



Mixed-severity burn mosaic of the 2002 Biscuit Fire in the rugged terrain of Oregon's Klamath-Siskiyou region.
Credit: D. Donato

Mixed-fire Regime of the Klamath-Siskiyou: New Postfire Potentials

Summary

Effects of postfire management are becoming more important as wildfire frequency, extent and severity appear to be increasing. Researchers set out to measure the effects of postfire salvage logging on fuel loads, vegetation, and wildlife communities in the Klamath-Siskiyou region of the Pacific Northwest. Natural recovery processes revealed some important findings that provide viable options for managers whose objectives include regenerating forests, sustaining natural processes, and maintaining landscape biodiversity.

The researchers found that the mixed-severity fire regime of the region, which includes patches of repeated severe fire, supports abundant, natural postfire conifer regeneration and regionally significant biodiversity. Salvage logging aimed at reducing risk of severe reburn appeared to make little difference in reducing surface fuels or potential fire behavior. Allowing the postfire early seral shrub phase to run its natural course has the potential to bolster the success and efficiency of several diverse management goals.

Key Findings

- There was no reduction in surface fuels or re-burn potential from salvage logging. Managed and unmanaged stands exhibited the same surface fuel loads 17–18 years after fire, when re-burn potential is high.
- The potential for severe re-burn was driven by the inherent structure of young vegetation, and much less by residual woody material from the previous fire.
- Natural conifer regeneration typically exceeded prescribed densities without additional planting or intervention in areas within 400 yards of live forest edges.
- Extended periods of early seral shrub dominance and short interval, high-severity fires appear to be important for conservation of avian biodiversity.
- Short-term fire effects on small mammal communities were more significant than those of postfire salvage logging.

Postfire management in southwestern Oregon

In recent years, wildfires have become larger, more frequent and severe, while funding for recovery activities has been declining. This widening gap has prompted increasing study of the effects of common postfire management methods. Recovery operations are often based on the assumption that intervention accelerates forest recovery, and assures that forests will regenerate in a form consistent with cultural expectations and management goals.

The course of action after wildfire is determined by management objectives, funding, forest type and historic fire regime. Increasing portions of federal lands are managed with the objective of supporting biodiversity and natural processes. In the Pacific Northwest, there is a strong legacy of timber production. In areas where this is a priority, postfire objectives involve rapid restoration of forests and merchantable timber. Salvage logging is commonly employed to recover economic value and with the idea that future fire risk will be reduced through the harvest of fire-killed trees. Proceeds from harvest help pay for reforestation, which typically includes planting conifer seedlings and the use of vegetation control measures designed to optimize their growth. The idea is that these activities will accelerate the return of the forest we have come to know and depend on, both culturally and economically.

As fire science evolves and the knowledge of fire as an ecosystem process grows stronger, scientists and managers remain challenged by the magnitude of how much more there is to learn. Even though salvage logging and conifer reforestation are commonly employed, land managers need more information about the ecological responses of these postfire management practices. There aren't many solid, well-replicated scientific studies that have looked at either the short- or long-term effects of salvage logging. And the efficacy of natural conifer regeneration following very large wildfires has received little study.

“Our science-based knowledge of postfire management is really low,” says Joe Fontaine, wildlife biologist and postdoctoral research assistant at Oregon State University. “We need to accumulate more information so that we're not basing management on untested assumptions.”

Fire severity, forest life cycles and the human perspective

The term “fire severity” is used to refer to the degree of impact that a fire has on an ecosystem. Fire severity can be defined through the degree of plant mortality. In cases where severity is low, there isn't much above ground plant mortality. In high-severity fire, most if not all vegetation is killed. Plants that are fire adapted are able to regenerate even after severe fire. Some species readily re-sprout from their underground roots. Others (i.e., most conifers) are able to regenerate from seed.



The Biscuit Fire burns a patch of conifers in July of 2002.

