2004 science accomplishments

of the pacific northwest research station

vision and mission

We are highly sought for our scientific leadership and impartial knowledge. Our mission is to generate and communicate scientific knowledge that helps people understand and make informed choices about people, natural resources, and the environment.

a message from the pnw executive team

The best reward for research well done is not a scientific honor or award, but to see our findings making a difference on the ground. Perhaps the sincerest compliment is when agencies outside the Forest Service use our findings and management tools because they find our work valuable.

PNW Executive Team (from left): Cynthia D. West, Deputy Station Director; Thomas M. Quigley, Station Director; Cynthia L. Miner, Director for Communications and Applications; Paul Dunn, Assistant Station Director; and Rolando Ortegon, Director for Operations.

In our contacts with people this past year, we learned of many fine examples of how scientific research from the PNW Research Station is making a difference regionally, nationally, and internationally, in resource management.

- The FishXing software, used to design fish-passable culvert replacements, is used in thousands of counties across the United States, saving time and money.
- Active intentional management (AIM), an integrated system for managing a forest's ecological processes, was adopted by the Washington Department of Natural Resources as the preferred alternative for managing 2 million acres of Washington state forests.
- The fall 2003 fires in southern California were disastrous for people and ecosystems. After the fires, one of our program managers headed a national team that tested a new way to rapidly deliver scientific and technical information to people greatly in need.
- Work is underway to adopt BlueSkyRAINS, the smoke management and information system, across the West and possibly nationally.
- The FIA BioSum software is a tool now used in several Western States to analyze the effectiveness of fire hazard reduction and the financial feasibility of fuel treatments, helping people find a balance between desired outcomes and acceptable costs.
- Hunting regulations have been changed in many Western States as a result of the Starkey Project research on elk, deer, and cattle ecology.
- An international workshop on "Balancing Ecosystem Values" was held in Portland, partly because of our scientists' contributions to large-scale sustainable forestry experiments.
- Our research on how urbanization and other social changes affect forest management is used nationally by long-range planners and policymakers.

We are proud that our scientists and other employees are sought out for their knowledge, expertise, and insight. Our scientists are invited to present their findings to federal agency heads, state boards and commissions, Congressional groups, and many nongovernment organizations, and they are asked to fill posts at national and international levels in scientific societies. Our communications professionals are asked to take the lead on national publications.

Our accomplishments are possible only in concert with our partners, cooperators, and clients. We look forward to seeing our research results and products continue to benefit a changing society and continually changing ecosystems.

PNW Executive Team
March 2005

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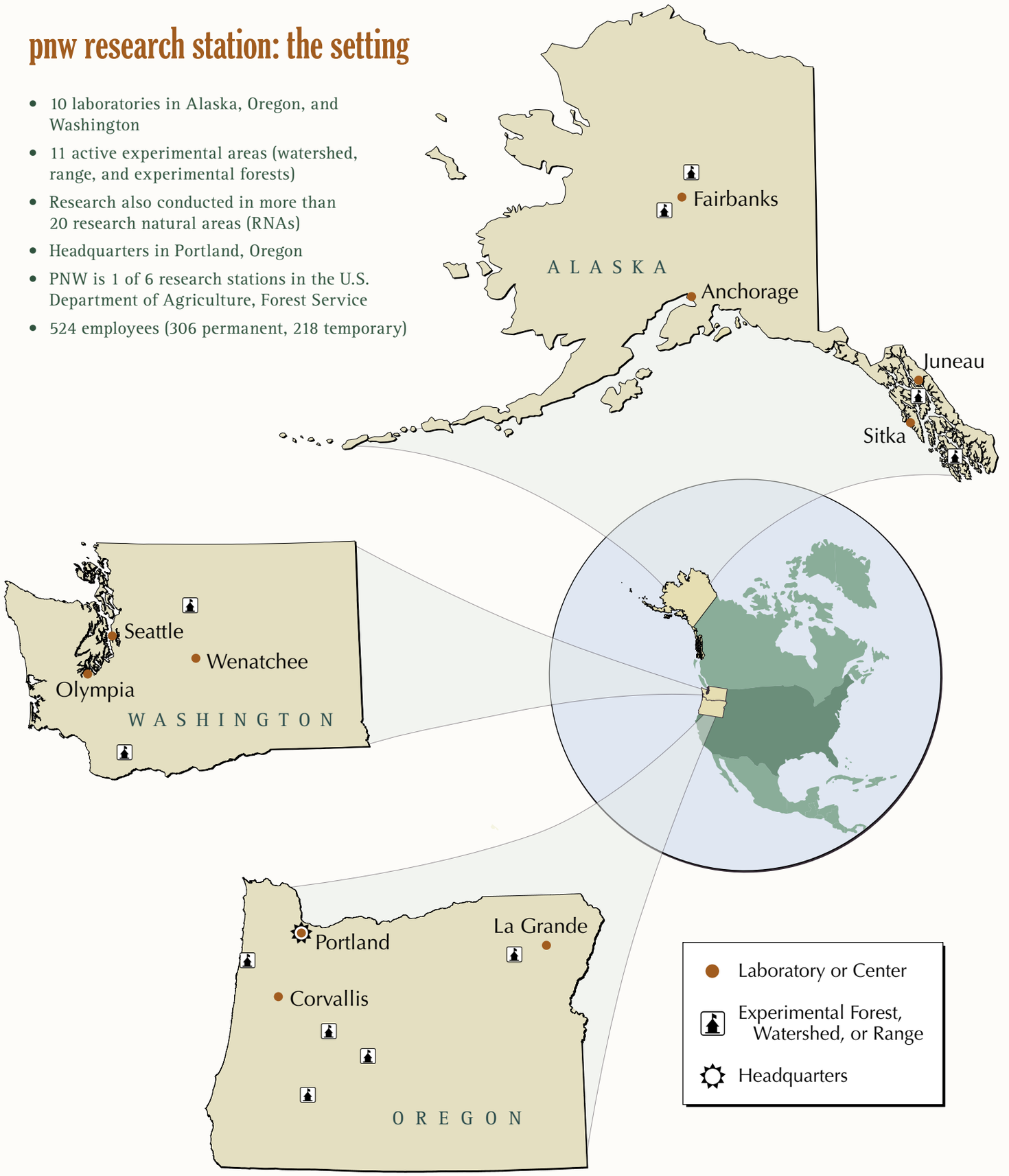
pnw research station: the setting

