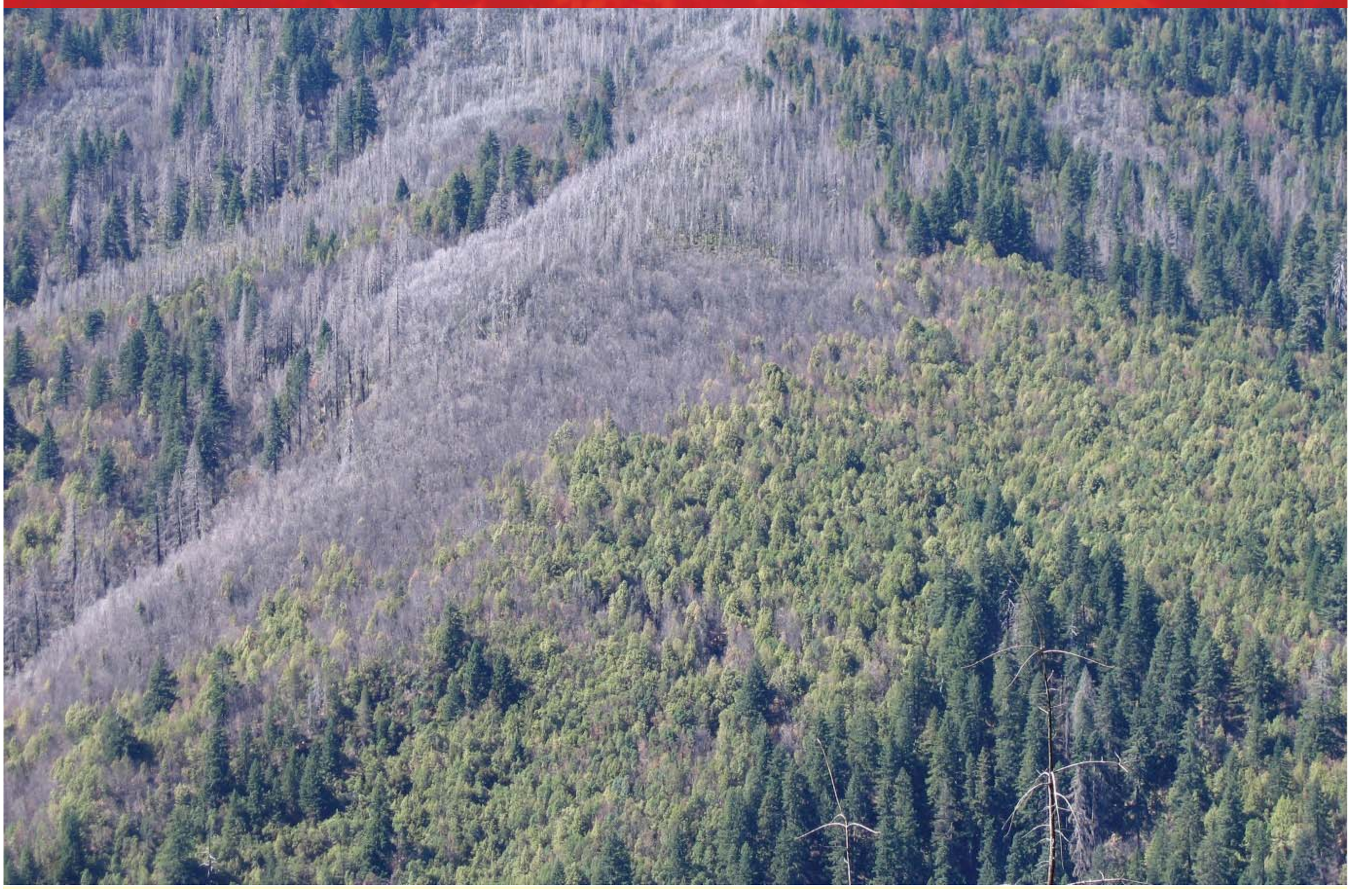
Joint Fire Science Program
Fire Science Brief
RESEARCH SUPPORTING SOUND DECISIONS



Landscape mosaic of low to high canopy damage in hardwood (light green color) and conifer stands. Credit: Tom Spies.

