The Use of Prescribed Fire in the Silviculture Of Loblolly Pine

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BEFORE READING my paper, I can't help but comment on the fact that woods burning two years back was something like a dirty word, and woods burners were treated accordingly. Here today so-called woods burners are meeting in convention under the name of fire ecologists and talking about prescribed burning, so I'm going to talk about prescribed burning.

Prescribed burning is defined as the skillful application of fire to natural fuels under conditions of weather, fuel moisture, and soil moisture that will allow confinement of the fire to a predetermined area and at the same time will produce the intensity of heat and rate of spread required to accomplish certain planned benefits to one or more objectives of silviculture, wildlife management, or grazing or hazard reduction. A basic objective is to employ fire scientifically to realize maximum net benefits at minimum damage and acceptable cost. A simpler definition can be stated as follows: Prescribed burning is the deliberate use of fire on land whereon burning is restricted to a predetermined area and intensity.

Regardless of simplicity of definition, the fact remains that a complex of many fire uses involving a wide range of forest conditions requires considerable intensive research before widespread or practical application of prescribed fire becomes possible.

Researchers have studied the use of fire in southern pine types for many years. Present practice is largely backed up by research findings. Furthermore, any future modification of technique or wider application of prescribed fire should be guided by research results. In this connection we have recently established the Macon Forest Fire Laboratory where prescribed burning research is among the priority projects. Also a number of research centers in both Southern and Southeastern Station territories have active projects investigating the use of fire.

In the South Carolina coastal plain some research began as far back as 1924 when the Southern Station established prescribed burning plot studies at Lanes, South Carolina. Current research at Charleston Research Center's Santee Experimental Forest in Berkeley County, South Carolina, dates back to 1946. Studies such as these were of material aid in the development of a positive program of prescribed burning in the Loblolly Pine type on the Francis Marion National Forest and elsewhere in the Virginia-Carolina coastal plain.

We have recently completed evaluating the effects on soil, tree growth, and understory development from a 10-year series of experimental fires which include dormant- and growing-season burns applied annually or periodically. I shall try to point out some research results from slides which follow:

First of all, let's consider the main purposes for prescribed fire in Loblolly Pine silviculture in the South Carolina coastal plain. There the primary silvicultural reasons for prescribed burning appear to be: (1) in young stands, to reduce heavy fuel accumulations to minimize possible damage from wildfire; (2) in immature stands, to kill or weaken undesirable hardwoods and shrubs which may later prevent the establishment of pine seedlings; and (3) in mature stands, to remove heavy litter and any residual plant competitors which may interfere with natural reseeding at the time of timber harvest. Research at the Santee Experimental Forest has been mainly concerned with the use of fire for hardwood control and seedbed preparation in Loblolly Pine stands of pole size and larger trees.

Formal prescribed burning tests were carried out on 1/4-acre plots located in two typical South Carolina coastal plain Loblolly Pine stands. The treatments compared summer and winter fires, including annual versus periodic applications. One series of plots was established in 1946 followed by a partial series in 1951. Three replications of all plots were on the Santee Experimental Forest and two replications at the nearby Westvaco Forest, making a total of thirty-five plots. Some of the fire treatments included in the described study are backed up by tests on larger areas of coastal plain Loblolly Pine in and out of the Santee Experimental Forest. These pilot burns ranged up to about fifty acres.

The experimental forest plot installations were in previously unmanaged but well-stocked, even-aged Loblolly Pine stands containing uniformly distributed, heavy understories. Many hardwood species occupied the understories. The major ones included Sweet-gum, Black-gum and mixed oaks such as Post Oak, Blackjack Oak, Willow Oak, and Southern Red Oak. Among the less important trees numerically were Flowering Dogwood, Red Maple, American Holly, and miscellaneous hickories. Approximate stocking by tree species-group was sixty per cent gum, thirty per cent oak, and ten per cent other species. Southern Bayberry, Pepperbush, and Gallberry comprised most of the shrub understory. About sixty per cent of the understory stems were trees, the remainder shrubs.

As the slide clearly shows, small stems in the understory are effectively girdled by the winter fires. On those up to about one-inch d.b.h. the kill is high but rapidly diminishes as stem size approaches two inches, and is quite negligible among larger sizes. However, most rootstocks survive to bear sprouts early in the following growing season. On better sites, the recovery rate for the understory is about five years, and on the poorer sites up to about ten years. Thus, periodic repeat fires are needed to maintain a desirable level of understory control during the life of a stand.

