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Post-fi re Logging: An Effective Tool for Managing Future Fuels in Coniferous Inland Northwest Forests

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RESEARCH SUPPORTING SOUND DECISIONS

Snags, fuels, and recovering vegetation about 15 years after high-severity wildfire, followed by logging (Tyee Fire near Wenatchee, WA). Credit: R. Harrod.

Post-fire Logging: An Effective Tool for Managing Future Fuels in Coniferous Inland Northwest Forests

Summary

This study involved a chronosequence of 68 stand-replacing wildfires that happened between 1970 and 2007 in dry coniferous forests of eastern Washington and Oregon. The authors compared snag decay and surface fuel accumulation with and without post-fire logging. Without logging after a fire, woody fuels accumulate for 15–30 years because the rate of fuel deposition on the ground is greater than the rate of wood decay. Stands that were more dense prefire have greater accumulations of fuel. Predominant tree species and size influenced rates of fuel deposition and snag decay. Thin trees fell before larger trees and ponderosa pines typically fell before Douglas-firs. Within about 30 years of the fire most downed logs (>7.5 centimeters diameter) were rotten and soft. Cavity-nesters used various tree species and sizes for nests, but cavities occurred most frequently in snags with broken tops and in trees of at least 30-centimeter diameter. Post-fire logging that did not include slash removal at first increased surface fuels. But within 10 years after the fire, fuel loads were lower on logged sites than unlogged sites, and remained thus for at least 35 years. The researchers found no evidence that post-fire logging hindered tree regeneration on the study sites.

Key Findings

- After severe wildfires in dry low- to mid-elevation forests of eastern Washington and Oregon, maximum surface fuel loads are reached within 15 to 30 years. These loadings typically remain high for 35 to 40 years and are highest in areas with higher pre-fire basal area.
- More than half of large woody fuels were rotten within 30 years post-fire, and the proportion continued to increase with time since fire.
- Cavity-nesters used all size classes of trees at different times, but preferred broken-topped medium to large trees (>30 centimeters).
- In stands that were logged post-fire, all sizes of surface fuels were reduced following a short period of heightened fuel loads.

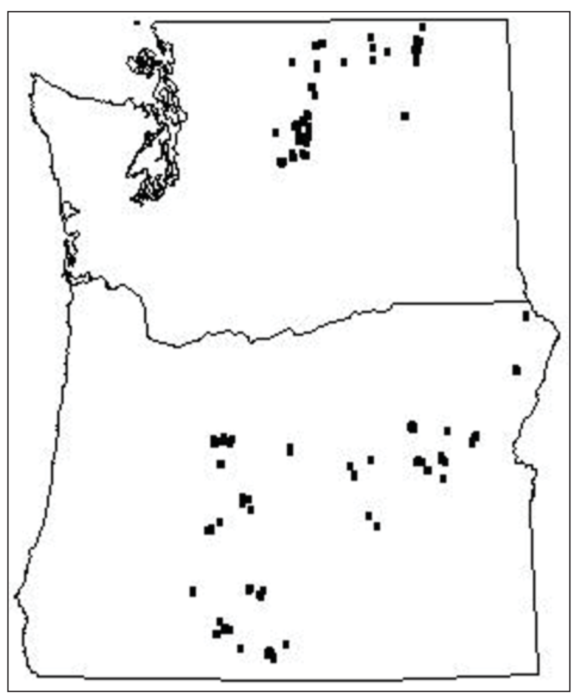
Timber utilization versus natural processes?

People engaged in the debate over post-fire logging tend to divide into two camps: those who favor timber utilization and those who favor letting natural processes take their course. Those who favor harvesting snags (fire-killed standing trees) after fire argue that it can generate income for the community and may help reduce the risk of insect and/or disease outbreaks. Those who favor natural processes complain that post-fire logging may increase the fire hazard in the short term by increasing surface fuels. Furthermore, they say that post-fire logging can harm soil properties; increase runoff and erosion, thereby harming water quality; degrade wildlife habitat; slow future forest growth; and aid the spread of invasive and/or exotic species. Focusing instead on fuels management may be a valid third perspective.

