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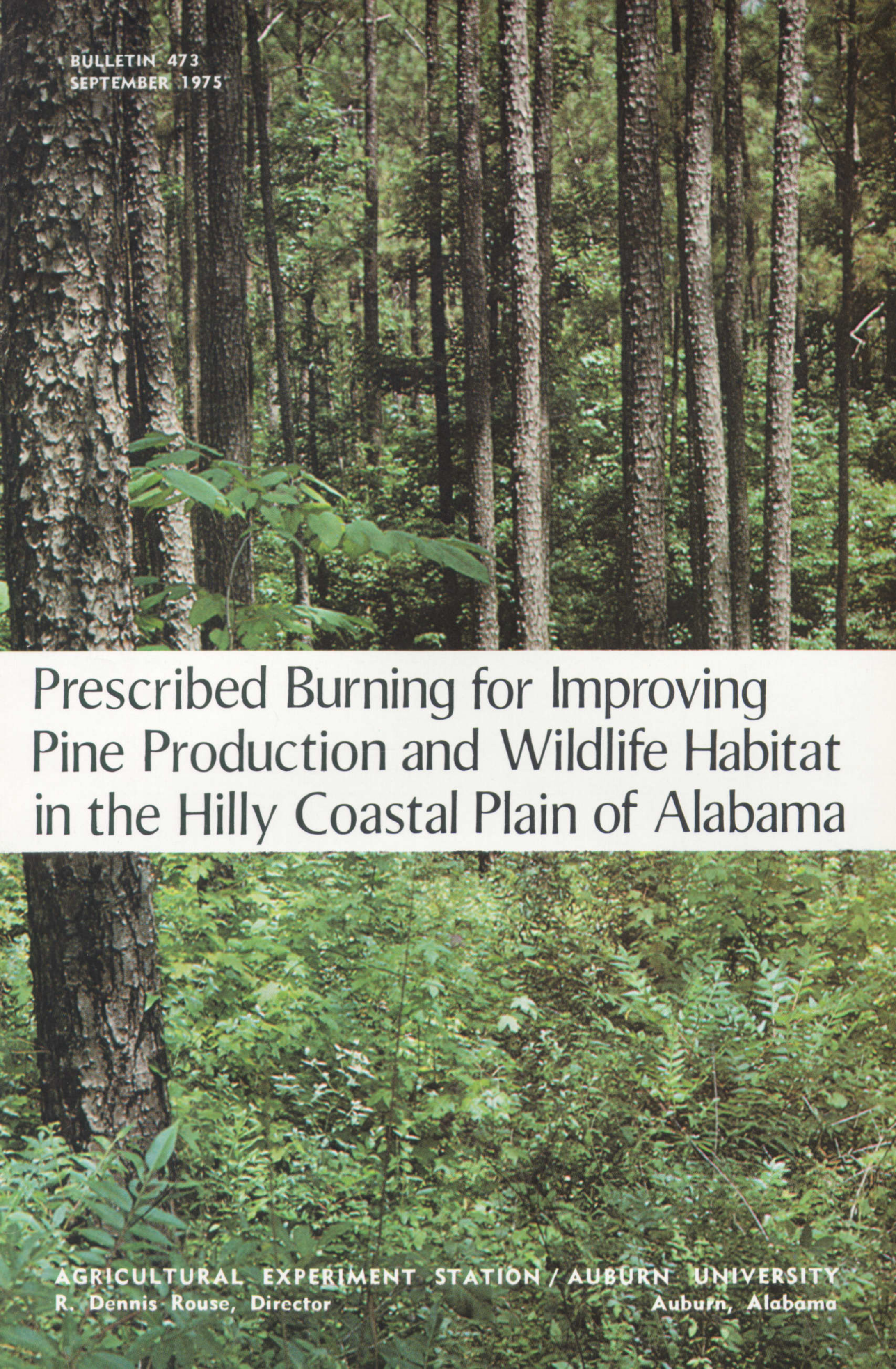

Prescribed Burning for Improving Pine Production and Wildlife Habitat in the Hilly Coastal Plain of Alabama

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THE LOBLOLLY (*Pinus taeda* L.) and shortleaf (*P. echinata* Mill.) pine forests of the southeastern Coastal Plain progress naturally in time toward a composition of mixed hardwood species *(17)*. The invading species must be controlled by the forest manager if he desires to grow continuous crops of pine. Further, invading understories of hardwoods in young pine stands, if left undisturbed, will normally contribute in time to the "wildlife barren" habitat so often characterizing such stands. They become too tall for effective deer browse, and at the same time their competition retards the development of other wildlife plant species in the understory *(2,15)*.

