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# Eradicating Understory Hardwoods By Repeated Prescribed Burning

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*In a loblolly-shortleaf pine stand containing abundant litter, one winter fire killed 94 percent of the stems of understory hardwoods up to 3.5 inches in diameter at the base. Prolific sprouting ensued. Eleven annual summer burns eliminated sprouting on 85 percent of the rootstocks, and seven biennial summer burns eliminated sprouting on 59 percent of them.*

Some form of hardwood control is necessary for the management of loblolly (*Pinus taeda* L.) and shortleaf (*P. echinata* Mill.) pines on most sites in the South. Since plant succession in these stands is toward a hardwood climax, the hardwoods will dominate unless they are kept in check. Furthermore, the rate of succession in this direction is apparently faster on good than on poor sites (*8*). The hardwoods first appear in pine stands as dense understories that hamper establishment of reproduction and may reduce growth of the overstory (*4*).

Of the various methods of killing the aboveground portions of hardwoods, fire is the most economical. However, the rootstocks of many hardwood species in the South sprout prolifically, making permanent control difficult. To completely eradicate hardwoods, the rootstocks must be killed or prevented from sprouting. Encouraging results were obtained with repeated fires in the Southeast and Atlantic Coastal Plain in the 1950's. Foresters in the Midsouth wanted to know if repeated fires would be equally effective in their area where conditions are highly favorable to hardwood growth, and resprouting is vigorous and persistent. A 13-year study designed to find the answer is described here.

The project was done cooperatively by the USDA Forest Service and the Crossett Division of Georgia-Pacific Corporation.

## STUDY AREA

The test was made in a mature even-aged loblolly-shortleaf pine stand growing on Grenada and Calloway silt loams in Ashley County, Arkansas. These are imperfectly drained loess soils underlain by a fragipan at a depth of 18 to 24 inches. A 2-percent north-to-south slope provided good surface drainage. At the beginning of the study the overstory contained about 64 square feet of pine basal area per acre in trees averaging 15 inches d.b.h., and 17 square feet of oaks and gums averaging 8 inches d.b.h. The understory was very dense; it contained about 10,000 small hardwood plants per acre, whose tallest stems averaged 1.6 inches in diameter 6 inches above ground. Southern red oak (*Quercus falcata* Michx.), sweetgum (*Liquidambar styraciflua* L.), and blackgum (*Nyssa sylvatica* Marsh.) were predominant. Elm (*Ulmus americana* L.), sumac (*Rhus* spp.), ash (*Fraxinus* spp.), dogwood (*Cornus florida* L.), hickory (*Carya* spp.), red maple (*Acer rubrum* L.), American holly (*Ilex opaca* Ait.), and hawthorn (*Crataegus* spp.) were present in lesser numbers.

## METHODS

The burning treatments chosen for study were those that had proven most successful in other areas. Most earlier investigators concluded that repeated summer fires provide greater and longer-lasting sprout control than repeated winter burns (*1, 2, 3, 5*). However, a heavy accumulation of ground fuel makes initial summer burns in pine stands hazardous. Thus, it was decided to have a winter fire initially to minimize the risk, and summer fires thereafter.

Ferguson's experiences in a pine-hardwood stand in Texas indicated that headfires kill more of the original hardwood stems than backfires (*3*). Headfires were therefore used in the present study.

Two treatments were tested. The first burn in each was made in the winter of 1954-55. In one treatment the plots were burned again in the summer of 1956 and each summer thereafter, except in 1958 when burning conditions were unfavorable. In the second treatment a burn was made in the summer of 1957 and every second summer thereafter. The two treatments were replicated four times in a randomized block design.

Study plots were too small, 0.1 acre, to confine the fires to individual plots. To measure the effect with momentum well established, fires were set well outside the plot boundaries and permitted to burn into the plots. The eight study plots were located inside a 15-acre area. In the initial burn, the entire area was fired. This procedure was followed whenever the schedule required the annual and biennial plots to be burned on the same date. When the annual plots alone were to be fired, the biennial plots were isolated by a fireline.

Litter samples for each plot were obtained prior to each burn to determine the pounds per acre, ovendry weight, of ground fuel. After the initial burn the fuel supplies represented 1 and 2 years' accumulation for the annual and biennial burns. Final burns for both treatments were made in 1967. Thus, 12 annual and seven biennial burns were made.

