Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

The Cone Fire put fuel treatments, such as thinning and prescribed burning, to the test. Photo by USDA Forest Service

The Cone Fire: A Chance Reckoning for Fuel Treatments

Summary

In late September 2002, an accidental fire ignited on Blacks Mountain in the dry pine forest of the Cascade Range of northeastern California. The fire burned through the Blacks Mountain Experimental Forest where a large-scale, long-term study was already underway to test ecological responses to two different stand structures the scientists had created using various treatments: *high diversity*, with and without prescribed fire, and *low diversity*, with and without prescribed fire. The study was not originally designed to test the effects of severe wildfires.

The Cone Fire created an opportunity to evaluate the effects of different treatments on tree survival in the presence of wildfire. Fire severity, as observed through tree death, was high in the untreated areas adjacent to treated stands. Stands with ladder fuels reduced by thinning and a follow-up surface fuel treatment by prescribed fire had the best survival and lowest occurrence of damage to boles (trunks) and crowns. Stands in which ladder fuels were thinned, without follow-up treatment of surface fuels by prescribed fires, were intermediate between the other two. However, even the stands with thinning only brought the fire mostly to the surface with no more than occasional torching.

Key Findings

- The Cone Fire dropped from the crown to the surface within a few feet of entering the treatment units.
- Trees in close proximity to the treatment unit boundary were less likely to survive than those within the unit.
- Survival rates of trees more than 80 feet from the boundary increased dramatically for all but the smallest trees in the unit without prescribed fire. Small trees are less likely to survive a surface fire than larger trees with thicker bark.
- The Cone Fire burned with much greater severity outside the Blacks Mountain Ecological Research Project treatment areas. Treatments acted to drastically reduce fire severity and subsequent tree mortality inside the treated areas.

Igniting a forest and letting it burn across a vast landscape to test how effective different fuel reduction treatments are in modifying severe wildfires would be considered egregious by most people. Because of our social, cultural, and physical fear of large-scale fire, scientists test the ability of treatment types to modify fire behavior with simulations and models. So when the Cone Fire invaded an experimental area designed with other study goals in mind, it created an accidental opportunity for Carl Skinner, geographer, and Martin Ritchie, biometrician, with the USDA Forest Service's Pacific Southwest Research Station, to observe how treated versus untreated areas in a forest were affected by fire. "These findings will help inform fuels programs," Skinner says, "by documenting the effects of fuel treatments so that expected results are based on more than just theory."

Preparation Meets Opportunity: Fire Enters the Picture

In the hot, dry, early afternoon of September 26, 2002, a fire ignited in the Hat Creek Ranger District of the Lassen National Forest, on the south slopes of Blacks Mountain. In the young, tight stand of ponderosa pine and white fir growing in the rain shadow of the Cascade Range of northeastern California, fire swelled into a high-intensity surface fire, pushed on by winds out of the north. The fire blazed, and torched in some areas, throwing spot fires a mile and a quarter ahead of the main front. Firefighters battling the blaze, attempted to burn out areas to thwart the conflagration's advance. By the third day, when it was subdued, the Cone Fire had burned over 2,000 acres, mostly of the Blacks Mountain Experimental Forest, a research facility where a large project was underway. The Blacks Mountain Ecological Research Project (BMERP), a long-term, large-scale, interdisciplinary research project begun in 1991, was established to learn how different stand structures affect the health of interior ponderosa pine ecosystems, to measure the resilience of ecosystems to natural and human-made disturbances, and to determine how these ecosystems can be managed for sustained resource values. The BMERP was not, Skinner says, originally intended for studying the effects of severe wildfires. However, the BMERP became a prototype for the National Fire and Fire Surrogates Study, an undertaking that examines the effects of different fuel reduction techniques on fire and on environmental and economic concerns.

Six years before the Cone fire added another dimension for Ritchie and his team to study, the researchers had created areas with two distinct structures found in northeastern California pine forests: high structural diversity or HiD and low structural diversity or LoD. Twelve units, six of each structural type, ranging from 190–350 acres in size

High structural diversity and low structural diversity study plots received lop and scatter treatment.

for a total area of 3100 acres, received different treatments. Ritchie's team created HiD structure by thinning from below and retaining the larger trees. HiD's purpose was to extend the longevity of the larger, older trees while removing most of the ladder fuels, and to simulate more historical conditions of the mature forests.

