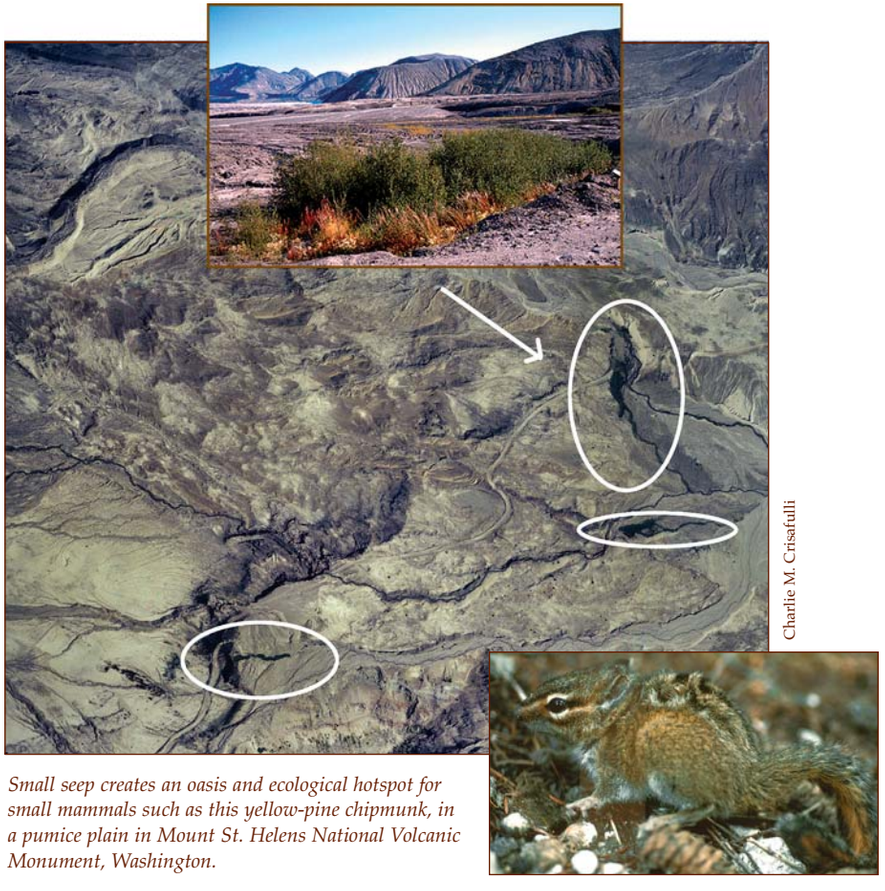
These headwater systems support multiple predators; the concept of "intraguild predation" may explain this coexistence. The headwater stream ecology work blends concepts of habitat associations and species interactions, supporting management of these areas as systems rather than applying species-specific management criteria.

In another study, scientists learned which habitat features in headwater streams have the most influence on fish and amphibians in those streams. In general, the fish were more strongly influenced by instream habitat features such as pools, riffles, substrate type, and stream gradient. Headwater stream-dwelling amphibians, however, were influenced more by riparian and landscape variables such as forest age class, watershed vegetation type, road density, slope, and elevation. The amphibians generally preferred high-gradient streams with old riparian and upland forests, and they were less abundant in low-gradient streams, streams bordered by young forests, and watersheds with high road densities.

Thus, fish may be better indicators of site-scale stream conditions; amphibians may be better indicators of landscape-scale riparian and upland features. The most influential landscape variables were riparian vegetation, hillslope vegetation, and elevation. Moderately influential variables were landslides, average gradient, watershed area, and road density. The least influential variables were drainage density and watershed aspect. Of all the variables, forest management can influence riparian and hillslope vegetation, landslide frequency, and road density, but management has little influence on the other variables.

Headwater streams are small and potentially may be strongly influenced by silvicultural treatments near them. A new study will examine the effects of thinning and regeneration harvest on shade, water quality, instream habitat, arthropods and primary production, microclimate, and vegetation.

Contact for ecology of headwater streams: Deanna H. Olson, dedeolson@fs.fed.us, Aquatic and Land Interactions Program
Contact for habitat features, fish, and amphibians in headwater streams: Peter A. Bisson, pbisson@fs.fed.us, Aquatic and Land Interactions Program
Contact for timber harvest influences on headwater streams: Sam Chan, schan@fs.fed.us, Agenda 2020 program; Charley Peterson, cepeterson@fs.fed.us, Resource Management and Productivity Program
Partner for harvest influences on riparian vegetation: Weyerhaeuser Company



Charlie M. Crisafulli

Small seep creates an oasis and ecological hotspot for small mammals such as this yellow-pine chipmunk, in a pumice plain in Mount St. Helens National Volcanic Monument, Washington.

Riparian oases are ecological hotspots for small mammals on Mount St. Helens pumice plains

In Mount St. Helens National Volcanic Monument, scientists have been studying the responses of small mammals since the major eruption in 1980. Small mammals, including the yellow-pine chipmunk, deer mouse, and Cascade golden-mantled ground squirrel, have been monitored in four distinct volcanic disturbance zones.

After the big eruption in 1980, small mammal survival ranged from high survival in areas where cool pumice and ash fell to loss of all species close to the volcano. In the first years after the eruption, small mammal populations were limited in numbers and associated with patches of surviving vegetation. Riparian plant communities grew in small oases and created ecological hotspots within the landscape. These hotspots supported the greatest number of mammal species and the highest mammal abundances.

Twenty years after the eruption, species assemblages in the disturbance zones generally are not converging with those in undisturbed sites. This suggests that establishment of late-seral mammal assemblages will take many decades. The scientists also identified roles that small mammals play in plant succession and assessed the factors influencing biological reassembly and colonization after the catastrophic volcanic eruption.

Contact: Charlie Crisafulli, ccrisafulli@fs.fed.us, Aquatic and Land Interactions Program
More information: Science Findings 34, May 2001. *The Rule of Time and Chance: Mount St. Helens and Its Legacy of Knowledge.* www.fs.fed.us/pnw/sciencef/scifi34.pdf.

Progress was made toward understanding the ecology of the Columbia spotted frog

The Columbia spotted frog is a species of concern in northeastern Oregon. Frogs at some sites are significantly smaller than frogs at other sites. To find out why, scientists are studying the frogs at six pond and stream sites in Union and Wallowa Counties. Stomach flushing will show what the frogs are eating, and sticky traps, dip nets, and aerial sweeps should reveal the types and abundance of prey available for the frogs. The scientists will also determine what predators are eating the Columbia spotted frogs and how abundant the predators are. Research results should provide better information to forest managers about habitat needs of this species.

Contacts for Columbia spotted frog ecology: Jane Hayes, jlhayes@fs.fed.us, Evelyn Bull, ebull@fs.fed.us, Managing Disturbance Regimes Program

Red alder is associated with higher levels of stream nutrients

Historically, forest managers regarded red alder as an undesirable species. Research indicates, however, that red alder has a positive influence on the productivity and biodiversity of forest ecosystems in southeast Alaska. Scientists are working to understand the ecological roles of red alder in managed young-growth forests, including relations to stream chemistry, nutrient linkages, effects on productivity of other trees, and influences on aquatic and terrestrial invertebrates, fish, birds, and deer. The findings are changing the way red alder is managed in Alaska, and they have management implications for other parts of western North America.

In upland headwater zones associated with landslides, alder coverage was more extensive in young-growth stands than in old-growth forests. Alder increases nitrate, and the alder coverage is significantly related to the amount of nitrate, a crucial nutrient for algae and thus stream productivity, in streams. The highest nitrate concentrations occurred in streams within alder-dominated young-growth forest. However, not all streams with high alder coverage had high nitrate concentrations. The streams that had high alder coverage but low nitrate levels were larger and originated within alpine zones on ridge tops, suggesting that landform and source area also may be important factors regulating nutrient levels.

Red alder appears to influence the productivity of young-growth conifer forests. When red alder is present in the regenerating stand, it may mitigate some effects of clearcutting and may increase total wood production from the forest. Red alder may have potential as a tool for restoring ecosystem functions in southeast Alaska.

Contacts for effects of red alder on stream nutrients: Mark Wipfli, mwipfli@fs.fed.us, Richard T. Edwards, rtedwards@fs.fed.us, Aquatic and Land Interactions Program
Contacts for effects of red alder on young conifer forests: Robert Deal, rdeal@fs.fed.us, Human and Natural Resources Interactions Program
Partners: Oregon State University, University of British Columbia, USDA Forest Service Alaska Region

Western hemlock seedlings may depend on down wood substrate

Western hemlock is a key part of old-growth forests in the Pacific Northwest. As a moderately shade-tolerant tree, hemlock typically adds trees of different ages to the forest and layers to the forest canopy. A significant association was found between large down wood on the forest floor and hemlock establishment at the microsite, but the association does not seem to depend on the total amount of down wood in the stand. The implication is that western hemlock seedlings depend on down wood as a substrate and have difficulty surviving on other substrates. The presence of large down wood can be used to predict the presence of western hemlock saplings in a stand.

