LOW-COST REGENERATION TECHNIQUES FOR MIXED-SPECIES MANAGEMENT – 20 YEARS LATER

Thomas A. Waldrop and Helen H. Mohr

ABSTRACT

Four variations of the fell-and-burn technique, a low-cost regeneration system developed for pine-hardwood mixtures in the Southern Appalachian Mountains, were tested in the Piedmont of South Carolina. All variations successfully improved the commercial value of low-quality hardwood stands by introducing a pine component. After 20 years, pines were almost as numerous as hardwoods and more than twice their height. Summer site preparation burning reduced hardwood size and increased the number of pine volunteers but did not affect pine diameter, height, or volume. This study represents the first definitive measurement of volume resulting from low-cost regeneration techniques in the Southeastern Piedmont. Nonindustrial private forest landowners may find these techniques useful as a means of increasing stand value from a low initial investment.

INTRODUCTION

Improving productivity on nonindustrial private forest (NIPF) lands for both hardwood and softwood timber has been a goal for decades. NIPF landowners control the majority of commercial forest land in the Piedmont region of the Southeast, and much of their land is poorly stocked or unmanaged (Bechtold and Ruark 1988). Conversion of these stands to pine plantations is expensive so many choose to leave their forests unmanaged. Low-cost alternatives for regeneration may attract NIPF landowners to management if these alternatives are cost effective and meet multiple goals.

In the late 1980s and early 1990s, research on low-cost regeneration alternatives focused on pine-hardwood regeneration. The goal was to introduce planted pines among hardwood sprouts to improve stand productivity and value. A number of papers discussed hardwood competition control (McGee 1986, 1989), herbicide application (Zedaker and others 1987, Zedaker and others 1989), mechanical release (Lloyd and others 1991), season of harvest (McMinn 1989), and fire effects (Robichaud and Waldrop 1994, Waldrop 1997). Most of this research concentrated on a low-cost system called the fell-and-burn technique (Abercrombie and Sims 1986) which was developed for the Southern Appalachian Mountains. This technique regenerated hardwood stands to mixtures of pine seedlings and hardwood sprouts at less than half the price of conversion to pine plantations (Phillips and Abercrombie 1987). Briefly, the system involved clearcutting a hardwood stand, felling residual stems in spring when leaves are almost fully developed, summer broadcast burning, and planting pine seedlings at a wide spacing. Each step is designed to control hardwood sprout growth enough to allow pine seedlings to become established and grow. Full descriptions of the system were given by Abercrombie and Sims (1986) and Phillips and Abercrombie (1987).

Results of the first attempt to use the fell-and-burn technique in the Southeastern Piedmont were described by Waldrop and others (1989) 1 year after regeneration and by Waldrop (1997) 6 years after regeneration. That study included four variations of the fell-and-burn technique and compared winter and spring felling and burning with no burning. Results indicated that season of felling had no impact on pine survival or hardwood height after six growing seasons. Burning had no impact on pine survival but did reduce hardwood height. Planted pines overtopped hardwoods in burned plots within 6 years but remained shorter than hardwoods in unburned plots. The fell-and-burn technique was never fully adopted by NIPF landowners in the Piedmont, partially because there were no reliable projections of growth and yield. This paper compares pine and hardwood growth among the four variations of the fell-and-burn technique (Waldrop 1997) after 11 and 20 growing seasons.

METHODS

Study sites are on the Clemson University Experimental Forest in Pickens and Anderson Counties of South Carolina. These sites are similar in aspect, soil, and vegetation. All sites are classified as subxeric to xeric (Jones 1989), occur on south-facing slopes, and soils are Typic Hapludults. Site index at 50 years is 60 feet for pines and 40 feet for oaks. Before harvesting in December 1987 and March 1988, common overstory tree species included white oak (*Quercus alba* L.), southern red oak (*Q. falcata* Michaux.), post oak (*Q. stellata* Wangenh.), black oak (*Q. velutina*

Team Leader and Forester, respectively, U.S. Forest Service, Southern Research Station, Clemson, SC 29634-0331.

