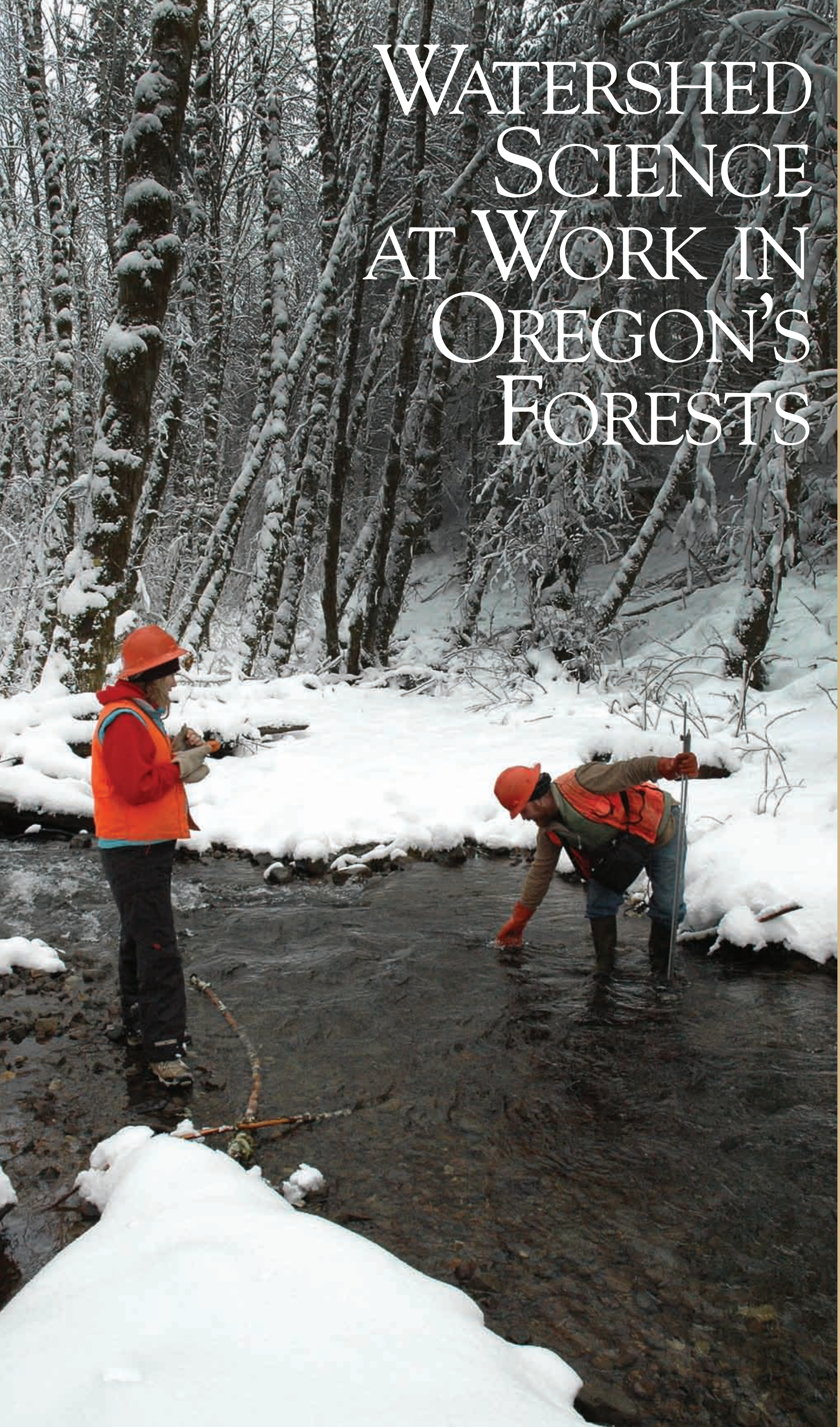
Watershed Science at Work in Oregon's Forests



New Paired Watershed Studies Look at Effects of Contemporary Forest Management on Streams

A Special Report of the Oregon Forest Resources Institute

For the past century, scientists have found the paired watershed study a useful method to assess the effects of forest management on streams. One of the first such studies in Oregon took place from 1959 to 1973 in the Alsea River basin, and its results helped guide foresters, scientists and policymakers as they drafted the original Oregon Forest Practices Act in 1971. While aquatic research has been ongoing since then, paired watershed projects are less common because of their complexity and cost. So it is unusual that at present there are three new, large paired watershed studies underway in Oregon. Because forest management has changed so much since the time of the Alsea study, there is a need to reexamine the effects of contemporary forest practices on water quality and aquatic habitat. This report examines these studies, their importance and their implications for the future of forestry in Oregon.

On the cover: Faculty Research Assistant Amy Simmons (left) and research technician Nick Bonzey maintain equipment and conduct regular stream hydrology monitoring high in the Trask River watershed.

The Paired Watershed Study

Do fish leave a stream if there is a timber harvest nearby? If so, for how long? Where do they go? Does their overall abundance in the watershed increase or decline? Do amphibians, birds and insects have the same response? Does water temperature increase or decrease after timber harvest? How do streamflow and other water quality parameters such as turbidity and the amount of sediment change? Do localized disturbances dissipate quickly? Are disturbances evident downstream and if so, to what extent? Do responses change if different timber harvest methods are used and if so, by how much? Paired watershed studies are a means to answer such questions as they relate to the impact of forest management activities – as well as natural events – on forest streams.

Though complex to execute effectively, paired watershed studies are simple in concept. To identify and quantify the effects of timber harvest on water quality and aquatic habitat, select two watersheds in the same general locale that have similar characteristics. Leave one untouched, and on the other conduct some forest management activity, or in scientific parlance a "treatment." In the scope of this report, a treatment means anything related to the growing and harvesting of trees, such as site preparation, road construction, harvest activities, tree planting and fertilization. Monitor streams in both watersheds before, during and after treatment to develop predictable relationships between basin streams and then measure differences after treatment from the expected response. The observed difference of the response in the stream after treatment compared to the expected response based on the pre-treatment relationship is a measure of the effects of that activity.