- 10 laboratories in Alaska, Oregon, and Washington
- 11 active experimental areas (watershed, range, and experimental forests)
- Research also conducted in more than 20 research natural areas (RNAs)
- Headquarters in Portland, Oregon
- PNW is 1 of 6 research stations in the U.S. Department of Agriculture, Forest Service
- 524 employees (306 permanent, 218 temporary)



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goal 1:

develop a fundamental understanding of ecological, social, and economic systems and their interactions

key findings

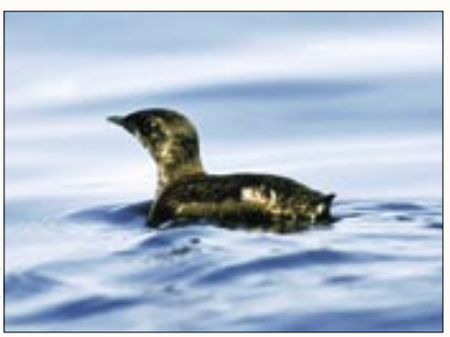
- Tree diameter correlates strongly with the occurrence of natural platforms in trees in Washington forests and may be a potential indicator of suitable marbled murrelet nesting habitat.
- Marbled murrelet group size at sea may be a gauge of productivity, giving managers a practical way to assess murrelet reproductive success.
- Station scientists discovered a previously unknown species, the Scott Bar salamander, and learned new information to help land managers protect rare woodland salamanders in northern California and southwestern Oregon.
- Detailed maps of coastal Oregon forests show relations among forest composition and structure, and climate, disturbance history, and land ownership, with implications for regional conservation planning.
- Pileated woodpeckers in the southern Oregon Cascade Range forage in small-diameter downed wood for beetle larvae, not only for carpenter ants in large-diameter wood; this finding can help refine existing habitat guidelines for this keystone species.
- Low-copy nuclear markers give more accurate genetic information for pine and mallow species than two more commonly used classes of genetic markers. Now that accuracy has been tested, the low-copy nuclear markers can be used to study genetic questions related to the more than 300 sensitive plant species in the Pacific Northwest.

accomplishments

tree diameters may help predict murrelet nest sites

Marbled murrelets are small seabirds that spend time in both marine and terrestrial ecosystems—they forage in coastal waters and nest inland on the branches of large coniferous trees in the Pacific Northwest. Federally listed as a threatened species, the marbled murrelet is a species whose conservation is an important part of the Northwest Forest Plan.

Platforms, defined as limbs greater than 4 inches in diameter covered with moss or infected by mistletoe, or as larger bare limbs, are one factor critical to defining suitable nesting habitat. However, data on these nesting platforms are not typically gathered as part of ongoing forest inventories. Because of the lack of data on platforms, scientists used tree diameter and species to predict the abundance of platforms in forests in Washington. Scientists performed a statistical



Marty Raphael

analysis that found a very strong correlation between tree diameter and the occurrence of platforms, a relationship that differed among tree species. Among all species surveyed in the Washington forests, trees with diameters greater than 40 inches had a 50-percent or greater likelihood of having platforms. These findings suggest that commonly measured stand attributes—in this case, tree diameter—may be used to predict potential suitability of marbled murrelet nesting habitat.

Results of this work provide scientific support for defining a threshold of tree diameter that can be used to define potential murrelet nesting habitat and have been critical in developing maps of potential habitat in support of the Northwest Forest Plan effectiveness monitoring program.

Contact: Martin G. Raphael, mraphael@fs.fed.us, Ecosystem Processes Program

Partners: USDA Forest Service, Pacific Northwest Region; Washington Department of Natural Resources; USDI Fish and Wildlife Service

Data showing that Puget Sound marbled murrelet populations are relatively stable was critical to a recent U.S. Fish and Wildlife Service status review of the threatened species.

murrelet group size at sea may be a gauge of productivity

Marbled murrelets are fast-flying seabirds that divide their time between foraging in coastal marine waters and nesting inland in large coniferous trees. During the nesting period, both parents take turns incubating their single egg, switching duties every 24 hours. Thus on any given day during incubation, one member of a breeding pair is alone on the water while the other is sitting on the nest. Because of the birds' unusual nesting behavior, scientists have not been able to estimate from marine surveys alone what proportion of the murrelet population is actually nesting inland in any given year, an important productivity measure for this threatened species.

Scientists tested a new technique for estimating murrelet nesting activity by using marine surveys. Based on studies with murrelets that were radio-tagged, scientists found that nesting birds were significantly more likely to be solitary while on the water than were nonnesting birds. By counting numbers of single birds versus paired birds, as determined by boat surveys, scientists created an index of productivity found to be successful in 4 out of 5 years tested (1997 to

Marty Raphael

Marbled murrelet group size on the ocean may yield clues about nesting status of the adult birds.

Tom Iraci

2001). This finding may lead to a tool that managers can use to assess murrelet reproductive status from data routinely collected during ocean surveys.