Contact: Vicente MonLeon, vmonleon@fs.fed.us, Forest Inventory and Analysis Program

Scientists improve understanding of forest gaps

Small forest gaps are places where new plant species, including some that need specialized habitats, get started, and plants grow faster in gaps than under canopy shade. In mature Douglas-fir forests, canopy gaps of different sizes have distinct combinations of light, temperature, and soil moisture, with strong gradients of each occurring within individual gaps. In gaps of all sizes, soil moisture levels increased when gaps formed. In small gaps, low light levels were the primary constraint holding back plant growth.

Contact: Andy Gray, agray01@fs.fed.us, Forest Inventory and Analysis Program
Partner: Colorado State University
More information: Science Findings 43, April 2002. *Canopy Gaps and Dead Tree Dynamics: Poking Holes in the Forest.* www.fs.fed.us/pnw/sciencef/scifi43.pdf.

Water movement through trees may be governed by universal rules

When it comes to studying basic processes over the long term, large trees are much more difficult to study than saplings, and the lifetime of a large Douglas-fir is longer than the lifetime of a scientist.

With the Wind River canopy crane in the Wind River Experimental Forest, scientists are now measuring the same physiological processes in mature trees that they have measured previously in seedlings and saplings. Comparable work is being done on tropical forest canopy trees at the Smithsonian canopy crane in Panama. The results are beginning to reveal patterns in tree physiology and function.

The results suggest that water movement through different tree species may be governed in a universal manner by features of hydraulic architecture—the plumbing system—of trees. Scientists are extending this work from the hydraulic properties of single water-conducting cells to the hydraulic properties of whole trees and, they hope, eventually to the hydraulic properties of the whole canopy. If universal rules can be established, scientists would be able to predict such forest processes as water use by vegetation, ecosystem discharge of water to streams, and carbon uptake and storage across broad landscapes and over long periods. This knowledge will be a valuable tool for assessing the effects of management options on key forest processes.

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Partners: University of Washington, Oregon State University, Smithsonian Institution

Genetic mapping data are providing estimates of how much genetic divergence exists between geographically distinct populations of plants, and how much genetic variation exists in seed-based natural populations.

Piperidine alkaloid concentrations are not correlated with Sitka spruce resistance to white pine weevil damage

In the coastal forests of the Pacific Northwest, forest managers are interested in growing Sitka spruce in its historical range, but the white pine weevil is damaging young Sitka spruce trees extensively. White pine weevils deposit eggs in the terminal shoots of young trees, and weevil larvae consume the phloem, often killing tree leaders, deforming stems, reducing the growth rate, and reducing eventual wood quality.

Sitka spruce seedlings from six resistant and six susceptible families were planted in field trials in the Oregon Coast Range. Scientists looked for differences that distinguished resistant from susceptible trees.

Six piperidine alkaloids were tracked; these are a class of secondary compounds produced by some spruce and pine species that may influence the trees' chemical resistance to insects or pathogens. Although clear differences in alkaloid concentrations were observed among families, none of the compounds were associated with top-kill. Therefore, the alkaloids are not useful indicators of tree resistance to white pine weevil attack.

Contact: Rick Kelsey, rkelsey@fs.fed.us, Managing Disturbance Regimes Program

Yellow-cedar decline in Alaska affects slope stability

Yellow-cedar (or Alaska-cedar) has great ecological, social, and economic value. But a phenomenon known as yellow-cedar decline is killing large numbers of these valuable trees on over 494,000 acres in southeast Alaska. The decline is a mystery to forest managers. Yellow-cedars are dying in unmanaged stands as well as managed stands, and the mortality does not appear to be caused by viruses, bacteria, fungi, or other biological agents. The symptoms exhibited by dying yellow-cedar trees indicate they may be suffering from freezing injury or soil toxicity. Another clue is that cedar decline is concentrated on saturated soils.

In 2002, scientists collected data on soil temperature, soil chemistry, and hydrology at different sites, to find potential risk factors that might relate to yellow-cedar mortality. Currently, scientists are evaluating the data for risk factors such as soil toxicity, soil freezing, and soil saturation, hoping to find relations that may reveal causes for cedar decline. Soil toxicity is determined through chemical analyses for potentially toxic substances such as aluminum and manganese.

Scientists also are concerned about the possible effects of the dying cedars on slope stability. Landslides are more likely to occur when tree roots, a major factor in soil cohesion, die. Another risk factor for landslides is high soil pore pressure. When soil becomes saturated with water, pore pressure increases, soil can liquefy, and landslides can occur. A slope stability model was used to compare the relative influence of yellow-cedar root decay and soil pore pressure on hillslope stability in southeast Alaska.

Results indicate that for shallow soil less than 2 feet deep, slope stability is influenced more by root deterioration than by soil saturation. For soil deeper than 2 feet, soil saturation has a greater effect on slope stability than does root deterioration. Landslides are most likely 50 years or more after tree death, when most cedar root strength has been lost and root strength from young trees has not yet fully developed. These results are relevant to any forested slopes with shallow soil, not just for slopes with yellow-cedars; roots deteriorate after any tree death. Study results may help managers predict the effects of tree death on erosion and sedimentation patterns.

Contact for yellow-cedar decline: Mike McClellan, mmcclellan@fs.fed.us, Resource Management and Productivity Program
Contact for yellow-cedar and slope stability: Adelaide Johnson, ajohnson03@fs.fed.us, Aquatic and Land Interactions Program

Genetic mapping approaches were adapted for forest resource management

Many techniques used in human and plant genome mapping are species-specific, limiting their application to a few key species of economic importance, and providing minimal benefit to less-studied organisms. One technique—single-strand conformational polymorphism (SSCP) analysis—is unique in that it requires minimal preliminary genetic information, yet it is able to identify DNA sequences differing by only a single mutation. In SSCP, double-stranded DNA is reduced to single strands, which are then separated on the basis of their size and charge. Strands differing by a single mutation can be resolved, allowing one to screen rapidly for differences between individuals and populations. SSCP is very similar to the techniques used in human forensics but is used more frequently in screening for unknown mutations related to human disease. The approach permits simultaneous evaluation of genetic variation across many different genes in the cell nucleus, mitochondrial, and chloroplast genomes.

Scientists adapted the SSCP approach to screen genetic variation in a variety of plants, including Brewer's shorthair reedgrass, a rare species; antelope bitterbrush, a shrub used in restoration; sulfur cinquefoil, an invasive weed; and conifers. With the SSCP approach, scientists can screen 192 samples in one day. Traditional methods would screen about 60 samples per day but reveal less than a third of the total mutations uncovered by the SSCP approach. SSCP data are providing estimates of how much genetic divergence exists between geographically distinct populations of plants, and how much genetic variation exists in seed-based natural populations.

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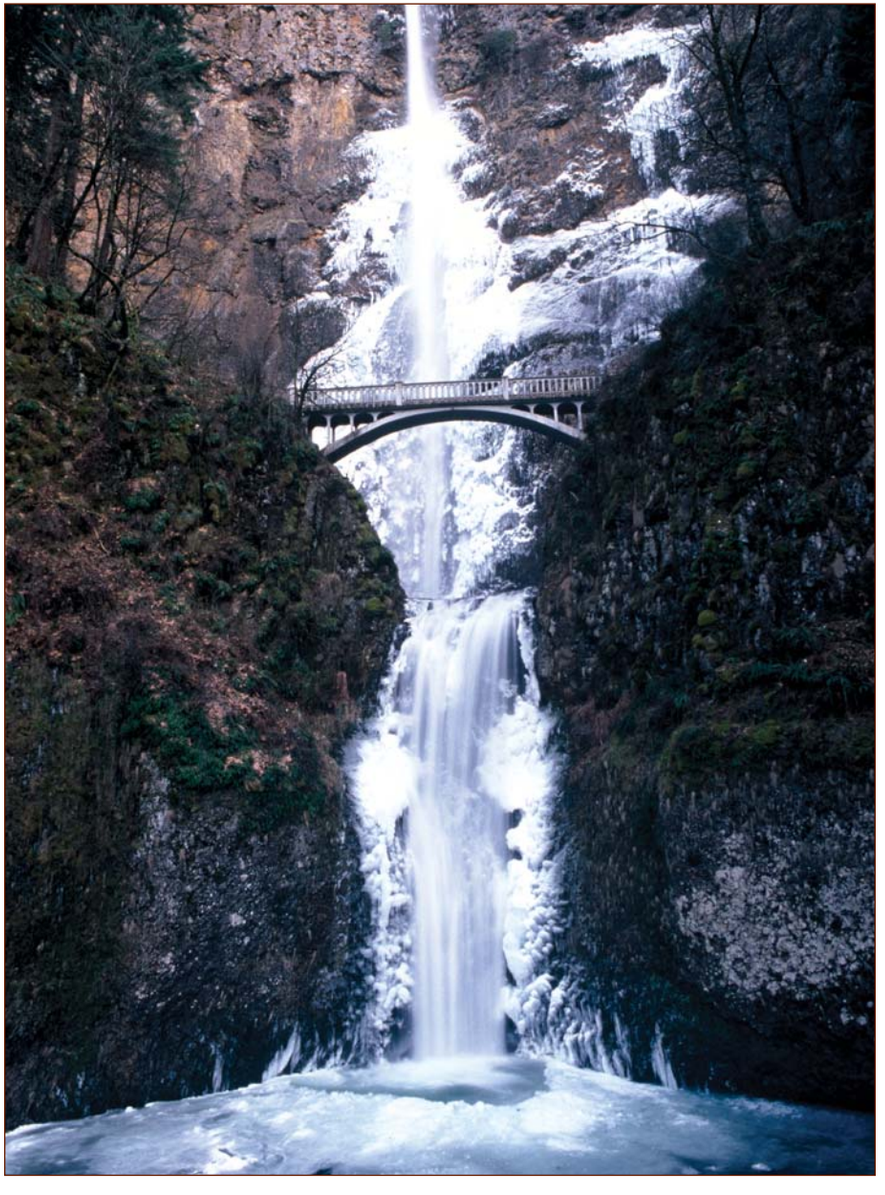


