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General management practices for hazardous fuels management in loblolly pine (*Pinus taeda*) forests

Douglas J. Marshall and Pete Bettinger, University of Georgia
Michael Wimberly, South Dakota State University
John Stanturf, USDA Forest Service, Southern Research Station

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What are hazardous fuels?

In the South, the concept of hazardous fuels is related to human activities and concern over property protection in addition to fuel accumulation and potential fire behavior and effects. Humans are the cause of most wildfires in the South, with arson and debris burning being the main sources. Furthermore, nearly all loblolly pine forests will support a wildfire, with fuel levels and weather largely determining fire severity. Therefore, the risk of wildfire occurring in a forest is mostly dependent on human activity outside of the forest (e.g. campers or homeowners burning yard wastes) rather than actual fuel levels. In addition, given the population density of some areas and the human-caused nature of fire ignitions, wildfires in the South are often situated near buildings and roads, cause a large amount of property damage, and may result in human injury. Finally, since the population in many parts of the South is rapidly increasing, the danger to people has to be considered not only in terms of existing homes and infrastructure, but also expected future development.

Therefore, a practical definition of hazardous fuels in loblolly pine forests consists of a dense under- and midstory and accumulated live and dead vegetation that could threaten the loblolly pine overstory. If a land manager decides that hazardous fuels exist and the risk of not treating them is too great, then there are several management options available, with the choice determined not only by fuel management objectives, but also by site-specific operational constraints.

Examples of hazardous fuel situations

- Pine timber stands next to:
  - residential areas where debris burning is likely
  - a well-traveled road with heavy fuels in the shoulders that could be easily ignited by a discarded cigarette
  - homes with heavy fuels in their associated yard that could be easily ignited by wildfires
- Forests that contain:
  - a red-cockaded woodpecker colony with associated resin-coated nest trees
  - a heavy midstory of fire-prone species such as saw-palmetto or yaupon
- Infrequently burned hardwood areas intermixed with pine stands where:
  - there is a heavy midstory that could lead to crown fires
  - there is a high density of residential or vacation homes

Fuel management objectives will vary by location, protection priorities, budgetary resources, and the long-term management goals of each landowner. For example, wildland areas have different constraints than areas considered to be in the Wildland-Urban Interface (near developed areas). The most common objective related to fuel management is to manipulate forest vegetation in order to reduce the potential for severe fires. Another common objective is to manipulate forest vegetation in order to form a protective barrier around a stand or resource. The main idea behind fuel management treatments in a loblolly pine forests is either to reduce the density of some targeted species of vegetation, or to effectively change the structural condition of the forest. A number of techniques might be used to accomplish this, including prescribed burning, mechanical treatments (e.g. mulching or chipping), or herbicide applications.

Figure 1: Hazardous fuels on Conecuh National Forest, Alabama, before and after a mulching operation (photos courtesy of U.S. Forest Service)

Figure 2: Homes in Virginia with dense surrounding fuels

Figure 3: Thick hardwood midstory at Bankhead National Forest, Alabama (photo courtesy of U.S. Forest Service)

Prescribed burning

Prescribed burning is the most common tool for managing fuels in the South due to the relatively low cost per acre and the ability to reduce fuel levels rather than rearrange them. Prescribed burning has historically been used to provide access and improve hunting and farming conditions. However, today it is commonly called upon to reduce hazardous fuels, improve wildlife habitat, and control competing vegetation. The long-term use of prescribed burning in some areas of the South is becoming problematic due to restrictions on burning near dense housing and roads, and it is likely that some current burning programs will become infeasible within the next 20 years, regardless of the intent of the landowner. The use of prescribed burning may be restricted due to concerns from escaped fires, but more generally, is restricted due to smoke effects (road safety and regional air quality). However, in many parts of the South, social and economic conditions still allow the regular use of prescribed burning and probably will continue to do so for the next few decades.