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Partners: USDI Fish and Wildlife Service; USDI Bureau of Land Management; Washington Department of Natural Resources; Washington Department of Fish and Wildlife; USDA Forest Service, National Forest System

surveys reveal relative stability of marbled murrelet populations

Scientists completed development of the first population survey protocol for the marbled murrelet in 2000. Since then scientists have been using the protocol to monitor murrelet populations in the Puget Sound region. Data indicate a relatively stable population of marbled murrelets, averaging about 8,000 birds, over the past 4 years. This finding was critical to a recent U.S. Fish and Wildlife Service status review of the marbled murrelet, a species listed as federally "threatened."

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northern spotted owls prefer nocturnal arboreal rodents

Scientists summarized 30 years of northern spotted owl diet data based on a sample of 24,497 prey items collected from 1,118 owl territories in Oregon—the longest and largest data set ever collected on diets of spotted owls, which are listed as threatened under the Endangered Species Act. The vast majority of species preyed upon by spotted owls, which numbered at least 131, were mammals. On average, the majority of species taken were nocturnal arboreal mammals. Although northern spotted owl diets tended to differ among owl territories, geographic regions, and years, they generally were dominated by northern flying squirrels, woodrats, red tree voles, western red-backed voles, deer mice, and gophers. These findings suggest that management practices that promote healthy populations of these species should benefit northern spotted owls in Oregon and Washington. This study serves as a reference to management agencies for regional variation of diets of the northern spotted owl in Oregon.

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scientists clarify east-side ecological webs involving spotted owls and their prey

The northern flying squirrel, a nocturnal arboreal rodent, is part of a complex ecological web that includes the northern spotted owl. Owls prey upon flying squirrels, which, in turn, consume truffles, underground fungi that are symbiotic with trees and vital for high tree productivity. Although much is known about this ecological web in the moist Douglas-fir forests of western Oregon and Washington, data are few for low-elevation, dry forests of the eastern Washington Cascades. Scientists studied the demography of flying squirrels and how it relates to forest cover types variously used by spotted owls, woody debris, and truffle and lichen food abundance over 4 years in eastern Washington. Flying squirrels were abundant in mature mixed-conifer forest that is primary spotted owl habitat, but also were abundant in young mixed-conifer forests and pine forests less used by spotted owls; hence prey abundance may not be the prime driver of spotted owl habitat use.

The flying squirrel data generated by this study have been used for the 5-year status review of the spotted owl being conducted by the U.S. Fish and Wildlife Service and the interpretation of the 10-year analysis of long-term demography studies of the northern spotted owl. The data also

are being used for the wildlife viability analysis of the Northwest Forest Plan revision for the Okanogan and Wenatchee National Forests.

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Partners: USDA Forest Service, Okanogan and Wenatchee National Forests; Central Washington University; Oregon State University

station scientists discover a new species while helping land managers protect rare woodland salamanders

Station scientists are helping land managers protect the habitat needs of several rare salamander species endemic to northern California and southwestern Oregon, and in the process recently discovered a previously unknown salamander species. Station scientists used field surveys and innovative techniques to learn more about the distribution of these woodland salamanders, some of which were survey-and-manage species under the Northwest Forest Plan. Surveys revealed that Shasta salamanders are indeed rare and largely restricted to a small zone near Shasta Lake, California,

Steve Tilley

Scientists identified a new species of woodland salamander, the Scott Bar salamander.

but they are not solely associated with limestone rock outcrops, as once thought. Two new, isolated populations of Shasta salamanders were found distant from the main population center. Mitochondrial DNA analyses identified three discrete populations of Del Norte salamanders in northern California and southwestern Oregon. Genetic analysis of nuclear microsatellite markers identified two discrete populations of Siskiyou Mountain salamanders and revealed limited gene flow between them. By analyzing genetic and morphological traits, scientists were able to discover a new species, the Scott Bar salamander (*Plethodon asupak*).

These salamanders are part of the hidden biodiversity within our national forests, and the new information will help land managers better protect their habitat. For low-mobility, rare, endemic species such as these terrestrial salamanders, the isolated populations may need to be considered as separate species management units.

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Partners: Oregon State University; University of California at Berkeley; USDA Forest Service, Pacific Northwest and Pacific Southwest Regions, Shasta-Trinity National Forest, Klamath National Forest; USDI Fish and Wildlife Service; USDI Bureau of Land Management, Medford District

new maps lend insight into biodiversity patterns and causes

Conservation of biodiversity is an important forest policy issue and management objective for many individual forests across the region. The patterns and causes of biodiversity in any given forest differ depending on the individual landscape. Scientists used new, highly detailed maps of forest vegetation in coastal Oregon to examine biodiversity patterns and their causes. They found that gradients in tree species composition were strongly linked to environmental factors, especially climate, and were insensitive to disturbance, such as timber harvesting, fire, and disease. Forest structure, however, was found to be strongly linked with the history of disturbance and land ownership and only weakly linked with environment. The detailed tree-, stand-, and species-level data in the maps revealed regional trends that would be masked in a coarse-filter assessment.

Findings suggest that regional conservation planning include all ownerships and land allocations, as well as fine-scale elements of vegetation composition and structure. These detailed vegetation maps are used as input to models that simulate future landscape conditions to evaluate effects of silvicultural treatments and forest policies on vegetation, aquatic, wildlife, biodiversity, and commodity values.

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Partner: Oregon State University

Tom Iraci

small-diameter down wood is important foraging habitat for pileated woodpecker

The pileated woodpecker is a large, striking red-crested species that requires live and dead trees with heartwood decay for nesting and roosting, as well as standing dead and downed wood for foraging. The woodpecker's foraging and cavity excavation provide many ecological benefits, including habitat for other cavity-using species. But the pileated woodpecker, a keystone species, is also a species of special concern because of its habitat requirements.

