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Science
FINDINGS

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INSIDE

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

Managing Competing Vegetation in Douglas-Fir Plantations: The Benefits of Forest Floor Complexity

Tim Harrington

With its bright yellow flowers, Scotch broom was introduced to the Pacific Northwest in the 1850s as a garden ornamental. Now it's considered an invasive species. Until recently, herbicides were thought to most effectively control it following intensive timber harvest. Forest Service research reveals that retaining logging debris on site may be more effective.

IN SUMMARY

In the Pacific Northwest, clearcutting is the preferred method for harvesting wood products from Douglas-fir plantations because it's economical and mimics a large-scale disturbance. Following a clearcut, Douglas-fir seedlings are planted throughout the recovering native plant community. Yet the newly planted seedlings and native plants aren't the only vegetation claiming the open ground. Invasive plant species, such as Scotch broom and sweet vernalgrass, can also colonize the site and compete with the seedlings for water, nutrients, and light.

Eradicating Scotch broom requires repeated herbicide applications, but even this approach might not fully control the infestation. Tim Harrington and David Peter, both researchers with the U.S. Forest Service Pacific Northwest Research Station, conducted a 5-year study near Matlock, Washington, to test if logging debris, in combination with herbicide applications, could reduce the spread of Scotch broom and other invasive plants; thereby improving regeneration of Douglas-fir.

They found that leaving logging debris reduced the spread of invasive plants and encouraged the development of the native plant community. Douglas-fir seedlings on these sites also grew faster and had higher survival rates than seedlings on sites where logging debris was removed. These results suggest that retaining logging debris offers a potentially cost-effective and beneficial long-term solution for managing invasive plants.

"The bearings of this observation lays in the application of it."
—Charles Dickens

Windstorms and ice storms; root rot and wildfires: Nature adds a dose of disturbance to forests west of the Cascade Range in various ways. In the disturbance's aftermath, pioneer tree species, such as red alder, bitter cherry, and Douglas-fir, are among the first seedlings that sprout from the forest floor to claim the available growing space. These species grow best under full sunlight. This is one reason clearcuts are the preferred method for starting a new cohort of Douglas-fir trees.

"We're emulating a natural disturbance such as a windstorm when we clearcut," explains Tim Harrington, a research forester with the U.S. Forest Service Pacific Northwest (PNW) Research Station. "Our clearcutting systems do have artificial features though. They're always discrete openings in a forest where there are basically no trees left, and that's not how Mother Nature would tend to operate."

Another artificial feature of a clearcut is the removal of all the logging debris from the site. "We learned to pile the logging debris and burn the piles from agricultural practices because that was what farmers were doing," says Mike Warjone, vice president of operations of Port Blakely, a timber company. "For 100 years, that's how we've prepared the site for planting.

We've had good tree survival by having a clean, bare site, and it's easier planting the trees."

Yet this practice creates a landscape that is ideal for more than just Douglas-fir seedlings. Invasive plant species such as Scotch broom (Cytisus scoparius) and sweet vernalgrass (Anthoxanthum odoratum) also thrive in the abundant sunlight and clean, bare ground. Managing Scotch broom in Douglas-fir plantations is a priority for many forest land owners in the Pacific Northwest because this noxious weed competes with Douglas-fir seedlings for nutrients and water. And Scotch broom seeds appear to remain viable in soil for 50 years or more.

Throughout his 17-year career with the Forest Service, Harrington has collaborated with private forest land owners throughout the Pacific Northwest to identify methods for controlling Scotch broom and other invasive species. "Researchers such as Harrington are absolutely critical to the success of this industry because he is bearing the burden of what would have been done by companies internally," Warjone says. "We'll support Harrington's research because it's so critical, and there really just isn't any other mechanism to get this research done."

Harrington has studied the use of herbicides because removing Scotch broom by hand is expensive, and mechanical equipment disturbs the soil and usually provides only short-term vegetation control. By happenstance in 2010, he came across another possible method while visiting one of his research sites that is part of the North American Long-Term Soil Productivity (LTSP) network; the LTSP network is a national program that was established in 1989 to study the long-term effects of soil disturbance and organic matter removal on forest productivity.

