve how we plan for and manage fire in these communities. Researchers have created a measurement scale (like the Richter scale for earthquakes) that maps a community's expected

Modeling shows long-term forest carbon stocks not affected much by management

How do fuel reduction treatments affect long-term forest carbon stocks in fire-prone forests? Assessing this has been difficult because of uncertainties regarding treatment and wildfire impacts on any given landscape.

To reduce some of this uncertainty, scientists performed a sensitivity analysis to determine how landscape-wide carbon stocks over 80 years are affected by treatment lifespan, fire impacts, forest recovery rates, forest decay rates, and the longevity of wood products. Their results indicate a surprising insensitivity of long-term carbon stocks to both management and biological variables. After 80 years, a 1,600-percent change in either forest growth or decomposition resulted in only a 40-percent change in total system carbon, and a 1,600-percent change in either treatment application rate or efficacy in arresting fire spread resulted in only a 10-percent change in total system carbon. There was no indication that thinning and prescribed burning increased long-term forest carbon stocks through the aversion of wildfire mortality and combustion. On the other hand, the analyses suggest that the carbon costs to reduce wildfire effects through fuel treatment appear relatively small.

The simulations showed that long-term, system-wide carbon stocks are more influenced by the capacity of fuel treatment to halt wildfire

spread to adjacent stands than by stand-level efficacy in reducing fire impacts. This supports the notion that treatment placement is much more important than treatment intensity. Similarly, the sensitivity analysis found the rate at which forests reestablished after fire was more important to maintaining long-term carbon stocks than either disturbance frequency or intensity.

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Salvage logging followed by fuels treatment significantly reduced fuel loadings, fuelbed depth, and smoke emissions

Salvage logging, or the removal of dead merchantable timber following disturbances, is a controversial management practice on federal and private lands in North America. Most field studies have examined salvage logging effects following wildfires. Station scientists, however, examined the effects of salvage logging after a major windstorm. They found that salvage logging, followed by piling and burning of slash, significantly reduced fuel loadings, fuelbed depth, and smoke emissions.

These results illustrate potential differences between the effects of salvage logging after

Karl Greer



Salvage logging after the 2013 Elk Complex Fire in Idaho.

windstorms and the effects of salvage logging after wildfire. This information will help National Forest staff to prepare documents in accordance with the National Environmental Policy Act.

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Kari Greer

Low-intensity fire in a ponderosa pine stand.

Ponderosa pine growth in Blue Mountains unaffected by repeated prescribed burning

Prescribed burning is increasingly used to reduce fuel loads and the risk of uncharacteristically severe wildfires. Repeated burns at regular intervals are required to maintain reduced fuel loads. Fuels managers generally have two opportunities when weather and moisture conditions permit burning: spring and fall. Because the effects of seasonal differences in conjunction with repeated burning on the growth of ponderosa pine is poorly understood,

scientists conducted an experiment in the Blue Mountains of eastern Oregon. Sample trees were evaluated for growth 5 and 10 seasons after the initial prescribed fires. Scientists found that repeated prescribed burning in the fall or spring does not affect ponderosa pine growth. This information is useful to forest managers in the Blue Mountains region; they can implement repeated prescribed burns in both spring and summer without negatively affecting the growth of ponderosa pine.

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Resource Management

As conceived by Gifford Pinchot, managing our forest resources to benefit society is at the heart of the Forest Service mission. 🌀 Pinchot established a research branch of the Forest Service to experiment, learn, and share new knowledge. 🌀 The station continues this tradition, producing needed information and tools so that Pacific Northwest forests continue producing benefits for people.



Eni Lowell

Woody material can be converted to biofuel or used to generate electricity.



Andrew Gray

Demonstration of the green tree retention method, Willamette National Forest, Oregon.

Highlights in 2013

- ▶ Heavy biomass removal from nutrient-rich, productive soil did not negatively affect 10-year tree growth. In nutrient-poor soil, tree growth was greater when logging debris was retained on site.
- ▶ Applications of verbenone reduced mountain pine beetle infestation of lodgepole pine trees in treated areas when populations built gradually, or when outbreaks in surrounding untreated forests were of moderate severity.
- ▶ Northwest Advanced Renewables Alliance is assessing sites in western Oregon and Washington with potential to become part of a sustainable biofuels supply chain.
- ▶ New maps depict sensitivity of summer streamflow in Oregon streams to climate-related groundwater discharge and timing of snowmelt.

Keith Routman



Climbers ascending Mount Thielsen, Oregon.

Science-based tools used for recreation management decisions

Balancing human uses with resource protection is a complicated task for resource professionals on national forests. Through a series of studies to better understand the decision-making process, station scientists found that resource managers faced with complex recreation management decisions could benefit from defining priorities at a smaller scale and using science-based decision tools.

The study shows that science-based decision tools are being used in National Environmental Policy Act assessments for recreation and travel management. Science-based decision models could also be used to help guide specific site decisions and help resource managers develop solutions that suit local conditions.

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Productive soil shows no negative effects on 10-year tree growth after heavy biomass removal or soil compaction

Branches and needles—byproducts of logging—are sometimes removed from the site and used as a source of renewable energy. Concern has arisen that removal of this biomass and all the nutrients it contains, along with compaction from heavy equipment used to collect the biomass, could negatively affect soil productivity. The Fall River Long-Term Soil Productivity Study in western Washington was designed to assess potential impacts of biomass removal on Douglas-fir tree growth on productive soil. This trial is an affiliate site in the North American Long-Term Soil Productivity Study.

Scientists found that the size and 10-year growth rate of planted Douglas-fir trees were not significantly affected by heavy biomass removal treatments. They also found that soil compaction, without other soil disturbance or displacement, had no negative effects on tree growth or tree size over this time period. Thus, this productive site with deep, nutrient-rich, low-density soils demonstrated substantial resilience to management practices that may be a concern on other types of sites.

These results and their comparison with results from other locations will provide guidance to managers interested in maintaining long-term productivity of their soils.

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Partners: University of Washington, Weyerhaeuser NR Company

Douglas-fir seedlings growth increases when logging debris retained on low-nutrient site

Scientists conducted a 4-year study on two recently harvested forest sites in western Washington and Oregon to determine how logging debris and competing vegetation

Washington Department of Natural Resources and timber industry apply findings to aid forest regeneration.

interact to affect growth of planted Douglas-fir seedlings. They found that stem growth of seedlings with

40-percent debris cover and competing vegetation was greater than that of seedlings with zero or 80-percent debris cover because the intermediate cover of debris both reduced herb abundance and increased availability of soil water and nitrogen. Where competing vegetation was removed, seedling growth was greatest with 80-percent debris cover because it reduced soil temperature and evaporation, resulting in greater availability of soil water and nutrients.

Forest managers of Green Diamond Resource Company and Port Blakely Tree Farms, LLC, are using the information to justify retention



Tim Harrington

A researcher collects a soil sample that will be analyzed to determine how retention of logging debris affected nutrient levels.



of moderate levels of logging debris in combination with herbicide treatments to provide short-term control of competing vegetation and increased growth of planted conifers.

The Washington Department of Natural Resources is using this information regarding the benefits of retaining logging debris on low-nutrient sites to aid forest regeneration to inform planning for biomass energy harvesting, animal damage control, and wildfire hazard reduction.

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Partners: Green Diamond Resource Company; Port Blakely Tree Farms, LLC; University of Minnesota; Weyerhaeuser NR Company; Virginia Tech

Variable-retention harvests provide flexibility for regenerating complex, diverse forests

Variable-retention regeneration harvests are being advocated as a means to create early-seral habitat in young, managed forest stands that currently have limited abundance and diversity of understory vegetation important to some types of wildlife. Patterns of conifer regeneration were studied over 12 years as part of a regional-scale experiment in variable-retention harvest in the Pacific Northwest, the DEMO Study.

Early survival of planted conifers differed by species when overstory trees were retained in aggregated clumps or as broadly dispersed individuals. Through the first decade, seedling growth was less when a greater percentage of overstory trees were retained (40 percent versus 15 percent) or when overstory trees were retained as dispersed individuals. Natural regeneration tended to be more abundant in areas of dispersed overstory retention than in the openings of the aggregated treatments. The ability to manipulate retention pattern and level to influence the abundance and species of regeneration provides managers with flexibility in developing structurally complex and compositionally diverse forests.

This study assesses the effectiveness of Northwest Forest Plan overstory retention standards for harvests in meeting long-term objectives for forest regeneration and near-term objectives for providing early-successional wildlife habitat. Variable-retention harvests are the basis of “Ecological Forestry” pilot projects being implemented by the Bureau of Land Management and under consideration by some national forests in the region.

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Partners: University of Washington; USDA Forest Service Gifford Pinchot National Forest, Umpqua National Forest; Washington Department of Natural Resources



Leslie Brodie

A two-age stand is developing on this study site in Washington's Capitol State Forest.

Residual density of overstory trees affects growth of planted conifer seedlings

A growing number of landowners and managers have expressed interest in harvest treatments that retain a partial overstory of trees to reduce the visual impact of the harvest and benefit wildlife or other ecosystem components. Past discussion has suffered from a lack of data on the effects of retaining overstory trees on the growth of both the overstory and understory components of two-age stands. A study on three sites in western Washington compared the effects of six levels of overstory

density on growth of Douglas-fir, western hemlock, and western redcedar seedlings.