Exploring Patterns of Burn Severity in the Biscuit Fire in Southwestern Oregon

Summary

Large wildfires are important ecologically and economically, but their behavior and effects are not well understood, especially in the Klamath-Siskiyou region, which is characterized by a diversity of conifers and evergreen sprouting hardwoods, steep topography, variable geology, and strong climatic gradients. These studies used new analytical tools to characterize conditions before and after a large wildfire and to analyze those data across the entire landscape of the fire. Some of the general findings may apply to other forest regions, but the details may be unique to southwestern Oregon and northwestern California. The results improve our understanding of how post-fire management affects fire risk and subsequent fire severity in the short term (approximately 15 years), and show that previous actions can affect how future wildfires burn. However, the studies also indicate that it can be difficult to generalize trends because of the complexity of interactions among weather, vegetation, and topography.

Key Findings

- Areas that burned with high severity (measured as Differenced Normalized Burn Ratio [dNBR]), a satellite remote sensing index of overall change) in a previous wildfire (in 1987, 15 years prior) were more likely to burn with high severity again in the 2002 Biscuit Fire.
- Areas that were salvage-logged and planted following the 1987 fire burned with somewhat higher fire severity than equivalent areas that had not been logged and planted.
- Vegetation structure and weather explained most of the variability in crown damage from the Biscuit Fire.
- Stands of large conifers were least likely to burn with high severity.

Introduction

"Large mixed-severity wildfires are important ecologically and economically, but their behavior and effects are poorly understood," says Tom Spies, research forester at the Forest Service Pacific Northwest Research Station. "The largest 1 percent of wildfires is responsible for more than 95 percent of the total area burned. While there are many more small wildfires, it is the less common large wildfires (e.g., greater than 50,000 acres) that have the most effect on landscapes and ecosystems." Large fires typically burn under extreme weather conditions, when high temperatures, low humidity, and high winds make fire suppression very difficult.

Our scientific understanding of the behavior and effects of large mixed-severity wildfires is quite limited. Their size and infrequency make it difficult for scientists to study them in the field. We typically do not have data on what conditions were like before the fire, and when fires burn over tens of thousands of acres, it is impossible to understand their pattern and effects with just a few post-fire sample plots because they burn unevenly. Current simulation models are not up to the task of simulating the behavior of large wildfires burning under extreme and unpredictable weather conditions. Consequently, says Spies, "when big wildfires burn, they have typically been scientific opportunities lost—until now."

Spies and Jonathan Thompson (then a graduate student and now a scientist at the Smithsonian Institution) used satellite imagery and aerial photography to assemble a picture of the landscape before and after the Biscuit Fire at a spatial extent and level of detail unachievable with ground-based plots.

The Klamath region and the Biscuit Fire

The study area, the Klamath region in the Rogue River-Siskiyou National Forest in southwestern Oregon and northern California, is relatively wet and productive compared to the interior West. Species diversity is high, and fire-adapted hardwood trees and shrubs sprout back quickly.

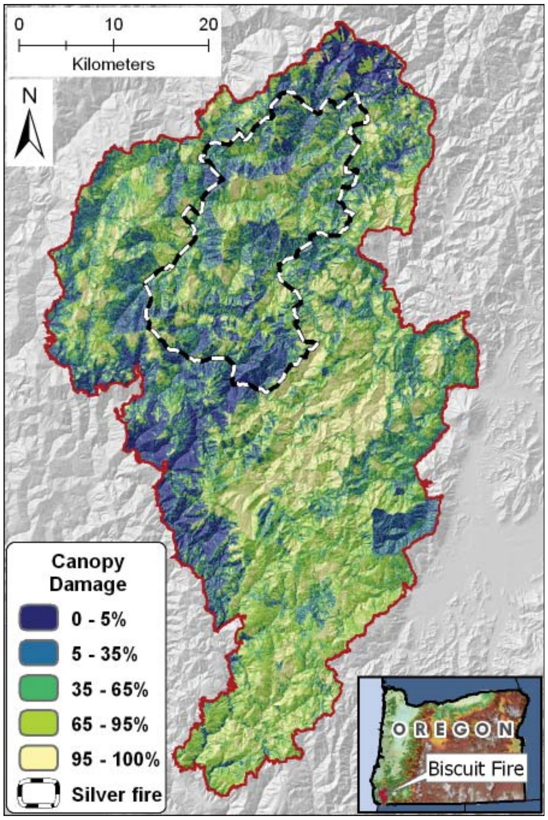
A portion of the area had burned previously in 1987 in the 93,000-acre Silver Fire, and about 3 percent of this area was salvage logged. In 2002, the Biscuit Fire burned 500,000 acres, completely enveloping the Silver Fire area. So conditions were ripe to study how previous fire history and post-wildfire management affect severity of a subsequent fire.