Goal 2: Assess the Status and Trends of Ecosystems and Natural Resources and Their Uses

Key Findings:

- Private forests will play an increasingly larger role in the forest sector both as providers of wood and other environmental services, as timber harvest levels stay low on federal and other public lands. More intensive management on more acres of private forest land will increase wood supply from these lands.
- Oregon's land use program appears successful in reducing the overall rate of conversion of forest and farm lands to more developed uses and has been successful at containing urban expansion within areas zoned for more development.
- Projections suggest that future population growth in western Oregon will lead to significant expansion of low-density and urban development over the next 50 years, bringing more people living closer to western Oregon's forest lands.
- Long-term monitoring of northern spotted owls suggests that populations are declining in six out of eight long-term study areas, and populations are stable or close to stable in the other two areas.
- A positive correlation exists between the number of juvenile coho salmon in a stream reach and the amount of large wood in the reach. The number of juvenile coho salmon also increased as the number of pools increased. The improved monitoring protocols can be used to measure the quality of stream habitat across the Pacific Northwest.
- On forest lands of all ownerships in Oregon and Washington, the presence of snags was closely related to patterns of forest succession and timber harvest. Down wood, however, was more closely associated with a stand's long-term history and site productivity than with timber harvest.
- Southeast Alaska inventory data provided significant improvements to the Alaska vegetation classification system. Site index values are now available for forested types. Seven forest types and one nonforest type not shown in the original system have been described.
- Satellite images provide a cost-effective technique for the stratification phase of forest inventory. The least expensive satellite image-based method cost only 5 percent as much as traditional aerial photo interpretation, with only a slight decrease in accuracy.

Accomplishments

Fewer acres of private forest land are projected to produce more wood

Scientists project that for the entire United States, the total amount of forest land area will decrease by 3 percent, or 23.2 million acres, by 2050. Half of the forest area loss is in the Pacific coast region and one-third of the loss in the South. The losses will occur mainly because of growing cities and related land uses as the country's population increases by another 126 million people. Forest cover types will shift on remaining forest lands. In the South, projections suggest that the area in upland hardwoods will decrease, and pine plantations will increase by 14 million acres. Many pine plantations will be managed to produce sawtimber and wood fiber on short rotations; investment and management often will be at high levels. Some people have raised concerns that Southern forests will lose diversity in both forest types and forest structures as a result.

Yet even as total forest land area decreases, private forests are projected to be the main source of increased wood supply in the United States. This result can happen only through more intensive management of more acres of private forest land. But at the same time, society also expects environmental services from private forest lands. The concentration of timber production is already underway, but its effects on biodiversity and other ecological issues are still evolving.

Contacts: Richard Haynes, rhaynes@fs.fed.us, Human and Natural Resources Interactions Program
Partners: Oregon State University, Ohio State University, Northeast Research Station, and Forest Products Lab

Conversion rate for Oregon forest and farm lands stays low during economic boom of 1990s

New research suggests that Oregon's land use planning program is successful in reducing the overall rate of conversion of forest and farm lands to development, and the program is containing most urban expansion within areas zoned for development. Previous research had shown that in western Oregon, the conversion of forest and farm lands to residential and urban uses declined dramatically from the 1973-1982 period to the 1982-1994 period. Land use planning had started just before the latter period, but the slowing conversion rate also could have been caused by the decline in population growth and personal income growth that happened during those years.

Tom Iraci

Columbia Gorge, Oregon.

However, the new research finds that in 1994-2000, both population and personal income increased rapidly in western Oregon. Despite these changes, the conversion rate for forest and farm lands remained low, suggesting that land use planning was the cause. As of 2000, most western Oregon communities seemed to have significant space within their designated urban growth boundaries to accommodate development. In western Oregon, 65 percent of private forest land is still free of the effects that population or development might have on forest management.

Contact: Dave Azuma, dazuma@fs.fed.us, Forest Inventory and Analysis Program
Partner: Oregon Department of Forestry

Spotted owl populations are declining in six out of eight long-term study areas, and populations are stable or close to stable in the other two areas.

More people will live near forests in western Oregon

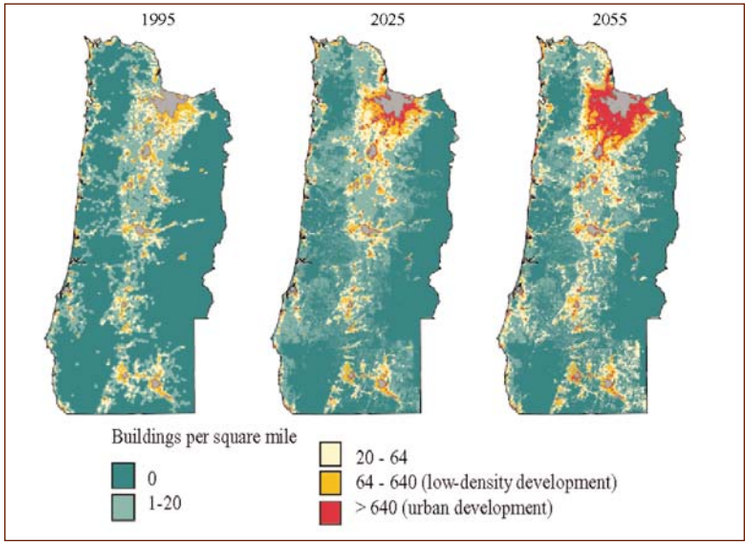
In western Oregon, the proportion of land in low-density and urban developed uses is projected to nearly double by 2055, according to new projections from the coastal landscape analysis and modeling study (CLAMS). Although the majority of new development is projected to occur near existing cities, development will occur also in forested areas. This projection suggests that more people will live near forests in western Oregon in the future.

Additional research done with the Oregon Department of Forestry suggests that low density and urban development near forests is correlated with a decreased likelihood that forest owners will have tree planting and precommercial thinning done after timber harvest, and with reduced forest stocking on private forest lands.

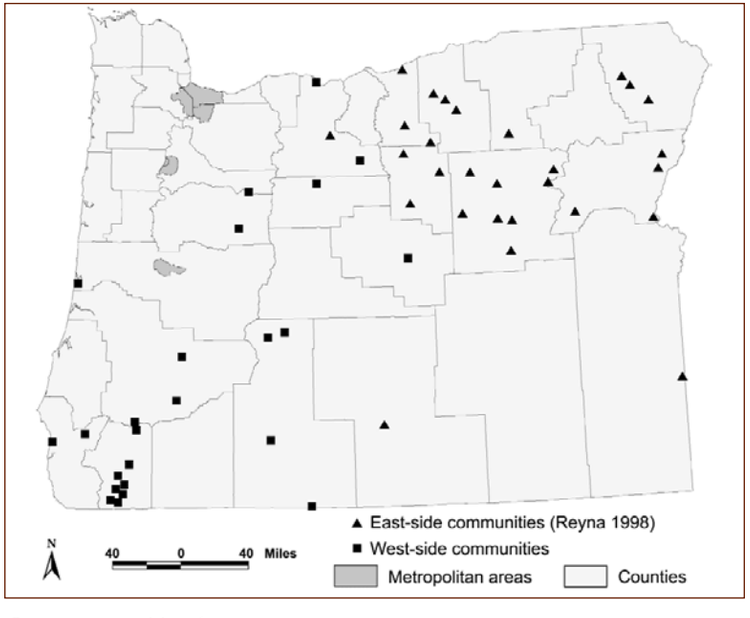
Contacts: Jeffrey Kline, jkline@fs.fed.us, Ralph Alig, ralig@fs.fed.us, Human and Natural Resources Interactions Program
Partners: Oregon Department of Forestry, CLAMS collaborators
More Information: Science Findings 45, July 2002. *Changing the Scale of Our Thinking: Landscape-Level Learning.* www.fs.fed.us/pnw/scicenf/scifi45.pdf.

