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Is That Tree Dead? Quantifying Fire-Killed Trees to Inform Salvage and Forest Management

In fire-dependent forests of the western United States, tree species adapt in several ways to survive fire. In low-elevation forests that evolved with frequent, low-severity fire, many species have thick bark protecting the living tissues of cambium and phloem from wildfires' destructive heat. Longer, thicker needles or those enclosed in thick scales protect growing buds. Some tree species even shed their lower branches, which reduces the chance of fire climbing into their crowns. Still other tree species are easily killed by fire but can readily resprout, or their seeds survive to quickly regenerate burned areas. Collectively, these adaptive measures allow species survival in fire-prone areas. However, high-intensity wildfires can generate temperatures that overwhelm a tree's adaptations to survive fire. The result: thousands of acres of Federal, Tribal, State, and private forests filled with trees having charred bark and burned crowns. And the sight can be distressing.

"People aren't used to looking at burned trees," explains Sharon Hood, a research ecologist with

Although wildfires are a natural disturbance in the western United States, their frequency is expected to increase because of climate change. The challenge for land managers is how to manage an increasing number of acres comprised of dead, dying, and living trees. The First Order Fire Effects Model is one of several tools used by the U.S. Forest Service to model post-fire tree mortality for planning prescribed fires and predicting wildfire severity (photo: U.S. Forest Service).

SUMMARY

Wildfires are natural disturbances in the western United States. Managing the resulting stands of dead and dying trees requires balancing conflicting priorities. Although these trees provide wildlife habitat and salvage logging revenue, they also pose public safety hazards.

One criticism of salvage logging is that forest managers may overpredict tree mortality and remove trees that will recover from their wildfire injuries. Sharon Hood, a research ecologist with the Rocky Mountain Research Station, has studied tree mortality following wildfires to identify characteristics of fire injuries that will result in tree death. Through her research over the past decade, she has improved the First Order Fire Effects Model (FOFEM), a modeling tool that forest managers can use to predict tree mortality and subsequently plan for salvage and other management activities. In addition, she has collaborated with the U.S. Forest Service Northern Region (1) and the Pacific Southwest Region (5) staff to develop post-fire tree-marking guidelines to assist timber-marking crews laying out salvage sales. By adopting similar tree-marking guidelines through the use of FOFEM, forest managers can improve the efficiency, consistency, and transparency of salvage logging projects.

