EFFECTS OF PLANTING DENSITY AND GENOTYPE ON CANOPY SIZE, CANOPY STRUCTURE, AND GROWTH OF 25-YEAR-OLD LOBLOLLY PINE STANDS IN SOUTHEASTERN OKLAHOMA

Thomas C. Hennessey, Rodney E. Will, Thomas B. Lynch, Robert Heinemann, Randal Holeman, Dennis Wilson, Keith Anderson, and Gregory Campbell[1]

Abstract—Leaf biomass and its display within the canopy are important driving variables of stand growth because they reflect a tree or stand's capacity to intercept radiation, reduce carbon dioxide, and transpire water. We determined the effects of planting density (4- by 4-, 6- by 6-, 8- by 8-, and 10- by 10-foot spacing) on annual needle fall biomass, intercepted radiation, and canopy openness and then related these measures of canopy size to current annual increment and basal area for 25-year-old stands planted with two loblolly pine (*Pinus taeda* L.) seed sources: North Carolina Coastal (NCC 8-01) and Oklahoma/Arkansas (O/A mix 4213). The study site is located on an excessively drained, mountain site in southeastern Oklahoma. Litter was measured using randomly located traps and summed for a phenological year (Apr. 1 to Mar. 31). Intercepted radiation and canopy openness were measured using hemispherical photographs and the WinScanopy canopy analysis software. After 25 years, initial planting density no longer significantly affected litterfall, intercepted radiation, or canopy openness. Canopy openness was greater for the North Carolina Coastal than the Oklahoma/Arkansas genotypes. Somewhat surprisingly, the measures of canopy size were not related to current annual increments. In contrast, basal area (or standing volume) was correlated to canopy size (R^2 = 0.12 for litterfall, R^2 = 0.45 for intercepted radiation, and R^2 = 0.13 for canopy openness). Possible reasons for lack of a relationship between canopy size and current annual increment could be due to varying and sometimes intense intraspecific competition, environmental variation across the site, varying and sometimes large amounts of woody biomass relative to foliage, and previous stochastic events. Correlation between basal area and canopy size indicates canopy variables have some ability to predict basal area.

[1] Professor, Associate Professor, and Professor, Oklahoma State University, Department of Natural Resource Ecology and Management, Stillwater, OK; Superintendent, Research Staff, Research Staff, Research Staff, and Research Staff, Oklahoma State University, Kiamichi Forestry Research Center, Idabel, OK, respectively.

Effects of planting density and genotype on canopy size, canopy structure, and growth of 25-year-old loblolly pine stands in southeastern Oklahoma

Thomas C. Hennessey, Rodney E. Will, Thomas B. Lynch, Robert Heinemann, Keith Anderson, Dennis Wilson, Randal Holeman, Gregory Campbell & Ed Lorenzi

respectively, Professor, Associate Professor, and Professor, Dept. Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK and Station Superintendent and research professionals, Kiamichi Forestry Research Station, Idabel, OK

ABSTRACT

Leaf biomass and its display within the canopy are important driving variables of stand growth because they reflect a tree or stand's capacity to intercept radiation, reduce carbon dioxide, and transpire water. We determined the effects of planting density (4 x 4, 6 x 6, 8 x 8, and 10 x 10 foot spacing) on annual needle-fall biomass, intercepted radiation, and canopy openness and then related these measures of canopy size to current annual increment and basal area for 25-year-old stands planted with two loblolly pine seed sources: North Carolina Coastal (NCC 8-01) and Oklahoma/Arkansas (O/A mix 4213). The study site is located on an excessively drained, mountain site in southeastern Oklahoma. Needle litter was measured using randomly located traps and summed for a phenological year (1 April to 31 March). Intercepted radiation and canopy openness were measured using hemispherical photographs and the WinScanopy Canopy Analysis Software. Somewhat surprisingly, the measures of canopy size were not related to current annual increment. In contrast, basal area (or standing volume) was correlated to canopy size.

OBJECTIVE

1) Determine the effects of planting density (4 x 4, 6 x 6, 8 x 8, and 10 x 10 foot spacing) on annual needle-fall biomass, stand-level basal area, intercepted radiation, and canopy openness for 25-year-old stands planted with two loblolly pine seed sources: North Carolina Coastal (NCC 8-01) and Oklahoma/Arkansas (O/A mix 4213).

2) Determine the relationships between measures of canopy size and stem current annual increment.

METHODS

The research site, near Broken Bow, Oklahoma is a droughty, mountain soil outside the native range of loblolly pine. Soils were classified as the Goldston–Carnasaw–Sacul association, which are upland, gravelly, moderately steep, silt loams with low water-holding capacity. The average annual rainfall of the area is 125 cm (49 in.), and the average annual temperature is 17 °C (63°F). Rainfall is usually adequate through May, but droughts 2–6 weeks in duration are common from June through October. Except for subsoiling at planting, no other stand-level treatments were applied. Stands were established in 1983. Treatments were a combination of spacing (4 x 4, 6 x 6, 8 x 8, and 10 x 10 foot) and seed source (Oklahoma-Arkansas vs. North Carolina Coastal). Between 3 and 5 plots per spacing x genotype combination were measured.

Diameters of all trees and heights of a subset of trees were periodically measured. For trees with height measurements, volume inside bark was calculated. Subsequently, treatment specific regressions between individual tree volume and basal area were used to calculate the volumes of the remaining trees. Current annual increment was calculated from successive dormant season measures of volume. Needle litter was measured using five randomly located 1 m^2 traps per plot and summed for a phenological year (1 April to 31 March). Canopy openness, an estimate of percent canopy not obscured by foliage, was measured using hemispherical photographs and the WinScanopy Canopy Analysis Software. Intercepted radiation was measured in September using the SunScan Canopy Analysis System. All variables were calculated at the plot-level. Regressions between canopy variables and current annual increment and basal area were conducted.

