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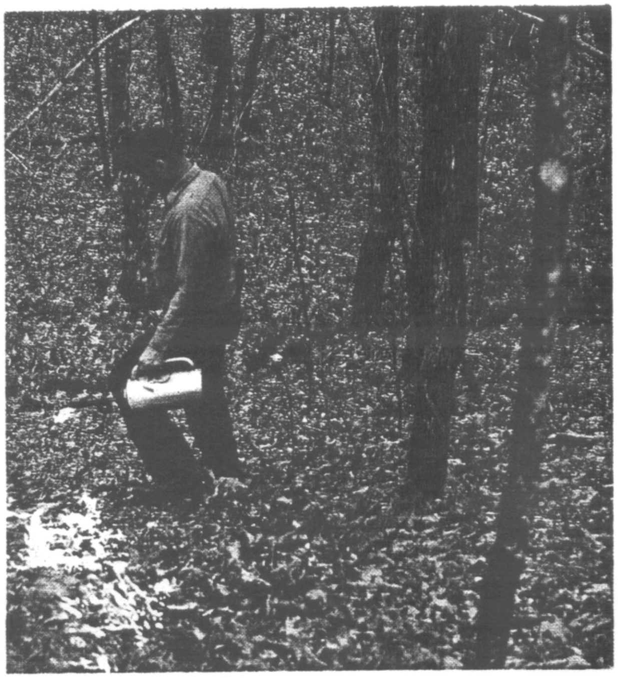

PRESCRIBED BURNING AND OAK ADVANCE REGENERATION IN THE SOUTHERN APPALACHIANS

BY

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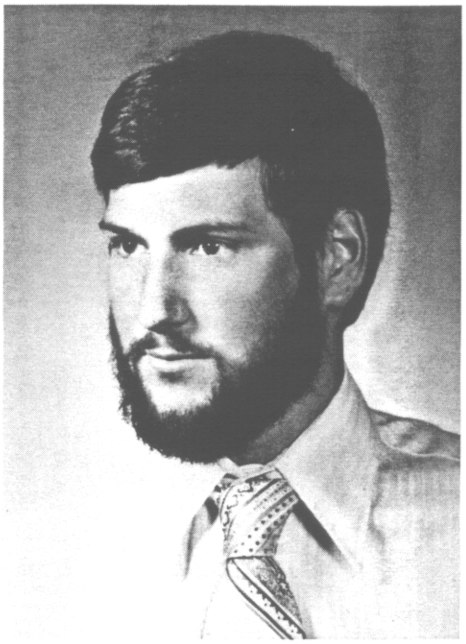

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INTRODUCTION

Although the oak resource in the Southern Appalachians may appear vast, concern has been expressed that oak is a much smaller component of new stands than of those currently being harvested. This situation presents a problem not only for oak timber users, but for wildlife enthusiasts as well, because the production of acorns for wildlife food is diminishing. The basic problem is that not enough oak advance regeneration is becoming established beneath existing stands, especially on the better oak sites.

A popular hypothesis attempting to explain this dearth of oak advance regeneration is that the increasingly successful exclusion of fire from upland hardwoods has substantially altered their ecology, resulting in less regeneration. If this is true, the introduction of prescribed fire into these forests may improve oak regeneration.

The major objective of this study was to determine the effects of dormant season prescribed backfires on understory tree species composition in Southern Appalachian mixed pine-hardwoods. The effect of such fires on the abundance and vigor of oak advance regeneration was of particular interest.

Study Area

This study was conducted on two burning units on the Andrew Pickens Ranger District of the Sumter National Forest in South Carolina and one burning unit on the Talullah Ranger District of the Chattahoochee National Forest in northeast Georgia. The forest cover on the Poor Mountain area is a large pole-size stand on the verge of becoming a sawtimber stand. About 40 percent of the stocking is oak, 20 percent hickory, and the remainder shortleaf pine and miscellaneous species. The Double Branch Creek area is characterized by a forest of a more mature nature, with about half its volume in sawtimber. The composition is about 50 percent oaks, with the remainder consisting of hickories, shortleaf pine, and miscellaneous species. Of the three areas, the Wolf Creek area, in Georgia, has the least mature forest. Most of its stocking is in pole-size trees, with less than 20 percent in sawtimber. Over 50 percent of the stocking is in oaks, with the remainder being made up of shortleaf pine and miscellaneous species. Species composition is similar on all three sites except that hickories are conspicuously scarce on the Georgia area.

Table 1. Fire weather conditions on the day of each burn.

	Area		
Item	Poor Mtn.	Dbl. Br. Cr.	Wolf Cr.
Date	11-19-79	12-17-79	4-1-80
Starting time	11:30 AM	12:15 PM	1:00 PM
Surface wind	8 Kph	8 Kph	9 Kph
Transport wind	16 Kph	13 Kph	14 Kph
Relative Humidity	31%	35%	50%
Temperature	19° C	18° C	21° C
Days since rain	6	6	6

Table 2. Basal diameter classes used in woody stem inventory.