Modeling Software Helps Land Managers Make Decisions

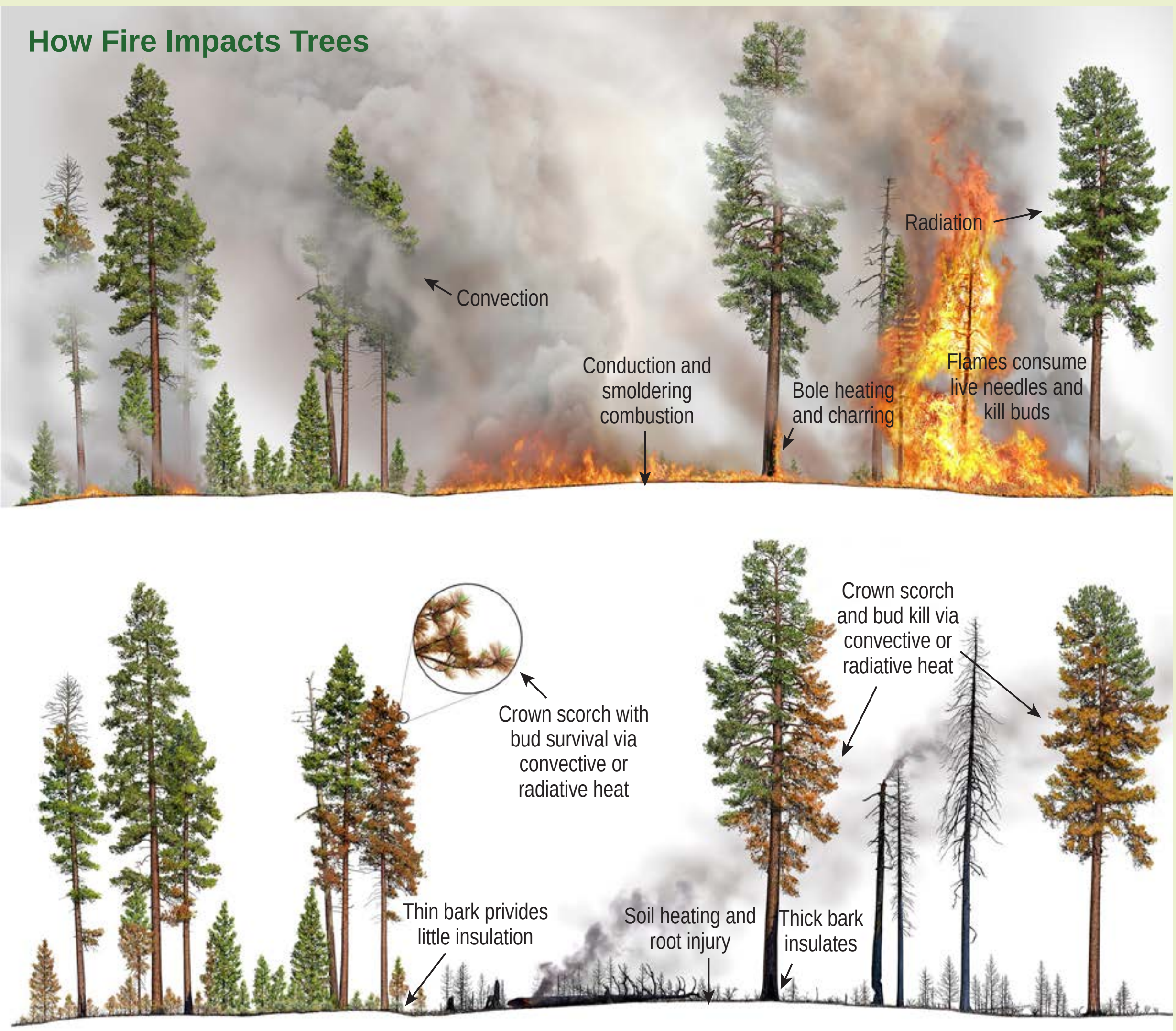
Wildfire can injure a tree by burning its crown, charring its bark, or killing its roots. The severity of these injuries, subsequent attacks by bark beetles, and environmental conditions such as drought, will determine if the tree lives or dies. The First-Order Fire Effects Model (FOFEM), BehavePlus, and FFE-FVS are free modeling software programs used by land managers to estimate the probability of mortality from these wildfire injuries. This helps managers as they design salvage logging projects and other post-fire management activities.

These programs are also invaluable for developing prescribed fire plans to meet mortality-related objectives (such as the flame length and intensity needed to kill trees of some species and size classes or to not kill desirable species of some size classes); scenario planning to decide the most effective prescribed fire treatment option; and anticipating which trees will die after a fire to model future forest species composition and structure (useful when estimating carbon stores and snags for wildlife over time).

FOFEM: https://www.firelab.org/project/fofem.

BehavePlus: https://www.frames.gov/behaveplus/home.

FFE-FVS: https://www.firelab.org/project/ffe-fvs.



Heat is transferred to living tissues of trees during fire (top panel), resulting in injuries to different parts of trees after fire (bottom panel). Fire causes injuries to different parts of trees—buds, foliage, cambium in the stem, and roots—through different heat transfer processes. To learn more about the heat transfer process, read the publication Fire and tree death: understanding and improving modeling of fire-induced tree mortality (also found in Further Reading list on page 10) (graphics by R. Van Pelt).

the Rocky Mountain Research Station (RMRS). “Right after a fire, everything tends to look worse than it is, and you’d think that all those trees will die. Yet if you wait a year, things often look better.”

The landscape does recover. Burnt needles fall off and are replaced by the emergence of new needles. Understory vegetation takes advantage of the open canopy conditions, and the burned area greens up. Trees that survive their injuries are seed sources for the next cohort of trees. However, many trees do not survive. They may die soon after the fire is extinguished, because their crowns were extensively burned or the heat penetrated the bark to kill the cambium. Other trees may die several years later as they exhaust their energy reserves trying to recover from their injuries.

The challenge for forest managers is how to manage a forest that is a mosaic of live, dead, and dying trees, because species respond to fire differently and there are conflicting priorities. The newly dead and dying trees create desirable habitat for threatened and endangered species and disturbance-associated species, such as cavity-dwelling woodpeckers. However, standing dead trees are a public safety hazard for agency personnel and planting contractors working in the area, as well as members of the public hiking through a burn scar. Trees that have recently died also have commercial value, which diminishes quickly over time. Salvage logging generates economic returns to rural and natural resource-dependent communities adjacent to National Forests and facilitates reforestation efforts.

Since management decisions such as whether and where to conduct salvage logging must be made promptly following a wildfire, forest managers cannot afford to wait several years to observe which trees die—which is where modeling is useful to predict post-fire tree mortality.