Fire severity was visually classed as:

**Light.** Fire sluggish and discontinuous, leaving unburned patches. Surface litter consumed but lower layers largely intact. Leaves of hardwood understory scorched, and base of stems lightly charred.

**Medium.** Momentum of fire well sustained; clean, even burn of litter over the entire area. Some green hardwood leaves consumed and the remainder completely scorched. Decided charring of hardwood stems.

**Intense.** Clean, hot burn over the entire area. Litter, including lowest layer, completely consumed. The leaves and the stem and branch ends of most small hardwoods ignited. Small hardwood stems deeply charred or destroyed.

All burns were made with the wind. For safety, fire was set on the flanks slightly in advance of the head. When possible, the summer burns were made on days when the relative humidity was 45 percent or less and a steady wind of 2 to 5 miles per hour was blowing. Ambient temperatures during the summer burns usually were between 85 and 100° F. Relative humidity in excess of 45 percent or little air movement resulted in inefficient, discontinuous burns, especially where ground fuel was light.

On each plot, 60 sample hardwood plants were pinned, tagged, and numbered for repeated examination throughout the study. The identity of each plant was maintained in all inventories. Three species groups were recognized: oak, gum (sweetgum and blackgum), and others (elm, maple, hickory, dogwood, sumac, persimmon, hawthorn, holly, and ash). Stems were placed in one of four diameter classes: 0.5 inch or less, 0.6 to 1.5, 1.6 to 2.5, and 2.6 to 3.5 inches. All diameters were measured 6 inches above ground. If the plant consisted of several stems, only the tallest one was measured. On each study plot, five hardwood plants in each of the 12 species-diameter categories were represented. Plants were examined prior to each burn to determine number and condition of the original stems, number of sprouts, and diameter of the individual stem or the dominant sprout in a clump. Final examinations were made in 1968, 1 year after the last burn.

## RESULTS

Prior to the first burn the dense hardwood understory had contributed materially to the 11,332 pounds of litter per acre which had accumulated on the plots. After a few burns the contributions from this source was negligible, particularly on the annually burned plots. Needle litter became the principal fuel. After the sharp reductions resulting from the 1955, 1956, and

1957 burns, the fuel mass tended to stabilize at about 4,600 pounds per acre. Because of their 2-year accumulation period, the biennial plots generally had a greater fuel supply per burn than the plots burned annually. Table 1 shows the severity of individual burns and the amount of fuel available for each.

Table 1.—*Burning record*

| Year | Litter | | Temperature | Relative humidity | Wind | Fuel moisture | Fire intensity | |
|---|---|---|---|---|---|---|---|---|
| | Annually burned plots | Biennially burned plots | | | | | Annually burned plots | Biennially burned plots |
| | *Lbs. per acre*[1] | | *°F.* | *Percent* | *M.p.h.* | *Percent* | | |
| 1955 | 11,450 | 11,240 | 78 | 60 | 8-15 | 7 | Medium | Medium |
| 1956 | 7,320 | . . . | 96 | 58 | 1-2 | 7 | Light | . . . |
| 1957 | 5,760 | 8,160 | 96 | 34 | 3 | 6 | Severe | Severe |
| 1958 | (2) | | | | | | | |
| 1959 | 4,850 | 3,550 | 86 | 52 | 1-2 | 6 | Light | Light |
| 1960 | 4,750 | . . . | 85 | 50 | 3 | 6 | Very light | . . . |
| 1961 | 4,830 | 4,780 | 75 | 20 | 1-2 | 5 | Light | Medium |
| 1962 | 4,600 | . . . | 96 | 45 | 2 | 5 | Medium | . . . |
| 1963 | 4,590 | 6,170 | 87 | 40 | 7 | 7 | Severe | Severe |
| 1964 | 3,600 | . . . | 94 | 48 | 4 | 9 | Medium | . . . |
| 1965 | 4,240 | 5,240 | 98 | 40 | 2 | 10 | Medium | Medium |
| 1966 | 3,860 | . . . | 94 | 40 | 3-5 | 9 | Severe | . . . |
| 1967 | 4,040 | 4,880 | 92 | 45 | 3 | 15 | Medium | Medium |

[1]Ovendry weight.
[2]No burn made.