Class designation	Basal diameter range
	cm
A	< 0.7
B	0.7 - 1.3
C	1.4 - 2.5
D	2.6 - 5.1
E	5.2 - 7.6
F	7.6 - 10.2

Methods

The prescribed burns were conducted by the U. S. Forest Service in the 1979-1980 dormant season. The fires were low, relatively cool backfires started from the tops of slopes and ridges. Winter backfires were used because headfires and summer fires are more lethal to understory hardwoods.

Flame heights seldom exceeded 0.3 m, although in certain spots they were as high as 3 m. These flare-ups represented a small portion, perhaps 1 to 2 percent, of the total area. Burning days were selected so that the lower organic layers would still be moist, but the litter layer would burn crisply. Temperatures did not exceed 21° C. for any burn, and relative humidities were all between 30 and 50 percent (Table 1).

Effects of burning on advance regeneration pools were evaluated using paired plots. A total of 24 pairs of 0.025 ha plots was established. Ten pairs were installed at Poor Mountain in South Carolina, four near Double Branch Creek in South Carolina, and ten near Wolf Creek in Georgia. These plot pairs were arbitrarily located, after thorough reconnaissance, to include areas with different proportions of oak in the overstory, and various amounts of oak advance regeneration and competing vegetation in the understory. An effort was made to locate the pairs so the adjacent plots would be similar in slope, aspect, and vegetative cover. Slopes ranged from 14 to 70 percent, aspects ranged from northeast, through south, to west. All slope positions, lower-, middle-, and upper-third were represented.

A fire line adequate to ensure exclusion of the fire was raked around each randomly chosen control plot. Prior to the burn, an inventory of all tree species stems with a basal diameter of 10.2 cm or less was taken on each plot. Stems were classed by species group, either oaks, hickories, red maple, black gum, dogwood, sourwood, or miscellaneous, and by the basal diameter classes presented in Table 2. A similar inventory was taken three times after burning; these were in early summer 1980, autumn 1980, and early summer 1981.

Data obtained from these inventories were analyzed for each species group-size class combination for each of the three postburn inventories. The analysis did not compare preburn to postburn counts, but compared burned plot counts to control plot counts for one inventory, adjusted for any preburn differences.

To assess how oak advance regeneration of different sizes would respond to

Table 3. Changes in oak advance regeneration densities caused by prescribed fire.

Inventory date		Size Class A	B	C	D	E	F
Early summer	1980	0	-	-	-	0	0
Autumn	1980	0	0	-	-	0	0
Early summer	1981	+	0	-	-	0	-

Legend: - significant decrease
0 no significant change
+ significant increase

prescribed burning, 50 oak regeneration stems of various sizes were individually tagged at the Georgia site. The stems were labeled with foil tags prior to burning, and the height and root collar diameter, as well as the form (either flat-topped or possessing a leader) of each were recorded. In the early summer after the burn, the stems were inspected for survival and sprouting. This was repeated again in autumn 1980 and early summer 1981. Attempts were made to relate topkill, number of sprouts, height of the tallest sprout, and diameter of the tallest sprout to the original stem basal diameter.

Results and Discussion

The early summer 1980 inventory, which allowed for an initial growth flush in the spring, revealed no increase in the number of oak stems due to burning. Numbers of stems in the smallest, and largest two size classes remained unchanged, while size classes B, C, and D showed reduced numbers. By the end of the first growing season size class B had gained sufficient stems to return it to a level equivalent to that of the control plots. The final inventory, in early summer 1980, showed an increase in size class A, no change in size class B, persistent reductions in classes C and D, no change in class E, and an unexplainable reduction in size class F (Table 3).

The response through time of the various size classes to prescribed burning is depicted graphically in Figure 1. Prior to burning, the smallest size class contained 1638 stems/ha. This number was no doubt reduced immediately by the fire, but early season sprouting resulted in an increase in population to nearly 8000 stems/ha. All these stems, however, did not persist through the growing season, so by autumn 1980 only about 3000 stems/ha of this size were present. Sprouting it appears, is a springtime phenomenon, and in early summer 1981 there were 5837 stems/ha in size class A.

Size class B was reduced from 371 stems/ha to 114 stems/ha by the fire. Many of these 114 stems were not original stems, but unusually vigorous sprouts. Enlargements of sprouts through the summer increased this population to 143 stems/ha by autumn, 1980. Rapid growth the following spring resulted in a population of 474 stems/ha of size B by the final inventory.

The original population of size class C was 309 stems/ha, but was reduced to 10 stems/ha by the fire. No recovery was made during the first growing season, but by the final inventory ingrowth had increased the density to 52 stems/ha. Size class D originally contained 227 stems/ha, but was reduced to 72 immediately following burning. Continued mortality further reduced the count to only 10 ha by autumn 1980. The final inventory revealed no recovery. The largest two size classes exhibited no meaningful changes in response to fire.

