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Science
FINDINGS

INSIDE

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"Science affects the way we think together."
Lewis Thomas

Logging Debris Matters: Better Soil, Fewer Invasive Plants

Tim Harrington

Logging debris that is left on site helps conserve soil water and modifies the decomposition of dead roots and stumps, leaving more nutrients available for newly planted trees. Above, a researcher prepares to survey coverage and weight of debris within a study plot near Matlock, Washington.

IN SUMMARY

The logging debris that remains after timber harvest traditionally has been seen as a nuisance. It can make subsequent tree planting more difficult and become fuel for wildfire. It is commonly piled, burned, or taken off site. Logging debris, however, contains significant amounts of carbon and nitrogen—elements critical to soil productivity. Its physical presence in the regenerating forest creates microclimates that influence a broad range of soil and plant processes.

Researchers Tim Harrington of the Pacific Northwest Research Station; Robert Slesak, a soil scientist with the Minnesota Forest Resources Council; and Stephen Schoenholtz, a professor of forest hydrology and soils at Virginia Tech, conducted a five-year study at two sites in Washington and Oregon to see how retaining logging debris affected the soil and other growing conditions at each locale.

They found that keeping logging debris in place improved soil fertility, especially in areas with coarse-textured, nutrient-poor soils. Soil nitrogen and other nutrients important to tree growth increased, and soil water availability increased due to the debris' mulching effect. The debris cooled the soil, which slowed the breakdown and release of soil carbon into the atmosphere. It also helped prevent invasive species such as Scotch broom and trailing blackberry from dominating the sites.

Forest managers are using this information to help maximize the land's productivity while reducing their costs associated with debris disposal.

"This upper limit of earth at our feet is visible and touches the air, but below it reaches to infinity."
—Xenophanes

An intensive logging operation can produce six tons of debris per acre. The question is, what to do with it all?

Often it is piled where it's either burned or it slowly decomposes. If left on the ground, the branches and treetops get in the way of planting new seedlings. The debris also can become a ready fuel for wildfire. In Europe, logging debris often is used as a feedstock for bioenergy, and recently there's been interest in doing so in the United States.

Tim Harrington, a forestry scientist working with the Pacific Northwest (PNW) Research Station in Olympia, Washington, along with his colleagues Rob Slesak, a soil scientist with the Minnesota Forest Resources Council, and Stephen Schoenholtz, a professor of forest hydrology and soils at Virginia Tech, are looking at logging debris from a different angle: as a possible benefit to the soil that can boost productivity on the site for the next generation of trees.

The scientists hypothesized that the effects of leaving logging debris would differ from site to site, depending on soil characteristics. To test this, they chose two research sites with very different soil profiles. One site is near Matlock, Washington, on the southern Olympic Peninsula. On average, it receives 94 inches of precipitation per year, mostly during the winter. In the summer, the coarse-textured soil quickly dries out. The soil is typical of Northwest soils that formed in ice-age glacial sediments. It is low in nitrogen and carbon.

The second site near Molalla, Oregon, in the western Cascade Range, is more fertile. It has fine-textured soils with higher levels of soil nutrients and carbon. Precipitation is about 63 inches a year—about 30 inches less than at Matlock—but the Molalla soil has greater capacity to hold water and thus dries out more slowly in the summer. The soil profile is typical of the western Cascades where forests are managed for timber production.

The research, now in its ninth year, is affiliated with the North American Long-Term Soil Productivity (LTSP) experiment, a joint venture among the U.S. Forest Service, forest industry, and universities. The LTSP experiment seeks to determine how potential effects of intensive forest management—such as organic matter removal, soil compaction, and competing vegetation control—influence forest productivity across a wide range of sites in the United States and Canada.

At the heart of the study is a desire to increase forest productivity. In Europe, where forestry has been practiced for centuries, productivity was found to be lower in areas where all surface organic matter, including logging debris, was removed, Harrington explains. Similar effects were also observed on nutrient-poor soils in Australia.

"That raised concerns here, which is a reason we did the research," says Harrington. "Forest landowners need to know this information so they can decide what to do with logging debris."

The scientists found that leaving debris on a logging site acts much like mulch in a garden. The debris helped the soil retain moisture and limited the development of invasive, nonnative plant species that compete with young conifer seedlings. It also helped the soil retain carbon, nitrogen, and other nutrients that can be utilized by the next generation of trees. The benefits of retained logging debris were most pronounced at the site with poorer soil.

