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After a Southern Pine Beetle Epidemic

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Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

Prescribed burning is one treatment investigated for cleanup and fuel reduction of sites damaged by the southern pine beetle. Credit: USDA Forest Service.

After a Southern Pine Beetle Epidemic

Summary

Southern pine beetles are a serious insect threat to pine forests in the South, from eastern Texas to Virginia. Beetles attack most pine species by boring through the bark of the tree and constructing long, winding tunnels between the bark and the wood, eventually girdling and killing the tree. They also introduce a fungus called "bluestain," which further damages conductive systems of the tree. After an outbreak, the area of dead standing timber is usually no longer of commercial value.

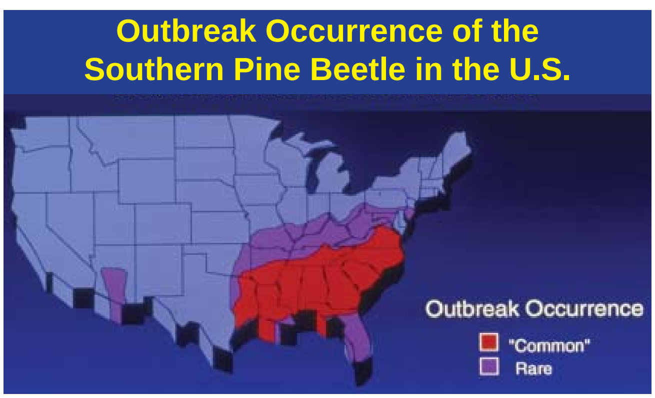
Forest managers are interested in reducing these fuel hot spots, both to allow forest regeneration and to reduce wildfire risk. Recent research evaluated the use of prescribed burns or mechanical mastication for this purpose. Researchers concluded that high-intensity prescribed burns in localized beetle-killed areas are practical and do effectively reduce fuel levels. Mastication results in initially higher woody fuel loads than either control areas or prescribed burn plots, but fuels quickly compact and decompose. Researchers felt that the best strategy is the use of high-intensity spring burns to reduce fuel loads and prepare the forest for regeneration. When done by trained professionals, these burns can readily be controlled.

Key Findings

- Because of high fuel levels, prescribed burning in beetle-killed areas may result in high-intensity fires, but these can be controlled because of their limited area.
- High-intensity fires consumed significantly higher levels of 10-hour and 100-hour fuels than low-intensity fires.
- High-intensity fires provided longer protection from wildfire. By the second year after a low-intensity fire, the woody fuels, litter and duff were not significantly lower than unburned controls.
- Mechanical mastication resulted in woody fuel loads 2.5 to 6 times higher than those observed in control plots or in areas treated with prescribed burns. However, these high fuel levels quickly compacted and decomposed, resulting in an open stand with little or no fire risk.
- Pine seedlings planted one year after the fuel reduction activities grew well. The best seedling growth was in areas which had been treated with mastication.

Southern pine beetle damage widespread

From eastern Texas, in a wide swath east and north to Pennsylvania, the southern pine beetle (*Dendroctonus frontalis Zimm*) is a major threat to pine forests. It attacks most pine species by burrowing through the bark and the female beetle creates serpentine tunnels between the bark and the wood, eventually girdling the tree and killing it within one season or less. As many as seven generations of beetles can propagate each year, although this is variable. Beetle outbreaks last from one to three years, and often reoccur in from seven to ten years. Outbreaks tend to be spotty, with individual outbreak areas ranging in size from a single tree to five acres or more.



Extent of southern pine beetle infestations. Credit: Texas Forest Service.

After the outbreak has passed and the beetles have moved on, there is usually a patch of dead pines left of all ages. From a forest management perspective, the issue now is how to deal with this patch of dead, down or standing trees. Whether the goal is to return the area to commercial production, to restore it to its previous character, or simply to lower the fuel concentration to reduce the risk of wildfire, it is desirable to reduce the dead timber.