MANAGEMENT IMPLICATIONS

- A warming climate is expected to result in increases in wildfires and beetle outbreaks, which means forest managers will have to balance multiple objectives when managing the post-wildfire landscape, such as whether to conduct salvage logging, how best to reduce erosion, regeneration priorities, and providing wildlife habitat.
- The First Order Fire Effects Model is free modeling software that managers can use to model post-fire tree mortality, both for planning prescribed burns and for predicting wildfire severity.
- When the U.S. Forest Service Northern Region (1) and Pacific Southwest Region (5) developed scientifically defensible tree-mortality guidelines, it provided transparency in how trees are marked for salvage. The guidelines continue to help streamline the NEPA process and approval of the salvage sales.
- Tree mortality guidelines can be customized for a specific region and include a probability scale for the likelihood of tree death. This provides users an opportunity to apply a different probability of mortality depending upon the situation when making management decisions.
- Although there is a spike in beetle-related tree mortality following a wildfire, the spike is temporary, and the bark beetle attacks don’t persist or expand into adjacent unburned areas.

Management decisions such as whether and where to conduct salvage logging must be made promptly following a wildfire. Forest managers cannot afford to wait several years to observe which trees die, which is where modeling is useful to predict post-fire tree mortality.

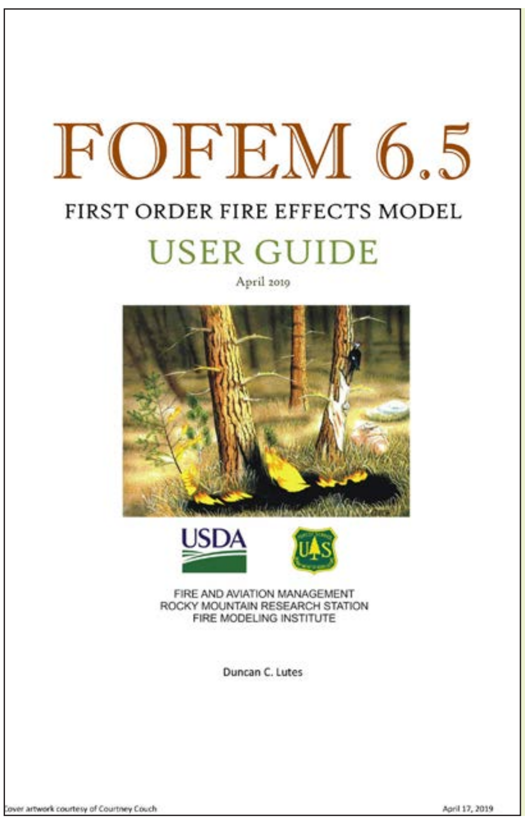
Photo: U.S. Forest Service

Building Trust Through Improved Tree Mortality Modeling

The First Order Fire Effects Model (FOFEM) is one of several free software programs used by the USDA Forest Service and other organizations to model post-fire tree mortality, both for planning prescribed burns and for predicting wildfire severity. First developed in 1997 by scientists at the RMRS Missoula Fire Sciences Laboratory, the tree mortality module in FOFEM was based upon models developed in 1988 using post-fire tree data collected in the northern Rockies on seven conifer species. However, subsequent revisions to FOFEM added the ability to predict post-fire mortality for 219 species across the United States. According to Hood, field-collected data isn't available for 150 species of these 219 species, which means the models may be overpredicting or underpredicting mortality depending upon the tree species. This uncertainty is problematic if forest managers are using FOFEM to estimate tree mortality volumes for a salvage logging project or to forecast future forest conditions for natural resource planning, such as wildlife habitat or carbon stores.

"In a true salvage, the only trees that get cut are already dead or anticipated to die in the near future," Hood explains. "If you're overpredicting mortality, that's not building trust within the community; it looks like you're trying to cut more trees than necessary. On the other hand, if you're underpredicting mortality, then many dying trees will be left."

In California, in particular, forest managers observed a disconnect between mortality modeling predictions and the observed tree mortality, which called into question the validity of the tree-marking guidelines used to identify fire-injured trees for salvage. Recognizing that FOFEM was an invaluable tool for managers but that mortality predictions needed improvement, the Pacific Southwest Region (5) provided funding to Hood for collecting post-wildfire tree


FOFEM 6.5

FIRST ORDER FIRE EFFECTS MODEL

USER GUIDE

April 2019

FIRE AND AVIATION MANAGEMENT
ROCKY MOUNTAIN RESEARCH STATION
FIRE MODELING INSTITUTE

Duncan C. Lutes

Cover artwork courtesy of Courtney Couch

April 17, 2019

The First Order Fire Effects Model (FOFEM) is one of several free software programs used by the USDA Forest Service and other organizations to model post-fire tree mortality. The predictions have many applications, from natural resource planning to salvage logging. Since its introduction in 1997, the FOFEM tree mortality module has been refined to include a wider range of species and other features that forest managers wanted.