Some Oregon forest communities have low adaptability to changing economic conditions

The Montréal Process for Sustainable Forest Management, an international process, recognizes that forest-dependent communities must be healthy for forest management to be truly sustainable. The Montréal Process calls for evaluation of the "viability and adaptability to changing economic conditions, of forest-dependent communities, including indigenous communities," as an indicator of well-being. Sustainability, as defined in this process, means meeting the needs of the present without compromising the ability of future generations to meet their own needs. In a viable, well-adapted forest



Projected building density categories in western Oregon.



Oregon communities of concern.

community, forest management sustains a flow of timber and other benefits that promote the well-being of the community and its forest industries.

Several hundred rural communities in Oregon were assessed in terms of their socioeconomic well-being, with measures including jobs, connections to service centers, and proximity to public lands. For all characteristics combined, 54 Oregon communities rated low and were considered less adaptable to changing socioeconomic conditions.

Contacts: Ellen Donoghue, edonoghue@fs.fed.us, Human and Natural Resources Interactions Program
Partners: Oregon Department of Forestry, Sustainable Roundtable, Oregon State University
More information: Science Findings 37, September 2001. *Absorbing the Shock: Helping Communities When Change Erupts*. www.fs.fed.us/pnw/sciencef/scifi37.pdf.

Trends in western Oregon forests: amount of forest land has changed little in the last 70 years

About 80 percent of western Oregon is forested. The total amount of forest land has changed little in western Oregon since the first inventory was done in 1930. Many acres have changed into or out of forested status over the past 70 years, but the total amount has been fairly stable.

About 52 percent of western Oregon forest land is managed by the USDA Forest Service, USDI Bureau of Land Management, and other federal agencies. Another 41 percent is privately owned, and the remaining 7 percent is managed by the Oregon Department of Forestry and other nonfederal public agencies.

On nonfederal forest lands, the average annual growth of trees is almost twice the annual amount dying through harvest and natural mortality. One-third of the inventory plots on nonfederal lands have one or more noxious weeds, with Himalayan blackberry, thistle, and Scotch broom the three most common species. As for insects and diseases, dwarf mistletoes, root diseases, bark beetles, and insect defoliations were recorded on many acres. Monitoring for ozone injury began in 1998 on several ozone-sensitive tree species such as ponderosa pine and red alder, but so far no injury has been detected in western Oregon forests.

Contact: Sally Campbell, scampbell01@fs.fed.us, Forest Inventory and Analysis Program
Partner: Oregon Department of Forestry

Long-term monitoring shows northern spotted owl populations declining in some areas

Spotted owl populations are declining in six out of eight long-term study areas, and populations are stable or close to stable in the other two areas. To learn more about owl population dynamics, scientists studied the birds' success in different habitats.

Gila Fox

Northern spotted owl, Cascade Range, Oregon.

Spotted owls usually select older forests for foraging, roosting, and nesting when those forests are available. If owls are living in young forest areas, they tend to select the oldest part of the forest. Other studies indicate that corridors of deciduous riparian forest may be good foraging habitat for spotted owls. In the north Coast Range of Oregon where little old forest is available, owls forage extensively in young forest and riparian hardwoods. However, the north Coast Range owls have very large home ranges and their population is dwindling, suggesting they are struggling to survive in that environment. Two recent studies suggest that spotted owls may survive or reproduce best in areas that include a mixture of older forests and openings.

Spotted owl management has become increasingly complex as a result of the invasion of the barred owl and the need to integrate habitat management for owls with long-term goals for biodiversity and forest management. The status of the northern spotted owl was last assessed across its entire range 4 years ago. The next range-wide assessment of the owl's status is scheduled to occur in winter 2003, at which time researchers from all the long-term study areas in Washington, Oregon, and California will convene to conduct a meta-analysis of the data.

Contact: Eric Forsman, eforsman@fs.fed.us, Ecosystem Processes Program

Total carbon storage was greatest on national forest lands, intermediate on other public and forest industry lands, and lowest on private non-industrial lands.

New information was obtained about habitat for two elusive species, the red tree vole and marbled murrelet

Information is limited about some wildlife species managed under the Northwest Forest Plan. Scientists have learned more about two species difficult to observe.

The red tree vole is an important prey for the northern spotted owl in parts of its range. The Northwest Forest Plan calls for management of high-priority sites for the red tree vole, but until recently, it was not known to what extent the late-successional reserves and other management provisions were providing adequate habitat for red tree voles in coastal forests.

Surveys for red tree voles have now been completed in over 4,000 locations, covering more than 140,000 acres. The results indicate that red tree vole abundance differs significantly among locations in western Oregon. In 70 percent of sites, no red tree vole nests were detected and, in locations where voles were detected, most sites had only a single vole nest. The results suggest that not all late-successional reserves are equally suitable for all late-successional species and that, in fact, most high-elevation forests in reserves are of little value as red tree vole habitat. The likelihood of red tree vole occurrence begins to decline near 3,500 feet elevation in most late-successional reserves, although in the southern Oregon Cascades, some tree vole locations do occur as high as 5,400 feet. These results improve knowledge about red tree vole ecology and suggest new management considerations for tree vole habitat.

The marbled murrelet, a seabird that nests in forests, is listed as threatened throughout its range in Washington, Oregon, and California, primarily from loss of nesting habitat. The Northwest Forest Plan calls for murrelet nesting habitat to be retained in a system of reserves throughout the bird's range. Because murrelets can die from unfavorable ocean conditions, it is difficult for managers to identify the influence of nesting habitat conservation on population trends. New research shows that the number of marbled murrelets flying into large drainages during the nesting season can be predicted from the amount of potential nesting habitat within those drainages.

For 3 years in a row, as the amount of habitat increased, the number of marbled murrelets increased also, in a strong positive correlation. The linear relationship suggests that murrelets are territorial and that their numbers are limited by available nesting habitat. This finding provides the missing link that will allow managers to relate population trends to management of murrelet habitat.

Contact for red tree vole and marbled murrelet: Martin Raphael, mraphael@fs.fed.us, Ecosystem Processes Program
More information: Science Findings 39, November 2001. *Under the Radar: Advances in Murrelet Monitoring.* www.fs.fed.us/pnw/sciencef/scifi39.pdf.

Juvenile coho salmon numbers increase as large wood and pools increase in streams

Scientists developed improved monitoring protocols for juvenile coho salmon and their freshwater stream habitat. The protocols are objective, consistent, repeatable, and effective at detecting changes in habitat conditions. Using the protocols, scientists found a positive relation between the number of juvenile coho salmon in a stream reach, and the amount of large wood in the reach. The number of juvenile coho salmon also increased as the number of pools increased.

These procedures can be used to measure the quality of stream channel habitat and the response of stream habitat to land use across the Pacific Northwest landscape, in both managed and unmanaged areas. The protocols are effective in a range of landscape types and over timeframes of different lengths. National

forest managers are using the protocols to assess the status and trends of stream habitat used by anadromous salmonids and to assess the effects of land management on aquatic and riparian habitats.

Also, the monitoring protocols are being used to identify streams and watersheds that could benefit from restoration programs. Finally, the protocols can be used to evaluate restoration success.