KEY FINDINGS

- Coarse-textured, low-nutrient soil at a study site near Matlock, Washington, conserved water and accumulated more carbon, nitrogen, and other nutrients when logging debris 6 to 12 inches deep was left on the ground, compared to areas where debris was removed immediately after timber harvest. The retained logging debris improved growing conditions for young conifer seedlings and helped to reduce competition from invasive, nonnative plant species.
- Finely textured, more fertile soil at a study site near Molalla, Oregon, similarly benefited when logging debris was left on site, although the improvements were less pronounced than at the Matlock study site.
- At both study sites, the retained logging debris shaded the soil. The cooler soil temperatures led to slower soil respiration, and thus less carbon dioxide was released to the atmosphere, compared to study plots where logging debris was removed.

Tim Harrington

Logging debris is often piled after harvest to facilitate subsequent planting of conifer seedlings.

Purpose of PNW Science Findings

To provide scientific information to people who make and influence decisions about managing land.

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Rhonda Mazza, editor; rmazza@fs.fed.us

C. Hugh Luce, layout; chluce@fs.fed.us

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USDA United States Department of Agriculture

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SOURCE MATERIAL

When a tree falls in the forest, and no one's around to move it, it can take decades to centuries to completely decompose. A lifetime spent photosynthesizing—pulling carbon dioxide from the air, adding water to convert it to plant food with oxygen as a byproduct—leaves a wealth of stored carbon in the tree. But if trees are a bank, the soil is the treasury. Soil carbon is the largest pool of terrestrial carbon. In the absence of disturbance, Harrington explains, carbon storage in a forest remains in balance as the slow decay of a fallen tree returns carbon to the soil while making nutrients available to new photosynthesizers.

"The more carbon a forest stores in living and dead trees and in the soil, the less carbon it will release into the atmosphere," Harrington says. "When you cut trees, you stop carbon fixation in those trees. The sooner you replant, the sooner you renew the process of carbon fixation."

With the harvested trees gone, the forest floor suddenly receives a lot more light. Warmer soil temperatures lead to increased microbial activity in the soil. The soil microorganisms begin consuming and processing organic matter and nutrients in the soil at a faster rate than they did in cooler soil. As a result, soil carbon is cycled back to the atmosphere as carbon dioxide more quickly than before the harvest.

"Carbon is important for soil health," Harrington says. "It keeps soil permeable. It increases water retention. It has a complex set of functions. So, we approached this research with the question of how do you protect the soil carbon you have and possibly even increase it?"

SITE SPECIFICS

As recently as the 1980s, the slash remaining after clearcuts of 200 acres or more was routinely burned after harvest to clear the area for replanting. Today, forest practices have changed in several ways, Harrington says. Generally, clearcuts are smaller, burning is done more selectively, and often debris is piled out of the way to avoid burning it at all.

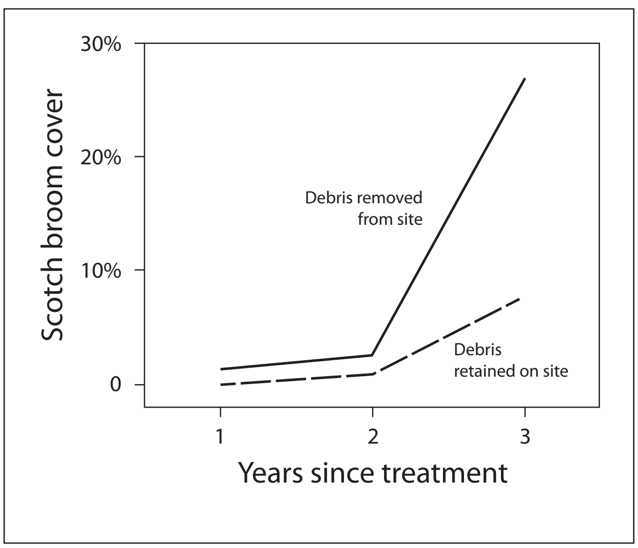
Because finding ways to increase productivity was a major goal of the study, private landowners were happy to help. The study was done on land owned by Green Diamond Resource Company in Matlock and Port Blakely Tree Farms, LLC, in Molalla. Each study site was clearcut-harvested in 2003, and treetops and branches were left on the ground. The study sites were then divided into plots where debris was either piled, removed (material smaller than two inches in diameter was retained), or left in place.