The scientists created LoD structure by removing larger trees from the overstory and the smaller trees (ladder fuels) from the understory, leaving mostly intermediate trees. LoD's purpose was to simulate the stand structure that would be found in thinning operations in previously partial cut stands. Although the design did not include untreated controls, four Research Natural Areas (RNAs), each about 100 acres in size and well distributed within the experimental forest, provide information on untreated systems.

After logging and thinning, the scientists split each unit in half, with one half receiving prescribed fire and the other half receiving only lop and scatter. Lop and scatter occurs when the branches of a fallen tree are cut off, or lopped, and the cut branches and chunks of the trunk are scattered around to decompose. Following the intentions of the original study, the scientists will continue to measure the response of various ecosystem components and processes—fuel build up, decay of coarse woody debris, soil quality, nutrient cycling, microorganisms, vegetation, insects, and wildlife—to the plant structures.

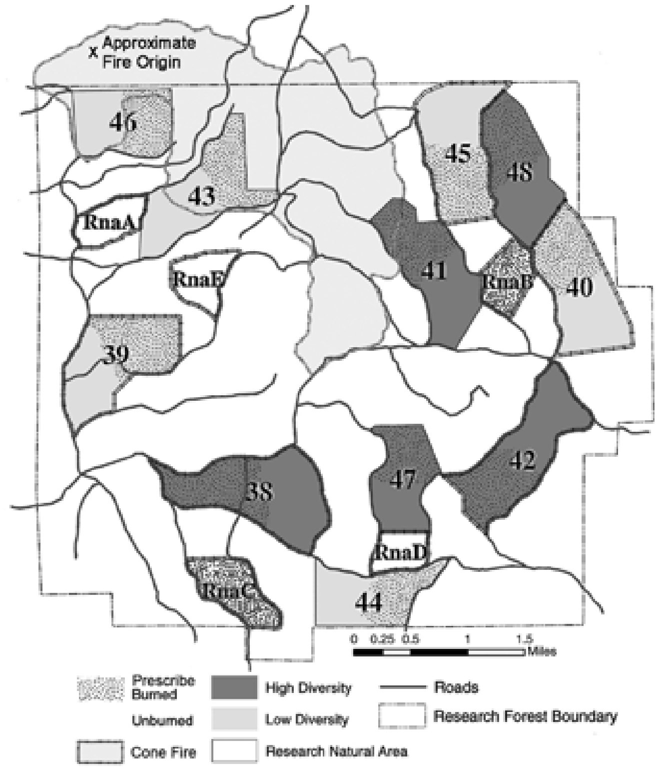
The unplanned event of that September day in 2002 put three BMERP treatment units to a test, two LoD treatment units and one HiD treatment unit, giving Skinner something every striver seeks—the moment where preparation meets opportunity.

The Cone Fire created a stark edge between the dead forest and the living one. The team's study revealed pre-fire treatments played a critical role in preserving living trees.

Postcards from the Edge: A Stark Image Where Treated Meets Untreated

To a lay person looking at different photographs of the wildfire at Blacks Mountain Experimental Forest, a stark edge between burned and unburned forest is obvious. What were the factors that made this edge? Ritchie, Skinner and their team set up a new study—one in which they lacked experimental control because they could not choose the treatment plots that had been burned—to answer this question.

In early summer 2003, the scientists placed 25 strip plots (in five groups), across the treatment boundaries of the three units affected by the Cone Fire.



The Blacks Mountain Ecologial Research Project was not originally intended for studying the effects of severe wildfires. The scientists created study plots to take advantage of the opportunity for studying fire's effects that the Cone Fire created.

Five strips were placed in a high-structural diversity thinning treatment with prescribed fire (HiDF), fifteen in a low-structural diversity thinning treatment with prescribed fire (LoDF), and five in a low-structural diversity thinning treatment with lop and scatter without prescribed fire (LoDLS). These 30-foot-wide plots extended 300 feet into the treated areas and 160 feet across the other side of the treatment boundary into the untreated area. On each of the strip plots, the team recorded the following data for all trees and snags: species, distance from treatment boundary, diameter at breast height, mortality class (live or dead), indicator of scorched or torched, total height, height of bole (trunk) char in all directions, height of crown scorch in all directions, and height to base of live crown before wildfire. If they found no green foliage 9 months after the fire, the scientists classed those trees as dead.

To understand the conditions that would have been present those 3 days in September, Skinner used a model to simulate the Cone Fire's behavior in the vicinity of the strips. He input canopy bulk density, average canopy base height, average stand height, total canopy fuel weight, canopy cover, area of trees, and trees per unit into the program FUELCALC. Fire weather and fuel moisture conditions that existed during the Cone Fire were used in the fire behavior simulation using the spreadsheet program NEXUS.

