

Pacific Northwest Research Station Science Accomplishments



2016



OUR 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.

2016 IN REVIEW

At the Pacific Northwest Research Station (PNW), we respond to today's pressing needs for information with a growing body of scientific work. For example, in 2016, our fire research helped protect human health and safety by providing information that helped communities take timely action to anticipate smoke from wildfire and reduce their exposure. We help people understand how to manage fire risk—sometimes by using fire itself to reduce risk of uncontrollable fire. Decades of research are illuminating how forests can be best managed to restore their resiliency in relation to fire, which historically has and will continue to shape western landscapes.

Groundbreaking work published in 2016 revealed how moss can serve as a bioindicator of urban air quality. Our findings led to the prompt abatement of two sources of toxic metals in Portland, Oregon. Policies and practices were changed to ensure broader protection of human health throughout the state. This research continues—and will likely help cities across the world improve their air-quality monitoring.

In 2016, the station also produced scientific information for understanding the economic impacts of recreation and timber harvest; understanding carbon in forests; and managing fish, wildlife, and their habitat. We did so with the help of more than 80 partners from nongovernmental organizations, private companies, state and federal agencies, tribes, and universities.

The demand for scientific information from those who manage, use, and enjoy forests for a multitude of benefits only increases as the population increases. The following pages highlight recent work in ways that demonstrates our strong commitment to helping meet the demand for science that directly benefits people and their environments.

◀ *Fremont-Winema National Forest*

Front cover: Forest Inventory and Analysis crew in coastal Alaska, Mike Ausman

Back cover: Jerry Bednarczyk

LOCATIONS

The Pacific Northwest Research Station is one of five research stations in the U.S. Department of Agriculture, Forest Service.

- Headquarters are in Portland, Oregon
- 11 laboratories and research centers in Alaska, Washington, and Oregon
- 12 active experimental areas (forests, ranges, and watersheds)
- Research is conducted in more than 98 research natural areas
- Forest inventory is conducted in Alaska, California, Hawaii, Oregon, Washington and the U.S.-affiliated Pacific Islands.



Yap, part of the Federated States of Micronesia, is one of the Pacific Islands where PNW Forest Inventory and Analysis works with local foresters and students to inventory the island's forests. ►



Finances and Workforce

FISCAL YEAR 2016

Two sources of funding support the PNW workforce: federal appropriations, which contributed 92 percent of the funds in fiscal year 2016, and direct client support, which comes from organizations in need of scientific information.

The numbers below are for the fiscal year October 1, 2015, to September 30, 2016.

Incoming Funding

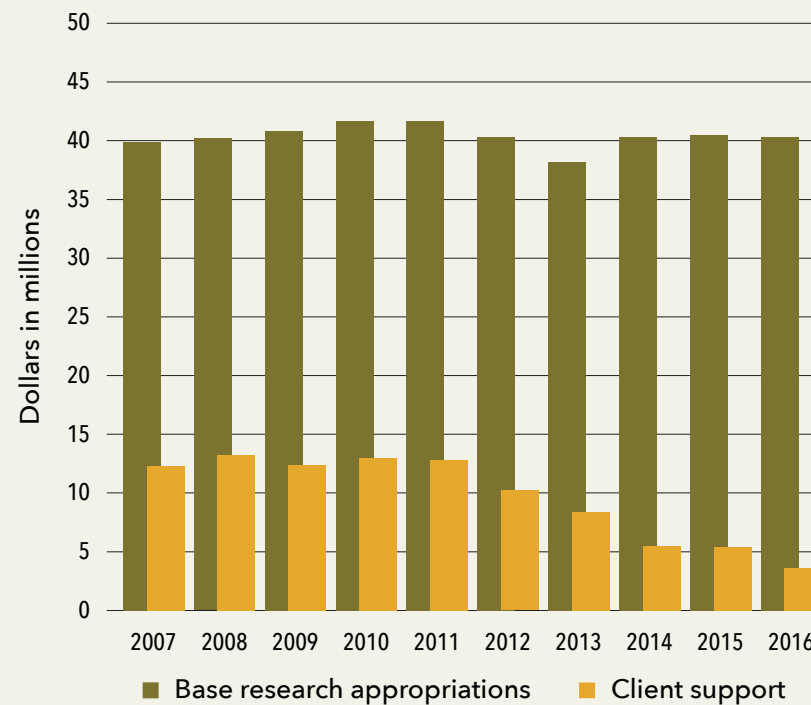
Base research appropriations: \$40.3 million (92%)

Client support: \$3.6 million (8%)

Total funding: \$43.9 million

Discretionary funding: 45%

Nondiscretionary funding: 55%



◀ Mixed conifer and madrone in Ashland, Oregon.

Distribution of Funds

Permanent employee cost: \$27.3 million (56%)

Support and operations: \$8 million (16%)

Distributed to cooperators: \$13.5 million (28%)

Of the \$13.5 million to cooperators, 68 percent went to educational institutions

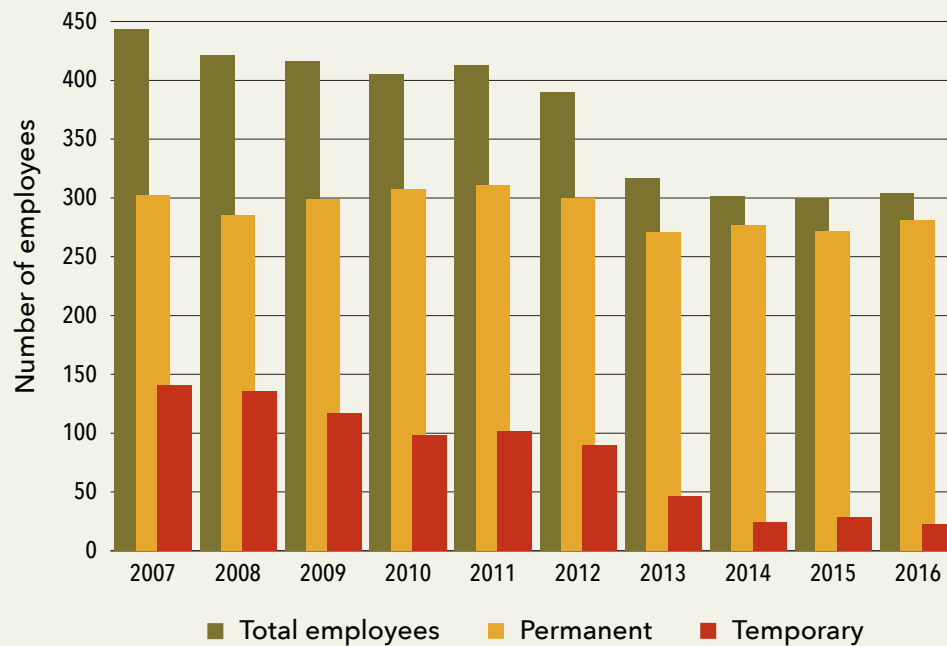
Workforce

Total station workforce: 304

Permanent workforce: 281

Of the permanent workforce, 73 employees (24%) are scientists

Temporary workforce: 23





Science Delivery Highlights

BY THE NUMBERS

Delivering science in accessible formats to the people who need it to make informed decisions is a key part of the station's mission. In 2016, PNW scientists engaged with our stakeholders, using a variety of formats to share information. A few of the events are highlighted below. In summary, station scientists gave:

- ~300 presentations
- ~65 consultations
- ~30 workshops
- ~30 webinars

Web Visitors

- Total number of visitors: **124,866**
- Total number of page views: **309,204**
- Percentage of new visitors: **77%**

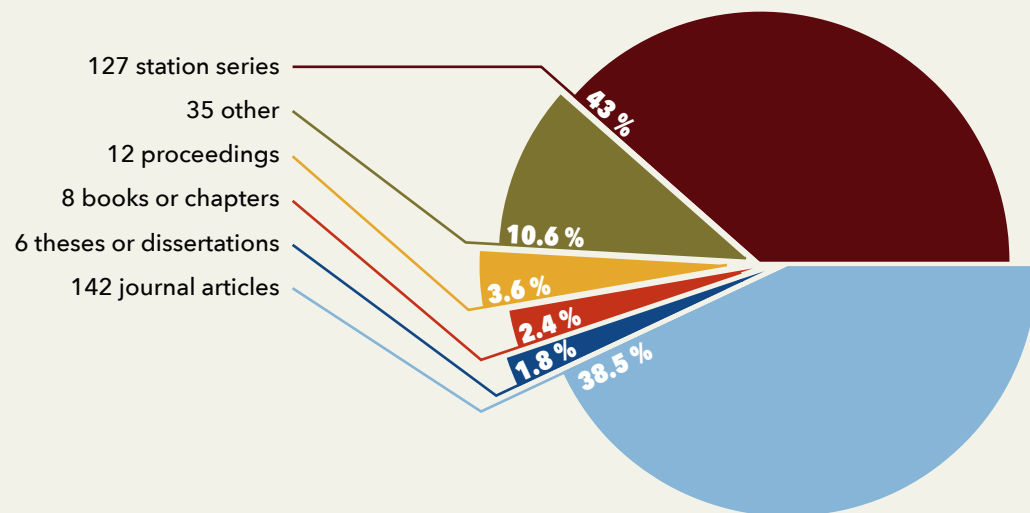
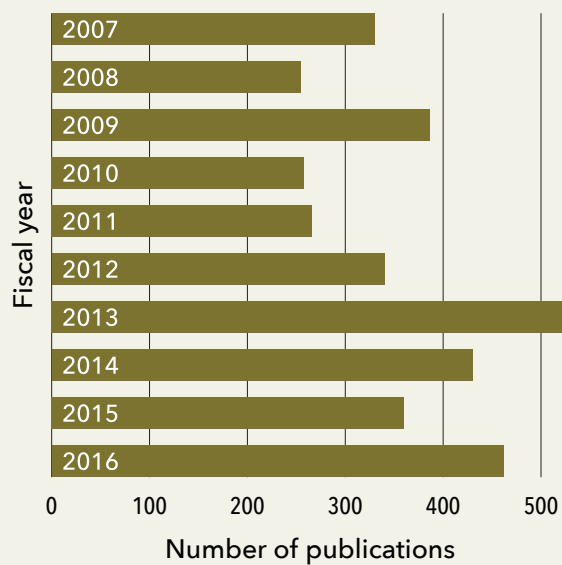
Twitter

PNW's Twitter account has 2,003 followers—up from 1,523 in 2015. Reporters, natural resource professionals, and nonprofit groups comprise the majority of subscribers, who receive instant electronic alerts (tweets) about station news releases, new publications, and other information.