Winter fires are also well suited for fuel reduction, espe-

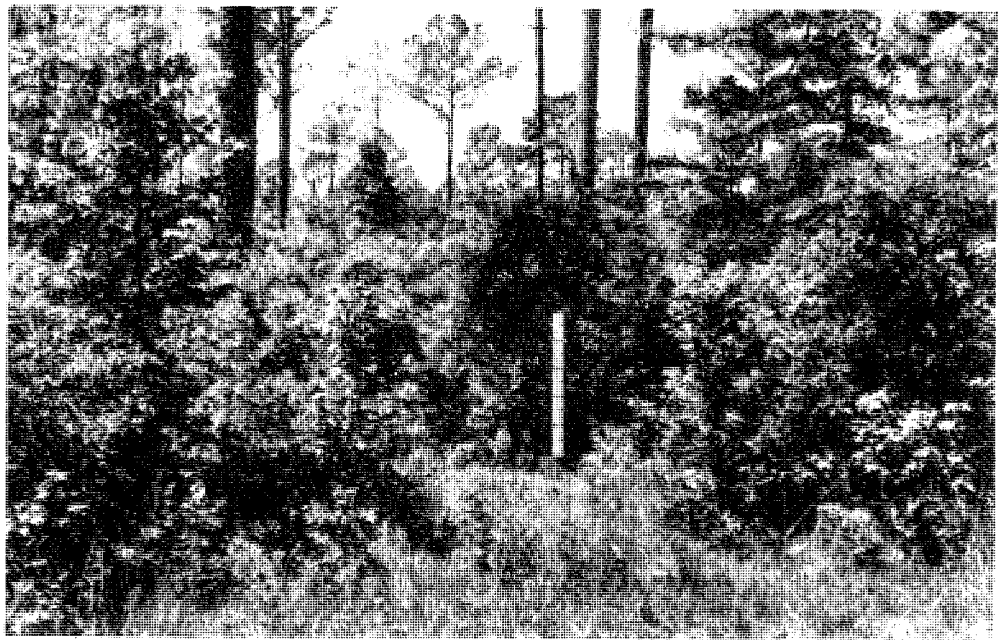

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Fig. 4. Although Loblolly Pine seed trees are present, this site was captured by the advance understory at the time of harvest cutting. Understory control before cutting assures pine regeneration on sites like these.

cially in young stands. These fires consume flash fuels principally. Such light fuels consist mainly of pine needles draped on understory vegetation and of several years accumulation of surface litter. Because the soil and a compact layer of organic material lying directly above are generally moist, the prescribed fire seldom burns down to mineral soil. This minimizes the chance of direct damage to the soil and any roots lying close to the surface.

This rather poor slide illustration, taken at a 60° angle, is of the forest floor, minutes after a winter burn. The upper half shows consumed surface material. This has been removed in the lower half to show unburned surface organic matter (about one-half inch thick) and the mineral soil surface with exposed fine roots. A properly planned and conducted burn seldom results in a scorch line above shoulder height. On the occasionally crown-scorched, dominant tree, damaged foliage is soon replaced through the dormant buds which are highly resistant to heat damage.

On the other hand, burning in the winter for seedbed

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Fig. 5. After four prescribed burns the understory is no longer a problem in this 50-year-old stand of Loblolly Pine now ready for regeneration.

preparation has some handicaps. Ordinarily the Loblolly Pine seedfall begins in mid-October; however, over half the seed is down by November 15, eighty per cent by December 15, and ninety per cent by January 15. Consequently most, if not all, of the seed falling on a given area could be destroyed by a poorly timed burn. When this is followed by a harvest cutting, rather full dependence must be placed on the next seed crop for regeneration. In the meantime, the area may be taken over by hardwood and shrub sprouts or the space available for pine reproduction proportionately reduced. Thus, in stands scheduled for regeneration cuttings, it is best to burn before seedfall begins or as soon thereafter as feasible.

This leads up to a discussion of the possible use of summer, or growing-season, fires in the management of Loblolly Pine. So far, there has been a limited use of summer fires except in areas being "cleaned up" in advance of planting.

