FERTILIZATION AND THINNING IN A 7-YEAR-OLD NATURAL HARDWOOD STAND IN EASTERN NORTH CAROLINA

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Abstract—Young even-aged hardwood stands undergo a period of intense competition and self-thinning during the early years of stand development. During this time relatively little growth is accumulated by stems which will persist until rotation age. Silvicultural manipulations which accelerate the rate of stand development, concentrate growth on fewer stems of desirable species and reduce rotation age would be useful options for forest managers. This study reports on an experiment in a 7-year-old stand in northeastern NC, in which growth responses to thinning to 3000 trees per acre and fertilization with N and P were evaluated. Findings indicate that after 3 years, thinning alone did not significantly enhance growth, while fertilization alone or in combination with thinning enhanced growth, and in similar amounts.

INTRODUCTION

Accelerating the growth of naturally regenerated hardwood stands is an important goal of forest managers. Across the southern U.S. many of these stands are even-aged, having regenerated following clearcutting. Through the natural processes of regeneration (including stump and root sprouts, and seedlings), stand consolidation and self-thinning, timber typically reaches merchantable size in 40 to 60 years. Common methods of promoting the growth of these stands take place when the timber is at least pole-sized, often 20 to 30 years old, and stand density has naturally declined to a few thousand stems per acre. Fertilization and thinning in younger stands may accelerate the rate of stand development, concentrating growth on fewer and more valuable stems, and reducing rotation age. These changes could have significant economic advantages.

Studies in natural hardwoods have long demonstrated that thinning can have many positive benefits in production forestry, provided damage to the residual stand and soils are prevented (Gingrich 1971, Heitzman and Nyland 1991). Few studies have reported on stands less than 10 years old. Most reports are from Appalachian uplands. Fertilization in natural stands has been infrequently studied, with reports indicating a variety of stand responses (Dunn and others 1999, Graney and Rogerson 1985, Farmer and others 1970). It is well established that enhancing site resources through fertilization, and reducing inter-tree competition (and herbaceous competition) through density control, and these factors in combination, can enhance productivity, often for many years following treatment (Johnson and others 1997). In the current study we report initial findings from a fertilization and thinning trial in a young North Carolina coastal plain upland hardwood stand.

METHODS

The study site is located on International Paper Company land (formerly a Union Camp Corporation site) in northeastern North Carolina (Northampton County) on a coastal plain mineral flat of somewhat poorly to poorly drained silty clay loam (Lenoir series). These soils can be phosphorus-deficient, with relatively low productivity. The stand consists of naturally regenerated mixed pine-hardwoods, which grew following a commercial clearcut of the prior natural stand in 1990. The current dominant species are sweetgum (*Liquidambar styraciflua* L.), and red maple (*Acer rubrum* L.).

The experimental design was a 2 x 2 factorial (thinning and fertilization as main effects) with three blocks. Treatments were imposed when the stand was 7 years old with a density of approximately 8500 stems per acre. Treatment plots measure 166 ft. x 166 ft., with interior measurement plots of 100 ft. x 100 ft. Within each measurement plot there were 13 circular 154 sq. ft. subplots. Thinning was done in winter 1997 by reducing density to circa 3000 stems per acre with a brushcutter, using spacing and desirable species as a guide. Fertilizer was hand broadcast applied in spring 1998 as 200 lbs. per acre N (in urea and diammonium phosphate [DAP]) and 50 lbs. per acre P (in DAP).

Here we present data on mean tree size (Height and DBH) at age 10 (measured winter 2000/2001), and the 3 year increment between age 7 (measured May 1997) when treatments were applied and age 10. Stand volume, and increment, by treatment are also presented. Volume was estimated by summing subplot standing volumes for each treatment plot, and using an expansion factor to express them on a per acre basis. DBH and height were measured for all stems > 4.5 ft. tall and > 1.5 inches diameter (DBH). Stem volume was calculated as $(DBH^2*Height)*(0.002)$.

