PERFORMANCE OF MIXED PINE-HARDWOOD STANDS 16 YEARS AFTER FELL-AND-BURN TREATMENTS

Elizabeth M. Blizzard, David H. Van Lear, G. Geoff Wang, and Thomas A. Waldrop[1]

Abstract—Four variations of the fell-and-burn technique were compared for height and volume production on dry Piedmont sites. A two-factorial randomized complete block design of winter versus spring felling, with and without a summer burn, was implemented, followed by planting of loblolly pine (*Pinus taeda* L.) at 15 x 15 foot spacing. After 16 growing seasons, the winter fell with summer burn treatment resulted in greater planted pine volume (1,087.1 ± 72.8 cubic feet per acre) than either unburned treatment (652.4 ± 89.2 cubic feet per acre). The winter fell with no burn treatment resulted in greater oak volume (373.5 ± 71.3 cubic feet per acre) than did either burn treatment (108.7 ± 58.3 cubic feet per acre). Modifications of the fell-and-burn treatment can be used to alter the dominance of pine or hardwood components in developing mixed pine-hardwood stands. Stands should be monitored for further effects of canopy closure, self-thinning, and growth of oaks into micro-canopy gaps.

INTRODUCTION

Forest owners may be left with low-quality hardwoods after a pine overstory is removed (Wear and Greis 2002). While owners may not wish to return to predominately pine stands, they are willing to manage their forests for desired characteristics (Hull and others 2004). The fell-and-burn technique (Abercrombie and Sims 1986) was used in the 1980s and early 1990s to regenerate mixed pine-hardwood stands in the southern Appalachians. This technique, along with its three variations, was tested for suitability on drier Piedmont sites in order to provide landowners with the option of adding pines while improving hardwood quality (Waldrop 1997, Waldrop and others 1989). The treatments were: winter fell with no burn, spring fell with no burn, winter fell with summer burn, and spring fell with summer burn.

Growing season felling was proposed to reduce hardwood sprout vigor, which would allow planted pines to become established (Zedaker and others 1989). Moving felling from growing season to dormant season was proposed to improve hardwood competitiveness on drier Piedmont sites (Newcomer and others 1986, Zedaker and others 1989).

Not burning was also proposed to increase hardwood competitiveness, although burning provides a larger proportion of better quality sprouts (Augspurger and others 1986). Not burning saves landowners money and simplifies the regeneration process, but logging slash remains on site, and there is a greater proportion of stool sprouts versus more desirable basal sprouts (Augspurger and others 1986). Basal sprouts occur closer to the root collar and generally produce healthier, better quality boles. Burning kills the cambium above the root collar, leading to a higher proportion of basal sprouts.

Spacing of planted pines affects hardwood competitiveness after the pines overtop the hardwoods and canopy structure develops. Pines planted too closely may force hardwoods to bend and become misshapen. An ideal spacing allows room for oaks to grow in micro-gaps between the pines and encourages the pines to self prune some. Although pine spacing used in other studies ranged from 6.6 x 6.6 feet to 10 x 10 feet (McGee 1989, Nix and others 1989, Zedaker and others 1989), a larger pine spacing of 15 x 15 feet was used to improve the competitiveness of hardwoods when testing the fell-and-burn technique on drier Piedmont sites.

The objectives of our study were (1) to determine if pines survive beyond crown closure when planted among hardwood sprouts on drier Piedmont sites and (2) to compare pine and oak volumes in 16-year-old pine-hardwood stands as impacted by four site preparation treatments (table 1).

METHODS

The study sites are located in northeast South Carolina on the Clemson Experimental Forest. Soils are Typic Halpudults, with 7 to 10 percent slope and southern exposure (Waldrop 1997). Plant communities were classified as xeric and subxeric. The subxeric sites contained, for example, post oak, black oak, and lowbush blueberry. Xeric sites contained species such as white oak, scarlet oak, and deerberry (Jones 1989, Waldrop and others 1989).

The treatment design was a two-factorial randomized complete block with winter fell with no burn, spring fell with no burn, winter fell with summer burn, and spring fell with summer burn treatments. Complete descriptions of the treatments were given by Waldrop and others (1989) and Waldrop (1995,

Table 1—Oak and planted pine species on study sites

Common name	Scientific name
Black oak	*Quercus velutina* Lam.
Blackjack oak	*Q. marilandica* Muenchh.
Chestnut	*Q. prinus* L.
Loblolly pine	*Pinus taeda* L.
Post oak	*Q. stellata* Wangenh.
Scarlet oak	*Q. coccinea* Muenchh.
Southern red oak	*Q. falcata* Michx.
Water oak	*Q. nigra* L.
White oak	*Q. alba* L.

[1] Forestry Technician, Bowen Professor, and Associate Professor, respectively, Clemson University, Department of Forestry and Natural Resources, Clemson, SC 29634; and Research Forester, USDA Forest Service, Southern Research Station, Clemson, SC 29634.

Citation for proceedings: Connor, Kristina F., ed. 2006. Proceedings of the 13th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS–92. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 640 p.