Publications

The station produced 330 publications in fiscal year 2016. This includes station series publications, journal articles, books or book chapters, theses and dissertations, and other publications.

- **103,200** hard copies of station publications distributed
- **5,111** station publications available online through Treesearch
- **12** issues of *PNW Science Findings* published, about 8,000 copies of each issue distributed or downloaded



Lost Lake, Mount Hood National Forest, Oregon. ►

Living With Fire

Rain is essential, but floods can be devastating. The same goes for fire. Fire keeps forests healthy, but when too big, too hot, and out of control, fire is catastrophic. PNW fire science is helping society better live with fire—from dealing with smoke, to optimizing fuel treatments, to using fire to renew habitat. Key research activities include:

- Providing guidance for smoke managers and public health officials
- Delivering smoke science tools to wildfire incident operations
- Mapping risk to communities from wildfire
- Studying effects of wildfire on Chinook salmon habitat—it can be beneficial

Protecting public health with smoke science

Smoke from wildland fire poses a public health hazard, particularly for people with asthma or weakened respiratory systems. Smoke can drift hundreds of miles, affecting communities far downwind from the fire.

PNW scientists provide custom, daily smoke forecasts and information that is used by fire professionals and public health officials to inform communities about anticipated smoke conditions. In 2016, PNW scientists continued to support Incident Command Teams deployed across the country by providing direct technical consultations and science-based tools and equipment aimed at serving the needs of fire management.

A signature product is daily smoke model predictions at high resolution, produced in partnership with the National Weather Service, as well as new tools for generating and archiving reports from air quality monitors near the incident, and improved Web access to smoke monitoring data.

PNW scientist were asked to:

- Join NASA's Health and Air Quality Applied Science Team. This work will further inform decisions, communications, and response by wildfire Incident Command Teams and local public health agencies dealing with smoke.
- Provide smoke monitoring, smoke modeling, and air quality/smoke data analyses for the Washington Department of Natural Resources' Forest Resiliency Burning Pilot Study.

◀ *Smoke from the 2016 Pioneer Fire, Idaho. The PNW AirFire Team provided smoke modeling support for this fire. Daily modeling output was used by air resource advisors deployed to the fire and by the Idaho Department of Environmental Quality.*



Mapping risk of wildfire transmission from national forests to adjacent lands

The Forest Service has nearly doubled its use of fuel treatments since 2001, under the guidance of the National Fire Plan. But each year, communities in the wildland-urban interface are threatened by fire, and homes and even lives are lost. Can fuel treatments be conducted where needed?

To better understand risk to communities, Forest Service leadership requested that PNW map the transmission risk of large simulated wildfires spreading from national forests to adjacent properties.

These simulations revealed:

- Wildfires are most likely to ignite where mechanical fuel treatment is permitted and in fire-adapted dry forests that are the primary target for accelerated restoration.
- Overall, landscape forest restoration programs can target areas where risk of wildfire transmission to the wildland-urban interface exists.
- However, many areas of national forests in the Pacific Northwest that contribute fire risk to communities are not within the boundaries of community wildfire protection plans. Created as an incentive under the 2003 Healthy Forests Restoration Act, these plans are a means for communities to address their wildfire risk. Because this risk can lay outside the plan boundaries, a “scale mismatch” is created between the area covered by the plans and the large amount of area within national forests where fire could spread from the forests into the adjacent wildland-urban interface.

Opportunity: If done at the scale of individual national forests, mapping the risk of cross-boundary transmission may improve efforts to restore forest health, increase forest resiliency to disturbances, and protect communities.

◀ A prescribed burn on the Tahoe National Forest, California.

Keeping track of what has burned

As the agency assesses its fuel treatment program, key information is knowing the acreage that burns each year and the severity of the fires. The only national-scale fire-severity classification uses satellite image change-detection to produce maps for fires that are larger than 1,000 acres.

The question: How much forested area burns in smaller fires?

Ground-based estimates of fire severity reveal information undetected by satellite-imagery analyses, PNW scientists found. This new method revealed that 21 percent of forested land in the National Forest System in Oregon and Washington experienced wildfire or prescribed burning between 1993 and 2007 that were not noted on the maps generated by satellite-based analyses.

Opportunity: This method can be applied using existing data from the national Forest Inventory and Analysis program to provide improved monitoring of the effects of fire.

Integrating fire management and aquatic habitat restoration

How does fire affect fish habitat? Working with the Okanogan-Wenatchee National Forest, PNW scientists modeled the effects of wildfire on habitat used by spring Chinook salmon in the Wenatchee River subbasin in Washington.

They found a potentially positive link between wildfire and habitat for spring Chinook salmon. For example, habitat conditions improved for adult and overwintering juvenile fish with increases of instream wood, a byproduct of fire. However, a short-term increase in fine sediment following fire can temporarily degrade egg and fry habitat.

Opportunity: This work supports holistic goals for fire management. Additional national forests have asked for similar modeling work on their watersheds to better inform fire management and plans for aquatic habitat restoration.



Malheur National Forest. As they fall, fire-killed trees can create beneficial instream habitat for fish.



MANAGING FOREST WITH MIXED-SEVERITY FIRE REGIMES IN THE 21ST CENTURY

"In a time when public land management is shifting toward truly restorative management, it is important to be clear about what we mean by restoration: restoration for what reasons and to accomplish which ends?" says Paul Hessburg, a research landscape ecologist with the station.

Hessburg and 17 colleagues developed nine strategies aimed at reconciling potentially conflicting management goals for forests with mixed-severity fire regimes in interior forests of Washington, Oregon, and California. These strategies are being used in discussions that inform a variety of agency and collaborative planning efforts in the region.

Forests where "mixed-severity" fire was the historical norm cover a large part of the western United States. "These are the fire severities that fall between low and high severity—a fairly messy catch-all bin," says Hessburg.

"Within it, though, there is a lot of variability, and that variability was important to providing a broad diversity of habitats for interior-forest-associated species. And what's more, these habitats occurred at fine to fairly broad scales. So, if you think about it, mixed-severity fires had a powerhouse role—they reinforced a broad variability of habitats, which in turn supported perhaps the widest variety of plant and animal species. Understanding their role on the landscape, their variability by geographical area, and the variation in vegetation patterns they supported becomes really important in this light."

Hessburg and his colleagues also emphasize the need to be forward thinking. Forest conditions that differ from historical conditions may be needed to create future forests that are more resilient and resistant to future stresses related to climate change. In fact, management can buy time for climate adaptation by purposefully creating corridors for species migration.

◀ *The 2012 Wenatchee Complex burned about 60,000 acres.*

Similarly, habitat networks can be maintained to support early, mid-, late-successional, and old-forest specialists. Regional and local landscape planning will be critical for gauging risks, evaluating tradeoffs, and restoring dynamics that can support these species. Tools to achieve restoration objectives include managed wildfire, prescribed burning, and low or variable-density thinning coupled with prescribed burning, at the appropriate scales. Specifics on “how much and where” will differ according to physiographic, topographic, and historical templates, and by regulatory requirements, and may best be determined by means of a socioecological process.

The Nature Conservancy and other groups are already using these principles to restore the Manastash-Taneum area in Washington. Collaboratives across Idaho, Montana, Oregon, and Washington are also learning to apply these principles to more sustainably manage fire-prone ecosystems.

Partners: Oregon State University; Pennsylvania State University; The Nature Conservancy; University of California; University of Montana; University of Washington; USDA Forest Service Deschutes National Forest, Okanogan-Wenatchee National Forest, Rocky Mountain Research Station, and Pacific Southwest Research Station; Warm Springs Reservation



Historically, mixed-severity fires had a powerhouse role—they reinforced a broad variability of habitats, which in turn supported perhaps the widest variety of plant and animal species.



People and Nature



From jobs to recreation to intrinsic appreciation of nature, the PNW Research Station works to understand the relationships people have with the land. Land managers use the station's science to foster environments where these relationships can thrive.