Lam.), scarlet oak (*Q. coccinea* Muenchh.), chestnut oak (*Q. prinus* L.), hickory (*Carya* sp.), and shortleaf pine (*Pinus echinata* Mill.). Stand basal area included 18.0 square feet per acre of pines and 57.3 ft^2/ac of hardwoods. A total of 87 sample plots was established in 3 replications of 4 treatment combinations in a 2 by 2 factorial arrangement. One treatment factor was season of felling residual stems (winter vs. spring) and the other was burning (burned vs. unburned). Treatment combinations included: spring felling of residuals over 5 feet tall followed by summer broadcast burning (the fell-and-burn technique), winter felling with burning, spring felling with no burning, and winter felling with no burning. Each treatment combination was randomly assigned to one of four treatment areas within each replication. Treatment areas were approximately 2 acres and included 5 to 8 sample plots. Each sample plot was 1 chain x 1 chain square (1/10 acre).

Phillips and Abercrombie (1987) suggested that sprout vigor would be reduced by felling residual hardwood stems in late spring when carbohydrate reserves in root systems are typically low. Winter felling and spring felling were used in this study to test this hypothesis. Chainsaw crews felled all residual stems over 5 ft tall. Winter felling was done during the first week of March 1988; spring felling was done during the third week of June 1988.

Burning occurred on July 7, 1988, 2 days after a rainfall of 0.5 in. Humidity at the time of burning was 5060 percent; wind speed was approximately 5 mph. Moisture content of 10hr timelag fuels (0.251 in. in diameter) was 12% at 10:00 A.M. and 9% to 10% after noon. Backing fires were started along the edges of the units, followed by striphead fires to ignite the interior fuels. Disturbance by skidding and the presence of tree tops affected fuel loading which ranged from none to very heavy. Fuels consisted of large logs, old down material, freshly felled residuals, logging slash, and leaf litter.

Improved loblolly pine seedlings were hand planted by contract crews in all treatment areas during March 1989. Observations on fell-and-burn areas on the Sumter National Forest in South Carolina indicated that pines outcompete and overtop hardwoods by age 7 to 10 (Waldrop and others 1989). Therefore, in this study, loblolly pines (*P. taeda* L.) were planted at a spacing of 15 x 15 feet (194 per acre) instead of 10 x 10 feet (454 per acre), which was used in the mountains, to reduce costs and to allow favorable conditions for hardwood development.

For this paper, all plots were measured after the 11th (1998) and 20th (2007) growing seasons except those in one replicate which had been lost to southern pine beetles (*Dendroctonus frontalis*) before the 20th year. Measurements included species, height, and diameter at breast height (dbh) of all pines and hardwoods in sample plots. Cubic foot volume was estimated from tables provided by Clark and Souter (1996) for pines and Clark and Schroeder (1985) for hardwoods. Treatment differences were compared by analysis of variance with each variable for all pine and all hardwood species groups. Mean separation was by linear contrast ($\alpha = 0.05$).

RESULTS AND DISCUSSION

Tests of the season of felling residual stems showed no significant differences for all variables including number, dbh, height, and volume of pines and hardwoods after both growing seasons (11 and 20). This pattern was emerging after the 6th growing season (Waldrop 1997) and remained consistent through the next 14 years. Therefore, winter and spring felled plots were combined for additional analyses. Season effects will not be discussed, and comparisons will be made between the burning and no burning treatments only.