RESULTS

After 25 years, initial planting density no longer significantly affected needlefall, intercepted radiation, or canopy openness. Canopy openness was greater for the NCC than the OA genotypes (Tab. 1). [For more detailed analysis of volume and basal area, see poster by Will et al.] The canopy variables were not related to net current annual increment (Fig. 1) or gross current annual increment (data not shown). However, the canopy variables were correlated to basal area (Figure 2) and standing volume (data not shown).

Table 1. Mean attributes for stands from two genotypes (*Geno*) planted at four densities (*Spacing*). Genotypes were from North Carolina (NCC) and Arkansas/Oklahoma (OA). *BA 08* is basal area at the end of the 2008 growing season. *CAI 08 net* is net current annual increment for the 2008 growing season. *CAI 08 gr* is gross current annual increment (volume of trees that died during the 2008 growing season were added back into calculations. *Litter 06* is the foliage cohort that developed during the 2006 growing season and remained on the trees into early 2008. *Int rad* is the percent of radiation intercepted by the canopies. *Can open* is the percent of canopy not obscured by foliage.

Geno	Spacing (tpa)	n	BA 08 (ft^2 ac^{-1})	(s.e.)	CAI 08 net (ft^3 ac^{-1} y^{-1})	(s.e.)	CAI 08 gr (ft^3 ac^{-1} y^{-1})	(s.e.)	Litter 06 (lbs ac^{-1})	(s.e.)	Int rad (%)	(s.e.)	Can open (%)	(s.e.)
NCC	436	4	180.2	12.8	226.8	26.4	283.7	2.5	4257	92	87	0.4	33.3	9.8
NCC	681	5	185.7	8.8	198.5	15.9	211.6	10.3	4171	35	84	0.2	33.2	12.9
NCC	1210	3	215.7	23.2	246.0	10.0	273.5	7.1	4264	25	86	0.1	30.0	2.1
NCC	2723	3	234.0	14.9	164.3	8.9	344.2	15.2	4342	54	89	0.2	29.8	5.7
OA	436	3	196.4	18.2	243.6	26.7	243.6	11.7	4418	39	91	0.1	29.1	0.6
OA	681	4	197.7	11.2	189.1	19.6	194.6	8.9	4059	53	89	0.3	29.3	12.0
OA	1210	3	199.4	13.7	132.3	14.2	153.7	4.4	4077	8	89	0.2	30.3	3.4
OA	2723	3	200.7	16.7	189.5	17.1	394.4	6.3	4191	69	87	0.3	30.5	2.1

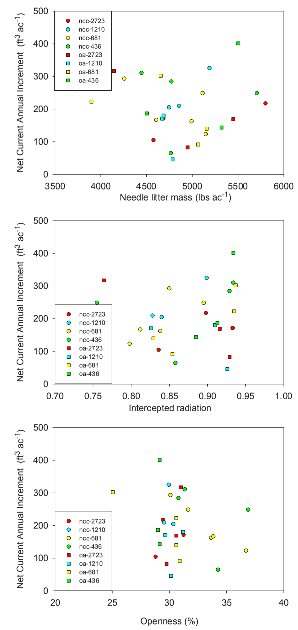
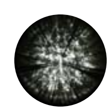


Figure 1. Relationship between current annual increment for the 2008 growing season and litter mass of the 2006 foliage cohort, radiation intercepted by the canopy, and canopy openness. Numbers in legend correspond to planting density. OA refers to Oklahoma/Arkansas and NCC refers to North Carolina Coastal.

Litter trap in front right

SunScan Canopy Analysis System (ceptometer)



Example hemispherical photograph

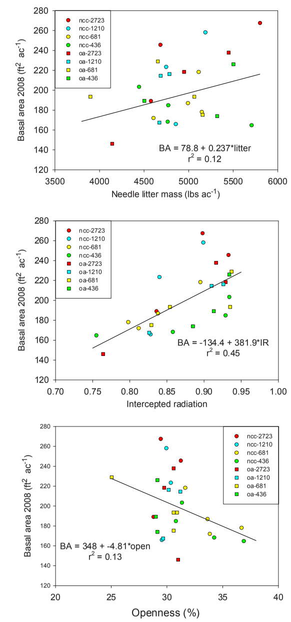
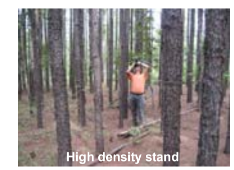


Figure 2. Relationship between basal area following the 2008 growing season and litter mass of the 2006 foliage cohort, radiation intercepted by the canopy, and canopy openness. Numbers in legend correspond to planting density. OA refers to Oklahoma/Arkansas and NCC refers to North Carolina Coastal.



DISCUSSION

While common in younger and/or more vigorous stands, we found no relationship between current annual increment and canopy size in these 25-year-old, dense stands. Possible reasons for lack of a relationship could be due to varying and sometimes intense intraspecific competition, environmental variation across the site, varying and sometimes large amounts of woody biomass relative to foliage, differences in partitioning to biomass components such as branch and roots, and previous stochastic events. Correlation between basal area and canopy size indicates canopy variables have some ability to predict basal area.

Acknowledgements

We thank Phil Dougherty and Weyerhaeuser for establishing the study plots and the U.S. Forest Service for continued site maintenance.