1997). Heights and diameters of all stems 6 feet high or greater were measured on planted pines within 1/20 acre plots and on oaks within nested 1/40 acre plots after 16 growing seasons. Height data reported by Waldrop (1997) through the 6th growing season were combined with data collected after the 11th growing season to diagram change in heights over time. Heights collected after 11 growing seasons were of the dominate sprout within a clump. Mean separation was performed using pair-wise comparisons of least square means (α = 0.05).

RESULTS AND DISCUSSION

Waldrop (1997) concluded after six growing seasons that planted pines overtopped hardwoods on each treatment, indicating that season of felling and the use of a summer burn were not factors in planted pine success on drier Piedmont sites. This trend continued through the 16th growing season (fig. 1); however, significant differences in treatments became apparent after canopy structure developed and impacted tree growth. Volumes of planted pines and oaks synthesize these treatment affects over time. Affects of treatments are discussed below.

The winter fell with summer burn treatment resulted in greater planted pine volume (1,087.1 ± 72.8 cubic feet per acre) than either unburned treatment (652.4 ± 89.2 cubic feet per acre) (tables 2 and 3). Results for the spring fell with summer burn treatment (990.6 ± 75.5 cubic feet per acre) are inconclusive. With only two replications there is an increased risk of declaring an insignificant difference when there is a significant difference. In a few years, spring fell/summer burn treatments may

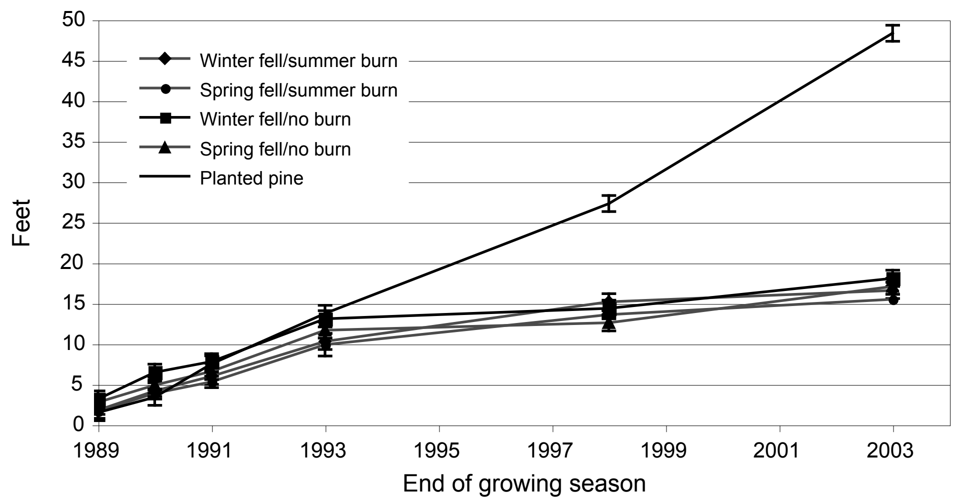

Figure 1—Effects of silvicultural treatments on planted pine and hardwood heights over time. Planted pine heights are averaged across treatments. Hardwood heights include all hardwoods and are represented by treatment.

Table 2—Mean planted pine and oak volume (cubic feet per acre) ($\bar{X}$ ± SE) by species group and treatment after 16 growing seasons

Treatments	Planted pine[a]	Oak[b]
	- - - - - - - *cubic feet per acre* - - - - - - -	
Winter fell/ no burn	658.4a (±90.7)[c]	373.5a (±71.3)
Spring fell/ no burn	646.3a (±87.7)	203.6ab (±69.0)
Winter fell/ summer burn	1,087.1b (±72.8)	116.3b (±57.2)
Spring fell/ summer burn	990.6ab (±75.5)	101.1b (±59.4)

[a] Pine volume includes stemwood to a 4 inch top, based upon d.b.h. and total-tree height for 5 inches d.b.h. and up.
[b] Oak volume consists of above-stump total tree wood for 2 inch d.b.h. and up. Oak species found were scarlet, southern red, white, post, black, chestnut, water, and blackjack.
[c] Least square means with the same letter within a column are not significantly different at α = 0.05. Standard error means are in parentheses.

Table 3—Planted pine volume t-statistics[a]

	Spring fell/ burn	Spring fell/ no burn	Winter fell/ burn	Winter fell/ no burn
Spring fell/ burn		0.0588	0.4252	0.0670
Spring fell/ no burn	0.0588		0.0306	0.9298
Winter fell/ burn	0.4252	0.0306		0.0346
Winter fell/ no burn	0.0670	0.9298	0.0346	

[a] Probability of a t-statistic greater than the absolute value of t for the null hypothesis that the least square mean of treatment i equals the least square mean of treatment j.

Table 4—Oak volume t-statistics[a]

	Spring fell/ burn	Spring fell/ no burn	Winter fell/ burn	Winter fell/ no burn
Spring fell/ burn		0.1302	0.9321	0.0254
Spring fell/ no burn	0.1302		0.1371	0.1418
Winter fell/ burn	0.9321	0.1371		0.0258
Winter fell/ no burn	0.0254	0.1418	0.0258	

[a] probability of a t-statistic greater than the absolute value of t for the null hypothesis that the least square mean of treatment i equals the least square mean of treatment j, based upon analysis of ranks.

also have significantly greater volume than unburned treatments at $\alpha = 0.05$.