Paired Watershed Studies

A paired watershed study is a scientific method to compare two or more watersheds. It has three phases - a period of baseline data collection (pre-treatment), then some forest management activity related to harvest (treatment), and finally, more data collection to assess the effects (post-treatment). Each phase lasts several years, so the complete study can last a decade or longer. Scientists select two or more watersheds in close proximity whose general characteristics are similar. They begin by conducting a calibration, or pre-treatment, period to develop an ability to predict the response in one watershed from the performance of the other. The reference, or control, watershed remains undisturbed with no forest management activity. In the other watershed, the treatment watershed, they conduct various types of forest management. Streams in the reference and treatment watersheds are carefully monitored for water quality as well as fish and wildlife response. By comparing results in both watersheds, researchers are able to ascertain the effects of forest management above and beyond the effects of natural variability.

George Brown
Forest Hydrologist and
Dean Emeritus
OSU College of Forestry
Corvallis

"I had the distinct honor of working on the original Alsea study as a graduate student, so it's particularly gratifying to see this research carried on and updated. Paired watershed studies do have limitations, such as the high cost in time, people and money, as well as the difficulty in extrapolating results to other watersheds. But they also provide invaluable knowledge for the management of wildlands. They represent real-world, real-time measurements, and they make a true contribution to the policy deliberations on the best management practices."

Judith Li
Associate Professor Emeritus
OSU Department of Fisheries and Wildlife
Corvallis

"As one who's working on all three watersheds, I can say that there's been an extraordinary effort to coordinate these studies across all of the watersheds so they can provide a reasonable comparison. In the case of the Alsea in particular, the original study did not look at invertebrates, and Plum Creek Timber Company really wanted to do that. We sample from the stream bottom as well as what drifts on the surface, and we even check the content of fish stomachs to see what they've eaten. In the larger picture, we're trying to ascertain how forestry affects the bugs, then how that affects fish."

Why is it important to understand the effects of timber harvest and related activities around forest streams? One reason is that most of the drinking water that serves Oregon's cities and towns comes from streams that flow through private and public forestland. Another is that forest streams provide important habitat for fish and other wildlife, including salmon species that hatch there, migrate to the ocean, and return to spawn.

Stream Dynamics

On a stream's journey from mountain to river to sea, it is subject to extreme events like storms, floods, landslides and fire – all disturbances that are natural events in Pacific Northwest forest ecosystems. Most ecologists recognize that ecosystems are dynamic and constantly in a state of change due to regular disturbance. This concept is not yet well understood by the general public, which is still more familiar with the older static, or "balance of nature," paradigm.

In the forest, all natural disturbances affect water quality and wildlife habitat, and we have little control over them. There are, however, some forest-related activities we do have the power to control, including commercial timber harvest and associated management activities, which have the potential to affect water quality. For some time, professional foresters, scientists and public officials have recognized this relationship. As a result, they have included extensive protection rules in Oregon Forest Practices Act (OFPA) regulations to eliminate or mitigate practices that have negative effects on water quality and fish and wildlife habitat. But to create effective and responsive rules, regulators need to be able to distinguish the effects of natural disturbances from those caused by forest management. This is why the paired watershed study has proved valuable for studying forest harvest effects.

Fisheries experts pay close attention to fish in the watershed studies, monitoring their locations and abundance. Here an adult male coho salmon moves up Needle Branch in the Alsea River watershed.

Crafting Forest Stream Regulations

It has been half a century since the Alsea Basin Logging and Aquatic Resources Study began – one of the most recent paired watershed studies in Oregon. Other aquatic research has taken place, and some has resulted in updated and improved stream rules. But forestry professionals and public officials recognize that we do not know the effects of contemporary forest management practices under the improved regulations.

Logging equipment is much smaller and lighter today. In sensitive areas, logs are directionally harvested and skillfully removed from the forest by cable systems and even helicopters. Reforestation, generally by hand, is required within two planting seasons to ensure a quick transition to the new forest. Buffer strips – also known as riparian management areas, or RMAs – of varying widths along fish-bearing and domestic-use streams are now required, which was not true during the original Alsea study. As a result of these changes, contemporary forest management leaves a much different "environmental footprint" than it did in the past.

All of these improvements are intended to reduce human-caused soil disturbance, erosion and the movement of sediment into streams. Beyond following these improved regulations, over the past decade private forest landowners, as well as federal and state forest managers, also have voluntarily invested millions of dollars as part of the Oregon Plan for Salmon and Watersheds to upgrade forest roads and culverts. This has improved water quality, removed man-made barriers to fish passage, and increased habitat complexity in fish-bearing streams.

Through all of these improvements, it is likely that impacts on water quality and fish and wildlife habitat have been improved, but scientists do not know by how much. In 1999, the Oregon Department of Forestry (ODF) formed a committee to determine what, if any, changes in forest practices are necessary to meet water quality standards and to protect and restore salmon.

Committee member Dan Newton, a former timberlands manager for Roseburg Resources, remembers the group's frustration at having to make policy recommendations using decades-old data that no longer reflected current forest management practices. "I've seen how difficult it is to provide the most effective regulatory framework in the absence of definitive research," he said. "We need to have good science so that the deliberations of forest management policymakers can be reasoned and well-informed." This is the intent of the three watershed studies currently underway in Oregon.

Forest Science Responds

From a subsequent discussion that Newton had with Arne Skaugset, a hydrologist with the Oregon State University (OSU) College of Forestry, the Hinkle Creek Paired Watershed Study began to take shape. In 2001, Roseburg Forest Products

Dick Beeby
Operations Manager
Roseburg Forest Products
Roseburg

"I'm the on-the-ground person responsible for harvest activities on Hinkle Creek. My crews and I have been quite excited about watching scientific inquiry at work, and we're looking forward to results with as much anticipation as the researchers. It's something that's necessary for us to know, and will help us continue to do what's best for fish and water quality when we're working near streams."

Bob Bilby
Chief Environmental Scientist
Weyerhaeuser Company
Trask Co-lead Investigator
Federal Way, Wash.