Sprouting hardwood shrubs and trees seven years after the Biscuit Fire in a stand that burned with high severity. Credit: Tom Spies.

"The Biscuit Fire generated an enormous amount of controversy," Spies notes. "It burned in a wilderness area and ecological reserves that were designed to protect old growth and [northern spotted] owls. There were lots of debates and lawsuits and controversies about post-fire management here. So it not only was scientifically interesting and significant, but it was a very politically charged fire from a post-management standpoint."

Disturbance history affects fire severity

"Prior to this study," Spies explains, "it was unclear if an earlier high-severity fire would reduce the severity of a subsequent fire because fuel loads would have been reduced." The effects of salvage logging on subsequent fire behavior are also not well studied. Some foresters think that post-fire logging and planting may reduce the effect of subsequent fires. But others think that the opposite is true—that post-fire management could increase the reburn potential by adding slash and low, dense, uniform vegetation.



Map of crown damage created by the 2002 Biscuit Fire and boundaries of 1987 Silver Fire. Map prepared from imagery taken immediately after the fire. Credit: Tom Spies.

Spies and Thompson set out to determine the degree to which the pattern of burn severity in the Silver Fire and vegetation condition setup at the Silver Fire affected how the Biscuit Fire burned. They measured burn severity of the Biscuit Fire using a satellite imagery index called Differenced Normalized Burn Ratio (dNBR), which is an overall measure of change in vegetation and soil reflectance pre- and post-fire.

Analysis showed that managed areas burned with somewhat higher severity in the Biscuit Fire compared to unmanaged areas where the vegetation had been allowed to resprout or reseed naturally. “The findings suggest,” Spies says, “that management—in this case, including salvage logging and planting—did not reduce fire severity at 15 years compared to unmanaged areas. This finding applies only to fires burning at about a 15-year interval, but it does suggest that efforts to create dense conifer plantations in this environment also create homogeneous live and dead fuel beds that can increase the risk of high-severity fire even after some large wood is removed through logging. The finding that both managed and unmanaged young vegetation burned with high severity also suggests that in this relatively high productivity environment fuels can fairly rapidly accumulate after a fire and lead to a high-severity reburn within a few years.” This is counter to the situation in less productive parts of the West, where wildfire can effectively reduce fire hazard for many years after a fire by reducing the fuel source.

We need to learn more about how the fuel structure differs in the Klamath region versus other forest types of the West, Spies says. He speculates that for the plantations established after the Silver Fire, the broadcast burning treatments may not have been as effective as they could have been at reducing logging slash and fine fuels. Or, he says, high densities of fine live and dead fuels near the ground in dense plantations may elevate the fire hazard above that in naturally regenerated forests, which contain gaps and patches of sprouting hardwoods that create a more variable surface fuel environment.

Refining the results using aerial photography

In a separate study, Thompson and Spies used aerial photography to analyze crown damage—one component of overall burn severity. This technique allowed the researchers to get better resolution on the vegetation structure—whether conifers or hardwoods and their relative size—than with satellite imagery. They looked at some of the same questions as in the first study, but also addressed new ones by expanding the study across most of the Biscuit Fire area.

Spies explains: “The salvaged and managed stands had higher crown damage than the unmanaged stands, but the differences between the two treatments were smaller than the differences measured with the dNBR metric, which measures changes in vegetation canopy and soil reflectance. This suggests that some of the strongest differences in the fire effects between the two treatments were related to changes at the soil surface. The ecological effects of these small differences in canopy damage and presumably larger soil changes are not known. They may make no difference to post-fire recovery, or on the other hand, for example, small patches of surviving vegetation could be an important source of seeds or animals for the regenerating site. Clearly, long-term ground-based studies are needed.”

“Our results indicate some major challenges to reducing fire hazard in this particular region,” says Spies. Other studies of the Biscuit Fire indicated that thinning stands and then burning the slash led to less intense reburn. But thinning and not burning the slash led to higher severity reburn. The latter creates a thicker fuel bed and heightens the risk of high-severity fire for years after the management action. Management actions that open up the canopy can also create slash and growth of understory vegetation, which, if not treated, can increase fire hazard.

