

## Tested by Fire



Photo: Glen Everest

### The Cone Fire and the Lessons of an Accidental Experiment

*Catastrophic wildfires burn every year in the forests of the Western United States. In the past, low-intensity wildfires were common and played an important ecological role that benefited these forests. But fire suppression policies over the last century have interrupted natural fire regimes. As a result, forests that were once characterized by an open structure and large trees are now densely packed with underbrush and smaller trees. As a further consequence, fires today tend to be uncharacteristically intense and destructive. Fire management treatments that reduce fuels through thinning and prescribed burning have proven to decrease wildfire severity.*

The dry Ponderosa pine region of Northern California is no stranger to fire. A bird's-eye view of the Lassen National Forest reveals the evidence: a mosaic of green, grey, and black. On September 26, 2002, the Cone Fire began in a part of the forest thick with underbrush and trees, and quickly grew into a high-intensity crown fire. Left behind were the charred skeletons of trees and a forest floor turned to ash. But islands of green remained, telling a compelling story about fire.

Wildfires in the drier forests of the Western United States have grown in intensity over the last century, and have come to be viewed as natural disasters. Every year, fires burn with destructive force over vast regions of Western forests, threatening the places where people and wildlife live, and impacting the economic and recreational values of forest lands. Summertime brings with it images of fire-fighters dressed in yellow and green fire-resistant uniforms against the backdrop of blackened earth. Airplanes drop orange fire retardant over treetops engulfed in flames. These are familiar scenes from a century-long battle that has been waged with the intent to protect our forests. But it wasn't always this way with fire.

Before the time that forests were actively managed, wildfires occurred frequently and burned unimpeded. In dry Western forests, fires historically covered vast areas, but tended to be low in intensity. Fire played an important ecological role, thinning the forest and reducing competition for large older trees. Fire also works to decompose forest materials, returning nutrients to the soil. In some forests, fire helps certain species regenerate. Ironically, regular wildfires helped to control the intensity of subsequent fires by creating an open forest structure, preventing the build-up of needles, twigs, branches, brush, small trees, and dense overstories—the fuels for more destructive, high-intensity fires.

The beginning of the 20<sup>th</sup> century saw the rise of fire suppression efforts. After a season of devastating fires that swept across the Western States in 1910, fire exclusion became a national policy. A century of successful fire exclusion has led to unintended consequences for today's forests: uncharacteristically severe fires that burn out of control owing to the accumulation of fuels.

The hazards of accumulated fuels have been recognized in the scientific literature for over 40

# From Science...

## Major Themes

**The Role of Fire:** Dry Western forests historically experienced frequent, low-intensity wildfires across the landscape, consuming understory vegetation and surface fuels that would otherwise fuel higher intensity fires.

**Effects of Fire Suppression:** A century of fire suppression has led to the buildup of fuels that feed the severe fires that have become common in Western forests.

**Active Management:** Fuel reduction treatments are needed to minimize wildfire hazards and forest damage.

## Research Results

**High-Intensity Crown Fire:** Such fire killed most trees in its path in stands that had not received fuel reduction treatments.

**Treatments Stopped the Fire:** In stands that had been treated with thinning and prescribed burning, the fire was rapidly reduced to a surface fire and then went out.

**Combined Treatments Work Best:** The lowest tree mortality was experienced in stands where **both** thinning and prescribed burning had been implemented.

## Blacks Mountain Experimental Forest

In 1934, the 10,000-acre Blacks Mountain Experimental Forest was set up for ecological study within the Lassen National Forest. Located in the southern Cascade Range of northeastern California, the region is dominated primarily by ponderosa pine and Jeffrey pine forests. Long-term studies have been in place to compare the effects of various forest management techniques.

## Blacks Mountain Ecological Research Project

The Blacks Mountain Ecological Research Project (BMERP) was initiated in 1991 as a large-scale interdisciplinary study of forest structural diversity, ecological response to disturbance, and sustainable management principles. A region of the experimental forest was divided into 12 research plots of approximately 250 acres each, with a total treatment area of approximately 3,000 acres. Treatments included two thinning prescriptions and prescribed burning. The study was specifically designed to compare two stand types. The first stand type has large trees and high structural diversity (i.e., a wide range of tree sizes reminiscent of historical conditions), referred to as high-diversity (HiD) stands. The second stand type has mid-sized trees and low structural diversity, simulating harvested stands where the largest trees have been removed. These are referred to as low-diversity (LoD) stands. Treatment plots were thinned to create HiD or LoD

conditions, and each plot was divided, with one half being subjected to prescribed fire. All treatments had occurred within 5 years before the Cone Fire.