Our research shows that a short series of annual or biennial summer burns will practically eradicate heavy understories from Loblolly Pine stands. For example, the cumulative mortality of a common shrub, Southern Bayberry, is about ninety per cent after four successive annual fires. A comparable level of kill is obtained with fires spaced two years apart up to about the third fire. For some unknown reason the fourth biennial fire is found not to be as effective as the fourth annual fire. Mortality among tree species in the understory follows a pattern similar to that for bayberry, although the kill is not quite so rapid. In any case, all survivors lose considerable vigor, and the net result is effective understory control. In managed stands this could be of long duration through a reduction of rootstocks by fire and the elimination of hardwood seed sources by a series of improvement cuttings.

It follows, then, that summer fires can be used effectively as a regeneration tool. During the interim stages of stand development, periodic winter burning can be used for fuel reduction and as a means of keeping understory stems small, even though not reduced in number. As the stand approaches harvest, a short series of successive annual or biennial summer fires would serve to minimize the understory competition as well as to prepare the seedbed by reducing the accumulated surface litter in advance of seedfall. As a matter of fact, this procedure can establish reproduction even before the overwood is harvested.

We have tested the foregoing technique and have had no trouble obtaining excellent catches of seedlings. In the illustrated fifty-year-old stand of Loblolly Pine, our burning schedule called for an initial winter fire to reduce the heavy thirteen-year-old rough. This was followed by a succession of three annual summer fires. The result was a nearly perfect condition for regenerative purposes.

In an earlier evaluation, it was found that a gradual reduction in understory competition brought about by summer fires, or the setback of the understory from winter fires, did not result in any measurable growth benefits or losses to the pine overstory during the first five years of the study. This was also true after ten years. As before, the growth measurements were based on increment borings from every pine on the plots;

from these, mean yearly radial growth was determined by treatments and crown classes for the ten-year periods before and after installation of the study. In sum, the data show no statistically significant increase or decrease in growth of the dominant trees attributable to prescribed burning.

The illustrated chart compares growth on the check, annual summer, and periodic winter burn plots. The lower graph represents rainfall the first six months of each year. You will note that the trend of annual growth was downward, which is considered normal for stands of the ages and densities sampled in this study. Much of the yearly variation in growth seems to be closely related to the amount of rainfall during the first six months of each year, growth dropping when rainfall during this period was short and taking a sharp turn upward when abundant. An exception is in 1948, which showed a downward trend in growth in the face of a wet first half. A cold early growing season may have been responsible. Furthermore, the possible effect of hot initial burns on growth should not be overlooked, in that the heavy fifteen-year accumulation of fuel causes these fires to be more intense than any of later ones, with possible adverse but short-lived effects on growth.

The various soils analyses—organic matter, physical, and chemical—indicate no evidence of serious damage to soil as a consequence of any of the prescribed burning treatments; in fact over the ten-year period of treatment there is a definite increase in organic matter content of the surface two inches of forest soil as a consequence of annual burning. Please note that the values in the last column of this tabulation represent per cent organic matter based on oven-dry weight of the soil.

The incorporated organic matter in the burned plots was very black and gave the appearance of being like fine bits of charcoal. Apparently it was not, as the analytical technique (wet combustion method) excludes ninety to ninety-five per cent of the charcoal. Much of the surface litter is not converted to ash, and the material which appears to be charcoal is actually charred matter. This fine residual left after a fire can enter the mineral soil by gravity or by water if it is not washed away, which is unlikely in the flat coastal plain. This is in contrast to the unburned forest floor, where litter slowly changes to humus and while a portion of it is being incorporated into the mineral soil, much of the material volatilizes as carbon dioxide and water vapor.

Analyses of the upper two inches of surface soil revealed that organic matter significantly increased with all fire treatments except periodic winter fires—in which case organic matter remained at about the same level as on the unburned areas. Furthermore, the soil nutrients, nitrogen, phosphorus, potash, calcium, and magnesium, were closely correlated with the organic matter content in the surface soil. Finally, type and frequency of fire treatments tested resulted in no detrimental effect on the physical properties of bulk density, porosity, or percolation rate, all of which are more or less related to the organic matter in the soil.

It should be pointed out that organic matter in the soil was already of sufficient quantity so that the measured increases are not important biologically. At least there is now confidence that on the level sandy soils of the Carolina coastal plain no site deterioration results from a program of prescribed burning in the Loblolly Pine type.