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Table 1—Mean growth response after 3 years of trees treated at age 7, in a naturally regenerated North Carolina coastal plain upland. Means within a column followed by different letters are significantly different at P = 0.10, by protected LSMeans. "ANOVA" indicates the statistical analysis for each parameter across treatments, and "Fertilization" and "Thin X Fert" indicate the significance of the main effect or treatment interaction for each parameter. Thinning was not a significant main effect.

	- *Measures at Age 10* -		
Treatment (Statistics)	Height (ft.)	DBH (in.)	Volume (cu. ft. per ac.)
Control	22.7 ab	2.43 a	353 a
Thinned	22.0 ab	2.44 a	317 a
Fertilized	23.8 ab	2.52 a	557 b
Thinned + Fertilized	24.6 b	2.82 b	660 c
(ANOVA)	F = 5.99, P = 0.025	F = 6.90, P = 0.018	F = 39.73, P=0.0002
(Fertilization)	P = 0.030	P = 0.070	P = 0.0001
(Thin X Fert)	P = 0.327	P = 0.233	P = 0.056
-	- - - - - - - - - - - *3-Year Cumulative Increment Age 7 to 10* - - - - - - - - - - - - - -		
Control	4.2 a	0.33	266 a
Thinned	4.5 a	0.35	220 a
Fertilized	5.8 b	0.50	479 b
Thinned + Fertilized	6.1 b	0.70	538 b
(ANOVA)	F = 8.57, P = 0.011	F = 2.52, P = 0.145	F = 39.56, P = 0.0002
(Fertilization)	P = 0.010	P = 0.040	P = 0.0001
(Thin X Fert)	P = 0.972	P = 0.434	P = 0.086

Canopy cover was estimated with a spherical densiometer in mid-August 2000. Data were analyzed by the General Linear Model procedure, and when significant differences among treatments were found, means were separated by the LS Means procedure (SAS 1989).

RESULTS AND DISCUSSION

Differences in tree size and cover among the treatments were visually apparent 3 years after thinning and fertilization. Densiometer readings of canopy cover were, control 77 percent, fertilized 86 percent, thinned 56 percent, and thinned + fertilized 83 percent. Ground cover patterns, data not reported here, reflected the inverse of the densiometer readings, and trees were noticeably larger in the treatment plots than the controls. Given the demonstrated positive relationships between leaf area, as approximated by densiometer readings in this case, and productivity (Albaugh and others 1998), we would expect that the treatment plots with high canopy cover would be more productive.

There were no significant differences (P = 0.10) in height, DBH or estimated volume among treatment plots in May 1997 immediately post treatment. Three years after the treatments were applied, mean height, DBH and volume, and 3-year cumulative increments for these measures, differed significantly among treatments (table 1). The interaction between thinning and fertilization was only significant for the volume estimates (table 1). Blocking effects were significant at age 10 for all parameters (P < 0.05). In general, the control and thinned plots did not differ, and had smaller trees than the fertilized and thinned + fertilized plots, which were similar to each other. For all parameters measured, the thinning effect was not significant (P > 0.10), and the fertilization effect was significant (table 1).

The data suggest that height growth was more responsive to the treatments than diameter growth, and that thinning alone did not generate a substantial growth response, whereas fertilization did. Observations of the thinned only plots suggested that thinning in this stand resulted in site resources being made available to competing plants (herbaceous, woody shrubs [notably wax myrtle, *Myrica cerifera*], and stump sprouts of cut trees), without benefit to the residual stand. When thinning was coupled with fertilization, however, the residual stand was apparently able to capture a significant portion of the newly available and added site resources, and exhibit a positive growth response.