## Historical Fire Regime

Studies of old-growth ponderosa pine trees, up to 800 years old, chart the history of the region's past fire regime. Carl Skinner, Biogeographer with the Forest Service's Pacific Southwest Research Station, explains that in the tree rings of these ancient trees, fire scars show a pattern of low to moderately intense fires occurring about every 7 to 10 years. Low-intensity fires covering vast forest regions occurred about every 20 years. According to Skinner, no pattern of large-scale high-intensity fires is evident in the research thus far, suggesting that the magnitude of fires that we see today does not reflect the natural fire regime of this forest type.

Fire was a regular occurrence for the Blacks Mountain region until the 1880s. At that time, sheep herds were



Carl Skinner discusses the fire history of a tree based on fire scars evident in its growth rings.

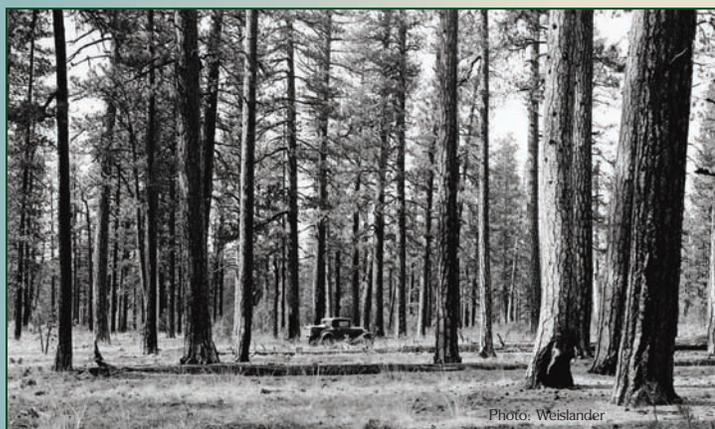
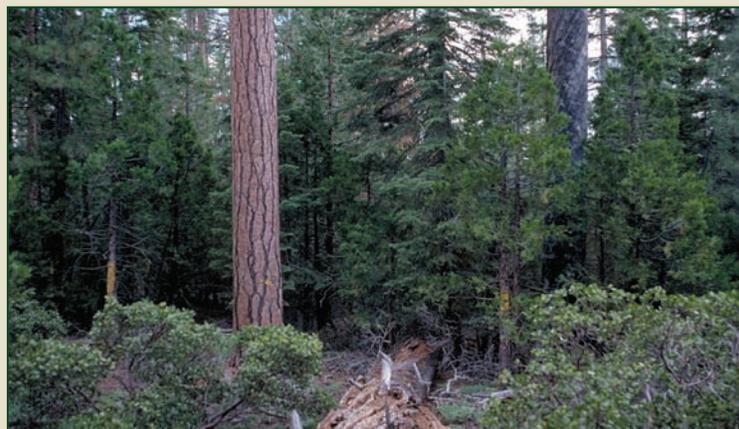


Photo: Weislander



Forest structure has changed during the 20<sup>th</sup> century. Once open with many large trees, as in this 1931 photo, the Blacks Mountain Experimental Forest is now brushy and densely packed with smaller trees, as in this photo taken of the same forest in 1994 when planning for the BMERP began.

introduced to the area. The grazing sheep removed much of the shrubs and herbs, essentially eating the fuels that once fed low-intensity surface fires. Grazing was joined by fire suppression efforts in the early 1900s to interrupt the forest's historical fire regime, shutting off fires completely. The once open forest grew dense with small and intermediate sized trees. In some untreated areas of the experimental forest, Skinner estimates that tree density has increased to over 2,000 trees per acre, compared to approximately 100 trees per acre in the treated stands.