The size of oak advance regeneration is extremely important in relation to its ability to perform upon release. For a stem to develop into a desirable tree in a new stand it should be at least 1.4 m tall and have a root collar diameter in excess of 1.3 cm. It can be seen from Figure 1 that there has been a shift toward smaller stems caused by burning. This is seen as a reduction in the status of oak advance regeneration, and is a disadvantage of prescribed burning. However, this reduction is only temporary, and if a recovery of size can be made without a concomitant loss of numbers, there will be an improvement in the oak regeneration potential.

There is some controversy over how many established oak regeneration stems/ha are needed for oak to be a significant component in a new stand. Traditionally it was believed that about 1000 stems/ha were required. Recently, however, it has been suggested that oaks have the ability to remain in an overtopped

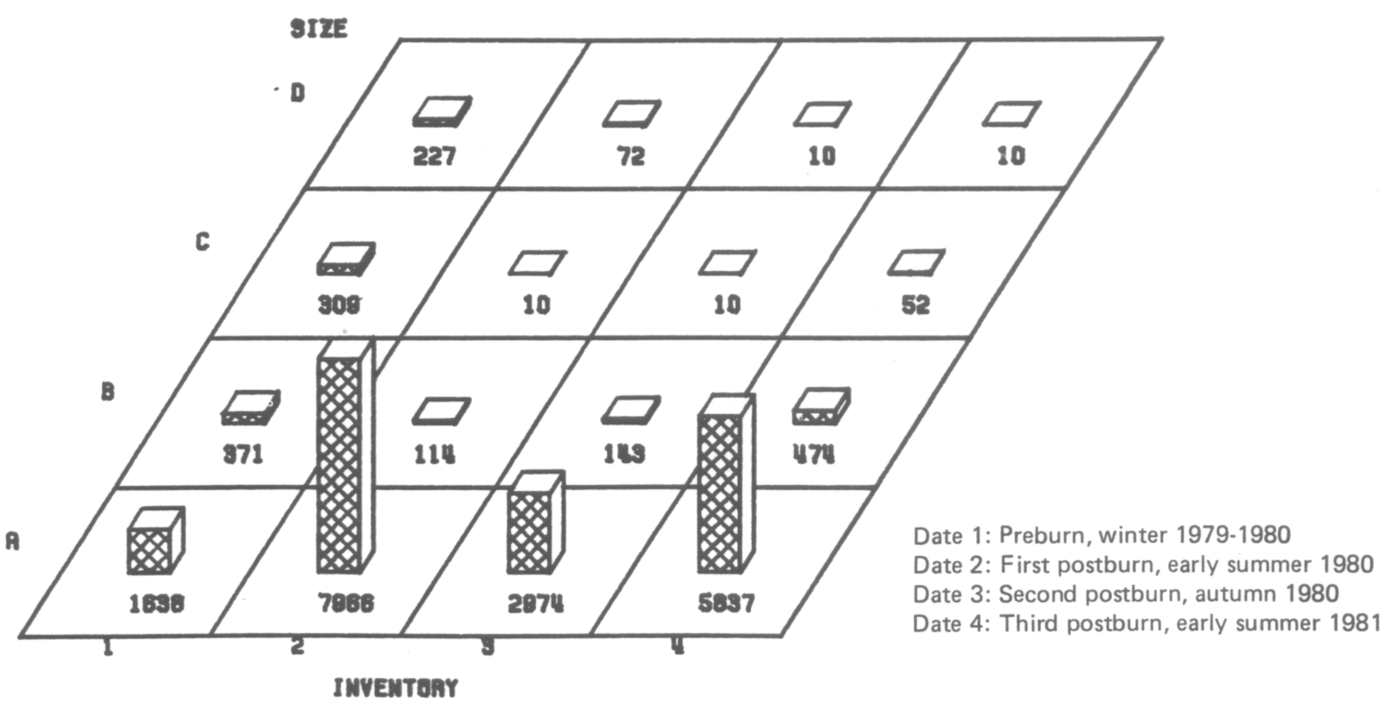


Figure 1. Stem densities for oak advance regeneration treated with fire.

position for 25 to 35 years, and then rise to dominance. Because of this ability, some researchers claim that the status of oak in a new stand is often underestimated, and fewer stems are needed than traditionally believed. According to this theory, 150 well established, evenly distributed stems/ha will suffice.

If the traditional estimate is correct there were insufficient stems present prior to burning, because size classes A and B cannot be considered well established, or 1.4 m tall with a basal diameter of more than 1.3 cm. In this case the fire only served to make a bad situation worse. If the more recent theory is correct, and we only need 150 stems/ha, the fire made a satisfactory condition unsatisfactory. In either case the prescribed burning was disadvantageous in relation to oak regeneration. However, if a size recovery is made without a complete loss of the frequency increase, as mentioned before, the fire would have been helpful in improving the oak regeneration situation.

The proportion of oak in a new stand following harvest cutting is directly related to the proportion of oak in the total advance regeneration pool of all species present before harvesting. Therefore it is important to look at what effect fire had on reproduction size stems of other tree species.