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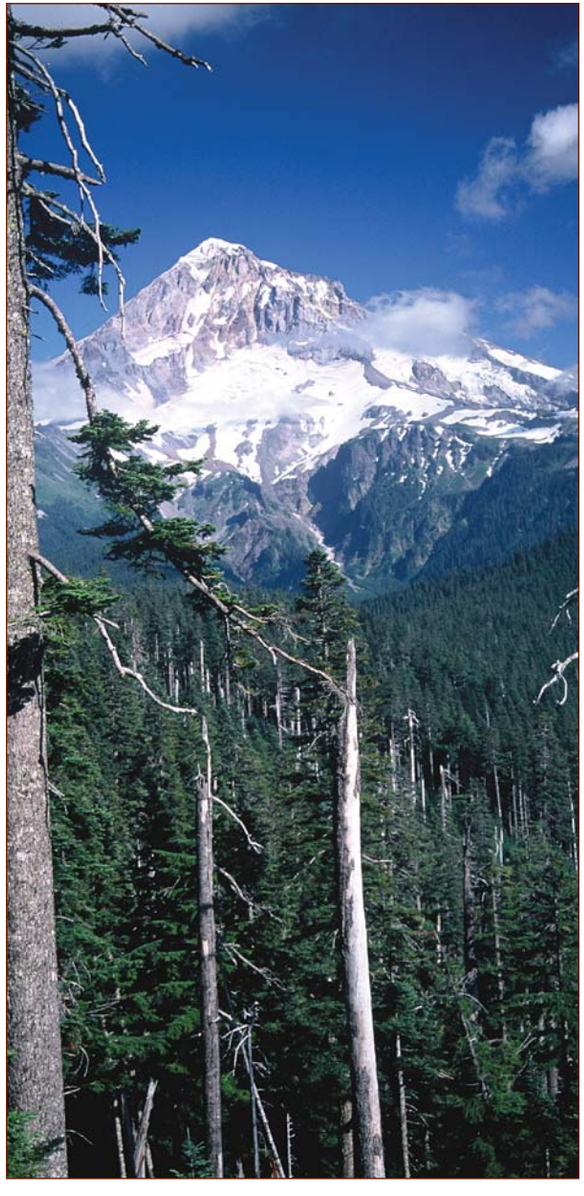
Down wood levels are more closely associated with long-term forest histories

Dead wood is a crucial component of healthy, biologically diverse forests. But little information has been available about the distribution and characteristics of snags and down trees in Pacific Northwest forests. Scientists compiled data on dead wood across about 49 million acres of east- and west-side forests in Oregon and Washington. The results, based on over 16,000 field plots, are the most comprehensive study yet of dead wood across both managed and unmanaged forests of all ownerships in Oregon and Washington.

For snags at least 10 inches in diameter, the average density ranged from 3 to 91 trees per acre. For down wood at least 5 inches in diameter, the average density ranged from 47 to 670 pieces per acre. The presence of snags was closely related to patterns of forest succession and timber harvest. For example, large snags were more than twice as dense in forests that had never been harvested than in forests that have had any kind of harvest in the past.

Tom Iraci



The presence of snags is closely related to patterns of forest succession and timber harvest.

Down wood, however, was more closely associated with a stand's long-term history and site productivity than with timber harvest. The amounts of large down wood were similar in harvested and unharvested stands, except in high-elevation forests where down wood volume was greater in harvested stands than in unharvested stands.

Total carbon storage was greatest on national forest lands, intermediate on other public and forest industry lands, and lowest on private nonindustrial lands. The studies have greatly improved scientists' ability to answer more specific questions on the density, size, and decay class of dead wood needed to maintain wildlife habitat and ecosystem functions, and on how much carbon is being stored in snags and down wood in the Pacific Northwest.

Contact: Karen Waddell, kwaddell@fs.fed.us, Forest Inventory and Analysis Program

More information: Science Findings 42, March 2002. *Dead Wood All Around Us: Think Regionally to Manage Locally.* www.fs.fed.us/pnw/sciencef/scifi42.pdf.

Inventories and surveys extend plant and forest knowledge in southeast Alaska

A systematic inventory was done in southeast Alaska on both forested and nonforested land. Scientists used the data to make significant improvements to the Alaska vegetation classification system. They added descriptions for seven forest types and one nonforest type not in the original classification system, and they added site index values for all forest types. The inventory also improved knowledge about the extent of some forest types. For example, the closed-canopy mixed-conifer forest type was believed to be uncommon in the Stikine area. The new data shows that this type covers about 6.5 percent of the unreserved forest area of the Petersburg and Wrangell Ranger Districts, a substantial proportion for one vegetation type. Also, the new inventory extended the known ranges for plants such as blue-pod lupine, false Solomon's seal, and red mountain heather, among others.

Crews surveyed the bird, mammal, and vegetation communities in seven research natural areas (RNAs) in southeast Alaska. These natural areas represent a broad cross section of the region's pristine biotic communities and will be left in natural, or unmanaged, conditions.

Results provide the first baseline description of biotic communities in the seven RNAs. They also contribute information about regional biodiversity and species distributions in pristine forests of southeast Alaska. Scientists found 31 species of vascular plants previously unconfirmed in RNAs for the region. Data were collected on the abundance and breeding status of 65 bird species. A total of 331 small mammals representing 6 species were captured, and an additional 5 species were documented from visual observations or physical evidence.

Bob Szaro

New data give the first ecological picture of seven research natural areas in southeast Alaska.

Contact for AVCS inventory in southeast Alaska: Bert Mead, bmead@fs.fed.us, Forest Inventory and Analysis Program
Contact for survey of Tongass research natural areas: Winston P. Smith, wsmith02@fs.fed.us, Aquatic and Land Interactions Program

Baseline condition was established for whitebark pine in the Umpqua National Forest

Whitebark pine usually lives at high elevations and is seen more often from hiking trails than from roads. Its seeds are an important food for high-country animals, but the five-needled pine has been hit hard by white pine blister rust.

A survey was done to evaluate the distribution, condition, and health of whitebark pines along the Pacific Crest National Scenic Trail on the Umpqua National Forest in Oregon. In general, whitebark pine was found in stands with lower overall densities and fewer late-seral species. The proportion of pines ranged from less than 1 up to 24 percent of the trees on transect plots. Most whitebark pines were less than 15 feet tall.

Forty-four percent of the trees were alive and healthy, 46 percent were alive but infected by white pine blister rust, and 10 percent were dead. Two-thirds of the mortality was due to white pine blister rust, 13 percent was due to mountain pine beetle, and 18 percent to a combination of the two. White pine blister rust affected trees in all but the largest size class. No cones were observed on whitebark pine in any of the survey plots. The species was common in laminated root rot areas where that disease had created large canopy openings. The survey results establish a reference condition for whitebark pine in this part of southwest Oregon.

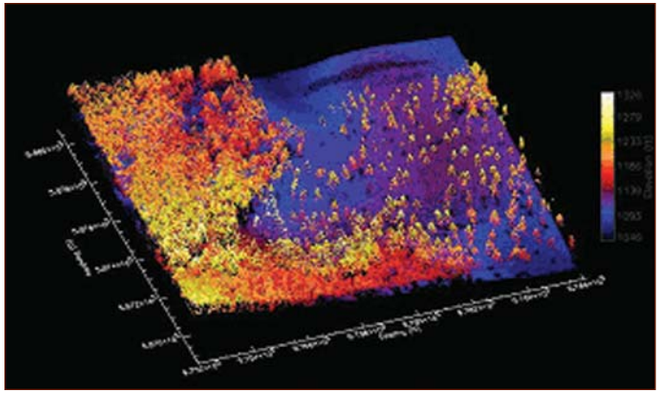
Contact for whitebark pine: Sally Campbell, scampbell01@fs.fed.us, Forest Inventory and Analysis Program
Partner: USDA Forest Service Pacific Northwest Region

Satellite images provide cost-effective technique for two-phased forest inventory

Aerial photographs are traditionally used in forest inventories to stratify expensive field plots. The stratification, or division of the inventory area into types so sampling is representative, increases the accuracy of inventory estimates of forest land area and forest volume. With satellite images readily available, scientists have looked into the cost-effectiveness of using the satellite images instead of aerial photos for the stratification phase of the inventory.

Scientists used a 2.5-million-acre study area in northern California to test new techniques. Three satellite image-based geographic information system layers were evaluated as alternatives to conventional photo interpretation, and accuracy as well as cost of the two methods were compared. Photo stratification was still more precise, with a standard error of 2.9 percent per million acres, compared to a standard error between 3.5 and 4.2 percent for satellite image-based stratification. However, the least expensive satellite image-based method cost only 5 percent as much as traditional aerial photo interpretation, a considerable savings.

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



Airborne laser scanning measures forest biomass accurately, even in dense forests.

Airborne laser scanning measures forest canopies and provides data on forest biomass

Lidar (light detection and ranging) is the technology of airborne laser scanning. Lidar instruments can be used to measure the vertical structure of forests and thus hold great promise for estimating the amount of forest biomass, key information for estimating the amount of carbon stored in forests. The lidar sensing, currently done from aircraft, provides information about the presence or absence of tree canopies at the given location. It is accurate enough to detect the difference between, for example, an old-growth forest and a second-growth stand with limited vertical structure. Field measurements confirm the accuracy of the lidar data.

Scientists compared the relation between lidar-measured forest canopies and field measurements of aboveground biomass at sites in temperate deciduous forest (Maryland), temperate coniferous forest (western Oregon), and boreal coniferous forest (northern Manitoba). The scientists developed separate equations to predict biomass in each of the three different forests, and then developed a general equation for all three sites. The general equation predicted biomass essentially as accurately as the three individual equations. Results so far show the lidar data can be very accurate, even in heavily forested areas, and that canopy density has little effect on the accuracy.