"In a true salvage, the only trees that should get cut are already dead or anticipated to die. If you're overpredicting mortality, that's not building trust within the community. It looks like you're trying to cut more trees than necessary. On the other hand, if you're underpredicting mortality, then many dying trees will be left."

— Sharon Hood

Science-Based Guidelines for the Field: A Regional Perspective

In 2009, the Pacific Southwest Region (5) Forest Health Protection program released *Marking Guidelines for Fire-Injured Trees in California*. According to Sheri Smith, one of the authors who worked with Hood and the regional entomologist with Forest Health Protection, the guidelines were adopted immediately across the Region's National Forests, and they were very well received.

"One of the problems we've had in court cases, not only with fire-injured marking guidelines but also with hazard-tree marking guidelines, is that our 18 National Forests in California were using different marking guidelines, but the same groups were appealing us in court," Smith explains. "Now the whole region is using these fire-injured marking guidelines, so we're very consistent and transparent with the public, internally and externally, because everyone knows this is what the U.S. Forest Service is using in Region 5."

The science-based guidelines describe how to evaluate cambium injury, crown injury, and red turpentine beetle (for pines) activity for the seven major species in California: lodgepole pine, Douglas-fir, red fir, white fir, sugar pine, incense cedar, and yellow pine (Jeffrey pine and ponderosa pine). In addition, Hood, Smith, and Danny Cluck, also an entomologist with Forest Health Protection, developed a mortality probability scale based on crown scorch, cambium injury, and insect attack as another tool to inform decision-making. "The challenge of applying FOFEM to a management situation is taking the output of the model and the continuous variable where you have a probability from 0–100 percent chance that a tree will die and turning that into a binary outcome of 'Yes, this tree will die,' or 'No, this tree won't die,'" Hood says.

With this probability scale, "Line officers have the opportunity to use a different probability of mortality depending upon if they want to be more aggressive or conservative when making management decisions," says Smith. "For example, if there is adequate moisture and the trees aren't stressed, forest managers might want to be a little more conservative and give the trees the benefit of the doubt. If it's in the middle of a drought, a manager might select a lower probability of mortality."

Maurice Huynh, a silviculturist with the Mount Hough Ranger District on the Plumas National Forest, used the guidelines following the Chips Fire in 2012. As he walked through the areas, the guidelines helped him visualize what trees will live and serve as a seed source. "A lot of times the trees are completely red and dead, so there's not a doubt," Huynh says. "But for the trees that are green or singed at the edge, the guidelines help us determine if the injury is as bad as it looks."

Huynh shared that the probability scale of mortality was especially useful to inform management decisions. "For roadside treatments, for example, maybe we want to go with a lower probability of mortality because of public safety and we don't want to come back and remove more trees in the future," he explains. "Versus farther out in the forest, maybe we will select a higher probability of mortality and leave more trees."

The guidelines were revised in 2011, and Smith says that as they've received feedback they have been improved upon over the years particularly in clearly articulating the tradeoffs between being more or less conservative while factoring in project-specific conditions. Armed with this information, forest managers can make fully informed, science-based decisions. Smith and Cluck also worked with the California Department of Forestry and Fire Protection (CAL FIRE) to create a joint publication that outlines similar marking guidelines.

Smith praises Hood for not only conducting the long-term research to collect tree mortality data across California to improve FOFEM, but also translating the model outputs into guidelines that could be used out in the field.

"It's important that the work that Forest Health Protection provides funding for goes toward solving land managers' problems," explains Smith. "Hood knew from the start that our ultimate goal was getting easily applicable, science-based guidelines for the field. Translating the research into on the ground guidelines was a critical piece."

"It's great to have a standard guideline that we can all use, but one that has the flexibility of being able to choose the probability of mortality and make that call for the home unit," Huynh says. "It's a great product and very useful for us. In the unfortunate case of post-fire salvage when we get these large mega-fires, it helps us figure out what our management strategy will be."

Cedar Fire in the Sequoia National Forest near Kernville, CA, on August 22, 2016 (USDA photo illustration by Lance Cheung).

"One of the problems we've had in court cases, not only with fire-injured marking guidelines but also with hazard-tree marking guidelines, is that our 18 National Forests in California were using different marking guidelines, but the same groups were appealing us in court."

