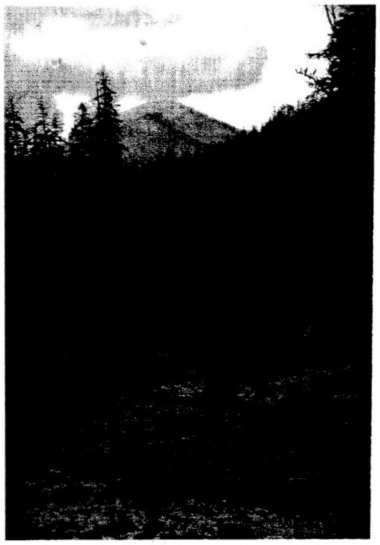


WATER: It covers a lot of territory

Water-related research is looking at large landscapes over long periods

Water. It is everywhere in the physical environment. Our Earth's landforms owe their shape in large part to the movement of water, and water is the primary constituent of all living cells.

Water represents many powerful forces, not least the power of nature, manifested in sometimes-frightening ways: floods that wash out bridges, and landslides that crush homes.

Because water is vital to our lives, people care about it. They worry about having enough good water to support human communities. They worry about keeping watersheds in a suitable condition for the fish and other wildlife that depend on them for survival.

They also worry about whether managed forests can furnish both high-quality water and healthy fish and wildlife populations in our watersheds. For these reasons, a lot of forestry research, at OSU and elsewhere, is devoted to the role of water in forests.

Taking the measure of the stream. *Above, Lookout Creek flows down from Lookout Mountain in the Andrews Experimental Forest. Opposite, researchers on a Forest Service site in the mid-1960s.*

Connections

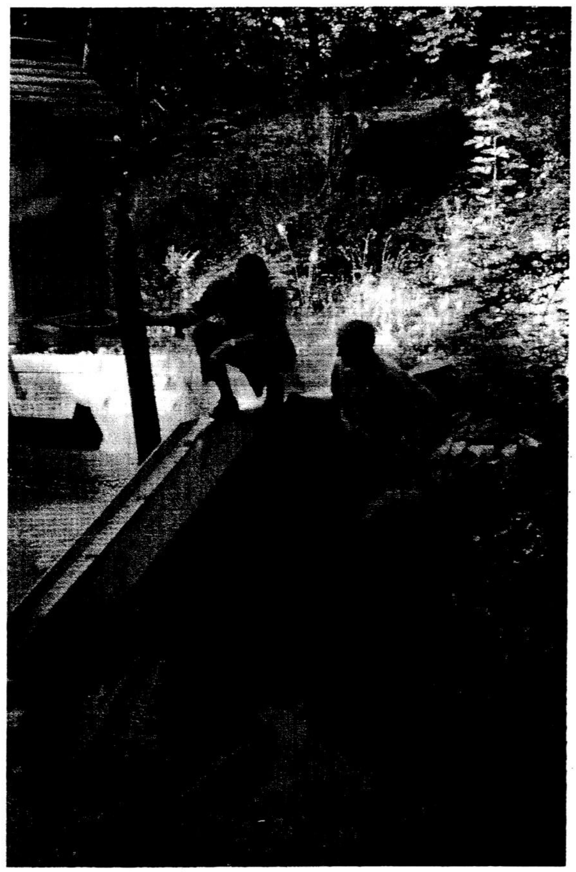
Scientists who study water-related topics are increasingly interested in how water relates to our broader environment—its landscape and ecological connections. They want to better understand how water processes in forests shape river channels and hillsides, how they influence the growth of trees and other plants, and how they affect the life cycles of salmon and salamanders. They want to know how these processes themselves shape, and are shaped by, the needs and desires of human communities.

Like water itself, this research covers a lot of territory. More and more, it tends to look at large landscapes over long periods. Tools like geographic information systems, satellite imaging, and powerful computers are helping to provide new ways to conduct large-scale studies. And faithful measurements of research plots over the years are yielding ever-richer sets of data for scientists to work with.

This research is shedding light on such urgent questions as how well fish can handle disruptions in their habitat (answer: they have persisted in an environment of periodic natural catastrophes, but there are limits beyond which they won't thrive), and whether logging and roadbuilding increase the likelihood of landslides (probably, but not as much as some people think).