Snag stands produced by high-severity wildfire present high potential for future surface fuel loadings.
Credit: R. Harrod.

Crown fires have become more common in many dry coniferous forests that historically burned with frequent, low intensity, surface fires. Crown fires primarily consume foliage and small branches. Standing snags remain. Over time, snags decay, break, and fall, resulting in an increase in the surface woody fuel load where rates of decay are relatively slow. Many people assume that these uncharacteristically severe fires reset the landscape back to a more natural fire frequency, but that may not be true because of the potential for woody fuels to accumulate after a fire. The "reburn hypothesis" says that this mass of fuel can significantly influence the behavior and effects of future fires. If severe fires do recur, they may have detrimental impacts on tree regeneration and hinder the site's ability to recover.

This study examined fuel succession in dry ponderosa pine and Douglas-fir forests in eastern Washington and Oregon. Such forests historically burned at low or mixed severity about every 3–36 years. A chronosequence of 255 sites was examined within the area of 68 stand-replacing wildfires with and without post-fire logging. At each site researchers assessed woody debris fall and decomposition; the effects of post-fire logging on fuel succession, potential fire risk, and long-term forest regeneration; and snag use by cavity-nesters.



Study site locations in Washington and Oregon.
Credit: D.Peterson.

"We developed this 40-year chronosequence approach," says project leader David Peterson, research forester with the Pacific Northwest Research Station, "because we didn't want to wait 40 years for the answers, but we have had a lot of high-severity fires in eastern Washington and Oregon since 1970. If we look at enough of those sites, we get a good idea of the pattern of fuel succession and its variability."

They focused on dry, low to mid-elevation forests of large ponderosa pine or Douglas-fir where historically most fires would have been of low or mixed severity, killing few trees. Historically, fires were fairly frequent in these areas, and managers want to encourage low-severity fire there in the future. In this study, they examined uncharacteristic stand-replacing fires where tree mortality was essentially 100 percent.

Fuel accumulation over time

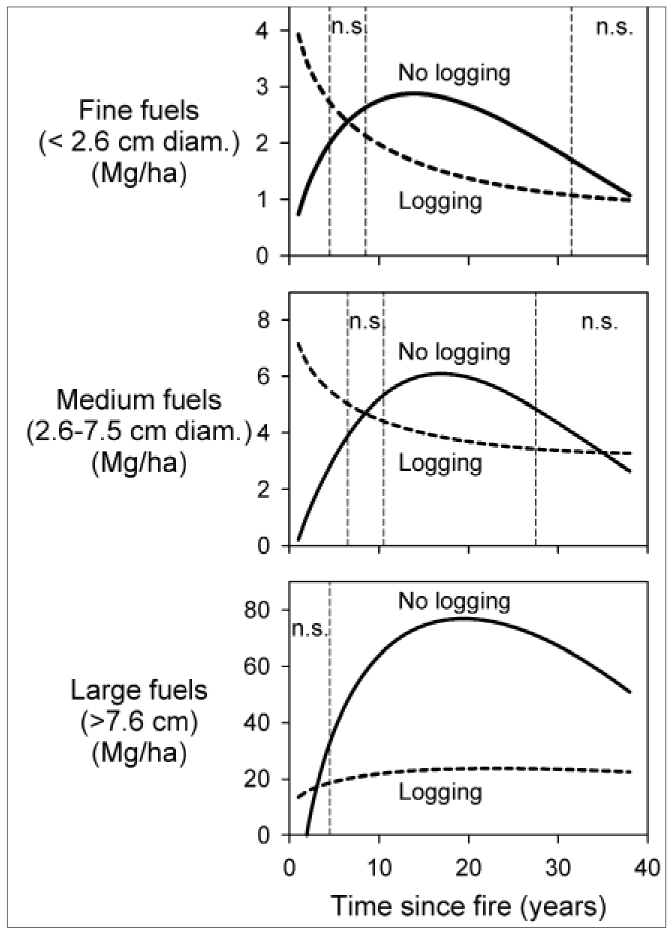
The study had three main components. In the first, Peterson and his team wanted to know how much fuel accumulates after an uncharacteristically severe wildfire in this area, and when. To find out, they reconstructed the stand structure at the time of the fire because this is the major source of variability for what the site will look like 20 years later. By having enough study sites they could account for much of this pre-fire variability and its effects on post-fire fuel succession.