On Green Diamond Resource Company timberland located near Matlock, Washington, Harrington and his team were monitoring the long-term effects of harvesting and logging debris retention upon Douglas-fir seedlings and the soil. The distribution of Scotch broom caught his attention.

"We saw that the Scotch broom had totally invaded areas with light logging debris retention," he says. "We didn't plan it that way." Intrigued by this observation, Harrington collected field data to learn more. He suspected that the amount of Scotch broom was related to the amount of logging debris left behind. When he reviewed existing literature for other studies that might have explored this hypothesis, he found no mention of logging debris retention as a viable management tool for controlling invasive plant species.

Designing an Experiment

Although Harrington had field data to confirm his suspicions, a formal study was needed. "Without research, you're just guessing whether you have the mechanisms to support what you're observing, whether you're conducting the treatment correctly, or whether the practice works on all sites," he explains.

Harrington approached Shawna Bautista, a colleague with whom he had previously worked on the management of invasive plant species. As the Pesticide Use and Invasive Plant Coordinator for the Forest Service's Pacific Northwest Region (Region 6), Bautista knows firsthand why Scotch broom needed to be controlled. "In 2014, the state of Oregon did an economic impact analysis of invasive plant species," she says. "Scotch broom and Himalayan blackberry accounted for the vast majority of the impacts and an annual economic loss of $79 million."

Bautista identified the Forest Service's Special Technology Development Program as a funding source for Harrington's study. "The purpose of this internal grant program is to help promote the development of techniques and tools that will help us do a better job of our land management," says Bautista. "Harrington's research was looking at a specific logging technique—the treatment of the postharvest debris—and how its use could improve the landscape and save money, both in terms of getting trees established and reducing invasive plants and management costs associated with invasive plants."

Harrington reached out to two colleagues to join the project: David Peter, an ecologist with the PNW Research Station who worked with Harrington on earlier native plant community and herbicide treatment research; and Robert Slesak, the director of applied research and monitoring for the Minnesota Forest Resources Council who worked with Harrington on the Long-Term Soil Productivity research.

In 2011, Harrington and the team found a new research site near the LTSP site, so they could replicate their experiment under similar environmental conditions. The site contained a 58-year-old natural stand of Douglas-fir that was scheduled to be harvested. Importantly, the understory included Scotch broom from a previous disturbance. This indicated a high likelihood that the species would invade soon after the timber harvest. Dubbed the Dry Bed

KEY FINDINGS

- Retaining a 12-inch layer of logging debris (roughly 9 tons per acre) increased the survival and growth of planted Douglas-fir during the first 4 years after timber harvest; the debris shaded the forest floor, thereby reducing soil temperatures and conserving soil water..
- Mulching effects of the logging debris increased survival and growth of the planted Douglas-fir seedlings during the summers of 2015 and 2016 when extreme drought occurred.
- Retaining logging debris also decreased the cover of nonnative plants and increased cover of native vines and shrubs. This canopy of native species fostered resistance to future invasions by nonnative plants.
- Soil nutrient concentrations and carbon stores were not affected by the retention of logging debris; however, the logging debris could be a source of nitrogen for the planted seedlings.

Purpose of PNW Science Findings

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

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Tim Harrington

A study plot near Matlock, Washington, where woody debris was spread less than 6 inches deep after harvest.

Tim Harrington

A study plot where logging debris was spread about 12 inches deep. A year later, tree planters putting in Douglas-fir seedlings reported no difficulty in working through the debris.

Creek Study because it's near a creek that runs dry during the summer, the glacial outwash soils make it a difficult site for growing Douglas-fir.

"Initially, Douglas-fir won't grow as fast as Scotch broom, so if you have broom on the site, you're going to have trouble," says Harrington. "You will want to implement a management activity that disfavors grasses and Scotch broom."

Over the summer, 12 main plots were established, and each was randomly assigned to receive either a heavy or light logging debris treatment soon after forest harvesting. Each of these 12 plots in turn was divided into 4 split plots that would randomly receive one of the following treatments: an aminopyralid herbicide application, a triclopyr ester herbicide application, a combination of an aminopyralid and triclopyr ester herbicide application, or no herbicide application. (These herbicides were selected because aminopyralid has soil activity on germinating Scotch broom seedlings; whereas triclopyr ester has foliar activity on existing Scotch broom plants.) Soil samples were collected to estimate nutrient pools, and an inventory was taken of the overstory Douglas-fir trees.