The fire behavior simulated by NEXUS indicated that each of the low diversity with prescribed fire and high diversity with prescribed fire units would experience a passive crown fire outside of the plot dropping to a surface fire within. In fact, in both of the low diversity with prescribed fire units, the fire would not burn into the treated area and went out at the edge of the unit. The fire did come into the high diversity with prescribed fire unit, but dropped immediately to a very low-intensity surface fire within the treated area as the model predicted. However, NEXUS made predictions on fire behavior, such as crown fire, and torching in the some of the treatments areas that the scientists did not observe on the actual landscape after the fire.

High Diversity

Striking differences are apparent in the amount of dead trees between treated and untreated areas at Blacks Mountain.

As the pictures tell, the casual viewer can see striking differences in the amount of dead trees between the treated and untreated areas at Blacks Mountain. Tree diameter and distance from treatment unit boundary had a significant impact. The survival rate of trees in the untreated area adjacent to the high-structural diversity with prescribed fire treatment was about 1 percent. Within the high diversity with prescribed fire unit, the survival rate of trees exceeded 80 percent beyond 80 feet from the boundary. The untreated adjacent stand was very dense with trees, and wind drove the fire directly into the treated unit. This probably reduced the survival numbers of trees along the boundary within the unit.

Low Diversity

The low diversity with prescribed fire units showed an abrupt change in fire behavior. In looking for signs of survival, bole char, and crown scorch, Skinner and his team

Treated versus untreated low diversity plots show dramatic differences.

found the fire did not carry through surface fuels in these units despite the severe weather conditions and efforts on the part of suppression crews to burn out these areas. Crown scorch in these units was limited to the very edge of the treatment plot, and the degree of bole and crown scorch on the interior of these units was near zero.

The low diversity without prescribed fire unit had tree survival rates lower than the other treated units, probably owing to higher levels of surface fuels in this unit, which had tops and limbs from the largest trees cut off and scattered. Tree survival outside this unit in the untreated area was 53 percent, higher than observed in other untreated areas of the forest. This was probably due to thinning 20 years prior to the Cone Fire. As conditions were similar between the adjacent area and the low diversity lop and scatter treatment area, very little difference existed in these areas in the amount of dead trees.

The Context of Place and the Contemplation of Goals

To burn or not to burn, cut or not to cut—that is the question fire managers face as they consider the lessons of the Cone Fire. The answer to that question can be had straight from this fire's investigator. "The first principle to address in solving our widespread fuel problems," Skinner offers, "is the context of place. Not every forest is a high-priority candidate for treatment." Wet Sitka spruce, coastal Douglas-fir, high elevation forests such as mountain hemlock or subalpine fir, historically burned infrequently but with high intensity. Other forests have long dry seasons each year and have easily combusted forest floors, such as ponderosa pine, mixed conifer, and drier Douglas-fir forests. The types of fires occurring today in these dry forests are very uncharacteristic of historical fire regimes. Through the experience of the Cone Fire, Skinner, Ritchie, and the team were able to observe the effects that different levels of treatment had on tree death or survival in an interior ponderosa forest. The scientists urge caution in extrapolating the results to other forest types and fires occurring under different weather conditions. Using caution, and context, fire managers can contemplate these factors while planning critically needed reduction of fuels in the West:

Condition Matters: Residual fuel played a role. Where the Cone Fire encountered thinned and burned stands, the fire went out. Where it encountered thinned stands with only lop and scatter of fuels left after harvest, the Cone Fire burned as a surface fire with patches of scorched tree crowns in the stand.

Character Matters: Large trees with high crowns and thick bark are the most fire-resistant trees, and when maintained in the stand help to create fire-resistant stands. Nearly 100 percent of the trees located 80 feet from the treatment boundary in the high diversity without prescribed fire unit survived even though the unit had surface fuel accumulations. Land managers should keep enough trees of different ages across a landscape to provide for replacement of the larger trees as they die. Where large trees are not present, and thinning is considered, the largest of the small trees should be reserved.

Size Matters, Scale Matters: Treatments with substantial edge adjacent to untreated units are likely to suffer high numbers of dead trees along the boundary owing to radiant heat, even if fire behavior is reduced. Narrow fuel breaks or small treatments areas, as may be common in fragmented ownerships such as the rural-urban interface, will have more edge areas. The size of an area should be considered in the design and implementation of fuel treatments.