Of note in 2016, our scientists:

- Estimated annual health savings provided by “metro nature” in the United States to be \$6.7 billion.
- Worked with the Mount Baker–Snoqualmie National Forest to gather, map, and synthesize public input about forest access as the national forest prepared its Sustainable Roads Strategy Report.
- Quantified the economic activity generated in nearby communities from recreation and tourism in national forests.
- Assessed how expanded forest restoration under the Forest Service Pacific Northwest Region's Eastside Strategy and Oregon's Federal Forest Restoration Program affected forest employment and the forest products sector in eastern Oregon.
- Discovered that moss in urban areas is a bioindicator of air quality and can be used to identify pollution hotspots at a very fine scale.

◀ *Hiking in the Columbia River Gorge National Scenic Area, less than an hour's drive from Portland, Oregon.*

Olympic National Forest. ▶



FROM WILDERNESS TO CITIES

Our social science spans the continuum from urban setting to wilderness. With 80 percent of the U.S. population living in urban areas, one facet of the station's social science explores questions related to urban forests. Study over several decades has revealed the importance of trees to people's well-being. But when it comes to allocating city budgets, city trees and other metro nature are often viewed more as amenities than necessities. To provide a fuller picture, in 2016, PNW scientists and university collaborators measured the economic benefits of metro nature to public health. They found the annual U.S. health services savings attributed to metro nature could be as much as \$6.7 billion. As health costs soar, this information is increasingly valuable for communities wanting to invest in preventative health options. It may enable local and state planners to justify better programs for planning, planting, and managing urban greenspaces.

Economic activity from forest restoration in eastern Oregon

Forest collaboratives are active in eastern Oregon, where increasing the pace, scale, and quality of federal forest restoration is a current focus. Two key efforts are the Forest Service Pacific Northwest Region's Eastside Strategy and Oregon's Federal Forest Restoration Program funded by the state legislature. These efforts committed millions of dollars to expand federal forest restoration in eastern Oregon, particularly in the Blue Mountains. Social scientists assessed the effect of these programs. They found that:

- In 2014, timber sale volumes from eastern Oregon national forests were 5 percent greater than the annual average over the prior 5 years.
- Federal forest spending on contracts for restoration work increased 1 percent compared to spending in the last decade.
- National forest restoration treatments resulted in more than 1,800 full- and part-time jobs in eastern Oregon in 2014; more than 850 of those jobs were in the Blue Mountains region of Oregon.



Oregon Department of Forestry/Flickr

Accelerated restoration treatments on the Deschutes National Forest.

◀ Deschutes National Forest.

A framework for testing assumptions about ecological intervention in wilderness

With restoration a focus on many federal lands to make them more resilient to disturbances such as fire, drought, and insect outbreaks, questions about managing wilderness are rising to the fore. Wilderness is often envisioned as a state of existing with very little management. But climate change is triggering changes in key ecological processes, prompting debate about the appropriateness of ecological restoration and other intervention in wilderness areas.

In 2016, PNW scientists developed a framework that can be used by land managers to test assumptions about the management of wilderness. The framework developed makes three general recommendations:

- Operationalize broadly stated management goals.
- Test the assumptions used to justify intervention.
- Weigh the benefits and harms of intervention.



Forest Service staff discuss the concept of "wilderness" while in the Flat Tops Wilderness, Colorado.

Roger Poirier



Mapping favorite destinations in national forests

Frequent visitors to national forests often have favorite places—a lucky fishing hole, a scenic campsite, the best place to harvest huckleberries. Access to these special places is near and dear to those who may have memories of time spent there with family and want to share the experience with their children.

Recognizing this, the Mount Baker–Snoqualmie National Forest, Washington, when initiating work on its 2016 Sustainable Roads Strategy Report, requested assistance from social scientists with the PNW Research Station and Portland State University. The scientists used a human ecology mapping approach where more than 1,800 participants used maps to identify forest destinations and roads that were important for recreation, livelihood, cultural connections, food and resource gathering, and other values.

From this, they developed a spatial database with technical documentation for the Mount Baker–Snoqualmie planning team and decision frameworks that prioritized roads based on high volume and activity diversity.

The human ecology mapping approach is currently being used in the Deschutes and Ochoco National Forests in Oregon in preparation for forest planning. The approach also is being used by the Bureau of Land Management in planning for the Browns Canyon National Monument in Colorado.

Eric White



Community members and Forest Service staff in Issaquah, Washington, discuss maps created by the public as part of the public engagement process in travel management planning for the Mount Baker–Snoqualmie National Forest.

◀ An angler in the Umatilla National Forest.



Human ecology mapping helps national forests systematically identify and prioritize access to special places valued by the public, such as this camping site along the Cowlitz River.

The effects of national forest recreation on our economy

More than 240 million Americans live within 100 miles of a national forest or grassland, and many take advantage of the recreational opportunities on these public lands. Spending by recreation visitors benefits many local communities around national forests. To quantify this economic effect of recreation, a PNW-led study analyzed visitor spending in local communities, factors influencing that spending, and how climate change may affect recreational opportunities and thus related spending. This information can help communities capitalize on opportunities presented by a growing population and changes in demographics.

Visitor spending in communities near national forests

\$9.3 billion: annual spending in communities near national forests resulting from recreational opportunities provided by the National Forest System.

\$580: the amount spent by groups on overnight trips and staying in hotels or Bed and Breakfasts in nearby towns.

\$36: the amount spent by groups on day trips to the national forest.

Paddling on the Tualatin River, Oregon. ►



Forest collaboratives: understanding this current evolution in public engagement

Public engagement is increasingly important in the management of public land. From sustainable road strategies to forest restoration activities, processes and mechanisms for involving communities have evolved over the past several decades to find common ground, recognizing that social values are at the heart of natural resource management. Successful collaboration is important for natural resource management because it provides an avenue for diverse stakeholders to make collective decisions and implement action regarding important issues.

Eric White



Forest Service staff and the Lakeview Stewardship Group discuss posttreatment monitoring in the Fremont-Winema National Forest.

◀ *Umatilla National Forest, Oregon.*

Organized forest collaboratives have become increasingly common and popular in many western states—Oregon is a leader in this trend, with at least 25 forest collaboratives and each national forest covered by at least one collaborative. As these collaboratives become an increasingly common tool used in managing national forests, it is important to understand them. Although collaboration offers promise for resolving conflict and building consensus, it poses many challenges. Understanding the organizational characteristics and governance along with motivations behind why participants invest in collaboration can provide insight into conflict or communication barriers that exist within collaborative groups. For example, PNW social scientists and partners found that, in Oregon, forest collaboratives do not consistently have similar traits and values—in particular, agency and nonagency participants differed demographically and had differing motivations for, and satisfaction with, collaboration.



Susan Charnley

Forest collaborative members, scientists, and land managers observe and discuss forest restoration needs of the Umatilla National Forest.



Bob Nichols,



THE PORTLAND MOSS AND AIR QUALITY STUDY

"Our study shows that moss bioindicators have the potential to improve air-quality monitoring by serving as a screening tool to help cities strategically place their air-quality monitors," explains Sarah Jovan, a research lichenologist at the PNW Research Station.

Urban air pollution monitors are very expensive and often too widely spaced to identify many sources of air pollution. Mosses, which are ubiquitous in a damp locale like Portland, Oregon, accumulate pollutants from the atmosphere. In this novel study that garnered intense local and national attention, a PNW-led science team gathered moss (*Orthotrichum lyellii*) samples around the city, had them analyzed for heavy metals and other elements, and then developed citywide maps showing concentrations of 22 elements in moss across Portland and identifying potential air pollution "hotspots."

Julie Jonhson



A PNW scientist gathers a moss sample from a neighborhood tree in Portland, Oregon.

◀ *Orthotrichum lyellii*.

A detailed spatial analysis of cadmium levels in the moss found hotspots of extremely high concentrations around two stained-glass manufacturers, neither of which were previously known as cadmium emitters. With this information in hand, the Oregon Department of Environmental Quality (DEQ) placed a temporary air monitor near the largest cadmium hotspot. The instrument measured cadmium concentrations that exceeded health benchmarks by 49 times.

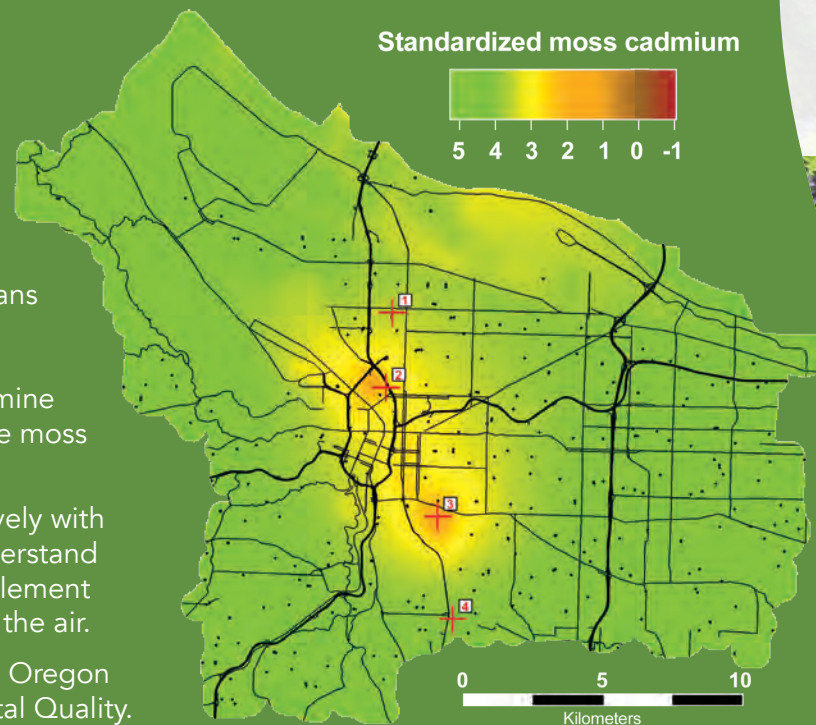
Both stained-glass manufacturers voluntarily stopped using cadmium after the results were made public. Atmospheric cadmium levels dropped precipitously in both locations.