Red maple responded to fire by vigorous sprouting, about comparable to that of the oaks. The first postburn inventory revealed a five-fold increase in the density of stems in size class A. A year later this response was about a four-fold increase over the preburn count. Size class B also increased in numbers in response to fire, but the increase was delayed until the second growing season, when the preburn count of 114 stems/ha had grown to 267 stems/ha. The larger size classes exhibited drastic reductions, as did all species groups except sourwood and miscellaneous (Figure 2).

The hickories were also vigorous sprouters, but growth of the sprouts into size classes B and C was not as prevalent as in some of the other species groups. The first postburn inventory revealed 1781 stems/ha in size class A, where there were only 124 stems/ha prior to burning. This density dipped to 946 stems/ha by autumn 1980, but sprouting and seed germination increased it to 1730 stems/ha by early summer the following year. Size class B was eliminated by autumn 1980; however, growth of sprouts brought its density up to 82 stems/ha by the final measurement period. The larger size classes were drastically reduced and little recovery has been made (Fig. 3). The low density of hickories, coupled with their reportedly slow response to release, make them relatively inconsequential as oak competitors. Any response of the hickories to prescribed burning will have little influence on the status of oak reproduction.

The responses of black gum and dogwood were very similar to that of hickory (Figs. 4 and 5). The response of these species to overstory removal is greater than that of the hickories, so that they are seen as significant competitors of oak in a new stand. For this reason, the increase in stem density for these species is a detriment, while a reduction in numbers in the larger size class is an advantage. The relative importance of these two factors is not known at this time.

Sourwood sprouted prolifically in response to prescribed fire. The preburn density of 82 stems/ha for size class A had increased to 1040 stems/ha by the last inventory. The density of size class B increased from 20 stems/ha to 124 stems/ha over the same period. Populations of the larger size classes were very low prior to burning, so no significant

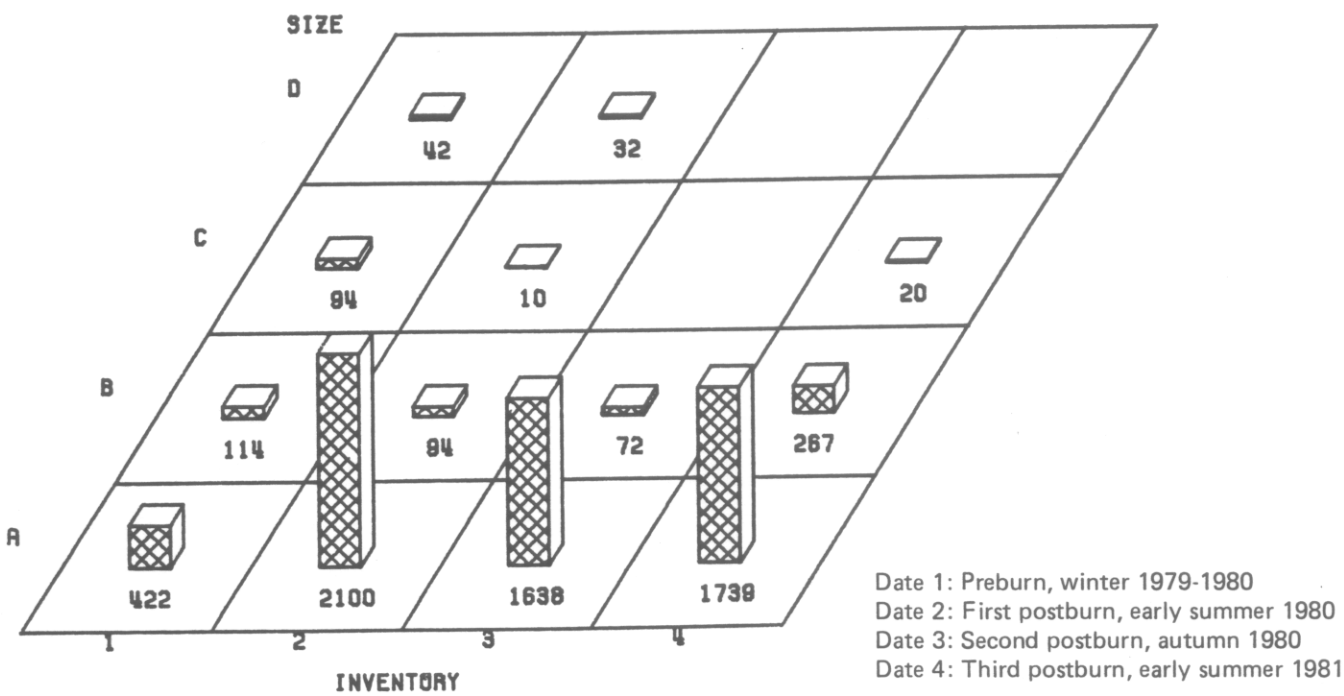


Figure 2. Stem densities for red maple advance regeneration treated with fire.