It is helping citizens and lawmakers grapple with tough issues. How much do forest practices influence flooding? Sediment? The amount of water in streams? Careful research, says Paul Adams, helps people probe the simplistic conclusions, the plausible explanations that are sometimes wrong or at least misleading.

"Of all the important messages that the forestry profession needs to get across to the public," says Adams, a Forest Engineering professor and Extension watershed specialist, "the most important is the two simple words, 'It depends.' So often the media repeats broad generalizations, like 'clearcutting causes erosion which harms fish habitat.' Those who know the research know there are many qualifications to this, and that in many instances the statement is wrong."



Adams recently reviewed more than 100 papers and reports on the effects of timber harvesting on water quantity and quality. His conclusion: the research says the effects are sometimes positive, sometimes negative, sometimes mixed, and often insignificant. There was a lot of variability among sites, and some of the impacts, says Adams, stem from logging practices that are no longer common, or even legal.

"The public has the misconception that we're still in the Dark Ages on the problems facing our watersheds," Adams says. "In fact, we've learned a lot, and we're already applying that knowledge to prevent most problems of the past."

"The public has the misconception that we're still in the Dark Ages. In fact, we've learned a lot."

—Paul Adams

Streamside management

Starting about four decades ago, forestry research at OSU began to move toward the long-term, landscape-level studies that are coming to be of great interest to scientists today. The Alsea Basin cooperative watershed study, begun in 1959, was the first in the Northwest to combine measures of water quality, stream-channel habitat, and fish response to logging across several watersheds.

The study compared the effects of complete clearcutting and hot slash burning on nearly an entire basin—the accepted practice of the day—with those of clearcutting three separate patches of 40 to 65 acres each in another basin, leaving 50-to-100-foot stream buffers. Measurements in both basins were compared with those taken from an untreated control basin.

The study sites were three small watersheds in the Alsea River drainage, about 10 miles from the Oregon coast. The work was done by agency and OSU scientists, including a young forest hydrologist named George Brown (please see profile of Dean Brown on page 14).

The Alsea study was innovative in many ways. It prescribed seven years of information-gathering before any logging was done. Measurements were taken for seven years afterward, producing relatively long-term data on the effects of logging on fisheries.

Concurrent watershed research on the Andrews Experimental Forest, a cooperative OSU-Forest Service research forest on National Forest land east of Eugene, was already looking at the effect of logging on erosion and water runoff. The Alsea study extended this work by becoming the first in the Northwest to look at the impacts of logging on fisheries.

Changing forest practices

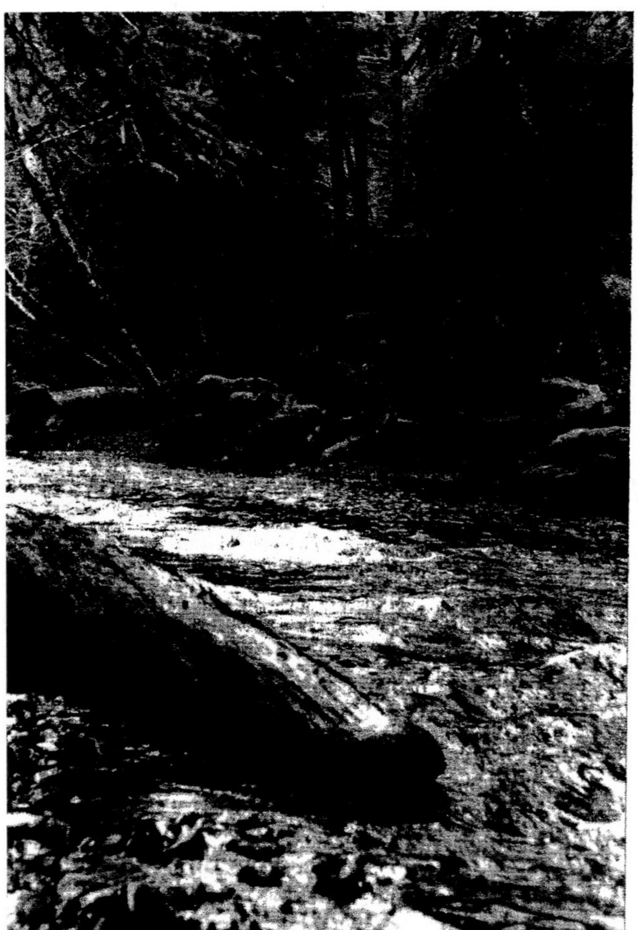
More importantly, the Alsea study results were the first to influence Oregon forest practices in a major way. The study found a five-fold increase in sediment in the stream after intensive logging and slash burning. The suddenly unshaded streams also became too warm for fish to thrive.