**The Consequences of Fire Suppression: Accumulation of Fuels and Uncharacteristically Intense Fires**

When suppressing wildfires first became national policy, the ecological role of fire was not well understood. The interruption of fire has led to the accumulation of surface fuels (litter, twigs, branches, herbs, shrubs), ladder fuels (small trees), and canopy fuels (crown density of larger trees). A dense understory creates a fuel ladder that carries a surface fire up to living tree materials high above in the forest canopy, becoming what is referred to as a crown fire. Wildfires that used to burn at a low intensity along the forest floor now frequently kill large trees and destroy entire stands of timber.

**The Cone Fire—A Unique Research Opportunity**

Weather conditions were ripe for a severe fire on the autumn day the Cone Fire ignited: very dry, with winds coming out of the north. The Cone Fire quickly became a high-intensity crown fire as it moved toward the research area. Skinner points out that the BMERP was not originally intended for studying the effects of severe wildfires. But the Cone Fire presented a unique research opportunity: “Few formally designed studies of forest management techniques have been tested by wildfire to see how they perform under severe fire conditions,” says Skinner. Skinner and his colleagues were able to use the rigorous data they had collected for the BMERP to study the effectiveness of these treatments to reduce fire severity.

Three BMERP treatment areas were affected by the Cone Fire. Two were LoD

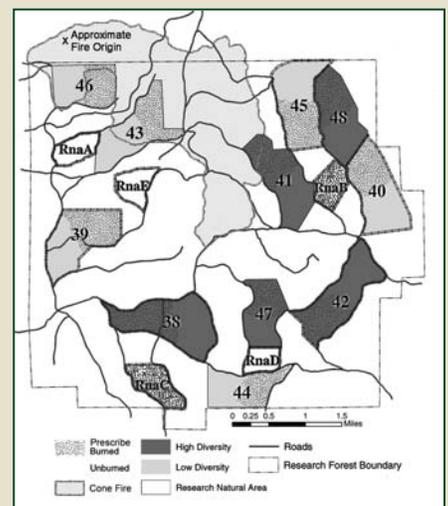
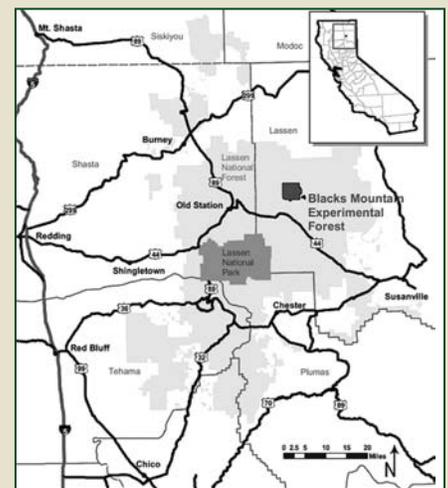
stands, and one was a HiD stand. Upon entering the treated stands, the fire dropped rapidly from the forest canopy (crown fire) to the forest floor (surface fire). In the HiD stand, the fire burned at a very low intensity along the surface and then rapidly snuffed out. After dropping to the forest floor immediately in the thinned LoD stands, the fire became a low- to moderate-intensity surface fire before dying out. In the LoD stands where thinning had been followed by prescribed burning, the fire died out almost immediately.

The results of the Cone Fire study show dramatic differences in the level of fire impact between the treated and untreated stands. The fire burned with much greater severity and resulted in significantly higher tree mortality outside the treatment areas. Tree mortality inside treatment plots seemed mostly driven by an “edge effect”—trees on the inside boundary of the treated plots were scorched by the extremely intense fire burning immediately adjacent in the untreated plots. The lowest fire impact was evident in the stands that had been treated with both thinning and prescribed burning. In these stands, there was almost no tree mortality. The postfire assessments made it clear that the type and scale of the treatment, as well as the time since the treatment had been administered, influenced the behavior and effect of the wildfire.

**Fire Resiliency and Landscape Management**

The fire dropped to the ground or stopped in the treated stands because of the open forest structure created by the treatments: the surface fuels, ladder fuels, and the crown spacing were not sufficient to sustain the high-intensity crown fire. These conditions are reminiscent of forests of the past: forests that were well adapted to fire. The results of the Cone Fire present a strong case for management approaches that improve a forest's resiliency to fire, rather than simply suppressing unwanted fires.