An abundance of fuel and favorable weather generated a very effective initial burn. The fire killed the original stems on 91.6 percent of the hardwood plants on the annually burned plots and 96.7 percent on the biennially burned plots. In the final inventory in 1968 only 1.2 percent of the original stems on annually burned plots and 1.7 percent on biennially burned plots still survived. These few were invariably the largest stems.

Although mortality of original stems was similar for the two treatments, sprouting differed significantly[1] by burning interval (fig. 1). In 1968, 85.0 percent of the plants that had been top-killed on annually burned plots were free of sprouts. On biennially burned plots, 59.2 percent of such plants were not sprouting. These plants were presumed to be dead.

If a given degree of hardwood control is desired in the shortest possible time, the results show that annual burns are superior. To determine whether the greater fuel accumulations for the individual biennial burns made them more effective than individual annual burns, results of the first seven annual fires were com-

[1]Only the 5-percent level of significance is reported in this paper.

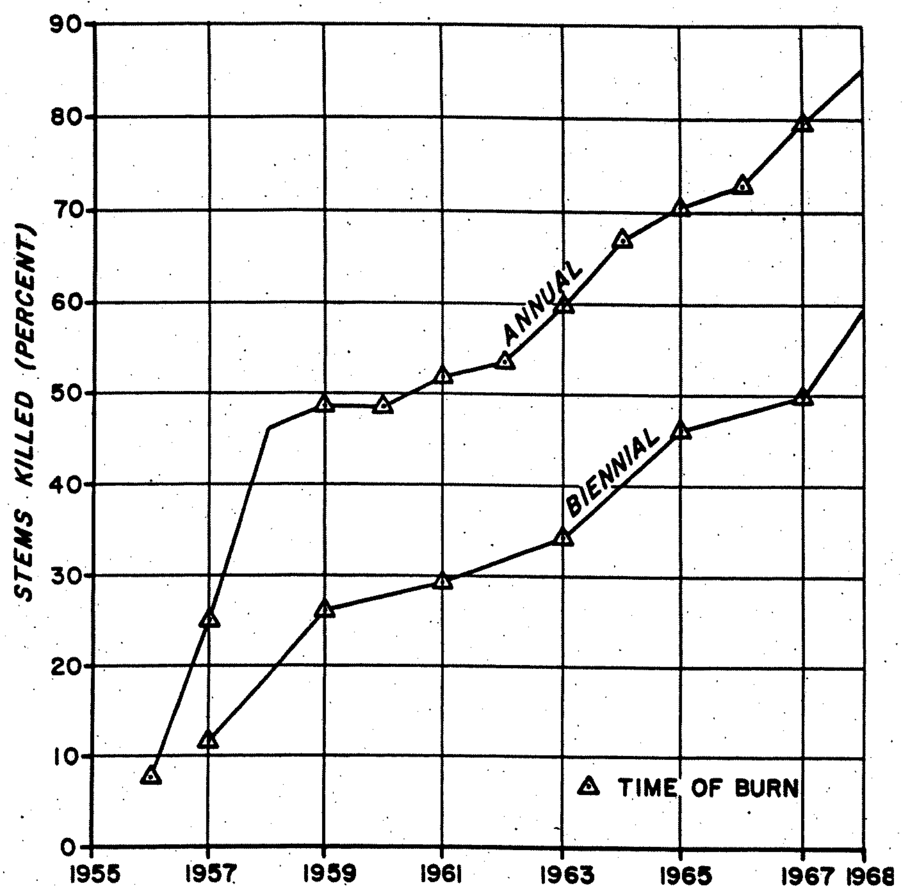


Figure 1.—*Percent of original stems of all species killed by annual and biennial burns and not sprouting. Inventories were taken prior to each burn.*

pared with those of the seven biennial fires. In five of the seven cases, fires spaced 1 and 2 years apart were equally effective in controlling sprouting. The total control after seven burns was almost identical—59.6 percent killed and not sprouting for annual burns versus 59.2 percent for biennial burns.