These findings were instrumental in justifying the 1971 Forest Practices Act and subsequent rules, which called for leaving a strip of streamside trees and other riparian vegetation to "buffer" the negative effects of logging on the stream. Riparian buffer strips have been an important regulatory tool for protecting streams ever since.

The considerable volume of stream research conducted since the Alsea study has revealed more about what makes for good fish and wildlife habitat in and along streams. Some of it has contradicted earlier, seemingly commonsense policy.

For instance, during the 1960s and 1970s, loggers often were required to remove logs and branches that fell into streams during logging operations, along with wood that had accumulated naturally. It was thought that too much wood in the stream channel would block fish from swimming upstream to spawn.

How much is enough? *Researchers are looking at what happens to woody debris in streams (below) over time and refining their prescriptions for how much is needed.*



There was indeed quite a bit of logging-related debris in many Oregon streams at the time, and people were also worried that it would wash out bridges and cause flooding during major storms. In addition, there was some concern—stemming from other Alsea Basin findings—that large quantities of decomposing plant material used up the dissolved oxygen in the water, stealing it from the fish and other aquatic life.

So it was not uncommon for fisheries agencies to require loggers to clean the streams with cable yarding equipment or even bulldozers. Often they removed even the woody debris that was already in a stream before the area was logged.

Then OSU scientists, including Hank Froehlich, a now-retired Forest Engineering professor, as well as fisheries biologists Jim Sedell and Stan Gregory, pointed out that streams in unmanaged forests were full of chunks of wood, big and small. And the fish seemed to thrive in these streams.

These observations, and subsequent studies that proved them right, turned forest practices around. Now it's not unusual for loggers to drop logs and stumps into streams that are judged to lack sufficient woody debris. Some management objectives call for logging alder (carefully) from streambanks in order to establish conifers, which make larger-sized, longer-lasting woody debris when they eventually die and fall into a stream.

Recent research is also showing that some of the large wood now lying in streams did not fall in from the immediate streambank, but entered the stream in landslides from steep terrain farther upslope. This finding is helping managers refine strategies for leaving trees in places where they will achieve the most effective environmental benefits.

The book is not yet closed on woody debris. There are undoubtedly differences in function between a 700-year-old log that fell into a stream in 1915 and a 100-year-old log that was placed there last year after a harvest operation. There's still uncertainty about how much woody debris is enough, where in the stream it does the most good, and what its precise effects are on fish and other aquatic life.

College of Forestry scientists and their research partners in the College of Agricultural Sciences, the Forest Service Pacific Northwest Research Station, and other agencies are continuing to probe these questions. Scientists and forest managers are also working together to monitor the habitat effects of both natural and artificially placed wood chunks in forest streams over time.

Landslides and floods

Today's research is forcing a rethinking of the common notion that landslides and floods are always "bad." Northwest forests are dynamic and unstable places. Large swaths of trees were periodically flattened by wildfires, floods, and windstorms before humans arrived on the scene.

For people, landslides and floods can be inconvenient and occasionally tragic—washing out roads and bridges, and sometimes taking human life. For fish and other wildlife, they can thoroughly disrupt habitat functions in some locations.

Nevertheless, these events are part of the pattern of large and small disturbances that gives the Northwest forest its essential character. The fish and wildlife species living in these forests are adapted to surviving and thriving in a dynamic landscape, where major disturbances come and go in a recurring though irregular fashion.

The February 1996 floods brought flood and landslide issues into sharp focus. "These are natural events happening in a managed landscape," says Fred Swanson, Forest Service geologist and courtesy professor in the Forest Science Department, "and they vividly illustrate how complex are the watershed and ecosystem responses to floods, especially floods in steep, forested landscapes."

Swanson is a team leader at the H.J. Andrews Experimental Forest, which is managed jointly by the Forest Service Pacific Northwest (PNW) Research Station and the Willamette National Forest, with OSU as a research cooperator. College of Forestry scientists are collaborating with Forest Service scientists and others in many studies on the Andrews.