John Laurence

On Sun Pass State Forest south of Crater Lake, pileated woodpeckers open small down logs to capture wood-boring beetle larvae.

Work on the Sun Pass State Forest in southern Oregon has yielded new findings on the pileated woodpecker's foraging ecology. Scientists found that during the snow-free months, pileated woodpeckers foraged in small-diameter down wood (9 inches at the large end), not only in large-diameter wood. They also found that the prey species in this wood is more often large wood-boring beetle larvae, not carpenter ants as had been thought previously. These findings can help refine management guidelines for pileated woodpecker habitat on the Sun Pass State Forest, also benefitting the many other species that use woodpecker-created cavities.

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Partner: Oregon Department of Forestry

Willamette National Forest managers are developing guidelines for sustainable harvest of beargrass by using a new finding that beargrass pollen helps wild pollinators to survive.

beargrass supports biodiversity by feeding nearly 40 species of insects

Beargrass is a native, perennial plant important internationally in the floral trade and important regionally as a traditional and commercial nontimber forest product. Scientists have been studying the ecology and reproductive biology of beargrass to determine methods and conditions of harvest that are sustainable and do not harm the viability of individual plants and communities. Earlier work showed that foliage quality, which is strongly influenced by overstory cover, is a major factor in the market value of plants, and therefore, to some extent, the harvest pressure.

New research characterizes the reproductive ecology and pollinators of beargrass. Scientists found that overstory strongly influences the growth and flowering of beargrass; almost no flowering occurs under dense canopies. In forests where canopy has been reduced by selective harvest, beargrass flowers are pollinated by nearly 40 species of insects, including pollen-eating flies, beetles, and small bees. The nutrient-rich beargrass pollen helps these wild bees and other pollinators survive, and these insects pollinate other flowers that are less common or whose pollen is less nutritious. Thus beargrass feeds many pollinating insects in cool, high-elevation forests, which generally are not rich in flower species, and so it aids the reproductive success of other plants, an important support for biodiversity.

Nan Vance

Nearly forty species of insects feed on nutrient-rich beargrass pollen; these same insects also pollinate other less common flowers.

Tom Iraci

Managers on the Willamette National Forest are using these findings as they develop guidelines for the sustainable harvest of beargrass. Their guidelines reduce or eliminate picking of the plant's flowers, which typically bloom from May to June.

Contact: Nan Vance, nvance@fs.fed.us, Resource Management and Productivity Program

Partners: USDA Forest Service, Willamette National Forest; St. Louis University

more accurate approach should improve results in plant genetic studies

Molecular genetic information has dramatically affected the study of species relationships and evolutionary biology, and DNA sequences are now routinely used to identify and classify different species. New research on the genetics of pine and mallow species shows that two classes of genetic markers commonly used for plants are often inaccurate, and a different class of marker is much more accurate. Much genetic research has been done on pines and mallows (domestic and wild species of cotton), making them good groups for testing genetic analysis techniques.

The two commonly used markers, chloroplast DNA and nuclear ribosomal DNA, give misleading results up to 30 percent of the time, too high a rate to accurately reveal genetic relationships. Scientists found that DNA sequences derived from multiple low-copy nuclear genes were more accurate. (These genes come from the cell nucleus; "low-copy" means that they have unique, unambiguous identities.) The low-copy nuclear markers gave clearer, more certain information on the genetic relations and evolutionary biology of pine and mallow species. Now that accuracy has been tested, the same markers can be used to study genetic questions in any family of plant species. The low-copy nuclear markers should provide unambiguous answers to questions about relations and evolutionary biology in plant families. Use of nuclear markers can yield more accurate species definitions, clarify relations among the more than 300 sensitive species in the Pacific Northwest, and yield information on interspecies hybridization, a suspected factor in the success of weeds such as cheatgrass.

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Resource Management and Productivity Program

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sea-run coastal cutthroat trout have small, genetically distinct populations throughout their range

Sea-run coastal cutthroat trout are sensitive to the effects of land management on freshwater streams and are often used as an indicator species for stream condition. For the last few years, sea-run coastal cutthroat trout have been a species of concern. The National Marine Fisheries Service has reviewed the status of this fish in Washington, Oregon, and California, and has designated six distinct genetic groups, or evolutionarily significant units (ESUs), for this species. The ESUs are based on scientific information, including the ecological, environmental, and genetic attributes of the coastal cutthroat.

Nan Vance

Station scientists examined populations of sea-run coastal cutthroat trout across their range, which extends from northern California to Prince William Sound in Alaska, to analyze how these populations interact and how distinct they are from each other. They found that compared to other species of anadromous salmon and trout, the individual populations of coastal cutthroat trout had large amounts of distinctive genetic information (genetic information unique to a particular population). This finding suggests that the cutthroat trout populations are more independent and isolated than the populations of the other species. The cutthroat populations on the southern and northern edges of the range were the most distinctive genetically, suggesting that these populations may have the greatest potential for adapting to future changes in environmental conditions. If the same criteria of genetic similarity used to delineate ESUs for other salmon and trout were used for coastal cutthroat, the species would be classified into more than the current six ESUs.

Tom Iraci

This finding can be used in designing conservation programs for sea-run coastal cutthroat trout and in minimizing potential impacts on local populations. It also provides a scientific basis for identifying population segments that could be considered as candidates for listing under the Endangered Species Act.