This study deals with the experimental use of fire for controlling invading hardwoods in the understory of the young pine forest. The results are measured in terms of specific hardwood suppression and in terms of changes in wildlife food and cover.

PREVIOUS WORK

Previous studies in loblolly-shortleaf pine forests seem to have been oriented toward either pine or wildlife production but never toward both goals simultaneously. That is to say, the studies have reported either on the success of prescribed fire in control-

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ling the hardwoods *or* on the results of prescribed fire in terms of changes that were important to specific wildlife species.

Studies reporting on the success of prescribed fire in controlling unwanted hardwoods have been done in South Carolina, Georgia, Texas, Arkansas, and Alabama. In the Coastal Plain flatwoods of South Carolina *(16)*, five successive summer fires, applied either annually or biennially, killed 80 percent or more of the rootstocks of small sweetgums (*Liquidambar styraciflua* L.) and bayberries (*Myrica cerifera* L.), and about 50 percent of blackgums (*Nyssa sylvatica* Marsh.) and oaks (*Quercus* sp.). Winter fires did not kill appreciable numbers of rootstocks, but they did top-kill (complete kill of the above-ground portion of the tree) most hardwoods 2 inches and less in d.b.h. (diameter breast high). On hilly terrain of the Georgia Piedmont *(3)*, single summer burns top-killed most 1 and 2-inch hardwoods; single winter burns top-killed most 1-inch hardwoods. Single repeat burns caused little additional top-killing. Strip headfiring[2] was the most efficient technique, and resultant soil erosion was negligible. Similar results were obtained from single summer and winter burns applied in the Hilly Coastal Plain in Fayette County, Alabama *(13)*: summer-burning top-killed 62, 52, and 38 percent respectively of 1, 2, and 3-inch hardwoods; winter-burning top-killed 46, 5, and 0 percent respectively.

In the Coastal Plain flatwoods of Texas *(18)*, single fall, winter, or spring burns top-killed 21 percent of 1 to 5-inch hardwoods in young pine stands of pulpwood size and 11 percent in cut-over older pine stands of sawtimber size. Repeat burns after either 2 or 3 years brought these percentages to 40 and 31 respectively. In clay soils of the upper Coastal Plain of Texas *(11)*, single summer burns in well-stocked young pine stands top-killed 75 percent of understory sweetgums and 55 percent of the oaks. Rootstock kills were 21 and 9 percent respectively. For single winter burns, all percentages were much lower (top-kill: 41 and 19 respectively; rootstock kill: 11 and 1 respectively). In a well-stocked pine stand with abundant litter on a loess terrace in southeastern Arkansas *(12)*, one winter burn top-killed 94 percent of understory hardwoods up to 3.5 inches in diameter at the

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[2] Setting headfires to burn across successive narrow strips. Each strip burns into the rear of a previously fired strip. For detailed instructions of all burning techniques see "A Guide to Fire by Prescription" (10), available free from USDA Forest Service, Southern Region, Atlanta, Georgia.

base. Eleven subsequent annual summer burns eliminated sprouting on 85 percent of the rootstocks, and seven subsequent biennial summer burns eliminated sprouting on 59 percent. In a well-stocked shortleaf pine stand in the Ouachita Mountains of Arkansas *(21)*, three summer burns reduced the number of understory hardwoods under 5.5 inches by 83 percent.

The principles and techniques of burning in pine stands to improve wildlife habitat are fairly well established for bobwhite quail (*Colinus virginianus* L.), white tailed deer (*Odocoileus virginianus*), and wild turkey (*Meleagris gallopavo*) *(5)*. In the Piedmont of Alabama *(19)*, annual winter burning increased coverage of quail food plants about 1,400 percent. Both summer and winter burning increased the coverage of quail food plants on the Coastal Plain in Fayette County, Alabama *(13)*. In central Louisiana *(1)*, food conditions in a loblolly pine plantation were improved for white tailed deer through burning at 4 to 5-year intervals. Browse plants were kept within reach of deer, the more palatable plant species were increased at the expense of less palatable ones, and the nutritional quality of the deer browse was improved. For wild turkey management in Southeastern pine forests, winter-burning at 3 to 5-year intervals was advocated from the sapling stage through the mature sawtimber stage to encourage grass and forb production and to maintain high accessibility for turkeys *(5)*. Certain developing fruit-bearing shrubs and trees had to be protected from the burning, however, as an essential corollary measure.