> Today's research is forcing a rethinking of the common notion that landslides and floods are always "bad."

College scientists serve on salmon team

Five OSU faculty members, including two from the College of Forestry, are serving on a seven-member scientific panel that oversees salmon recovery efforts in Oregon, efforts collectively known as the Oregon Plan.

The OSU team members are John Buckhouse of the Department of Rangeland Resources; Stan Gregory of the Department of Fisheries and Wildlife; Katy Kavanagh, a Forestry Extension and Forest Resources faculty member; Logan Norris, head of the Department of Forest Science and chair of the team; and William Pearcy of the College of Oceanic and Atmospheric Sciences.

The team, which reports to the state legislature, is assessing the scientific credibility of conservation efforts by state agencies and groups of local citizens. Its members act as peer reviewers of agency land management plans and the plans of local watershed councils. Its findings will amount to an ongoing scientific review of the Oregon Plan.

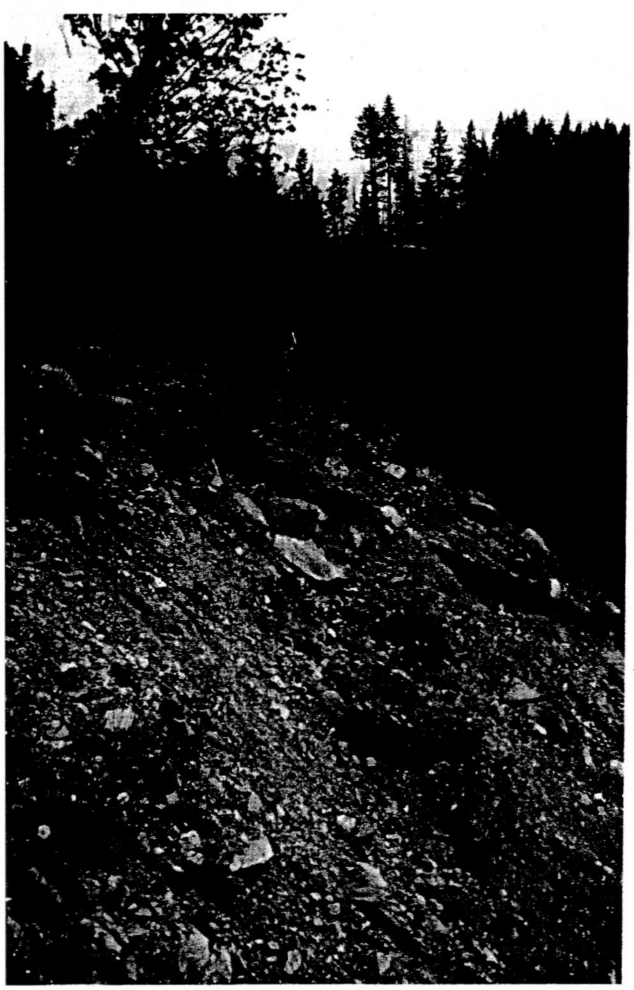
Other team members are Wayne Elmore of the Bureau of Land Management and Jim Lichatowich, a private consultant.

A dynamic landscape. Slides like this one occur throughout the Coast Range, in both managed and unmanaged forests.

The floods, Swanson says, have inspired new studies and new looks at long-term sets of data. Partly because of its political currency, forest hydrology—the study of how water behaves in a forested environment—is undergoing "a quantum step" in sophistication, he says. "Our ability to understand the inner workings of a watershed is greater than ever before."

Even so, scientists still can't say for certain which flood and landscape effects are wholly natural and which ones are influenced by forest management, and how much they are influenced. Studies on how logging and roadbuilding affect high water flows in streams, for instance, have been conducted by disparate methods in several quite different watersheds, leading to varying conclusions that have sparked vigorous scientific debate.

It all comes back to complexity—the tangled web of causes and effects in a natural system that has been heavily influenced by human activity. The complexity can be bewildering, making it tempting for nonscientists, especially, to simply throw up their hands. Says Swanson, "There's a tendency to conclude that the world is *so* complex that we can't regulate practices and assign responsibility. But science is saying, 'Let's go on to the next step. Let's try to disentangle the complexity with new studies.'"