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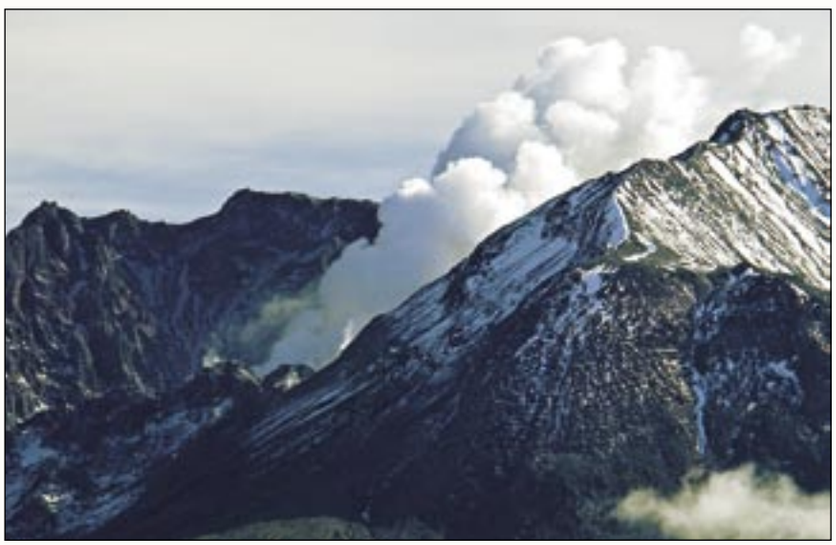
Partners: USDC National Oceanic and Atmospheric Administration Fisheries, Northwest Indian Fish Commission



Tom Iraci

At Mount St. Helens, new eruptions in fall 2004 were part of the continuing disturbances that scientists expect to see at the volcano for decades to come. Studies over the past 25 years have yielded many new findings on disturbance ecology.

ecological recovery at mount st. helens: 25 years of learning

The year 2005 marks the 25th anniversary of the Mount St. Helens eruption on May 18, 1980. Pacific Northwest Research Station scientists and others have been on the ground since a few days after the eruption, and over the years they have been continually surprised by what they have learned about natural recovery from such a large-scale disturbance. Springer-Verlag will publish a book in 2005 on these findings about the long-term biological and physical recovery around Mount St. Helens. The findings will give managers new insights on ecological recovery and restoration planning for severely disturbed areas. See the following two stories for information about some recent findings from Mount St. Helens research.

fish recover faster than expected in food-rich streams and lakes around mount st. helens

The eruption of Mount St. Helens on May 18, 1980, killed nearly all fish in rivers and streams around the volcano. But many fish protected under ice and snow cover in high mountain lakes survived with the notable exception of Spirit Lake, where an avalanche displaced the entire lake temporarily and water refilling the lake was depleted of oxygen for several years. The type and intensity of volcanic disturbance, determined by location of the water body relative to the eruption, strongly influenced ecological recovery; streams and lakes in the path of pyroclastic flows or inundated by mudflows were severely changed, whereas others were less affected.

Scientists have monitored fish recovery for two decades, and the rebound has been remarkable. For the first few years, as the organic forest debris thrown into waterways decayed, oxygen shortages limited fish recovery, especially in lakes. But nutrient-rich lakes and streams eventually created a food-rich environment for fish. Once streambeds stabilized, fish that survived under ice-covered lakes recolonized blast-zone streams. Although stream habitat was poor, with high temperatures, few pools, and little cover, the abundance of terrestrial and aquatic insects in the late 1980s and 1990s led to rapid recovery of fish in streams, showing the importance of food resources for salmon and trout. Likewise, the proliferation of abundant, large trout in the blast zone's nutrient-rich lakes provides further support for the importance of food resources. The first rainbow trout since the eruption was found in Spirit Lake in 1993, and more have been found since.

The 1980 eruption and subsequent recovery are an excellent case study on rates and patterns of fish and stream recovery after a large disturbance. The findings should be relevant for predicting fish response to other disturbances and to fish restoration.

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Partners: Weyerhaeuser Company, Washington Department of Fish and Wildlife, Utah State University

Tom Iraci

feedback loop among mycorrhizal fungi, elk, rodents, and plants is vital for ecological development after catastrophic disturbance

The 1980 eruption of Mount St. Helens killed most plants and fungi over a 230-square-mile area around the volcano. Scientists have found that the reestablishment of mycorrhizae, fungi that live in a tightly coupled relationship with plant roots, is an important part of plant recovery, because most plants depend on their fungal partner for a large part of their nutrients and water. At first, plants grew in small patches where gophers, other rodents, and erosion mixed volcanic deposits with soil. On the pumice plain, patches of lupines grew in symbiosis with nitrogen-fixing bacteria, increasing organic matter and nutrients for other plants.

Mycorrhizae concentrated in these first patches were dispersed most effectively by animals, particularly elk and rodents, that carried the fungal spores in their digestive tracts and deposited them in their feces. Although the mycorrhizae did not improve plant growth at first in the extremely nutrient-poor soil, the lupine patches provided carbon and nitrogen for establishing a mycelial matrix. That matrix encouraged the establishment of plants that depend on mycorrhizal fungi to supply nutrients, and a feedback loop was established. As green patches became more diverse, more animals were attracted to them, further increasing the diversity and dispersal of mycorrhizal fungi; thus more plant species took root, and so on, spreading plants, animals, and fungi across the landscape. The dynamic interactions between plants, fungi, and animals became driving factors for the spread of communities across the volcanic landscape. Within two decades, mycorrhizae were well established throughout all disturbance zones, and most elements were present for forest development to begin.

This work has illuminated some of the most fundamental and important relationships within terrestrial ecosystems. Insights about the role of mycorrhizae in ecological recovery can be applied in restoration after other disturbances, such as wildfires and mining.

