Forest Ecology Research, Ecosystem Processes Program

Pacific Northwest Research Station
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The snapshots below summarize on-going forest ecology research in the Ecosystem Processes Program. Each of these studies relates to a goal of the Station, as stated in our Strategic Plan.[1]

Old-growth forest

Old-growth forests are regionally more diverse in structure and development than previously thought

The composition and structure of today's old-growth forests— which vary regionally due to unique developmental pathways—may not be seen again in future forests because of modern climates and disturbances like fire.

Pacific coastal old-growth forests are diverse regionally in both their structures and their development. The diversity is a result of regional differences in climate history, fire history, site productivity, and species composition. Although the forests share the same general definition and similar attributes such as large live and dead trees, the details differ and no one specific definition describes all Pacific coastal old-growth forests.

Today's old-growth forests developed along multiple pathways. Some developed under open conditions created by multiple fires, and with different levels of biological legacies such as large live and dead trees. Others developed from closed, dense stands after a single major fire or other disturbance. In very wet, cool parts of the region, some old-growth forests developed without fire; these forests are dominated by shade-tolerant tree species in a mosaic of patches.

All these forests developed from disturbances and under the climate conditions of the last millennium. The particular composition and structure of these old-growth forests may not occur again under modern climates and disturbance regimes.

Outcome: Forest managers use our models and understanding of old-forest development to plan strategies for re-establishing old-growth stands. *Contact: Tom Spies; Corvallis, Oregon; tspies@fs.fed.us*

[1] Goal 1–Develop a fundamental understanding of ecological, social, and economic systems and their interactions; Goal 2–Assess the status and trends of ecosystems and natural resources and their uses; Goal 3– Develop science-based options that enhance management; and Goal 4– Communicate science findings and enhance their application.

Measuring flow direction in roots

Universal rules describe biophysical controls on utilization and redistribution of water by trees

There may be universal rules that govern how trees' roots take up and redistribute water during droughts, regardless of the type of tree or the characteristics of the site in which it grows.

Plant roots take up water from deep soil layers and then redistribute it near the surface during seasonal drought cycles. Studies we have conducted at three temperate coniferous forest sites and three tropical savanna sites indicate that there may be universal rules governing these processes, regardless of vegetation type or other site-specific characters.

Our studies in ponderosa pine and Douglas-fir stands in Washington and Oregon suggest that redistribution of soil water from deep to shallow roots plays a key role in diminishing the impact of summer drought on the functioning of shallow roots. Water redistributed from wetter, deep soil layers to shallow roots prevents drying of shallow soil layers to critical levels that would cause total failure of the shallow root water transport system.

Other factors may also affect stand water use and hydrology. Work carried out at the Wind River Canopy Crane Research Facility showed that old-growth western hemlock trees infected with dwarf mistletoe change their hydraulic architecture to compensate for the loss of transport efficiency in branches due to the disease. These adjustments minimize the impact of the mistletoe on the water status of canopy leaves; however, it results in sharply reduced rates of whole-tree water use and photosynthesis in infected trees compared with uninfected trees of similar size.

Our results have implications for modeling belowground processes involving movement and utilization of water in ecosystems dominated by woody plants. Further, water use in the stand affects total watershed hydrology; thus, understanding the processes involved will lead to a better understanding of water movement through forests and into streams.

Outcome: Models using universal rules for water use in trees will improve understanding of tree growth and productivity, stand regeneration, and watershed and regional hydrology. *Contact: Rick Meinzer; Corvallis, Oregon; fmeinzer@fs.fed.us*

DecAID home page

A new tool is available to advise forest managers on the role and importance of dead wood

Using the DecAID advisory system, land managers can evaluate and implement management practices that consider a landscape's decayed wood elements.

Decayed wood elements – snags, down wood, and live decaying trees—are habitat for many organisms that live in terrestrial ecosystems and contribute to other aspects of ecosystem productivity and diversity. Maintaining an adequate level and mixture of these habitat elements can be a challenging task for any forest land manager. We developed an advisory system called "DecAID" from a new synthesis of data and research

results pertaining to forests in Oregon and Washington. The DecAID Advisor is a planning tool intended to help advise and guide managers as they conserve and manage snags, partially dead trees, and down wood for biodiversity.

DecAID is an advisory tool to help managers evaluate effects of forest conditions and existing or proposed management activities on organisms that use snags and down wood. DecAID also can help managers decide on snag and down wood sizes and levels needed to help meet wildlife management objectives. In this way, the name "DecAID" can be read as decayed wood advisor and management aid ("decay-aid" or "decision-aid").