Swanson was one of six team members on a study conducted jointly by OSU, the Forest Service, and the City of Salem to determine why such massive quantities of sediment flowed down the flooded North Santiam River in the spring of 1996, during and after major storms. The sediment prompted water bureau managers to shut down Salem's municipal water-treatment system for eight days.

Logging and roads in the National Forest watersheds in the upper North Santiam basin seemed to some to be the obvious cause. Yet the study, which used X-ray and electron microscope analysis to "fingerprint" soil particles in stream water and determine their origin, challenges that assumption.

Smectite clays, the smallest of the clay-mineral particles, are common in unstable soils in the Cascades. Because they settle slowly, smectite clays are also the main constituent of the most persistent turbidity in streams, and the cause of many water-quality problems.

The North Santiam study found that much of the smectite clay responsible for the turbidity came from the bottoms, or "toes," of ancient, large, deep-seated landslides in many places in the watershed. "This indicated that natural erosion processes and identifiable source areas were major contributors," says Swanson. Roadcuts and smaller, shallower landslides in steep areas also contributed some clay, but in smaller concentrations.

The timing of the sediment's flushing down the river was complicated by releases of water from Detroit Lake, which acted as a catch basin for silt. Water released through Detroit Dam over the few weeks after the flood carried sediment still suspended in the lake waters.

Finally, the team concluded, the first flush of sediment probably came mostly from sources below the dam, where many human influences, not only logging, have made a heavy imprint on the landscape.

"Overall, this study improved our understanding of the inner workings of the watershed," says Swanson. "We can use these findings to identify the kinds and locations of remediation or regulation practices we need, and to provide a technically sound foundation for public discussion."

Where does the sediment come ***from?*** *In one study in the Cascades, some sediment entered streams as a result of recent landslides (as in the photo at right, taken in the Coast Range), but more appeared to come from erosion processes at work on ancient earthflows.*

Where does the sediment come from? *In one study in the Cascades, some sediment entered streams as a result of recent landslides (as in the photo at right, taken in the Coast Range), but more appeared to come from erosion processes at work on ancient earthflows.*

Signal and noise

"The natural signals from the Northwest forest landscape are very noisy," says Marv Pyles, professor of Forest Engineering and one of four College of Forestry authors of a special report to Oregon Governor John Kitzhaber on forest practices and landslides, prepared in the aftermath of the 1996 floods.

"Landslides are aperiodic and unpredictable, and they happen in the absence of human activities," he says. "We are usually powerless to know whether a particular landslide would have occurred had there been no management in the vicinity. We have a number of widely varying historical averages for landslide activity, but they don't help in predicting specific events."

Does forest management—logging and roadbuilding—increase landslides? The science is not quite so emphatic as some of the opinions in the popular media, Pyles says. "Our highest-quality data say yes, but the data are so variable that it's not a profound yes. Logic and reason and physics suggest that the changes we make in the forest landscape contribute to instability. But we can't put a watershed-wide, forest-wide, or state-wide number on it."

Pyles and his team, which included Forest Engineering professors Paul Adams, Bob Beschta, and Arne Skaugset, looked at on-the-ground survey results to get an accurate picture of where slides have occurred, how much earth was moved, and where it landed.

Most other landslide inventories used only aerial photos, yielding an incomplete picture, Pyles says. "From the air, you can't see many of the natural landslides that occur under forest cover. So these don't get counted." And that makes the link between logging and landslides look stronger than it really is, he says.

The state legislature, in response to public concern, gave the Oregon Department of Forestry authority to temporarily ban logging on areas identified as high-risk for slides, and where a slide might endanger human life. "It's important, though, for the public to recognize that the hazard exists even in the absence of forest management," says Paul Adams. "Logging may increase the risk, but the risk is there to start with."

A good home for fish

Some dirt in the water is not a bad thing for anadromous fish, those salmon and trout species that grow to maturity at sea but return to their native rivers to spawn. In fact, the particular mix of soil particles in a river may be one of the signals that lead fish back to their native streams.

Excess sediment, however, or sediment in the wrong places or at the wrong times, is not good for fish. It's one of the several factors that contribute to the degradation of habitat for anadromous fish in the Northwest, and the subsequent decline of their populations.

What's to blame for this decline?

"People don't realize how variable these forests are."