A sizable acreage is treated each year in the Virginia-Carolina coastal plain. In South Carolina alone the Francis Marion National Forest aims to treat annually 40,000 to 50,000 acres, primarily in the Loblolly Pine type; private interests in the state burn at least 30,000 acres per year, mostly on industrial forests.

Cost values are more elusive than acreage figures. The cost of burning may differ in relation to size of area, burning method, fuel type, or prevailing weather—to name a few variables. In 1958 the average cost on the Francis Marion National Forest is about forty-five cents per acre. There careful planning, the burning of large blocks, and long experience help to keep the costs down. Elsewhere, and on smaller areas, costs could easily reach $1.00 per acre.

Basic equipment for burning consists of a conventional back-firing torch and a tractor-plow unit. Fire-line plowing may be done in advance of, or during the scheduled burning, as determined by a previously prepared plan. This prescribed burning "block plan" is based on a reconnaissance of an area to determine: (1) month to burn; (2) desirable weather conditions for burning, including days since one-half inch of rain, wind direction, and velocity; (3) type of fire to use (back, head, strip, or flank); (4) specific location of plow lines; (5) sequence in which to fire various lines; and (6) whether to plow lines in advance or at time of burn.

In young stands, especially for initial burns, the usual technique requires a light backfire burning into a gentle but steady wind on cool days. The soil should be moist and the surface fuels only partially dried out whenever any of this burning is done. As the stand ages and becomes more open from thinnings, the need for understory brush control becomes more important. As the bark thickens with age and crowns reach higher into the air, susceptibility to fire damage decreases. Consequently, headfires are commonly used in pole-size and larger

Fig. 6. The cost of prescribed burning is low because it can be done with small crews using simple hand tools and low-cost plowed fire lines.

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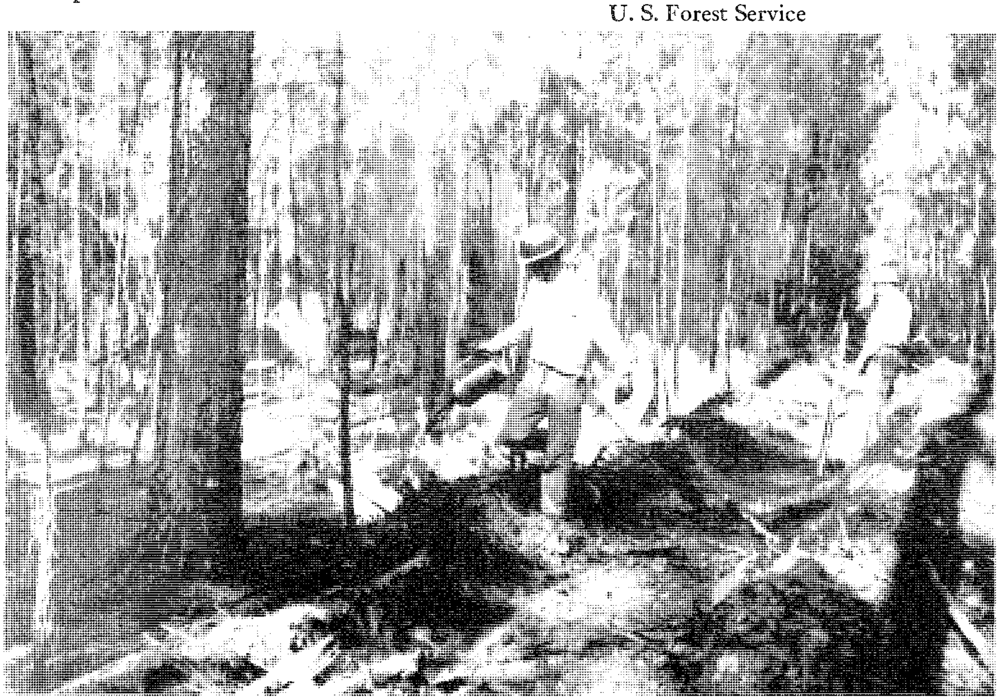

stands, especially when set to burn in narrow strips. To speed up burning in areas too risky for headfires, a flanking fire angling into the wind is often used. Decision as to specific method of burning may have to be made just prior to setting a fire. After the fire, the absence of any large amount of crown scorch is firsthand evidence that a proper decision was made.