"When the Oregon Department of Forestry approached us about mounting a paired watershed study, I was quite interested because of the Trask's complexity and the fact that the watershed was in different ownerships with different objectives. I also liked the mix of researchers. I have some of my own people working on hydrology, water quality and organic matter, but we have collaborating scientists from the Forest Service, OSU, USGS and EPA. There's great strength in so many points of view focused on the same watershed."

Amphibians and the way they respond to timber harvest and other forest management activities is part of the paired watershed research. The tailed frog (above), a species unique to the Northwest, is one of the amphibians in the Trask River watershed.

dedicated 5,000 acres of its forestland to the project for 10 years – the duration of the study – agreeing to forego harvest in the reference basin and to time and place harvests in the treatment basin according to the scientists' needs rather than the timber market's. Skaugset became the study's lead investigator. He is also the director of the Watersheds Research Cooperative (WRC), which serves as the umbrella organization for all three studies. He assembled a group of researchers willing to devote a decade to the project – specialists in hydrology, fish, invertebrates, amphibians, stream water chemistry and soils – from the OSU College of Forestry, the OSU College of Agricultural Sciences, the U.S. Geological Survey (USGS), and the Forest and Rangeland Ecosystem Science Center (FRESC). Financial and in-kind support came from Roseburg Forest Products, Douglas County, the Oregon Forest Industries Council (OFIC), the Oregon Watershed Enhancement Board (OWEB), the Oregon Department of Forestry (ODF), the Oregon Department of Fish and Wildlife (ODFW) and the U.S. Forest Service (USFS). Monitoring to gather baseline data began in 2001.

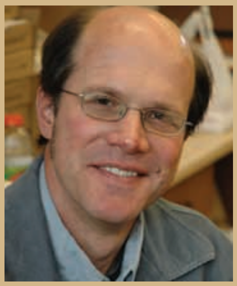
Meanwhile, hydrologist George Ice, principal scientist with the National Council for Air and Stream Improvement (NCASI), was following the development of the Hinkle Creek study with interest. Since the late 1980s, Ice had thought about ways the original Alsea study could be updated. It had been decades since its work concluded, and the forest there had been growing steadily. What an opportunity, he thought, to do a follow-up study, particularly since data were available from the original study. The timing, Ice felt, would be perfect. The trees on the privately owned portion of the Alsea study belonged to Plum Creek

Timber Company and were nearing harvest age. Working with Jeff Light, a biologist with Plum Creek Timber Company, and OSU researchers Steven Schoenholtz, Cody Hale and later Jeff McDonnell, the Alsea Watershed Study Revisited was initiated. The reference watershed is part of the Siuslaw National Forest and is managed as a research natural area. The new Alsea study joined the Hinkle Creek study as a second WRC project in 2006 and will conclude its work in 2016. Ice serves as the lead investigator.

Farther north in Oregon in the Trask River watershed, which flows into the Tillamook Bay and whose headwaters are high in the Coast Range, a new forest had returned and reached harvest age following the historic Tillamook Burn, a series of forest fires that took place more than half a century ago. A portion of the watershed is owned by the state and managed by ODF. Liz Dent, a forest hydrologist with ODF, following the lead of the Tillamook foresters, identified the Trask as an excellent candidate for a paired watershed study. The headwaters of the Trask are owned by Weyerhaeuser Company, creating an excellent private-public collaborative opportunity.

Dent began talking with Bob Bilby, Weyerhaeuser's chief environmental scientist, and ODF and Weyerhaeuser agreed to fund the 10-year study jointly, with additional funding for equipment from OWEB. Sherri Johnson, research ecologist at the USFS's Pacific Northwest Research Station, signed on as a co-lead with Bilby. Other researchers from OSU, USGS, FRESC and the U.S. Environmental Protection Agency (EPA) joined the team. Pre-treatment field studies began in 2006; harvest is planned for 2012 with post-harvest studies to continue until 2016.

Elevated log removal as in this operation at Hinkle Creek minimizes soil disturbance and resultant erosion. This system calls for roads sited on ridge tops rather than near streams.



Jason Dunham
Aquatic Ecologist
U.S. Geological Survey
Corvallis

"The Trask is interesting in terms of fish because we're monitoring at a scale and level of control where we can measure things quite precisely. But we're hoping to dig even deeper. Over time, a linked series of graduate studies will help reveal cause and effect relationships behind the long-term patterns we measure. Measurement can tell you only so much. It's like having your cholesterol measured, but it doesn't tell you anything about the effects of diet or exercise. By studying both patterns and relationships, we will have a stronger understanding of natural and human influences on fish and watersheds."

Modern Tools and Methods Aid Scientists

Over the century of their existence, watershed studies have changed dramatically with new technology and methods. Technology has become more sophisticated, resulting in countless monitoring hours saved and data collection of a frequency and precision that would not have been possible, even as late as the original Alsea study. Scientists in each watershed replicate the research projects to compare and contrast the results. All of the studies examine water quality, water quantity, fisheries and macroinvertebrates. In the Trask and Hinkle Creek studies, researchers also study amphibian populations. Dissolved oxygen in the streams - critical to aquatic habitat - is measured in the Alsea and Trask studies before and after harvest. The major research projects are listed below.

Water Quality and Quantity

Hydrologists in the three studies have set up gauging stations where automated equipment collects data on stream temperature, discharge, turbidity and suspended sediment. The capability exists to automatically increase the frequency of data collection during intense rainfall when stream levels are the highest and the majority of the sediment transport occurs. All these data are collected and stored electronically, then transferred to computers for processing and analysis.

Fisheries

A recent development in tracking fish allows scientists to monitor the movement of individual fish throughout stream networks. In each watershed, biologists capture resident fish and without harming them, implant tiny microchips known as PIT tags (Passive Integrated Transponders, similar to the microchips veterinarians implant in pets), then release the fish back into the stream. Biologists return at intervals with "wands" that can read tags and track the movement of individual fish.