PNW published the raw data to enable continuing investigation of possible pollution sources, and identified seven locations for further study with a map that shows hotspots with elevated levels of two or more of the six most toxic elements such as arsenic, lead, and nickel.

Past research shows that element concentrations in moss reflect atmospheric concentrations, although the strength of these relationships differs by element and is currently unknown for most of the elements sampled. This means atmospheric concentrations need to be measured by an air-quality monitor to determine if hotspots suggested by the moss indicator pose a health risk.

PNW is working collaboratively with Oregon DEQ to further understand the relationships between element concentrations in moss and the air.

Partners: Drexel University; Oregon Department of Environmental Quality.



A fine-scale map of relative cadmium levels in moss in Portland.

Findings from this study contributed to new pollution controls, reexamination of the state's regulatory exemptions for the stained-glass industry, and the creation of "Cleaner Air Oregon," a new state program.

Resilience

Resilience is an antidote to stress. Drought, fire, and temperature extremes are a few of the stressors that affect forest ecosystems. To manage for resilience—facilitating conditions in which vegetation and wildlife are better able to withstand the exposure to a stressor or multiple stressors—requires understanding the mechanisms organisms have for dealing with stress and the likelihood of exposure to one or more stressors. PNW science is helping land managers manage for resilience in several ways:

- Uncovered previously unrecognized processes employed by trees and other plants for maintaining hydraulic functioning in the face of potential moisture deficits. This information provides foundational understanding to issues of forest productivity, resilience, and adaptation.
- Quantified the long-term effects of climatic variability on growth of Douglas-fir, finding that lower growth rates of Douglas-fir are a near-certain outcome of climate change in the western United States.
- Produced a Climate Change Vulnerability Assessment for the Kenai Peninsula and Chugach National Forest in Alaska. The Chugach is using this assessment as it revises its forest management plan.
- Produced customized maps for Oregon and Washington to support climate change vulnerability assessments for national forests in south-central Oregon and the Blue Mountains. The Central Oregon Fire Management Service has used maps from this study in discussions with policymakers about overlapping threats in central Oregon.
- Modeled the effects of landscape restoration strategies on fire and ecosystem services. The Deschutes National Forest and the Deschutes Collaborative Forest Landscape Restoration Project are using the information to facilitate discussion and development of policies and practices for accelerating landscape-scale forest restoration efforts.

◀ *A field tour with the Lakeview Forest Landscape Collaborative in the Fremont-Winema National Forest.*

TREES AND DROUGHT

Why can some tree species better tolerate moisture stress than others? And when does a tree reach its breaking point? PNW scientists investigate these foundational questions about how trees function biologically because the answers provide key insights into a tree's ability to acclimate to changing climatic conditions.

Carbon acquisition by trees via photosynthesis requires a sufficient water supply to leaves. Maximizing water transport within a tree enhances carbon assimilation and can provide a competitive advantage. Unregulated water transport, however, can lead to disruptions (embolisms) in the continuum of water being transported through the tree via the conducting tissues, resulting in a decreased water supply to the foliage. Thus, there can be a tradeoff between maximizing water transport and minimizing the risk of xylem embolism.

Connie Harrington



When stressed for moisture, trees must balance their need to photosynthesize (which requires water) with maintaining a continuous column of water in their conductive tissue from root tip to leaf tip.

- ◀ Five years of consecutive drought, an increase in bark beetle infestations, and warmer than normal temperatures have killed 66 million trees in the southern Sierra Nevada region of California since 2010.

Beyond providing information about the means by which trees currently compete and survive, understanding the hydraulic mechanisms provides insight into ways that trees are affected by and the degree to which they may acclimate to rapidly changing climatic conditions.

So what does this mean for tree growth rate? Douglas-fir is one of the most ecologically and economically important tree species in western North America. Private and public land managers are very interested in knowing how it will respond to increased moisture stress. In the largest empirical study of growth of a single species, researchers found that lower growth rates of Douglas-fir are a near-certain outcome of climate change in the western United States. This will slow wood production in areas where timber is harvested. It will also affect the vigor and competitiveness of the species, especially in the southern and lower elevation portions of its range, compounding future stress from increasing wildfire and insect outbreaks.

Management options for addressing this issue include intensifying stand-density management, revising genetic guidelines for tree planting, and including new growth-climate functions in forest growth-and-yield modeling. Monitoring growth trends in Douglas-fir and other species will provide an early warning of the effects of climate change on national forest lands.

Early forecast of tree mortality in California used as warning system for fire risk

A new statistical method forecasts bark beetle locations and intensity in California 6 months earlier than traditional aerial surveys. California's Department of Forestry and Fire Protection (Cal Fire) is using the early forecast, produced before the fire season is in full swing, as a warning system for increased fire risk. Forest Service managers in the Pacific Southwest Region are using the forecast to identify areas in need of spot treatment.

Comparison of the 2015 forecast with the 2015 survey data showed only 2 percent of the forecast fell outside the expected range of mortality. This method was developed in partnership with the Forest Service's Western Wildland Environmental Threat Assessment Center, Pacific Southwest Research Station, Pacific Southwest Region, and Forest Health Protection.



RESEARCH FOR RESILIENT FORESTS

Key to planning is knowledge about current conditions. This year, the station completed two key projects to meet the needs of national forest managers and provided updated information about the status of yellow-cedar in Alaska.

The Climate Change Vulnerability Assessment for the Chugach National Forest and Kenai Peninsula

This report, completed in partnership with federal, state, university, and nongovernmental organizations, evaluates the effects of future climate change on ecological systems and ecosystem services. The Chugach National Forest is using the findings as it revises its forest management plan.

John S. Lang

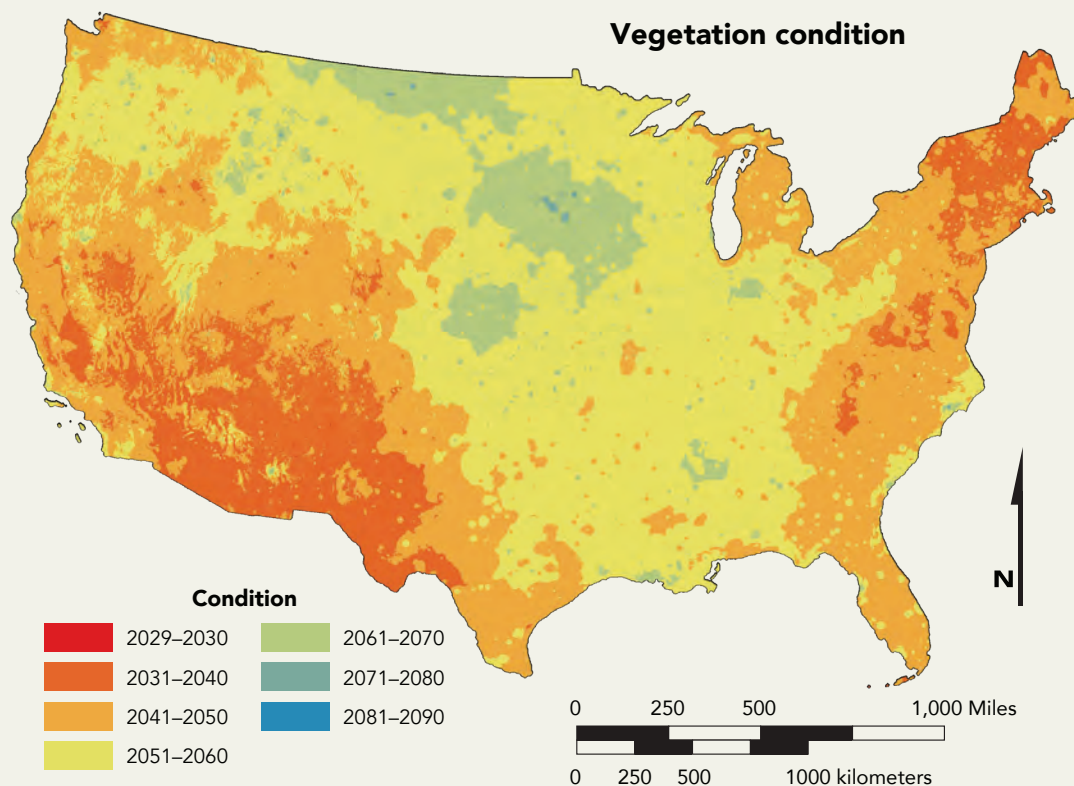


A flooded stream near Cooper's Landing on Alaska's Kenai Peninsula.