The Cone Fire results also suggest that the size of an area to be treated is an important consideration when planning and implementing a fuel management program. Because of potential edge effects, small-scale



*Extent of the Cone Fire within the Blacks Mountain Experimental Forest. Bold block numbers and letters indicate BMERP treatment units.*

or narrow fuel treatment areas may not be sufficient in reducing the impacts of a fire.

Landscape-scale fuel management strategies are also supported by the Cone Fire study. Fuel treatments being applied everywhere in all forests is unlikely. But strategically placed treatment areas may be effective in slowing down a high-intensity crown fire by impeding its ability to burn freely across the landscape. Landscape features and forest conditions over broad areas are important considerations in determining where and what type of treatments should be applied.

Funding for the Cone Fire research project was provided by the U.S. Department of the Interior/ U.S. Department of Agriculture Joint Fire Science Program

# ...To Management

## A Conversation with Carl Skinner

**Q: What do the results of the Cone Fire study tell us about ways in which forests can be managed differently to reduce the dangers of wildfires? How might your findings inform current programs?**

The results of this study and other postfire assessments tell us that adhering to the basic principles of forest fuel reduction treatments (reduce surface, ladder, and crown fuels, and maintain largest trees in the stand) will help to reduce the severity of subsequent wildfires. These findings will help inform fuels programs by documenting the effects of fuel treatments so that expected results are based on more than just theory.

**Q: What are some of the obstacles to using fuel-reduction treatments on a widespread and continued basis?**

Lack of funding is the biggest obstacle—much of what needs to be done will not pay for itself. Where it can pay for itself, there are often competing interests (economic, recreational, wildlife, etc.) that reduce the area and effectiveness of potential treatments. The Blacks Mountain study did pay for itself. However, it did so by cutting large trees. The low-diversity treatments made approximately \$2,500 per acre. The high-diversity treatments (where all trees greater than 18 inches d.b.h (diameter at breast height) were kept and only small trees taken) cost about \$300 per acre. However, one could treat 8 acres of high-diversity for every acre of low-diversity and still break even on costs.

Smoke is another big obstacle to using fire to treat large areas. Many seem to like the idea of fire, as it is a “natural process,” until the smoke gets in their eyes. Others are leery about setting fires with the concern that they might get out of control.

There also needs to be a better understanding of baseline (prefire suppression) conditions, and what mixes of habitat conditions a fully functioning fire regime would likely create.

**Q: Is it possible to control wildfires and re-establish natural fire regimes?**

There needs to be some reconciliation between the goal of “reducing wildfires and acres burned” vs. “restoring fire regimes.” You can’t do both. We have a problem because not enough forest area has been allowed to burn, and today when an area does burn it tends to burn at too high of an intensity. We need to think of it more in terms of reducing the area of high-intensity burning, and increasing the fire resiliency of forests.

