How Did Prefire Treatments Affect the Biscuit Fire?

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Most scientific literature supports forest thinning to reduce the severity of wildland fires, but the effectiveness of thinning in modifying fire behavior has not been well documented. The Biscuit Fire of 2002 offered a great opportunity to study the effects of mechanical thinning on fire behavior during a megafire.

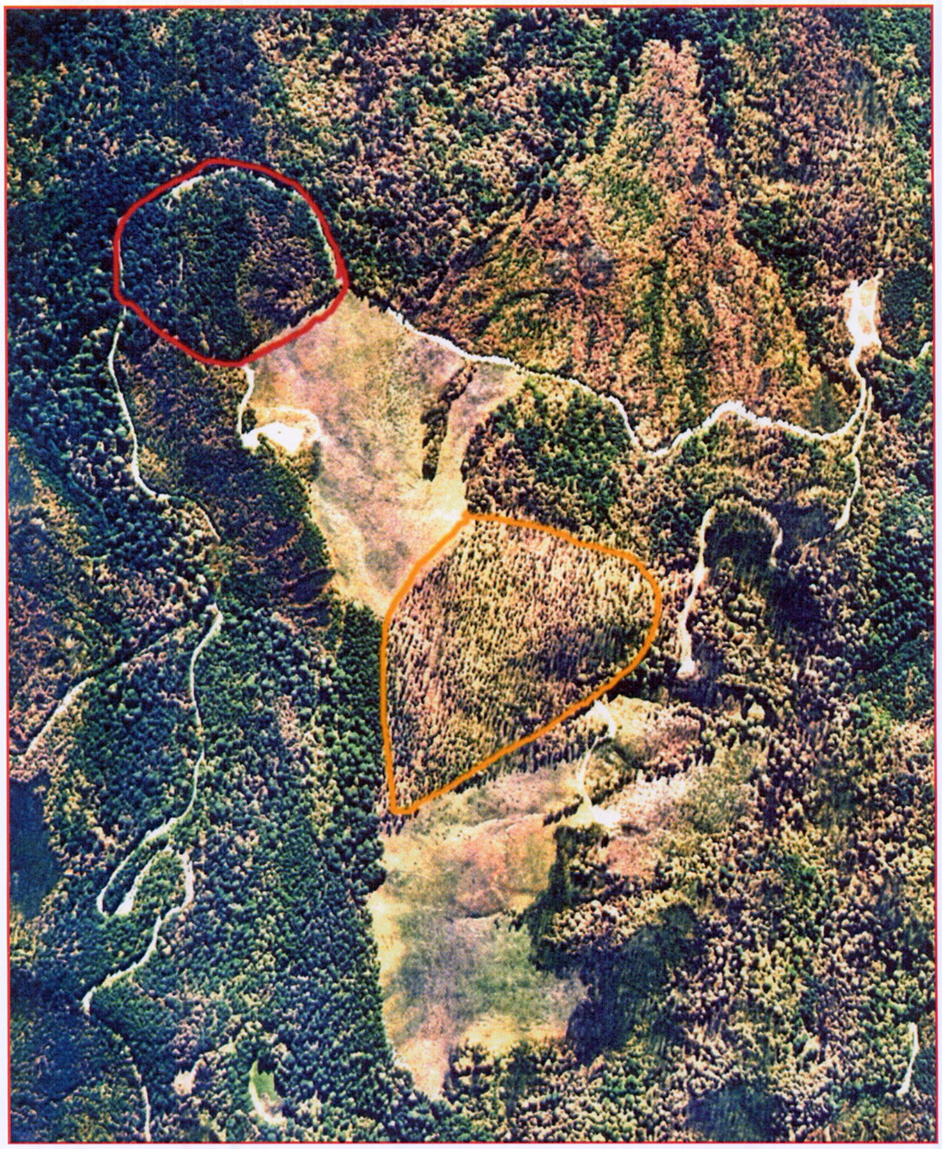
The Thinning Theory

Forest thinning is done to prevent surface fires from transitioning to crown fires. Theoretically, reducing canopy fuels and eliminating ladder fuels will decrease the probability that a crown fire will initiate and spread (Cron 1969; Omi and Martinson 2002; Pollet and Omi 2002; Scott and Reinhardt 2001; Stephens 1998).

Most studies on fuel treatment efficacy focus on forests with low-severity, high-frequency fire regimes, such as ponderosa pine and Douglas-fir forests in the Interior West. As a result of fire exclusion, these forests are dense, producing greater canopy and ladder fuel loadings (Agee 1993).