These types of interacting biotic and abiotic constraints to growth have been reported, and typically support the idea that thinning alone, when the residual stand is not immediately able to occupy the new space (typical of young stands), does not result in enhanced growth (Graney and Rogerson 1985, Kolb and others 1989, Romagosa and Robison 1999). However, when coupled with weed control and/or fertilization, the response can be substantial (Schuler and Robison, this issue). In the current study, fertilization alone resulted in increased growth for most parameters, and suggests that this low-cost silvicultural intervention may have good operational potential. Although thinning coupled with fertilization did not appreciably increase growth over fertilization alone, the data trends and significant interaction between these treatments (table 1) suggest that over time, the combined effect may be greater than either individual treatment.

The treatments in the current study do not indicate what the effect of thinning + weed control might have been, however other studies suggest that the positive aspects of density reduction can be realized in young stands when weed control is used (Pham 1988, Schuler and Robison, this issue). Further, it cannot be determined which fertilizer element was responsible for the positive effects recorded in this study, nor does this study reveal optimum rates or timing for fertilization. However, the results reported here suggest that substantial productivity gains may be realized in very young stands.

CONCLUSIONS

Fertilization alone and in combination with thinning nearly doubled the 3-year stand volume increment from age 7 to 10 in this study in young natural hardwoods. Thinning alone did not enhance growth in the 3 years post treatment. These findings suggest that early stand silvicultural interventions may substantially accelerate stand development and shorten rotation age, with clear operational potential. If through such practices, species composition and stem quality could also be improved, the benefits to timber production would be enhanced further.

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REFERENCES

Albaugh, T.J.; H.L. Allen; P.M. Dougherty; L.W. Kress; J.S. King. 1998. Leaf-area and above- and belowground growth responses of loblolly pine to nutrient and water additions. Forest Science. 44: 317-328.

Dunn, M.A.; K.W. Farrish; J.C. Adams. 1999. Fertilization response in a natural bottomland hardwood stand in north-central Louisiana. Forest Ecology Management. 114: 261-264.

Farmer, R.E.; Jr., G.W. Bengtson; J.W. Curlin. 1970. Response of pine and mixed hardwood stands in the Tennessee Valley to nitrogen and phosphorus fertilization. Forest Science. 16: 130-136.

Gingrich, S.F. 1971. Management of young and intermediate stands of upland hardwoods. Res. Pap. Darby, PA: U.S. Department of Agriculture, Forest Service, NE Experiment Station, Upper NE-195. 26 p.

Graney, D.L.; T.L. Rogerson. 1985. Development of oak, ash and cherry reproduction following thinning and fertilization of upland hardwood stands in the Boston Mountains of Arkansas. In: Prosceedures. Third Southern Silvicultural Research Conference: 171-177.

Heitzman, E.; R.D. Nyland. 1991. Cleaning and early crop-tree release in northern hardwood stands: a review. Northern Journal of Applied Forestry. 8 (3): 111-115.

Johnson, J.E.; J.J. Bollig; R.A. Rathfon. 1997. Growth response of young yellow-poplar to release and fertilization. Southern Journal of Applied Forestry. 21(4): 175-179.

Kolb, T.E.; T.W. Bowersox; L.H. McCormick; K.C. Steiner. 1989. Effects of shade and herbaceous vegetation on first-year germination and growth of direct-seeded northern red oak, white ash, white pine, and yellow-poplar. Gen. Tech. Rep. NC-132: U.S. Department of Agriculture, Forest Service.

Pham, C.H. 1988. Thinning young, natural hardwood regeneration with broadcast herbicide application. In: R.L. Hay and others eds. Proceedings of the Central Hardwood Forest Conference; 1987 February 24-26; Knoxville, TN: 205-215.

Romagosa, M.A.; D.J. Robison. 1999. An evaluation of biological constraints to the early growth of natural hardwood regeneration on North Carolina Piedmont clearcuts. ,In: Waldrop, T.A., ed. Proceedings of the Ninth biennial southern silvicultural research conference; 1997 February 25-27, Clemson, SC. Gen. Tech. Rep. SRS-20. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 39-42.

SAS (Statistical Analysis System). 1989. SAS/STAT User's Guide, version 6, 4th ed., Vols. 1 and 2. SAS Institute, Inc., Cary, NC.