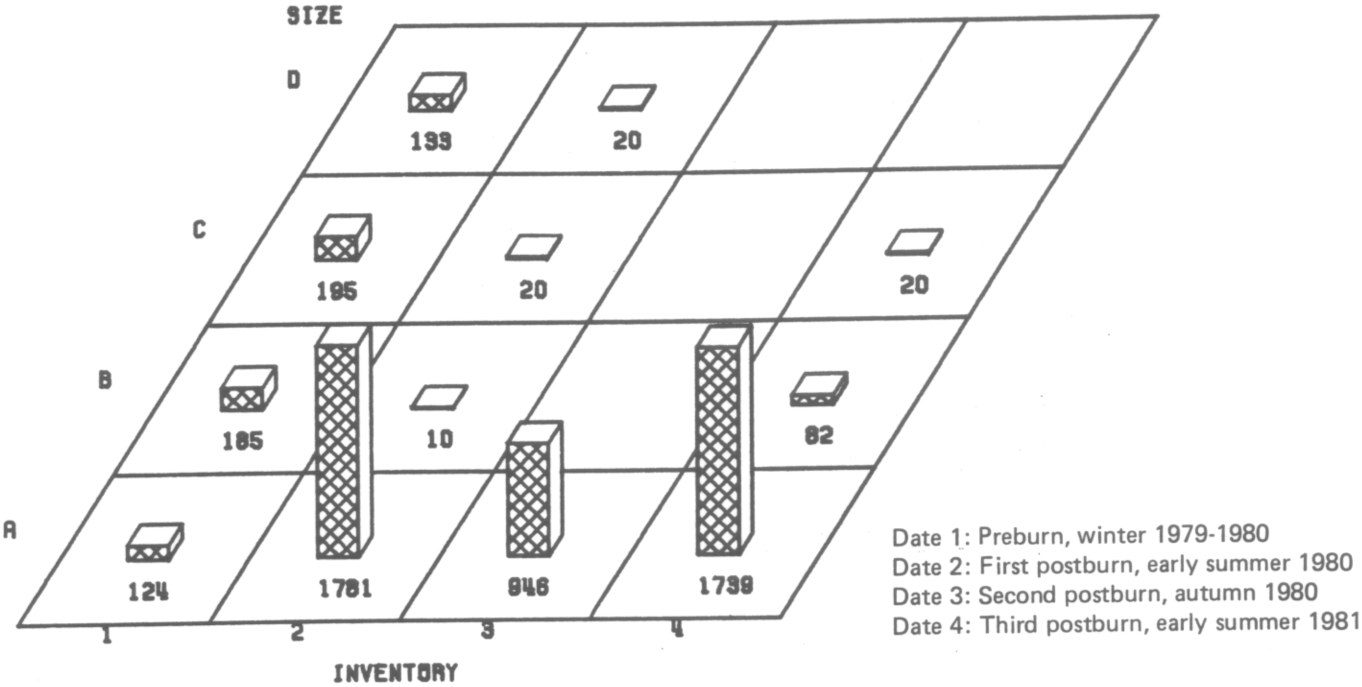


Figure 3. Stem densities for hickory advance regeneration treated with fire.