This simplified method to estimate aboveground biomass could reduce the effort and expense required to develop global biomass estimates from satellite lidar data, leading directly to improved estimates of global carbon storage.

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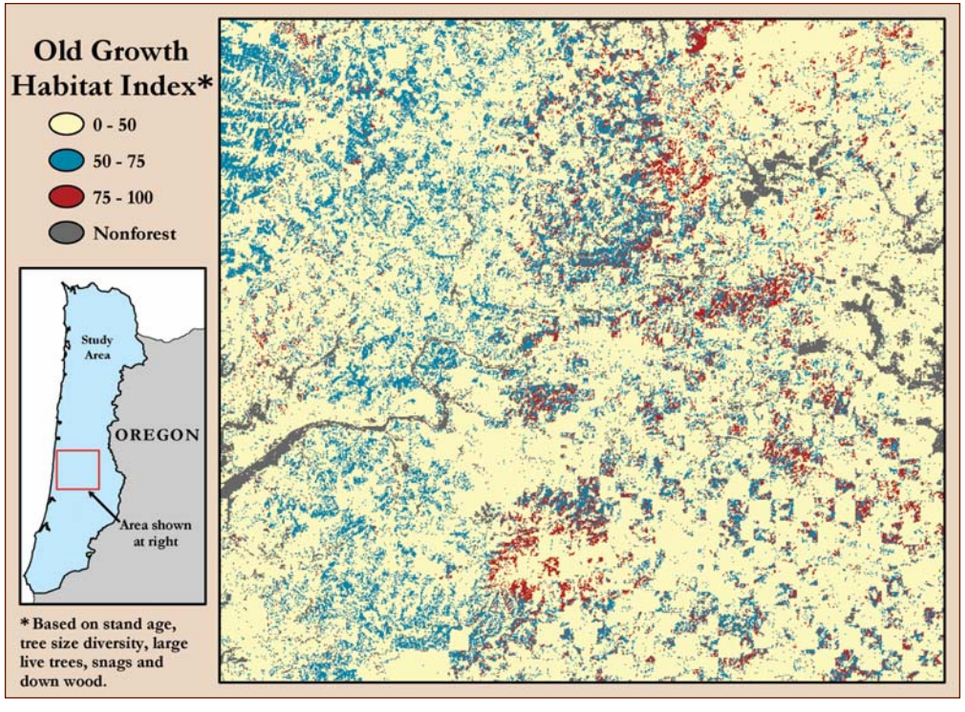
Partner: Oregon State University

Gradient-nearest-neighbor mapping method gives rich details of forest conditions across the Oregon Coast Range

Scientists developed a new method to map forest conditions across an entire region, with a richness of detail never before available at that scale. The gradient-nearest-neighbor method was developed as part of the CLAMS for the Oregon Coast Range.

The gradient-nearest-neighbor method uses statistical techniques to ascribe detailed data to each pixel in a digital landscape map. Thus each pixel (dot) on the map contains detailed information such as a tree species list and stand structure. The digital maps can show information such as tree species richness, forest structure, potential vegetation types, large dead wood abundance, and broadleaf vegetation distribution, over forest land of all ownerships in the Oregon Coast Range.



New method creates finely detailed regional maps, such as this map showing the presence of old-growth habitat characteristics such as large, old trees; large snags; down wood; and tree diameter diversity, in the Oregon Coast Range. Areas that rate highest are most likely to be old-growth forests.

The province-wide yet finely detailed maps are far more accurate and revealing than piecemeal analysis of some forest lands. Thus the maps can be used to evaluate the effects of forest policies on biodiversity, socioeconomic values, and forest sustainability. CLAMS is using the maps for simulations of future landscapes under policy alternatives and to assess potential effects on wildlife, aquatic habitat, and timber production.

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Partners: Oregon State University, Oregon Department of Forestry

HydroDB, a central database, coordinates data from ecological research sites

More scientists are putting databases on Web sites, and the volume of data is growing all the time at ecological research sites around the world. PNW scientists led the development of a system to "harvest" data from participating ecological research sites into a central database where the data is accessible to other scientists through a common Web interface. Participating sites keep local control over their climate and streamflow data, while allowing data to be regularly collected and incorporated into the central database.

The Web harvester system, known as HydroDB, makes available hydrologic and climatic summary reports, daily data for user download, and interactive graphical displays. HydroDB also collects common descriptive information at each site to assure that harvested data are accurately interpreted and integrated. The central database makes it easier for scientists to use data from a number of different research projects.

Contact: Don Henshaw, dhenshaw@fs.fed.us, Ecosystem Processes Program
Partners: National Science Foundation, USDA Forest Service Fire Evaluation Monitoring and Forest Health Monitoring

The MC1 model accurately predicted the fire susceptibility in the Southwest early in the season and the severe fires in the Pacific Northwest later in the 2002 season.

Goal 3: Develop Science-Based Options for Informed Management

Key Findings and Products:

- A new fire risk model accurately predicted the 2002 fire season, one of the worst fire seasons in decades. The model correctly predicted the fire susceptibility in the Southwest early in the season and the severe fires in the Pacific Northwest later in the season.
- People's attitudes about fire-hazard-reduction programs are remarkably similar across diverse regions of the country. Fire managers are most likely to get community support if they inform people about expected outcomes, risks, mitigation and contingency measures, and cost effectiveness.
- On federal forest lands in the interior Columbia basin, the probability has more than doubled that a wildfire will be a stand-replacement fire, because of fire exclusion, timber harvest, livestock grazing, and the introduction of exotic plant species. Middle-aged forests less than 100 years old are more common, and old, single-layer forests are less abundant than they were historically.
- Silvicultural treatments to reduce fire hazard can be compatible with management to restore old-growth habitats. New analysis tools can be used to design prescriptions that increase management efficiency, reduce fire hazard, and maintain habitat values.
- Elk, mule deer, and cattle changed their patterns of habitat use in response to fuel-reduction treatments in northeastern Oregon. The fuel-reduction treatments reduced fire risk and at the same time increased the forage available for elk, mule deer, and cattle.
- Commercial wood products can be made from small-diameter trees removed in thinning and fuel-reduction projects and also from some tree species not used commercially in the past. Some existing wood products can be recycled. Opportunities exist throughout the West.
- The BioSum planning tool can be used to identify the economic feasibility of using low-value wood removed in fire-hazard reduction in a biomass power plant. In a pilot analysis in southwest Oregon, only about 17 percent of acres available for treatment would return a net revenue of zero or greater.
- Simulated chronologies have been developed of vegetation and disturbance patterns for four landscapes: northeast Oregon, central Idaho, east-central Idaho, and northwest Montana. The chronologies describe the historical range and variability of landscape patterns for these areas.
- Restoration of sagebrush-steppe ecosystems will require substantial investment. The sagebrush-steppe restoration is fundamental to improving landscape conditions for sagebrush-dependent species such as the sage grouse.
- In northeastern Oregon, patch cuts seem to provide the best snowshoe hare habitat out of several experimental treatments. Dense hiding cover from overstory trees was close to small openings, which served as vantage points where hares can watch for predators in winter.

- Native plant diversity increased by 50 percent over the original level in variable-density thinned stands, compared to evenly spaced thinning. Exotic plant species did not increase in the variable-density stands, but they did increase in the evenly-spaced stands.
- Watershed restoration in western Oregon and Washington could focus on maximizing the positive effects of floods and landslides for streams, and storm-proofing roads and other spots where landslide effects would benegative. This approach is a shift from trying to buffer streams from all natural changes.
- Improved survey techniques provide rigorous, quantitative methods for gathering field data about survey-and-manage species such as rare fungi in the range of the northern spotted owl. A new tool can be used to analyze the field data to determine if the species are indeed rare.
- Potassium fertilizer may not protect Douglas-fir seedlings from laminated root rot.

Accomplishments

MC1 fire risk model accurately predicted the 2002 fire season

The severity of a fire season is determined partly by weather, such as drought, extended heat waves, and winds. If fire managers know in spring that the coming summer is likely to be a severe fire season, they can prepare accordingly.

Scientists developed a model, called MC1, that makes fire season forecasts. MC1 links weather conditions and fire occurrence from 1895 to the most recent month and produces 3- to 12-month forecasts of possible fire risks for the continental United States. In 2002, one of the worst fire seasons in decades, the model accurately predicted the fire susceptibility in the Southwest early in the season and the severe fires in the Pacific Northwest later in the season. The accuracy of the forecast validated the model, proving it could be a useful planning tool for fire managers.