—*Dave Hibbs*

Patchy and complex. *Above right, trees and shrubs grow alongside forest streams in a wide variety of patterns. Often there are hardwoods and shrubs along the stream and conifers farther upslope, but not always. Across, this CLAMS map shows another complex pattern, of land ownership in the Alsea Basin in Oregon's Coast Range.*

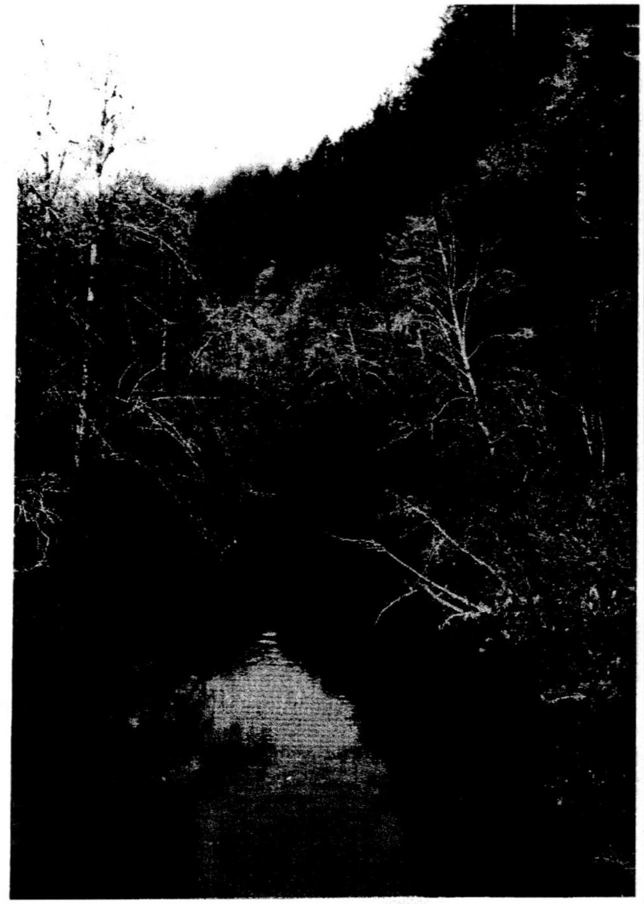
The list is long: dams, buildings, roads, parking lots, urban and suburban life, historical overfishing, today's commercial and sport fisheries, hatchery operations, predators, forestry, farming, ranching, mining, manufacturing—all the human activities that fall under the heading of "development." Natural temperature cycles in the ocean also play a large role, as do predators and diseases.

Given the many interlocking factors, how should society minimize the negative effects of logging and other development? Scientists agree that the quality of fish habitat is crucial. In streams flowing through Northwest forests, good habitat means lots of large woody debris—not only dead wood in the stream today, but standing live trees to fall in at some time in the future. It also means streambanks bearing conifers, hardwoods, and shrubs in some optimal or at least adequate mix.

Exactly what such a mix should look like, however, is a matter of some debate. "People often don't realize how variable these forests are, in both space and time," says Dave Hibbs, a Forest Science professor and expert in streamside hardwoods. "In unmanaged forests, as you move up and down the stream, you run into all kinds of conditions—conifers, hardwoods, shrubs, old trees, young trees, no trees. It's a very patchy set of vegetation patterns that shifts around through time. Whether you manage or whether you leave the forest alone, things are changing all the time."

Some scientists call for leaving streams alone as much as possible to repair themselves. "The first step is to stop doing whatever is causing the damage," says Bob Beschta, a forest hydrologist and Forest Engineering professor. "This is called passive restoration—letting nature heal itself."

Others (including Beschta, sometimes) advocate a more active approach. We've already noted one example: studies conducted by College scientists are looking at the effects of logging alders out of the streamside area and regenerating conifers there.



The big picture

Whatever measures are chosen, whether active, passive, or some mixture of the two, managers are increasingly considering an ecosystem-wide perspective, one that focuses on the connections among processes across the landscape.

Problem is, no one knows exactly how to do that. Science offers a lot of information about discrete *pieces* of the landscape—stream reaches, riparian areas, stand-size patches of forest, snags where woodpeckers live. But until recently there was very little knowledge about how all these pieces fit together, how seemingly unrelated events are linked across miles of ground or decades of time.

Now, satellite landscape imaging and powerful computers are broadening the view. They are offering a wall-to-wall picture of the current conditions of a given landscape, clues about how each part affects the other parts, and ways to predict the landscape's various potential futures.

