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After the Fall: A Destructive Bark Beetle in the Southern Appalachians Paves the Way for Restoration of a Vanishing Shortleaf Pine Ecosystem

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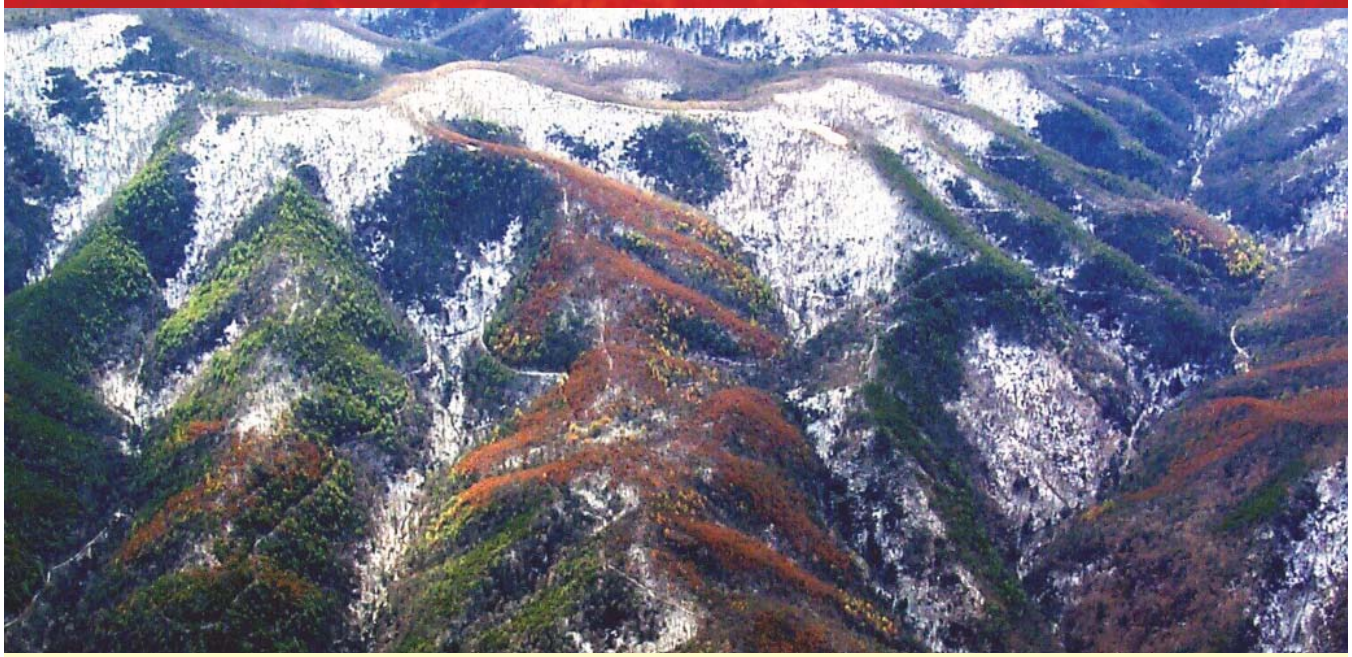
Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS



Aerial photograph of widespread damage to Cherokee National Forest by the southern pine beetle.
Credit: Richard Spriggs, Forest Service, www.Bugwood.org.

After the Fall: A Destructive Bark Beetle in the Southern Appalachians Paves the Way for Restoration of a Vanishing Shortleaf Pine Ecosystem

Summary

Between 1999 and 2003, an epidemic of southern pine beetles ravaged the southeastern United States from Virginia south to Florida and west to Texas. In five southern Appalachian states alone this destructive insect killed more than a million acres of pine and caused $1.5 billion in economic losses on state, federal, and private lands. In the aftermath, the massive amount of dead and downed trees has multiplied the risk of wildfire. The Forest Service regularly uses controlled burning with the primary goal of fuels reduction. After the latest outbreak of the pine beetle, the Forest Service is also using fire to promote a healthier and more resilient mix of pine and hardwoods, to reduce midstory vegetation that crowds out shade intolerant species such as shortleaf pine, and to establish a diverse forest floor and understory that supports a variety of wildlife. An experiment in the Cherokee National Forest in the southern Appalachians is helping guide these efforts. Researchers measured effects of fire on soil, water chemistry, and regeneration of pine, hardwood species, and understory vegetation. Results indicate that controlled burning or fell and burn had no significant adverse impacts on water chemistry or soil. In addition, while hardwoods regenerate spontaneously, shortleaf pine on these sites did not. Restoration will likely require planting seedlings on prepared sites, and additional mechanical or chemical treatments may also be necessary to knock back midstory vegetation.