Regardless of plant size, sprouting occurred on almost all of the original plants whose tops were consumed by the first burn (table 2). The number of plants sprouting diminished with succeeding burns. On annually burned plots, small plants may have had a slightly greater tendency to resprout than large plants, but this trait was neither pronounced nor consistent. After 12 burns, sprouting of stems 1.6 to 2.5 inches in diameter was significantly less than that of smaller stems, but it was also less than that of larger stems. On the biennially burned plots, there were no significant differences in resprouting capacity due to original stem

Table 2.—*Fire effects on hardwoods in relation to stem size*

| Number of burns | Original diameter class[1] 0.0-0.5 inch: Top-killed | 0.0-0.5 inch: Killed[2] and not sprouting | 0.6-1.5 inches: Top-killed | 0.6-1.5 inches: Killed[2] and not sprouting | 1.6-2.5 inches: Top-killed | 1.6-2.5 inches: Killed[2] and not sprouting | 2.6-3.5 inches: Top-killed | 2.6-3.5 inches: Killed[2] and not sprouting |
|---|---|---|---|---|---|---|---|---|
| | Percent | | | | | | | |
| | ANNUAL BURNS | | | | | | | |
| 1 | 100.0 | 8.3 | 100.0 | 5.0 | 95.0 | 6.7 | 70.0 | 8.3 |
| 2 | 100.0 | 26.7 | 100.0 | 13.3 | 96.7 | 25.0 | 78.3 | 30.0 |
| 3 | 100.0 | 41.7 | 100.0 | 31.7 | 98.3 | 51.7 | 90.0 | 58.3 |
| [3]3 | 100.0 | 41.7 | 100.0 | 35.0 | 98.3 | 58.3 | 93.3 | 58.3 |
| 4 | 100.0 | 35.0 | 100.0 | 36.7 | 100.0 | 61.7 | 93.3 | 60.0 |
| 5 | 100.0 | 38.3 | 100.0 | 40.0 | 100.0 | 65.0 | 95.0 | 63.3 |
| 6 | 100.0 | 41.7 | 100.0 | 41.7 | 100.0 | 65.0 | 95.0 | 66.7 |
| 7 | 100.0 | 50.0 | 100.0 | 48.3 | 100.0 | 70.0 | 95.0 | 70.0 |
| 8 | 100.0 | 58.3 | 100.0 | 53.3 | 100.0 | 80.0 | 95.0 | 75.0 |
| 9 | 100.0 | 63.3 | 100.0 | 60.0 | 100.0 | 81.7 | 95.0 | 76.7 |
| 10 | 100.0 | 61.7 | 100.0 | 66.7 | 100.0 | 88.3 | 95.0 | 78.3 |
| 11 | 100.0 | 68.3 | 100.0 | 73.3 | 100.0 | 93.3 | 95.0 | 81.7 |
| 12 | 100.0 | 76.6 | 100.0 | 86.7 | 100.0 | 95.0 | 95.0 | 81.7 |
| | BIENNIAL BURNS | | | | | | | |
| 1 | 100.0 | 15.0 | 100.0 | 3.3 | 96.7 | 10.0 | 90.0 | 16.7 |
| 2 | 100.0 | 30.0 | 100.0 | 21.7 | 98.3 | 20.0 | 91.7 | 35.0 |
| 3 | 100.0 | 31.7 | 100.0 | 25.0 | 98.3 | 20.0 | 93.3 | 40.0 |
| 4 | 100.0 | 30.0 | 100.0 | 33.3 | 98.3 | 31.7 | 93.3 | 46.7 |
| 5 | 100.0 | 45.0 | 100.0 | 45.0 | 98.3 | 41.7 | 93.3 | 51.7 |
| 6 | 100.0 | 45.0 | 100.0 | 51.7 | 98.3 | 41.7 | 95.0 | 60.0 |
| 7 | 100.0 | 61.7 | 100.0 | 61.7 | 98.3 | 51.7 | 95.0 | 61.7 |

[1]Diameter of dominant stems measured 6 inches from ground.
[2]Expressed as a percentage of top-killed trees.
[3]No burn made in 1958 but hardwood was inventoried.

diameter. Inasmuch as all the hardwoods involved in this study were 3.5 inches at the base or less, the similarity in sprouting response among size classes is not surprising.

Annual burns were equally effective on all three species groups. Biennial burns controlled sprouting of oaks significantly better than that of gums and other species. By the end of the study, the seven biennial burns had resulted in just about the same degree of sprout control on oaks as did the 12 annual burns (table 3). However, the annual burns were far more effective than the biennial burns in preventing sprouting of gums and other species.