Outcome: Using DecAID Advisor, managers can articulate their objectives in specific, quantitative terms that could be tested in the field. *Contacts: Bruce Marcot; Portland, Oregon; bmarcot@fs.fed.us; and Janet Ohmann; Corvallis, Oregon; johmann@fs.fed.us*

Aerial view of forest fragments

How much is enough to be a legacy? Studies of old-growth remnants

Even the smallest remnants of an old-growth forest retain subsets of old-forest-associated plants and invertebrates and some old-forest characteristics.

New forests take shape from our planned activities, such as reestablishment of trees, or from pools of organisms in adjacent undisturbed areas. "How much old forest does it take to 'seed' a new one?" is a question debated for years. Under the Northwest Forest Plan, a minimum of 15 percent of old growth in a watershed was to be retained to serve this purpose. Is that enough? Too much? Is it effective? To address the questions, we set out to document the ecological characteristics of remnant stands (0.01 – about 100 acres) of mature and old-growth forests in the south Washington Cascades and to evaluate their effectiveness as refugia and sources of dispersal for terrestrial lichens, bryophytes, vascular plants, and invertebrates. Results to date show that even the tiniest remnants have a subset of old-forest associated plants and invertebrates, and can serve as a refugium and source of dispersal. Our analysis further indicates that the 15 percent retention guideline means little unless the area, and biological composition, within which it pertains is specified.

Outcome: "How much is enough to be effective?" will advance ecological management of forest resources. *Contact: Bruce Marcot; Portland, Oregon; bmarcot@fs.fed.us*

Alder-spruce landscape

Managing young-growth forest for multiple resources in southeast Alaska

Including red alder in the overstory and performing "commercial-type" thinning in older, young-growth forest hold promise for producing forests in southeast Alaska that are capable of both providing wood and serving as wildlife and fish habitat.

Following harvest of timber in southeast Alaska, vast stands of second-growth forest were established. Managers are now faced with designing and implementing silvicultural prescriptions that address multiple resource objectives.

We studied even-aged, young-growth forests in southeast Alaska for ways of producing wood, wildlife habitat, and fisheries simultaneously. Of particular importance is the establishment of thriving understory vegetation in young forests to support deer populations. We explored two new ways of promoting diverse and productive understory vegetation in young-growth stands: inclusion of red alder in the overstory canopy, and "commercial-type" thinning of older, young-growth stands. Both approaches were much more successful than other silviculture treatments studied to date.

Potential benefits include increased wood production through silvicultural management of young-growth stands while simultaneously improving the stands for both wildlife and fish habitat.

Outcome: The Tongass National Forest is including red alder in young-growth stands in a large-scale adaptive management study. *Contact: Tom Hanley; Juneau, Alaska; thanley@fs.fed.us*

Old-growth forest

Simulations estimate the effects of thinning on development of late-successional forest structure

Thinning can result in forests with old-growth characteristics, but promoting large trees initially can result in fewer large dead trees in the long term.

Accelerating the development of late-successional forest through silvicultural manipulations is one current emphasis of management. However, experiments to develop appropriate prescriptions take years to complete and are quite costly. We used a simulation model to estimate the effects of different thinning intensities on development of late successional forest attributes. In general, heavy thinnings at ages 40 and 60 promoted rapid development of large boles, vertical diversity, and tree-species diversity, but provided the least amount of extracted wood volume and required artificial creation of dead wood. Thinning can accelerate the development of late-successional characteristics by several decades, but promoting large boles in the short run may reduce densities of large dead trees in the long term.

Outcome: Working cooperatively with forest managers, ecosystem modelers can simulate a variety of silvicultural prescriptions and quickly evaluate the likely outcome of the treatment. *Contact: Tom Spies; Corvallis, Oregon; tspies@fs.fed.us*

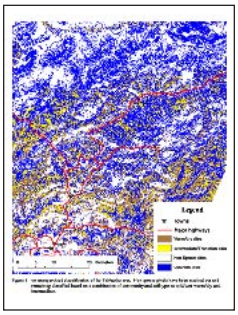
Chanterelles

Managing the chanterelle mushroom in the Pacific Northwest

Information critical to ensuring the continued abundance of chanterelle mushrooms, which grow in association with the roots of certain tree species in Pacific Northwest forests, was published as a PNW Station General Technical Report in 2003.