Key Findings

- The invasion of southern pine beetle between 1999 and 2003 caused significant mortality to pine species across the southern Appalachians, increasing the fuel load and hazard from wildfire.
- Controlled burning in the Cherokee National Forest consumes the leaf litter without damaging the humus layer or causing significant adverse effects on soils or in streams.
- The Forest Service is restoring pine forests to a healthier mix of pine and hardwood that should better resist damaging wildfire and outbreaks of the southern pine beetle.
- Further mechanical or chemical treatments and/or frequent rotations of controlled fire may be required to suppress midstory vegetation that competes with oak and pine.

Introduction

It may not be William Tecumseh Sherman, but like the Civil War general, the southern pine beetle (*Dendroctonus frontalis*) has few friends in the South these days. Between 1999 and 2003, this native bark beetle laid waste to more than a million acres of pine forest, leaving in its wake a massive fuel load of dead and downed trees and a greatly increased risk of wildfire.

(Left) Beetle in wood. (Right) Adult beetle with wings expanded in flight. Credit: Forest Service, Region 8 Archive, www.Bugwood.org.

The southern pine beetle typically feasts on trees that are highly stressed, whether from age or lightning strikes or drought. In the southern Appalachians, epidemic outbreaks tend to occur cyclically, about every 6 to 20 years. "Low level infestations by native insects are part of the ecosystem and help create a mosaic effect among young and old stands by reinitiating natural succession in forests, resulting in a new and younger forest composition," says James Vose, a research ecologist and project leader at the Forest Service's Coweeta Hydrologic Laboratory in Otto, North Carolina. "The extent and severity of the most recent set of southern pine outbreaks, however, is not what you would expect in a natural disturbance regime." These most recent events, which caused $1.5 billion in economic losses in five southern states alone—Virginia, Tennessee, Kentucky, North Carolina, and South Carolina—were a result of several factors. "A lot of southern pine stands were not healthy," says Vose. "They had not been thinned or regenerated by historical fire regimes." The region also suffered from two prolonged droughts in the mid to late 1980s and again in the late 1990s that increased susceptibility of pines to epidemic-scale beetle outbreaks. "The drought of the '90s is where the pines really got walloped."

Prior to the pine beetle outbreak, Vose and co-investigator Katherine Elliott were working in the Conasauga River Watershed in southeastern Tennessee and northeastern Georgia in conjunction with Forest Service managers applying controlled burns in a degraded forest. The goal was to restore shortleaf pine (*Pinus echinata*) and hardwood stands with a diverse vegetative understory, including native grasses, and determine the effect of low to moderate intensity, low severity fire on soil chemistry and water quality.

The headwaters of the Conasauga River are home to a diverse variety of sensitive aquatic species, including rare and endangered fish and mussels. If significant quantities of sediment and nitrates from fire leach into streams, they consume the oxygen and suffocate aquatic life. "You don't want to affect stream organisms, especially where you have these rare mussel species, or compromise water quality for human consumption," says Elliott, a research ecologist at the Coweeta Hydrological Laboratory. Experimental burns there reassured Forest Service personnel that the use of fire to reduce fuel loads and restore a mix of pine and hardwood to the watershed would have no long-term adverse effects on water quality. "The Forest Service wants this information quickly," says Elliott. "They need it to ensure that prescribed burning can be used as a management tool without unintended consequences."

The research also indicated that to restore healthy stands of shortleaf, a fire-tolerant and shade-intolerant hard pine that has been losing ground to less fire tolerant species such as white pine (*Pinus strobus*), managers will need to replant. "The big issue at Conasauga was encroachment by white pine and fire intolerant hardwoods," says Elliott. "Our work in the Conasauga watershed showed that shortleaf pine did not germinate and develop a viable seedling population with just burning, and suggested the need to plant shortleaf pine seedlings to enhance regeneration." In addition, common woody species such as red maple and sweet gum rebound quickly after fire, vying for the light necessary to the more shade intolerant hardwoods and shortleaf pine. To keep the understory at bay, mechanical treatments, and herbicide treatments where those are an option, may also be necessary.

As the research team was gathering these results, they began to notice the invasion of southern pine beetle on the site. "When we first started in Conasauga, the stands were intact, with no obvious signs of southern pine beetle. At the end, we were beginning to see significant damage," Vose

says. This observation was the springboard for a proposal to the Joint Fire Science Program (JFSP) to focus on a site in the Ocoee Ranger District of the Cherokee National Forest.

A conifer damaged by southern pine beetle. Credit: Richard Spriggs, Forest Service, www.Bugwood.org.

Ocoee district study

The Cherokee National Forest encompasses 640,000 acres stretching from Bristol in northeastern Tennessee to Chattanooga in southeastern Tennessee along the North Carolina border. It is divided into a southern and northern zone by the Great Smoky Mountains National Park. The research site was located in the Ocoee Ranger District in the Southern Zone of the forest in the extreme southeastern portion of Tennessee. The river that gives the district its name is best known as the venue for the 1996 Olympics canoe and kayak slalom competition and remains a favorite among whitewater enthusiasts.