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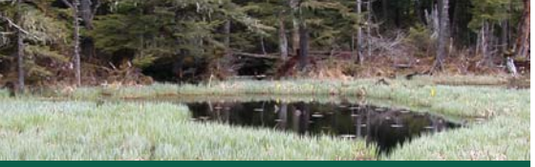
Partners: Oregon State University, Desert Research Institute, Scripps Institute of Oceanography

Ventilation model was used in the Biscuit Fire to assess smoke hazards for communities in the region

The ventilation climate information system, a computer model, was used during the Biscuit Fire in 2002, the largest wildfire in Oregon's recorded history. The fire's heavy smoke affected communities many miles away. The incident command team at the fire used the ventilation model, based on 40 years of data, to estimate continuing smoke impacts and issue smoke hazard warnings to the region around the fire.



Tom Iraci

The Biscuit Fire burned nearly 500,000 acres in southwest Oregon in summer 2002.

The ventilation model can be used at local, regional, or national scales to assess smoke risks to air quality and visibility. Because the model can be used at different scales and covers the entire continental United States, fire managers all over the country are using the model as a tool both in planning prescribed fire programs and in forest-level planning.

Contact: Sam Sandberg, dsandberg@fs.fed.us, Managing Disturbance Regimes Program
Partner: Joint Fire Science Program

Across the country, people have common concerns about fire hazard reduction programs

Before land managers can treat fuels and reduce fire hazard, they must have support from local communities. But many residents of the wildland-urban interface do not support specific fuel management strategies, and many people do not have fire-safe landscaping and defensible space around their homes, making it difficult and dangerous for firefighters to protect those homes. Scientists worked with people in four places across the country to find out what their concerns are and what they would need to know to support fire-hazard-reduction programs. The four regions had different situations of land ownership, forest resource uses, and recent fire history.

The results showed that people's attitudes about fuel treatments, and the reasons for their attitudes, are remarkably similar across diverse regions. Attitudes are linked most closely to expected outcomes, suggesting that people are more likely to accept management plans if they learn more about the plans, the expected outcomes, and the risks.

Based on this study, scientists recommend that fire managers cover specific issues when they present alternatives to people. For prescribed burning, the specific issues that should be covered are technical competence of the agency personnel, environmental conditions addressed in the plans, availability of resources, mitigation and contingency measures, and cost effectiveness. For mechanical treatment, the specific issues that should be covered are planning and preparation, mitigation to reduce aesthetic impacts, and cost effectiveness. For defensible space, the issues are "how-to" instructions tailored to local conditions, mitigation measures to reduce aesthetic impacts, and regulation and enforcement of ordinances.

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Partners: Paul Schissler Associates, Michigan State University

Tom Iraci

New landscape patterns have been created across rangelands and forests of the interior Columbia basin.

High-intensity wildfires are more likely in many parts of the interior Columbia basin

Station scientists have provided extensive support for management planning in the interior Columbia basin. Much of this work was completed in 2002.

On federal forest lands in the interior Columbia basin, the probability has more than doubled that a wildfire will be a stand-replacement fire, because of fire exclusion, timber harvest, livestock grazing, and the introduction of exotic plant species. Middle-aged forests are substantially more common than they were historically. Mature forests of large, widely spaced trees have declined by two-thirds or more from historical levels on federal lands in the interior Columbia basin.

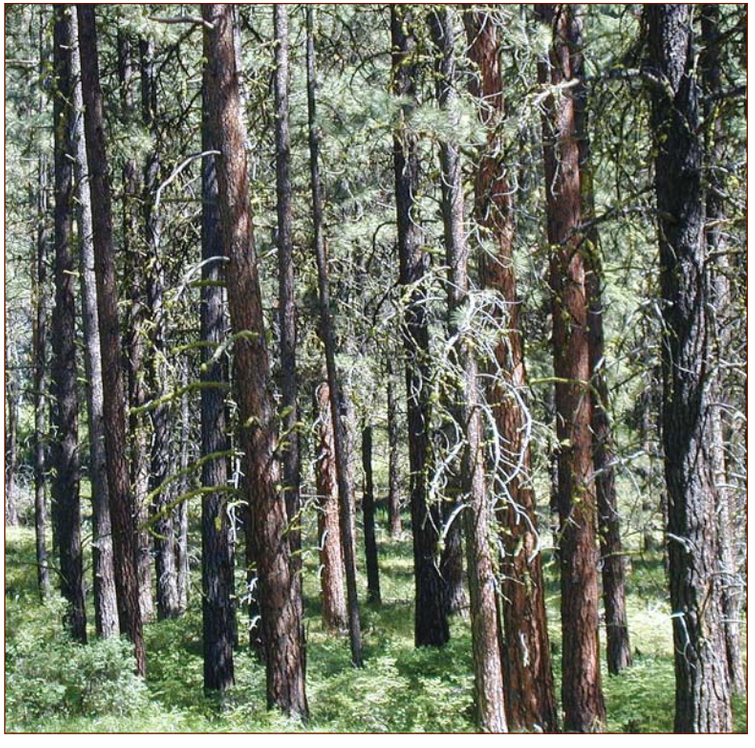
Landscape health is estimated at low to moderate on the majority of federal lands within eastern Oregon and Washington. For this analysis, scientists defined landscape health as the best fit of high land use values, high condition rating for native species habitats, low risks to ecological values, and low departure from the historical range of conditions.

The new landscape patterns are becoming apparent across large areas. These changes, set in motion partially by changed fire regimes, are creating a momentum that will be difficult to overcome. Current land management practices are not likely to reverse trends of increasing middle-aged, increasingly dense forests, or declining landscape health.

Salmon, steelhead, and native trout have lost significant amounts of habitat, and many populations are declining. Strong salmonid populations inhabit only between 0.1 and 33 percent of their historical habitat within the interior Columbia basin. Wildlife species that are declining are those associated with old forests, shrublands, and grasslands. Scientists also assessed socioeconomic conditions and found that across the interior Columbia basin, communities differ widely in their degree of resiliency and dependency on natural resources from federal lands.

The coordinated research program built a comprehensive picture of the current socioeconomic, ecological, and biophysical environments in the interior Columbia basin, a picture that was not available before. This body of research provides a sound basis for land- management decisions, insight on the large-scale consequences of site-specific decisions, and findings related to the management of risks and opportunities.

Contacts for key issues and landscape health: Becky Gravenmier, bgravenmier@fs.fed.us, Miles Hemstrom, mhemstrom@fs.fed.us, Managing Disturbance Regimes Program
Contacts for socioeconomic issues: Richard Haynes, rhaynes@fs.fed.us, Becky Gravenmier, bgravenmier@fs.fed.us, Human and Natural Resources Interactions Program



John Lehmkuhl

Fuel-reduction treatments can reduce fire risk and increase forage.

Compatible options exist to both reduce fire hazard and maintain spotted owl habitat

The range of the northern spotted owl extends east of the Cascade Range crest where dense multilayered canopies and down wood create suitable habitat. These structural characteristics increase susceptibility to fire and insects such as the western spruce budworm. Stand-replacement fires are increasingly likely to burn in these forests and are a risk to the habitat, streams, and possibly human communities. To reduce fire hazard and yet maintain spotted owl habitat, many small trees would have to be removed at a high cost and with low market value.

Various silvicultural options were analyzed for the Gotchen Late-Successional Reserve, in the Cascade Range in eastern Washington. The analysis integrated information on landscape patterns, key habitats and species, and economics. The results suggest that silvicultural treatments used to reduce fire hazard east of the Cascade crest may not conflict with management designed to maintain or

restore old-growth habitats. Forest managers could use the same analysis tools to increase the efficiency of management actions, reduce fire hazard, and maintain habitat values.