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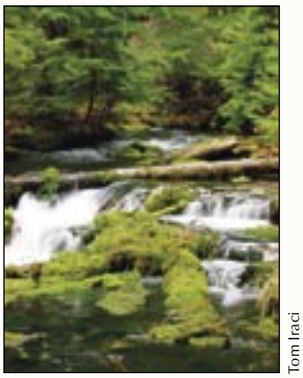
Partners: University of California-Riverside, Utah State University

quantification of regional carbon budgets demonstrates the strong link between climate and the regional carbon balance

Carbon moves between solid and gaseous states, for example, between carbon in trees and other living things and carbon dioxide in the atmosphere. The balance between carbon storage and carbon release is a critical factor in climate change. Attempts to define U.S. carbon sinks at the regional level have been full of uncertainties and contradictions. Scientists simulated the variability in the carbon stored by natural ecosystems from 1895 to the present in regions of the conterminous United States. The largest simulated variations in carbon fluxes occurred in the Midwest where large fires decreased vegetation biomass and soil carbon pools. The Southeast showed decadal-type trends in response to climate variations. The drought of the 1930s was most obvious in the Midwest and the Great Plains where it depleted soil carbon reserves. The Northeast showed the smallest amplitudes in the variation of its carbon stocks. Western region carbon dynamics reflected the effects of prolonged drought periods as well as regional increases in rainfall from climate regime shifts.



Tom Iraci

Tom Iraci

Forests store carbon in solid form, but fires release carbon into the air as a gas. Carbon dynamics and regional carbon budgets are part of the research being done on climate change.

Tom Iraci

Rather than predicting accurate levels of carbon sequestration or losses, this study highlighted areas that are most sensitive to small changes in predicted rainfall and temperature. As policymakers begin accounting for carbon sequestration, the distinction between human and natural causes of sequestration will become increasingly critical, and this work will assist in evaluating those issues.

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Partner: Oregon State University

models indicate potentially large impacts of climate change in california

California is an ideal venue for studying the potential effects of climate change on plant distribution, carbon storage, and fire. The state is arguably the most climatically and biologically diverse region in the country, and it is also home to over 30 million people. Global climate change will likely interact with and intensify the pressures of the state's growing population on its natural ecosystems.

To investigate the sensitivity of California's ecosystems to climate change, scientists dynamically simulated the response of vegetation distribution, carbon, and fire in the state to contrasting scenarios of climate change. Using MC1, a state-of-the-art dynamic vegetation mapping model that simulates fire over broad scales and changes plant distribution, growth, and nutrient cycling results in response to simulated climate changes, scientists projected reductions in the extent of alpine meadows and subalpine forests with increasing temperature. They also found that shrubland and woodland acres would be lost to forest under wetter scenarios, or lost to grassland under drier scenarios. All scenarios resulted in 3 to 6 percent increased carbon storage. Wetter scenarios produced larger increases in carbon stored in vegetation, and drier scenarios produced more soil and litter carbon. Drier scenarios also produced more frequent fires and greater burned areas. Wetter scenarios produced less frequent, but larger, fire events owing to greater fuel production that burned during the occasional dry years.

These findings have implications for timber production, biodiversity, fire management, and carbon sequestration in California. The MC1 ecosystem forecasting study was a key element of a larger project conducted by the Electric Power Research Institute for the California Energy Commission designed to help the state's natural resource managers and other policymakers better understand the potential effects of climate change on the state and develop adaptive policies.

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Partners: California Energy Commission, Electrical Power Institute, Yale University, Stratus Consulting

gravity affects height growth rate of large trees

The height of trees in a stand is one factor used by silviculturists to determine the quality of a site, but very little is actually known about the underlying processes that influence height growth patterns. Research at the Wind River Canopy Crane Research Facility in Washington and other locations showed that gravity plays a major role in limiting the height of trees. Gravity's force makes it difficult for taller trees to transport water to their uppermost leaves and branches and also reduces the turgidity, or internal pressure, of individual plant cells, which ultimately decreases leaf

Tom Iraci

The Wind River canopy crane has given scientists access to old-growth tree canopies, leading to new findings on tree physiology and canopy ecology.

and stem expansion and the emergence of buds. Collectively, these effects translate into increasingly slower growth rates as trees grow taller.

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Partners: Oregon State University, University of Washington

scaling of water use with tree size is not universal

A recent hypothesis asserts that as trees undergo dramatic increases in size from seedlings to large trees, their use of water and other resources increases in a universal manner for all species. However, using research conducted at the Wind River Experimental Forest in southwest Washington and other sites, scientists found that the changes in water use in relation to tree size, or scaling, were universal only among 17 flowering tree species, but differed from that of five Pacific Northwest conifer species. Water use scaled consistently with tree size within certain groups of conifers, but not others. Moreover, the type of scaling model obtained for both conifers and flowering trees was fundamentally different from that proposed in the universal scaling hypothesis.

This information is important to forest ecologists, hydrologists, and those involved in the management of watersheds, where the effect of tree size and species composition on water yield are of concern.

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Partners: Oregon State University, University of Washington

region's conifers opportunistically acquire water in summer

Although the Pacific Northwest is well known for its generous rainfall, forests in the region experience severe droughts in summer. Research conducted at the Wind River Experimental Forest in southwest Washington has shown that conifers in the region's forests are structurally adapted to maintain relatively stable water uptake rates throughout summer, despite the shortage of rainfall. Scientists found that the conifers have deep roots that allow the trees to access water stored in deeper soil layers as the upper portion of the soil

Tom Iraci

dries during summer months. In an old-growth Douglas-fir stand, scientists found that, at the beginning of summer, more than 60 percent of the water taken up by trees comes from the upper 1.5 feet of soil. But, by the end of summer, only about 20 percent of the water acquired comes from this layer, yet the trees are still using considerable amounts of water.