The options generally considered are to conduct low-intensity prescribed burns, high intensity prescribed burns, or to mechanically masticate the dead material. Some variability may occur in the proportion of the affected area which consists of dead pines, versus other conifers and hardwoods. Further, any technique used must consider the potential effect of fire or mastication on desirable tree species, or on adjacent forest lands.

Southern pine beetle attacks leave relatively compact areas of killed pines. This research focused on methods of treating these areas to promote regeneration of pines and reduction of fuel levels. Credit: USDA Forest Service.

Evaluating post-infestation solutions

To create appropriate guidance for treatment of post-beetle infestation sites in the Piedmont Region of South Carolina, research was initiated under a grant from the Joint Fire Science Program. It was believed that the results would also have applicability to wider areas of the South. The research project was conducted by principal investigator Thomas Waldrop, research forester and team leader at the Forest Service, Southern Research Station. Cooperating investigators included G. Geoffrey Wang, associate professor Forestry and Natural Resources Department, Clemson University, and Mac A. Callaham, Jr., research ecologist at the Forest Service, Southern Research Station. Cooperating with the research was S. Knight Cox, Jr., forest manager at Clemson University.

As eventually designed, the research focused on test plots in the Clemson Experimental Forest. This forest is located in the Piedmont Region in western South Carolina, near the University and the City of Clemson. Plots were established to evaluate the practicality and effects of high-intensity and low-intensity prescribed burns as well as the use of mechanical mastication equipment. Results were compared with control plots where no treatment was applied.

After a beetle infestation, patches of dead pines inhibit regeneration and increase the risk of wildfire. The question is how to remove these dead spots and encourage forest regeneration. Credit: USDA Forest Service.

Research goals

The goals were to evaluate the feasibility and the results of prescribed burning and of mechanical mastication, to determine if either or both of these were practical treatments for post-infestation areas. Additionally, the team gathered information on the effects of these treatments on seedling survival, fuel loading, log moisture levels, threats of invasive plants, and soil mycorrhizal inoculum potential. Additional information was gathered on greenhouse methods to grow sterile pine seedlings, and on the energy content of select hardwood leaf species.

Treatment details

To execute the research, 12 experimental units of approximately five acres each were established in beetle-killed areas. These were divided into three replications each of four treatments. Treatments were evaluated as potential site-preparation activities, and included high-intensity prescribed burns, low-intensity prescribed burns, mechanical mastication activities, and an untreated control.

In conducting prescribed burns, precautions were taken to limit the area of the burn. Waldrop explains, "Fire lines were plowed around each burn unit. Ignition followed a strip headfire pattern beginning with a backing fire followed by narrow strips to control intensity." He emphasizes that prescribed burns of this type, though relatively small in area, need to be conducted by appropriately trained and equipped personnel.

High-intensity prescribed fires had a mean temperature of 800°F, measured by thermocouples one foot above ground. Low-intensity fire areas had a mean temperature of 350°F. Mastication was conducted by commercial operators using a Gyrotrack® or Kodiak Kutter® machine. The machines felled standing dead trees and chopped all woody debris to pieces no larger than eight inches long and one inch think. Chopped woody materials were scattered over each site. Mastication treatments were done in May and June of 2005, and the prescribed burns were conducted in April 2006.

Kodiak Kutter® felled standing trees and chopped woody debris. Credit: USDA Forest Service.

Research results

Because of the accumulation of dead fuels, researchers concluded that prescribed burning in beetle-killed areas can easily escalate to high intensity levels. However, these fires are easily controllable because the heavy fuels are confined to a small area. It was also the researchers' experience that prescribed fires in beetle-killed areas can be difficult to ignite if moisture conditions are moderate and overstory hardwoods shade the burn unit.

Another aspect of the research was to compare the relative effectiveness of low-intensity and high-intensity fires in reducing fuel loads. Evaluation of areas after fires indicated that low-intensity and high-intensity fires had no significantly different effect on 1-hour and 1000-hour fuels, or on depth of residual litter and duff. However, high-intensity fires consumed significantly higher quantities of 10-hour and 100-hour fuels. According to Waldrop, "We rarely burn when conditions are dry enough to consume 1000-hour fuels."