Invertebrate Studies

At the same time, biologists are looking at components of the food web, monitoring invertebrates in the water (such as mayflies, caddis flies, stoneflies and snails), and in riparian zones (such as spiders, camel crickets and caterpillars). "We look for patterns in how these 'critters' are distributed and when they are eaten," said Judith Li, an associate professor emeritus of fisheries and wildlife at OSU, who conducts invertebrate research in all three watershed studies with faculty research assistants Bill Gerth, Janel Sobota and Rich Van Driesche. Fish feed on a combination of stream invertebrates and terrestrial invertebrates that fall into the water. "Aquatic invertebrates are less mobile than their predators, and they can be sensitive to environmental change," she said. "Thus, they can be good indicators of management activities."

Other Watershed Research

Watershed research does not stop with water quality and fish. Aquatic ecologists conduct research throughout the stream system and even up into small head-

waters that fish don't reach, monitoring the abundance and movement of amphibians such as salamanders and their responses to forest management. Other scientists determine the geology of the watershed and monitor carbon and nitrogen in the soil as well as nutrients in the water. They can observe changes as a result of disturbance, whether natural or human.

Cumulative Effects

On a broader scale, all of the studies are examining cumulative effects. Cumulative watershed effects occur as a result of water that flows through a watershed. They occur when the acceptable and site-specific effects associated with Best Management Practices (BMPs) accumulate in space and time. In forestry, BMPs are site-specific prescriptions – for such activities as buffer strips along streams, alternative harvesting systems and road drainage standards – designed to

lessen the environmental impact more than if the prescription was not used. The current OFPA rules, for example, are a set of BMPs. The concern is that though BMPs may result individually in an acceptable effect onsite, a number of effects might accumulate downstream, resulting in unacceptable impacts to aquatic resources. One of the overarching objectives of the studies is to investigate the existence of and the form that cumulative watershed effects might take. What parameters are most sensitive to cumulative effects, and what is the interaction between these parameters and fish? The answers to these and other similar questions will lead to a new layer of knowledge that will assess the likelihood of cumulative forest management effects on aquatic resources.

Statistical Significance

With new technology, researchers can collect more comprehensive data than ever. While a major advantage compared to earlier efforts, this huge quantity of information also presents an unexpected challenge. "What do all these data really mean?" is the key question asked by Lisa Ganio, associate professor and a statistician for the OSU College of Forestry and member of the Hinkle Creek research team.

Ganio helps the scientists determine what constitutes a significant treatment effect. "Protecting the survival and growth of fish and the quality of their habitat during timber harvest is an objective of contemporary forest management practices," Skaugset said. "The research objective is to detect ecological change. When we see numbers from harvested and non-harvested watersheds vary, we need to know if that is 'change' or 'natural variation.' The analysis methods are Lisa's purview. She keeps us honest as we strive to determine whether or not our data represent just natural variability or are truly management-induced changes. Beyond statistical changes, scientists need to interpret whether any observed change has ecological relevance."

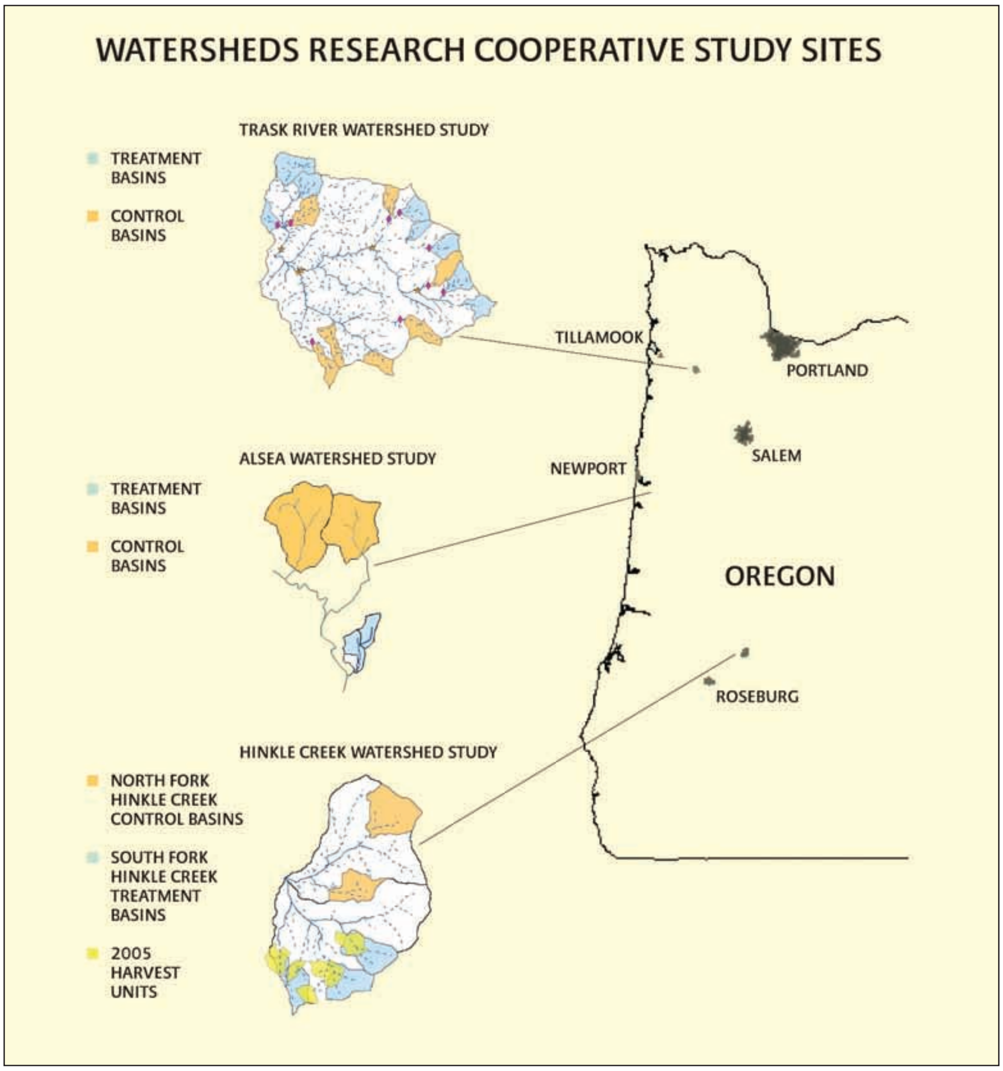
Arne Skaugset
Associate Professor
OSU College of Forestry
Hinkle Lead Investigator
Director, Watersheds Research Cooperative
Corvallis

"The biggest gap in our scientific knowledge is the effect that harvest in smaller, headwater, non-fish-bearing streams might have on fish-bearing streams farther down in the watershed. Would, for example, temperature increase downstream if it does in headwater streams? We also did not know the cumulative impact of multiple harvest areas around fish-bearing streams. That was the big parameter of interest when we started. Cumulative impact assessment requires a large spatial scale, and we were able to design the Hinkle Creek and Trask studies in a way that would address those questions."