In December 2011, Green Diamond Resource Company harvested the Douglas-fir trees. Harrington credits the loggers for accurately felling the trees to ensure the branches and tops remained on the heavy debris plots, and the equipment operators for using designated machine trails to reduce soil compaction and disturbance on the plots. Later, an excavator with a clamshell bucket came through and moved the debris until it was the depth that Harrington needed: about 12 inches on the heavy debris plots and 6 inches on the light debris plots.

In June 2012, Peter visually estimated understory plant coverage and then contractors applied the first round of herbicide treatments. In February 2013, Douglas-fir seedlings were planted across the 48 plots, and for the next 4 years, their growth was monitored, along with the canopy cover of the vascular plants in the overstory and understory. Soil water and temperature data also were collected throughout each of the five growing seasons, and the soils were resampled at the end of the experiment.

The Benefits of Logging Debris

Analysis of the vegetation data confirmed Harrington's observations: on all 48 plots, the native understory vegetation responded favorably to the available sunlight and growing space. However, there was greater coverage of native vegetation on plots with heavy logging debris, and one native plant in particular thrived as a result.

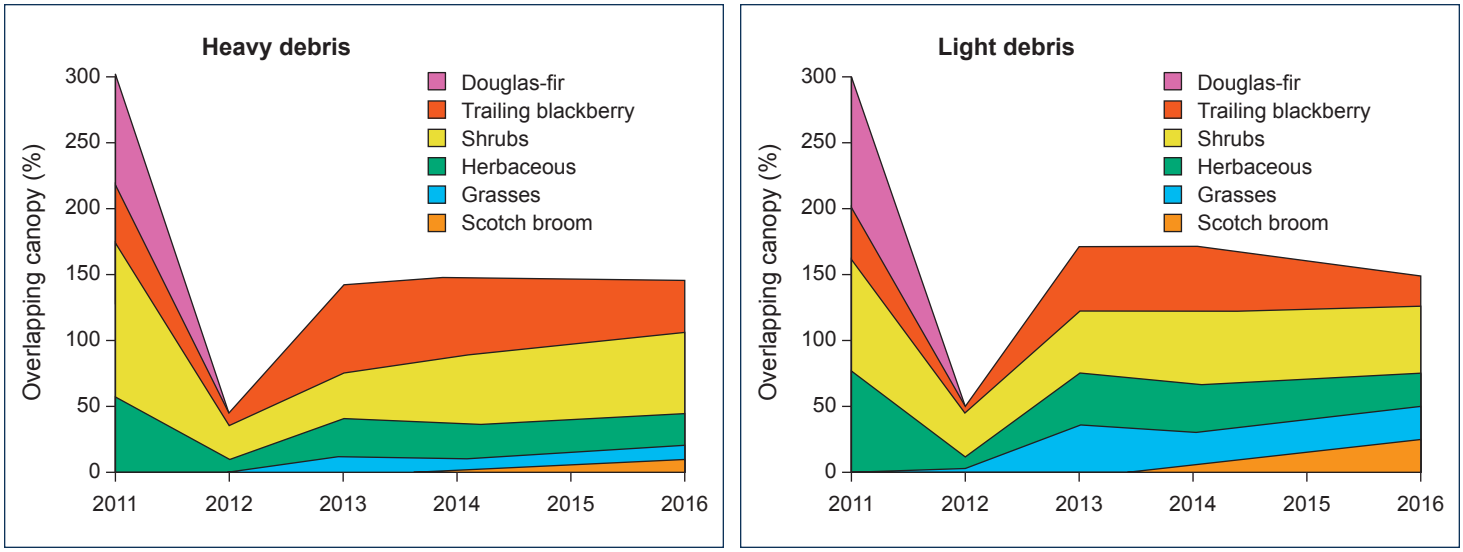
"As fast as the needles were falling off the branches, trailing blackberry was growing over the debris," Peter says. "Trailing blackberry is a vine, but it's not a strong climbing vine; it grows over debris and shrubs. In the preharvest stand, it climbed through the salal [a native shrub]. With all the trees cut down, on the plots with debris, it climbed over the debris and became a dominant plant." Unlike nonnative Himalayan blackberry (*Rubus armeniacus*), which can form impenetrable thickets up to 8 feet high, native trailing blackberry (*R. ursinus*) grows only 6 inches tall. Its competitive advantage comes from its ability to climb over other plants.