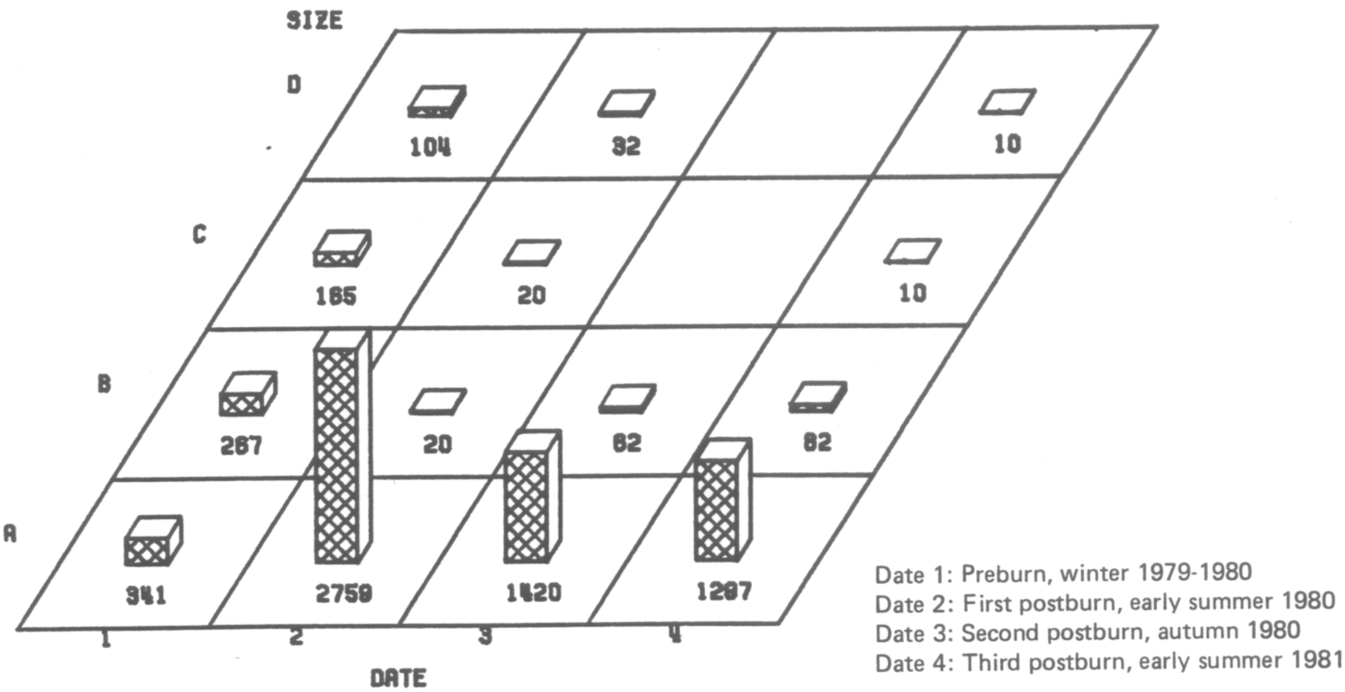


Figure 4. Stem densities for black gum advance regeneration treated with fire.

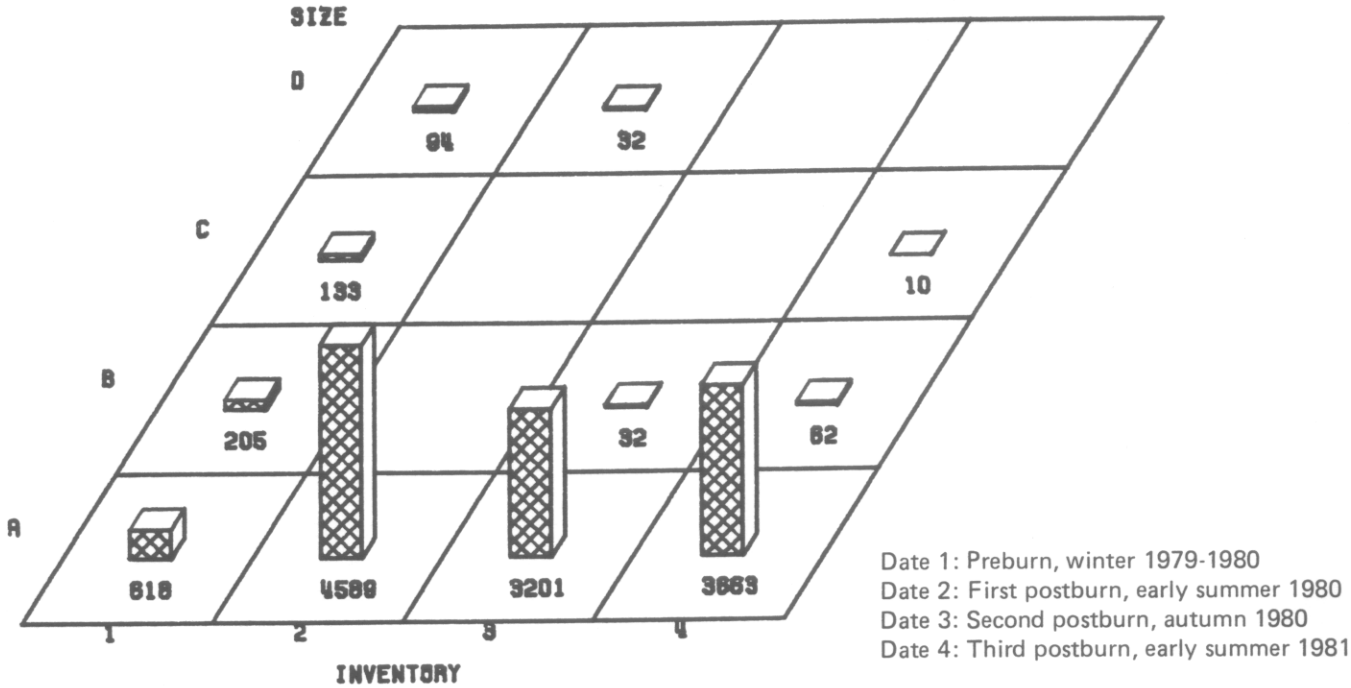


Figure 5. Stem densities for dogwood advance regeneration treated with fire.

reductions were caused by fire (Fig. 6). Therefore burning improved the status of sourwood, which may be disadvantageous to the oaks.

The miscellaneous species category exhibited moderate sprouting in response to fire, and seed germination of intolerants was enhanced by the reduction of litter, and perhaps by an increase in light and temperature, caused by burning. The first postburn inventory revealed nearly 9000 stems/ha in size class A, compared to 1514 stems/ha before burning. The density of this size class, however, was only 2181 stems/ha by early summer 1981. Many of the stems in this size class are yellow poplar germinants that will never become established. The larger size classes were all reduced and recovery has not been attained (Fig. 7). The response of this group to fire has been favorable to the oaks, because some members of this group, most notably yellow poplar and black cherry, can be intense competitors following harvesting.