Chanterelles are globally renowned as one of the best edible forest mushrooms—their international commercial value likely exceeds a billion dollars annually. A variety of chanterelle species fruit plentifully in Pacific Northwest forests, and their abundance has spawned a significant commercial harvest industry during the last two decades. Because chanterelles grow symbiotically with the roots of forest trees, managing the fungi for sustainable harvests also means managing forest habitats. The results of our research have been summarized in a major synthesis publication. It provides forest managers, policymakers, mushroom harvesters, mushroom enthusiasts, and research mycologists with accurate information for an informed debate about chanterelle management. We describe local species, discuss management issues, summarize recent research, and conclude with future research and monitoring designed to ensure a continued abundance of chanterelles in our forests.

Outcome: This synthesis is used by Forests and Districts (USDA Forest Service and Bureau of Land Management) to manage these valuable special forest products. *Contact: Randy Molina; Corvallis, Oregon; rmolina@fs.fed.us*


LANDSAT graphic

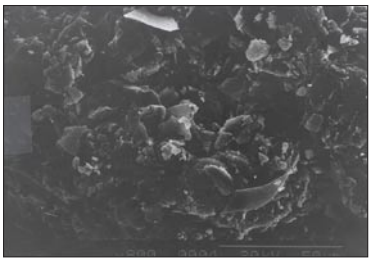
Black spruce on the landscape: Frost and fire

A study aided by a classification model suggests that fire plays an important role in determining the landscape pattern of black spruce communities in interior Alaska.

The boreal forest is the second largest biome on Earth and stores 30 percent of the global terrestrial carbon. In interior Alaska, black spruce dominates the boreal forest. Little is known about the dynamics of black spruce forests, and in particular, what controls their distribution on the landscape. We created a LANDSAT classification of spruce stands in interior Alaska based on a combination of soil conditions and vegetation. The boreal forest is the second largest biome on Earth and stores 30 percent of the global terrestrial carbon. In interior Alaska, black spruce dominates the boreal forest. Little is known about the dynamics of black spruce forests, and in particular, what controls their distribution on the landscape. We created a LANDSAT classification of spruce stands in interior Alaska based on a combination of soil conditions and vegetation. In this classification, sites are grouped into three categories: wet/cold, a "typical" black spruce site; dry/warm, a "typical" white spruce site; and an intermediate class. This classification, and the associated landscape characterization, has helped unravel the complex role of disturbance, particularly fire, in black spruce

communities. Based on our analysis, we have modeled the interactions between vegetation, permafrost, and abiotic factors, not as individual processes, but as intertwined relationships. We believe fire weakens these relationships and accounts for landscape pattern in black spruce communities in the interior of Alaska.

Outcome: Models of vegetation distribution under present and future climate scenarios are used to predict likely feedbacks of carbon into the atmosphere and associated climate change effects. *Contact: Teresa Hollingsworth; Fairbanks, Alaska; thollingsworth@fs.fed.us*


Rock eroded by alder growth

Alders and rocks lead to productive forest soils

Red alder, a nitrogen-fixing tree that is capable of extracting minerals from rocky soils, speeds up the growth rate of both under- and overstory plants and improves wildlife habitat.

Alders are an important component of many forests on the west side of the Cascade Mountains and in Alaska—they are the primary source of biologically fixed nitrogen in forests. With their ability to fix atmospheric nitrogen through a symbiotic relationship with actinomycetes in the genus *Frankia*, alders grow quickly, enrich the soil with nitrogen, and may be an important source of nitrate in stream waters. Alders grow well in rocky soils, accessing a substantial pool of base-element nutrients by accelerating the weathering of rocks with exudates from their roots and root-associated organisms. The result is an annual crop of leaf litter, high in nitrogen and other elements, that provides an organic substrate for nutrient release, maintains soil structure, and increases water-holding capacity. Both over- and understory plants profit from alder in the stand, resulting in faster growing trees and improved wildlife habitat.

Outcome: Managers are including alder in management plans to increase forest productivity and improve wildlife habitat. *Contact: C. Y. Li; Corvallis, Oregon; cli@fs.fed.us*

Mack Creek, H.J. Andrews Experimental Forest

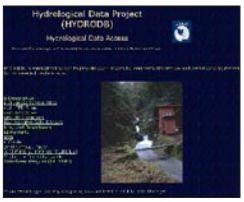
Stream temperature: Scaling of observations and issues for modeling

While both air and stream temperature respond to similar factors—such as solar radiation— local air temperature plays only a small role in heating streams. A more significant factor is the amount of time stream water spends in various upstream conditions, such as in shaded and unshaded areas.