Many current models of forest ecosystem behavior fail to acknowledge the role of deep roots in water acquisition; these findings will contribute to formulating new, more accurate models of forest behavior during droughts and have implications for hydrological models that predict the seasonal behavior of forested watersheds.

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Partner: U.S. Environmental Protection Agency, University of Washington, Oregon State University

douglas-fir show more drought effects than previously thought

Conventional wisdom and limited scientific literature have suggested that Douglas-fir, the most common commercial timber species in the Pacific Northwest, is not very sensitive to variation in climate. Recent data from the Cascade and Olympic Mountains suggest that in fact Douglas-fir is sensitive to the combined effects of dryness and temperature, with the potential for summer moisture stress. Growth in tree diameter was found to be less during years with low rainfall, especially at low elevations and dry sites, and was typically less during years with short growing seasons, especially at higher elevations. Douglas-fir growth is also sensitive to prolonged drier and wetter periods that are characteristic of the Pacific Decadal Oscillation.

Tom Iraci

The finding that Douglas-fir is sensitive to climatic variability has implications for managing this species for timber production and ecological values. Douglas-fir growth may be expected to be more sensitive than previously thought to anticipated climate variations.

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Partners: USDI Geological Survey, USDI National Park Service, University of Washington

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understory plant growth and abundance limited by belowground competition

A forest's understory plants are affected not only by the amount of light or shade but also by conditions belowground, such as root competition. Scientists studied the effect of reduced root competition, achieved through root trenching—the mechanical separation of roots and creation of belowground gaps—on vegetation in closed- and open-canopy locations in mature western Cascade Douglas-fir forests in northern Oregon and southern Washington. They found that trenched study plots averaged 92 percent total understory cover, whereas untrenched plots averaged 47 percent cover. They also found, contrary to their expectations, both vegetation and soil moisture responses to trenching were greater in areas of high tree canopy cover than in gaps with more sunlight. Scientists hypothesized that forests with thick canopy cover may have denser systems of roots, making the effects of reducing root competition more apparent. The soil in trenched plots was much moister than soil in untrenched plots, regardless of the trenched plots' canopy density.

Scientists concluded that understory plants at these sites were limited at least as much by belowground competition as by aboveground competition. These findings are contributing to the understanding of understory-overstory interactions and influences on understory growth, which is important browse and cover for wildlife species.

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Partners: Oregon State University; PNW Ecosystem Processes Program

hyporheic macroinvertebrate communities within different southeast alaskan stream types

The subsurface water under a stream channel or flood plain (hyporheic water) is not lifeless. Scientists are finding entire invertebrate communities living in hyporheic waters. In southeast Alaska, Station scientists found that hyporheic chemistry and invertebrate community structure differ among three stream types and within major habitats.

Tom Iraci

Bob Szaro

In the Tongass National Forest, three dominant stream types are glacial-meltwater streams, clearwater streams, and muskeg streams. Scientists measured dissolved oxygen, water temperature, specific electrical conductivity, and the dissolved nutrients carbon, phosphorus, and nitrogen, during the summer of 2003. Significant differences in dissolved carbon were observed, with low levels in the glacial stream, intermediate levels in the clearwater stream, and high levels in the muskeg stream. Preliminary data indicated that hyporheic invertebrate diversity and abundance differed among streams and across sample sites within the same stream type. The dominant taxa included true flies, nonbiting midges, stoneflies, green stoneflies, and segmented worms.

Further research will build on these preliminary results, eventually furnishing the first data on biodiversity of hyporheic communities in southeast Alaska. Hyporheic communities may actually be more diverse than instream communities. Also, the hyporheic organisms cannot migrate as easily as instream organisms if water quality fluctuates, so their presence—or absence—can reveal conditions not apparent when samples are taken, such as sediment flushes during storms.

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Partners: Michigan State University

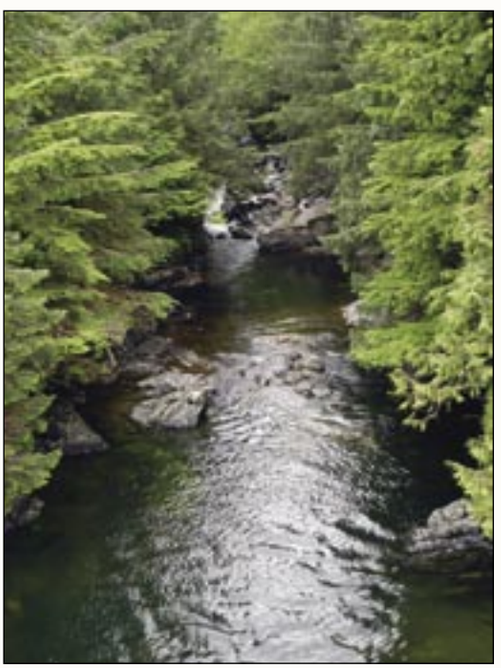
peak movement occurs in fall for small dolly varden and cutthroat trout in southeast alaska streams

Station scientists found that in southeast Alaska high-gradient streams, Dolly Varden, a char, and cutthroat trout move upstream and downstream during all seasons, but peak movement occurs during fall when high-flow events are common. Few fish move during winter, and most of those that do move downstream. The number of fish detected moving upstream decreased as the stream stage, or flow level, increased. Movement was detected by tiny, passive integrated transponder (PIT) tags implanted in fish from 3 to 6 inches long. Two stationary antenna-transceiver systems were installed in the study stream, the PIT tag numbers recorded each time a fish passed a transceiver, and the time recorded as well. Stream flow level was recorded separately.