As a group, these past studies have shown certain deficiencies. None tested prescribed burning as a tool for improving wood and wildlife production simultaneously. Further, more thorough and complete studies were applied only in well-stocked pine stands on relatively flat terrain. In the present study, burning was applied in open to dense pine stands on hilly terrain, and results were measured in terms useful to both wood and wildlife production.

STUDY AREA AND PROCEDURE

The study was established in 1960 in the main forest of the Auburn University Agricultural Experiment Station System's Lower Coastal Plain Substation at Camden, Alabama. The climate at Camden is characterized as hot and humid, with 237 frost-free days per year and 57 inches annual rainfall. Its phy-

FIG. 1. View of untreated check plot at the end of the treatment period. Hardwood understory has become a dense midstory.

FIG. 2. A strip headfire being set

FIG. 3. Strip headfire burning up-slope in winter in a two-year rough.

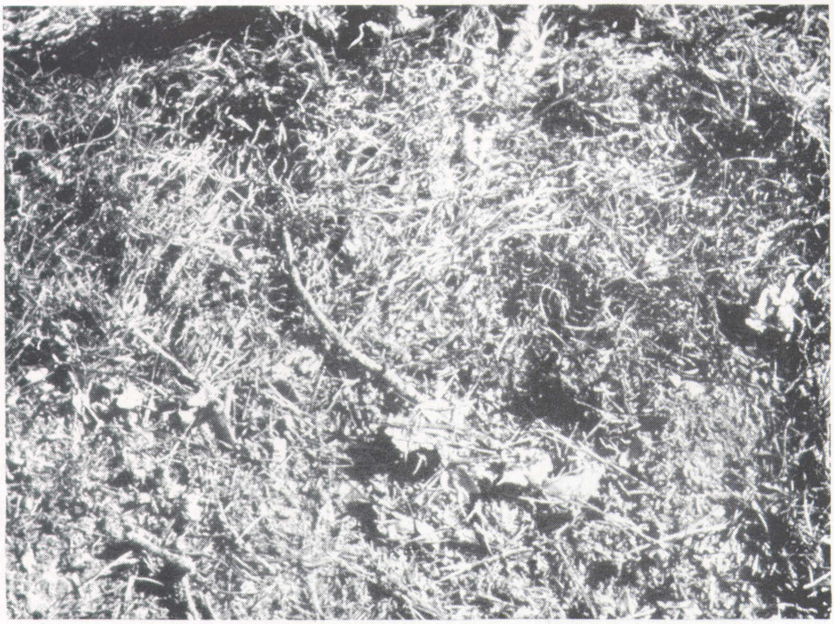

FIG. 4. View of residual moist duff after winter-burning.

siographic location is the Loam Hills Region of the Hilly Coastal Plain Province *(14)*. Slopes vary from 5 to 35 percent, and the soil types are Ruston and Susquehanna sandy loams, about evenly divided.

When the experiment was started in 1961, the pine forest (predominantly loblolly pine) was of old-field origin and about 40 years old. The trees were small for this age, however, because the forest had been logged to an 8-inch diameter limit about 20 years previously. Density of the pines was light to heavy, varying in basal area from 25 to 165 square feet per acre. Invading understory hardwoods were fairly dense, Figure 1, and were mostly under 3 inches d.b.h. Sweetgum, oaks, winged elm (*Ulmus alata* Michx.) and hickories (*Carya* sp.) were the most important species. Others were principally blackgum, flowering dogwood (*Cornus florida* L.), red maple (*Acer rubrum* L.), southern waxmyrtle, plum (*Prunus* sp.), hawthorn (*Crataegus* sp.), and tree sparkleberry (*Vaccinium arboreum* Marsh.). Important woody vines were greenbriers (*Smilax* sp.), Japanese honeysuckle (*Lonicera japonica* Thunb.), grape (*Vitis* sp.), yellow jessamine (*Gelsemium sempervirens* (L.) Ait. f.), Virginia creeper (*Parthenocissus quinquefolia* L.), and briars (*Rubus* sp.). Principal grasses were bluestems (*Andropogon* sp.) and panic grasses (*Panicum* sp.), and forbs were mainly composites and legumes. The fuel accumulation, mainly pine needles, was quite heavy since no known previous fires had occurred in the forest.