Scientists found that harvesting overstory trees resulted in only minor damage to the residual trees and no major differences in 10-year growth rates between treatments following logging. Nine years after planting, understory growth rates differed by species and retained overstory level, with the poorest growth at the highest retention levels. Overall, Douglas-fir seedlings were largest in diameter, western hemlock seedlings were tallest, and western redcedar seedlings were most browsed by wildlife. This information will help managers

decide on appropriate retention levels and species to plant.

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Natural pheromone repels mountain pine beetles in gradual and moderate outbreaks

The mountain pine beetle is native to western North America and its episodic breakout can kill millions of trees. Recent outbreaks, however, have exceeded the historical range of variability, affecting ecosystem goods and services at broad spatial scales.

Forest Service scientists found that applications of verbenone reduced mountain pine beetle infestation of lodgepole pine trees in treated areas when populations built gradually, or when outbreaks in surrounding untreated forests were of moderate severity. Verbenone is a naturally occurring compound produced by microorganisms in female bark beetles; when present in a tree, it indicates to other bark beetles that the tree has already been colonized. Verbenone did not protect trees when mountain pine beetle populations rapidly increased.

This work has had a significant impact on the way mountain pine beetle is managed in lodgepole pine across the western United States.

Robert Progar



No vacancy: This pouch, laced with the pheromone verbenone, tricks bark beetles into thinking the tree has already been colonized.

The number of verbenone pouches annually applied from 2008 to 2010 ranged from 50,000 to 58,000 across Idaho, Montana, Nevada, Utah, and Wyoming. In 2011, more than 67,000 verbenone pouches were purchased and utilized. An additional 49,000 in 2012, and 55,000 in 2013, were placed across this same geographic area. Verbenone is also being used extensively in the private sector by homeowners who are attempting to deter beetle attacks in the trees immediately surrounding their homes.

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Quarterly report on timber production and employment is a perennial favorite

Since it was first issued in October 1963, the *Production, Prices, Employment, and Trade in Northwest Forest Industries* quarterly report has provided current information on imports and exports of logs, lumber, veneer, plywood, paper, and chips in the Pacific Northwest. It also includes harvest levels, employment in forest industries, and forest production figures from Oregon, Washington, northern California, and Alaska. The report has a worldwide distribution and a large and dedicated following, which has increased over the years. People who regularly rely on these data are industry leaders, stockbrokers, lawyers, policymakers, students, consultants, and scientists.

Feedback for this product has been tremendous, particularly since an online version was introduced in 2010. Requests for information have come from the Forest Service and other federal agencies; the Oregon Department of Forestry; the Washington Department of Natural Resources; universities in Idaho, Montana, Oregon, and Washington; and private land management and consulting firms. When the printed publication is released, information from it is often reported in newspapers around the Pacific Northwest, and it is one of the top 10 most frequently downloaded publications produced by the Pacific Northwest Research Station.

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NARA

Northwest Advanced Renewables Alliance (NARA) is determining the feasibility of producing jet fuel from woody biomass in Oregon and Washington.

PNW helps national renewable biofuels project engage community and industry leaders

The Northwest Advanced Renewables Alliance (NARA) is a 5-year USDA research and outreach project focused on developing a biofuels industry in the Northwest. The aim is to turn one of the region's most abundant resources—woody biomass—into jet fuel. The NARA project brings together scientists from universities, government laboratories, and private industry. The project is working to form regional alliances and find communities that might fit into a sustainable biofuels supply chain. Two potential sites were identified in the northern Rocky Mountains that could process 1 million bone-dry tons of biomass annually for jet biofuel production. Scientists are currently assessing possibilities in western Oregon and Washington.

The station helps NARA conduct outreach and extension activities. The NARA has sponsored conferences, arranged webinars, and held client

and stakeholder meetings. The outreach team works with community stakeholders to tailor business strategies to local needs. The NARA has created a Web site (<http://www.nararenewables.org>), which generates an average of 50 hits a day.

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Partners: USDA National Institute of Food and Agriculture, Washington State University

Status of biomass cofiring facilities has implications for forest management

As a renewable energy source, biomass has substantial potential in the United States. One method for implementing biomass utilization for energy production is to “cofire” biomass

alongside coal in existing coal-fired boilers. Supplementing coal in this way can reduce emissions of sulfur dioxide and potentially lower costs. Many coal facilities have tested this method. Cofiring in small amounts can often be done with minimal changes to processing equipment. Station scientists summarized trends and success stories of biomass cofiring, and explained some of the technical challenges that arise. Potential feedstocks for these plants are diverse, but could include biomass salvaged from insect infestations or fire, which could create opportunities for forest management.

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Partners: USDA Forest Service Forest Products Laboratory



Susan Charnley

Biomass power plant in Burney, California.

Tool

FIA database user tools (PNW-FIADB)

Description:

This updated version of user-friendly database tools includes remeasurement data, expanded reporting features such as error estimates, and a large set of data summary tables that can be easily exported into spreadsheet or text editing software. This tool integrates a full public FIA database with documentation using a simple interface allowing users to begin working with complex FIA data to answer meaningful forest resource questions.

Users:

The database and tools are used by resource managers and policymakers to inform questions for decisionmaking. For example, data are used to model changes in carbon pools under various management scenarios and to assess trends in forest resource availability.

How to get it:

PNW-FIADB is available on the Web: <http://www.fs.fed.us/pnw/rma/fia-topics/inventory-data/>

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Sitka, Alaska.

Potential explored for biomass energy and other renewable sources in Sitka, Alaska

In southeast Alaska, energy issues are at the heart of the economic viability and sustainability of many communities. A complicating factor in energy management strategies is the two-tiered nature of energy generation: some communities in Alaska enjoy relatively low-cost hydroelectric power while other, often smaller communities depend exclusively on the costly use of diesel generators. With generally increasing fossil fuel prices, there is growing interest in renewable energy and energy conservation.

Scientists identified opportunities for Sitka to increase its energy independence through community energy management strategies. Hydroelectric power could be expanded and displace fossil fuels for current residential heating and future transportation needs, for example. However, this will require careful management of new electrical generating capacity, as well as a community-wide commitment to energy conservation.

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Adopting principles of the fast food industry brings efficiency and predictability to commercial tourism in Alaska, but at what cost?

Streamlining commercial outdoor recreation experiences, such as cruises, can help the tourism industry increase the diversity and number of visitors, and can help improve accessibility. This is happening in Alaska, where one of the

fastest growing industries is outdoor recreation and tourism. Commercial recreation has increased in the Tongass National Forest in the past decade, influenced in part by cruise lines. The scale of the increase in the tourism industry in Alaska has led to “McDonaldization” of some activities, which has the benefit of increasing the number of people exposed to nature-based activities. Tourism industry managers and



Cruise tourism continues to grow in southeast Alaska. Here, two ships dock at Juneau.

Linda Kruger

planners must weigh these benefits against the ability to customize activities and be flexible.

For the recreation and tourism industry in Alaska, the implications of this study reflect the tradeoff between tighter control of tourism activities and the possibility of undermining the wilderness experience.

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Partners: Downstream Strategies,
Oregon State University

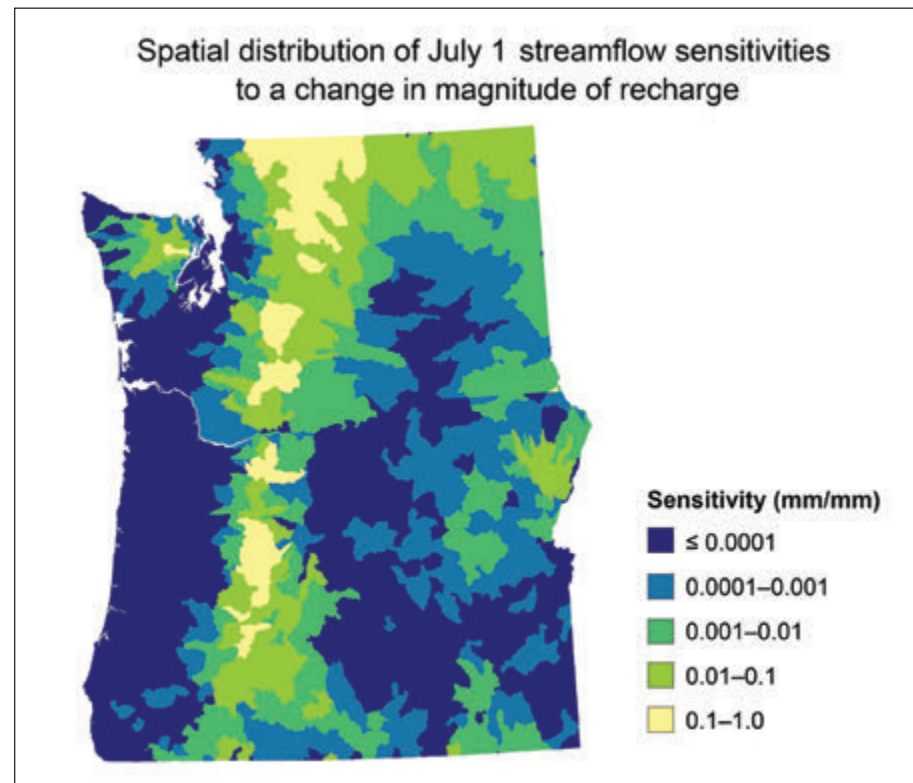
New analysis and tools help managers predict sensitivity of streamflows to climate warming

Reduced summer streamflows from climate warming is a major issue facing resource managers and water users across the western United States. Summer streamflows in the

Resource planners use new maps to assess risk to water resources.