Feasibility of using prescribed burning for hazardous fuels

There are many factors to be considered when deciding if prescribed burning should be used for fuel reduction. While most factors will not automatically preclude the practice, some problems may be major enough to make prescribed burning infeasible. Issues such as forest management objectives, the long-term accumulated costs of regular treatments, and the expected future development of the surrounding lands must be taken into account. Even if prescribed burning is desired and fuel conditions are favorable, constraints from issues outside one's property can effectively preclude the practice. Many southern states have established legal protection for prescribed burning in regard to damage to adjoining landowners' property, but the protection is not absolute and there is always some potential for legal action. This increased protection is often based on using a state-certified professional for the burning, and generally does not apply to non-certified burners.

How will prescribed burning affect hazardous fuels?

Pine needles, dead limbs, and understory vegetation are the primary fuels prescribed burns consume in loblolly pine forests. Maintaining pine-dominated litter at low levels is important for minimizing the intensity of a potential wildfire. Prescribed burning can be effective at reducing litter accumulations and maintaining low amounts of litter fuels. However, repeated applications are usually necessary because of rapid litter accumulation in loblolly pine forests.

Live fuels: Reduction of live surface fuels will typically be less if a prescribed burn occurs during the dormant season rather than during the growing season, even if annually treated. Winter burns, however, can increase herbaceous cover, especially the production of legumes. Annual winter burning can also increase the density of small (< 1 inch dbh) hardwoods, mainly because of re-sprouting of species like sweetgum. In open loblolly pine forests, most understory and midstory plant species re-sprout vigorously following fire. Grasses and forbs recover rapidly following a burn, but then decrease over time as shrubs recover and start to shade out the herbaceous layer. For common live surface fuels, like sweetgum and oaks, it is reasonable to expect a midstory to regain its former size within 3 to 5 years.

Repeated fires can reduce live fuels, but only if the fires occur frequently enough to either exhaust root reserves or kill short-lived plants before they can produce seeds. Experiments have found that 1-3 year growing season prescribed burns can convert a woody-dominated understory to a herbaceous-dominated one. However, prescribed burns every 3 to 7 years may not be sufficient enough to exhaust hardwood root reserves. The susceptibility of woody plants to topkill decreases with increasing stem diameter. Larger plants tend to have thicker bark that provides more insulation, and have foliage and buds that are high enough off the ground to be less susceptible to scorch. Most hardwoods become tolerant of low-intensity fires once they reach ground-level diameters of 2-3 inches.

Dead fuels: The amount of dead fuel consumed by a prescribed burn depends on fuel moisture, fuelbed structure, and weather at the time of the burn. If the litter is moist or a thick layer of green herbaceous plants is present, a prescribed burn may consume very little dead fuels. How quickly dead surface fuels return to pre-burn levels depends on several factors such as the density of live trees, how many deciduous trees are present, and the productivity of the site. As a general rule, dead fuels re-accumulate quickly during the first few seasons, as released resources are utilized for foliage production, and then slows down as resources are depleted. If there are no further fires, equilibrium is eventually reached between decomposition and litter production.

Application

It is highly recommended that those without burning experience obtain training through a state-certified burn manage program before attempting to conduct a prescribed burn. For more information on conducting a burn, the 1989 U.S. Forest Service publication “A guide for prescribed fire in southern forests” by Wade and Lunsford is recommended and is available at forestry agencies or can be accessed at the Georgia Forestry Commission website www.gfc.state.ga.us/ForestFire/PrescribedBurningMenu.cfm.

In 2006, the average cost of contracted prescribed burning in the South was $20-30 per acre. Costs can be as low as $10 per acre in situations where the concerns about smoke and fire escape are low, or as high as $40 per acre where careful attention needs to be paid around residential or urban areas. Many state forestry agencies will assist or conduct a prescribed burn for small landowners (for a price), and some will lend landowners drip torches and other equipment. In addition, most agencies will assist landowners in the development of a prescribed burning management plan.

It is important to schedule a burn at the proper time. If a site is burned during winter to minimize fire intensity from the dead fuels, there will be little impact on re-sprouting woody species. On the other hand, if a fire is performed soon after spring starts and susceptible green growth is being produced, the number of stems can be reduced via exhausting root reserves. However, if plants are given too much time for growth, the site may produce too much high-moisture green fuel to be effectively burned.