Overall Study Objectives

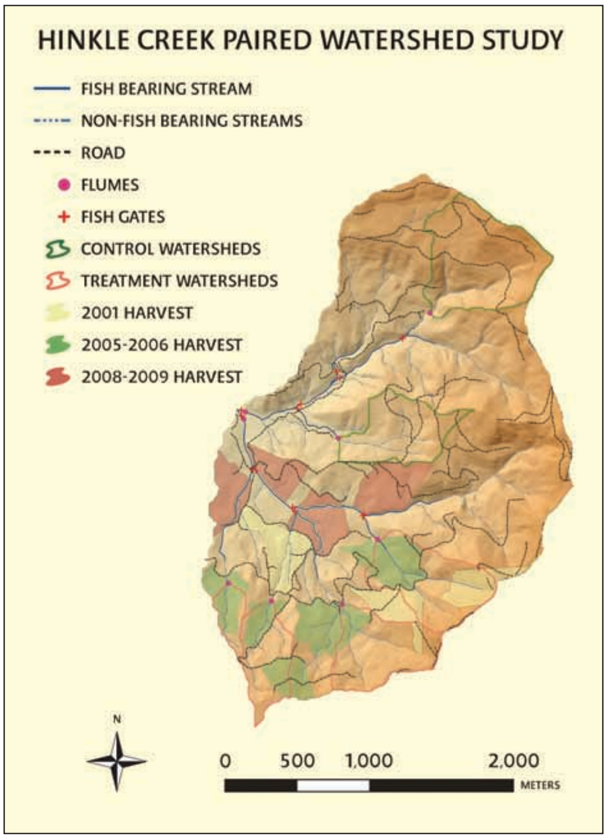
The paired watershed study researchers are interested in detecting subtle effects that might occur with newer harvest methods. Each of the three studies is designed to address specific areas where scientific knowledge is limited. Combined they will present a picture – in space and time – of the effects of contemporary forest management practices on fish, water quality, streamflow, aquatic biota and in-stream habitat. The headwater areas – the upper reaches of fish-bearing streams and the non-fish-bearing streams that feed them – are the primary geographic focus of each of the three studies. While each study has a set of interrelated research hypotheses, critical common research questions link the three studies:

- What are the effects of forest harvest on the physical, chemical and biological characteristics of small streams?
- To what extent do alterations in stream conditions caused by timber harvest along headwater channels influence the physical, chemical and biological characteristics of fish-bearing streams farther down in the watershed?



The Hinkle Creek Study

Nationally, several watershed studies from the 1950s through the 1970s continue today; however, Hinkle Creek is the first of a resurgence of new paired watershed studies in Oregon designed to assess the effectiveness of the OFPA rules. It is also the first one to take place entirely on private forestland. At 5,000 acres, the area draining into the North Fork and South Fork of Hinkle Creek is considered large for a paired watershed study. Skaugset explained that the study is set up to measure not only impacts at harvest sites but also the cumulative effects, that is, the downstream effects of site-specific disturbances.



In the Hinkle Creek study, there are two reference sub-watersheds in the North Fork that are unharvested. These provide the baseline to compare with the four treated watersheds in the South Fork. Four harvest units with non-fish-bearing streams flowing through them were logged in 2005, in compliance with OFPA regulations. Existing roads were used and logs were removed with skyline yarding equipment. A second entry occurred in 2008-09 downstream along fish-bearing streams. Post-harvest monitoring will continue until the study concludes in 2011.

Monitoring focuses on streamflow, suspended sediment and water temperature (some 45 thermistors track stream temperature throughout the watershed). More than 4,000 cutthroat trout have been PIT tagged. Fixed antennas and crews with mobile antennas track fish movement and location over the study area. Field researchers monitor aquatic and terrestrial invertebrates to assess their response to disturbance. They also inspect the content of fish stomachs to monitor how changes move through the food chain. Scientists, including biologists, hydrologists and ecologists, note changes in soil and stream chemistry after disturbance and monitor amphibian populations.

Although definitive findings will not be available until the study's conclusion,

HINKLE CREEK RESEARCH TIMELINE

2001, 2002, 2003, 2004, 2005	Baseline Data Collection
2005, 2006	First Harvest
2006, 2007	Post-Treatment Data Collection
2008, 2009	Second Harvest
2009, 2010, 2011	Post-Treatment Data Collection

ALSEA RIVER RESEARCH TIMELINE

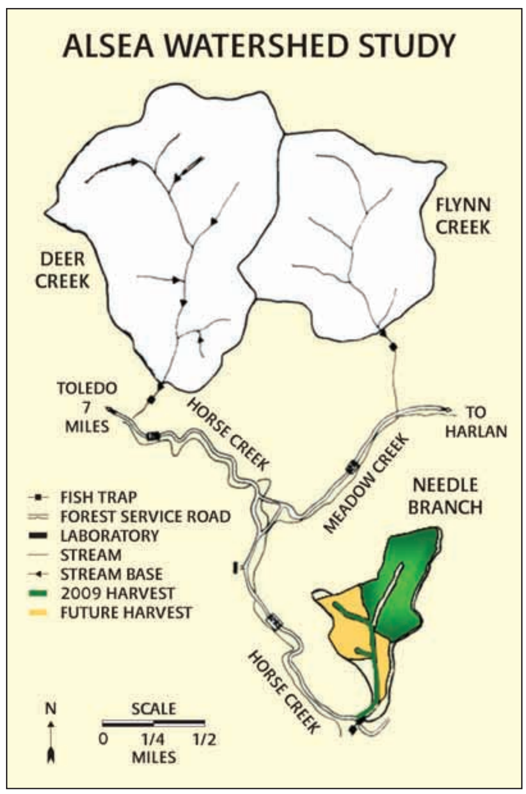
2006	Baseline Data Collection
2007	
2008	
2009	First Harvest
2010	Phase I Post-Treatment Data Collection
2011	
2012	
2013	Second Harvest
2014	Phase II Post-Treatment Data Collection
2015	
2016	