Pete Bisson

The Tongass National Forest may have to replace some 2,000 culverts; if so, findings on the movement of fish in Alaska streams will contribute to replacement and design criteria.

Federal law requires that normal migration and movement not be disrupted for aquatic organisms, and state of Alaska law requires no artificial blocks to fish passage in all streams except during peak streamflows that occur 1 to 2 percent of the time (at peak streamflows, the high-velocity flow through culverts may temporarily prevent



Tom Iraci

Southeast Alaska streams are famous for their wild salmon. Research on fish migrations and also on biodiversity in subsurface waters contributes to conserving and managing the wild salmon.

Bob Szaro

fish from swimming upstream). To meet federal standards, the Tongass National Forest may have to replace more than 2,000 culverts, with a potential cost of $20 million total. The findings on fish movement will contribute to criteria for culvert replacement and design.

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Partner: USDA Forest Service, Tongass National Forest

yellow-cedar decline is associated with factors influencing soil temperature

Yellow-cedar, a valuable tree species, is dying on nearly half a million acres across southeast Alaska. No scientific explanation has been found yet, although previous research has found associations with soil temperature variations and possibly soil nutrient chemistry. A team of scientists from two research stations and two universities is investigating risk factors associated with the cedar decline, and they have found additional clues. The severity of yellow-cedar decline follows soil temperature isoclines on the landscape (contour lines that show temperature gradients rather than elevation gradients). The team has found evidence that factors influencing soil temperature, such as snowpack and exposure, combined with seasonal cold tolerance, may be closely related to the mechanisms of decline.

Bob Szaro

These results have led to expanded cold-tolerance experiments in collaboration with the Northeastern Research Station and the University of Vermont. Although scientists do not yet have definitive evidence of a specific mechanism related to the tree death, the new work is a big step forward, focusing research on climate-related factors. The climate link has interested researchers from the University of Alaska, Fairbanks, who are studying regional climate change, and spurred them to join the research team.

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Partners: USDA Forest Service, Northeastern Research Station; University of Vermont; University of Alaska, Fairbanks

environmental risk factors associated with yellow-cedar decline have been identified and assessed

A risk-analysis approach has been used at two small watersheds to evaluate the most likely environmental variables that could cause extensive yellow-cedar death in southeast Alaska. Hydrology and soil chemistry are associated factors, but the most promising potential causal factor appears to be related to exposure. Areas of dead trees have more extreme variation in air temperature during most seasons, and generally warmer soil temperatures, especially in early spring. Cover, in the form of live tree canopies or snow, significantly delays spring soil warming. It is hypothesized that this warming contributes to dehardening and other phenological processes, making yellow-cedar more susceptible to springtime freezing. A companion study demonstrates that yellow-cedar has a high degree of cold tolerance (that is, freezing resistance) in fall and winter, but dehardens in spring earlier than the associated western hemlock.

This new information brings scientists closer to understanding the cause of yellow-cedar decline and the contributing role of a warming climate. Monitoring of environmental variables, including snowpack, is being expanded to new sites and includes testing the soil warming-dehardening hypothesis with seedlings. These findings will be integrated with applied research on the value

of wood from dead trees and methods of regeneration to help formulate an overall management strategy for this valuable tree species.

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Partners: PNW Resource Management and Productivity Program

Tom Iraci

PNW Station research on southeast Alaska wetlands is being used by Native Alaska corporations, private industry, and federal, state, and local agencies.

southeast alaska wetlands export dissolved organic carbon to streams

Carbon cycles and budgets, always important ecologically, are now also a focus of climate change research, as carbon sources and sinks in nature play a key role in how much free carbon reaches the atmosphere. Wetlands are major sources of dissolved organic carbon (DOC) and can provide a great deal of carbon to streams through the export of DOC.

Southeast Alaska has many wetlands, but little was known before about their soil carbon budgets. Station scientists and partners have found that peat in southeast Alaska wetlands sequesters, or stores, hydrocarbons and lead, but the lead is much more mobile than had been thought and could possibly influence fish-bearing streams. Another study showed that in watersheds dominated by wetlands, the carbon concentration in streams varied more by season than in watersheds with less wetland area. In some watersheds, DOC sources shift from soils, where waterflow moves the DOC from decomposing matter downslope, to the streams themselves, during salmon-spawning season.

These studies contribute basic knowledge about the carbon cycle, DOC movements between ground and streams, and in particular the role of wetlands, in watersheds with significant wetland acreage. The research has established basic values for carbon, nitrogen, and phosphorus that will be used to develop methods for evaluating watershed conditions. Also, the findings are useful in estimating the carbon content of southeast Alaskan soils, as part of global carbon budget research.

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Partners: University of Alaska, Southeast; Alaska Department of Environmental Conservation

Bob Szaro

new tool

southeast alaska wetlands guidebook

Description: Station scientists made major contributions to the hydrogeomorphic (HGM) approach, which is widely used to evaluate riparian wetlands in southeast Alaska. The HGM approach distinguishes wetland types by using soils and landforms as criteria, owing to their influence on hydrology. Researchers developed a rating system for wetland functions based on conditions measured in reference wetlands.

Function: The rating system establishes objective criteria to evaluate wetlands with a rapid assessment method and to evaluate changes in wetland functions over time.

Outcome: Managers are already using the guidebook, and the team is developing similar guides for other wetland types in southeast Alaska. The guidebook is being used to evaluate regional wetland mitigation banks proposed by private industry and federal, state, and local agencies. In particular, Sealaska Corporation, a Native Alaskan-owned corporation and the largest private landowner in southeast Alaska, is using the guidebook as it establishes a wetland mitigation bank.

Partners: Alaska Department of Environmental Conservation; University of Alaska, Southeast

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

Continue to Part 2