In February 2004, the sites were planted with Douglas-fir seedlings. Half the plots received regular herbicide applications for five years to control competing vegetation; the other half did not. The areas were fenced to prevent animal damage to young seedlings.

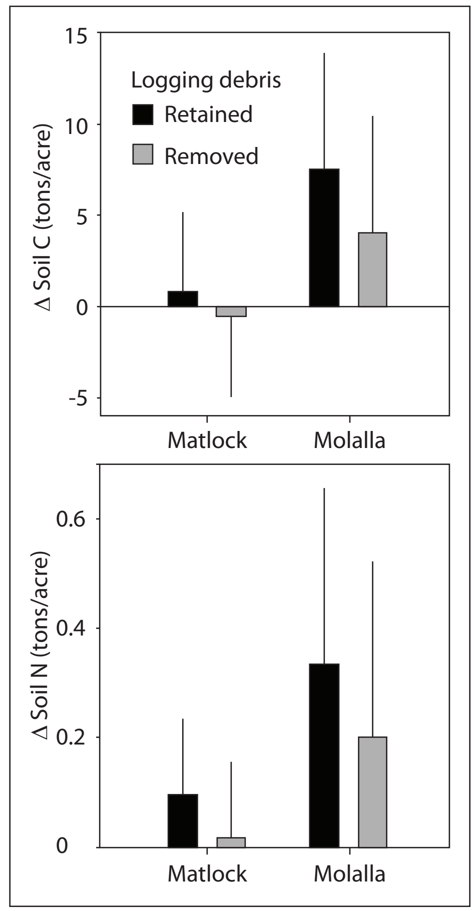
The scientists returned to the sites two years and then five years after the harvest to collect and analyze soil samples from various depths. They measured moisture content and the chemical composition of the soils, particularly nitrogen and carbon.

They found that areas where debris was retained—especially at the Matlock site, which had relatively poor soils to begin with—tested higher in carbon, nitrogen, calcium, and magnesium compared to the areas where most of the debris was removed.

The research showed that retaining logging debris on coarse-textured soils such as at Matlock insulated the ground surface to reduce the growing-season soil temperatures by 4 to 7 °F, which cut down on evaporation. The additional soil water that was retained at the Matlock site was sufficient to prevent conifer seedlings from reaching the wilting point during summer drought. This cooling effect also slowed the rate at which soil carbon was lost to microbial respiration.



Three years after logging debris was removed, 27 percent of the study area was covered by invasive Scotch broom. Where logging debris was retained, Scotch broom covered only 8 percent of the study area.



Five years after timber harvest, more soil carbon and nitrogen were present where logging debris was retained on site (shown here as a net change in each element), compared to areas where debris was removed.

THIS SPOT IS TAKEN

Invasive plants that find a niche in a new home and take over like an unwanted guest are a problem throughout the world. Sometimes, all it takes to invite them in is providing an open spot where their seeds can germinate.

That's the case in logged areas throughout the Pacific Northwest.

"Some we can manage effectively before they're a problem. Others we can only mitigate to reduce their negative impacts," Harrington says.

Invasive plants create a domino effect in places where they take root. They have been observed to change the insect and bird populations, and in fact change the whole wildlife profile on a site. Some nonnative species such as Scotch broom may have a toxic effect on native plant species. Trailing blackberry, a native species common to forest sites throughout the Pacific Northwest, can be considered an invasive species because it grows fast, competes aggressively with conifer seedlings, and is difficult to control.

During the research period at the two study sites, Harrington witnessed an explosion of Scotch broom, trailing blackberry, false dandelions, and other invasive species in the areas that were cleared of debris. They competed with young Douglas-fir, and they excluded native species. David Peter, an ecologist with the PNW Research Station who works with Harrington, did an in-depth analysis of the plant communities at each of the two sites and identified competitive relationships between the native and nonnative plant species.

Tim Harrington

A field crew sprays herbicide on Scotch broom so the invasive plant will not crowd out planted Douglas-fir seedlings. Logging debris was removed at this site.

In the areas where debris was removed, Scotch broom was particularly abundant, covering an average of 27 percent of the exposed areas that were not treated with herbicides. In the areas where debris was retained, the coverage of Scotch broom was only 8 percent.