Because of the more complete burn of 10-hour and 100-hour fuels, it was concluded that high-intensity fires provide longer protection from wildfire. By the second year after burning, woody fuels, litter and duff were not significantly different between low-intensity plots and unburned controls, but all fuels were significantly lower in plots burned at high intensity.

High-intensity fires consumed higher levels of 10-hour and 100-hour fuels, providing longer protection from wildfire.

Mastication resulted in initial woody fuel loads that were 2.5 to 6 times greater than observed in control plots or those areas that had been treated with a prescribed burn. However, these fuels compacted and decomposed quickly, resulting in an open stand with low fire risk.

Understanding rainfall effects

Because most of the range of the southern pine beetle overlaps with areas of significant spring and summer rainfall, it was felt by researchers that it would be useful to understand the effect of rainfall on dead logs in the larger size classes. If rainfall has a significant moistening effect on these logs, it would be appropriate to consider recent rainfall in decisions to perform prescribed burns. In order to gather data, a Colorado rainfall simulator was used to test wetting of air-dried logs under various scenarios of rainfall amount, duration and intensity.

Researchers concluded that both pine and hardwood logs did not increase in internal moisture content after single rainfall events of up to four inches per day, indicating that most rainfall runs off logs and fuels remain combustible. In situations where small amounts of rain fell over a period of one to two weeks, gradual increases in log moisture occurred, particularly among pines. These fuels eventually reach a moisture content where combustion is unlikely.

Light rainfall (1 inch) that occurred once a week did not increase log moisture content. Logs tended to dry to pretreatment levels if rainfall was less frequent than weekly. Work is continuing in this area, studying logs of varying sizes, species and moisture contents to determine ignition probability and amount of combustion to be expected.

Seedling survival

Another part of the experimental work was evaluating pine seedling survival in treated beetle-killed areas. Herbicide was applied to treated areas in October 2006 and in February 2007, and one-year-old loblolly pine seedlings were planted on one-half of each treated site. Of interest was whether newly established pine seedlings would prosper following the prescribed burn or mastication treatments. Survival of pine seedlings planted one year after planting was apparently unaffected by previous prescribed burn treatment. The mastication treatment areas had a higher seedling survival, which was probably due to the mulching effect.

Effects on forest regeneration

Because forest regeneration following a beetle outbreak has benefits both for commercial forest production and for general forest habitat improvement, researchers were interested in studying regeneration following the fuel treatments. By evaluating the treatment areas several conclusions were reached. Site preparation burning and mastication treatments affected the density of hardwood stems that regenerated after treatment. Oak regeneration (less than 3-feet-tall) was significantly higher in areas burned at high intensity than control plots and areas subjected to mastication. This suggests that fire may be useful to promote oak regeneration.

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Advanced regeneration of oak (3 to 6 feet) was not affected by burning, but was significantly reduced by mastication. Regeneration of hardwoods other than oaks was not affected by either low-intensity or high-intensity burning, but was significantly reduced by mastication for two years. Survival of planted pines one season after planting was unaffected by prescribed burning. Those in the areas with previous mastication treatment had a higher survival rate, probably due to the mulching effect of mastication.

In all areas following a pine beetle attack, non-native plant species expanded, providing future challenges for land managers trying to achieve commercial or habitat restoration goals. Site preparation treatment—both burning and mastication—reduced the prominence of non-native invasive plants. Invasive species numbers remained low except for Japanese honeysuckle (*Lonicera japonica*), which increased to pretreatment levels in plots treated with mastication. Mastication opens the site to high levels of sunlight, which is beneficial to some invasive species and may necessitate additional treatments (fire or herbicide) to control these invasive species.

Soil quality effects

Research on fuel treatments in beetle-killed pine areas included an evaluation of the effect of the treatment on forest soils. Included in these considerations were soil structure, soil fertility and soil inoculum potential. Of special interest was the potential effect of prescribed burning or mastication treatments on soil inocula, and especially levels of certain mycorrhizal fungi. Forest research is increasingly showing the importance of the symbiotic role played by mycorrhizal fungi in tree nutrient and water uptake.