◀ *The Chugach Mountains, Kenai Peninsula, Alaska.*

Customized maps of overlapping stressors for Oregon and Washington

Much of the conterminous United States will be exposed to heightened wildfire potential, insects and disease risk, urban and exurban development, and unprecedented climate change by the middle of the century. At the request of the Forest Service Pacific Northwest Region, PNW scientists produced customized maps for Oregon and Washington to support climate change vulnerability assessments for national forests in south-central Oregon and the Blue Mountains. The Central Oregon Fire Management Service has used maps from the study in discussions with policymakers about overlapping threats in central Oregon.



The anticipated arrival of average annual temperatures that are outside historical ranges within the conterminous United States if greenhouse gas emissions continue to rise throughout the 21st century (Representative Concentration Pathway 8.5).





Modeling tradeoffs among fuel treatments, timber, and wildlife habitat

This study, done in collaboration with the Deschutes and Fremont-Winema National Forests and Deschutes and Lakeview Forest Landscape Collaboratives, yielded information and a landscape modeling tool that are being used in discussions among stakeholders about the effects of alternative approaches to forest restoration policy. The project is continuing to explore how different approaches to management affect fire and ecosystem services.

A broader view of the status of Alaska yellow-cedar

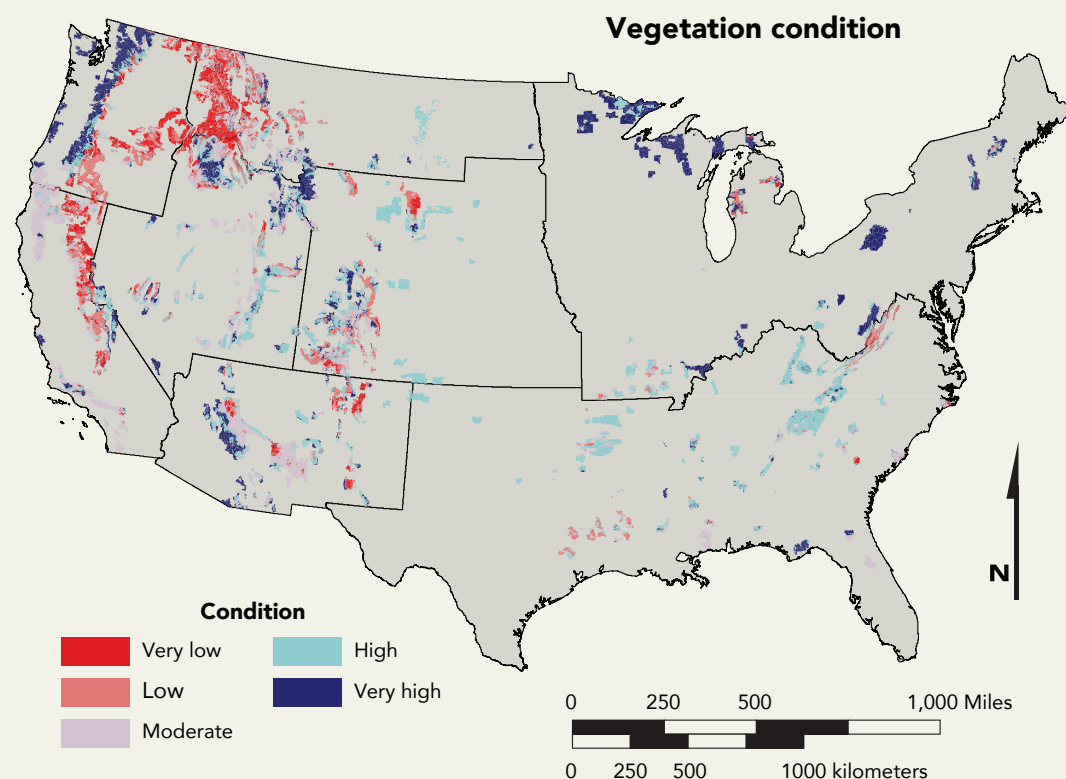
Pacific Northwest Research Station scientists have been investigating yellow-cedar in Alaska since the 1970s—during a massive, mysterious die-off of the species. In the past 40 years, station scientists determined the tree's shallow roots made it particularly susceptible to freeze damage, particularly in years with low snow, which serves as insulation. This knowledge has been used to develop management considerations for planting yellow-cedar seedlings in areas where spring snow accumulation is more likely.

The latest field measurements taken between 1995 and 2013 on plots established by the Forest Service's Forest Inventory and Analysis program show no regional-level decrease of yellow-cedar in Alaska. The data reveal that in most unmanaged forests in Alaska, yellow-cedar has recently increased, as measured by live tree basal area, and the average mortality rate has been relatively low. This information will further help land managers prioritize their efforts to manage this culturally, ecologically, and economically important tree.

◀ *Seedling survival after four burns at 5-year intervals (foreground) vs. a nonburned site (background) near Burns, Oregon.*

Providing decision support

The Ecosystem Management Decision-Support (EMDS) tool has been providing spatial decision support for environmental assessment and strategic planning since 1997, supporting adaptive management at project, forest, region, and national scales. New features added in 2016 included support for tactical planning, management action scenarios at landscape scales, multiscale hierarchical planning, and the ability to export desktop EMDS applications to the Web. The National Forest System is using EMDS to assess terrestrial ecosystem conditions in all national forests through an objective, consistent process.



The Terrestrial Condition Assessment uses formal evidence-based reasoning to interpret and synthesize information on 37 environmental data inputs. This map for vegetation condition summarizes conditions related to fire regime departure, wildfire potential, risk of mortality from insects and pathogens, and vegetation departure from historical conditions.

IDENTIFYING MECHANISMS FOR RESILIENCE WITHIN DOUGLAS-FIR

The Douglas-Fir Seed-Source Movement Trial, initiated by PNW scientists in 2009, is providing critical information that is helping public and private land managers plan ahead. When planting Douglas-fir seedlings for harvest in 40 to 60 years, land managers need information now to select a seed source from a Douglas-fir population that will thrive under the anticipated future environmental conditions. Climate projections for the Northwest indicate that trees may be exposed to greater moisture stress in the summer and damaging cold snaps in the fall.

“Our nine study sites in Washington and Oregon encompass a range of climate and soil conditions, and we have many families of Douglas-fir from diverse climates all planted together,” says Connie Harrington, a PNW research forester. “We can monitor both plant growth and survival and study some of the basic mechanisms involved in plant responses. Plus, the study involves many cooperators, so we are all asking questions and learning together.”

The study is providing some very specific results about Douglas-fir and the adaptive traits of different population within the species.

For example, the researchers have learned that Douglas-fir populations from colder climates can better tolerate drought and cold, compared to

Brad St. Clair

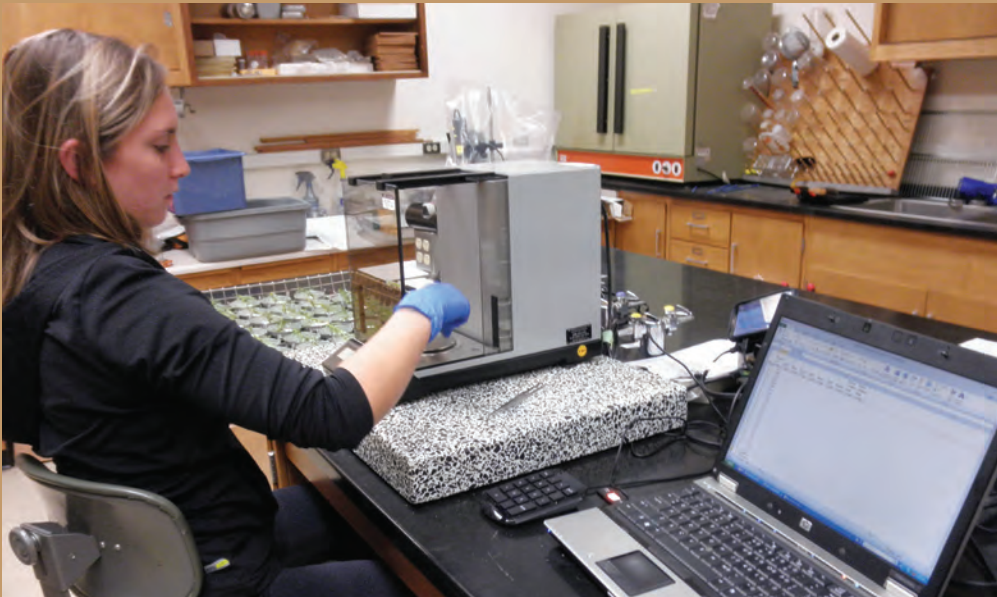


Drying twig samples from different populations of Douglas-fir.

populations from warmer regions as some of the mechanisms that plants use to cope with summer drought stress also help plants cope with winter desiccation. They also found a strong relationship between needle cast diseases and seed-source environment. Moving sources from environments with dry summers to ones that are substantially wetter increases the risk of symptoms associated with needle cast diseases.

The study sites are popular for field tours, and scientists involved with the study have been asked to share their early results at multiple meetings throughout the region.

Partners: Port Blakely Tree Farms, Cascade Timber Consulting, Giustina Land and Timber, Hancock Forest Resources, Lone Rock Timber, Oregon State University, Roseburg Resources, Starker Forests, USDA Forest Service Pacific Northwest Region, USDI Bureau of Land Management, Washington Department of Natural Resources



A researcher measures the dried twig sample to learn its rate of water loss and water storage capacity—characteristics that influence a tree's drought tolerance.