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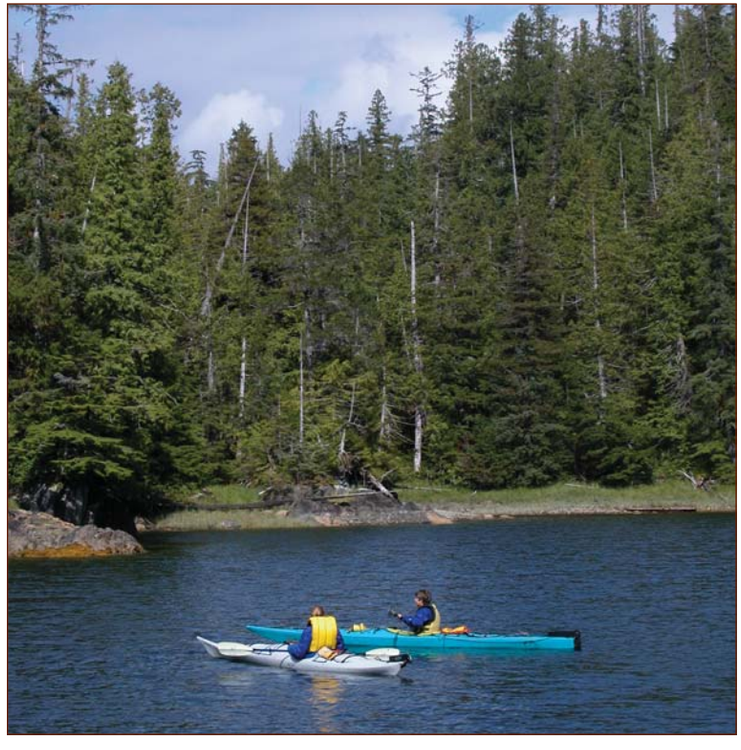
Partners: University of Washington, University of Montana, Gifford Pinchot National Forest

Fuel-reduction treatments in northeastern Oregon reduce fire hazard and increase available forage

A study in northeastern Oregon focused on the effects of fuel-reduction treatments on grazing patterns of wild elk and mule deer and domestic cattle. On the Starkey Experimental Forest, fuels have been reduced in overstocked stands of true fir and Douglas-fir where many trees died during the spruce budworm outbreak in the late 1980s. Both native and domestic ungulates changed their patterns of habitat use in response to the fuel-reduction treatments. The changes in animal distribution, in turn, caused shifts in grazing and browsing pressure, thereby changing how the forest stands develop. The fuel-reduction treatments reduced the risk of catastrophic fires in the areas treated and, at the same time, they increased the forage available for elk, mule deer, and cattle.

In another grazing study, scientists found that cow age affected the grazing patterns of cattle on forested rangelands. Heifers (2-year-old cows) preferred riparian habitats and did not travel as far from water as mature cows. This effect was most pronounced during mornings, with little difference in where the cows grazed from noon to early evening. Mature cows ate more because they were larger than heifers, but the mature cows ate less per pound than did heifers. Also, the mature cows selected diets of greater botanical diversity and higher nutritional quality than did the heifers.

Contact for fuel reduction, cow age, and grazing effects studies: Marty Vavra, mvavra@fs.fed.us, Managing Disturbance Regimes Program



New tools can be used in developing plans to reduce fire risk

The interior Northwest landscape analysis system (INLAS) is a set of computer-based models that simulate the long-term consequences of current or proposed forest management actions intended to reduce fire risk. As its name suggests, the models are designed for the Pacific Northwest east of the Cascade Range crest. Modules within the model are being developed to predict how different management policies would affect streams and forests, how much wood could be used for products, and how communities would be affected by wildfires, insect outbreaks, tree diseases, and grazing. In 2002, the utilization module was

used in northeastern Oregon's Blue Mountains region to analyze the potential timber volumes and financial return, by county, that would be generated from hazardous fuel treatments.

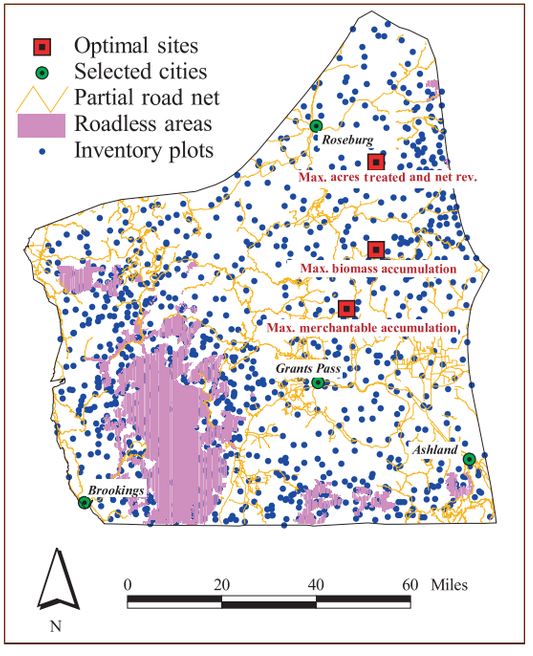
The community action prioritization system (CAPS) is an evalation system that compares forest conditions, human needs, and fire threat, among national forest regions such as the Pacific Northwest Region, Rocky Mountain Region, and so forth. This decision-support model produces numerical rankings that also can be displayed in maps. The Forest Service will use this system as it makes the initial distributions of economic action plan funds to Forest Service regions in 2003.

Contacts for INLAS and CAPS: Jamie Barbour, jbarbour01@fs.fed.us, Focused Science Delivery Program; Jane Hayes, jlhayes@fs.fed.us, Managing Disturbance Regimes Program
Partners: Managing Disturbance Regimes Program, North Central and Rocky Mountain Research Stations

BioSum model estimates the cost-effectiveness of biomass power from fuels-reduction projects

Most fire-hazard-reduction work involves cutting small-diameter trees, and many questions are raised about which areas are highest priority, the possibility of wood products, and treatment effectiveness. The BioSum model is a strategic planning tool that can be used to determine which sites are the most important for fire-hazard-reduction work, and if it is economically feasible to use the otherwise low-value wood for a biomass cogeneration plant. BioSum uses off-the-shelf data and methods to rapidly identify the best locations for a biomass power plant, assess the likely effect of treatments on the fire hazard, estimate how long biomass feedstocks would last, and estimate cost-effectiveness for a power plant. Scientists from several Station programs collaborated on the model.

A BioSum prototype had already been developed for southwest Oregon before the Biscuit Fire burned almost 500,000 acres of the area in summer 2002. The pilot analysis prior to the fire predicted that only about 17 percent of the acres available for treatment would have returned a positive net revenue.



BioSum can identify the best locations for siting biomass plants that produce power.

Contact for BioSum: Jeremy Fried, jsfried@fs.fed.us, Forest Inventory and Analysis Program
Partner: Human and Natural Resources Interactions Program, Focused Science Delivery Program

Small wood and old wood have use for commercial wood products

The wood available for wood products is changing. Large Douglas-fir logs are less available than in the past. What are available are small-diameter trees removed in thinning and fuel-reduction projects,

Dean Parry

Old utility poles can be recycled into high-value wood products.

tree species once neglected for commercial uses, and existing wood products that can be recycled. Scientists are finding ways to use these wood sources for commercial wood products.

Many small-diameter trees will be cut in fuel-reduction and thinning projects. If the work can pay for itself, these stewardship activities are more likely to get done. A new database indicates that the infrastructure is currently not in place to economically use all the small-diameter timber and wood biomass that would result from fire-hazard-reduction operations.

However, at least some of the work can be funded by the sale of small-diameter trees for wood products. Scientists worked with one small-roundwood manufacturer as a case study. They developed a model of log recovery and value from the manufacturer's working knowledge of the business. This model helps to identify the best use of logs with different characteristics and the amount that can be paid for logs, considering the end uses.

Scientists found that old western redcedar and Douglas-fir utility poles can be recycled into high-value wood products. The Bonneville Power Administration replaces 1 to 3 percent of its 80,000 wood utility poles every year. The retired poles are either western redcedar with creosote-treated butts, which were installed in the late 1940s, or newer, penta-treated Douglas-fir. The western redcedar poles can be turned into split-rail fencing and siding boards. Douglas-fir poles are being tested for their suitability for structural wood uses.

Contacts for wood products from small-diameter trees: Eini Lowell, elowell@fs.fed.us, Human and Natural Resources Interactions Program
Partners: Southern Research Station, Greater Flagstaff Forests Partnership, Northern Arizona University
Contact for small log economics: Roger Fight, rfight@fs.fed.us, Human and Natural Resources Interactions Program
Partners: Northern Arizona University, Alpine Trucking and Specialty Woods
Contacts for recycling utility poles: Dean Parry, dparry@fs.fed.us, Human and Natural Resources Interactions Program
Partners: Bonneville Power Administration, Oregon State University, Rediscovered Wood Products

Simulation sawing program can be used to evaluate wood product possibilities

Scientists developed a computer program that tests different ways of sawing logs. The AUTOSAW program can simulate sawing logs in a mill by using data on log diameters at both ends, position and size of knots, the sawing procedure to be used, and board dimensions desired. An operator can use the program to "saw" the same logs over and over again, trying different patterns to minimize knot defects and evaluate wood product options. The program was recently used to estimate the volume of clear lumber in the butt logs of pruned trees. A study found that AUTOSAW had a good ability to re-create sawing volumes but is still limited in its assessment of defect.

Contacts: Dean Parry, dparry@fs.fed.us, Human and Natural Resources Interactions Program
Partners: Forest Research New Zealand, University of Oregon, Northeast Research Station

Specialty products and improved wood recovery offer opportunities in Alaska wood products

Alaska is often a special case for wood products manufacturing, because the distance from forest to market is immense. Several projects are finding good

CONTINUE