Generally, ectomycorrhizal (ECM) fungi are more important for tree genera including hickory, beech, pine and oak. Vesicular arbuscular mycorrhizal (VAM) fungi are more important for trees such as maples, ash, yellow-poplar, cherry and sweetgum. Research here suggested that high-intensity fires tended to promote regeneration of ECM-favoring trees, and cooler fires benefited regeneration of VAM-favoring trees.

Similarly, soil fertility was largely unaffected by any of the treatments. Burning caused some short-term reductions in concentrations of phosphorus, calcium and aluminum. Mastication caused short-term reductions in phosphorus and aluminum and an increase in potassium. However, no differences in these nutrients were found two years after treatment.

Soil structure was temporarily impacted by treatment. Burning reduced litter and duff depth over the two years of the study. Mastication covered the existing forest floor with a thick layer (up to 1.5 feet) of wood chips. These changes were not correlated with soil inoculum potential. In general, none of the treatments had significant impact on permanent soil structure, or soil fertility.

Treatment recommendations

Researchers concluded that the best choice to restore beetle-killed areas of the southeastern Piedmont appears to be prescribed burning, particularly high-intensity fires which promote oak regeneration in this area. These fires reduced heavy fuel loads for several years, but were not difficult to control because fuel loads were heavy only in a small area. However, these fires should only be conducted by trained professionals with proper equipment.

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These high-intensity fires promote the soil inoculum potential for ectomycorrhizae which are favored by target species such as hickory, beech, pin oak and other oak species. Mastication may be the best choice for commercial pine forests because it nearly eliminated the hardwoods and allowed the highest survival of pines. However, mastication increased the cover for non-native invasive plants, particularly Japanese honeysuckle, which would indicate a need for continuing treatment with fire or herbicide.

Management Implications

- Regeneration of forest growth following an infestation of southern pine beetles is achievable with either the use of prescribed fire or mechanical mastication.
- High-intensity prescribed burns are more effective than low-intensity burns in reducing fuel levels for more than two years.
- Mechanical mastication initially creates larger fuel loads, but these quickly decline with compaction and decomposition, resulting in an open stand with little fire risk.
- High-intensity prescribed burns are the best choice for reducing fuel loads and encouraging restoration of forests in the southeastern Piedmont area.
- Mechanical mastication may be the best choice if the goal is to eliminate hardwood growth, as in a commercial pine plantation.
- Generally a high-intensity burn can be readily managed because of the relatively small beetle-killed areas encountered in the southeastern Piedmont, and thus this technique is the preferred method for regeneration in these areas.
- Fires should only be conducted by trained personnel with proper equipment.

Further Information: Publications and Web Resources

Waldrop, Thomas A., G. Geoffrey Wang, Mac A. Callaham, Jr.; Epidemic Southern Pine Beetle Attacks; A Problem of Fuel-Loading or an Opportunity for Management; Final Report on JFSP Project 04-2-1-33, 2008.

Information on Southern Pine Beetle:
http://www.clemson.edu/extfor/pest_management/forlf5.htm

Information on Clemson Experimental Forest:
http://www.clemson.edu/cafls/departments/forestry/cef

Scientist Profile

Thomas A. Waldrop is Research Forester and Team Leader for Fire Science in the Southern Research Station's Center for Forest Disturbance Science in Clemson, SC. His work emphasizes fire ecology in the Piedmont and Southern Appalachian Mountains with research on firing techniques for stand replacement of Table Mountain pine, fire history, fuel loading characteristics of the Southern Appalachians, and impacts of stand replacement fire on various components of mountain ecosystems. In more recent years, he has been a leader in the National Fire and Fire Surrogate Study which studies ecological impacts of fire and mechanical fuel reduction techniques in and across numerous ecosystems of the United States. He is currently developing the Consortium of Appalachian Fire Managers and Scientists to enhance science delivery for fire professionals in the Central and Southern Appalachian region.

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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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