Integration of Crown Morphology and Leaf-Level Physiology as a Tool for Explaining Differences in Aboveground Productivity among Elite Families of Loblolly and Slash Pine

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To a growing extent, current silvicultural systems involve the deployment of genetically improved planting material, together with high-input silvicultural treatments to increase forest productivity. As forest plantations become increasingly uniform, factors that limit tree growth should be identified in order to effectively alleviate those limitations.

Forest production depends on CO_2 assimilation, but is rarely solely a function of leaf-level photosynthesis. Crown characteristics may affect tree growth by altering light interception and photosynthesis at canopy level. Strong light gradients are present in forest canopies, which often result in parallel changes in leaf morphology and leaf nitrogen for efficient use of light in photosynthetic CO_2 uptake. The genetic basis of crown and canopy trait differences among southern pine taxa are not well understood, but are critical for predicting growth and productivity differences for managing sustainable forest ecosystems.

In our study we investigated effects of intensive silvicultural treatments on crown morphology and within-crown leaf-level physiology, and the relationship to aboveground productivity of selected families of loblolly and slash pine. In young stands, before canopy closure, we found significant among-family differences in crown structure and between-species differences in leaf area density per unit of crown volume. Loblolly pine had larger crowns than slash pine trees of the same age or size, but maintained lower leaf area per given crown volume. The two pine species also differed in specific leaf area and leaf nitrogen at age four. These traits were highly variable within crowns, reflecting leaf-level acclimation to light gradients within a canopy when stands approach canopy closure. Leaf-level photosynthesis rates varied among different crown positions at only one of two experimental sites and was not affected by intensive silvicultural treatment. Area-based leaf photosynthesis increased from the lower to the upper portion of the canopy for loblolly pine, but was lower at the upper than in the middle crown position for slash pine. However, species did not differ in leaf-level photosynthesis rates at any crown position.

High intensity treatments, although effective in increasing biomass accumulation in all examined families, did not affect leaf morphology or physiology. Aboveground biomass production differed among tested families and was related more to accumulated leaf area and its display within crowns than to differences in rates of leaf-level photosynthesis.