A cooperative research program dubbed CLAMS (Coastal Landscape Analysis and Modeling Study) is pioneering a landscape-level study of the Coast Range. CLAMS scientists are using satellite images, along with information about current conditions on the ground and the intentions of landowners, to build computer models projecting how the nature and timing of various management strategies might play out on the watersheds of the Coast Range over the next 100 years.

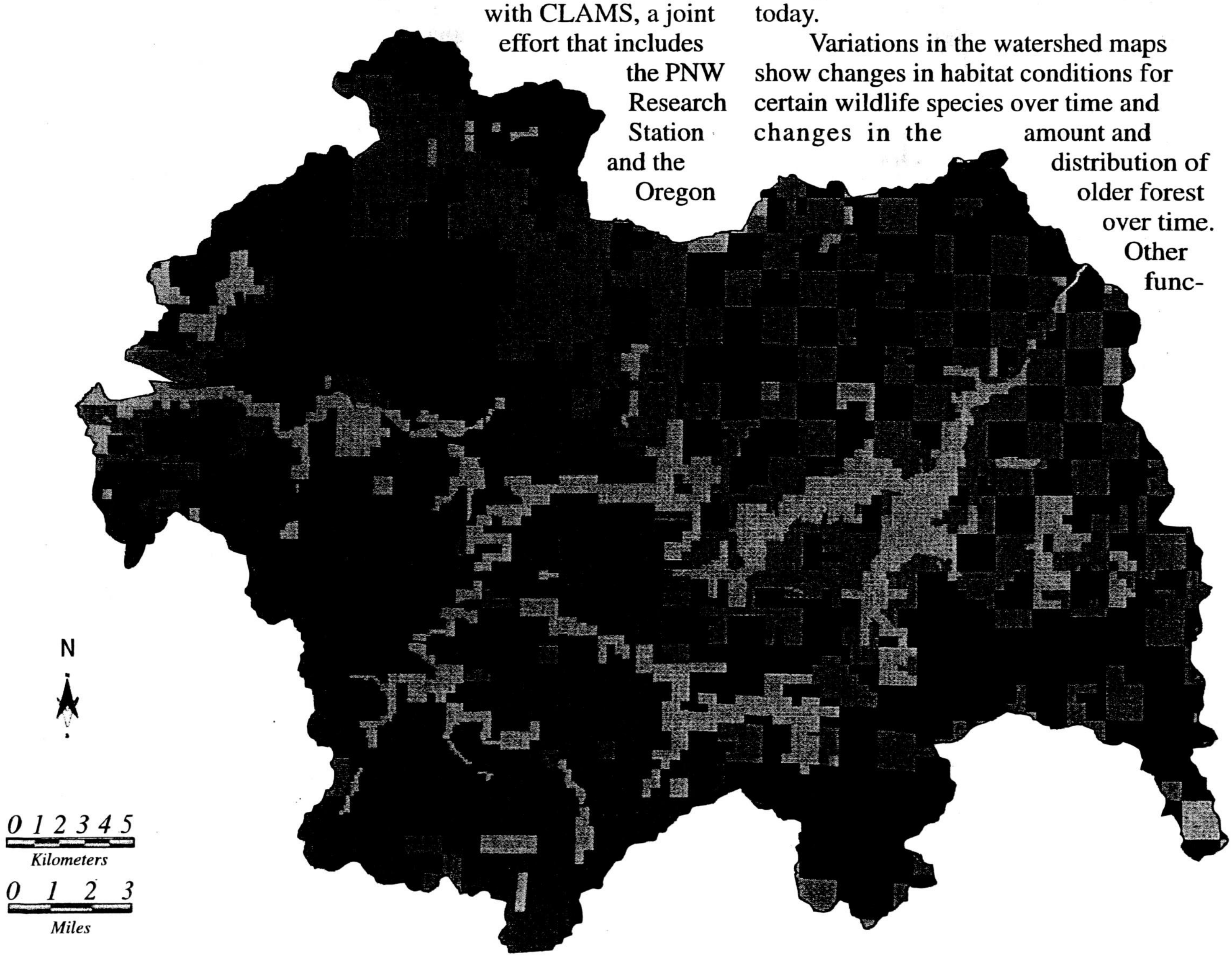
The models will predict not only how the trees and other vegetation will look at various points in space and time, but how their distribution will likely affect fish and wildlife habitat, recreational opportunities, and the area's economy.