Time Matters, Treatment Matters: Though both HiD and LoD treatments where prescribed fire had followed the thinning worked well in halting the high intensity fire, there were differences. The fire stopped at the edge of the LoD treatments. It continued as a very low intensity surface fire through needles up to approximately 300 feet into the HiD stand before going out. The difference appears to result from the litter cast from the larger trees in the HiD stand, which covered the surface more completely than in the LoD stands. *Evidence from the Cone Fire and other wildfires supports the concept that forests treated to reduce fire burn with less severity than adjacent untreated areas.* Once initial restoration treatments are complete, length of effectiveness is likely a matter of place. Where fuels build up quickly, this may be less than a decade. Fuel treatments need to be periodically reapplied in order to maintain their effectiveness.

Concern Matters: The decision to use prescribed fire must consider air quality and the health effects on local residents. Concerns about the negative environmental impacts, from thinning and burning, must be weighed.

"No action" is not risk-free, Skinner maintains. The goal, Skinner offers, is not suppression of unwanted wildfires, but the ability of the forest to sustain itself in the presence of wildfire. The challenge is to expand the scale of fire-resilient forests using socially acceptable treatments. Reduced fuel loads, he believes, can help dry forest landscapes survive into succeeding centuries.

Management Implications

- Re-establishing healthier, dry forest landscapes by thinning to create openings between trees, and by retaining larger, fire-resistant trees, as well as reducing fuel loads will allow forests to sustain themselves in the aftermath of wildfire.
- Thinning and burning can have negative impacts that must be weighed against the benefits of reducing severe fire hazards.
- The operational costs of leaving large trees and thinning smaller trees often makes altering stand structure costly to apply. Removal of some larger, merchantable trees can be used to offset harvesting costs while maintaining stand structure.
- After a wildfire, different management options will engender controversy: Salvage timber or leave it? Future fire hazard? Or habitat opportunities for birds and insects?

Further Information: Publications and Web Resources

Agee, J.K. and C.N. Skinner. 2005. Basic principles of forest fuel reduction treatments. Forest Ecology and Management. 211: 83-96.

Maleki, S. 2007. Tested by Fire: the Cone Fire and the lessons of an accidental experiment. Science Perspectives, Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture, Albany, CA.

Oliver, W.W. 2000. Ecological research at Blacks Mountain Experimental Forest in northeastern California. Gen. Tech. Report PSW-GTR-179. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 66 pp.

Ritchie, M.W., C.N. Skinner, and T.A. Hamilton. 2007. Probability of wildfire-induced tree mortality in an interior pine forest: effects of thinning and prescribed fire. Forest Ecology and Management 207:200-108

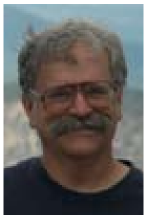
Skinner, C.N. 2005. Reintroducing fire into the Blacks Mountain Research Natural Area: effects on fire hazard. In: Ritchie, M.W., D.A. Mcquire, and A.Youngblood, eds. Proceedings of the Symposium on ponderosa pine: issues, trends, and management. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, 245-257.

Skinner, C.N., M.W. Ritchie, T. Hamilton, and J. Symons. 2004. Effects of prescribed fire and thinning on wildfire severity. In: S. Cooper, ed. Proceedings of the 25th annual forest vegetation management conference. Redding, CA: University of California Cooperative Extension, 80-91.

Symons, J.N. 2005. Planned treatment versus unplanned treatment forestry management: differences in effects on wildfire severity at Blacks Mountain Experimental Forest, California. Chico, CA: Department of Geography and Planning, California State University, M.A. thesis.

All photos and graphics are used courtesy of the USDA Forest Service Pacific Southwest Research Station unless otherwise noted.

Scientist Profile



Carl Skinner began his career with the Forest Service in 1968 as a forest firefighter. After receiving a Master's degree in Biogeography with an emphasis on fire ecology from California State University, Chico, Skinner began directing prescribed fire programs for the Shasta-Trinity National Forests. In 1995, he became a research geographer with the PSW, and in 2001, became the Science Team Leader on fire management research at the PSW Redding Laboratory.

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Martin Ritchie, biometrician with the PSW Lab, received two Master's degrees in Forestry and Statistics, and a Ph.D. in Forestry specializing in forest modeling from Oregon State University. Ritchie began his work with the Forest Service in 1987 as a consulting statistician for the PSW-Redding Laboratory. In 2000, he became a Science Team Leader and is the manager for two experimental forests (Blacks Mountain and Swain Mountain). Ritchie is also the team leader for the Blacks Mountain Ecological Research Project.

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