Bottom line: simply leaving logging debris on the ground can cut the establishment of Scotch broom by more than two thirds without having to resort to herbicides. It cuts down on invasive species because it denies soil-stored seeds (in the case of Scotch broom) and wind-blown seeds (in the case of false dandelion) a favorable place to germinate. This allows less competitive native species—which are adapted to the cool, shady environment of a forest understory—to reproduce and occupy the new growing space.

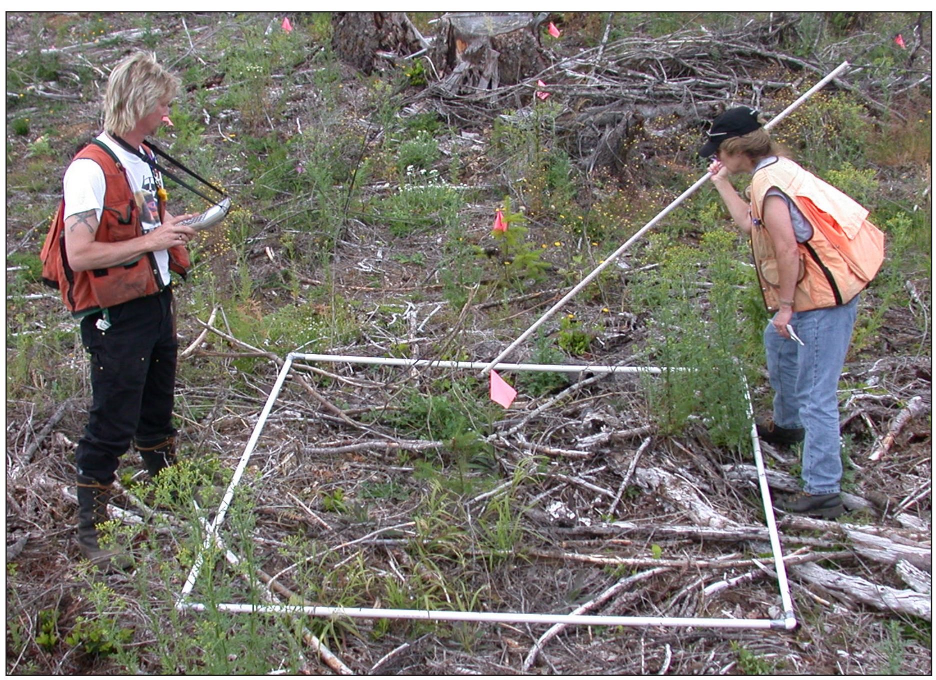
However, these results largely depended on soil quality. The strongest invasion of nonnative species in areas where debris was removed happened at Matlock, where the soil was relatively poor. Peter and Harrington concluded that in areas where the soil is richer and retains more moisture, clearcut logging by itself has a greater influence on the influx of invasive plants than the way in which logging debris is treated.

LEAVING SPACE FOR NATURE

These findings contribute to a holistic perspective of the role of logging debris in newly developing forest stands. The take-home point may be that the role of logging debris depends on soil type. Soil that's coarse, dry, and nutrient-poor may benefit when debris is retained on site.

Randall Greggs, forestry operations manager with Green Diamond Resource Company, says the soil at the Matlock site "is almost dry as a bone in the summer, and it doesn't drain well in the winter." Lack of organic material is one reason for the poor quality. Gregg says this study helped him verify that even piles of small-diameter debris can improve the soil. This site is also where the presence of logging debris had the greatest influence on reducing invasive plant species.

Port Blakely Tree Farms, LLC, owner of the Molalla site where the soil was better to start with and thus the benefits of retaining debris were not as pronounced, is using this research to identify sites where logging debris can be harvested with minimal impacts to soil



Tim Harrington

Technicians survey the abundance and variety of vegetation 1 year after timber harvest in a plot where logging debris was retained.

productivity. The company has also helped communicate the study results to foresters and silviculture instructors.

Harrington and his colleagues have initiated new research to identify some of the mechanisms by which debris retention limits invasion of nonnative plant species. In a laboratory study, they are simulating the effects of different depths and colors of logging debris on light intensity and quality (spectra) to determine if they trigger different germination responses in Scotch broom.