Like much of the southern Appalachian forests, the study site was decimated by the most recent onslaught of southern pine beetles. The pitch pine and shortleaf pine stands were already in a degraded state due to their age and the stress of severe drought in the late 1980s and late 1990s.

Shortleaf pine is part of a fire dependent ecosystem that includes hardwoods such as oak and hickory and grasses such as big bluestem (*Andropogon gerardii*) and little bluestem (*Schizachyrium scoparium*). This ecosystem was historically maintained through a frequent fire regime. "Bluestem remnants are rare," says Vose. "There is one example of the desired condition nearby, a stand that had been prescribe burned 10 times previously by the Cohutta Ranger District, Chattahoochee National Forest as a demonstration area and was beginning to approach the disturbance regime that has been changed so dramatically. This is the kind of system you would expect under a frequent fire regime."

The research team investigated the effects of burning alone, partial felling followed by burning, and no treatment. In August 2005, Forest Service personnel in the Ocoee Ranger District felled all smaller diameter trees (10 inches, or 25.4 centimeters or less) that were killed by the southern pine beetle epidemic on two 12-acre (5-hectare) areas. The fire treated plots were burned in March 2006.

The burn only treatment brought down standing dead trees and increased the amount of large woody mass on the forest floor, while fell and burn resulted in high intensity fire that effectively consumed downed wood and litter layer while leaving the lower duff, the humus layer, intact. Vegetation sampling after the treatments revealed recruitment of desirable hardwood species, but at the same time woody species such as scarlet oak, red maple, and blackgum rebounded. This finding suggests that follow-up treatments such as repeated burning, mechanical treatment, and herbicides, alone or in combination, may be required to prepare for planting seedlings of shortleaf pine, which does not regenerate on its own.

Heavy fuel load at the Ocoee site before restoration. Credit: Katherine Elliott, Forest Service.

Prescribed fire at the Ocoee site, March 2006. Credit: Katherine Elliott, Forest Service.

In April 2006, Ocoee Ranger District personnel planted shortleaf pine seedlings spaced 20 feet (6 meters) apart, and the researchers broadcast big bluestem and little bluestem seeds on all the treatment sites. In July 2006 and 2007, the team identified all plant species in subplots established around the seedlings, including grasses and woody species. The results showed that the fell and burn treatment produced the greatest survival of seedlings and recruitment of bluestem species. Fell and burn treatment creates a more open canopy, which spurs growth of the bluestem species, and the more intense flames of the fell and burn treatment also stimulate germination of these grasses. In addition, the fell and burn treatment achieved a more complete removal of woody species and of litter layer.

The study also produced some cautionary findings for restoration of mixed pine/hardwood/bluestem habitats. Amanda C. Newman, a master's student at the University of Georgia at the time, participated in the research. She notes in her thesis that the survival of shortleaf pine seedlings may be improved by planting earlier in the spring. Moreover, average precipitation in spring during both years of the study was below normal and these dry conditions affected the survival of planted seedlings.

In 2009, the Forest Service conducted a survival check on the sites that were planted in shortleaf pine in 2005 and 2006. Larry Byam, timber management assistant for Ocoee and Tellico Ranger Districts, reports that in 2009, the survival rate of planted seedlings was 75 to 90 percent, and oak and poplar are returning on their own.

Newman notes that restoration of the shortleaf/bluestem ecosystems in the southern Appalachians will require major investments in management and a better understanding of the conditions favorable for recruitment of these species.

Shifting tactics

The Forest Service routinely burns up to 20,000 acres a year in the Cherokee National Forest with three purposes in mind: fuel reduction, site preparation for replanting, and wildlife habitat improvement. The southern pine beetle infestation has required managers there to alter their tactics. "The dead timber that hit the ground has caused a massive fuel loading and increased wildfire hazard," says Dave Martin, the South Zone Fire Management Officer in the Ocoee District of Cherokee National Forest. In addition, the number of standing dead trees led to closure of many of the trails in the area and added to the danger for firefighters and those conducting controlled burns. "Falling trees kill more firefighters than fire," he says.

The increased risk of fire is of particular concern in forests adjacent to populated areas. "One area that was blistered with beetle kill was adjacent to a private nursing home and hospital," he says. Deciding where to burn requires juggling multiple concerns including, in the South, arson. In western forests, most fires are lightning set or accidentally set by people. "Most of our wildfires are arson set," he says, and though it's highly unpredictable, the arsonists tend to return to the same sites. This knowledge helps guide Forest Service decisions on where to apply controlled burns. "We have to be particular about where we choose to burn to get the most bang for the buck," Martin says.