Pacific Northwest are largely from melting snow and ground-water discharge. As the climate warms, diminishing snowpack

and earlier snowmelt will cause reductions in summer streamflow. For planning purposes, simulations of future conditions need to capture smaller scale topographic controls and other important watershed processes. Deep aquifers, for example, play an important role in mediating streamflow response to climate change, so ground water needs to be explicitly incorporated into sensitivity assessments.



This map shows the sensitivity of watersheds in Oregon and Washington to a change in the magnitude of July streamflow; warmer colors indicate higher sensitivity. Watersheds in the Cascade Range (high sensitivity) are the primary source of water for these two states.

To meet this need, scientists developed and applied an analytical framework for characterizing summer streamflow sensitivity to a change in the timing and magnitude of recharge in a spatially explicit fashion that incorporates ground-water processes. They then developed detailed maps of low flow sensitivity for Oregon and Washington landscapes that provide a

robust, practical, and scalable approach for assessing risk to water resources at the landscape scale. These maps are being used by resource planners in the Forest Service, Bureau of Land Management, and Oregon Watershed Enhancement Board.

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Partner: USDA Forest Service Pacific Northwest Region



Kevin Wingert, Bonneville Power Administration

Bonneville Lock and Dam, Columbia River, Oregon and Washington.

Powerful new budgeting tool helps Army Corps maintain infrastructure

The U.S. Army Corps of Engineers manages \$800 billion in infrastructure across the United States including dams, reservoirs, levees, coastal-protection structures, canals and locks, and recreation areas. Corps headquarters annually receives about 20,000 funding requests from field units to maintain, repair, or construct

infrastructure. In recent years, the annual budget for infrastructure maintenance has been about \$5 billion. Until advent of this decision-support technology, Corps business-line managers manually sifted through thousands of lines of spreadsheet reports to develop the Corps' annual budget allocation to projects. A major shortcoming in this budget-allocation process routinely cited by federal oversight

agencies has been lack of a rational, transparent, and repeatable process for managing this annual investment.

The solution provided by this research directly addressed the latter shortcoming. Senior Corps executives reviewed progress on this project at the end of FY2012 and approved continuing development toward a full enterprise version delivered via Web services.

This research supports the Corps by streamlining and optimizing budget-allocation decisions. It expedites assembling and analyzing alternative budget portfolios, and explicitly

considers value to the Nation of infrastructure condition and Presidential direction to the Corps on national goals of energy independence, economic competitiveness, and jobs. Progress in FY2013 moves the system significantly closer to a full production, enterprise system.

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Partners: InfoHarvest, Inc.; Rules of Thumb, Inc.; U.S. Army Corps of Engineers; University of Redlands

Riparian Areas, Fish, and Water

Walk down by a stream and you enter a different world. The air is cooler, laced with the smell of water. 🐟 The vegetation growing along the banks is different than what is found just upslope. Within the stream, minnows dart, micro-organisms respire, and salmon may even spawn. 🐟 Research by station scientists has revealed how closely linked aquatic systems are to the surrounding terrestrial ones. This information is being used to manage both so they continue to be productive and resilient.



Field work in the Copper River Delta, Alaska.



Olympic State Experimental Forest, Washington.

Highlights in 2013

- ▶ Riparian reserves with upland thinning retained headwater amphibian species in western Oregon, but fewer bank-dwelling salamanders were detected in treatments with the narrowest buffers (20 to 50 feet) over a 15-year time period.
- ▶ Broad-scale patterns of salmon distribution can be understood by exploring fine-scale relationships between life stages of fish and the distribution of habitats.
- ▶ Study documents influence of water temperature on salmonid life histories.
- ▶ Modeling indicates that managing for shade in riparian areas can mitigate increases in summer stream temperatures.
- ▶ Near-pristine forested streams are showing changes in nitrogen concentration, increasing in some while decreasing in others.

Riparian reserves with upland thinning retained headwater amphibian species in western Oregon

The Density Management and Riparian Buffer Study of western Oregon was established to examine the stand-scale effects of thinning with alternative stream buffer widths

Two narrowest buffers negatively affected amphibians.

on aquatic-riparian resources, including sensitive vertebrates such as amphibians.

This is the first study to report on the effects of the interim riparian reserves of the federal Northwest Forest Plan and two narrower riparian buffer widths (20 feet to 50 feet), with upland thinning.

Ten years after thinning, scientists found that amphibian counts along streambanks

decreased within stream reaches with the two narrowest buffers examined. Instream amphibian counts did not decrease with any buffer width, and species occurrences were retained both instream and along stream banks. Risk to aquatic-dependent vertebrates is a high-profile consequence of timber harvest with riparian management. These results will be useful to understand and manage risk to species of alternative riparian management approaches, and in particular, will inform future discussions of riparian buffers in west-side forests.

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Partners: Oregon State University, USDI Bureau of Land Management



Loretta Ellenburg

Ensatina salamanders are associated with down wood and often are found in headwater drainages of the Oregon Coast Range and western Cascade Range.

Report summarizes two decades of thinning and riparian management research for western Oregon and Washington

The adoption of the Northwest Forest Plan in the early 1990s brought about fundamental shifts in forest management practices on federal lands in western Oregon and Washington. Commodity-driven clearcut regeneration harvests gave way to thinning of young stands intended to accelerate the development of late-successional forest habitats and conserve important aquatic and riparian ecosystems.

Density Management in the 21st Century: West Side Story presents abstracts and peer-reviewed papers from a 2011 regional conference highlighting more than 20 years of research related to the new practices of forest thinning and associated aquatic and riparian conservation measures. Collectively, the contributions summarize many important forest dynamics and ecosystem responses to partial overstory harvests.

Targeting resource management practitioners, decisionmakers and researchers, the collected works provide a reference to the current and future roles and issues of density management as a tool for forest ecosystem management. The various research synopses will be directly applicable to project-level planning and envi-



ronmental analyses (NEPA), as well as providing context for large-scale planning and policy discussions.

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Citation: Anderson, P.D.; Ronnenberg, K.L., eds. 2013. Density management in the 21st century: west side story. Gen. Tech. Rep. PNW-GTR-880. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 249 p.

Publication reviews ecology and management of riparian zones in the coastal temperate rain forest of southeast Alaska

Riparian zones include zones of influence beyond the near-stream areas of coastal southeast Alaskan forest streams. Wetlands that extend well into the upland mosaic are notable contributors to riparian function. Impacts to riparian zones such as climate change must be considered along with past disturbance such as harvest.

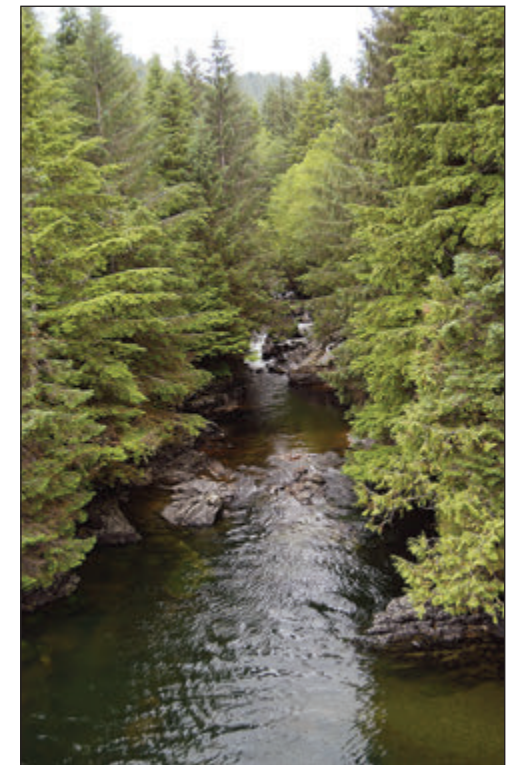
A review of coastal Alaskan forest management in the context of stream function and riparian zones provides a perspective for managing these systems into the future. Riparian zones are complex and their interaction with surrounding landscapes and response to disturbance must be understood to implement man-

agement plans on national forests and achieve future desired functions in these systems.

This is a new framework for assessing long-term impacts to riparian ecosystems applicable to all lands in coastal southeastern Alaska, with potential applications to south-central Alaska and coasts of British Columbia.

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Maybeso Experimental Forest, southeast Alaska.

Tom Iraci



Dede Olson

A thinned riparian buffer as part of the Density Management and Riparian Buffer Study in western Oregon.

Efficiency of riparian microclimate monitoring is increased by new modeling methods

Scientists used statistical modeling to identify cost-effective approaches to monitoring relative humidity in riparian areas. The strong relationships between relative humidity and air temperature, topography, and vegetation cover allowed for relative humidity estimation. Using more extensive, less expensive sampling of air temperature and site attributes, patterns of

relative humidity for small stream basins could be discerned from relative humidity measurements at a strategically distributed subsample of three to five locations. The methods developed provide a means toward decreasing the costs of monitoring microclimate attributes of importance to riparian area function.

This finding could influence possible modifications to the Riparian Standards and Guidelines of the Northwest Forest Plan. Information about relative humidity patterns within riparian

areas and adjacent uplands are necessary to the design of effective buffers that protect stream and riparian habitats during and after timber harvests.