Twenty-one 1/5-acre plots were located at random in a 500-acre block of the forest. Three treatments were assigned at random, (1) winter-burning, (2) summer-burning, and (3) check, with seven plots per treatment. Thirty-nine understory hardwoods per plot, from 5 feet tall to 3.5 inches d.b.h., were numbered with wired-on metal tags. These hardwoods were divided approximately even among the following species groups: sweetgum, winged elm, hickories, laurel-water oaks (*Quercus laurifolia* Michx. and *Q. nigra* L.), and red oaks. The principal red oak was southern red oak (*Q. falcata* Michx.).

The burning technique employed for all fires was strip headfiring, figures 2 and 3. This technique is generally faster and cheaper than any other and is highly flexible for different weather and fuel conditions. Burning was always applied when forest litter was dry (4 to 8 percent moisture) but soon enough after a soaking rain that the mineral soil and duff immediately above it were still moist. This ensured that a mulch layer would remain and protect the soil after the fire, Figure 4.

Because of the heavy fuel accumulations, both winter-burn and summer-burn plots were burned for the first time in the winter, during February 1962. Subsequent burns were applied on the winter-burn plots in February 1964, January 1965, February 1968, February 1969, March 1970, and March 1971. Subsequent burns were applied on the summer-burn plots as frequently as adequate fuel accumulated on all plots for repeat burns. Dates were August 1963, August 1965, June 1967, August 1969, and September 1970. Air temperatures during the summer burns were generally well above 85°F.

Tagged understory hardwoods were tallied each summer as to condition. The tallies were made after full leafing, but prior to the summer burning. The condition classes recognized were: 1. Complete top-kill without sprouting. 2. Complete top-kill with sprouting. 3. Defoliated more than 50 but less than 100 percent. 4. Defoliated less than 50 percent.

"Complete kill" or "rootstock-kill" is the same as condition class 1. The term "top-kill," without any reference to sprouting, combines classes 1 and 2. The tallies were expressed as percentages, which for analysis of variance were converted to arcsine equivalents.

Additional data were taken in the late summer of 1971 after the completion of all burnings. One hundred feet of line intercept *(9)* were used in each plot to measure the cover percentage of (1) hardwood canopy more than 6 feet above the ground, (2) hardwood canopy 6 feet or less above the ground, and (3) woody and perennial vines including the briars. Weight of herbage was sampled by clipping all herbage from four randomly located 3.1-foot squares in each plot *(6,7,8)*. Herbage was separated into grasses, legumes, and other forbs, and fresh weights were determined. Dry weights were determined through oven-drying subsamples to a constant weight at 75°C. Litter depths were measured on each plot at four randomly located points.

RESULTS AND DISCUSSION

Effects on Tagged Hardwoods

The initial winter-burning, applied to all burn-treatment plots for the primary purpose of reducing excessive fuel accumulations, caused extensive top-killing of the tagged understory hardwoods, Table 1. Rootstock killing was negligible. Almost all winged elm were top-killed; sweetgum, red oaks, and hickories were relatively resistant. Almost all of the ultimate mortality in the pine overstory resulted from crown scorch during the initial burning. Mortality of the pines, mostly of smaller trees 4 to 7 inches d.b.h., averaged 23 trees, with a basal area of 4.75 square feet per acre. The initial burning was considerably more damaging in the crowns than anticipated, leading to the conclusion that backfiring[3] would have been a more satisfactory technique than strip-headfiring for reducing excessive fuel accumulation on this hilly terrain.

The effects of subsequent winter-burning and summer-burning on the tagged understory hardwoods are portrayed graphically in Figure 5. Both top-killing and complete killing progressed slowly with successive fires. Of course the drastic effect of the initial, fuel-reduction burning left very little additional top-killing to be accomplished, but the possible increase in complete

TABLE 1. EFFECTIVENESS OF INITIAL WINTER BURNING ON TAGGED HARDWOODS IN SUBSEQUENTLY WINTER-BURNED AND SUMMER-BURNED PLOTS

Species	Damage classes[1]				
	1	2	3	4	1+2[2]
			(Percent)		
Winged elm	0	95.3	0	4.7	95.3[a]
Laurel-water oaks	0	85.4	0	14.6	85.4[ab]
Sweetgum	3.7	73.0	1.9	21.6	76.7[b]
Red oaks	1.1	71.9	2.2	24.7	73.0[b]
Hickories	0	65.7	4.5	29.8	65.7[b]
Average all species	1.3	77.1	1.8	19.7	78.4

[1] 1. Complete top-kill without sprouting.
2. Complete top-kill with sprouting.
3. More than 50 percent but less than 100 percent defoliated.
4. Less than 50% defoliated.