Research technician Richard Van Driesche takes an invertebrate sample from the streamflow using a Surber sampler at Hinkle Creek. The same team is conducting invertebrate research on all three of the paired watershed studies.

there have been some preliminary observations. Statistically significant effects were detected at the scale of individual streams after the 2005 harvests. Maximum daily temperatures increased slightly in two of the four streams monitored, stayed constant in one and decreased in the fourth. However, all of the impacts on stream temperature were within natural variability on a watershed scale. Expected increases in water yield due to timber harvest were observed. As for fish living downstream of the harvest units, no differences in abundance pre- and post-harvest were observed. Also, there did not appear to be any difference in growth or distribution of mature coastal cutthroat trout. Data analysis is ongoing, however, and these results will be enriched over time.

The Alsea Study Revisited

The Alsea Watershed Study Revisited is unique in that it returns to the same area 50 years after the original landmark study began. According to lead investigator George Ice, scientists will have opportunities to compare the effects of clearcutting and forest practices in the 1960s to management taking place today under present OFPA regulations.



Landowners in the Alsea study – Plum Creek Timber Company and the U.S. Forest Service – are both private and public. The study area comprises about 1,400 acres. On the private land, after some 40 to 50 years of growth, the predominantly Douglas-fir forest is ready for harvest, this time with dramatically different harvest practices such as skyline logging that lifts logs in the air and transports them to a landing high above and distant from the stream. Tree-dominated buffer strips will be left alongside small fish-bearing streams in the harvest units, a practice that was not used during the 1960s harvests on the same site.

Monitoring is largely similar to that at Hinkle Creek, and includes water quantity and quality, fish and their habitat, and invertebrates. Unlike Hinkle Creek, however, streams in the Alsea study contain coho salmon and sea-run cutthroat trout, species that migrate to the ocean. These are monitored using annual whole-basin census methods. To improve fish habitat impacted by the 1960 harvest, researchers will add large wood to the treatment stream toward the end of this study to create hiding cover, pools and backwaters (a practice consistent with OFPA rules). Unique among the three studies is research being conducted by Jeff McDonnell of the OSU College of Forestry and doctoral student Cody Hale, using stable isotopes to trace the sources and flowpaths of water. Because each water source – groundwater or rainwater, for example – has an isotopic “signature,” its movement can be traced and quantified down-

Spanning Generations of Watershed Research

Besides sharing first names, hydrologists George Brown (left) and George Ice have much more in common. Brown began his career at the OSU College of Forestry in the 1960s, and as a graduate student worked on the original Alsea study. Later, as a young faculty member, he was adviser to Ice, then a graduate student himself. Ice is now principal scientist with the National Council for Air and Stream Improvement and lead investigator on the current Alsea study. Having followed watershed monitoring for such a long period, Brown can appreciate the improvements in monitoring technology. "Back in the first Alsea study," he said, "we used instruments like thermographs and hydrographs that recorded temperature and streamflow on paper charts. Most had to be changed weekly and these analog data were laboriously transferred to data forms. The data were processed and analyzed using slide rules and calculators."

George Ice
Principal Scientist
National Council for Air and Stream Improvement
Alsea Lead Investigator
Corvallis

"There are just five studies in the U.S. where you can go to a decades-old site of a study and compare effects today, and the Alsea is one of them. What excited me about revisiting the Alsea study was the opportunity to compare today's harvest methods with those of 50 years ago. Most people don't really understand the regenerative power of forests, and here we have a situation where we can look at a clearcut in the mid-1960s that has become a healthy, mature forest today and about to undergo another harvest."

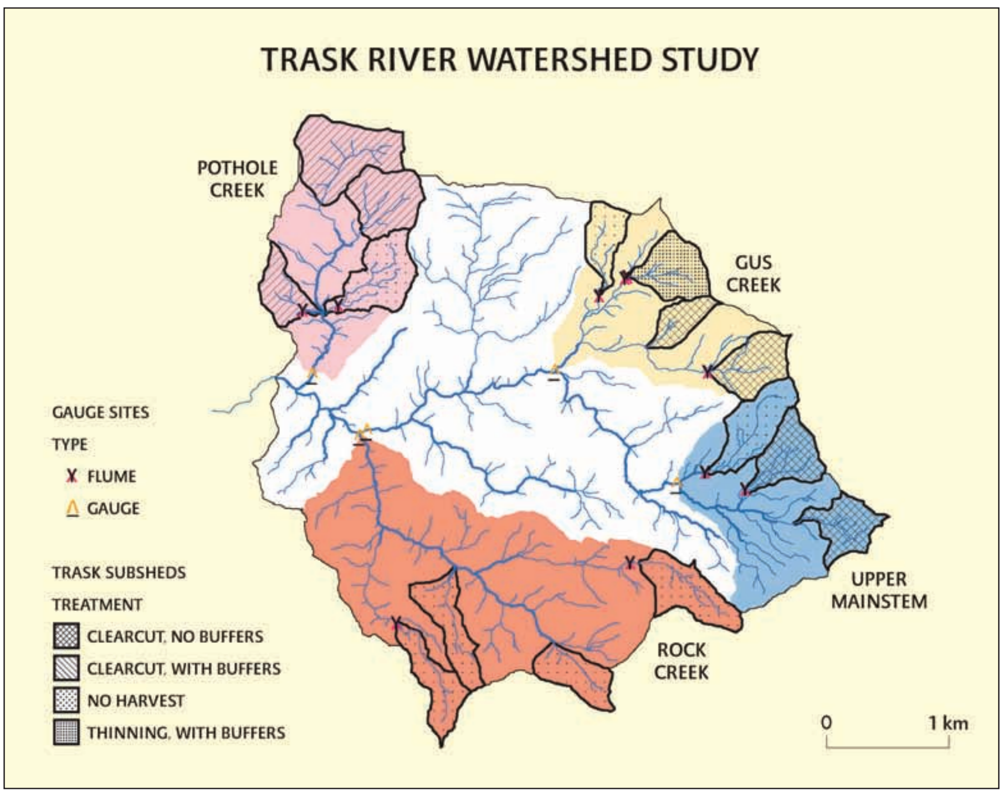
stream. The intent is to determine how contemporary forest management affects the quantity, quality and timing of streamflow.