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Martin, the burn boss on the experimental site who helped write the burn prescription and conduct the burns, says the JFSP funded research in the Ocoee district has helped determine where to burn. "Studies like these give managers more depth on the science end of things," he says. "We are tasked with reducing the fuels, but we also affect other things when we do that. The wrong places are where there are more sensitive plant and animal species or in sensitive water sheds." In addition, some places where burns had been planned were not burned. "We backed out because natural regeneration was doing just fine even after the southern pine beetle kill."

Preparing for the next invasion

Before the turn of the last century, southern pine beetle outbreaks came and went and did not constitute a significant event for human beings, says Paul Merten, an entomologist with the Forest Service's Forest Health Protection in Asheville, North Carolina. Forest management, or lack thereof, has changed the landscape considerably, however.

Aerial photography of the early 1950s and earlier shows open agricultural land that later reverted naturally to forest or was planted to plantations, primarily of conifers. In either event, the forest was overstocked and under managed. "Most stands were planted with good intentions of doing something and nothing ever happened," says Merten, "and they were planted at a density that was too high." Today these stands are weakened by drought and aging. "Like human beings, older trees are less apt to fend off attackers."

Aggressive control methods such as timber harvesting or felling trees to create a buffer can slow the progression of the beetle, but it can be hard to mount an adequate response during a severe outbreak, or sell timber when the market is glutted. The Forest Service is implementing ingenious preventative measures to fend off a future invasion.

The southern pine beetle kills trees by boring through the bark to the phloem, the living tissue that carries nutrients to the tree. In addition, the beetle carries with it the spores of a blue stain fungus which very effectively girdles the tree, maybe better than the beetle itself. "It disrupts the water transport of the tree, like taking a hatchet and girdling the bark all the way around the tree," says Merten.

Pine killed by beetle with blue stain fungus, cross section of a log. Credit: Ronald F. Billings, Texas Forest Service, www.Bugwood.org.

The beetle is so small, about the size of a peppercorn, that it can't take a tree down by itself, but thousands of them can overwhelm the natural defenses of the tree. "A pioneer beetle emits a pheromone when it successfully attacks a tree," says Merten. This pheromone attracts others that come in droves to feed on the tree. A healthy tree has a sufficient

flow of resin, which is a protectant for any entry. “The resin doesn’t poison the beetle, it drowns them in it.” A wounded conifer will ‘pitch out’ the pine pitch. It’s not uncommon that the first pioneer beetles become absorbed in this glob of resin.

Pitch tubes and pitchout on loblolly pine, close-up. Credit: Erich G. Vallery, SRS-4552, Forest Service, www.Bugwood.org.

Each spring, federal and state cooperators in all 13 states of the Forest Service’s Southern Region participate in a southern pine beetle survey. Traps are set at about the time of dogwood bloom and then checked weekly for one month. Trapping material from southern forests, including the Cherokee National Forest, is sent to the Southern Forest Health office in Asheville and counted. The number of southern pine beetles is compared to the number of checkered beetles (Family *Cleridae*), which are considered a biocontrol agent that preys on wood-boring beetles. If southern pine beetles outnumber the clerids, that is an indication of rising southern pine beetle activity and an increased risk of an outbreak. The methodology is about 80 percent accurate. “If we believe there is increased evidence of activity, we rachet up our reconnaissance.” First, a forest health specialist flies over and looks for red trees. A dead tree here or there is not cause for alarm, but if the specialist spots 10 or more in one area, a ground survey is conducted to verify the finding.

Management Implications

- Shortleaf pine does not regenerate on its own. To restore this pine, seedlings must be planted.
- Controlled fire, especially fell and burn, reduces the risk of wildfire and can be used to prepare a site for replanting.
- If conifers are replanted after an outbreak, they should be planted at a lower density to make them less prone to re-infestation.
- Where controlled fire is not feasible, mechanical thinning can slow or deter an outbreak of southern pine beetle.

As a principle component of the southern Appalachian forest ecology, regular fire promotes a mixed pine/hardwood forest. These hardwoods interspersed within the conifers help disrupt the pheromone plume and thus the pine beetle’s method of launching a mass attack.

Since 2003, the Southern Pine Beetle Prevention Initiative, a joint effort of the Southern Group of State Foresters and the Forest Service, has offered landowners across the southern states financial and educational assistance to accomplish thinning and encourage restoration of degraded forests to more resistant species. Together, state and federal land managers and private landowners are now taking a stand to prevent, rather than react to, an inevitable future outbreak.

Further Information: Publications and Web Resources

Elliott, K.J. and J.M. Vose. 2005. Effects of understory prescribed burning on shortleaf pine (*Pinus echinata* Mill.) mixed-hardwood forests. *Journal of the Torrey Botanical Society* 132(2). Pp. 236–251.

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Results presented in JFSP Final Reports may not have been peer-reviewed and should be interpreted as tentative until published in a peer-reviewed source.

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