

ACCELERATING DEVELOPMENT WITH FERTILIZATION IN A YOUNG NATURAL PIEDMONT MIXED HARDWOOD PINE STAND

B.J. Berenguer, M.H. Gocke, J.L. Schuler,
E. Treasure, and D.J. Robison¹

Abstract—A rising two-year-old even-aged naturally regenerated upland Piedmont mixed hardwood-pine stand was broadcast fertilized with N, N + P, and N + P + K to evaluate stand level responses to fertility treatments. There were significant positive stand responses in self thinning and mean stem size measured two growing seasons after fertilizer applications. Findings suggest efficient ways to enhance productivity with implications for age at final age harvest and economic value.

INTRODUCTION

Very many acres across eastern North America are managed (or perhaps best managed) as naturally-regenerated even-aged mixed-species stands, with growth rates not as fast as desired. A central question for foresters managing these stands for commodity production is: Can these growth rates be accelerated? In addition, very many acres of these stands are not managed at all, or not between the time of regeneration and when they reach pole-size. The relevant question in this regard is: Can young stands, ages 1 to 15, be managed efficiently to enhance growth rate?

In the current study we sought to evaluate the impact of broadcast fertilization of N, N+P, and N+P+K on the growth of a rising two-year-old naturally regenerated mixed species upland Piedmont stand in NC. A number of other researchers have addressed similar questions in natural hardwoods, with a wide variety of results (Auchmoody 1989, Beckjord and others 1983, Dunn and others 1999, Graney and Pope 1978, Johnson and others 1997, Lamson 1978, Newton and others 2001).

METHODS

The study was conducted in central NC on an upland mixed-species Piedmont site (site index 23 m for loblolly pine at 50 years) on the NC State University Hill Demonstration Forest in Durham County (Kirby 1976). The site has previously been occupied by a maturing 33-year-old loblolly pine plantation with a large component of mixed hardwood understory and some hardwood overstory. That stand was salvage clearcut in early 2003 following severe ice storm damage. All trees greater than 4 cm d.b.h. were either cut during the harvest, or girdled before the installation of the current study.

Across the site 4 blocked replications of 20.4 by 10.2 m plots were delineated in rising 2-year-old natural regeneration in May 2004. Each replication included four treatments of hand broadcast fertilizer (table 1).

An initial inventory of stems was conducted in June 2004 (one month after the fertilizer treatments were applied)

whereby a single 2-m wide transect through the middle of the plot was delineated and the height of each stem to the 2003 growth cessation point was recorded for all stems greater than 60 cm tall. No significant differences in stem density or height were found among treatment plots or blocks. In October 2005, two growing seasons after fertilizer treatment a second inventory was conducted. This time two 2-m wide transects per plot were delineated and stem height and ground-line diameter (GLD) for stems over 60 cm tall were recorded.

The most common species on the site were 29 percent loblolly pine (*Pinus taeda*), 16 percent sweetgum (*Liquidambar styraciflua*), 13 percent red maple (*Acer rubrum*), 12 percent red oak group (*Quercus* spp.), 10 percent tulip poplar (*Liriodendron tulipifera*), 6 percent hickory (*Carya* spp.), and 5 percent white oak group (*Quercus* spp.).

RESULTS AND DISCUSSION

There were significant differences among fertilizer treatments plots in mean stem height, groundline diameter (GDL), and a volume index of GLD*GLD*height (table 2).

On this site there were significant growth responses to the treatments, generally with Control < N < N + P = N + P + K for groundline diameter, height and volume index. While there were no significant differences among treatments with

Table 1 — Fertilizer treatments applied to rising 2-year-old natural mixed hardwood-pine regeneration on the Hill Forest, Durham County, NC

Treatments	Kg of N/ha	Kg of P/ha	Kg of K/ha
Control	0	0	0
N	200	0	0
N+P	200	50	0
N+P+K	200	50	100

Note: N applied as ammonium nitrate (34-0-0), P applied as triple super phosphate (0-46-0), K applied as potash (0-0-60).

¹Department of Forestry and Environmental Resources, Hardwood Research Cooperative, North Carolina State University, Raleigh, NC. (Current address for Schuler is School of Forest Resources, University of Arkansas, Monticello, AR.)

Table 2—Two year whole stand all species combined growth response to fertilizer treatments as measured on naturally regenerated 3-year-old mixed hardwood-pine stems on the Hill Forest, Durham County, NC

Measurement Parameter	Control	Fertilizer N only	Treatments N + P	N + P + K	Level of ANOVA Significance
Density (Number per ha)	52,000	39,000	35,000	37,000	ns
Groundline Diameter (GLD) (cm)	1.4	1.7	2.1	1.9	P<0.05
Height (Ht) (cm)	128	173	212	177	P<0.05
Volume Index (GLD*GLD*Ht)	65	108	169	147	P<0.05

respect to stem density after two years, there was a strong trend to suggest that the accelerated growth of stems under any of the fertilizer treatment regimes had promoted self thinning and a reduction in stem density (table 2).