— Sheri Smith

mortality data across California. With these data, she could refine both the existing tree-marking guidelines and FOFEM's tree-mortality models.

Better Models Need More Data

In 2005, Hood developed the sampling protocol that Danny Cluck, an entomologist with the Forest Health Protection program, and his team used to collect field data across California. For several years, the team visited areas that had recently experienced wildfire, and the surviving trees were assessed for the level of crown scorch and basal injury such as bark char. These factors were selected because they were mortality indicators used in FOFEM's models. If too much of the crown is burned, the tree won't be able to produce the energy needed to recover. Extensive bark char can be an indication that the underlying cambium is dead, which means the tree can't deliver sugars from the crown down to its roots. An additional observation Hood included in the data collection was whether the tree had evidence of bark beetles. Bark beetles attack already weakened trees and can cause additional mortality beyond the fire itself. For the next 3 years, crews annually visited plots to assess whether the trees were alive or dead.

Collecting tree data for 3 years post-wildfire allowed Hood and her team to determine what type and severity of injuries will result in mortality. These data were used to improve the First-Order Fire Effects Model, which is one of the tools forest managers use to guide post-wildfire management decisions (photo: U.S. Forest Service).

This new dataset improved FOFEM's models for the conifer species growing in California, and the Pacific Southwest Region (5) Forest Health Protection program published *Marking Guidelines for Fire-Injured Trees in California*. However, Hood saw there was still a need to combine previously collected post-fire tree mortality data throughout the Pacific Northwest and Rocky Mountains. The Joint Fire Science Program, as well as Forest Service's State and Private Forestry, Forest Health Protection unit, agreed and provided funding to broaden the data collection efforts.

Hood, in conjunction with Barbara Bentz and Kevin Ryan, both scientists at RMRS, initiated several studies to examine post-fire tree mortality and bark beetle activity in Arizona, Idaho, Montana, and Wyoming using similar protocols to the ones in her California study.

These studies, combined with data previously collected by Kevin Ryan, provided data on dozens of prescribed fires and wildfires and many more conifer species in the western United States, including other prevalent western conifer species, such as whitebark pine, lodgepole pine, and white fir.

With this dataset that encompassed over 17,000 trees, Hood refined and developed new FOFEM post-fire tree mortality models. In 2010, an updated version of FOFEM was released that included improved modeling for 12 conifer species found in the western United States. The new version was "well received," says Hood, adding that the update also included a model that forest managers wanted—how to incorporate bark beetle attack and basal injury into the predictions of tree mortality following wildfires.

"After a fire, there are trees that have some level of fire injury, and the concern is these trees are stressed so bark beetles are going to come in, attack the trees and cause additional level of mortality," Hood explains. "People worry the beetles will build up in high populations and spread to adjacent unburned areas."

The data revealed this was an unfounded concern. Although there is a spike in beetle-related tree mortality, Hood cautions, "It's just a spike; bark beetle attacks don't persist or expand into unburned areas."

Tree-marking guides, such as the Post-Fire Assessment of Tree Status that was developed by the Northern Region, allow marking crews to be consistent and efficient when assessing a tree's injuries, such as this cambium injury, to to determine whether it is likely to survive or die in the years following fire (photo: U.S. Forest Service).

The Value of Tree-Marking Guides

In addition to her model analysis work with FOFEM, Hood also assists in applying FOFEM out in the field. "You can use FOFEM to develop scientifically defensible marking guidelines of what to expect after fires," says Hood. "These guidelines give managers a tool to determine whether trees survive after a fire."

Hood has worked with both the Northern Region and the Pacific Southwest Region to develop tree-marking guidelines that staff use when surveying fire-injured trees out in the field. One of her collaborators is Renate Bush, a forester who oversees vegetation inventory and analysis for the Northern Region. Bush's staff is responsible for assisting the forests with acquiring, storing, and analyzing inventory data to meet information needs from project-level planning to forest plan revisions. In the fall of 2017, Hood was asked to assist with developing a method to assess tree survival for species found in the Northern Region, based on the impacts of fire. Over the summer, there were a number of major fires in Montana that included the Rice Ridge Fire on the Lolo National Forest, the Caribou Fire on the Kootenai National Forest, and Meyers Fire on the Beaverhead-Deerlodge National Forest.