Every forest type has evolved with a different pattern of fire severity and frequency. Fire can burn with uniform severity across large areas, or skip certain areas entirely. Variations in fire severity leave behind a mosaic of different effects. The Klamath-Siskiyou is known for its ‘mixed-severity’ fire regime. This means that fires there tend to burn in patches of different size and severity across the landscape. A severely burned patch may be surrounded by areas that burned with moderate or low severity—or vice versa. Recently burned patches may burn again within a decade or two.

“When we go outside and look at a forest, we have a static view of things,” Fontaine says. “We see the green forest

sitting there and think that's how it's always been and that's how it will always be. We haven't experienced forests as dynamic systems where multitudes of processes are at work all the time. For a century we've been mostly without the biggest, most dramatic process all—the one that brings the most change the fastest—wildfire. So today when forests burn severely—and then some burn again—it can be alarming. As a culture we resist the idea that fires can be beneficial when they take place in natural patterns, intervals and intensities that are appropriate for a given forest type and region.”

Setting the stage

The Klamath-Siskiyou Mountains run east-west between the Cascade Range and the coastal mountains of southwestern Oregon. The area has the most diverse vegetation of any national forest in the western U.S. It's characterized by open shrublands, dense conifer forests, deep river canyons and rocky ridge tops.

The 2002 Biscuit Fire burned a half million acres of national forest in southwestern Oregon and northern California. It was the largest fire in the nation that year and the largest in recorded history for the state of Oregon. Thirty to forty percent burned with high severity. The fire also re-burned many areas that had burned in the relatively recent past, providing an outstanding lab for Donato and Fontaine.

Re-burns are not a stranger to the region. The Tillamook fires burned in Oregon during the 1930s, 1940s, and 1950s. They consisted of an initial large fire followed by three re-burns six, twelve and eighteen years later, eventually burning more than 330,000 acres.

The Biscuit reburned the 1987 Silver Fire, which had been partially salvage logged and replanted after the initial burn. Areas that burned severely in 1987 reburned severely in 2002. Areas that had been salvage logged and replanted after the initial fire burned more severely than areas that were unmanaged. This was attributed to a combination of logging slash and/or the more homogeneous live fuel distribution in stands planted with conifers following salvage.

What was the stand structure of the Silver Fire before it was re-burned by the Biscuit? Nobody had been tracking vegetation conditions in treated areas of the Silver before the Biscuit reburned it. In addition, work was still needed to tease out logging effects (stem removal, slash generation) from the effects of conifer plantations on re-burn severity.

Donato and Fontaine sought to fill these gaps by including the Galice Fire in their study. Like the Silver, the Galice burned in 1987, much of which was subsequently logged and replanted. But the Galice Fire did not reburn in 2002, so it provided a proxy forest of sorts. It still possessed conditions and characteristics that were likely in the Silver Fire before the Biscuit re-burned it. They also studied yet another 1987 burn—the Longwood Fire. It contained pockets of unmanaged vegetation and fuels, which allowed them to investigate natural postfire fuel structure.

In addition, they sampled areas of the 1987 Silver Fire that were re-burned by the 2002 Biscuit Fire (in patches that

had burned twice with high-severity). This allowed them to assess the response of vegetation and wildlife to two severe fires occurring within a short time period.



The 1987 Longwood Fire was not reburned in the Biscuit Fire. It contained pockets of unmanaged vegetation and fuels which allowed the researchers to investigate natural postfire fuel structure.

In all study sites, Donato and Fontaine measured all aboveground biomass (fuel)—live and dead, fine and coarse, standing and down—as well as wildlife communities and vegetation regeneration. All study sites had been forested with mature to old-growth Douglas-fir-dominated forest before burning, and had biophysical characteristics common to the Klamath-Siskiyou region.

Mixed-severity mosaic

Natural conifer regeneration proved to be abundant in the Biscuit Fire, despite its large size. Naturally regenerated stands demonstrated the capacity to meet or exceed prescribed densities. Donato attributes this to the mixed-severity mosaic which left behind a broad distribution of viable seed sources.