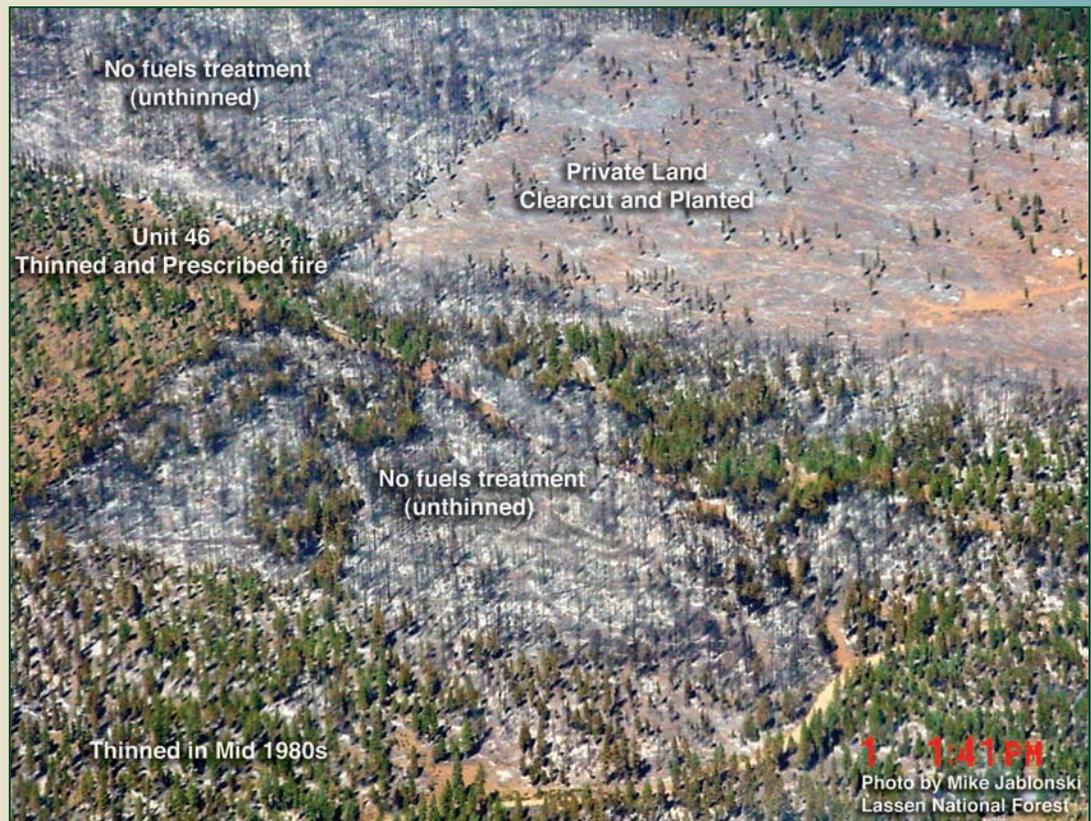
## Major Themes

**Fuels management** is necessary to deter catastrophic fire events.

**Restoring Fire-Resilient Forests:** Re-establishing a forest’s ability to sustain itself when it experiences a wildfire would be an effective fire management goal. This goal requires reducing the conditions that lead to higher intensity fires (fuels reduction), maintaining larger trees, and applying treatments strategically across the landscape.

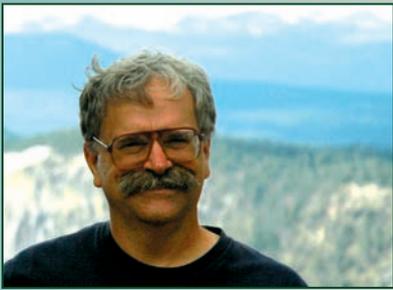
**Potential Negative Impacts:** Thinning and burning can have negative impacts that must be weighed against the benefits of reducing severe fire hazards. With prescribed fire, air quality and safety concerns must be considered for those living near treatment areas. For thinning, there are potential watershed impacts such as soil compaction, road construction, or increased fuels from partial tree removal.

**Cost:** The operational costs of leaving large trees and thinning smaller trees often makes altering stand structure costly to apply. However, removal of some larger, merchantable trees can be used to offset harvesting costs while maintaining stand structure.



*Aerial photo of the Lassen National Forest shortly after the Cone Fire. The dramatic differences in fire severity are evident between the different types of management treatments.*

## Lead Scientists Profiles



**Carl Skinner, Geographer**  
Pacific Southwest Research Station  
USDA Forest Service  
3544 Avtech Parkway  
Redding, CA 96003

Phone: 530-226-2554  
e-mail: cskinner@fs.fed.us  
www.fs.fed.us/psw/redding

Carl Skinner has a long history with fire. His first lessons on the benefits of prescribed fire were as a child on his family farm in northern California. "Our neighbor was an influence on my thinking about fire" said Skinner. "I learned to appreciate the use of prescribed fire from him as I was growing up." Together they would burn the understories of forests on their two ranches with low-intensity fires to improve forage for their livestock. Skinner's career with the Forest Service began in 1968 as a forest firefighter. As fate would have it, his first assignment was at the Blacks Mountain Guard Station on the Lassen National Forest. For 10 years, Skinner worked to put out fires through fire prevention and law enforcement programs. After receiving a Masters degree in Biogeography with an emphasis on fire ecology from California State University - Chico, he began directing prescribed fire programs for the Shasta-Trinity National Forests. It was another 10 years before Skinner moved into fire management research, working as a forestry technician at the Pacific Southwest (PSW) Lab in Redding. In 1995 he became a Research Geographer with the PSW, and in 2001 became the Science Team Leader on fire management research. Skinner has been