"We needed to very quickly start determining salvage opportunities, salvage units, and how much volume we would have available, so we could put together these

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>
> — Renate Bush

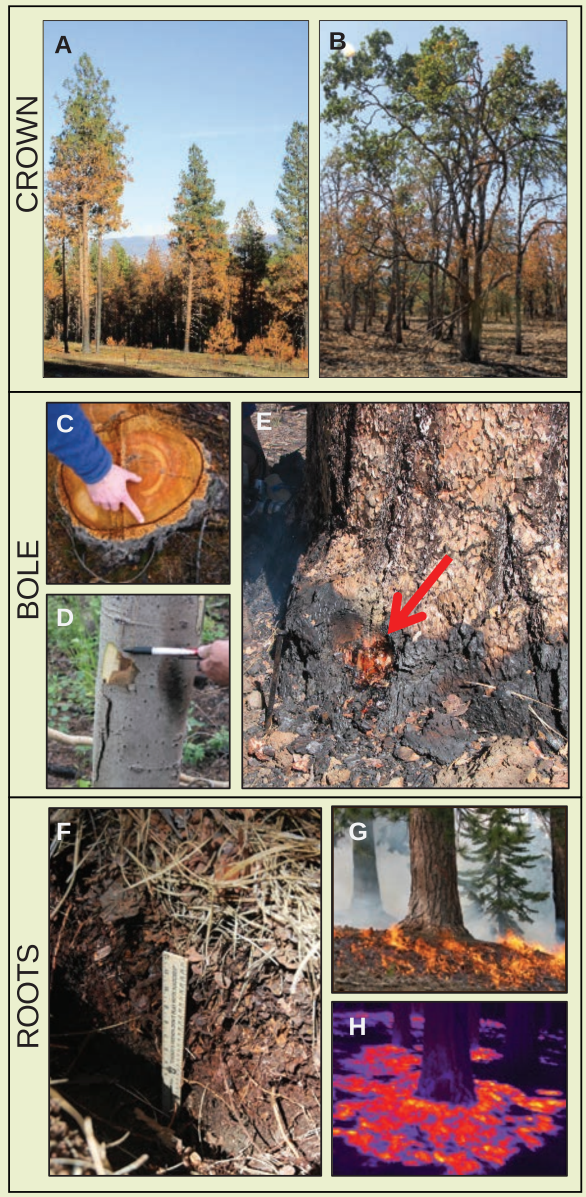
salvage sales," Bush explains. "We could pretty much determine which trees were dead. It was determining that latent mortality in trees that still had green crowns which may ultimately die, even though they didn't look dead at the time [that was difficult]."

Using FOFEM and the latest post-fire tree mortality research, Hood developed criteria for predicting the likelihood of death for 18 tree species in the Northern Region based on their level of injury and bark beetle attacks. From this information, Bush, Hood, and others wrote *Post-Fire Assessment of Tree Status*, a guide that identified whether the tree would live, whether it was dead, or would be dead within three years based on species, tree diameter at breast height, crown scorch, and the extent and severity of bark char at root collar. Hood then held a series of training sessions out in the field to teach staff how to assess burned trees and determine their

Life and Death After Fire: What Does It Look Like?

Forest managers and staff are tasked with making plans at both landscape- and individual-level scales after a fire. Training sessions held by scientists in the field and field guides provide research-based information to make informed and timely decisions about forests, trees, and habitats. Guidelines developed by scientists provide consistency across National Forests in a region, which in turn makes the process of preparing for salvage sales transparent to all interested parties.

Visual guides are an important source of information when determining whether trees are likely to survive in the years following a fire.



Fire-caused tree mortality results from injuries to the crown, bole, and roots. ***Injuries to the crown:*** *Injuries to foliage and buds occur due to direct consumption during the fire, and convective and radiant heating during the fire which causes tissue death. The portion of the crown foliage killed (A, B) is termed crown scorch and develops a characteristic red color soon after fire. Bud kill is typically assumed to equal crown scorch.* ***Injuries to the bole and resistance to bole injuries:*** *Bark thickness, char depth, height, and the proportion of the circumference of the bole charred are indirect estimates of potential injury to the living secondary vascular cambium between bark and wood. Thick bark (C) protects vascular cambium and epicormic buds, increasing survival from fire. Even low-intensity fires kill the cambium of thin bark species (D). Direct measurement requires bark removal to determine if the cambium is dead (E; at arrow).* ***Injuries to roots.*** *Consumption of ground and surface fuels adjacent to the tree may be an important variable in ecosystems with deep accumulations of fuel (F). A surface fire burns near the bole of a tree (G). Thermal image of smoldering combustion near tree base after flaming has stopped (H). (Warmer colors = higher temperatures). Figure and caption are from Fire and tree death: understanding and improving modeling of fire-induced tree mortality (also found in Further Reading list on page 10).*

likelihood of surviving for the next 3 years.