They found that almost two thirds of the areas that burned with high-severity in the Biscuit fire were within approximately two hundred yards of green trees. “There is this mix of green and black out there,” he explains. “There are burned-out patches over here, and over there you see patches of green that survived. Those surviving patches are apparently serving as seed sources for the black patches. It turns out that even though this fire burned half of a national forest; it's actually difficult to get very far from a seed source.”

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Given the increasing trend of larger fires, this clearer understanding of mixed-severity fire and how it influences regeneration can help managers prioritize limited resources. Managers can often take advantage of abundant, natural postfire regeneration. Natural postfire succession in the Klamath-Siskiyou region includes prolonged periods where

early seral hardwoods and shrubs are dominant and conifers grow in the understory. The time it takes for the conifers to reach maturity varies, as does the spatial pattern and density of growth. These are among the variations that shape the area's unique floral diversity and mixed-severity fire regime.



Measuring the progress of a naturally regenerating conifer seedling after the Biscuit Fire Credit: J. Fontaine

In areas where management objectives include dominance of specific species and uniform densities, active reforestation may be required. Areas farther than approximately 400 yards from live forest edges, and areas where the soils have low capacity for water retention, had lower regeneration density. Mapping out such areas would be helpful when prioritizing postfire planting. With respect to attaining prescribed densities alone however, postfire planting may be unnecessary in many areas of mixed-severity fires in this forest type.

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Fire begets fire

Young re-growth burned severely in both managed and unmanaged stands. Donato explains that it's not so much the dead material left by a previous fire that drives that severity, but the inherent structure of the regenerating live vegetation. Regenerating shrubs and conifers are generally ten to fifteen feet tall with continuous foliage reaching all the way to the ground. And there is often very little space between shrubs – whereas in mature forest there are typically different canopy levels, a clear understory and a bit of distance between the crowns and the ground. Mature trees have big, thick, fire resistant trunks with thick bark. Young trees, whether naturally or artificially regenerated, have tiny stems and thin bark and aren't very fire resistant.

“It may be very difficult to manage your way out of that situation if you're interested in preventing high-severity re-burn,” explains Donato. “Once an area burns at high-severity, all that young vegetation is very susceptible to another stand-replacing fire for a period of time. If another fire comes through, there's a high probability that it would pretty much kill everything.” But in the Siskiyou, he

continues, these severe re-burns have likely been part of the fire regime for millennia. “In this region, fire begets fire because regenerating vegetation is very susceptible. This process has probably been happening here for a very, very long time.”



Young shrubs regenerating four years after the Biscuit Fire. Credit: J. Fontaine

In fact, Fontaine and Donato found that following severe re-burn, vegetation response was prolific and diverse—more so than following a single fire. And the response included conifers and hardwoods. This response further indicates that these vegetation communities are well adapted to what we consider to be ‘extreme’ events, and that these processes have likely occurred in the past. In terms of what we might expect from forest response to re-burns, it seems that the average length of the fire interval may not matter as much as the range of intervals and severities to which vegetation is adapted.

Salvage logging and surface fuel loads

In this study researchers found that, at 17–18 years after fire, managed stands had fewer snags, similar woody fuel loads on the ground, and greater amounts of live conifer biomass compared to unmanaged stands. Thus, postfire logging apparently made little difference to surface woody fuels contributing to fire spread and intensity, but conifer planting may have altered the live fuel bed in such a way that on average, fire severity was higher.

Given that some material was removed by postfire logging, why the lack of difference in woody fuels on the surface between managed and unmanaged stands? In unmanaged areas, fire-killed trees and their branches decayed fairly rapidly (particularly the more fire-available fine material) and fell on nature's schedule over several years. Natural accumulations of fine and coarse fuels from fire-killed trees were within commonly accepted ranges both 3 and 18 years after previous fire. In contrast, the process of felling burned trees after fire brought all the woody debris down to the forest floor at the same time. About 40% of this residual woody material was composed of non-merchantable materials such as branches, bark and tree tops, which are left behind during the logging operation. This large pulse of

material on the ground resulted in higher fuel levels initially, and fairly similar levels by 17–18 years.