"We were using a space-for-time model," Peterson explains, "so we were looking at these different-aged fires and stands within the fires. The idea was since the oldest fire sites are only about 40 years old now, and because they haven't been subsequently disturbed by fire or anything, basically all the wood is still there."

Within each study plot the field crew noted all of the trees that were still standing or had fallen and measured the diameter at breast height. The researchers also measured cut stumps and adjusted for diameter at breast height. These measures allowed them to calculate pre-fire stand basal area, density, and species mix. Peterson says there's a little error, especially for fires in the more distant past, but you can generally tell whether a tree was alive or dead at the time of the fire. The field crew also surveyed surface woody fuel loads and inventoried snag and log conditions within each study plot.

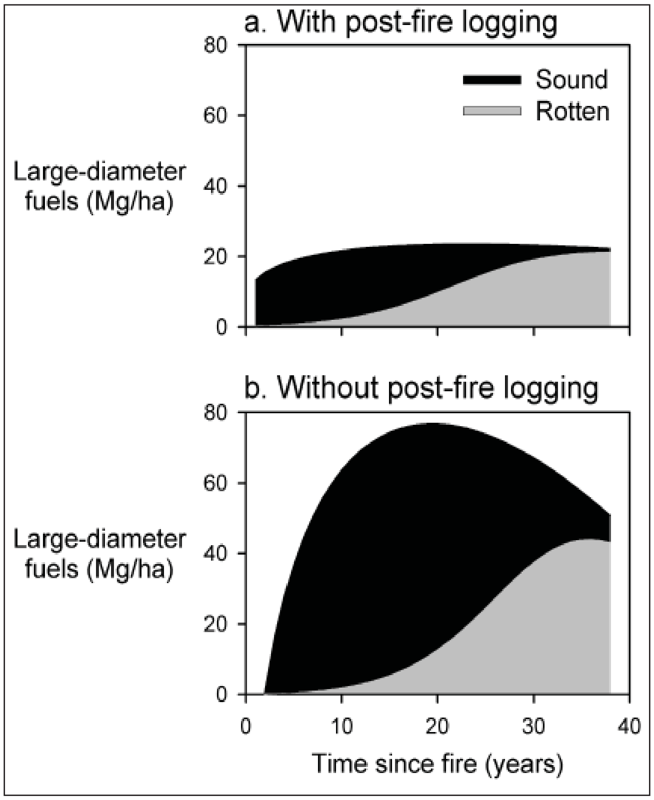
The period of greatest fuel loading was 15–30 years post-fire. Small- and medium-sized fuels typically peaked within 15 years, followed by a period during which fuel decomposition exceeded fuel deposition. Fuel loads were greatest in stands with more basal area killed. The amount of large fuels continued to increase for almost 30 years. Total loads remained high for about 40 years. Because this is longer than the historic fire return interval, heavy fuel loading leaves these areas vulnerable to uncharacteristically severe wildfire during this period.

Snags and accumulating surface fuels 10 to 15 years after high-severity wildfire in Washington. Credit: R. Harrod.



Fuel succession patterns differ for sites with and without post-fire logging and for different fuel diameter size classes. Median pre-fire basal area of 27 m^2/ha (Mg/ha=megagrams/hectare). Credit: D. Peterson.

Large downed logs began to rot at about 15 years post-fire, and more than half were rotten within 30 years. Rotten wood tends to burn more thoroughly than solid wood and may increase the potential for smoldering fire. A long-smoldering log will heat the soil, which can damage site productivity by burning off soil nutrients and reducing plant sprouting. A smoldering fire can also increase erosion and loss of soil carbon. Soil heating and loss of site productivity is often not factored into the debate about post-fire logging.