"Having the training and the guide to refer back to made assessing the trees so much easier for the staff doing field reconnaissance," Bush says. "They were more confident and consistent in determining trees that would experience latent mortality. Those trainings, combined with a field guide, were very useful."

The forestry staff also worked more efficiently and safely because they weren't lingering in hazardous areas while conducting assessments. On the Lolo and Kootenai National Forests, the guide was also used by biologists to assist with determining the potential effects of the fire to lynx habitat since both Rice Ridge and Caribou fires overlapped critical lynx habitat.

The *Post-Fire Assessment of Tree Status* guide was also a key resource for the staff writing the National Environmental Policy Act (NEPA) document, which is required when designing a management project, and developing the salvage sales, since it provided consistent definitions across all the National Forests in the region. "Using the assessment guide helped to have consistency across the units in how we did our evaluation and provided transparency in our methods," says Bush.

If Forests within the Northern Region are preparing for salvage sales as a result of wildfires, Bush says she'll remind them of the guide and that Hood is available for training.

What's Next for Modeling Tree Mortality

It's anticipated that with a warming climate, high-severity wildfires and beetle outbreaks will increase, which will likely result in more opportunities for salvage logging. Prescribed burning is also used increasingly to restore fire-dependent forests and reduce hazardous fuels. More opportunities for salvage logging and prescribed burning means land managers will use FOFEM to make management decisions.

As was seen in the Northern Region, the use of FOFEM and the *Post-Fire Assessment of Tree Status* streamlined the NEPA process and the approval of the salvage sales—

KEY FINDINGS

- Managing for the public's trust and salvage logging requires cutting dying trees without leaving too many dead trees that can impede forest management goals and objectives.
- The use of tree marking guidelines that include examples of how to quantify tree-level and stand-level post-fire mortality allows timber-marking crews to efficiently and consistently identify trees that meet salvage logging guidelines.
- The First Order Fire Effects Model (FOFEM) now includes updated post-fire tree mortality predictions for 12 western United States conifer species.

Prescribed burning in California to reduce hazardous fuels and kill small, shade-tolerant fir, while limiting mortality of large diameter, old pines. The mortality models in software programs such as FOFEM, BehavePlus, and FFE-FVS are used to develop prescribed burn plans to meet mortality-related objectives in the burn (photo by Sharon Hood, U.S. Forest Service).

something that Hood says that forest managers should take note of. "The Forest Service can use these new models and turn them into consistent salvage guidelines, which could help with ensuring all the forests are interpreting the models the same way, which strengthens the NEPA document," Hood advises.

With Washington and Oregon having experienced a number of high-severity wildfires in recent years, the Pacific Northwest Region (6) reached out to Hood to develop a guideline for their region, and that work is currently underway.

Although Hood has already spent over a decade collecting data to improve FOFEM, there is still more research needed. "Anytime you build an empirical model based upon observations, you're limited by the range of data you collect," she explains. "Maybe you're missing small trees or large trees, or the observations might not cover all the range of crown scorch." For example, data on post-fire mortality for hardwood species are still very limited; unlike conifers, many hardwoods can resprout if their tops are killed, complicating efforts to model tree death.

Currently, Hood is working on an active Joint Fire Science Project to create a database with post-fire tree mortality data for species around the country. The eventual goal is to also add in climate data so that forest managers can model the interactions of how drought could affect a tree's survival following a wildfire.

FURTHER READING

Hood, S.; Varner, M.; van Mantgem, P.; Cansler, C.A. 2018. Fire and tree death: understanding and improving modeling of fire-induced tree mortality. Environmental Research Letters. 13: 113004. https://www.fs.fed.us/rmrs/publications/fire-and-tree-death-understanding-and-improving-modeling-fire-induced-tree-mortality.

Hood, Sharon; Lutes, Duncan. 2017. Predicting post-fire tree mortality for 12 western U.S. conifers using the First-Order Fire Effects Model (FOFEM). Fire Ecology. 13:66-84. https://www.fs.fed.us/rmrs/publications/predicting-post-fire-tree-mortality-12-western-us-conifers-using-first-order-fire.

Hood, Sharon M.; Bentz, Barbara. 2007. Predicting postfire Douglas-fir beetle attacks and tree mortality in the Northern Rocky Mountains. Canadian Journal of Forest Research. 37:1058-1069. https://www.fs.fed.us/rmrs/publications/predicting-postfire-douglas-fir-beetle-attacks-and-tree-mortality-northern-rocky.