These findings indicate that on relatively low fertility Piedmont sites that the growth of natural regeneration can be greatly enhanced by modest fertilizer applications. The N and P fertilizer rates used in this study are similar to those used to promote the growth of planted pines in the region. The use of K fertilizer in the current study was exploratory, given some indication in other studies that sweetgum might respond favorably to K addition (Coleman and others 2003). While in the current analysis it can not be determined how sweetgum specifically responded to K, it is evident that overall stand response was similar between the N + P and N + P + K plots. There is some unexplained indication that the addition inclusion of K with N and P reduced the growth response relative to N + P only.

Fertilizer application to planted pine forests in the U.S. south has become fairly routine (Albaugh and others 1984), and could be readily expanded to naturally regenerated mixed species stands, on sites justifying the intervention. Stand response at very young ages, as measured in the current study, may serve to promote stand development through self thinning, and the concentration of growth on fewer stems. These processes could lead to reduced rotation age, and perhaps enhanced species composition if differential species response could be targeted, and thereby enhance economic returns (Siry and others 2004). Very young stands in similar conditions have also responded positively to the effects of thinning and herbaceous competition control (Romagosa and Robison 2003, Newton and others 2001, Schuler and Robison 2006), and together with fertilization there may

practical ways to promote the development and value of these stands.

LITERATURE CITED

- Albaugh, T.J.; Allen, H.L.; Dougherty, P.M. [and others]. 2004. Long term growth responses of loblolly pine to optimal nutrient and water resource availability. *Forest Ecology and Management*. 192: 3-19.
- Auchmoody, L.R. 1989. Fertilizing natural stands. In: Clark, F.B.; Hutchinson, J.G. (ed.) *Central hardwood notes*. Note 6.11. U.S. Forest Service, North Central Forest Experiment Station, St. Paul, MN.
- Beckjord, P.R.; Melhuish, J.H. Jr.; McIntosh, M.S. [and others]. 1983. Effects of nitrogen fertilization on growth and ectomycorrhizal formation of *Quercus alba*, *Q. rubra*, *Q. falcata*, and *Q. falcata* var. *pagodifolia*. *Canadian Journal of Botany*. 61: 2507-2514.
- Coleman, M.D.; Chang, S.X.; Robison, D.J. 2003. DRIS analysis identifies a common potassium imbalance in sweetgum plantations. *Communications in Soil Science and Plant Analysis*. 34: 1919-1941.
- Dunn, M.A.; Farrish, K.W.; Adams, J. C. 1999. Fertilization response in a natural bottomland hardwood stand in North Central Louisiana. *Forest Ecology and Management*. 114: 261-264.
- Graney, D.L.; Pope, P.P. 1978. Response of red oaks and white oak to thinning fertilization in the Boston Mountains of Arkansas. In: *Proceeding second central hardwood forest conference*: 357-369.
- Johnson, J.E.; Bollig, J.J.; Rathfon, R.A. 1997. Growth response of yellow poplar to release and fertilization. *Southern Journal of Applied Forestry*. 21: 175-179.
- Kirby, R.M. 1976. Soil survey of Durham County, North Carolina. USDA Soil Conservation Service. 73 p.
- Lamson, N.I. 1978. Fertilization increases growth of sawlog-size yellow poplar and red oak in West Virginia. Research Paper NE-403. U.S. Forest Service, Northeastern Forest Experiment Station, Broomall, PA.
- Newton, L.D.; Robison, D.J.; Hansen, G. [and others]. 2001. Fertilization and thinning in a 7 year old natural hardwood stand in eastern North Carolina. In: *Proceedings of the 11th biennial southern silvicultural research conference*. Gen. Tech. Rep. SRS-48. U.S. Forest Service, Southern Research Station. Asheville, NC: 193-195.
- Romagosa, M.A.; Robison, D.J. 2003. Biological constraints on the growth of hardwood regeneration in upland piedmont forests. *Forest Ecology and Management*. 175: 545-561.
- Schuler, J.L.; Robison, D.J. 2006. Stand development and growth responses of 1- and 3-year-old natural upland hardwoods to silvicultural treatments. *Forest Ecology and Management*. 232: 124-134.
- Siry, J.; Robison, D.J.; Cubbage, F.W. 2004. Economic returns model for silvicultural investments in young natural hardwood stands. *Southern Journal of Applied Forestry*. 28: 179-184.