Prior to the first burn there were 344 stems on the 240 sample plants on the annually burned plots (fig. 2). One year later the number had increased to 1,383. After this a continuous decline ensued; 147 stems were present in 1968. Similar but slower trends were observed on the biennially burned plots. Here the original

Table 3.—*Fire effects on small hardwoods, by species groups*

| Number of burns | Oak: Top-killed | Oak: Killed[1] and not sprouting | Gum: Top-killed | Gum: Killed[1] and not sprouting | Others: Top-killed | Others: Killed[1] and not sprouting |
|---|---|---|---|---|---|---|
| | Percent | | | | | |
| | | | ANNUAL BURNS | | | |
| 1 | 91.2 | 6.2 | 97.5 | 10.0 | 85.0 | 6.2 |
| 2 | 92.6 | 21.2 | 98.8 | 25.0 | 90.8 | 27.5 |
| 3 | 97.5 | 43.8 | 100.0 | 46.2 | 93.8 | 47.5 |
| [2]3 | 98.8 | 43.8 | 100.0 | 47.5 | 95.0 | 53.8 |
| 4 | 98.8 | 45.0 | 100.0 | 48.8 | 96.3 | 51.2 |
| 5 | 98.8 | 48.8 | 100.0 | 52.5 | 97.6 | 53.8 |
| 6 | 98.8 | 53.8 | 100.0 | 50.0 | 97.6 | 52.5 |
| 7 | 98.8 | 55.0 | 100.0 | 63.8 | 97.6 | 61.2 |
| 8 | 98.8 | 60.0 | 100.0 | 76.2 | 97.6 | 65.0 |
| 9 | 98.8 | 62.5 | 100.0 | 77.5 | 97.6 | 73.8 |
| 10 | 98.8 | 63.8 | 100.0 | 81.2 | 97.6 | 72.5 |
| 11 | 98.8 | 71.2 | 100.0 | 88.8 | 97.6 | 82.5 |
| 12 | 98.8 | 75.0 | 100.0 | 95.0 | 97.6 | 85.0 |
| | | | BIENNIAL BURNS | | | |
| 1 | 95.0 | 6.2 | 100.0 | 13.8 | 95.0 | 15.0 |
| 2 | 95.0 | 22.5 | 100.0 | 26.2 | 97.5 | 31.2 |
| 3 | 95.0 | 32.5 | 100.0 | 27.5 | 98.8 | 27.5 |
| 4 | 95.0 | 43.8 | 100.0 | 27.5 | 98.8 | 35.0 |
| 5 | 95.0 | 62.5 | 100.0 | 37.5 | 98.8 | 40.0 |
| 6 | 96.2 | 65.0 | 100.0 | 41.2 | 98.8 | 42.5 |
| 7 | 96.2 | 72.5 | 100.0 | 56.2 | 98.8 | 48.8 |

[1]Expressed as a percentage of top-killed trees only.
[2]No burn made in 1958 but hardwood was inventoried.

335 stems increased to 960 in the 2 years after the first burn, although the sprouting 1 year after the burn was probably similar to that on the annually burned plots. By 1968 sprout numbers had declined to 660.

Distribution of sprouts among sample plants within plots was not uniform. Often an individual plant within a species group proved to be an unusually prolific sprouter. On the average annually burned plot, one oak plant accounted for 33 percent of the oak sprouts found at the end of the study. Likewise, one gum accounted for 56 percent of the gum sprouts and one plant accounted for 62 percent of the sprouts of other species on the average plot. A similar situation prevailed on the biennialy burned plots.

Stem numbers increased sharply as a result of burning, but the average diameter of the bases of dominant stems dropped steadily with each burn from a high of 1.6 inches to a low of 0.1 inch (fig. 2). Proportionately, the biggest diameter decrease followed