Researchers collect data for the Douglas-Fir Seed Source Movement Trial. This ongoing study is testing how seeds grown from different populations respond to temperature and precipitation conditions that differ from current local conditions. ►

Brad St. Clair



A person wearing a yellow hard hat, a red long-sleeved shirt, dark pants, and black rubber boots is standing in a forest. They are holding a yellow measuring tool (likely a laser level or a similar device) and a clipboard, appearing to be taking measurements or recording data. The forest is dense with tall, thin trees and a thick layer of green ferns and moss on the ground. A large, fallen log lies in the foreground, partially covered in moss. The scene is brightly lit, suggesting a sunny day.

The Role of Carbon

Carbon is everywhere—the air, the soil, and in all organisms, living and dead. This key element is in flux, cycling through land, water, and air. For eons, this cycle was driven by growth and decomposition. Pulses of carbon release from wildfires were balanced by absorption by the ocean and subsequent regrowth on burned areas. With the onset of the industrial revolution in the late 1700s, however, the increasing combustion of fossil fuels has led to more carbon being released into the atmosphere than is absorbed by terrestrial and aquatic systems.

With millions of trees photosynthesizing and storing carbon, national forests are the biggest carbon banks in the country. This means forest management has a key role to play in carbon management. PNW research supports these efforts by providing needed information to land managers and decisionmakers in Alaska, Washington, and Oregon.

Highlights in 2016

PNW scientists produced new information about carbon flux—its movement through terrestrial, aquatic, and atmospheric systems—and how forest management can influence aboveground carbon pools.

- Supported national efforts by contributing to a baseline carbon inventory for the state of Alaska. The Energy Independence and Security Act of 2007 mandated a nationwide accounting of the carbon stock and flux of carbon in all lands and waters of the United States. The Alaska report on carbon storage and greenhouse-gas fluxes, done in partnership with the U.S. Geological Survey and others, completes the U.S. baseline carbon inventory.
 - The Chugach and Tongass National Forests are using this information as they revise their forest plans, which guide the management of resources and activities in the forests.
- Assessed the effect of forest management on carbon sequestration in young-growth forest in southeast Alaska.
- Measured rates of carbon accumulation in Oregon's old forests.
 - Understanding the rates of carbon accumulation in different-aged stands is a critical component for developing carbon markets and offsets.
- Uncovered the role of headwater streams in carbon export, which may influence the global carbon cycle.



Tom Iraci

This information makes it possible for land managers to make informed decisions on ways to enhance carbon sequestration. It is also critical to policymakers developing climate mitigation strategies and incentives to encourage private forest landowners to manage for carbon.

Carbon and forest management

Forest management can influence the rate of carbon accumulation and the amount of carbon stored in the forest. PNW scientists are working to quantify these effects. This type of foundational information will be essential to future policies for carbon management, including the requirement for carbon consideration in national forest planning under the 2012 Forest Service Planning Rule.

Carbon in Alaska's young-growth forests

Alaska's coastal young-growth forests sequester carbon rapidly for the first 40 years and store large amounts of carbon in aboveground biomass (about 400 metric tons per hectare) over the first 100 years of stand growth. However, carbon stock is reduced by precommercial thinning, and this reduction is maintained over 100 years. This information helps land managers assess the tradeoffs between maximizing carbon storage and other management goals.



USDA Forest Service

Fifty-year-old young growth in southeast Alaska, before and after thinning.

◀ H.J. Andrews Experimental Forest, Oregon.

Carbon accumulation in old trees

An Oregon-based study found that old-growth forests and trees larger than 3 feet in diameter are important carbon stocks, but they play a minor role in additional carbon accumulation. The researchers found that forests 200 to 400 years old accumulated significant to moderate amounts of carbon, but after 400 years, mortality offset new growth, leading to no net change in total woody carbon accumulation.

Carbon flux in streams

While trees and soil play key roles as carbon cycles through terrestrial systems, small streams are big players as carbon moves from land to water. The subsurface of the streambed—known as the hyporheic zone—substantially influences carbon export from Pacific Northwest headwater streams.

Algae and other organisms in headwater streams capture, store, and release carbon through instream primary production and respiration. Microbes in the hyporheic zone under a stream can also convert terrestrial organic carbon into carbon dioxide, which is subsequently released to the atmosphere.

Working in the H.J. Andrews Experimental Forest in western Oregon, scientists found that a small headwater stream was a significant exporter of carbon to the larger river network and the atmosphere. It exported 159 kilograms of carbon per hectare per year, similar to the global exports for large rivers. Because headwater streams are about 90 percent of the total global river length, collectively, they might contribute substantially to the transformation and export of carbon with repercussions for the global carbon cycle.

Researchers work streamside at the H.J. Andrews Experimental Forest. The pipes are packed with streambed sediment, and streamwater is continuously pumped through to simulate the hyporheic flowpaths through the streambed. The pipes create matching experimental units for conducting biogeochemical experiments.



Steve Wondzell



Identified need: Equations for calculating wood carbon after low- and moderate-severity fires.

How much wood-based carbon remains after a fire? It depends on the severity of the fire. Using California as their study area, scientists examined the dynamics of aboveground forest woody carbon pools—live trees, standing dead trees, and down wood. They found that carbon trajectories for stand-replacing fires may not be appropriate for the majority of California’s forest area that burned at low to moderate severities.

What if... Oregon had a carbon offset sales program?

Private forest lands are also critical in sequestering carbon. Western Oregon has significant potential to store additional forest carbon. Payment for the carbon sequestration services provided by their forests would be an

Jeff Kline

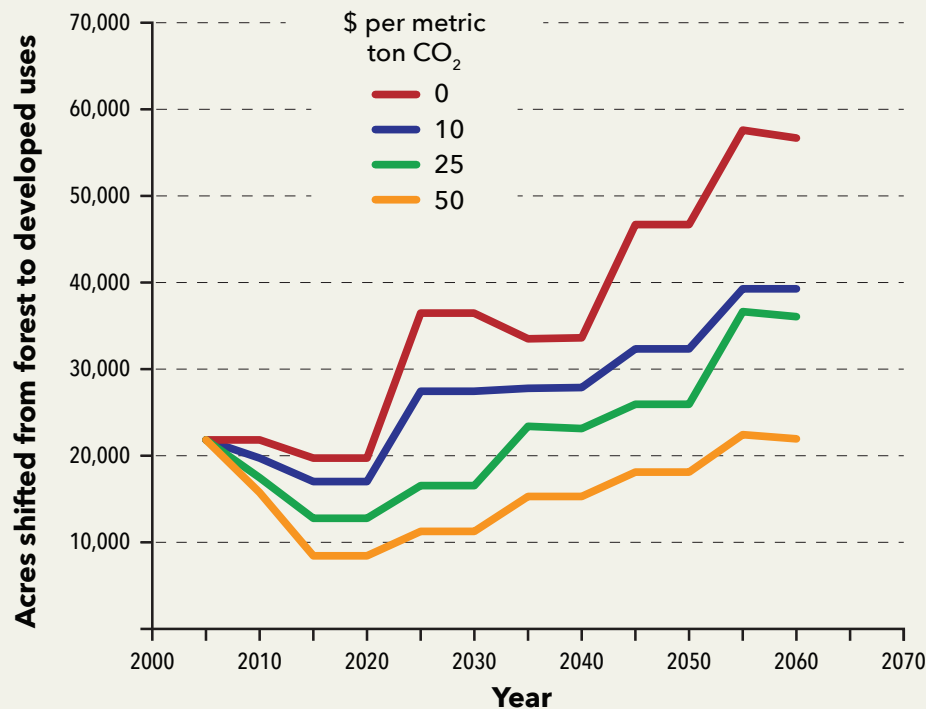


Managed forest land in western Oregon.