Davis, Ryan S.; Hood, Sharon; Bentz, Barbara J. 2012. Fire-injured ponderosa pine provide a pulsed resource for bark beetles. Canadian Journal of Forest Research 42: 2022-2036. https://www.fs.fed.us/rmrs/publications/fire-injured-ponderosa-pine-provide-pulsed-resource-bark-beetles.

Grayson, Lindsay M.; Progar, Robert A.; Hood, Sharon A. 2017. Predicting post-fire tree mortality for 14 conifers in the Pacific Northwest, USA: Model evaluation, development, and thresholds. Forest Ecology and Management. 399: 213-226. https://www.fs.fed.us/rmrs/publications/predicting-post-fire-tree-mortality-14-conifers-pacific-northwest-usa-model-evaluation.

USDA Forest Service Region One. 2017. Post-fire Assessment of Tree Status. Vegetation Classification, Mapping, Inventory and Analysis Report. Report 17-17 v2.0. December 21 2017.

Smith S.L., Cluck D.R. 2011. Marking Guidelines for Fire-Injured Trees in California. Report RO-11-01. USDA Forest Service, Forest Health Protection, Region 5, CA, 15 p.

Photo: U.S. Forest Service

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—Sharon Hood

SCIENTIST AND MANAGER PROFILES

The following scientists and managers were instrumental in the creation of this Bulletin:

SHARON HOOD is a Research Ecologist with the Fire, Fuel, and Smoke Science Program of the Rocky Mountain Research Station. Her primary research focuses are on the causes and mechanisms of postfire tree mortality; understanding the effects of reduced fire frequency in fire-dependent ecosystems; and how fire affects a tree's susceptibility to bark beetle attack. Since 2001, Hood has worked for the Forest Service at the Fire Sciences Laboratory in Missoula, Montana. She earned an undergraduate degree in Forestry from Mississippi State University; a master's degree in Forestry from Virginia Polytechnic Institute and State University; and a doctorate in Organismal Biology and Ecology from the University of Montana. Connect with Sharon at https://www.fs.fed.us/rmrs/people/shood.

SHERI SMITH is the Regional Entomologist for Forest Health Protection, State and Private Forestry, Region 5. She has forest health program management responsibilities for California, Hawaii, and the western Pacific Islands and has worked for the Forest Service since 1989. She received an undergraduate degree in Biology and a master's degree in Entomology from Utah State University. Her work interests include bark beetle semiochemicals, fire injuries and bark beetle interactions, invasive insects, and individual tree protection methods. Connect with Sheri Smith at https://www.fs.usda.gov/detailfull/r5/communityforests/?cid=stelprdb5346010.

RENATE BUSH is a Forester with the Northern Region and oversees vegetation inventory and analysis for the Northern Region. Her staff is responsible for assisting the forests with acquiring, storing, and analyzing inventory data to meet information needs from project-level planning to forest plan revision. Bush has spent her entire career working in forest sampling, warehousing of inventory data, and subsequent analysis. She earned undergraduate degrees from the University of Montana (UM) in Resource Conservation and Statistics and earned a master's degree from UM in Applied Analysis.

MAURICE HUYNH is a Silviculturist with the Mount Hough Ranger District on the Plumas National Forest in the Pacific Southwest Region. Huynh has been the District Silviculturist since 2012. Prior to that, he was a Small Sales Forester and Environmental Planner. He earned an undergraduate degree in Forestry from the University of California, Berkeley and a master's degree in Forestry from Northern Arizona University.

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ROBERT PROGAR, formerly of the Pacific Northwest Research Station who served as the science lead on the R6 data collection effort for this project and who is now National Program Lead, Entomology & Pathology for the Forest Service Washington Office. Learn more about Robert: https://www.fs.fed.us/research/people/profile.php?alias=rprogar

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SYCU

SCIENCE YOU CAN USE BULLETIN

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POSTAGE

The purpose of the Science You Can Use Bulletin: To provide scientific information to people who make and influence decisions about managing land.

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Rocky Mountain Research Station researchers work at the forefront of science to improve the health and use of our Nation's forests and grasslands.

RMRS is one of 7 Forest Service Research & Development Stations located throughout the U.S. Within the 12 state RMRS footprint, we maintain 12 research locations, conduct long-term ecological research on 14 experimental forests, ranges and watersheds and work in hundreds of research natural areas.

You may also be interested in regular science delivery bulletins similar to Science You Can Use, produced by the Pacific Northwest and Southern Research Stations: PNW Science Findings and SRS CompassLive.

More information about the Rocky Mountain Research Station can be found here www.fs.fed.us/rmrs and you can learn more about Forest Service Research at www.fs.fed.us/research.