**Martin Ritchie, Ph.D., Biometrician**  
Pacific Southwest Research Station  
USDA Forest Service  
3544 Avtech Parkway  
Redding, CA 96003

Phone: 530-226-2551  
e-mail: mritchie@fs.fed.us  
www.fs.fed.us/psw/redding

involved in extensive research in his years with the PSW Lab, with specialties in dendrochronology-based fire histories, long-term landscape-scale influence of fires on the development of forest ecosystems, fire and climate interactions, and the effects of prescribed fire on vegetation at multiple scales.

Skinner works closely with Martin Ritchie, Biometrician with the PSW Lab, who is the Principal Investigator for the Cone Fire project. Ritchie 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 1995, he became a research statistician working primarily on young stand modeling in northern California and southern Oregon. In 2000, he became a Science Team Leader for vegetation dynamics, supervising various projects including the Blacks Mountain Research Project. Ritchie is the manager for two experimental forests (Blacks Mountain and Swain Mountain). He oversees sampling and monitoring efforts, and has developed numerous modeling tools for various forestry applications.

Continued from page 1

years. Fuel management has been advocated for even longer, since the mid-1920s. But it has been the extent and severity of wildfires over the past 20 years that has raised public awareness about the seriousness of fuels and wildfire.

The cost of suppressing severe fires, and the dangers those fires pose to life and property, highlight the need for large-scale active management. Nevertheless, significant controversy exists over how, or even if, forests should be managed to reduce the potential for severe wildfires. Some question whether fuel management can be effective under severe fire conditions. Others are concerned about how fuel management may affect other issues such as wildlife habitat, soil stability, or human health and safety.

Opportunities to study the effectiveness of fuel reduction treatments have been limited. A controlled experiment in which a high-intensity fire is intentionally started for research purposes is too dangerous a proposition in the dry forests of the Western United States. This is particularly true as the urban-wildland interface continues to expand in this region. Despite the controversies and lack of information, land management agencies have been directed by Congress and the Administration to expand fuel treatment programs.

Owing to the unplanned nature of wildfire, observational studies have been the primary means for evaluating the effectiveness of fuel treatment; i.e., assessing the condition of stands with a known treatment history after the stands have experienced a severe wildfire event. One such opportunity presented itself with the 2002 Cone Fire. Named for the hill where the fire was thought to have ignited, the Cone Fire burned over 2,000 acres of national forest land, mostly on the Blacks Mountain Experimental Forest. It happened that, on this part of the experimental forest, researchers were studying how different stand structures and prescribed fire affect forest ecosystems. The research was not originally designed to study wildfire. But, as the Cone Fire swept through the Blacks Mountain research area, it became an "accidental" experiment revealing how different management techniques affect the behavior and severity of wildfire.

**Writer's Profile:** Sussanne Maleki is a science writer based in Corvallis, Oregon. She received her Bachelor's degree in English Literature and Environmental Science from the University of Wisconsin-Madison, and her M.S. in Resource Ecology and Management from the University of Michigan-Ann Arbor. Sussanne is a co-author of a book on Ecosystem Management published by Island Press. Her publications also include various research reports for Oregon natural resource agencies and the U.S. Environmental Protection Agency.

## What's Next

Skinner and his research team will continue to study the effects of the Cone Fire, focusing mostly on the untreated areas of the forest that experienced severe fire damage and tree mortality. The team will monitor the response of returning understory vegetation, and the length of time that the trees killed by the fire will continue to stand. The team has also initiated new research, dubbed the "Variable Retention Study," designed to look at the effects of different levels of salvage logging on understory vegetation, soils, and woodpeckers. Two manuscripts stemming from the Cone Fire are currently in review.