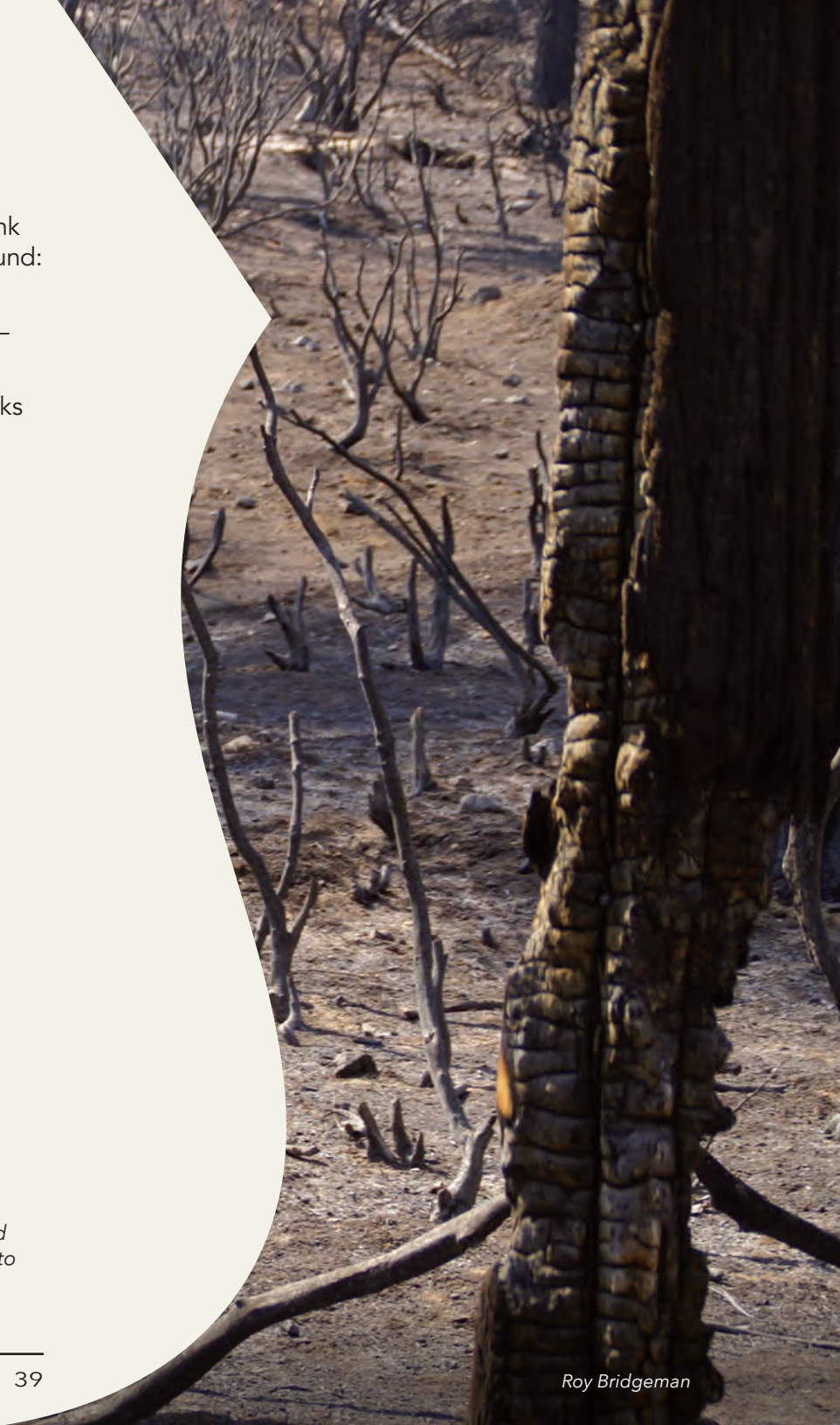
◀ *Soil scientist Brad Rust evaluates a burned area on the Rim Fire, California.*

additional incentive for landowners to maintain their forests rather than convert the land to more developed uses. To see how this would play out, a PNW scientist and collaborators developed modeling simulations that link land use, forest management, and a carbon offset sales program. They found:

- A carbon offset sales program could reduce forest land loss to development in western Oregon by about 4,700 acres over the 2010–2060 simulation period for each \$1 increase in the carbon price.
- At \$10 per metric ton of carbon dioxide, regional private carbon stocks would be roughly stabilized at current levels over the period to 2060.
- Rotations would lengthen on enrolled lands, but use of planting, thinning, and uneven-age management would decline.



Projected land loss from private forest to developed uses in western Oregon by simulated carbon dioxide price. A carbon offset sales program could encourage forest landowners to manage in ways that increase the amount carbon stored on their land.



WOOD ENERGY: USING LOCAL RESOURCES IN ALASKA

"Local products have many benefits for the local community," says Dave Nicholls, a PNW forest products technologist based in Sitka, Alaska.

This is particularly true in many remote Alaska communities where anything that isn't produced locally must be delivered by plane or barge. Heating oil is one such item, and the added transportation costs are one reason Alaska's statewide average annual energy costs per household are frequently more than twice the national average. Wood, however, is a local source of potential energy. Allen Brackley, a PNW research forester also in Sitka, and Nicholls have been exploring what it takes to make wood-based energy a viable option in Alaska.

"Developing policies with respect to economic development of energy products requires understanding environmental and economic impacts, as well as the sources of, and cost associated, with manufacturing. We have focused on defining environmental and economic benefits and conducting case studies to monitor the development of bio-based energy facilities," says Brackley.

The scientists and colleagues analyzed the potential environmental benefits of local wood-pellet production in southeast Alaska. Wood pellets are an emerging, renewable energy source in the region. They can be made from mill residues and can be used in residential or larger, automated boiler

The 2016 e-book Community Biomass Handbook—Volume 3: How Wood Energy Is Revitalizing Rural Alaska highlights successful examples in remote Alaska communities. Modern wood boiler systems are being used to heat schools and health clinics in communities where snowmobiles are the vehicle of choice and frozen rivers are the "highways" during the winter. Some communities are starting to monitor their wood energy systems over the Internet and share that data with others, which improve reliability, reduces maintenance costs, and is creating educational opportunities.



Dan Bihn

Mill residues are collected at a Ketchikan mill in southeast Alaska. Wood pellets can be made from this scrap wood and, in turn, be used as fuel for residential heating systems or larger ones, automated systems in schools, or in other public spaces.

systems. Currently, most pellets used in southeast Alaska are imported from Washington, nearly 900 miles to the south. One scenario in this carbon accounting assessment revealed that producing pellets locally, and using them to replace 20 percent of the local home heating oil usage, would result in 14 percent fewer emissions that contribute to global warming.

Nicholls also worked with the Sealaska Corporation and the Tlingit-Haida Regional Housing Authority in Juneau, which both use wood pellet burners to heat their facilities, to determine the economic benefits of this heating method. The case study revealed cost savings over a range of operating conditions, despite importing the pellets from Washington. The Alaska Native organizations are using the information produced by the case study as they attempt to develop a regional demand for wood pellets, while more efficiently using their pellet resources.

As a whole, this research is providing wood-energy adopters with needed practical and scientific information regarding best practices for their communities.

Partners: Consortium for Research on Renewable Industrial Materials; USDA Forest Service State and Private Forestry, Alaska Region; University of Alaska Fairbanks Alaska Center for Energy and Power

Applying what we've learned

Forest Service facilities in Alaska are embracing a path of sustainability by using wood-based heating systems at the federal building in Ketchikan, the Sitka Ranger District, and others.

Dan Bihn



A resident on Prince of Wales Island feeds wood pellets into a pellet burner that heats his home.

A close-up photograph of two small, slender fish swimming in clear water. The fish in the foreground is slightly below and to the left of the one in the background. Both fish have a light, silvery-gold color with a darker, brownish-black lateral stripe running along their sides. Their scales are fine and closely packed. The background is a soft-focus view of the water, showing some greenish-brown particles and light reflections. The overall lighting is natural, highlighting the texture of the fish's scales and the clarity of the water.

Fish and Wildlife

The PNW Research Station works proactively to identify and study the habitat needs of wildlife and threats to that habitat. Conservation and recovery of at-risk species requires understanding how habitat changes over time in response to factors such as human activities, wildfire, climate change, and biological invasions, and how these changes influence species distributions. The fieldwork, computer modeling, and other tools developed by PNW scientists are used by national forests and state and other federal agencies to make informed decisions about habitat management.

Of note in 2016, PNW scientists:

- Developed a framework for guiding the reintroduction of wildlife to areas where they were locally extinct.
- Continued leading the North American Response to emerging amphibian diseases with further study and amplified communication among scientists, managers, and policymakers.
- Documented two persisting populations and 27 individual martens in Oregon's coastal forests.
- Developed a cost-effective method for estimating the distribution of northern spotted owls and their habitat.
- Updated modeling-based assessment that is informing global polar bear conservation efforts.

◀ *Oregon chub (Oregonichthys crameri), were listed as endangered in 1993 under the Endangered Species Act and was delisted in 2015. A framework for guiding reintroduction of locally extinct wildlife, developed in part by a PNW scientist, has contributed to this success.*

A PNW research wildlife biologist listens for fisher in the Rogue-Siskiyou National Forest. ▶





Connie Harrington

Guiding reintroductions

PNW contributed to a novel framework for considering a holistic approach to the science, sociology, and practical applications of reintroducing wildlife to new or previously occupied locations. This work is being integrated into recovery planning and activities under the U.S. Endangered Species Act by U.S. Fish and Wildlife Service biologists and managers. It has been used, for example, in the reintroduction and recovery of the Oregon chub (*Oregonichthys crameri*), a small, short-lived imperiled fish, in western Oregon.

Working proactively to protect salamanders

Partners in Amphibian and Reptile Conservation are working through scientific, management, and political channels to forestall the North American arrival of a salamander-killing fungal pathogen. *Batrachochytrium salamandrivorans* (Bsal) is rapidly spreading in Europe, and North American salamanders are vulnerable to the disease caused by the fungus. In response to research by the task force, an interim rule of the Lacey Act prohibits imports or interstate transportation of more than 200 salamander species without a permit.



Elke Wind

Rough-skinned newts (*Taricha granulosa*) are commonly seen in Pacific Northwest forests. Laboratory experiments have shown the species to be vulnerable to the salamander chytrid fungus, Bsal.