Is prescribed burning a viable option?

Legal issues

Do

- Know all state and federal laws related to prescribed burning as it is the burner's responsibility

Don't

- Burn or contract for a burn without understanding who is legally responsible for problems, or understanding what actions are covered by state prescribed burning laws

Air quality

Do

- Be aware if local industry, heavy traffic, or dust from roads, agricultural fields, and construction sites already produce a heavy load of small airborne particles (<2.5 micrometers) since these are what cause smoke and smog

Don't

- Produce smoke from a fire in an area where the local atmosphere already has a heavy particulate load. A prescribed burn is more likely to be blamed for air quality problems than multiple diffuse sources.

Fuel accumulation around the bases of overstory trees

Do

- Before any burns, if the litter is thick around the bases of valuable trees, rake most of the litter away to avoid killing the roots or thermally-girdling the trees

Don't

- Burn without considering possible impacts of smoldering fires on root systems

Roads

Do

- Develop a plan that utilizes appropriate weather conditions and minimizes the possibility that the smoke will endanger people driving on nearby roads

Don't

- Plan a burn where in areas where roads cannot handle large fire fighting vehicles, should a fire get out of control

Firebreaks

Do

- Make the firebreaks wide and extensive enough to control a prescribed burn

Don't

- Plow through wetlands or high potential erosion areas

Is prescribed burning a viable option? (cont.)

Housing and other smoke-sensitive areas

Do

- Develop a plan that utilizes the appropriate weather conditions and thus minimizes the possibility that smoke or escaped fire endangers nearby populated areas

Don't

- Burn near areas with high concentrations of at-risk people (children or the elderly) if the smoke will move in their direction

Topography

Do

- Consider the topography of both your property and adjacent land for potential smoke problems and offsite fire risk

Don't

- Burn under conditions where it is likely that smoke will settle in depressions near roads and bridges or be channeled by nighttime conditions to nearby homeowners

Concurrent burning operations

Do

- Coordinate with other local burners in order to share resources and limit smoke production for any one day

Don't

- Produce more smoke than can be dispersed by local weather conditions
- Overtax area fire-fighters if burning conditions suggest that fires could escape

Fuel loads

Do

- Use a series of low-intensity late winter / early spring fires to gradually reduce fuel loads to levels where summer burns are safe

Don't

- Create fires that are hot enough to scorch the majority of the overstory canopy or thermally-girdle the trees
- Burn under moist conditions where little fuel is consumed

Mechanical treatments

If prescribed burning is not an option, then a mechanical treatment like thinning, mulching (mastication), or chipping may be a viable option. These types of treatments can either redistribute the fuels closer to the ground (mulching) or actually remove the fuels from the site (thinning and chipping). However, the use of mechanical operations for fuel management in the South can be challenging for several reasons. First, southern forests have rapid growth rates and a large number of hardwood species that vigorously re-sprout after harvest. If the hardwoods are only cut and not killed, it may only take a few years for them to regain their previous size and negate any fuel reduction benefits. Second, wet soils and seasonal wetlands can limit the use of heavy equipment for extended periods of the year. Third, while the potential of using chips for energy (bioenergy) has increased in the South in recent years, the market prices are highly dependent on crude oil prices and hauling distances. Consequently, demand for furnace-quality chips will vary by location and time. Finally, mechanical treatments are very expensive compared to prescribed burn or herbicides, with costs often starting at $200 per acre or more in 2006.

Feasibility of using mechanical treatments for hazardous fuels

For most southern operations, mechanical treatments target the understory and midstory plants, although a selective thinning of the overstory is also a possibility. If the mechanical operations are intended as precursors for subsequent prescribed burning, the feasibility of a burning program should also be evaluated. Compared to prescribed burning, offsite problems from mechanical operations are less important while cost, terrain, access, and productivity rates are very important. In addition, the presence of clay-dominated slopes in Piedmont sites can limit the use of wheeled equipment (traction problems) while the use of tracked equipment in sandy Coastal Plain sites can cause root damage problems. Mechanical treatments in the Wildland-Urban Interface are being developed based on smaller machines than those used in wildland areas, due to the risk of thrown objects, noise, and other impacts of large machinery.