At the opposite end of the spectrum are forests with high-severity, low-frequency fire regimes, such as Pacific coastal, subalpine, and boreal forests. However, because weather influences fire behavior more than fuels in these ecosystems (Bessie and Johnson 1995; Turner and others 1994), thinning is less effective in reducing fire severity than it is in forest ecosystems with a higher fire return frequency.

Little information exists for forests with mixed-severity fire regimes, which encompass a wide range of fire frequencies, extents, and severities. The result of this variability makes it more difficult to quantify the ecological role of fire than in forests with low-severity fire regimes.



Aerial view of fire damage on thinned and untreated plots 1 month after the Biscuit Fire. Thinned plots are circled in orange and untreated plots are circled in red. Photo: USDA Forest Service, 2002.

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Biscuit Fire: A Research Opportunity

In 1992, scientists from the USDA Forest Service's Pacific Northwest Research Station started the Long-Term Ecosystem Productivity (LTEP) study on the Siskiyou National Forest in southwestern Oregon. The initial goal was to assess the effects of plant community composition and large woody debris on the processes that affect forest ecosystem productivity. When the Biscuit Fire roared through the area on August 16, 2002, the goal changed.

The Biscuit Fire was Oregon's largest recorded fire and one of the largest ever to occur on national forest land. It burned more than 499,000 acres (202,000 ha), and cost more than $150 million to suppress. Although weather contributed to fire severity through high temperatures, low nighttime relative humidity, and dry east winds, the LTEP sites burned under more moderate weather conditions.

Crown scorch of overstory trees on a thinned plot (left) and an untreated plot (right). The thinned plots studied suffered more damage in the Biscuit Fire than the untreated plots, probably because there were more fine woody debris and dense hardwood sprouts, fueling a more intense surface fire. Photo: Crystal Raymond, Fire and Mountain Ecology Lab, University of Washington, Seattle, WA, 2003.

> Data are sparse for forests with mixed-severity fire regimes that encompass a wide range of fire frequencies, extents, and severities.

The LTEP sites were on the western perimeter of the Biscuit Fire, about 12.5 miles (20 km) inland from the coast. Douglas-fir, with a small amount of sugar pine and knobcone pine in the overstory, dominates the area. The subcanopy is composed of hardwoods (tanoak, Pacific madrone, and chinquapin) and Douglas-fir. These stands, established approximately 100 years earlier following a stand-replacing fire, have seen little active management. The area is classified as a mixed-severity fire regime with a fire return interval of 90 to 150 years.

By the time of the Biscuit Fire, the LTEP sites had been carefully studied, with plenty of prefire data collected. A wildland fire burning through the area was a great opportunity to study the effects of thinning on fire severity in forests with mixed-severity fire regimes.

Experimental Treatments

In the winter of 1996, 10 of the 27 LTEP treatment plots, each from 15 to 20 acres (6–8 ha) in size, were mechanically thinned using a helicopter to remove the logs. The other 17 plots were either clearcut or left undisturbed to serve as a control. Thinning from below removed most of the subcanopy hardwoods and conifers, reducing tree density from approximately 419 trees per acre (1,035 trees per ha) to 85 trees per acre (210 trees per ha). Logging slash was minimally treated on the thinned plots. On eight treatment plots, tree crowns were removed together with the last log; on two others, crowns were left onsite. In the fall of 2001, Siskiyou National Forest resource managers conducted prescribed burns in the understory of thinned plots where crowns were left onsite.

The Biscuit Fire burned through three thinned plots, one thinned–underburned plot, and two untreated plots with minimal torching of overstory trees. Burned plots are from 2,690 to 3,610 feet (820–1,100 m) in elevation, with southeast and north–northeast aspects and slopes of from 15 to 40 percent.

Study Tactics

Before the Biscuit Fire, researchers collected extensive fuels and vegetation data before and after thinning, including data on forest structure and dead and down woody debris. Following the harvest, researchers established five permanently marked and mapped 0.08-acre (0.03-ha) tree plots per treatment plot. We tagged all live trees and snags and measured diameter, species, crown class, tree height, and canopy base height. Stem mapping of trees in the plots helped us locate all trees following the fire.