[2] Means with different superscripts differ at $P<0.05$.

[3] Allowing fires to "back down" the slopes, or against the prevailing wind direction on level terrain (10).

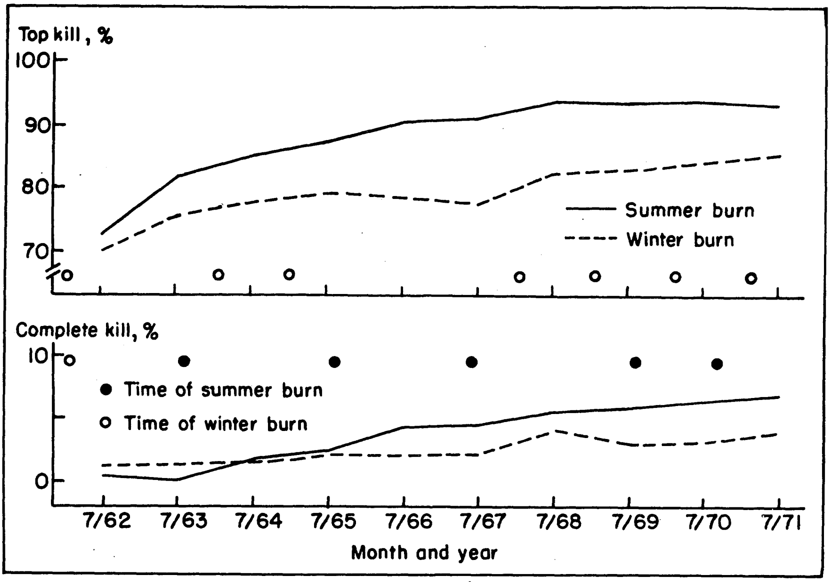

FIG. 5. Cumulative kill of tagged trees in hardwood understories through the treatment period, 1962-71.

killing was over 98 percent. Even the summer-burning, however, resulted in relatively little increase in complete killing, 13.2 percent of the tagged understory trees. This result contrasts rather sharply with the experiences of other workers *(12,16,21)*. None of the differences between summer-burning and winter-burning shown in Figure 5 were statistically significant.

The total effects of all burns, by species, are shown in Table 2 for the winter-burn plots and in Table 3 for the summer-burn plots. Sweetgum was noticeably more susceptible to rootstock-killing, 26.5 percent in the summer-burn plots, than all other species. Red oaks, hickories, and winged elm were resistant to complete killing, and laurel-water oaks were seemingly intermediate. Sweetgum and winged elm were probably the most susceptible species to top-killing, but winged elm was highly persistent in resprouting.

Vegetative Cover Changes

Based on the line-intercept data of 1971, results of the treatments on cover percentages of understory hardwoods and woody vines are summarized in Table 4. Note that both winter-burning and summer-burning greatly and significantly reduced the hardwood canopy more than 6 feet in height (See also figures 6 and 7). Winter-burning resulted in a significant increase in the lower canopy, however, with no significant change in the total hardwood canopy. The net effect of the winter-burning on hardwoods, therefore, seems to have been primarily a reduction in canopy height. Summer-burning, on the other hand, caused a significant decrease in the total hardwood canopy, since there was no gain in the lower canopy to offset the loss in the upper canopy. The net effect of summer-burning was not only to reduce the height of the hardwood canopy but also apparently to significantly reduce the vigor of hardwood re-sprouting.

Although Table 4 shows no significant differences for woody vine cover, differences in individual species of woody vines were noticed. Both types of burning greatly increased the cover of briars (*Rubus* sp.), and appeared to decrease Japanese honeysuckle and poison ivy (*Toxicodendron radicans* (L.) Kuntze).