As trailing blackberry spread, it shaded the soil and was likely responsible for the cooler soil temperatures found on the heavy logging debris plots for 3 to 4 years after the seedlings were planted. These microclimate conditions, in turn, improved the vigor of the Douglas-fir seedlings.

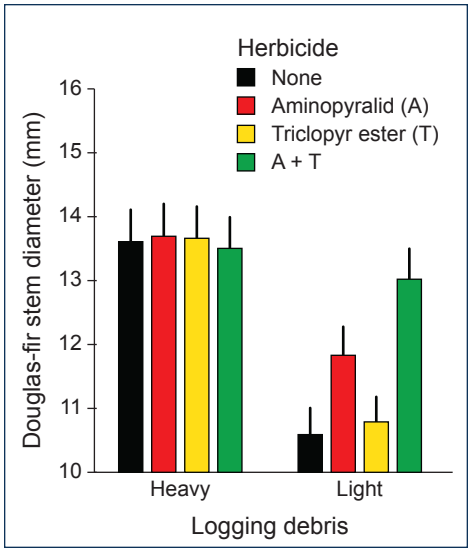
"The only way nutrients get into the tree is through water," explains Peter. "A planted tree has only the roots it came with, so it's only going to get the water in the hole it's planted in. If there is a slight difference in the amount of water available, that could make a big difference for the tree."

This difference was noted in the survival rates of the seedlings during the summers of 2015 and 2016 when the area experienced intense droughts. Although seedling survival declined across all the plots, the decline wasn't as severe in the plots with heavy logging debris.

To determine if retaining logging debris affected soil nutrients, Slesak analyzed the carbon and nitrogen levels of the pre- and post-treatment soil samples. He found the effects



The amount of logging debris retained on site affected the recovery of the native and invasive plant species following the 2012 clearcut. Native trailing blackberry and shrubs responded positively to the presence of heavy logging debris, whereas invasive Scotch broom and grasses grew more vigorously on plots with little retained debris.



Herbicide treatments had a mixed effect on the growth of Douglas-fir seedlings in the plots with light logging debris 4 years after planting. On sites with heavy logging debris, however, no herbicides were needed to produce growth responses similar to plots that received herbicide treatments.

were limited, which wasn't surprising. "Since we were looking at total pools of nitrogen and carbon, that's a larger amount and more variable, so that would explain why we saw no treatment effects in the mineral soil," he says.

However, when measuring forest floor mass, heavy debris plots had higher organic matter levels. There are probably two reasons for this, Slesak explains: "We retained the logging debris, and the small twigs and needles which decompose become part of the forest floor. The debris also shades the forest floor, so it inhibits the decomposition of the forest floor." One long-term implication of these higher organic matter levels is the greater availability of nutrients such as nitrogen, which could improve the productivity of the site and the growth of the Douglas-fir in the future.

And what was the answer to the overarching question: Did logging debris effectively control the Scotch broom? Yes, the data indicate that the heavy logging debris was associated with an 88 percent reduction in seedling density of Scotch broom. Yet there was another important finding as well. "If you have heavy debris, you don't need herbicides," Harrington says. "The two herbicides, applied in combination, provided the same benefits to tree growth that heavy debris accomplished alone."

Applying the Results Out in the Field

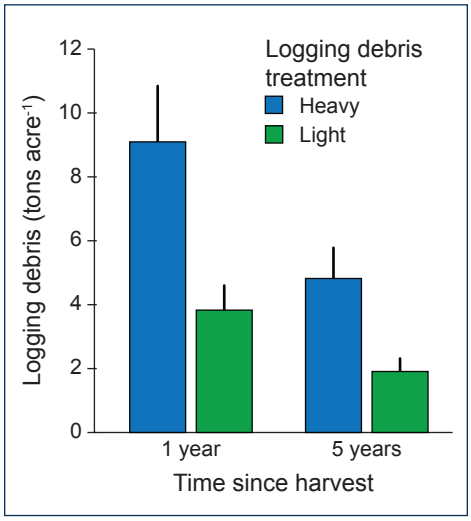
Although the benefits of retaining logging debris appear straightforward, Harrington adds the caveat that this research was conducted on a droughty site that is more prone to Scotch broom invasion. "We demonstrated some options that people can try if they have these types of sites," he says.