In a new field project supported by the State and Private Forestry branch of the U.S. Forest Service, different depths of logging debris, intensities of soil disturbance, and types of herbicide treatments have been combined to identify potential interactions that may influence subsequent development of invasive plant species and planted Douglas-fir. With the new research, the scientists hope to better understand how and where logging debris can be managed to provide the most benefits to forest productivity.

"The improvement of forest trees is the work of centuries. So much more the reason for beginning now."

—George Perkins Marsh

LAND MANAGEMENT IMPLICATIONS

- Logging debris can act as a mulch to conserve soil water, particularly on dry, coarse-textured soils. This helps to promote survival and growth of conifer seedlings.
- As logging debris decomposes, carbon and nitrogen stored in the debris are released back into the soil. The presence of logging debris also modifies decomposition of dead roots and stumps, further increasing soil carbon and nutrient pools. This can improve soil fertility and tree productivity. These benefits are more pronounced on poorer soil.
- Soil carbon helps sustain forest productivity by increasing water-holding and nutrient exchange capacities of the soil. The debris also insulates and cools the soil surface, slowing the rate at which carbon is lost from the soil.
- Soil nitrogen is a critical element for plant growth, and forest soils in the Pacific Northwest rarely have enough to maximize tree growth. More soil nitrogen, calcium, and magnesium were found where logging debris was retained on site, which may enhance forest productivity in the future.
- Logging debris limits the establishment and growth of invasive plant species by reducing the area suitable for germination of soil-stored or wind-dispersed seed and by reducing light to the soil surface. Many native plant species benefit from retained logging debris because they are more adapted to tolerate shade and the accumulation of organic matter than nonnative species.

Tim Harrington

The cycle begins again. These Douglas-fir seedlings at the Molallasite are sequestering carbon, producing oxygen, and will eventually be harvested and used in wood products.

FOR FURTHER READING

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WRITER'S PROFILE

John Kirkland has been writing about science, higher education, and business for more than 20 years. He lives in Portland, Oregon.

Science
FINDINGS

U.S. Department of Agriculture
Pacific Northwest Research Station
333 SW First Avenue
P.O. Box 3890
Portland, OR 97208-3890

SCIENTISTS PROFILES

TIMOTHY B. HARRINGTON joined the Pacific Northwest Research Station as a research forester in 2002. He received a M.S. in forest ecology and a Ph.D. in silviculture from Oregon State University. His current research focuses on forest regeneration, vegetation management, and invasive plant biology and management.

DAVID H. PETER is an ecologist at the Pacific Northwest Research Station. He received a M.S. degree in botany from Washington State University, and a Ph.D. in Ecosystems Analysis from the University of Washington. His work at the PNW Research Station has focused on Oregon white oak reproduction, effects of natural and historical anthropogenic fire, and relations between nonnative and native species.

Harrington and Peter can be reached at:
USDA Forest Service
Pacific Northwest Research Station
Forestry Sciences Laboratory
3625 93rd Avenue SW
Olympia, WA 98512

Harrington:
Phone: (360) 753-7674
E-mail: tharrington@fs.fed.us

Peter:
Phone: (360) 753-7654
E-mail: dpeter@fs.fed.us

ROBERT A. SLESAK is the site-level program manager for the Minnesota Forest Resources Council in St. Paul. His current research focuses on sustainable forest management with emphasis on forest soils, and assessment of invasive species impacts on ecosystem functions and development of practices to mitigate them.

Slesak can be reached at:
Minnesota Forest Resources Council
2003 Upper Buford Circle
St. Paul, MN 55108

Phone: (651) 603-6756
E-mail: raslesak@umn.edu

STEPHEN H. SCHOENHOLTZ is professor of forest hydrology and soils and director of the Virginia Water Resources Research Center at Virginia Tech. He has been conducting research and teaching courses that explore effects of forest management on water and soil resources for 22 years. He has a M.S. in forest biology and a Ph.D. in forest soil science from Virginia Tech.

Schoenholtz can be reached at:
Virginia Water Resources Research Center
210 Cheatham Hall
Virginia Tech
Blacksburg, VA 24061

Phone: 540-231-0711
E-mail: stephen.schoenholtz@vt.edu

COLLABORATORS

Randall Greggs, Green Diamond Resource Company

Jeff Madsen, Port Blakely Tree Farms