This suggests that this one-time pulse of fuel increases fire hazard in the short term—resulting in effects opposite of those intended. Options for eliminating it include mechanical removal or prescribed fire. The effects, or the effectiveness, of these follow-up treatments have so far received no direct study in postfire settings and warrant further research.



Salvage logging operation in the Todd Creek area of the Biscuit Fire. Credit: J. Fontaine

Severe re-burn: Working with the process

Severe re-burn appears to be a common factor in regenerating stands and likely serves many ecological functions in this mixed-severity fire regime. Because it appears that in the short-term typical stand level treatments aren't effective in reducing the potential for stand-replacing re-burns, Donato and Fontaine suggest working with the natural process of re-burn rather than against it. Strategic fuel breaks placed at the landscape scale can direct fire away from areas that are being managed for timber production.

“This can affect whether a fire even enters into a young stand at all,” says Donato. “In this forest type, that may be easier than trying to effect how severely it will burn if it does. On the other hand, if you're managing for landscape biodiversity, then let the re-burns go because they're a component of the process that maintains that.”

Wildlife takes wildfire in stride

The postfire period of broadleaf and shrub dominance appeared to enhance wildlife diversity at the landscape scale. The researchers studied the response of bird and small mammal communities to repeated high-severity fire and salvage logging. They measured what happened in each community as it experienced four distinct disturbance sequences—unburned, single fire, repeat fire and single fire logging. Results suggest that the birds and small mammals of this region are well adapted to repeated high-severity fire.

Deer mice delight in disturbance

Response of small mammal communities to postfire logging was measured less than one year following logging.

Response was negligible, with no differences in population densities of the three species captured.

In the short term, fire effects on small mammals were much more significant. Old, unburned stands contained mice, voles, and wood rats, while in disturbed areas only mice and chipmunks were found. Recently burned sites had lower diversity but higher abundance of the species that were present. After the first fire, the wood rats and voles were reduced, but the abundance of deer mice increased. That increase doubled after the re-burn.

Fontaine explains that the first fire had the big impact because this is when the magnitude of ecosystem change is greatest. “The first fire creates dramatic change. A dark, damp, cool forest is changed to a warmer, drier place with some standing dead trees, lots of sunlight and bare ground. So after logging part of that, the magnitude of change is much less. The wood rats and voles are already gone. The only things left are a few chipmunks and lots of deer mice, who really like disturbance. Things have already been disturbed by the fire. If you disturb it more you're not changing things that much for small mammals. But this is very much short-term,” he continues. “In the longer term it could be a totally different story. We really don't know. If the salvage logging changes the plant community, there might be a different outcome.”

A boost for bird biodiversity

Birds were more abundant in habitats that had burned twice than in habitats burned once with similar levels of species richness. In fact, fire did not reduce species diversity relative to unburned mature forest. The composition of the species changed somewhat—reflecting a blend of forest birds and species that like open habitat. The birds most highly associated with high-severity fire tended to be insect eaters, cavity nesters, bark foragers and shrub nesters. This suggests that high-severity fire generates important habitat for a variety of species.

“If you want landscape scale biodiversity, you need both habitats—unburned old growth and burned areas,” Fontaine explains. “In the mature forests you've got birds that like closed canopy conifers like hermit warblers and pacific slope flycatchers. But many species typically found in deep forest also used severely burned stands, like the western tanager or the red-breasted nuthatch. You've also got birds in the burn that love big open spaces, like hairy woodpeckers, and species that love bare ground like the dark-eyed junco. As time goes on you get the birds that love to nest in shrubs.”

The historic regime of frequent, mixed-severity fire indicates that these popular reburned habitats have occurred here in the past—right along side unburned, mature old growth. “The idea is that when you exclude fire, you'll be missing a big component of your regional biodiversity” Fontaine says. He goes on to explain how naturally regenerating conifers and postfire shrubs come back together to complement biodiversity.

“The postfire shrubs are very strongly associated with species richness and overall bird density. Conifers regenerate right along with the shrubs and create a twenty to sixty year

window where the conifers are underneath or slightly above the shrubs. Once they get above the shrubs they begin to shade them out and you transition to a conifer forest.”