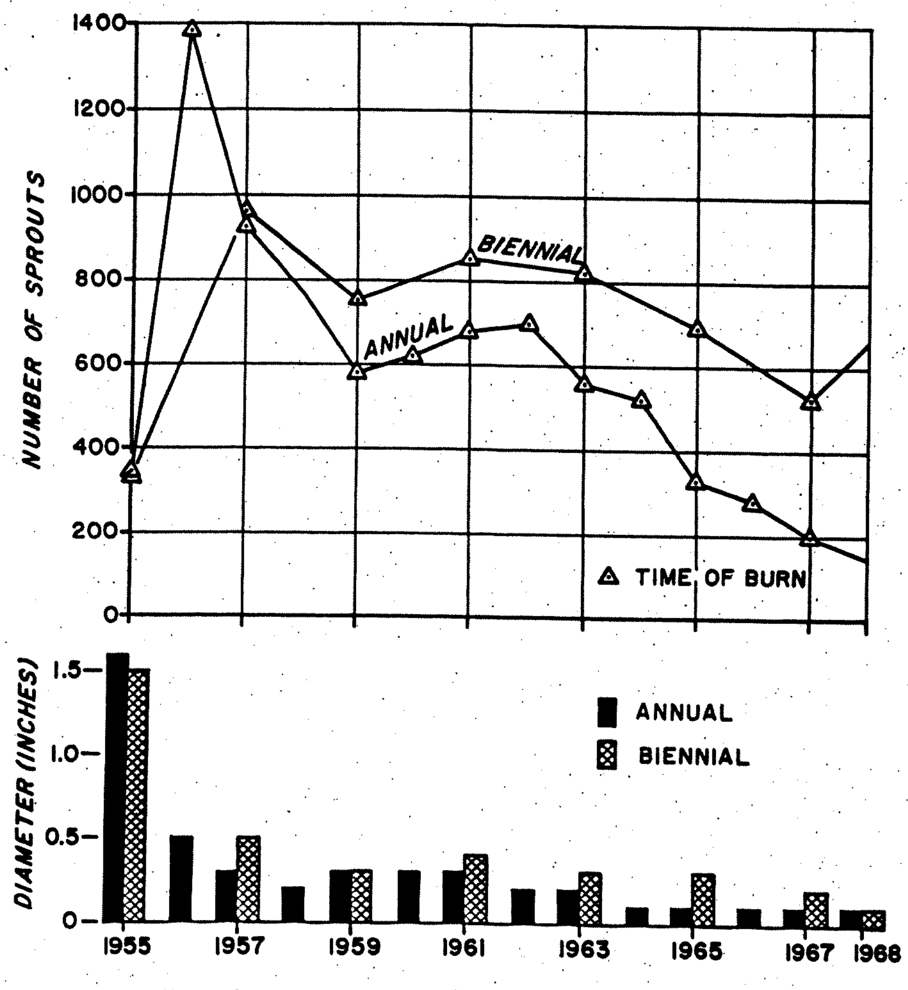


**Figure 2.**—*Effects of annual and biennial burns on sprouting (above) and diameter of dominant stems (below) on 240 sample plants. Diameters were measured 6 inches above ground and inventories were taken prior to each burn.*

the first fire. A reduction in average diameter to 0.1 inch was achieved in 8 years with annual burns and 13 years with biennial burns. However, the number of fires required was about the same—eight annual and seven biennial burns. Because of the drastic decrease in stem size, a spectacular reduction in vegetative cover took place, particularly on the annually burned plots (fig. 3).

## CONCLUSIONS

The results presented here and those of other studies show that when ample fuel is available a winter burn will destroy the

Figure 3.—*The understory after nine annual burns.*

aboveground portion of almost all hardwoods up to 3.5 inches in diameter at the base. Repeated summer burns at 1- or 2-year intervals can reduce sprouting to any desired degree, even under conditions highly conducive to sprouting. For practical purposes, equal numbers of annual or biennial burns will afford the same levels of sprout control, but annual burns achieve the results faster.

Despite fire's proven ability to control hardwoods, many land managers are reluctant to burn. Some fear that repeated prescribed burning will be expensive. Others fear deterioration of soil quality, damage to the overstory, and loss in growth. If the work is done properly, these fears are unjustified. In loblolly pine stands on the Virginia Coastal Plain, Trousdell and Langdon made an initial winter burn and three consecutive summer burns for about one-fourth the cost of disking (7). In the vicinity of the present study, industry has made initial burns at a cost of 50 cents per acre and subsequent burns for 40 cents per burn per acre. The danger to soil or stand is minimal if fires are correctly made

One winter and eight annual summer burns had little effect on the nutrient content and structure of the surface 4 inches of loess soil on flat forested terrain in southern Arkansas (*6*). On the basis of their own experience and a comprehensive review of the literature, Wenger and Trousdell concluded that neither winter nor summer prescribed burns adversely affect the growth of loblolly pine overstories (*9*). The 13-year test reported here supports their conclusion, for there were no losses in the pine overstory that could be attributed to fire.

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