The original Alsea study took a close look at how removal of streamside vegetation influenced stream temperature following logging. The new study will carefully monitor temperature and shade throughout the watershed. Preliminary findings from the new research indicate that stream temperatures have returned to the pre-harvest levels of the original study.

The Trask River Study

The Trask River Paired Watershed Study, in addition to studying fish-bearing streams at lower elevations in the watershed, places great emphasis on multiple non-fish-bearing headwater streams that have varying riparian treatments. Forest harvest will occur throughout entire headwater basins. Monitoring in those upper reaches, combined with downstream tracking, will help scientists evaluate the magnitude of response to harvest and whether effects are transferred downstream.

The 7,000-acre Trask watershed has a mixed ownership. The state of Oregon and Weyerhaeuser own most of the study area; a small amount of federal land is owned and managed by the Bureau of Land Management (BLM). This combination of ownerships offers an unusual opportunity to examine and test the effectiveness of three management regimes as they pertain to small, non-fish-bearing streams.



TRASK RIVER RESEARCH TIMELINE

2006	
2007	
2008	Baseline Data Collection
2009	
2010	
2011	Road Construction
2012	Harvest
2013	
2014	Post-Treatment Data Collection
2015	
2016	

Besides PIT tagging, electroshocking is a common technique that enables researchers to monitor fish. Following an electrical charge to the water, any fish present rise temporarily to the surface so that they can be identified and counted. Such research is conducted in all three studies.

The scale of the Trask's research endeavor also sets it apart. For example, while Alsea and Hinkle Creek have one reference and one treatment fish stream, the Trask has one reference and three treatment fish sites. In addition, the Trask headwaters contain 14 study basins, seven of which will have whole basin harvest in 2012, giving researchers a range of conditions to study.

The scope of research is also greater. Michael Adams, a research ecologist with the USGS who heads the amphibian research in the Trask, said that unlike Hinkle Creek, whose amphibian population consists largely of Pacific giant salamanders, the Trask has tailed frogs, giant salamanders and even torrent salamanders. Sherri Johnson of the USFS's PNW Research Station, and Linda Ashkenas of the OSU Department of Fisheries and Wildlife, are studying in-stream productivity, nutrient chemistry and the role of stream algae in forested streams. Joan Hagar of USGS is studying the role of songbirds in cooperation with the OSU Department of Fisheries and Wildlife. Jason Dunham of USGS is leading studies of native fishes, including coho salmon, cutthroat and steelhead trout, and sculpins. Weyerhaeuser and EPA researchers are conducting studies on organic inputs and soils, and Weyerhaeuser is doing extensive work on stream temperature and climate. Importantly, Trask researchers also are working together to study watershed processes, for example, fish and amphibian growth rates, stream productivity and aquatic life interactions.

Sherri Johnson
Research Ecologist
U.S. Forest Service Pacific Northwest Research Station
Trask Co-lead Investigator
Corvallis

"Three studies enable us to look at forest practices across a range of geology and climate, and they're all on second-growth forests. In the Trask, its geology and basin design enabled us to plan in more complexity – we have 14 sub-basins versus four in Hinkle Creek and one in the Alsea. Weyerhaeuser, the private landowner in the Trask, has a great research group and they and the Oregon Department of Forestry deserve a lot of credit for their financial support and personnel time. Both have committed to not harvesting for 10 years in prime timber areas to avoid influencing the study results."

Liz Dent
Forest Hydrologist
Oregon Department
of Forestry
Salem

"Following the lead of ODF's Tillamook foresters, we identified the Trask study area as a good candidate for this type of research. We needed to know more about the influence of forest management at the watershed scale in order to look critically at cumulative effects and fish response. The partnership with Weyerhaeuser was a critical factor in maximizing the study's potential. Coupled with the more recent involvement of BLM, we are researching questions about forest management practices on small non-fish-bearing streams at a scale large enough to detect downstream effects."

The Value of Multiple Studies

One of the inherent problems with and criticisms of paired watershed studies is that they are specific to the stream and watershed where they are conducted. "It may well be that you can make generalizations from the results of the Hinkle Creek study and apply them to other watersheds," said Skaugset, "but one could argue that it is only one data point that can't be extrapolated to any other stream or watershed – that in effect, it is just a case study." However, with three concurrent studies in three regions with differing geology, soils, climate and history, there is greater ability to see relationships and draw scientifically valid conclusions that may help inform forest policy.

Monitoring on a watershed scale involves construction and maintenance of a great deal of equipment, much of which must be designed to cope with extreme weather and protect sophisticated electronics. Graduate Research Assistant Cody Hale is actively involved in the hydrology research at the Alsea Watershed study and did his master's thesis on the subject.

Each of the studies is unique; but by design, there are also many parallels. For example, equipment is similar: gauging stations, flumes, climate stations, sediment recorders and PIT tags. Many of the scientists are participating in more than one of the watershed studies and in one case (invertebrates) all three. This cross-study participation helps ensure that research protocols complement each other. All of these factors should help limit the variation that results from different technologies and research methods and should allow for greater insights into cause-and-effect relationships.