Temporal changes in the expected amounts of rotten and sound large-diameter surface fuels on a site with median pre-fire stand basal area of 27 m^2/ha. Credit: D. Peterson.

Examining snag decomposition and snag use by cavity-nesters

The second major piece of this research was to examine the rate and pattern of snag decomposition and the importance of species and diameter in this decomposition.

Snags began to decay and fuel began to accumulate within about one year of the fire. Small snags tended to fall first, and larger snags began to break and drop branches.

"Most previous studies that have looked at snag decay have focused on it from a wildlife perspective," Peterson notes, "basically how long the trees have stood and whether they have woodpeckers in them or not."

Within 15 years post-fire, more than half of standing snags had broken tops, and almost all did within 25 years.

Peterson's crew found that although cavity nests occur in various species and sizes of trees over time, they are typically found a foot or two below the break in a fire-killed tree. So broken tops are a key predictor of whether cavity-nesters will use the tree. This may be because water can begin to break down the broken tree, making it soft enough for woodpeckers to break into, but hard enough to maintain a cavity. Cavity-nesters preferred ponderosa pines and medium-sized trees earlier post-fire than firs or large trees.

The fundamental management question here, says Peterson, is what's the relative value of a fire-killed tree for cavity-nesters compared to its fuel production capacity? Take, for example, a tree that's too small for woodpecker use or one that will fall over before a woodpecker could inhabit it; that's a high fuel/low habitat tree. Peterson's team wanted to learn enough about these patterns that they could tell managers that if they're going to log, they should leave a certain species and size mixture so the habitat remains viable for the next 40 to 50 years.

> *...what's the relative value of a fire-killed tree for cavity-nesters compared to its fuel production capacity?*

The kinds and sizes of trees in a stand influenced snag decay rates, in ways we might expect. Larger trees stood longer and decayed more slowly. Douglas-firs and true firs stood upright longer than ponderosa pines in the same size class.

Developing a snag calculator

"One of the questions you'd really like to be able to ask if you've just had a high-severity wildfire and you've got all these dead trees is, 'What is this going to look like in 10, 20, 30, 40 years down the road if I do nothing, or if I do "this" or "that" management procedure?'" Peterson explains.

His group is working on a snag calculator that they hope will be web-based and eventually become part of the Forest Vegetation Simulator, the Forest Service's national modeling system for forest growth and yield modeling. This tool would allow a manager to enter a stand inventory, then look at outcomes such as amount of fuel on the ground in 10 years, 20 years, etc. If you run, say, 100 simulations, Peterson says, the calculator would output an average or a range of values for fuel loadings in the different size classes at a particular time post-fire.

Is post-fire logging a viable fuel treatment?

The third key question the researchers wanted to answer was can post-fire logging be considered a viable fuel treatment? In the short run logging may generate a lot of fuel if the branches are left onsite, and the disturbance may hinder tree regeneration. These findings appeared in the journal Science in 2006 via a different research team (Donato et al.). This makes logical sense, but managers wanted to know what would happen in the long term.

If you do the same study 5 years post logging, you get very different results, says Peterson. Logging takes a lot of wood offsite, so fuels are reduced in the long run. Within about 5 years post-fire, the average total woody fuel loading and large woody fuel loading were greater on unlogged sites than on logged sites. Loads of small and medium fuels remained higher on unlogged sites for 35 to 40 years post-fire. Differences in fuel loads were greatest for sites with large trees and moderate to high basal area pre-fire. These are the stands most suited for post-fire logging.

Peterson states that management actions depend on whether you're most concerned about short- or long-term fire risk.

"If you just leave the dead trees where they fall," he explains, "you continue to have a problem in the future—there's still a lot of fuel when the next fire comes along. There is currently a difference of opinion over fuel management in the context of economic recovery versus wilderness/natural processes. The people who wanted this study done said, 'No, there's a third way. There is this middle ground of managing fuels.'"