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Partners: Oregon State University, USDI Bureau of Land Management

Use riverscape to guide salmon habitat restoration and recovery planning

Native fish are adapted to survive in the dynamic and interconnected network of streams that has come to be called the riverscape. Scientists sought to understand how broad-scale patterns of salmon distribution can be understood by exploring fine-scale relationships between life stages of fish and the distribution of habitats. Understanding how connection between habitats throughout a system affects fish populations over time can help to guide in-stream restoration by directing the focus of restoration activities toward specific locations within the stream network and filling essential gaps in habitat for different life stages.

In this research, scientists explored interannual patterns of distribution by juvenile coho salmon (*Oncorhynchus kisutch*) in multiple subbasins on the mid-coast of Oregon. They established that juvenile coho salmon distribution expanded and contracted around stream sections that were continuously occupied (core areas). They also established that network descriptions of habitat, such as the proximity



University of Oregon

Sockeye salmon in the Copper River, Alaska.

among seasonal habitat, better explain juvenile coho salmon density than more traditional in-stream habitat variables such as pool depth.

This research contributes to an effort to explain the processes behind spatial and temporal patterns of freshwater habitat use by salmonids in the Pacific Northwest, thereby enhancing understanding of the complexity of biological and environmental interactions over broad scales. Such understanding has important management implications with regard to habitat restoration planning, conservation, and population recovery assessment.

Contact: Rebecca Flitcroft, rflitcroft@fs.fed.us

Partners: Oregon State University, Western Oregon University

First documentation of the influence of water temperature on salmonid life histories

Water temperature influences a variety of behavioral and physiological processes in salmonids. For species like *Oncorhynchus mykiss* that can be either anadromous (steelhead) or a

A suite of processes influence life-history expression in salmonids.

fresh water resident (rainbow trout), understanding the influence of tem-

perature on life-history expression is critical for their management. Increases in temperature elevate the energy needed for survival and, thus, may reduce energy available for growth and maturation.

Researchers found that for *O. mykiss* reared under contrasting temperature regimes, warmer water temperatures reduced rates of freshwater maturation and increased anadromy. Females were more likely than males to become anadromous, regardless of rearing temperature, a pattern that mirrors findings from populations throughout the west coast of North America. Individual variation in metabolism also influenced life histories: females with relatively fast metabolic rates had an increased probability of becoming anadromous. These results indicate that a combination of sex, metabolic rate, and water temperature are important determinants of salmonid life histories.

These studies reveal a suite of processes influencing life-history expression in salmonids. The results will inform conservation and recovery programs for steelhead populations listed



Jamie Glasgow

A station scientist conducts a survey for salmonids in the Wynoochee River, Olympic National Forest.

under the Endangered Species Act. The influence of temperature on *O. mykiss* life histories had not been documented previously, and these results will be crucial for anticipating the effects of climate change.

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Partner: Oregon State University

Managing shade in riparian areas can mitigate increases in summer stream temperatures

Salmon populations are currently limited throughout much of their former range, which has prompted stream restoration to improve the amount and quality of available habitat. These

Riparian management can keep water cool even as climate warms.

restoration projects are expensive, and there is concern that the return on society's investment

will not be realized because increased air temperatures from climate change may make streams too warm to support salmon.

Scientists examined the likely future effects of climate change on stream temperature along 23 miles of the upper Middle Fork John Day River that contains most of the remaining spawning habitat for spring Chinook salmon. There, climate change projections suggest that mid- to late-summer decreases in stream discharge could be as great as 10 percent, before accounting for withdrawals for irrigation. Air temperatures could increase by as much as 9 or 10 °F by the middle of the next century.



Tree seedlings have been planted along the Middle Fork John Day River to help keep the water cool even as summer air temperatures increase.

Preliminary results show that, under current discharge and riparian vegetation conditions, a 7 °F increase in air temperature will increase the maximum stream temperature by about 3 °F; decreasing stream discharge by 30 percent increases stream temperature by 1 °F. In contrast, future maximum stream temperatures could be colder, even under a future climate when air temperatures are 7 °F warmer than present, if currently open, unshaded meadow reaches were converted to riparian forests. The temperature of the stream under a future, warmer climate depends on the height and density of riparian vegetation. Growing 100-foot-tall trees with 50-percent canopy density along the full 23-mile study reach would

decrease maximum stream temperatures by as much as 12 °F. These heights and canopy densities are easily obtainable by native riparian forests within the region.

These results are important to Oregon's Intensively Managed Watershed program in the Middle Fork John Day, and to both the Confederated Tribes of Warm Springs and The Nature Conservancy, each of which owns portions of the Middle Fork. These three entities and their partners have embarked on ambitious stream restoration projects along the upper Middle Fork John Day River.

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Partners: Oregon State University, USDI Geological Survey

In-stream habitat restoration promotes increased density of chinook salmon and greater growth in steelhead trout

Station scientists and cooperators evaluated the effectiveness of in-stream habitat restoration structures to enhance rearing habitat for juvenile salmonids from 2009 to 2011. Habitat

**Bureau of Reclamation
uses findings to inform
design of restoration
structures in Entiat River.**

restoration structures consisted of engineered log jams and rock barbs extending from streambanks in

the Entiat River watershed of the upper Columbia River basin. More chinook salmon were found in microhabitats with restoration structures compared with those without restoration structures early in the season in all 3 study years. Increased water depth at restoration structures appears to be a key factor leading to increased chinook abundance. Steelhead trout were much more variable in their use of restored versus unrestored microhabitats: numbers didn't always increase in response to habitat improvements, but steelhead did grow larger in treated habitat units compared with untreated units.

These results are being used by restoration planners and by a larger monitoring program to further improve the design and implementation of additional restoration structures in the same watershed and in other watersheds throughout the upper Columbia River basin. The Bureau of Reclamation has used this information to make



Entiat River, Washington.

decisions on the design of projects for future implementation in other reaches of the Entiat River.

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Partners: National Oceanic and Atmospheric Administration-Fisheries, Integrated Status and Effectiveness Monitoring Program (ISEMP), USDI Bureau of Reclamation, Cascadia Conservation District, Upper Columbia Salmon Recovery Board

River food webs are an important consideration for river restoration

Well-functioning food webs are fundamental for sustaining rivers as ecosystems and maintaining associated aquatic and terrestrial communities. The current emphasis on restoring

Bonneville Power Administration uses report to identify habitat restoration opportunities.

habitat structure—without explicitly considering food webs—has been less successful than hoped in terms of enhancing the status of targeted species.

As an illustration, scientists examined how the Columbia River basin, site of one of the largest aquatic-riparian restoration programs in the United States, would benefit from implementing a food web perspective. This complements ongoing approaches and enhances the ability to meet the vision and legal obligations of the Endangered Species Act, the Northwest Power Act (Fish and Wildlife Program), and federal treaties with Northwest Indian tribes while meeting fundamental needs for improved river management.

Based on a variety of reviews, meetings, workshops, site visits, and other feedback, the scientific underpinnings of many habitat restoration efforts in the Columbia River basin have been improved. Most notably, this effort increased attention to monitoring and evaluating restoration projects so that habitat managers can learn from their experiences and pass this information along to other practitioners.

This report was used by the Bonneville Power Administration as well as federal, state, tribal, and nongovernmental organizations to help identify habitat restoration opportunities where food web improvements could be implemented, and to make improvements in existing projects and programs.

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Active restoration of native species may be needed after noxious weed removal along riverbanks

Invasive Japanese knotweed and other species in the genus spread aggressively along rivers, establishing dense stands and reducing the diversity of native riparian plants and the func-

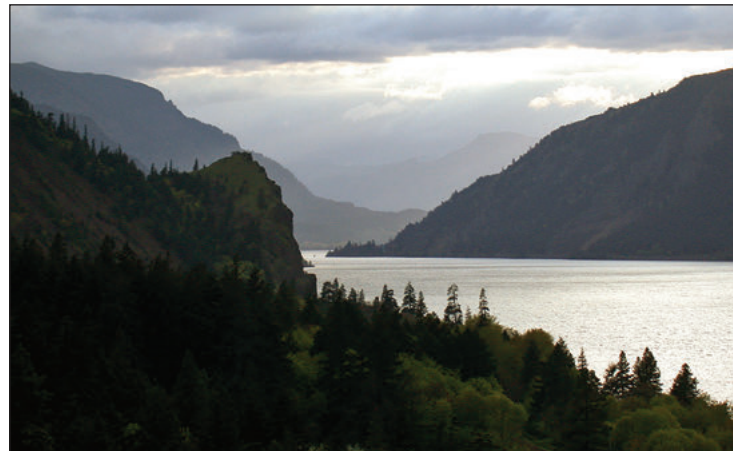
Olympic Knotweed Working Group pursues restoration strategy.

tioning of riparian areas. Programs to eradicate invasive knotweed with repeated herbicide applications often assume that

the system will naturally recover with native species. Studies on eradication efficacy, however, typically measure the amount of knotweed reduced, not the reestablished species diversity or plant origins.

Researchers working in western Washington found that herbicide applications successfully

reduced invasive knotweed and cleared sites for colonization by native plants, but also released other exotic invaders. Passive reestablishment of native riparian plants depended on site habitat conditions and stream size. Small streams with dense canopy cover and stable channels had primarily native plants.



Columbia River Gorge, Oregon and Washington.

Tom Iraci

In contrast, exotic forbs and shrubs were more abundant than native plants along a larger river. Large rivers tend to have little canopy cover and wide flood plains subject to seasonal flooding, which promotes exotic plant seed movement and survival.