The number of pines counted in burned plots was significantly higher than in unburned plots at both measurement years (Table 1). In both treatments and in both measurement years, the number of pines was much higher than the 194 per acre that were planted. Volunteers of loblolly and a few shortleaf pines were noted in earlier years, and many of those trees persisted through the 20th year. Site preparation burning probably helped prepare the seedbed thus allowing higher germination and survival of volunteer pines. By year 11, pines had grown enough that field crews were no longer able to distinguish between volunteer and planted pines, so estimates of survival were not possible. The dbh of pines was significantly higher in burned plots than in unburned plots after year 11, but there was no significant difference in year 20. Mean dbh in burned plots was lower after year 20 than it had been 9 years earlier suggesting that small trees had grown tall enough to measure dbh during that period, thus lowering mean dbh. Pines were too small to estimate volume after the 11th growing season. After the 20th growing season pine volume was 1,408 cubic feet per acre in burned plots and 1,212 cubic feet per acre in unburned plots but the difference was not significant. Managers of the Clemson Experimental Forest estimate that a loblolly pine plantation on those sites would yield 2,000 cubic feet per acre after 20 years.

The number of hardwood stems (all species) was significantly lower in burned plots (1,731 per acre) than in unburned plots (2,586 per acre) in year 11 (Table 2). However, that difference did not persist through year 20. By then, hardwood numbers had thinned to 531 and 601per acre in burned and unburned plots, respectively. Between years 11 and 20, hardwood numbers (Table 2) reduced much more than did pine numbers (Table 1), suggesting that pines may eventually outnumber hardwoods. Hardwoods remained small through the 20-year study period; most were too short to measure dbh after year 11 (Table 2). After 20 growing seasons, hardwood dbh and volume were significantly smaller in burned plots (1.7 in and 99 cubic feet per acre) than in unburned plots (2.2 inches and 176 cubic feet per acre). Waldrop (1997) saw a similar pattern in height growth after 6 growing seasons and suggested that the difference was caused by a shorter growing season after burning in year 1. Sprouts in unburned plots grew for the entire growing season while those in burned plots emerged after site preparation burning in July.

Site preparation burning showed a significant impact on hardwood height throughout the 20-year study (Figure 1). At every sampling period, hardwoods were significantly taller in unburned plots than in burned plots. By the end of the 11th growing season, hardwoods were 11.7 feet tall in burned plots and 16.4 feet tall in unburned plots. After the 20th growing season, the difference in height remained about 5 feet with hardwood mean height in burned plots of 15.1 feet and 20.3 feet in unburned plots. Hardwood height growth between year 11 and year 20 was only about 4 feet, emphasizing the dry conditions of these sites and the dominance of pines during this period. Height growth was almost identical in burned and unburned plots suggesting no long-term site damage from burning.

Pine heights were not significantly different between burned and unburned plots at any time during the study. Previous to the measurements made for this study, pines in burned plots had grown taller than hardwoods but were about the same height as hardwoods in unburned plots (Waldrop 1997). Measurements made after the 11th growing season showed that all pines (planted and volunteer, all species) were significantly taller than hardwoods for the first time during the study. Pines had a mean height of 20.5 feet and were approximately 4 feet taller than hardwoods in unburned plots. As these pines became taller than hardwoods, they began rapid height growth. During the next 9 years, pines more than doubled in height reaching a mean of 48.3 feet tall.

A shift in species dominance occurred during the 20 years of this study. During the first 6 years, sample plots would have been described as hardwood or hardwood-pine because hardwoods were taller than pines and outnumbered pines by a wide margin. Today, these plots would be described as pine or pine-hardwood. Pines are more than twice the height of hardwoods and are almost as numerous, particularly in burned plots. This study shows that loblolly pine is a strong competitor with all hardwood species on xeric and subxeric sites. Even though pines were planted at a low density, the hardwoods grew very slowly and did not become a component of the overstory. A higher planting density of pines may have proven to be a better choice if volume production was a goal.

CONCLUSIONS

This study confirms a previous suggestion from this study that the fell-and-burn technique would be successful on dry Piedmont sites. Pine regeneration was successful among hardwood sprouts regardless of treatment combination. The precise timing of felling residual stems during spring after clearcutting is not necessary because growth of pine and hardwood regeneration was the same after felling during winter or spring. Site preparation burning had a lasting effect on hardwood regeneration with fewer trees and smaller dbh and height. However, these reductions did not affect pine development as pines became the dominant canopy species by year 11 and were more than twice the height of hardwoods by year 20. One advantage of site preparation burning was to increase the number of pine volunteers, although this difference had no impact on pine dbh, height, or volume. This study also confirms an earlier suggestion that little or no site preparation is needed on dry Piedmont sites to establish pine seedlings among hardwood sprouts. The heavy dominance of pines also suggests that the fell-and-burn technique may be successful on sites with better fertility and more moisture where hardwoods would be stronger competitors. This study represents the first definitive measurement of volume resulting from low-cost regeneration techniques in the Southeastern Piedmont. NIPF landowners may find these results to be attractive because the value of these stands was increased after a low initial investment.