Each study can last 10 years or more, so the commitment of research scientists is considerable. So is the cost. The combined cost for all pieces of the three studies exceeds $2 million per year. Shortly after the Hinkle Creek study began, the WRC was formed to ease the administrative burden, seek additional funding and plan future studies.

Policy Informed by Science

From their beginnings, paired watershed studies have held great interest for land managers and forest policymakers. As with all field research, these studies have limitations, and scientists warn against extrapolating the results of one site-specific study to a whole landscape or to other sites. Yet, they do have tremendous value in guiding policy formation, improving regulations and encouraging forest management innovation. Trask researcher Johnson said she believes that major users of the paired watershed study findings will be land managers as they work to minimize effects of forest harvest on aquatic resources.

Jim Paul, chief of the private forests division for ODF, said that in the late 1990s, the policy discussions were moving ahead of the science and help was needed to inform that debate. Against a backdrop of work by advisory committees, discussion of listing salmon as a threatened or endangered species, and the establishment of the Oregon Plan as a voluntary means of salmon recovery, there was a need to revisit the effectiveness of the OFPA's aquatic rules. One obvious gap in the available data was the effect of contemporary forest practices on small non-fish-bearing streams high in the watershed, or the headwaters, as well as the potential cumulative effects on fish-bearing streams lower in the watershed. Those studying the issue could not, with any certainty, quantify the cumulative effects of multiple harvests around fish-bearing or non-fish-bearing streams.

The Oregon Forest Practices Act requires landowners to leave forested buffers on fish-bearing streams after harvest. Pictured above is a treatment harvest in the Hinkle Creek watershed, where forest operators leave buffers near stream edges undisturbed during operations just as they would during normal operations. The treatment areas will be compared to areas in which no harvest takes place to determine the effects of contemporary forest management.

Michael Adams
Research Ecologist
U.S. Geological Survey
Corvallis

"My lab is studying the survival, movement and density patterns of amphibians in the Hinkle Creek and Trask watersheds with an eye toward contrasting effects within and below harvests. Based on other research, I would anticipate some direct effects within headwater harvest units, but there has really never been a study like this. It remains to be seen how any effects will be distributed within the basin. We hope to have not only a lot of data on patterns of variation in these demographic parameters but also – given all the other information being collected – get a better sense of the mechanisms that might drive that variation.

Joel Nelson
Senior Resource Manager
Plum Creek Timber
Company
Coos Bay

"We met with scientists at the OSU College of Forestry and visited the Hinkle Creek research site, and felt it was a needed and worthwhile project. Arne Skaugset mentioned the need to find other sites for additional studies. Plum Creek had been thinking about ways to contribute to this type of endeavor, as we feel strongly about protecting fisheries and water quality. The sites logged in the original Alsea study had regenerated and were about ready for harvest, so we offered the Alsea Basin. We dedicated our scientific staff to the project, laid out a harvest plan, made some accommodations for the monitoring effort, and now we're underway."

Prior research was conducted in different forests, and there were questions about the applicability of the older findings to current conditions. According to Skaugset, nearly all of the early paired watershed studies involved the first harvest of old growth or late seral forests in those basins, whereas the current three studies are all looking at harvest effects of harvest-regenerated stands of trees as old as 40 to 60 years. Older studies were conducted prior to the enactment of forest practice rules, at a time when forest roads were built simultaneously with timber harvest, which caused significant accelerated erosion. The construction, maintenance and use of forest roads today have changed to minimize soil erosion and stream sediment impacts.

Needed now are studies that reflect contemporary forest management practices, harvest techniques and forest engineering technology. The Pacific Northwest region needs the new research provided by these three major watershed studies to evaluate current forest protection policies.

Looking to the Future

With these three powerful watershed studies running simultaneously, scientists are able to look at them as a unit. Having all the scientists in close proximity – and often having the same researchers working on multiple studies – provides professional synergy and continuity.

And the excitement is not limited to the scientific community. Part of the mission of the WRC is educational, and many tours are being conducted for land managers, other scientists and the general public. Organized visits of school groups enable students to witness scientists at work. Landowners and their crews also share in the excitement. Dick Beeby, an operations manager with Roseburg Resources, said he initially worried about conflicts in priorities between crews and researchers. But his fears were unfounded, he said. His logging crews have been both interested and supportive.

Researchers are particularly appreciative of the support and participation of the private landowners – Plum Creek Timber Company, Roseburg Forest Products and Weyerhaeuser Company – and feel that they all deserve recognition. Not only have they opened their land to public agencies for research purposes for a 10-year period, they are also either deferring harvest or scheduling harvest based on research needs. As well, landowners have willingly lent their biologists and environmental scientists to the work and have made generous financial contributions to the WRC. Typical of the landowners' response to the studies is that of Joel Nelson, senior resource manager for Plum Creek's Oregon operations, who said his company is committed to protecting fish and wildlife resources on the

Regular checking of weirs is just part of the monitoring program of the fisheries research scientists that takes place in the watershed studies.

basis of sound science. It's that commitment that drives the WRC's collaborators to be long-term partners.

"It's early," said Skaugset, "but we have detected statistically significant effects on hydrology, sediment, temperature, nutrients and aquatic invertebrates due to timber harvest at the scale of individual streams. The challenge ahead is to see if these effects translate into either physically or biologically significant impacts on fish or aquatic habitat downstream. That is our job as scientists. With three concurrent watershed studies, we should be able to draw conclusions and make inferences with more confidence. Our hope is that these studies will help inform landowners as they manage the forests and policymakers as they consider continued improvements to Oregon's forest practice regulations."

Jim Paul
Chief of Private Forests Division
Oregon Department of Forestry
Salem

"The current stream rules of the Oregon Forest Practices Act went into effect in 1994, defining nine stream types as opposed to the previous two, all with different regulatory standards. There followed a number of events later in the 1990s – the potential coho listing, meetings with federal agencies, and the work of our own advisory committees – that made us look critically at those regulations. In examining them and some of the watershed studies of that time, we realized that we had a lot of outdated information based on old practices that were no longer the norm. We're hopeful that these new studies will help inform an evaluation of the adequacy of the current rules and our future course."

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Watersheds Research Cooperative
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