Noxious weed control programs can benefit from including posttreatment plant community surveys to determine if continued management is needed to achieve restoration objectives. For example, successful reestablishment of native vegetation following knotweed removal may require active restoration, such as methods to control other exotic plants or replanting native species as riparian conditions change. These strategies are being pursued by the Olympic Knotweed Working Group, an organization promoting communication and collaboration among government, tribal, and private noxious weed control groups.

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Partners: Center for Natural Lands Management; U.S. Fish and Wildlife Service, Washington State Office

Invasive Japanese knotweed spreads aggressively along river banks, as it has here along Wildcat Creek in western Washington. Active restoration of native plants is often needed after the noxious weed has been eradicated.

Shannon Claeson



A researcher conducts a vegetation survey in a plot along the Satsop River, Washington, as part of a noxious weed study.

Shannon Claeson



Long-term nitrogen trends differ in pristine forested streams

Much of what is known about changes in stream water quality comes from studies where basins have been affected by human activity. Much less is known about trends over time in relatively undisturbed systems. This research intentionally focused on relatively undisturbed streams in seven experimental forests: H.J. Andrews, Hubbard Brook, Coweeta, Luquillo, Fraser, Marcel, and Fernow. These sites span a wide range of climatic, hydrologic, and vegetation conditions across the country and are largely undisturbed by land use or land cover changes.

Scientists found that even these near-pristine forested streams are showing changes in nitrogen concentrations; stream nitrate has declined in the Pacific Northwest, in the Northeast, and in Puerto Rico, but has increased in the Mountain West and the South.

Other key findings are that direction of trends in reference watersheds vary with length of record used, and that adjacent watersheds within a site do not necessarily show similar responses. The study is part of a larger effort to understand the effects of forest management and disturbances on water quality and to inform nutrient criteria standards, using natural variability of high frequency stream chemistry concentrations. An additional feature of this project is the development of a publicly accessible stream chemistry



Rhonda Mazza

Research at the H.J. Andrews Experimental Forest has yielded many insights about ecological processes. Above, a scientist prepares an experiment for testing the uptake processes of nitrogen in a stream.

database (StreamChemDB, <http://web.fsl.orst.edu/streamchem/>) to store and facilitate sharing of long-term stream chemistry data.

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Partners: Cary Institute of Ecosystem Studies, National Council for Air and Stream Improvements, Oregon State University, University of New Hampshire, University of Pennsylvania, USDA Forest Service International Institute of Tropical Forestry, Northern Research Station, Rocky Mountain Research Station, Southern Research Station

Understanding Forests and Ranges

Since 1925, the station has dedicated its efforts to understanding forests and rangelands. 🌀 Resilient forests are a promise to generations to come—a promise to replenish the air we breathe, the water we drink, and the places from which we gain sustenance. 🌀 Scientists provide understanding of how forests function and change through long-term studies and inventories. 🌀 Information is analyzed and tools are developed to help identify management options and make decisions for resilient forests that meet society's needs.



Alexi Hoelt

Field trip to the Olympic Habitat Development Study, Olympic National Forest, Washington.



Dominique Bachelet

Old-growth Douglas-fir trees, Drift Creek Wilderness, Oregon.

Highlights in 2013

- ▶ Estimates of aboveground carbon flux and storage in trees were developed for Tongass and Chugach National Forests and the entire circumboreal forest biome. These estimates are important for understanding future global carbon balance and dynamics.
- ▶ New study documents abundance of nonnative plant species across 24 states in the Midwest and Northeast. Land managers can use this information to target forest stands where management actions will be most effective.
- ▶ Using DNA sequencing technology, scientists identify genes in Douglas-fir that are responsible for climate sensing and climate adaptation.
- ▶ Douglas-fir Seed-Source Movement Trial yields information that will help tree breeders determine which seed sources will be well adapted to a particular environment.
- ▶ Host tissues in species affected by sudden oak death may have the ability to interfere with the growth of the responsible pathogen.

Carbon flux and storage in live trees on Chugach National Forest is changing

Station scientists developed the first estimates of aboveground carbon flux and storage in trees within the national forests of Alaska. While the Tongass

Chugach National Forest uses estimates to assess baseline carbon stocks.

National Forest had no detectable change in

aboveground tree carbon, the Chugach National Forest had an average annual increase of 182,000 metric tons of carbon. Managed and unmanaged forest within the Tongass National Forest had substantially different storage and flux in log, tree, and snag carbon pools. Species shifts on the Tongass National Forest included an increase in red alder, an increase in western redcedar on unmanaged lands, and a decrease in yellow-cedar on managed lands.

As of 2013, national forests are required to assess baseline carbon stocks, a prerequisite to including carbon services into forest management decisions. The Chugach National Forest, an early adopter of the new Forest Service planning rule, is using these results in its forest assessment.

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Partners: USDA Forest Service Alaska Region, Chugach National Forest

Jon Williams



FIA crew measuring a snag on the Tongass National Forest.

Taking stock of circumboreal forest carbon with ground measurements, airborne and spaceborne LiDAR

The boreal forest contains a large proportion of global forests but is largely inaccessible from the ground. It contains large stores of carbon in its vegetation and soils, and it will likely be subject to increasingly severe climate-driven disturbance. In this study, scientists used a combination of ground-, airborne- and space-based measurement techniques to derive the first satellite LiDAR-based estimates of aboveground carbon for the entire circumboreal forest biome.

The maps developed in this study establish a baseline for future quantification of circumboreal carbon, and the described technique should provide a robust, repeatable method for future monitoring of changes in the aboveground carbon content. These regions are expected to warm significantly in the future, and monitoring the effects of warming on these stocks is important to understanding future global carbon balance and dynamics.

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Partners: Canadian Forest Service, NASA Goddard Space Flight Center, Norwegian University of Life Sciences, Russian Academy of Sciences, Sigma Space Corporation, Université Laval (Canada), University of Maryland



Deciduous forest around North Branch Township, Pennsylvania.

In eastern deciduous forest, oaks less affected by persistent drought than conifers or maples

How will forested ecosystems respond to the predicted increases in the frequency and severity of seasonal droughts? To begin to answer this question, scientists measured tree sap flow during an exceptionally dry growing season at the Shale Hills Critical Zone Observatory in central Pennsylvania. They found that oaks were less affected by repeated drought cycles than either conifers or maples. Each of these three types of trees has a distinct type of sapwood.

Increases in the frequency or intensity of summer droughts in the study region could have multiple consequences on forest function across a broad range of scales. Although oaks are not thought to be climax species at most sites in the region, long-term changes in summer precipitation regimes could alter successional time

courses or climax species composition, resulting in increased dominance of oaks and other species with similar sapwood structure.

At the individual tree level, persistent drought is known to have a cumulative effect on whole-tree architecture with consequent impacts on forest canopy function. The gradual accumulation of a structural and physiological legacy in response to prior environmental conditions restricts the ability of trees to respond rapidly to more favorable growth conditions. Thus, after release from several years of episodic droughts, tree- and stand-level carbon and water fluxes would be expected to recover slowly as trees embark on new architectural trajectories.

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Partners: Pennsylvania State University, National Science Foundation Critical Zone Observatory Network



Pete Bisson

Mature hemlock forest.

High-elevation stands of young true firs and western hemlock can be very productive

True fir–hemlock forests at higher elevations in the Cascade Range and Olympic Mountains provide protective cover for watersheds and contribute much to the region’s scenic and

No gains in tree size by retaining more than 400 trees per acre in early thinning.

recreational resources. On some ownerships, the forests are important for timber production. Very little information,

however, has been available on growth of the true firs and high-elevation true fir-hemlock mixtures. This project created a wide range of densities in young stands at multiple sites in Washington and Oregon and followed responses for 20 years.

At the widest spacings, researchers found an increase in diameter increment of the largest trees, but height increments declined.

Researchers found no gains in tree size by retaining more than 400 trees per acre in early thinning, and considerably lower stocking may

be appropriate in view of the likelihood that future management of public lands may involve relatively long rotations and infrequent entries. Although true fir-hemlock stands have slower initial growth than Douglas-fir, their ability to maintain growth to advanced ages and to support high stand densities can result in very productive stands on high-elevation sites unsuited to Douglas-fir.

Contact: Robert Curtis, rcurtis@fs.fed.us

Partner: USDA Forest Service Pacific Northwest Region

Introduced plant species found on two-thirds of forest inventory plots in the Northeast and Midwest United States

Introduced plant species have significant negative impacts in many ecosystems and are found in many forests around the world. However, there are few data sources that enable the assessment of introduced species occupancy in native plant communities over broad regions. Vegetation data from 1,302 forest inventory plots across 24 states in the Northeast and Midwest United States were used to examine and compare the distribution of introduced species in relation to forest fragmentation across ecological provinces and forest types, and to examine correlations between native and introduced species richness.

Scientists found 305 introduced species recorded, with multiflora rose (*Rosa multiflora*)

being the most common species. Sixty-six percent of all forested plots had at least one introduced species, where they made up 7 percent of the plant flora in intact stands, but 14 percent of the flora on forest edges.

The study is the first to document the abundance of nonnative plant species over a broad region—specifically, 24 states and 14 ecological

provinces. Because it compares the distribution of introduced species to native species in relation to forest fragmentation across ecological provinces and forest types, the study can help managers target forest stands where management actions will be most effective.

Identifying seemingly benign introduced species that are more prevalent than realized will also help focus attention on newly emerging invasive plants.