Stream temperature is important to the health and productivity of aquatic ecosystems. Under current regulations, proposed management actions must include an evaluation of potential effects on stream temperature due to possible effects on fish. Often, increases in stream temperature are attributed to increases in air temperature without establishing cause instead of correlation. Our research demonstrates that air and stream temperature respond to the same controlling factors (such as solar radiation), but local air temperature contributes only a small percentage of the total heat flux to the stream. In fact, the resident time of stream

water in various upstream conditions (shaded versus unshaded, source of water, residence time, etc.) is an important factor in understanding influences on stream temperature.

Outcome: Management assessments might need to include upstream conditions, perhaps far removed from the site of the proposed action, to evaluate likely effects on stream temperature. *Contact: Sherri Johnson; Corvallis, Oregon; sherrijohnson@fs.fed.us*



HydroDB home page

HydroDB—Making our data available

Using HydroDB, managers can access baseline data useful in determining the effects of environmental change and disturbances, like fire, on watersheds. Managers can also use the database's data-harvesting system and web interface for further analyses of watershed data.

The hydrology database project (HydroDB) is a cross-site synthesis of long-term records of streamflow and meteorology from a network of USDA Forest Service Experimental Watershed sites and National Science Foundation funded Long-Term Ecological Research sites. The production databases we have assembled establish a baseline response of watersheds to climate variability for monitoring environmental change and assessing disturbance effects, and are widely used in intersite comparisons, modeling studies, and land management-related studies. The intersite hydrology database project (HydroDB) features a data-harvesting system, a central cross-site database, and a web interface to display, graph, and download data.

Outcome: Tracking of general web page use reveals HydroDB web pages average over 500 visitor sessions per month. Additionally, over 120 separate computers have viewed, graphed, or downloaded datasets in the past four months, which resulted in the display of 750 data plots, 250 data views, and 215 data downloads. *Contact: Don Henshaw; Corvallis, Oregon; dhenshaw@fs.fed.us*

Old-growth forest

Promoting habitat complexity in second-growth forests

Using six specific management techniques—that focus on preserving and enhancing old-growth forest characteristics— in conjunction with a comprehensive management plan can result in complex forests capable of providing a variety of ecological, economic, and social goods.

Habitat complexity can be encouraged by a variety of management techniques, including cavity-tree retention, coarse woody debris augmentation, underplanting, conservation of biological legacies, variable-density thinning, and extended-harvest rotations. When implemented collectively and according to a well-devised management plan, these techniques lead to complexity in both individual- and stand-scale structures. Complexity in structure results in diversity in species composition, the development of habitat breadth, and pre-interactive niche diversification.

Outcome: We distributed approximately 2,500 brochures describing the management tools that can promote habitat complexity to various groups, including National Forests, the USDA Extension Service, Washington State Department of Natural Resources, Oregon Department of Forestry, multiple environmental organizations, and private land managers. *Contact: Andrew Carey; Olympia, Washington; acarey@fs.fed.us*

Morels

Response of soil fungi to fire intensity and their potential to selectively inhibit invasive plant species

Different species of fungi react to fires in different ways—some may even possess the ability to influence the invasions of invasive nonnative plant species after a fire.

We have initiated a study to characterize the effects of fire of varying intensity on soil microbial communities and their role in inhibiting the invasion of unwanted plant species in post-fire recovery. Knowledge of the ecological role of the post-fire soil fungal community is important to the management of healthy forest ecosystems. Fire is an important disturbance process in most forest ecosystems, favoring early seral species of fungi as well as plants. Fire, especially high severity wildfire, usually facilitates invasion by nonnative plant species and the fruiting of a series of fungi that typically appear only after fire. High intensity surface fires also tend to kill mycorrhizal fungi in surface soil layers, destroy native seed banks, and alter the amounts of plant-available nitrogen. The release of nitrogen favors the establishment of both invasive plant species as well as saprotrophic fungi.

The negative impacts of invasive nonnative plant species on native plant species have been a concern for land managers for nearly a century. Promoting native soil microbes in disturbed ecosystems may influence the successful establishment of native plant species.

Outcome: Results from this study will provide knowledge that can be used to manage post-fire restoration and recovery efforts aimed at establishing native plant populations and excluding unwanted and invasive plant species. *Contacts: Jane E. Smith; Corvallis, Oregon; jsmith01@fs.fed.us; and Tricia Wurtz; Fairbanks, Alaska; twurtz@fs.fed.us*