In the summer of 2003, 1 year after the Biscuit Fire, we again measured stand structure and fuels and collected additional data to assess fire damage to overstory trees. Tree damage measurements included maximum bole char height, maximum crown scorch volume height, crown scorch volume (in percent—a visual estimate), and percent cambium kill. We extracted four cores per tree (uphill, downhill, and two cross-slope samples) at 1.6 feet (0.5 m) above the ground to assess cambium status. We tested each cambium sample for the presence of peroxidase, an enzyme found in all living plant tissue. One dead sample equates to approximately 25 percent cambium girdling, two samples to 50 percent girdling, and so forth.

Trees often take several years to succumb to fire damage, so mortality data collected a year after a fire do not reflect total tree mortality. However, previous studies of fire-caused Douglas-fir mortality show that percent crown scorch and percent cambium kill are the most important damage variables for predicting mortality (Peterson and Arbaugh 1988). These variables therefore allowed us to predict total fire-caused tree mortality. Crown scorch height and bole char height are more superficial damages and indicate less about long-term fire effects.

How Did Thinning Pan Out?

Our study encompassed only a few stands, and the sample size is not large enough for rigorous statistical inferences about differences in treatments. Therefore, the data presented here should be considered limited and observational rather than statistically based.

> A wildland fire burning through a long-term experiment with pre-fire data created a great opportunity to study the effects of thinning on wildland fire severity

Maximum bole char height and maximum crown scorch height were similar on all treatment plots. However, there were definite variations in crown scorch volume (fig. 1) and some variations in percent cambium girdled (fig. 2). On the thinned plots, overstory trees with a diameter at breast height of greater than 10 inches (24 cm) had the highest crown scorch volume and cambium death. On the thinned–underburned plots, overstory trees had the least crown scorch volume and cambium death. On the untreated plots, overstory trees had moderate damage and the most variability in crown scorch volume and cambium death.

The Biscuit Fire burned through the thinned and untreated plots as an intense surface fire but stopped at the edge of the thinned–underburned plot, unable to spread through the sparse surface fuels. On the thinned plots, the fire consumed the subcanopy layer of 5-year-old hardwood sprouts and the extensive fine wood that resulted from thinning. Crowns of overstory trees were nearly 100 percent scorched.

On the untreated plots, there was no evidence that subcanopy hardwood and conifer trees served as ladder fuels. The older, larger hardwood trees were not consumed. The untreated plots and the thinned–underburned plots had much lower quantities of fine woody debris prior to the fire and lower consumption of fuels during the fire.

Lessons Learned

Greater fire damage to trees from radiant and convective heat rather than crowning occurred in the thinned plots. Using Rothermel's (1983) fire prediction models in hypothetical stands, Graham and others (1999) provided a theoretical basis for greater surface fire intensity resulting from residual slash fuels and higher windspeeds in thinned stands. The high level of crown scorch within the thinned LTEP plots most likely resulted from convective heat rising from the intense surface fires below. The intensity of these surface fires was exacerbated in the thinned plots where there was more fuel in the form of fine woody debris and dense hardwood sprouts. These fuels were not present in the untreated plots, and they were consumed in the prescribed burning treatment in the thinned–underburned plot.