Although the results of the Cone Fire study make an important contribution to understanding the relationship between forest management and fire behavior, they are nonetheless specific to a particular forest type and specific weather conditions. Different forest ecosystems have different fire histories, weather, geography, and so on. Further and more extensive research is needed in areas across the Western United States affected by severe fires to better understand the effectiveness of fuels management, and the effects of salvage logging versus no action after fire.



Photo: C. Phillip Weatherspoon

*An abrupt transition. The fire raged through the untreated portion of this low - diversity unit (on the right), but left the portion treated with thinning and prescribed burning (on the left) virtually untouched.*



Published by  
Pacific Southwest Research Station, USDA Forest Service  
James R. Sedell, Station Director

800 Buchanan Street, Albany, CA 94710 • 510-559-6300 • <http://www.fs.fed.us/psw>

The United States Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, gender, religion, age, disability, political beliefs, sexual orientation, and marital or familial status. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at: 202-720-2600 (voice and TDD) To file a complaint of discrimination, write: USDA Director, Office of Civil Rights, Room 326-W, Whitten Building, 14th & Independence Avenue, SW, Washington, DC 20250-9410, or call: (202) 720-5964 (voice or TDD). USDA is an equal opportunity provider and employer. USDA is committed to making its information materials accessible to all USDA customers and employees.

Pacific Southwest Research Station  
USDA Forest Service  
P.O. Box 245  
Berkeley, CA 94701

## For Further Reading

- Agee, J.K.; Skinner, C.N. 2005. Basic principles of forest fuel reduction treatments. *Forest Ecology and Management*. 211: 83-96.
- Dolph, K.L.; Mori, S.R.; Oliver, W.W. 1995. Long-term response of old-growth stands to varying levels of partial cutting in the east-side pine type. *Western Journal of Applied Forestry*. 10(3): 101-108.
- Hartsough, B. 2003. Economics of harvesting to maintain high structural diversity and resulting damage to residual trees. *Western Journal of Applied Forestry*. 18(2): 33-142.
- Oliver, W.W. 2000. Ecological research at the 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 p.
- Oliver, W.W. 2001. Can we create and sustain late successional attributes in interior ponderosa pine stands? Large-scale ecological research studies in northeastern California. In: Vance, R.K, Edminster, C.D.; Covington, W.W.; Blake, J.A., comps. *Ponderosa pine ecosystem restoration and conservation: steps toward stewardship*. Proceedings RMRS-P-22. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 99-103.
- Ritchie, M.W.; Skinner, C.N.; Hamilton, T. [In review]. Probability of wildfire-induced tree mortality in an interior pine forest: effects of thinning and prescribed fire. *Forest Ecology & Management*.
- Skinner, C.N. 2005. Reintroducing fire into the Blacks Mountain Research Natural Area: effects on fire hazard. In: Ritchie, M.W., Mcquire, D.A., Youngblood, A., eds. *Proceedings of the Symposium and conservation: issues, trends, and management*. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 245-257.
- Skinner, C.N.; Ritchie, M.W.; Hamilton, T.; Symons, J. 2004. Effects of prescribed fire and thinning on wildfire severity. In: S. Cooper, ed. *Proceedings of the 25<sup>th</sup> 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 wildlife severity at Blacks Mountain Experimental Forest, California. Chico, CA: Department of Geography and Planning, California State University, M.A. thesis.

Symons, J.N.; Fairbanks, D.H.K.; Skinner, C.N. [In review]. Influences of stand structure and fuel treatments on wildfire severity at Blacks Mountain Experimental Forest, California. *Fire Ecology*.

### Web Resources

- [www.fs.fed.us/psw/programs/ecology\\_of\\_western\\_forests/projects/cone\\_fire\\_new/](http://www.fs.fed.us/psw/programs/ecology_of_western_forests/projects/cone_fire_new/)
- [www.fs.fed.us/psw/programs/ecology\\_of\\_western\\_forests/projects/blacks\\_mountain/blacks\\_mountainres.shtml](http://www.fs.fed.us/psw/programs/ecology_of_western_forests/projects/blacks_mountain/blacks_mountainres.shtml)
- [www.fs.fed.us/psw/programs/ecology\\_of\\_western\\_forests/projects/blacks\\_mountain/](http://www.fs.fed.us/psw/programs/ecology_of_western_forests/projects/blacks_mountain/)