The winter fell with no burn treatment resulted in greater oak volume (373.5 ± 71.3 cubic feet per acre) than did either burn treatment (108.7 ± 58.3 cubic feet per acre) (tables 2 and 4). Burning negates the advantage of winter felling by killing all sprouts and shortening the initial growing season. The spring fell with no burn treatment (203.6 ± 69.0 cubic feet per acre) was not significantly different from other treatments. The volumes were based upon oaks with d.b.h. ≥ 2 inches; further treatment effects may be detected as the stands continue to self-thin and shorter oaks enter micro-gaps in the main canopy.

SUMMARY AND CONCLUSIONS

While height growth is a good early indicator of successful tree establishment, longer-term treatment effects may not become apparent until canopy structure develops and impacts tree growth. Results after six growing seasons suggested that planted pine survival and growth on unburned treatments was similar to burned treatments (Waldrop 1997). The current results suggest that burning does improve planted pine volume. Oaks were taller on unburned treatments after 6 growing seasons, but only the winter felled with no burn treatment had greater volume than the winter felled and burned treatment after 16 growing seasons. Based upon these results, a landowner wishing to grow mixed stands of pines and hardwoods should use a summer site preparation burn to improve pine volume or avoid burning to improve oak volume.

ACKNOWLEDGMENTS

The College of Agriculture, Forestry, and Life Sciences at Clemson University funded 2003 data collection and analysis. Study sites are maintained on Clemson University's Experimental Forest. Initial funding for the study was provided by the Georgia Forestry Commission. Initial data and technical support came from the U.S. Department of Agriculture, Forest Service, Southern Research Station, SRS-4104, Disturbance and Management of Southern Ecosystem Research Work Unit.

LITERATURE CITED

Abercrombie, J.A., Jr.; Sims, D.H. 1986. Fell and burn for low-cost site preparation. Forest Farmer. 46(1): 14-17.

Augspurger, M.K.; Van Lear, D.H.; Cox, S.K.; Phillips, D.R. 1986. Regeneration of hardwood coppice following clearcutting with and without prescribed fire. In: Phillips, D.R., ed. Proceedings of the fourth biennial southern silvicultural research conference. Gen. Tech. Rep. SE-42. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 89-92.

Hull, R.B.; Robertson, D.P.; Buhyoff, G.J. 2004. "Boutique" forestry: new forest practices in urbanizing landscapes. Journal of Forestry. 102 (1): 14-19.

Jones, S.M. 1989. Application of landscape ecosystem classification in identifying productive potential of pine-hardwood stands. In: Proceedings of pine-hardwood mixtures: a symposium on management and ecology of the type. Gen. Tech. Rep. SE-58. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 64-69.

McGee, C.E. 1989. Converting low-quality hardwood stands to pine-hardwood mixtures. In: Proceedings of pine-hardwood mixtures: a symposium on management and ecology of the type. Gen. Tech. Rep. SE-58. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 107-111.

Newcomer, K.P.; Zedaker, S.M.; Smith, D.W.; Kreh, R.E. 1986. Even-aged regeneration alternatives for low quality mixed hardwood forests in the Virginia Piedmont. In: Phillips, D.R., ed. Proceedings of the fourth biennial southern silvicultural research conference. Gen. Tech. Rep. SE-42. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 169-175.

Nix, L.E.; Ruckelshaus, T.F.; Jones, S.M. 1989. Early crop tree presence in upland pine-hardwood stands related to site quality and preharvest stand composition. In: Proceedings of pine-hardwood mixtures: a symposium on management and ecology of the type. Gen. Tech. Rep. SE-58. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 112-116.

Waldrop, T.A. 1995. Variations in the fell-and-burn system to regenerate pine-hardwood mixtures in the piedmont. In: Edwards, M.B., comp. Proceedings of the eighth biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-1. Asheville, NC: U.S. Department of Agriculture, Forest Service Southern Research Station: 401-405.

Waldrop, T.A. 1997. Four site-preparation techniques for regenerating pine-hardwood mixtures in the piedmont. Southern Journal of Applied Forestry. 21(3): 116-122.

Waldrop, T.A.; Lloyd, F.T.; Abercrombie, J.A., Jr. 1989. Fell and burn to regenerate mixed pine-hardwood stands: an overview of research on stand development. In: Proceedings of pine-hardwood mixtures: a symposium on management and ecology of the type. Gen. Tech. Rep. SE-58. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 75-82.

Wear, D.N.; Greis, J.G. 2002. The southern forest resource assessment summary report. Gen. Tech. Rep. SRS-53. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 635 p.

Zedaker, S.M.; Smith, D.W.; Kreh, R.E.; Fredericksen, T.S. 1989. The development of five-year-old mixed upland hardwood pine stands. In: Proceedings of pine-hardwood mixtures: A symposium on management and ecology of the type. Gen. Tech. Rep. SE-58. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 100-106.