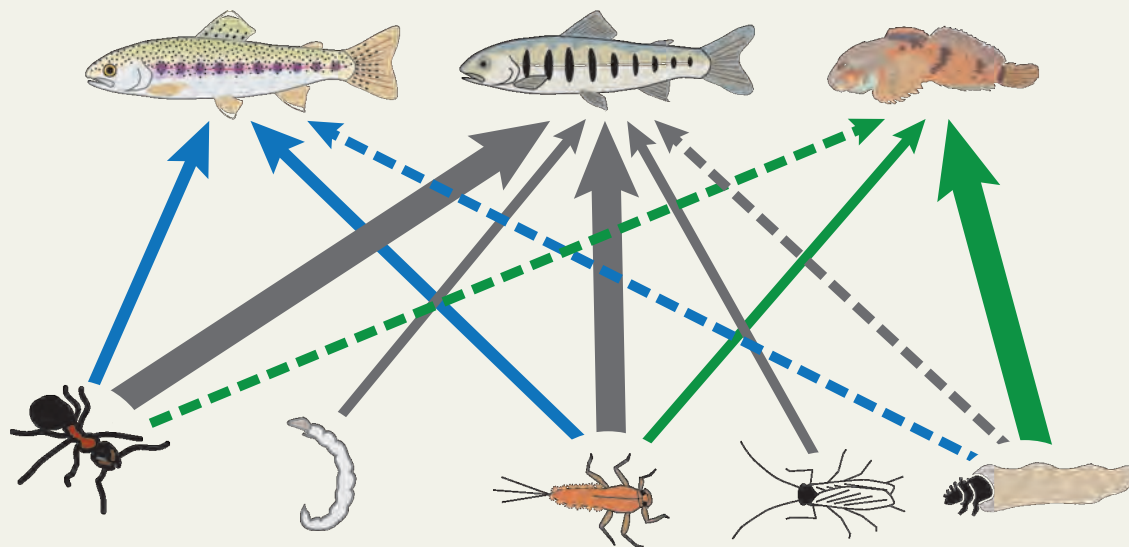
◀ Olympic National Forest.

Considering food web interactions in river restoration

Innovative research on the Methow River system in north-central Washington sheds light on the invisible food web connections that link species. PNW and many collaborators, including the U.S. Bureau of Reclamation, U.S. Geological Survey, and the Methow Salmon Recovery Foundation have been conducting a series of studies to understand how river fish are connected to the larger food web in which they participate. The modeling tool developed through this effort can be used to discern appropriate restoration actions among reaches within a watershed.

Model results illustrate that different locations in the river network do not respond equally to the same restoration strategy, and that changes to the structure of food webs that accompany the spread of nonnative species could undermine desired restoration outcomes.

River restoration is a billion-dollar-per-year global industry. This research contributes to a better understanding of the local environmental conditions and limiting factors to be considered when prioritizing restoration.



Rainbow trout (left), juvenile coho, and sculpin are part of an interwoven food web. Juvenile salmon response to restoration efforts depends on the response of their competitors, predators, and prey. Illustration by Kathryn Ronnenberg.

Monitoring northern spotted owls and documenting marten

In 2016, PNW scientists documented the presence of Pacific marten populations in Oregon's coastal forest. The marten population data are useful to the Oregon Department of Fish and Wildlife and the U.S. Fish and Wildlife Service to inform policy in regards to state trapping practices and federal protection under the Endangered Species Act.

PNW scientists also developed a reliable, cost-effective method to estimate density of northern spotted owls in dynamic landscapes. This model-based approach is an effective planning tool that will help land managers in their efforts to maintain this threatened species suffering from habitat loss owing to logging and fire and competition from the more aggressive barred owl.

Mark Linnell



A Pacific marten leaves a hair snare device in the Oregon Coast Range after providing a few hairs that will be used for genetic evaluation.

◀ *H.J. Andrews Experimental Forest.*

Polar bear stressors

Sea ice loss from climate change, reduction in future prey populations, parasites and disease, and human activities such as oil drilling are stressors that will affect future polar bear populations. Updated population models greatly expand the details of how these stressors could affect polar bear populations and show how human activities, if regulated, might slow the projected decline. The U.S. Fish and Wildlife Service's polar bear conservation and recovery team is drawing upon the models as it crafts a conservation and recovery plan for the species.



Bruce Marcot

As the climate warms, polar bears are not expected to fare well, but there are actions humans can take to minimize some of the stressors faced by the bears.

Polar bear tracks in northern Alaska. ►



Contributing to sage grouse restoration efforts

Saving the sagebrush ecosystem—home to the greater sage grouse and many other species—will happen through the efforts of many. Landscape assessments and models produced over the past two decades by PNW wildlife biologists are foundational for sage grouse restoration plans now being implemented by federal agencies and private land managers.

Identifying the dietary needs of native bees

Elk and native bees forage from many of the same flowering plants. For bees, their food choices shift across seasons and locales as different species come into bloom. The potential for dietary overlap among grazers and pollinators is a consideration of land managers managing for ecosystem services provided by bees, especially in restoration efforts.

Mary Rowland



A scientist conducts a sampling of native bees at a study site in the Starkey Experimental Forest and Range.

◀ **Starkey Experimental Forest and Range.**

Managing elk habitat

The elk nutrition and habitat models developed by scientists at PNW's Starkey Experimental Forest and Range continue to be updated with new information about the nutritional and energetic choices that elk make on landscapes, and the consequences of those choices on animal fitness. Resource managers can use model output to determine if active management is needed to improve elk habitat.

These models have been formally adopted by the Forest Service and Bureau of Land Management for management use in western Oregon and Washington. Similar models are being completed for use in northeast Oregon, southeast Washington, north-central Idaho, and western Montana.



Rachel Cook

An elk browses at the Starkey Experimental Forest and Range. Elk nutrition models developed at Starkey are being used to manage elk resources in Oregon and Washington.





HABITAT FOR THE FUTURE: WORKING IN PARTNERSHIP

Wildlife responds to climate. Along with direct effects such as increased thermal stress, there are many indirect effects of change in climate the availability of shelter, food, and water. Interactions between climate and indirect effects produce the most widespread impacts to wildlife populations.

As part of the South-Central Oregon Climate Adaptation Partnership, wildlife biologists from the station, the Deschutes, Fremont-Winema, and Ochoco National Forests, and Crater Lake National Park created a vulnerability matrix to systematically compile information on individual species' habitat associations, vulnerability to nonclimate stressors, vulnerability to climate change impacts, and adaptive capacity.

"We wanted to take climate impacts out of the world of climate change models and range shifts and put them in the context of providing shelter, food, and water for wildlife—things managers can actually do something about," Peter Singleton, a research wildlife biologist with the PNW Research Station, explains. Although this is a daunting task, Singleton says what left him feeling optimistic was the "level of engagement within the group. I think everybody was looking for new information and receptive to new ideas."

The wildlife team shared their findings with Oregon land managers during a workshop and through webinars. This work is one facet of the larger science-management partnership that is producing key information for landscape planning for the south-central region of the Cascade landscape.

Partners: USDA Forest Service Pacific Northwest Region, Deschutes National Forest, Fremont-Winema National Forest, and Ochoco National Forest; National Park Service Crater Lake National Park

◀ A field tour of the Fremont-Winema National Forest, a partner forest in the South-Central Oregon Adaptation Partnership.

PNW RESEARCH STATION ORGANIZATION

Executive team

P.O. Box 3890
Portland, OR 97208-3890

Station Director

Vacant

Phone: 503-808-2100

Assistant Director for Administration

Lesley A. Kelly

Phone: 503-808-2102

E-mail: lakelly@fs.fed.us

Assistant Director for Communications and Applications

Cynthia L. Miner

Phone: 503-808-2135

E-mail: clminer@fs.fed.us

Assistant Director for Program Development

Katherine L. Smith

Phone: 503-808-2104

E-mail: klsmith@fs.fed.us

Assistant Director for Research

Borys Tkacz

Phone: 503-808-2115

E-mail: btkacz@fs.fed.us

Program and centers

Ecological Process and Function

Paul D. Anderson

Forestry Sciences
Laboratory
3200 SW Jefferson Way
Corvallis, OR 97331
Phone: 541-758-7786
E-mail: pdanderson@fs.fed.us

Goods, Services, and Values

Simon M. Kihia

Pacific Wildland Fire
Sciences Laboratory
400 N 34th Street, Suite 201
Seattle, WA 98103
Phone: 206-732-7846
E-mail: smkihia@fs.fed.us

Land and Watershed Management

Susan J. Alexander

Forestry Sciences
Laboratory
11175 Auke Lake Way
Juneau, AK 99801
Phone: 907 586-7801
E-mail: salexander@fs.fed.us

Resource Monitoring and Assessment

Gretchen Nicholas

Forestry Sciences
Laboratory
620 SW Main St., Suite 400
Portland, OR 97205
Phone: 503-808-2034
E-mail: gnicholas@fs.fed.us

Threat Characterization and Management

Matthew G. Rollins

Forestry Sciences
Laboratory
1133 N Western Ave.
Wenatchee, WA 98801
Phone: 509-664-1726
E-mail: matthewgrollins@fs.fed.us

Western Wildland Environmental Threat Assessment Center

Nancy Grulke

3160 NE 3rd St.
Prineville, OR 97754
Phone: 541-416-6583
E-mail: ngrulke@fs.fed.us

Northwest Climate Hub

Bea Van Horne

3200 SW Jefferson Way
Corvallis, OR 97331
Phone: 541-750-7357
E-mail: bvhorne@fs.fed.us



U.S. Department of Agriculture
Pacific Northwest Research Station
1220 SW 3rd Ave., Suite 1400
P.O. Box 3890
Portland, OR 97208-3890

Official Business
Penalty for Private Use, \$300



Federal Recycling Program
Printed on Recycled Paper

USDA is an equal opportunity
provider, employer, and lender.