Final herbage weights, as per summer 1971, are given in Table 5. Winter-burning produced significantly more herbage than summer-burning, which in turn produced significantly more than the check treatment. As can be seen, the differences are of considerable magnitude, and the differences are faithfully reflected in the important legume component, Table 5.

Effects on Depths of Forest Litter

Forest litter depths, measured in the summer of 1971, are given in Table 6. The 0.4 cm. depth for the winter-burning treatment represents primarily litter remaining immediately after the burning, since there was no leaf-fall season between the burning and the measurement. As expected, depths for both burning treatments were significantly less than for the check treatment.

Overall Effects

When the changes effected by the treatment are considered from the standpoint of pine production combined with wildlife habitat improvement, the following results seem to be most important.

TABLE 2. EFFECTIVENESS OF SEVEN WINTER BURNS, 1962-71, ON TAGGED HARDWOODS

Species	Damage classes[1]				
	1[2]	2	3	4	1+ 2[2]
			(Percent)		
Sweetgum	15.6[a]	79.2	1.3	3.9	94.8[a]
Red oaks	9.5[a]	64.3	2.4	23.8	73.8[a]
Winged elm	5.7[ab]	86.8	0	7.5	92.5[a]
Laurel-water oaks	5.4[ab]	83.8	0	10.8	89.2[a]
Hickories	0[b]	68.5	9.3	22.2	68.5[a]
Average all species	7.7	77.7	2.6	12.1	85.4

[1] See Table 1 for damage classes.
[2] Means in the same column with different superscripts differ at $P<0.05$.

TABLE 3. EFFECTIVENESS OF ONE WINTER AND FIVE SUMMER BURNS, 1962-71, ON TAGGED HARDWOODS

Species	Damage classes[1]				
	1[2]	2	3	4	1+2[2]
			(Percent)		
Sweetgum	26.5[a]	69.4	3.1	1.0	95.9[a]
Laurel-water oaks	12.5[ab]	81.3	0	6.3	93.8[a]
Hickories	5.2[b]	81.0	3.4	10.3	86.2[a]
Winged elm	4.0[b]	96.0	0	0	100.0[a]
Red oaks	3.2[b]	87.1	3.2	6.5	90.3[a]
Average all species	13.2	80.2	2.2	4.4	93.4

[1] See Table 1 for damage classes.
[2] Means in the same column with different superscripts differ at $P<0.05$.

TABLE 4. NET EFFECTS OF THE BURNING TREATMENTS, 1962-71, ON THE COVER OF WOODY UNDERSTORIES[1]

Treatment	Upper canopy[2]	Lower canopy[3]	Total canopy[4]	Woody vines
		(Percent	*cover)*	
Repeated winter burning	22.0*	47.9*	69.9	16.8
Repeated summer burning	9.2*	29.5	38.7*	25.6
Check	67.8	24.3	92.1	20.8

[1] From line-intercept data, 1971.
[2] Canopy of hardwood trees and shrubs more than 6 feet above the ground.
[3] Canopy of hardwood trees and shrubs 6 feet and less above the ground.
[4] The sum of upper and lower canopies.
* Indicates a significant difference from the check at the 0.05 level.

FIG. 6. View of plot four months after seventh winter-burning. Untreated area in background.

FIG. 7. View of plot nine months after fifth summer-burning. Untreated area in background.

TABLE 5. NET EFFECTS OF THE BURNING TREATMENTS, 1962-71, ON HERBAGE PRODUCTION

Treatment	Grasses	Legumes	Miscellaneous[1]	Total herbage
		(Pounds per acre)[2]		
Repeated winter burning	157.9	272.3*	318.9*	749.1*
Repeated summer burning	58.8	106.0*	149.5*	314.3*
Check	33.8	14.4*	7.6*	55.8*

[1] Includes composites, mostly, and other forbs except legumes.
[2] Oven-dry weight.
* Indicates a significant difference at the 0.05 level when compared to any other treatment.

TABLE 6. NET EFFECTS OF THE BURNING TREATMENTS, 1962-71, ON AVERAGE LITTER DEPTH

Treatment	Year since last burn	Number of burns	Litter depth (cm)
Repeated winter burning	0.5	7	0.4*
Repeated summer burning	1.0	6	1.2*
Check	40.0+	0	2.4

* Indicates a significant difference at the 0.05 level when compared to check.