How will mechanical treatments affect hazardous fuels?

If a mechanical treatment is to be used as a stand-alone treatment, it should be understood that any changes to fuels will be temporary unless the tree canopy is closed and shady conditions suppress regrowth. Otherwise, regrowth from understory and midstory species will quickly occur. For example, a hardwood-dominated midstory on a moist site will probably only need 3 to 5 years to regain its former size after a mechanical treatment. If a mechanical operation will be used as a precursor to prescribed burning, the effects on fuels should be considered (how compacted and burnable they are).

Live/dead fuels: A mulching treatment can treat all fuels that are accessible to the cutting head. Examples of inaccessible fuels could be pockets of small woody vegetation protected by residual trees, or vegetation in wet areas susceptible to rutting or compaction. On one hand, mulch does not compact easily, since it is composed of large, irregularly shaped strips. On the other hand, it is usually not thick enough to prevent re-sprouting or seed germination. Since mulch is spread out across the landscape, it may not result in excessive flames or heat during a fire except under poor burning conditions. However, since the mulch strips have a high surface area, they readily absorb moisture, and excessive smoke from moist fuels may be an issue during a subsequent fire.

A chipping operation is more selective in the stems that are removed. If a chipper is designed for softwoods, pines and some hardwoods (e.g. sweetgum) could be utilized while other hardwoods (e.g. oaks) may be avoided. Furthermore, since tree stems are usually brought to the chipper with a skidder, the stems must be large enough to be practically handled and fed into the chipper (usually a minimum diameter of 3 to 5 inches). For furnace chips, a chipper with harder teeth, like those used by arboriculturists, can handle most woody species, although the diameter limitation would still apply.

Application

For commercial operations like chipping and thinning, profitability is based largely on pulpwood and diesel fuel prices, both of which can be highly variable. Since mechanical fuel management is a relatively new activity in the South, there are few guidelines for contractors or customers on how to estimate expected costs. For any operation, there are multiple financial variables involved, such as fuel type and density, tract size, equipment, and restrictions intended to minimize site damage. Therefore, it is not practical to provide an estimated cost for any particular fuel reduction treatment. Rather, based on recent operations in the South, it is recommended that $200 per acre be used to estimate the minimum cost for mulching in low-slope areas while $400-600 per acre be used for higher slopes (e.g. 15% or greater).

Figure 4: Heavy-duty mulcher at Bankhead National Forest, AL (photo courtesy of U.S. Forest Service)

Figure 5: Low-impact mulcher used at Conecuh National Forest, AL (photo courtesy of U.S. Forest Service)

Is a mechanical treatment a viable option?

Access

Do

- Ensure that the road system leading to the property is capable of handling large, heavy vehicles

Don't

- Create dangerous situations on crowded roads or road sides

Topography

Do

- Make sure that the property topography is capable of supporting heavy equipment
- Match equipment to the soils and to the number of trees to be retained undamaged

Don't

- Operate on slopes where erosion or rutting is possible (e.g. 25% or greater) or clay soils where traction may become an issue
- Use low-maneuverability tracked equipment in tight quarters where residual tree damage could occur

Fuel loads

Do

- Match equipment horsepower to the sizes of the main types of fuels. For example, 100 HP mulchers are limited to stems about 6 inches diameter or less for efficient use

Don't

- Leave so many trees that it is difficult to maneuver heavy equipment without causing residual tree damage

Available markets for chips

Do

- Determine demand and product specifications in local markets

Don't

- Make long-term plans for production of wood chips for furnace use as their use is highly influenced by volatility in other energy markets

Inaccessible fuels

Do

- Evaluate how much fuel will be inaccessible due to residual trees or wet soils, and if these fuels will need a different type of treatment, or whether they can be ignored