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Partner: USDA Forest Service Northern Research Station

New coupled model approach allows development of climate-informed state-and-transition models

Station scientists developed a process that links the mechanistic power of dynamic global vegetation models with the detailed vegetation dynamics of state-and-transition models to project local vegetation shifts driven by projected climate change. They applied this approach to a central Oregon landscape using three climate change scenarios to assess potential future changes in species composition and community structure.

Managers and other land stewards are using results to better anticipate potential climate-induced shifts in local vegetation and resulting effects on wildlife habitat. The Pacific Northwest Region of the Forest Service has

requested new models using this approach for the Blue Mountain Ecoregion as part of the Blue Mountains Restoration Strategy.

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Partners: University of Washington, Conservation Biology Institute, Washington Department of Natural Resources, Common Futures LLC, USDA Forest Service Pacific Northwest Region

New approach uses LiDAR data to assess sunlight availability in forest stands

LiDAR technologies employed over forested landscapes provide a detailed representation of tree crowns and ground surfaces. A study in Pacific Northwest forests showed that LiDAR data can be used to assess actual sunlight illumination regimes within forests.

The approach used overcomes limitations known to reduce the utility of satellite or airborne imagery for assessing light conditions. The method used explores the detailed, three-dimensional nature of the LiDAR, and uses ray tracing to determine if a component of a forested scene, such as ground or vegetation, receives direct sunlight from a given sun location. The process can be repeated for as many sun locations or time intervals as needed to provide location-specific daily, seasonal, or periodic assessments of sunlight availability. The methodology was evaluated using precisely georeferenced and timed field observations of ground illumination conditions in eastern



John M. Randall, The Nature Conservancy, Bugwood.org

Garlic mustard (*Allaria petiolata*) transforms forest understories and was found on 7 percent of the plots in the Northeast and Midwest.

Oregon. Remarkable agreement between recorded and derived lighting conditions was observed.

The methodology introduced in this study enables assessment of sunlight regimes wherever high-density LiDAR data are available. It has various potential applications including contributions to forest growth and yield models, assessment of regeneration potential, stream shading, and in support of management and tactical decisions.

Contact: Demetrios Gatziolis, dgatziolis@fs.fed.us

Various aspects of plant growth respond differently to environmental cues

The timing of periodic life-cycle events in plants (phenology) is an important factor determining how species and populations will react to climate change. Station scientists evaluated annual patterns of basal-area and height growth of coast Douglas-fir seedlings from four seed sources that were planted in four diverse environments as part of the Douglas-Fir Seed-Source Movement Trial.

Variations in the height- and basal-area growth metrics were correlated with different aspects of the seed-source environments: for height growth, precipitation, and for basal-area growth, minimum temperature. Our results indicate that multiple aspects of growth phenology should be considered along with other traits when evaluating adaptation of populations to future climates.



A researcher measures the diameter of a seedling in the Douglas-Fir Seed-Source Movement Trial at the J. Herbert Stone Nursery in Central Point, Oregon.

Genetic variation in growth phenology is a potentially important resource for mitigating some of the effects of climate change. Phenological traits can be considered with other factors in determining whether a genotype is well adapted to a particular environment. Distinction should be made between different aspects of growth phenology. Variation in diameter-growth phenology appears to be an adaptation to a

different set of environmental factors than budburst or height-growth phenology.

This type of information will be important in deciding how to make recommendations on selecting seed sources for planting.

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Partners: Hancock Forest Management, Port Blakely Tree Farms, USDA Forest Service J. Herbert Stone Nursery, USDI Bureau of Land Management, Washington Department of Natural Resources

Connie Harrington

Sterols and tannins in host tree tissues influence the growth and sporulation of sudden oak death pathogen

Sudden oak death, caused by *Phytophthora ramorum*, is rapidly changing the composition and structure of forests in California and other parts of the world. Host resistance to infection varies widely within and among species, but little is known about the complex physiological and biochemical interactions contributing to resistance. However, it is known that *P. ramorum* must capture sterols from its host tissues by secreting small proteins, called elicitors, to grow and sporulate. A recent study suggests that tannins in host tissues could potentially

interfere with the elicitor-mediated acquisition of sterols and thus affect the growth, sporulation, and virulence of *P. ramorum*.

Tree improvement and breeding programs can produce trees with increased resistance, but the development time can be accelerated, and quality of the new stock maximized when knowledge of traits contributing to resistance is acquired. The new information from this study furthers our understanding of host tree resistance to *P. ramorum*.

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Partners: Colorado State University, Santiago de Compostela University (Spain), USDA Agricultural Research Service

Scientists identify Douglas-fir genes used to sense season and climate

Douglas-fir and other conifers have exceptionally large and complicated genomes, with over 18 billion DNA “letters” (G, A, T, C). The size and complexity of the Douglas-fir genome has ham-

Gene atlas can help dramatically shorten breeding cycle.

pered efforts to identify the genes responsible for climate sensing and climate adaptation. Recent

improvements in DNA sequencing technology, however, have made it possible to sequence all the expressed genes from Douglas-fir to create a “transcriptome atlas.”

This atlas is now being used in conjunction with field experiments, including the Douglas-Fir Seed-Source Movement Trial, to determine how genes and pathways are used in trees that are climatically adapted to the local weather, and in trees that come from different climatic zones. When genes are linked to ecologically or economically important traits (such as drought or heat tolerance), this information can be used in marker-assisted breeding to select trees that are adapted for unique climate conditions. The current atlas includes 25,000 well-characterized gene sequences, and it identifies nearly 270,000 variants within these genes.

This atlas of genes will complement traditional breeding and hasten progress toward making healthier, more productive trees for future climates. Whereas traditional breeding methods require years of trait measurement and a decade or more for breeding, DNA variation



Dave Shaw

Fallen coast live oak (*Quercus agrifolia*) in California killed by sudden oak death.



associated with traits of value can be identified in young seedlings, leading to a dramatically shortened breeding cycle.

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Partners: Oregon State University, University of Minnesota—Morris, USDA Forest Service Pacific Northwest Region J. Herbert Stone Nursery, USDA National Institute for Food and Agriculture

Seed transfer zones developed for bluebunch wheatgrass

Seed zones and seed transfer guidelines developed from common garden studies are important for selecting plant material that is adapted to current and future climates. Scientists from the Pacific Northwest Research Station and their collaborators recently completed a common garden study of bluebunch wheatgrass (*Pseudoroegneria spicata*), an important restoration species for rangelands and forest lands of the interior western United States.

They found genetic variation among wheatgrass populations that influenced growth, reproduction, flowering phenology, and leaf morphology. Populations from warm, arid source environments were smaller, with earlier phenology, and had narrower leaves than those from moister environments. Later blooming was generally associated with populations from colder climates. Differences among native populations associated with source climates indicate that genetic variation across the landscape is adaptive and should be considered during restoration.

The seed zones and population movement guidelines developed from this research are being incorporated into the restoration plans of national forests in the Pacific Northwest Region and of the Bureau of Land Management to ensure that restoration activities use plant materials most suitable for the site.

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Partners: USDA Agricultural Research Service, USDA Forest Service Rocky Mountain Research Station and Pacific Northwest Region, USDI Bureau of Land Management

Bluebunch wheatgrass is often used to restore rangelands and burned forested areas. Above, the Blue Mountains near Pullman, Washington.

Nitrogen “loving” lichens increase in response to all types of nitrogen, challenging basis for pollution standards

Lichens are among the most nitrogen-sensitive organisms in boreal, temperate, and Mediterranean forest ecosystems. Shifts in lichen indicator species are commonly used to develop critical loads for nitrogen (N) deposition and critical levels for N gases, especially ammonia (NH_3). Critical load and critical levels quantify how much N an ecosystem can tolerate before its sensitive components are affected. They serve as guidelines for setting pollutant emissions limits and are currently used by the Environmental Protection Agency and the United Nations Economic Commission for Europe (UNECE).

Scientists studied lichen communities at forest monitoring sites that had an unprecedented diversity of N measurements: NH_3 , nitric acid (HNO_3), nitrogen dioxide (NO_2), ozone (O_3), and N in throughfall. This study was the first to directly compare effects of N gases and depositional pollutants. The study area in the Transverse Ranges of the Los Angeles Basin also provided a unique perspective because N emissions are dominated by oxidized N gases (NO_x) from motor vehicle emissions; most prior work had focused on agricultural regions, thus on N emissions dominated by NH_3 .

Their results challenge the widespread misconception that eutrophs (nitrogen-loving) lichens respond specifically to NH_3 , a core premise behind lichen-based critical levels for

NH_3 used by the UNECE. The scientists concluded that eutrophs are accurate, sensitive bioindicators for developing critical loads and risk assessments of total N deposition. Eutrophs are not suitable for developing critical levels or NH_3 mapping unless NH_3 is the only N pollutant in the vicinity.

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Visually striking fungal mats are “nutritional hotspots” in Pacific Northwest forests

The critical roles soil organisms play in ecosystem dynamics are often overlooked in ecosystem management because the function of little-known organisms is poorly understood. A single genus of symbiotic fungi, covering up to 40 percent of the forest floor in some Douglas-fir forests, significantly contributes to the availability of nutrients for plant growth. These mat-forming fungi serve as vital biotic links in how forests function, affecting tree survival and growth, as well as nutrient cycling, and serving as a major food source to many forest animals. Long-term ecological research spanning more than 20 years has shown that fungal mats are common features of the organic soil horizons of coniferous forests of the Pacific Northwest.