It's an ambitious goal, says Norm Johnson, professor in the Forest Resources department and a lead researcher with CLAMS, a joint effort that includes the PNW Research Station and the Oregon Department of Forestry. With its rugged landscape, checkered history of natural disturbance, complicated ownership patterns, and disparate effects of past land management, the Coast Range is about as varied as a landscape can be. This variability makes it difficult to trace meaningful patterns and connections.

"We've had some practice at projecting outcomes of various management strategies for the whole landscape, but only in the aggregate over time," says Johnson. "Now we have the capability of simulating the spatial *distribution* of these activities across the landscape."

Results of each simulation are displayed on maps showing what the forests of the Coast Range might look like at various points in the future, if certain management choices were set into motion today.

Variations in the watershed maps show changes in habitat conditions for certain wildlife species over time and changes in the amount and distribution of older forest over time. Other func-



tions of the model predict how these conditions may affect timber income and recreational opportunities in the area.

Joint learning

The CLAMS maps, says Norm Johnson, are not only powerful discovery tools for scientists; they are learning tools for policymakers and the public. An important objective of CLAMS, he says, is to make it possible for people to discuss the outcomes of alternative policies before they are adopted. "These maps seem to draw people into the analysis. They create a high level of interest—people can place themselves in the landscape, and envision what the outcomes of various policies might look like. That makes the maps a great tool for joint learning."

And the more educated and involved people are, says Johnson, the more likely it is that they'll act in an informed and deliberative way to craft a sound, long-term public policy. "My hope," he says, "is that our work will lower the level of rhetoric and increase the level of understanding for all of us."

For Oregonians who care about the natural environment—who care about the web of water that binds us and future generations together with the rest of our natural world—such an understanding would seem to be a dandy place to start.

> "These maps seem to draw people into the analysis. People can place themselves in the landscape."
>
> *—Norm Johnson*

COPE closes with major conference

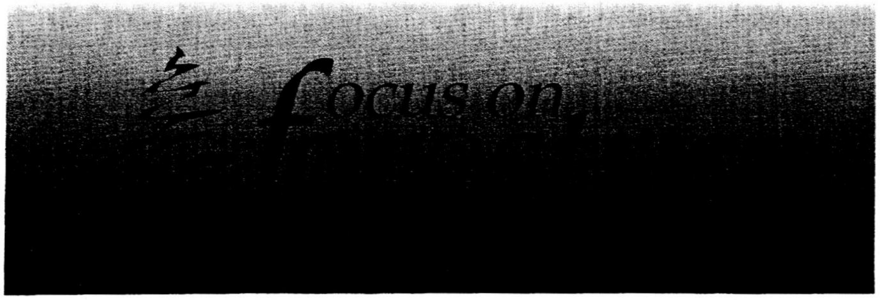
The Coastal Oregon Productivity Enhancement Program, a major cooperative research program focused on Coast Range forest resources, ended a successful 12-year run with a January symposium titled "Forests and Streams of the Oregon Coast Range: Building a Foundation for Integrated Resource Management."

More than 500 people attended the two-day conference at OSU. They heard presentations from more than 40 COPE researchers, including a score from the College of Forestry. The scientists spoke on such widely varying topics as the natural history of the Coast Range ecosystem, logging aimed at improving stream habitat, thinning of young-tree stands to cultivate older-forest characteristics, and the social and economic implications of changing land-use patterns.

"COPE has given us a new vision of the coastal forest, one that emphasizes the role of disturbance and diversity in shaping the landscape," said Dean George Brown in his closing remarks. "It's forced us to think outside the box in terms of what that means for management."

As Associate Dean for Research in 1987, Brown was instrumental in getting COPE organized. The project has been a joint effort among OSU and federal and state agencies, local governments, and private businesses. Its mission is to provide information to managers and the public on how to deal with the timber, fish, wildlife, and other resources of the Coast Range in an integrated manner.

COPE research findings are being compiled into a major book titled *Forest and Stream Management in the Oregon Coast Range*, to be published in the fall of this year.



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College of
Forestry

Learning more all the time. *A gauging station on Lookout Creek in the Andrews Experimental Forest.*

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