"We're trying to create that middle ground," Peterson continues, "and say, 'Of course you don't need to or want to cut down every tree that was killed by a fire, because, yes, fire-killed trees are a natural part of the ecosystem.' We want to retain enough of these trees, and we want them of different sizes and species, so that we get these habitat benefits and we maintain an ecosystem function. But, at the same time, if we start out with this uncharacteristically dense forest because of past management and fire suppression, and you just leave all these trees that are dead, you could end up with something that's even worse."

"We really need to work out a [post-fire logging] policy before the fire happens"

"We really need to work out a [post-fire logging] policy before the fire happens," Peterson says. If, because of lawsuits, post-fire logging does not start shortly after the fire, agencies often end up paying a company to remove the material, because it loses its economic value. "Once the fire happens the clock is ticking on these things and then you're trying to negotiate in a hurry," Peterson adds.

He suggests that perhaps a reasonable approach to post-fire logging that everybody could agree on ahead of time might go something like this: "We're not going to build a lot of new roads. We're going to focus on the little trees, but we're going to get in there really fast. We'll take out the little trees while they have some value, then we can leave all those big trees that everybody wants to leave anyway."

In addition to debate over whether post-fire logging is a viable fuel treatment, there is disagreement about the effect of this logging on forest regeneration. This study found that "post-fire logging did not delay forest regeneration or prevent full stocking." Peterson notes that this could be because most logged sites are replanted. But, he says, "The reality is we have at least as many trees on the logged sites as we did on the unlogged sites, on average." At any time post-fire, logged stands were more often fully stocked (at least 500 trees per hectare) than unlogged stands. Logged stands had sapling-sized trees (>1.35 meters) before unlogged stands did. Peterson's crew also found "no evidence for widespread reductions in forest regeneration caused by post-fire logging."

Management Implications

- Managers should consider multiple time frames when trying to determine if post-fire logging is helpful for reducing future fire risk. Fuel characteristics change over time, and these changes influence future fire behavior and severity.
- With no post-fire fuel treatments in these dry coniferous forests, the period of 20–40 years after wildfire is high risk for uncharacteristically severe wildfire. Post-fire management should keep in mind goals for this period.
- Post-fire logging is a valid fuel treatment in these dry coniferous forests.
- Small-diameter snags contribute a lot to fuels and not much to wildlife habitat, so these should be targeted if post-fire logging is done.
- Leaving various sizes and species of trees will help ensure habitat suitability for cavity-nesters.

Peterson wraps up the take-home message of the research this way: "Post-fire logging is a potentially effective tool for managing future fuels and fire behavior on dry forest sites that have experienced high-severity or stand-replacing wildfires." These fires "create a pulse of coarse woody debris and fuels." Without logging, if another fire comes along within 20–40 years, there's a good chance it'll again be high severity with potential for damaging soil heating.

To do: Effects of post-fire logging on vegetation recovery

Peterson says that the results of this study raise questions about whether post-fire logging significantly affects forest regeneration and stand development. He also sees the need for a study of the long-term effects of logging on vegetation recovery. He would like to see follow-up on the role of large wood in fire behavior and fire effects and better incorporation of that information into fire effects models.

Further Information: Publications and Web Resources

Peterson, D.W., and R.J. Harrod. 2010. Fuel succession, post-fire logging, and future fire behavior: Addressing the "reburn problem." Final report to Joint Fire Science Program. www.firescience.gov/projects/06-3-4-16/project/06-3-4-16_final_report_-_jfsp_06-3-4-16_-_peterson_et_al.pdf

Scientist Profiles

David W. Peterson is a Research Forester with the Pacific Northwest Research Station. He conducts research on restoration and management of dry coniferous forests of the interior Pacific Northwest, with emphases on evaluating forest ecosystem responses to high-severity wildfires, effects of post-fire management practices, and vegetation responses to fuels management treatments. He also maintains ongoing research in oak savanna ecology and assessing forest vegetation responses to climatic variability and change.

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