The proportion of oak in a new stand following harvest cutting is directly related to the proportion of oak in the total advance regeneration pool present before harvesting. Table 4 shows the percentage of the total advance regeneration pool accounted for by each species group at each inventory. The oak percentage was originally 31.9, dropped to 24.8, but then rebounded to 36.7 by the last inventory. This is an improvement in its reproduction status. The other important changes were in red maple and the miscellaneous group. As mentioned, several members of the miscellaneous group, and of course red maple, are serious competitors of the oaks after harvest cutting. Red maple declined from 8.9 to 2.4 percent, and the other group decreased from 24.5 to 13.9 percent, both favorable to the oaks.

Observations on the individually tagged oak stems showed that topkill from a winter backfire is likely in stems less than 2.5 cm basal diameter, occurring in 93 percent of the observed stems of this size. It is unlikely in stems in excess of 5.0 cm basal diameter, where no topkill was observed. The 2.6 to 5.0 cm size was intermediate, exhibiting 60 percent topkill. This fire did not completely kill any of the oak advance regeneration under observation. Therefore, although some reduction in size may occur, no reduction in numbers will be caused by prescribed fires of this nature.

For all the stems observed sprouting averaged 2.9 sprouts per stem in early summer 1980, dropping to 2.7 by the end of the 1980 growing season. In early summer 1981 the number of sprouts per stem had increased to 3.0. This means the total number of stems present more than tripled in response to fire, because not all the original stems were topkilled. This may be an improvement in the oak reproduction situation, although the number of root stocks has not been increased.

The height of the tallest sprout originating from an advance regeneration stem following fire was found to be strongly influenced by the basal diameter of the original stem. As would be intuitively expected, the relationship is direct, with thicker stems producing taller sprouts. The height of oak advance regeneration stems strongly influences their performance following harvesting. Stems should be at least 1.4 m tall to ensure acceptable trees in a new stand. The average height of the original stems was 2.16 m, but by the last measurement, the tallest sprouts averaged only 0.61 m. This loss of height, even though it will eventually be recovered, is a reduction in the ability of these stems to perform well when released.

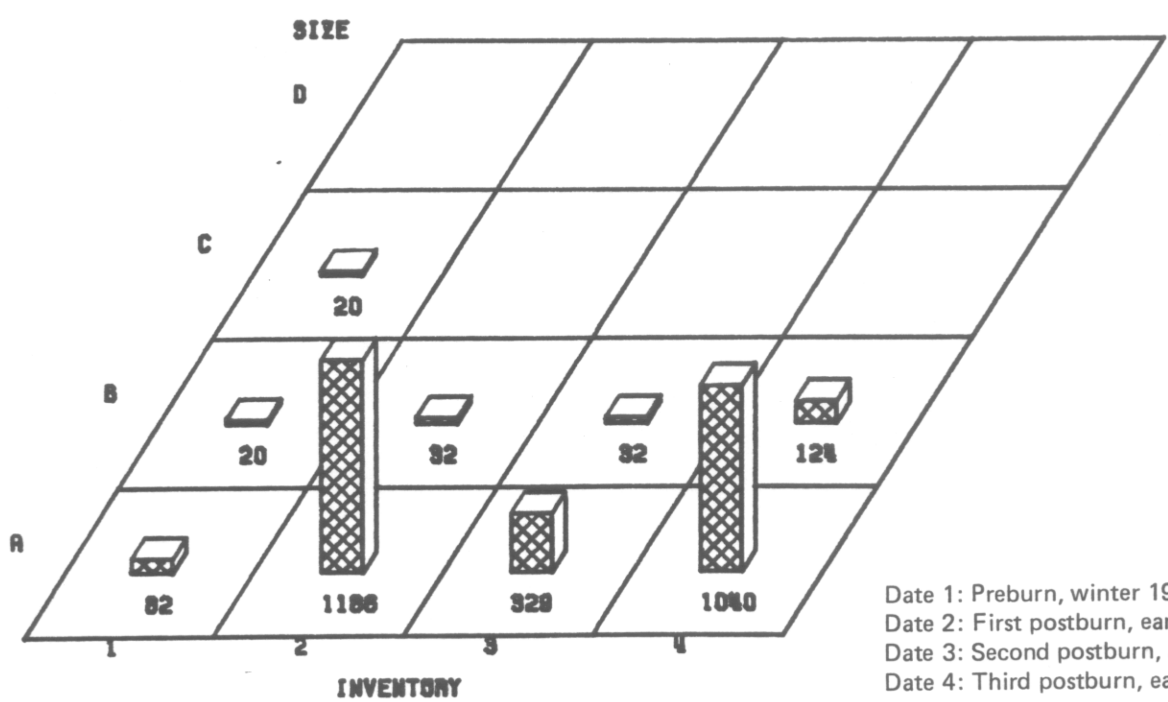
The average basal diameter of the original stems was 2.8 cm, but the tallest sprouts had a mean basal diameter of only 0.6 cm in early summer 1980. This increased to 0.7 cm by the end of the growing season. It continued to increase early in the second growing season, reaching 0.9 cm by early summer 1981. This is still less than the 1.3 cm minimum basal diameter that is desirable for oak advance regeneration.