Don't

- Create pockets of fuels that will create high-intensity fires during a prescribed fire

Figure 6: Heavy-duty mulcher used at Conecuh National Forest, AL

Figure 7: Mulched fuel bed at Conecuh National Forest, AL

Figure 8: Example on inaccessible fuels at Jones State Forest, TX

Figure 9: Example of Wildland-Urban Interface at Jones State Forest, TX

Figure 10: Backpack application of herbicide (photo courtesy of www.forestryimages.org)

Figure 11: Stem injection application of herbicide (photo courtesy of www.forestryimages.org)

Herbicide applications

Herbicides may not be able to replace prescribed burning or mechanical operations in cases where dead fuels must be removed or be repositioned closer to the ground. However, herbicides are useful as preliminary treatments to kill or suppress live fuels. They can also be useful as a follow-up treatment after a prescribed burn or mechanical operation to kill re-sprouting woody species.

Feasibility of using herbicides for hazardous fuels

The effectiveness of using herbicides is based on the existing vegetation, topography, and other local restrictions. Realistically, there are two cases where herbicides are practical for fuel management treatments:

1) The overstory trees are able to respond to released resources and fill in canopy openings after an herbicide treatment targeting the mid- and understory trees. The overstory trees must have healthy crowns (at least 1/3 of total height) and be able to respond to the release. In this situation, competition from the overstory is expected to limit the growth of re-sprouting vegetation in the understory.

2) If the overstory canopy is not dense enough to shade out re-sprouting vegetation after an herbicide treatment, follow-up treatments (mechanical or prescribed burning) will eliminate live and dead fuels. This type of forest will have to be regularly treated to slow natural vegetation succession and to maintain low levels of forest fuels.

How will herbicide treatments affect hazardous fuels?

The size of the target vegetation in a fuel reduction treatment can be a good indicator of the potential effectiveness of an herbicide. Generally speaking, larger trees require more herbicide to effectively remove them. For example, one study found that oaks greater than 6 inches dbh (diameter at breast height) were unaffected by soil active hexazinone. Some woody species are not affected by certain forestry herbicides and this can limit fuel reduction treatment effectiveness. For example, elms are not affected by imazapyr while sassafras is not affected by hexazinone. Even a non-selective herbicide like triclopyr that controls most hardwoods has little effect on grasses. In addition, some herbicides cannot be mixed together, or may be less effective in combination than if applied alone.

Application

The cost of a particular herbicide application is dependent on the amount of acreage to be treated, the mode of application (e.g. broadcast spray versus stem injection), and the type and amount of herbicides used. Since these factors are variable, a general cost for herbicide fuel reduction treatments is problematic. As a general rule, cost per acre will be highest for manual application of individual tree treatments (stem injections) due primarily to labor costs. Cost per acre will be lowest for granule (pellet) applications. For small tracts, manual application may have a lower total cost than mechanized or aerial applications since equipment move-in costs may be high.

Is an herbicide treatment a viable option?

Terrain

Do

- Limit ground applications (e.g. granules) to slopes less than 20% to avoid unintended movement during heavy rainfall

Don't

- Harm desired overstory trees due to the movement of herbicides across the land

Soils

Do

- Match the herbicide to the soil type

Don't

- Use soil-active herbicides in sandy soils where they can be leached out or move downslope to non-target trees with heavy rains or be ineffective due to low soil moisture. Conversely, clayey and loamy soils can quickly immobilize soil-active herbicide

Target vegetation

Do

- Select an herbicide to match the most common live fuel source and know which species of vegetation will be affected and which will not

Don't

- Inadvertently release a species tolerant of a certain herbicide and reducing fuel treatment benefits

Canopy of remaining overstory trees

Do

- Make sure that enough overstory trees remain and are vigorous enough to fill in canopy gaps

Don't

- Release the understory due to excessive overstory mortality

Herbicide labels

Do

- Follow instructions on the labels and follow safety procedures, including proper disposal of used containers

Don't

- Overtreat target trees as contamination of the site or unintended tree mortality may occur