Piloderma mats are some of the most visually striking ectomycorrhizal mats; they lace the soil with thick golden-yellow or cream-colored



Jane Smith

Piloderma fungal mats help make soil nitrogen available to plants.

cord-like rhizomorphs. Recent research shows that through their production of extracellular enzymes, *Piloderma* fungal mats are adept at breaking down complex organic substrates, making nitrogen available for plant uptake and growth.

Assessing the changes in communities and biogeochemical processes that occur with natural variations in temperature and moisture will aid in predicting long-term nutrient availability and soil-carbon storage responses to climate change. A better understanding of biogeochemical processes across seasons will assist in the development of best management practices aimed at mitigating the potentially negative effects of climate change.

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Forest mapping study may help identify regions with multiple threat potential, including wildfires

Station scientists developed a way to combine and display forest threat data at its appropriate spatial scale, and in a way that transcends county boundaries by using readily available GIS

National Fire Protection Association uses maps to inform public about wildfire risk.

analytical tools. Resulting maps show locations where threats and threat combinations are more prevalent relative to the landscape as a whole.

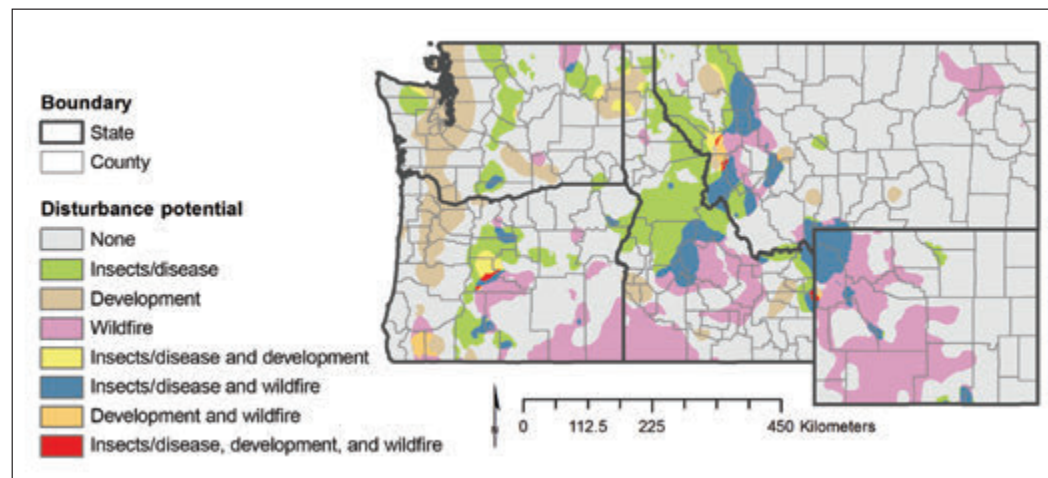
The maps are intended to assist policymakers and managers to identify locations where particular threats may be more concentrated relative to others and to identify where multiple threats intersect. This information can then be used when deciding how to allocate budgets to mitigate threats. The maps were published in June 2013 and are being used by the National Fire Protection Association in presentations about wildfire risk.

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The relationship between fire severity and changes to forest structure varies depending on forest type

The details of how fire modifies forest structure are difficult to evaluate because of complex interactions between fire, forest type, and forest



This map highlights where threats (wildfire, insects, and disease) exist, overlap, and intersect with urban and exurban development.

structure. Using a combination of airborne LiDAR data and Landsat-derived Relativized differenced Normalized Burn Ratio (RdNBR), researchers were able to measure the vertical and horizontal structure of canopy material and landscape patterning of canopy patches and gaps and relate these measurements to fire severity.

Each of the three forest types studied (ponderosa pine, white fir-sugar pine, and red fir) showed an individual trajectory of structural change as fire severity increased. Compared to stands outside fire perimeters, increasing fire severity generally resulted first in loss of canopy cover in lower height strata and increased number and size of gaps, then in loss of canopy cover in higher height strata, and eventually the transition to open areas with few or no trees.

However, the estimated fire severities at which these transitions occurred differed for each forest type.

Managers have been using fire as a management tool to thin forests for decades. This work suggests that even the low severities associated with prescribed burns will thin forests and create new gaps. Knowledge of the relationship between fire severity and forest structural change can help answer questions related to the level of fire severity that is likely needed to return forests to structural conditions similar to those prior to fire suppression.

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Wildlife

Tracks in the snow, a glimpse of a nest high above, flattened grass where deer have bedded—it's easier to see where the wildlife was than where it is. 🌀 For those who patiently look closer, however, more clues and sometimes even the animal itself appears. 🌀 Station research is revealing how land management can minimize its effects on forest inhabitants and even be used to improve their habitat.



U.S. Fish and Wildlife Service

Marbled murrelet.



© Susan C. Morse

Fisher with prey.

Highlights in 2013

- Findings from the Tongass-Wide Young Growth Studies indicate thinning treatments may improve deer habitat in young-growth forests in southeast Alaska.
- Scientists analyze habitat selection by fishers from north-central British Columbia to the southern Sierra Nevada in California. The fisher is a candidate for listing under the Endangered Species Act.
- Marbled murrelet and northern spotted owl habitat modeling helps inform management options in southern Oregon.
- Mapping of rapid worldwide emergence of viral amphibian pathogen continues; occurrence linked to temperature range.

U.S. Fish and Wildlife Service



Sitka black-tailed deer.

Thinning treatments show promise in improving deer habitat in young-growth forests in southeast Alaska

Forest management on federal, state, and private lands in southeast Alaska is rapidly shifting from an emphasis on logging old-growth forests to intensive management of young-growth

Multiagency initiative uses findings to increase sport and subsistence hunting.

forests. Public concerns about wildlife habitat, especially for Sitka black-tailed deer, have been an important driver in the policy shift as unmanaged young-growth forests are typically dense and lack understory vegetation. Deer are important in local subsistence economies and are considered a management indicator of broader habitat quality for wildlife.

The Tongass-Wide Young Growth Studies (TWYGS) are the primary means for monitoring the effects of young-growth management under the Tongass National Forest land and resource management plan. The adaptive management approach used here has garnered wide support from resource managers, scientists, and other land management agencies. Findings from this study are being used as part of a multiagency initiative to improve deer habitat on Prince of Wales Island. This will increase sport and subsistence hunting opportunities and support a healthy population of predators, such as wolves and bears.

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Management can hasten reintroduction of wood decay fungi, creating wildlife habitat in coastal Alaska forests

Wood decay fungi are particularly important components in the rain forests of coastal Alaska where the lack of fire allows trees to reach old ages. The fungi soften wood, leading to cavities in live trees, which serve as essential habitat for mammals and birds. Young forests that establish after timber harvests generally lack these cavities, and waiting for wood decay in live trees to return through the natural process of stand development can take more than 150 years.

Forest Service scientists found that the process could be hastened by accidental or strategic wounding of the tops or boles of young trees during commercial thinnings, or direct inoculation of fungi into trees. They also found slash from harvests created a physical barrier to deer for about 9 years after thinning and continued to shade understory plants for another 4 years.

The Tongass National Forest can use this information on forest health-wildlife interactions to decide how best to use resources to manage forests for multiple benefits.

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Habitat preferences of fishers described

Throughout the Pacific coastal region, fishers needing to rest tend to pick sites with steeper slopes, cooler microclimates, denser overhead cover, a greater volume of logs, and a higher prevalence of large trees and snags than are generally available. In areas within that region where fishers have not been studied and data on selection of resting sites are lacking, these findings provide empirical support for management or conservation actions for fishers that promote the retention or development of these environmental attributes. The fisher has been designated by the U.S. Fish and Wildlife Service as a candidate for listing under the Endangered Species Act within its range in the Pacific coastal states.

Prior to this study, the generality of observed patterns beyond the boundaries of each study area was unknown. So, researchers conducted a formal meta-analysis of habitat selection by fishers among eight studies located from north-central British Columbia to the southern Sierra Nevada in California, including all areas that currently contain established fisher populations. This is the first study to investigate the broader applicability of habitat selection patterns for fishers derived from multiple independent radiotelemetry studies conducted over a broad geographic area.

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Partners: Artemis Wildlife Consultants; Humboldt State University; University of Wyoming; USDA Forest Service Pacific Southwest Research Station, Rocky Mountain Research Station; U.S. Fish and Wildlife Service

Timothy Catton



A fisher uses a very large snag as a resting place.



Tom Iraci

Northern spotted owl.

Marbled murrelet and northern spotted owl habitat modeling helps inform management options

The Oregon governor's office used information provided by the Pacific Northwest Research Station to assess the ecological effects of proposed alternatives for managing lands

Governor's task force uses maps to inform plans for O&C lands.

under the 1937 Oregon & California Lands Act. The "O&C" lands are a checkerboard pattern of different federal and county ownerships.

In October 2012, Oregon Governor John Kitzhaber convened a panel of conservationists, O&C county commissioners, and timber industry representatives to advise him on issues related to management of the federally owned O&C Lands. The station contributed to the effort by advising the task group on how murrelet and owl habitat might be affected under seven different land management scenarios.

Station scientists developed detailed "wall-to-wall" maps of marbled murrelet and northern spotted owl habitat, both current and 50 years

into the future, under each scenario. The governor's task force used this information to better inform discussions about the feasibility of the proposed alternatives and to weigh consequences of each alternative on timber revenue as well as conservation value.