(1) The initial "fuel reduction" winter-burning was probably hotter than necessary. It caused appreciable, though modest, mortality in the pine overstory. It also produced such a high degree of initial top-killing in the understory hardwoods that little remained for subsequent burnings to effect in this category. And it may have depleted the initial fuel supply to the extent that an inadequate fuel supply was available for the next planned burning.

(2) From the pine-production standpoint, a high degree of rootstock-killing of understory hardwoods is desirable because it greatly simplifies pine regeneration following the final harvest. It was hoped that summer-burning would result in extensive complete killing, as had been reported by other experimenters *(12, 16,21)*. However summer- burning did not produce significantly more complete killing than did winter-burning, as shown in Figure 5, although it apparently did cause reduced vigor of re-sprouting as shown by total hardwood canopy cover, Table 4. For better results in compete killing, summer-burning should have been applied annually, but fuel build-ups in the hilly pine forest at Camden were not rapid enough and consistent enough over practical burning units to permit this. From the standpoint of wildlife food production, summer-burning resulted in as much browse as the check

treatment, Table 4, and several times the herbage weight, Table 5, but resulted in considerably less browse and herbage than winter-burning.

(3) Winter-burning was expected to (1) initially top-kill small understory hardwoods, (2) top-kill all subsequent sprouts before they reached 1-inch in diameter, and (3) produce an abundance of wildlife food in the forms of succulent woody browse, herbaceous forage, and leguminous fruits. The winter-burning program succeeded admirably on all points.[4] Although pine regeneration at the time of final harvest of the pine overstory will be complicated by an abundance of living hardwood rootstocks, it will not be impractical. Pine regeneration can be successful under this condition provided it is given an equal start with the latest crop of hardwood sprouts along with full exposure to open sunlight *(4,20)*. Or the density and vigor of the rootstocks can be significantly lowered at the time of pine harvest and regeneration by means of mechanical site preparation, the use of herbicides, or by the use of special summer burns utilizing logging slash as fuel.

(4) This study was not specifically designed for evaluating surface runoff and soil movement following burning treatments. It was planned that a moist, unburned duff layer would protect the soil surface from raindrop impact and, therefore, from resulting surface runoff and soil movement. However, the residual duff layer after burning was sometimes excessively thin, particularly after summer-burning. During the line-intercept measurements in 1971, soil movement was observable on some plots with steeper slopes, but no incipient erosion gullies were seen.

CONCLUSIONS

On the basis of this study and previous work, we conclude that prescribed winter-burning should be a very useful tool in the handling of immature and previously unmanaged loblolly-shortleaf pine forests of the Hilly Coastal Plain. Understory hardwoods up to 3 inches d.b.h. (diameter breast high) can be top-killed and their sprouts kept small and controllable. The supply of browse, herbaceous forage, and edible leguminous fruits is greatly enhanced. Summer-burning offers equivalent hardwood

[4] Leguminous fruit production was not actually measured. An increase is assumed as roughly proportional to the increase in weight of legume herbage, Table 5.

control but less enhancement of wildlife food supply, and there is greater risk of fire damage and soil erosion.

If there is a heavy fuel accumulation, with hanging pine straw in the tops of small trees and shrubs, the initial burning should be in the form of backfiring *(10)*, igniting fuels on ridgetops and allowing fires to "back" down the slopes. Subsequent burning can best be accomplished with the economical and highly adaptable strip-headfiring technique. Burning should always be done when the lower duff is still moist from a recent soaking rain, and it is advisable that very steep slopes with thin topsoils not be burned at all. Repeat burning should be withheld until just before the largest sprouts, originating after the previous fire, become too large to be top-killed by the repeat fire. Burning intervals of 2 to 4 years are likely to result from the application of this principle.

The wildlife foods enhanced by winter-burning are useful for highly important deer, turkey, and quail. Deer and turkey also require mast foods, such as acorns, which can ultimately be depleted under a regime of persistent periodic burning. Special provisions are needed, therefore, for replacing and developing mast-producers in forests that are systematically burned. These provisions could consist of protecting either selected mast-producing areas or individual trees from the fires.

Good prescribed burning of the understory is dependent on well distributed pine needle litter or grass litter for fuel *(13)*. Attempts to burn without such fuel are of doubtful utility. Burning to control scattered understory hardwoods or hardwoods over 3 inches d.b.h. is also questionable. Finally, prescribed burning may be considered a questionable practice wherever there is public sentiment against it as a possible source of hazard to human health or enjoyment.

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