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Table 1—Pine (all species) characteristics, 11 and 20 growing seasons after site preparation burning

Variable	Treatment	Year 11	Year 20
Number per ac	Burned	425 b[1]	392 b
	Unburned	336a	293a
DBH (in)	Burned	7.0 b	6.8a
	Unburned	5.5a	7.0a
Volume (ft^3/ac)	Burned	-	1,408a
	Unburned	-	1,212a

[1]Means for each variable followed by the same letter within a column are not significantly different at α=0.05.

Table 2—Hardwood (all species) characteristics, 11 and 20 growing seasons after site preparation burning

Variable	Treatment	Year 11	Year 20
Number per ac	Burned	1,731a[1]	531a
	Unburned	2,586 b	601a
DBH (in)	Burned	-	1.7a
	Unburned	-	2.2 b
Volume (ft^3/ac)	Burned	-	99a
	Unburned	-	176 b

[1]Means for each variable followed by the same letter withina column are not significantly different at α=0.05.

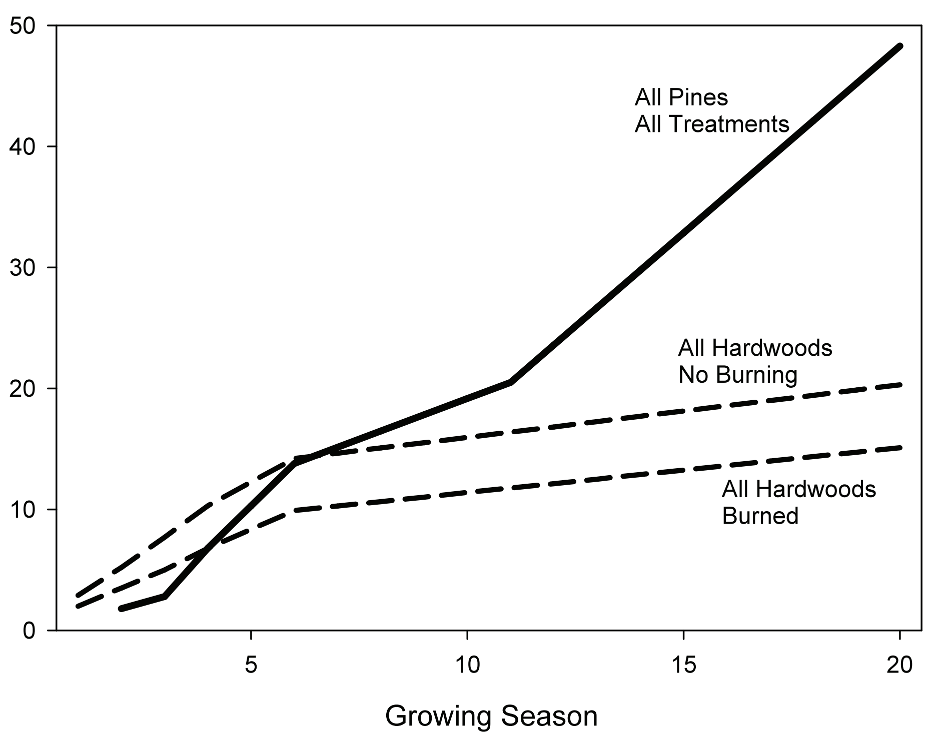

Figure 1—Height of pines (all species, all treatments) and hardwoods (all species) in burned and unburned plots through 20 growing seasons.