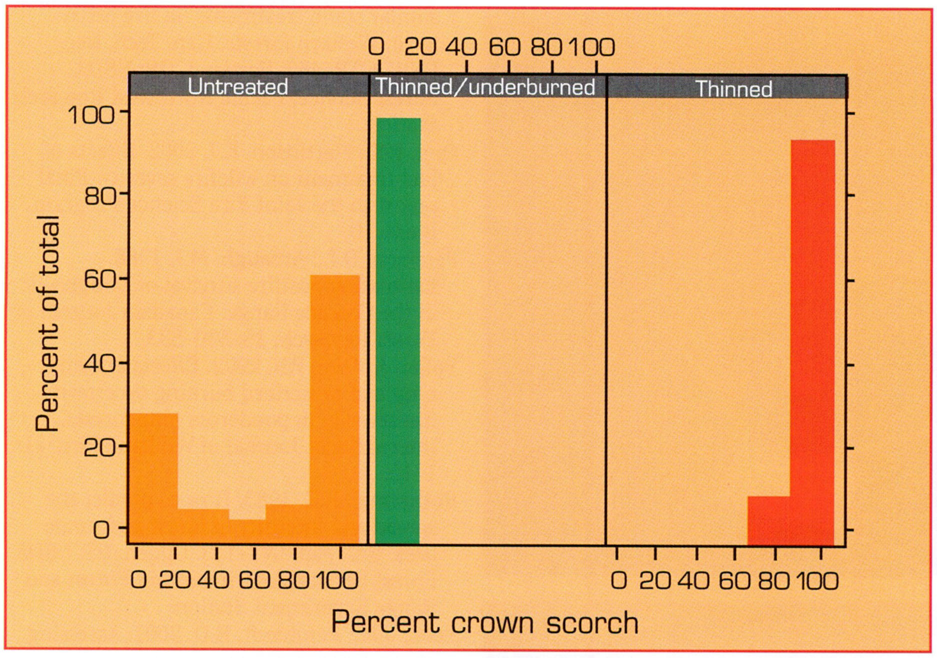

Figure 1—*Percent crown scorch in overstory trees on untreated, thinned–underburned, and thinned research plots following the Biscuit Fire of 2002. Damage was high on thinned plots, mixed on untreated plots, and low on thinned–underburned plots.*

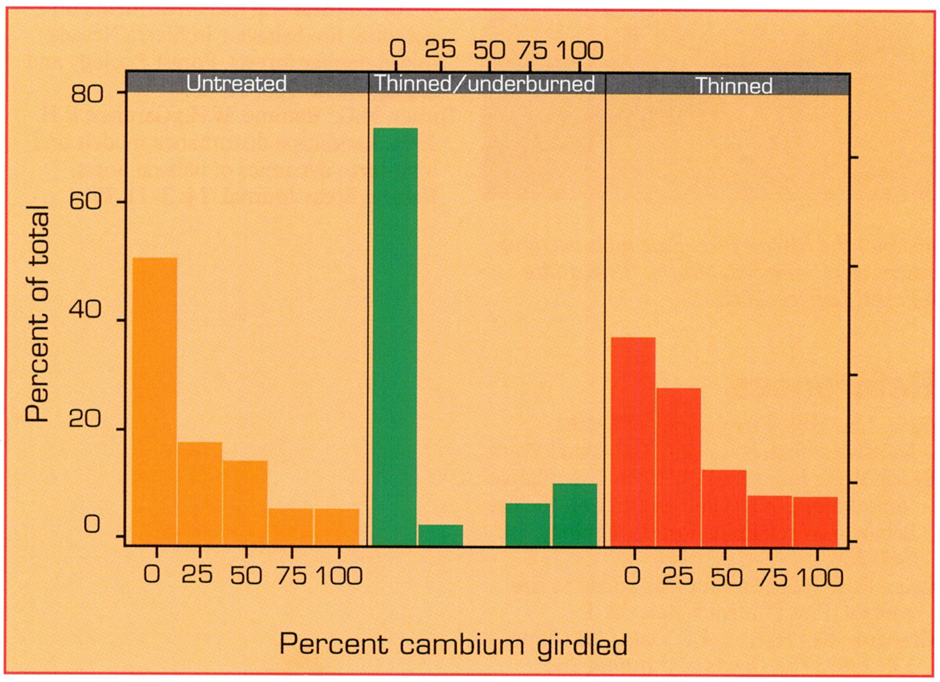

Figure 2—*Percent cambium girdled in overstory trees on untreated, thinned–underburned, and thinned research plots following the Biscuit Fire of 2002. Damage was higher on thinned and untreated plots than on thinned–underburned plots.*

In forests with mixed-severity fire regimes (especially where hardwoods are present), removing ladder fuels might actually increase damage to the remaining stand in a subsequent wildland fire. In the Biscuit Fire, the hardwood subcanopy affected fire behavior in ways other than serving as a ladder fuel. It is possible that shading by the hardwoods slowed the desiccation of dead surface fuels prior to the fire. During the fire, the hardwoods possibly decreased windspeeds in the untreated stands. In the thinned plots, consumption of hardwood sprouts probably contributed to crown scorch, whereas the older hardwoods in the untreated plots might have prevented the upward movement of heat to overstory conifers.

Observations suggest a two-step process to prevent wildfires from crowning in forests with mixed-severity fire regimes:

1. Thin dense stands to decrease ladder fuels; and
2. Remove post-thinning slash and other accumulated surface fuels to confine subsequent fire behavior to a relatively cool surface fire.

Although this two-step process is more time consuming and costly than thinning or prescribed burning alone, it appears to be more effective in enhancing suppression efforts and in reducing undesirable damage to overstory trees.

Fine fuel accumulation before (above) and after (below) the Biscuit Fire. Fine fuels accumulated following a thinning treatment after tree crowns were removed, but the Biscuit Fire almost completely consumed them. Photo: USDA Forest Service, 2003.

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