LONGLEAF PINE GROWN IN VIRGINIA: A PROVENANCE TEST

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In 2006 the Virginia Department of Forestry established a longleaf pine (*Pinus palustris* Mill.) provenance test on three sites near Richmond, VA, near the most northern native range of longleaf pine. Seedlings were grown in containers at the Virginia Department of Forestry New Kent Forestry Center during the 2005 growing season. The provenances originated from native trees in Virginia, a natural stand and a seed orchard in North Carolina, and natural stands in South Carolina, Georgia, Florida, Alabama, and Mississippi. The provenances were grown on three sites, two previous nursery sites that were treated with herbicide and watered periodically during year one (New Kent -- 37° 25’ N, 77° 01’ W and Garland Grey -- 36° 51’ N, 77° 10’ W) and a cut-over site (Sandy Point -- 37º 40’ N, 76º 55 W) that was mowed once in year one and not watered. Trees were measured for survival and height growth in years three, five and seven.

The sites varied widely in survival at age seven: New Kent (94 percent), Garland Grey (67 percent), and Sandy Point (57 percent). Height growth at Sandy Point was lowest at all ages: at age 7, mean height was 3.9, 3.9, and 2.7 m for trees at New Kent, Garland Grey, and Sandy Point, respectively. At age three, growth was greatest for the VA trees and decreased in a mostly clinal pattern (generally decreasing height growth from north to south). By age 5, the heights of the provenances on the nursery sites (New Kent and Garland Grey) had largely converged while the clinal pattern was maintained on the lower productivity Sandy Point site. After the seventh growing season, no provenance differences in height were observed on any site.

At the end of the fifth growing season, foliage was collected for analysis of carbon isotope discrimination ($\Delta^{13}C$). Measurement of the carbon isotope ratio of leaf tissue provides an assimilation-weighted average of the ratio of leaf intercellular CO_2 partial pressure (p_i/p_a) to atmospheric CO_2 partial pressure (Farquhar et al. 1989). This ratio (p_i/p_a) is important because it is a function of photosynthetic capacity and stomatal conductance. Changes in p_i/p_a are a function of changes in either, or both, photosynthetic capacity or stomatal conductance. Since leaf carbon isotope ratio provides information about processes integrated over the whole life of the leaf, it is particularly useful for examining subtle genetic differences in photosynthetic characteristics.

Water use efficiency (assessed via $\Delta^{13}C$) was greatest in the VA trees on all sites. A relationship between height and $\Delta^{13}C$ was observed (r = -0.55) only on the cut-over site (Figure 1), the site that had not been irrigated and had the lowest productivity. Theoretical (Farquhar et al. 1989) and empirical (Johnsen 1999) evidence indicates the faster growth associated with lower $\Delta^{13}C$ values was due to variation in photosynthesis. When the 25% best performing trees for height growth at age 5 and water use efficiency are identified (Figure 1), approximately half are from the Virginia seed source and the other half are from trees derived from more southern sources.

The current area of longleaf pine ecosystems in the southern United States is only approximately 3 percent of its former (pre-European) extent, and there is increasing interest in its restoration (Gilliam and Platt 2006). Such interest includes restoring such ecosystems in Virginia which

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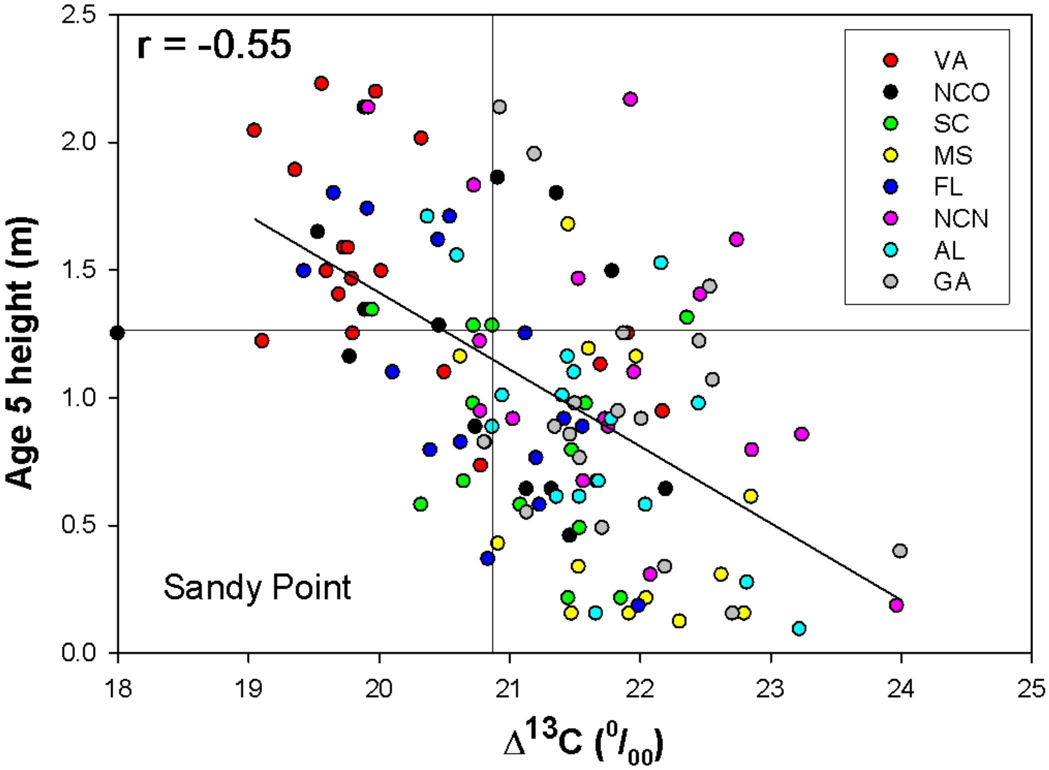

Figure 1--The relationship between height at age 5 and Δ^{13}C for all sample trees at the Sandy Point site. Water use efficiency decreases with increasing Δ^{13}C. The top left quadrant contains data from the 25 percent of trees with the greatest height growth and lowest water use efficiency.

contains what are thought to be populations near or at the most northern part of its historical range. Clearly, the first step in restoring longleaf pine ecosystems where no longleaf currently exists is planting longleaf pine seedlings. Schmidtling and White (1990) showed that a Virginia seed source of longleaf pine performed poorly, relative to other sources, even at their most northern planting site. Here we found the Virginia source to display the fastest early growth and equal growth to the other sources at age 7. However it must be noted that our Virginia source was the result of seed collection from only 10 trees from one small population. In addition, molecular genetic analyses indicate that the 40% of the Virginia trees in our study may have one maternal parent (Craig Echt, personal communication). Thus, our results may not be representative.

Schmidtling (2001) indicated that longleaf pine seed sources can safely be moved so that the average annual minimum temperature of the planting site is within 2.8° C (5° F) of the seed sources' and that transfers up to 5.6° C (10° F) are possible although some growth potential may be lost. In our small study with extremely divergent seed sources grown at the northern edge of its native range, although southern sources grew slower initially, by age seven they were as tall as northern sources. These results may have ramifications with respect to restoring the species in light of climate change. Although it would likely be unwise to totally ignore native seed sources, a useful strategy may be to inter-mix a percentage of more southern seed sources, perhaps using or even exceeding Schmidling's (2001) more liberal suggestion, in longleaf pine restoration efforts in the north to increase adaptive potential. Of course, variation in flowering phenology will need to be understood so that gene flow can be maintained across the seed sources via something approximating random mating.

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