The form of an oak advance regeneration stem influences its performance upon release. Stems that possess a prominent leader usually outgrow and produce better trees than flat-topped stems. Prior to burning only 42 percent of the observed stems displayed definite leaders. Inspection of the sprouts following burning revealed that 98 percent were of the desirable form in early summer 1980. This value dropped to 95 percent by autumn, and was down to 65 percent by early summer 1981. The initial improvement in stem form was encouraging, but it appears that a reversion to the original situation is occurring rapidly, although some improvement may persist.

The influence of prescribed fire of this nature on wildlife habitat is favorable. The increase in density of stems in the smaller size classes is advantageous from two standpoints. The amount of browse available is increased, and the amount and quality of cover are improved. Although it can't be concluded that burning will substantially increase the future acorn production, it seems that it at least has no adverse effect.

Table 4. Composition of advance regeneration stand by percent for each inventory period.

Species	Period Preburn	Postburn 1	Postburn 2	Postburn 3
			%	
Oaks	31.9	27.4	24.8	36.7
Hickories	8.0	6.1	7.3	10.7
Maple	8.9	7.5	13.4	2.4
Black gum	11.7	9.6	11.7	8.2
Dogwood	13.4	15.6	25.2	21.4
Sourwood	1.5	4.1	2.8	6.7
Miscellaneous	24.5	29.6	14.7	13.9



Date 1: Preburn, winter 1979-1980
Date 2: First postburn, early summer 1980
Date 3: Second postburn, autumn 1980
Date 4: Third postburn, early summer 1981

Figure 6. Stem densities for sourwood advance regeneration treated with fire.

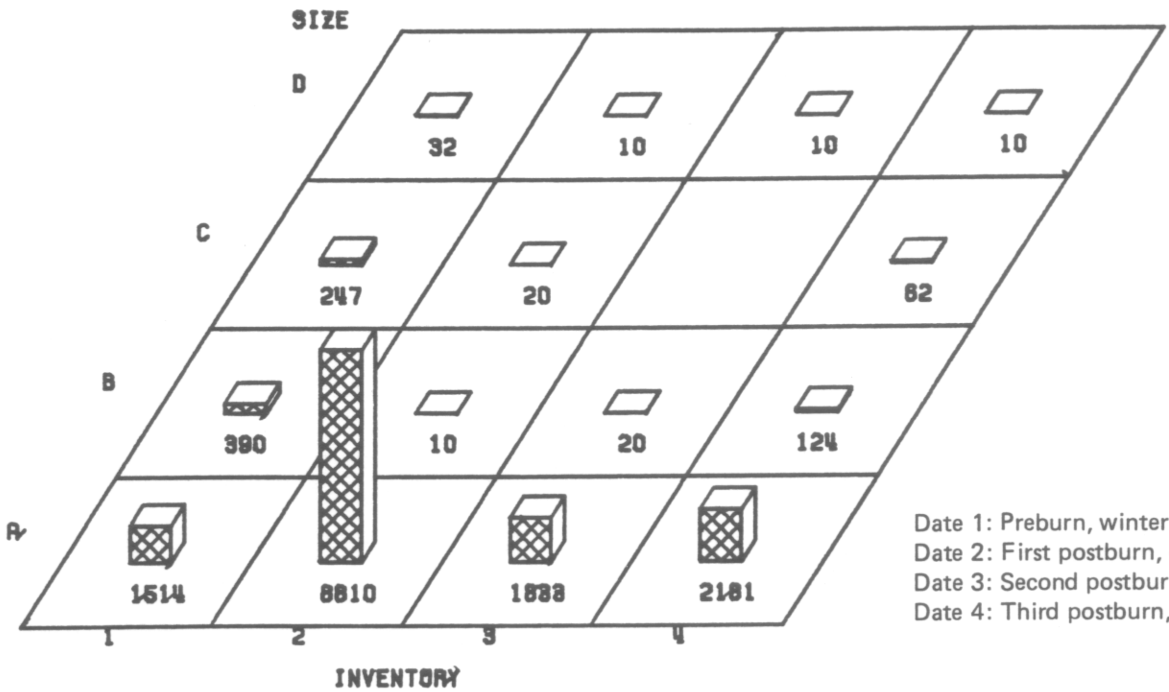


Figure 7. Stem densities for miscellaneous advance regeneration treated with fire.

CONCLUSIONS

It is widely believed that a shortage of oak advance regeneration is causing oak to be a smaller component of new stands than of those currently being harvested. This study attempted to document the effects of prescribed fire on the quantity and quality of oak advance regeneration. Advantages to burning include improved form of reproduction, increased reproduction density, an increase in the proportion of oak in the advance regeneration pool coupled with a decrease in the proportion of its fiercest competitors, and improved wildlife habitat. The gains in the oak regeneration status are slight, but the improvement in wildlife habitat is encouraging, and suggests continued use of prescribed fire.

The main disadvantage of burning is a loss of size of the advance regeneration stems present. This size reduction is significant enough to make burning solely for oak regeneration enhancement unfavorable, but not significant enough to discourage burning for wildlife habitat improvement.

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