"On more productive sites, the invasive plants aren't as much of a problem," Peter adds. "Instead, salal can be a problem, as can trailing blackberry, when it comes to competing with Douglas-fir seedlings. The important thing is to know what kind of site you have and put the appropriate treatments in."

An increase in wildfire risk resulting from retaining more woody debris on the landscape also should be acknowledged; however, after 5 years, the mass of heavy logging debris was similar to the mass of the light logging debris at the start of the study. As Peter points out though, "Scotch broom carries fire really well too when it gets dry. If you manage in a way that encourages Scotch broom, you're encouraging fuel even if you've removed the woody debris."

Forestry professionals have toured the research site and are now incorporating logging debris retention in their management activities. **"**We are scattering the nonmerchantable debris around as much as possible as an even blanket across the ground, and we are really only piling the debris on landings," says Warjone. "This approach has reduced the amount of burning we do by 50 percent. The tree planters have become pretty good at planting through that."

In 2011, Oregon State University Extension Service published *Best Management Practices for Maintaining Soil Productivity in the Douglas-fir Region,* and retaining logging



Five years after harvest, the amount of remaining logging debris in the heavy debris treatment did not significantly differ from the amount observed in the light debris treatment 1 year after harvest. This suggests that any increased fire risk related to greater debris retention was short lived.

PESTICIDE PRECAUTIONARY STATEMENT

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All use of pesticides must be registered by appropriate state or federal agencies, or both, before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

LAND MANAGEMENT IMPLICATIONS

- Managing competing vegetation in Douglas-fir plantations through retention of logging debris and use of designated machine trails to preserve litter layer and limit soil compaction can reduce the need for broadcast herbicide applications.
- Intensive soil disturbance from timber harvesting and removal of logging debris increased the persistence and competitiveness of nonnative species, such as Scotch broom (*Cytisus scoparius*) and sweet vernalgrass (*Anthoxanthum odoratum*) against native plant species.
- When logging debris was retained, tree planters were still able to find planting spots for the Douglas-fir and maintain a uniform spacing among seedlings throughout the plantation.
- Retention of logging debris increased the perceived risk from wildfire for 5 years following the timber harvest. Low-elevation forests of western Washington and Oregon have fire-return intervals of 40 years or more so debris retention may be considered a reasonable risk.

debris, as demonstrated by Harrington's research, was cited as a beneficial management practice.

Bautista has shared the research with the Region 6 invasive plant program managers so they can implement the findings when timber harvests are planned in areas with invasive plants. "Herbicides are very helpful as a tool, but treatments cost time and money," she says. "Knowing how best to combine the logging debris treatment and the potential herbicide use when targeting invasive plants, or in some cases, competing plants, is very helpful."

For Harrington and Peter, a key takeaway from the study was that forest floor complexity is underappreciated in even-aged Douglas-fir stands, and the complexity can benefit productivity.

"In this study, what really came through was that a good healthy dose of woody debris provided quite a boost for Douglas-fir as well as for native shrubs and herbs, which ironically had been targeted with the herbicides because it was thought they were competing with the Douglas-fir," Peter says. "But in fact, they weren't the competition problem we thought they were."

"You can observe a lot by watching."
—Yogi [Lawrence Peter] Berra, professional baseball player

Writer's Profile

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Tim Harrington

Intense drought during 2015 and 2016 killed a number of seedlings across the research area. However, fewer seedlings died in plots with heavy logging debris compared to those with light debris. The logging debris served as mulch, which resulted in higher soil moisture.

Further Reading

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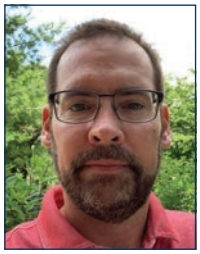

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