Spies explains the implications of these findings for management: “First, managers may have few options for reducing fire hazard in areas that have been recently burned in this forest type.” For 10 to 30 years after the first fire, risk of a high-severity reburn is probably high, regardless of post-fire management. “Second,” says Spies, “claims that post-fire logging and planting at high densities in this forest type will increase short-term resistance to fire should be avoided.” Even with logging and planting, forests can for years have a lot of fine dead and live fuel that heightens the risk of a high-severity reburn. He cites the importance of broadcast burning after logging to reduce fine fuel loads and suggests that planting a mixture of species and densities could introduce stand variability and lower the risk of high-severity fire. And finally, Spies says, focus on long-term goals in forest management. “What you might see at 15 years might be different than what you’d see at 30 or 100 years following a fire.”

His team is now studying 80 field plots within the Biscuit Fire area to better understand the post-fire vegetation and fuel environment across the gradient of burn severity. They can also reanalyze air photo and satellite imagery in the future to examine long-term trends.

What determines burn severity?

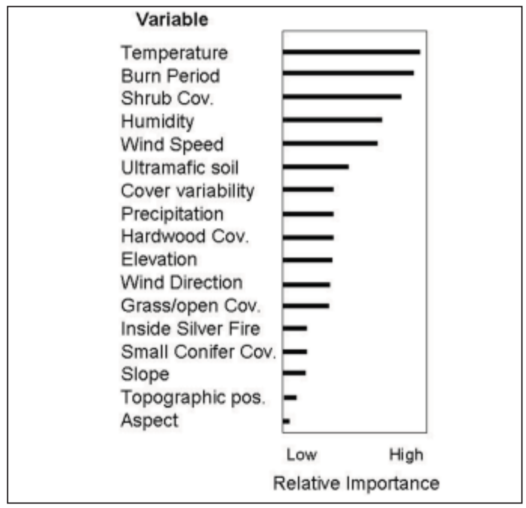
In a third study, Spies, Thompson, and colleagues used information about the boundaries of the Biscuit Fire for each day it burned along with weather data to determine major influences on fire behavior. “If we have a measure of burn severity—in this case, crown damage—across all 500,000 acres,” says Spies, “what explains that pattern? Is it topography? How much of it is the structure of the vegetation? And how much of it is weather?

The southwest Oregon landscape is a high-diversity mixture of conifer and hardwood trees and evergreen sprouting shrubs. Some foresters have observed that hardwoods and broadleaf shrubs don’t burn the same way as conifers do, and they don’t necessarily propagate the fire, perhaps because they have more moisture or because of their different morphology. “So,” explains Spies, “one hypothesis was that patches of conifers or trees mixed in with shrubs and hardwoods might actually survive the fire better or have less crown damage than those that were in more uniform patches of vegetation. And we didn’t find that.”

Sprouting hardwood shrubs 5 years after the Biscuit Fire. Credit: Tom Spies.

In fact, they found the opposite—that conifer trees were more likely to be damaged amongst shrubs than in dense older conifer forests. Spies says, “The effects of evergreen shrubs and hardwoods on fire behavior are really an enigma: we found that a shrub layer can increase risk of mortality to conifers during extreme weather events, but casual observations of others suggest that under less extreme weather a patch of shrubs can reduce fire intensity in these areas. We need to know more about the fire ecology of shrubs in these environments before we can make recommendations to managers about how to manage the composition of these forests to modify fire behavior.”

The research team concluded that the percentage of pre-fire shrub cover and average daily temperature explained “a fair amount” of the pattern of the burn severity, as measured by crown damage. Slope, aspect, topographic position, and elevation—measures of topography—explained relatively little of the variation in the fire. “This was a surprise because long-term fire history studies in the region show that fire severity patterns differ by topography,” says Spies. He explains this unexpected outcome by noting that areas such as lower topographic positions and northeast-facing slopes might be more moist or cooler, so they would be expected to burn with lower intensity. But, he says, if you’ve got 40-mile-per-hour winds from the east and low humidity, weather becomes the all-important driver. He cautions that these explanations apply only to large fires in the Klamath region, burning under extreme weather conditions.



