CONSORTIUM FOR ACCELERATED PINE PRODUCTION STUDIES (CAPPS): LONG-TERM TRENDS IN LOBLOLLY PINE STAND PRODUCTIVITY AND CHARACTERISTICS IN GEORGIA

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Beginning in 1987, a series of long-term study plots were installed to determine the effects of annual nitrogen fertilization and complete control of competing vegetation on loblolly pine (*Pinus taeda* L.) stand growth and development. The study had two locations, one at the Dixon State Forest (DSF) near Waycross, GA on the lower coastal plain and the other at the B.F.Grant Experimental Forest (BFG) near Eatonton, GA on the Piedmont. The Dixon State Forest is characterized by long, hot, humid summers, with an average maximum July temperature of 33°C, and winters that are cool and fairly short, with an average January low temperature of 2.6°C. Average annual precipitation is about 130 cm, with about 60 percent falling between April and September. Soils are spodosols or ultisols that are arenic or grossarenic with slopes < 1 percent. The B. F. Grant location is characterized by warm to hot summers, with average July high temperature of 33°C, and moderately cold but highly variable winters, with average January low temperature of 2.2°C. Average annual precipitation is about 120 cm, with a maximum in early spring, a minimum in fall, and fairly even distribution for the rest of the year. Soils are clayey ultisols with slopes < 15 percent. Within each location there were two study sites separated by less than 6 kilometers.

Loblolly pine stands were established at a density of 680 trees/ac in 1987, 1989, and 1993 at the DSF location and in 1988, 1990, and 1995 at the BFG location. Half-sib family 7-56 was planted (North Carolina State Tree Improvement Cooperative) at the DSF locations and half-sib family 10-25 (North Carolina State Tree Improvement Cooperative) was planted at the BFG location. Two treatment blocks of each stand age were established at each of the two sites within locations. The exception was only one block of the 1995 planting was established at each site at BFG location. Each treatment block comprised four 0.15 ha plots that were assigned one of four treatments. The plot-level treatments were a factorial combination of fertilization and interspecific competition control. The fertilizer treatment (F) was an annual fertilization regime, consisting of 280 kg/ha diammonium phosphate and 112 kg ha^{-1} potassium chloride in the spring and 56 kg/ha ammonium nitrate in the summer of the first two years after establishment, followed by a minimum of 168 kg/ha ammonium nitrate in the spring of subsequent years. The interspecific competition control treatment (H) was an herbicide treatment to eliminate all competing vegetation throughout stand development. The HF treatment was the combination of fertilization and competition control. The control treatment (C), received neither fertilization or competition control.

Response of tree growth to the treatments has been exceptional. In general, the effects of competition control were greatest during early stand development, causing an upward shift in the relationship between stand age and growth. In contrast, the fertilization treatment increased the slope of the relationship between stand age and growth. Overall, the response of competition control was greater at the BFG location than it was on the DSF location. Average tree height at the DSF location at age 14 was 52, 68, 56, and 69 ft for the C, F, H, and HF treatments respectively. At the BFG location at age 13, average tree heights were 45, 55, 54, and 60 feet for the C, F, H, and HF treatments respectively. Total standing volume for the DSF location was 2665, 5645, 3745, 6342 ft^3/ac at age 14 for the C, F, H, and HF treatments and was 2363, 3438, 3703, 4579 ft^3/ac for the same treatments at the BFG location at age 13. Basal area at the DSF location was 109, 183, 146, and 199 ft^2/ac for the C, F, H, and HF stands at age 14 and was 111, 142, 151, 172 ft^2/ac for the same plots at the BFG location at age 13. Mean annual increment of the fastest growing HF plots at the DSF location appeared to have peaked around age 13 at approximately 490 ft^3/ac yr. The HF stands at the BFG location were approximately 350 ft^3/ac yr at age 13, but had not yet reached their maximum. Current annual increment (CAI) of the F and the HF plots at the DSF location approached 800 ft^3/ac yr between ages 8 and 12, and then decreased. The CAI of the C and H plots have remained fairly stable, below 400 ft^3/ac yr, over the same age range. At the BFG location, CAI was greater for the H treatment than for the F treatment until age 9. After age 9, the opposite was true. Maximum CAI for the HF plots at the BFG location was approximately 600 ft^3/ac yr. At both locations, there was a positive and fairly linear relationship between LAI and basal area. Height to live crown and basal area also were linearly related. Although crown length increased with stand basal area, the increase was much smaller than that for the relationship between height to live crown and basal area. At both locations, the average number of branches per whorl increased with increasing height, reaching a maximum of about 3.5 at the DSF location and 4.0 at the BFG location.

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Fertilization and competition control had significant positive effects on litterfall-based estimates of stand leaf area index (LAI). All-sided LAI for the foliage cohort that developed in 1998 was 3.9, 5.3, 5.7 and 7.0 for the C, F, H, and HF treatment plots, respectively, at the BFG location and 5.3, 7.6, 6.1 and 8.2 for the corresponding DSF plots. The effect of fertilization on LAI was strongest in older stands at both locations (significant interaction between age and fertilization). Fertilization increased LAI at the BFG location by 3 percent, 34 percent, and 28 percent for stand ages 4, 9 and 11, respectively, and at the DSF location by 8 percent, 38 percent and 79 percent for stand ages 6, 10 and 12. Competition control influenced LAI most dramatically in the youngest BFG stands (significant interaction between age and competition control), where competition control resulted in more than four times greater LAI at age four compared with 23 and 29 percent greater LAI at ages 9 and 11. Treatment and age effects on foliar nitrogen concentration closely paralleled effects on LAI. Stemwood growth per unit of leaf area (GE) declined with stand age, with mean values of 480, 220 and 203 ft^3/ac yr proj LAI for stand ages 4, 9 and 11 at the BFG location, and 277 to 226 to 189 ft^3/ac yr proj LAI for stand ages 6, 10, and 12 at the DSF location. The response of nitrogen use efficiency (NUE) to fertilization and competition control was similar to that of GE.

At both locations, GE and NUE decreased linearly with tree size, indicating the decreases in GE and NUE were probably due to tree size rather than tree age. At the DSF location, but not the BFG location, fertilized stands had greater GE when compared to unfertilized stands with equal sized trees indicating that fertilization had a positive effect on GE throughout stand development. For instance, fertilization increased GE expressed on a biomass basis from 3.4 to 4.5 tons bolewood prod. per ton leaf biomass for trees 11 m tall and from 2.1 to 2.5 tons bolewood prod. per ton leaf biomass for trees 17 m tall. For NUE, the differences between the fertilized and unfertilized stands of equal size were less than those for GE due to greater nitrogen concentration in the foliage of the fertilized stands.