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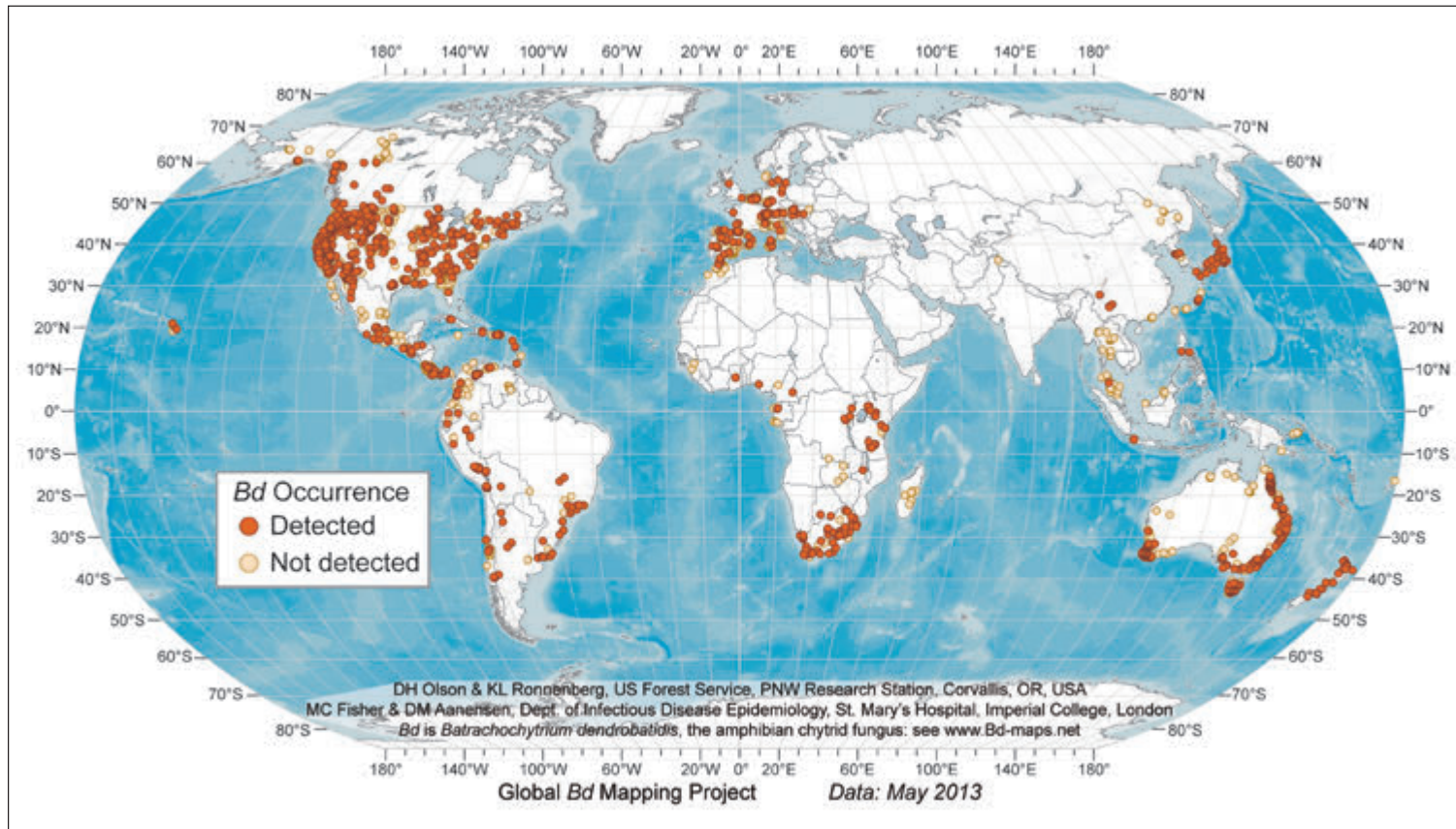
Global surveillance of amphibian fungus continues, odds of occurrence associated with temperature range

The rapid worldwide emergence of the amphibian pathogen *Batrachochytrium dendrobatidis* (Bd), the amphibian chytrid fungus, is having a profound negative affect

Maps used to support international and national efforts.

on biodiversity. The amphibian chytrid fungus has been reported in 52 of 82

countries sampled to date, and in 516 of 1,240 species. After analyzing these data, scientists found that the disease is associated with species richness and the occurrence of previously reported unexplained amphibian declines at sites. They found the odds of occurrence decreased with increasing temperature range at a site, linking disease emergence to climatic considerations.



The amphibian chytrid fungus has been reported in 52 of 82 countries sampled to date, and in 516 of 1,240 species. Source: www.bd-maps.net.

The global data set is helping to inform surveillance efforts, decontamination priorities, risks of water and animal transport, and amphibian conservation objectives. The project has led to a more rapid cycle of science development, science networking, results reporting, and management impact at the global scale.

The *Bd*-maps data have been used to inform the World Organization for Animal Health (OIE) for disease listing, and amphibian trade policy in the United States and elsewhere. Regionally, Forest Service and Bureau of Land Management fire managers have used the data to plan water draws for firefighting.

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Partners: Imperial College, London; London Zoological Society; Oregon State University; *Bd* Mapping Group

Elk unlikely to become pregnant in consecutive years

Researchers studied an elk herd at the Starkey Experimental Forest and Range to determine how energetic costs of reproduction in the current year affect survival and reproduction in the subsequent year. They observed no difference in survival probabilities between pregnant and non-pregnant elk. They did find that female elk that gave birth in the current year were less likely to become pregnant the following year. Increased body condition and higher precipitation contributed to greater probabilities of becoming pregnant in a particular year, regardless of reproductive state and previous recruitment. Costs associated with reproduction led to a reduced probability of future reproduction rather than a reduction in survival. Adult survival is maintained through variation in reproductive effort, resulting in high and stable adult survival but more variable reproduction.

Wildlife managers can use this information to estimate recruitment in elk herds based on winter precipitation and body condition. Potential tradeoffs between current and future reproduction is an important consideration when making predictions about population trajectories and determining how changes in resource availability influence population demographics.

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Partner: University of Nevada, Reno



Study assessed avoidance behavior by elk to different forms of recreation. Above, a packhorse train near Hell's Canyon, Oregon.

New ways developed to analyze human-animal interactions and movements

Researchers developed a statistical approach for analyzing movement data based on the concept that animals are moving on a space-time surface with regions or points of attraction or repulsion. They demonstrated the approach by analyzing movement data from a long-term controlled experiment to evaluate responses of elk to four recreation activities: (1) all-terrain vehicle (ATV) riding; (2) mountain biking; (3) horseback riding; and (4) hiking. These activities varied in space and time at the Starkey Experimental Forest and Range, as implemented in a controlled, manipulative experiment over a 3-year period.

The new approach proved useful for analyzing animal movements and animal responses to human activities in time and space at fine

scales and across large landscapes. Elk avoided all four types of recreation, with distinct areas of repulsion and avoidance in relation to the presence of recreationists. Analyses of movement patterns and responses with the surface function demonstrated a strong avoidance by elk to ATV riding up to 1 kilometer from the disturbance. Elk avoidance of mountain bikes was detected up to 500 meters from biking activities, and avoidance of horseback riders and hikers was detected up to 200 meters from these disturbances. Results have a variety of implications for analyzing human activity data and for managing recreation on public lands.

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Partner: USDA Forest Service Pacific Southwest Research Station

Honors and Awards

2013 National Silviculture Awards

Robert Deal, a research forester, was honored by the U.S. Forest Service for applied research that has had a direct and lasting impact on forest management on the Tongass National Forest, and his key role in advancing ecosystem services management.

Andrew Youngblood, a retired research forester, was honored by the U.S. Forest Service for developing new silviculture knowledge and applications, for major contributions to the fundamental understanding of vegetation dynamics, and the influences of natural disturbances and silvicultural manipulations.

Climate Action Reserve Recognizing Our Team Award

Olaf Kuegler, mathematical statistician, and **Glenn Christensen**, forester, received the Climate Action Reserve Recognizing our Team Award for their outstanding work as a partner in developing standards for a forest carbon offset protocol.

Endangered Species Recovery Champions

Research wildlife biologists **Martin Raphael** and **Bruce Marcot** were recognized by the U.S. Fish and Wildlife Service for their contributions as advisors in the development of models and tools used to define critical habitat for the northern spotted owl.

Jim Sedell Research Achievement Award

Peter Bisson, emeritus research fish biologist, was recognized for his long-term research contributions to fisheries and watershed management.

National Forest System Invasive Species Program Award for Innovative Control and Management

Robert Progar, a research entomologist, was recognized by the U.S. Forest Service for developing and implementing the concept of inundative release of *Aphthona* spp. flea beetles, a biological control agent, to control invasive leafy spurge.

Oregon State University Extension Association 4-H Award

The station received this award from the Oregon State University Extension Association for "Excellence in Natural Resources, Environmental Education Team" and was recognized as cooperator of the year for its contributions to the Inner City Youth Institute. **Becky Bittner** is the station's lead in this effort.



Rhonda Mazza

Trillium ovatum.

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Online Supplements

2013 Science Accomplishments of the Pacific Northwest Research Station is available online, along with PNW research program reports and all 2013 publications by PNW scientists, at <http://www.fs.fed.us/pnw/sa/2013/>.

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Front cover photographs—(left) *Cladonia amaurocraea*, by Sarah Jovan; (right) installing a water temperature data logger, Prince William Sound, Alaska, by Steve Wondzell

Back cover photographs—(left) pine marten, by John Hutmacher; (right) view of Mount Adams, Washington, by James Dollins

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U.S. Forest Service staff

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