Up to now most prescribed burning has been done during the dormant or winter season. Activity reaches a peak during December, January, and February. In November the herbaceous vegetation may not be cured sufficiently for a general burning program. In March high winds and an approaching growing season limit burning efforts. Summer burning is usually done during the four-month period May 15 to about August 15.

In the Santee Experimental Forest plot studies, favorable weather for burning include air temperatures of 60° F. or above in winter and 90° F. or above in summer, relative humidities under fifty per cent in both seasons, and winds steady as to direction, but generally within a range of one to seven miles per hour at about breast height in the stand. Such winds maintained sufficient draft to ignite fresh fuel, carried water vapor and heat at an oblique angle through the pine crowns (minimizing danger of crown scorch), and gave assurance that a fire moved in a direction and rate as planned. Fuel moisture, determined from basswood sticks, never exceeded ten per cent at the time of burning, and generally was around five to eight per cent.

Prescribed burning can yield some direct monetary benefits and thus help pay its way. This was determined by a comparison of extraction costs from two adjacent fifty-acre areas in the same Loblolly Pine stand. On an area that was relatively brush free after four prescribed burns, the logging costs for an intermediate cutting operation were reduced by $2.29 per thousand board feet of saw logs and $1.50 per cord of pulpwood, as compared to costs on the unburned and brushy area. This is the equivalent of $3.95 per acre of decreased logging cost in the burned area, based on a cut of 1,300 board feet and 0.6 cords per acre—enough to pay for eight burns instead of the four that were made.

To sum up this presentation it can be said that fire has a definite place in the silviculture of coastal plain Loblolly Pine. Even so, fire should be considered a tool to be prescribed when and where needed. At the discretion of the forest manager, fire can be used in immature stands of Loblolly Pine at least for the control of understory hardwoods and for seedbed preparation. The season and frequency of burning depend on the degree of effectiveness desired. In any event, the fires can be prescribed without fear of damage to the stand or site. Provided the burns do not get away and turn into wildfires, benefits far exceed any damage we have been able to measure.

The use of prescribed fire in the silviculture of Loblolly Pine is not a new notion. H. H. Chapman, writing in 1942, strongly supported its use in Loblolly Pine stands west of the Mississippi River. Chapman's work was given early recognition in 1949 by L. E. Chaiken in relation to the problem of controlling inferior species in Loblolly Pine stands of the Carolina coastal plain.

More than a decade of study on the Santee and Westvaco Experimental Forests has determined that, for understory hardwood control, the best results with prescribed fire are obtained in Loblolly Pine stands where the ground is covered with a continuous mantle of fuel consisting mainly of fallen pine needles and similar fine material. Furthermore, most of the understory stems should be under two inches d.b.h., as many larger stems can escape control by fire. Depending on the degree of control desired, a forest manager can use either winter or summer fires. The winter fires won't kill many of the hardwoods, as most resprout regardless of the frequency of burning. However, from a practical standpoint, winter burns can be spaced about five to ten years apart and the understory thus held to small-size stems subject to further control by fire as needed. The best use of a short series of summer fires is for hardwood eradication and seedbed preparation about the time of the harvest cut.

Experienced personnel can prescribe burn small tracts for less than fifty cents per acre. Consequently, a full schedule of winter and summer fires for hardwood control and seedbed preparation would cost about $5.00 per acre over a sawtimber rotation.

Furthermore, there is little to fear regarding possible damage from well planned and executed prescribed fires in coastal plain Loblolly Pine stands above sapling size. Damage to the pine stand from an intense summer burn is avoided by fuel reduction obtained from prior winter burns. Intensive plot studies show that prescribed burning causes no significant difference in the radial growth of dominant pine in any season, even after ten consecutive annual fires. As a matter of fact, the evidence is that radial growth is more sensitive to amount of soil moisture available in the early growing season than it is to any program of prescribed burning.

Of great significance is the fact that prescribed burning does no damage to the typical sandy loams of the coastal plain Loblolly Pine sites. No ill effects to the soil were measured over ten years of plot studies which included annual winter and summer fires (ten each) and periodic winter and summer fires (two each), as compared to no fires during the period.

It becomes apparent, then, that the benefits from prescribed burning overwhelmingly favor its use in the silviculture of coastal plain Loblolly Pine.