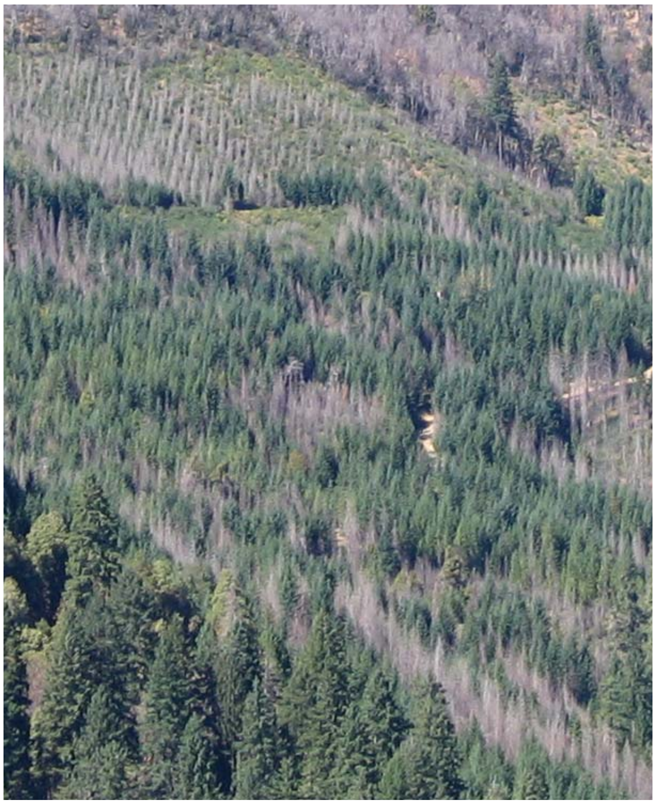
Relative importance of weather, vegetation, and topographic variables in predicting variation in conifer crown damage from the 2002 Biscuit Fire.

A broad, long-term view is needed

So should we encourage post-fire management in the Klamath region or not? It depends on management objectives and the nature of the management. There is no evidence that management actions can improve ecological outcomes in the short term, but they certainly can be used where economic return is a priority and may have some longer term ecological values. Remember, says Spies, “forest management is a long-term process, and sometimes short-term risks must be undertaken to achieve longer term ecological gains—for example, speeding the development of larger, more fire-resistant trees. We need to have a whole landscape and a long timeframe view on these situations.”

“There’s often an automatic assumption that a big high-severity fire is a bad thing,” says Spies. “But that is not necessarily the case; it depends on what your objectives are and what you’re really measuring as a response.” The Klamath region has historically had a mixture of low- and high-severity fires, so presumably both are important to the diversity of the ecosystem. Diverse early-successional vegetation created by mixed-severity fires has important biodiversity values that managers may not want to erase with intensive post-fire management.

The Silver Fire in 1987 burned at relatively low severity. The Biscuit Fire burned at fairly high severity. But all wildfires are patchy mosaics of different burn severities that produce different levels of damage to the canopy. Spies believes we need a better understanding of the ecological significance of that mosaic.



Variable canopy damage in a portion of the Biscuit Fire. Credit: Tom Spies.

The information gained from this work will help managers and policy makers design more effective responses to large wildfires. Spies warns, "It's probably not a good thing to propose that post-fire management and plantation establishment will reduce the short-term risk of wildfire. It quite possibly will *increase* the short-term risk. Whether you accept the short-term risk or not depends on what you think you can gain and what the alternatives are. I think what we're after from research is a better characterization of the risk ratings for different landscapes, different stand conditions, and under different weather and topographic settings. This analysis is just one piece of a much longer term effort to put together that information."

Next steps

Regarding future research needs in the Klamath region, Spies cites a need for studies of the ecological effects of various fire severities, the spatial patterns and ecological significance of large wildfires, and the long-term outlook for fuels and fire risk in the various patterns of vegetation created by fire and post-fire management. "The big questions for the Biscuit Fire," says Spies, "are what is the future ecological potential and fire risk for this landscape and what can managers do to help meet long-term management objectives?"

Management Implications

- There is no simple answer to whether to log and plant after fire in the Klamath region. The answer depends on factors such as long-term fire risk; reduction of hazards to fire fighters, residents, and structures; timber revenue; and biodiversity conservation.
- Following a fire in this region, young vegetation is at increased risk of reburning whether it is managed or not.
- Old-growth forests with large diameter conifers, tall canopies, and shady understories may be the most wildfire-resistant vegetation type in this landscape.
- Management should consider both short-term and long-term risks and goals.
- It is important to keep detailed records of forest management activities for use in future wildfire studies. It is only through careful monitoring of management actions that we can improve management for the future.

Further Information: Publications and Web Resources

Spies, T. A. 2007. Effects of disturbance history, landscape pattern, and weather on wildfire severity in southwestern Oregon: Implications for management of a fire-prone landscape. Final Report to the Joint Fire Science Program. Project 04-2-1-14.

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