“Birds love that window,” he concludes. “If managers find a way to be comfortable with an extended period before the conifers take over, avian biodiversity will be higher.”

To the birds—logging intensity matters

Results were mixed with regard to salvage logging and avian response. Researchers measured differences in bird response to both the size of logged areas and the percentage of trees removed within each unit. Logging creates edge habitat, and some species, like the olive-sided flycatcher, seemed to respond positively to edge creation. Shrub and open-space associated species (i.e., lazuli bunting) that responded positively to logging probably did so because most of the snags had been removed creating open conditions.

Fontaine emphasizes that the intensity of the logging was relatively low in their study areas, compared to previous studies that showed more negative effects. “On the Biscuit Fire, the patches of logged areas and the percentage of trees taken were relatively small, which is why we didn’t see a huge, precipitous decline reported by other studies in a large component of the bird community following salvage.”

Shrubs and severe fire in the Klamath-Siskiyou

Early seral shrubs appear to provide the backbone for many important aspects of postfire ecosystems in the Klamath-Siskiyou region. They typically co-occur with abundant natural conifer regeneration, support avian biodiversity, and help maintain the mixed-severity fire regime that’s critical for the landscape as a whole. As they’re regenerating, shrubs can be counted on to burn severely if ignited. But severe fire doesn’t appear to negatively affect the plants and animals of the region—even when it repeats itself—as long as it takes place in the context of the mixed-severity fire regime.

“We’re not seeing negative consequences to repeated high-severity fire in the same place, and that’s something people have rightfully been concerned about,” says Fontaine. “But it appears that if you want to have biodiversity at the regional level, you need all of these different levels and frequencies of disturbance on the landscape.”

Donato and Fontaine suggest that it may be time to consider including higher severity fire in prescriptions for forest types that are adapted to it. “The model of reintroducing low-severity fire applies well to a lot of ecosystems, but not everywhere,” Donato says. “I think this is often overlooked. The model needs to be extended to include mixed-severity and even high-severity fire where it’s appropriate, because these are ecosystem processes too.”

“It’s a lot harder for the general public or most people to get on board with this concept,” Donato concludes. “Our society has such an affinity for forests. You see a burned forest and it’s hard not to think that something’s been lost. But then, you have to take the long term view of things. This

Management Implications

- Process-based disturbance management, including the full range of variation in natural disturbance, will help perpetuate the landscape’s intrinsic diversity and mixed-severity fire regime.
- If the management objective is to reduce the risk of high-severity reburn, postfire management of dead wood may need to focus on non-merchantable material, which makes up a large portion of residual dead wood and is the most fire-available fuel.
- Young, regenerating stands will typically reburn severely because of their inherent structure. Common stand-scale treatments apparently do little to reduce fire hazard. Based on other studies, reducing fuel connectivity at the landscape scale via shaded fuel breaks may be more effective at reducing re-burn potential in young stands.
- In this forest type affected by mixed-severity fire, postfire planting would be necessary in some places and for certain objectives, but probably unnecessary in many areas, as natural regeneration typically exceeded prescribed densities without additional planting within 400 yards of forested areas.
- Because a mixed-severity fire mosaic can leave behind broadly distributed seed sources, even in very large burned areas, mapping and quantifying this distribution would be important for prioritizing postfire planting efforts. Areas farther than 400 feet from live-tree edges could be prioritized for planting if appropriate, as these areas were found to have lower regeneration density.
- Entry into stands for salvage, regardless of logging intensity, led to similar bird responses. However, overall salvage intensities were low at both stands and landscape levels reducing impacts on birds. The majority of bird species examined showed minor responses to salvage logging.
- Management aimed at avoiding repeated high-severity fire does not seem warranted with respect to birds in the Klamath-Siskiyou Mountains. Rather, recognition of the importance of a variety of early seral habitats will likely bolster the maintenance of regional avian biodiversity.
- Consider leaving a portion of severely burned areas unmanaged to ensure future opportunities for studying postfire ecology and management.

system is used to these variable disturbances. These are the processes that support all the things that live here.”