GENETIC DIVERSITY, PHYSIOLOGIC EXPRESSION, AND CARBON DYNAMICS IN LONGLEAF PINE AT THE HARRISON EXPERIMENTAL FOREST

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In 1960, an experiment was established on the Harrison Experimental Forest in southeast Mississippi to compare productivity of planted longleaf, loblolly and slash pines of local origin (Smith and Schmidlting 1970). Longleaf pine lagged in productivity during the early years, but eventually surpassed loblolly and slash pine. Hurricane Katrina (August 2005) left the experiment heavily damaged; especially the loblolly pine plots. Recently region-wide interest in restoring longleaf pine has developed, with an important goal being to increase forest resilience to climate change and extreme climate events. Little is known about the value and variability of adaptive traits in longleaf pine. Our goal is to better understand genetic control of these traits (survival, disease resistance, productivity) as expressed on a hurricane prone longleaf pine site characterized by relatively low soil fertility. This new installation will allow a direct comparison of longleaf pine families originating from four seed sources (ranging from southeast Texas to north Alabama) under three planting densities. Physiologic differences between and within the sources will be analyzed along with differences in height, diameter, stem taper and carbon allocation to specific components (foliage, branches, stems, roots) across the planting density gradient. Allelic states of several genes will be related to survival and performance traits. This experiment will inform development of genetic guidelines for restoring resilient longleaf pine ecosystems.

Previous Experimental Results

Key findings thus far:

- Age 9, intensive culture increased productivity of all species; loblolly pine had greater height and volume than longleaf or slash pine (Schmidtling, 1973). Mean yields in the highest fertilizer treatment were loblolly 41 Mg ha^{-1} (18.3 ton $acre^{-1}$) slash 29 Mg ha^{-1} (12.9 ton $acre^{-1}$), longleaf 12 Mg ha^{-1} (5.4 ton $acre^{-1}$).
- Age 25, longleaf surpassed slash and loblolly pine in height in the control plots, characterized by low nutrient availability. At the highest level of intensity loblolly was still >2 m taller than the other species (Schmidtling, 1986).
- Age 39, there were no species differences in diameter at breast height (dbh), though dbh increased with intensity level. Significant differences in height were attributed to both species (slash>longleaf>loblolly) and cultural intensity (3x fert.>2x fert.>1x fert>control>disking no fert).
- Age 45, Hurricane Katrina impacted the site; longleaf pine suffered the least mortality, followed by slash and loblolly pine respectively (7%, 15%, 26%) (Johnsen et al. 2009).
- In 2006, after Hurricane Katrina, mean basal area across all treatments was 23 m^2 ha^{-1} (100 ft^2 ac^{-1}) for longleaf, 12.4 m^2 ha^{-1} (54 ft^2 ac^{-1}) for loblolly, and 19.3 m^2 ha^{-1} (84 ft^2 ac^{-1}) for slash pine.

New Experiment

The new installation will compare four longleaf pine sources (ranging from southeast Texas to north Alabama) under three planting densities (746, 1329, 2197 trees per hectare or 303, 528, 889 trees per acre) using a randomized complete block design. Within each plot, there will be four genetic source split-plots: USFS Region 8 (R8) TX/LA source, R8 south MS/south AL source, R8 north AL source, and an unimproved local source (i.e., control, representing genetic quality of original planting). Each R8 source represents one generation of genetic improvement. Physiologic differences between and within the sources will be analyzed along with differences in height, diameter, stem taper and carbon content. Allelic states of several genes will be tested relative to survival and performance traits. Experiments such as this will inform development of genetic guidelines for restoring resilient longleaf pine ecosystems.

Discussion

The original experiment has been invaluable for comparing long term productivity and carbon dynamics between three species of planted pines and continues to have demonstration and research value. Instead of simply harvesting the entire site and starting over, a novel plan which includes retaining some of the original plots and moving them to uneven age management with thinning was devised. Natural regeneration of longleaf pine is most successful in large gaps in the canopy. We are installing each of the new measurement plots in 55 m by 55 m gaps (180 ft by 180 ft) created by clear cutting (Figure 1). Some of the original longleaf pine plots have accrued exceptional basal area, with a few plots approaching 45 m^2 ha^{-1} (196 ft^2 ac^{-1}); 11 plots will be thinned to 23 m^2 ha^{-1} (100 ft^2 ac^{-1}) to continue studying them under relatively high density (Figure 1). The rest of the plots will be thinned to 14 m^2 ha^{-1} (60 ft^2 ac^{-1}). Prescribed fire will be re-established on a 2 year cycle.

Several goals will be accomplished by this study: 1) creation of a longleaf pine planting density x genetic source study, 2) restoration of a longleaf pine ecosystem with fire and planting, 3) enhanced aesthetics and habitat with gap layout, 4) unique opportunity to study longleaf genetics and physiology at the Harrison Experimental Forest in a multi-age stand, and 5) initiation of a genetic field study for genetically mapping quantitative traits in longleaf pine. Thinning and harvesting are planned for summer 2011, site preparation in fall 2011, followed by planting during the winter of 2011-2012.

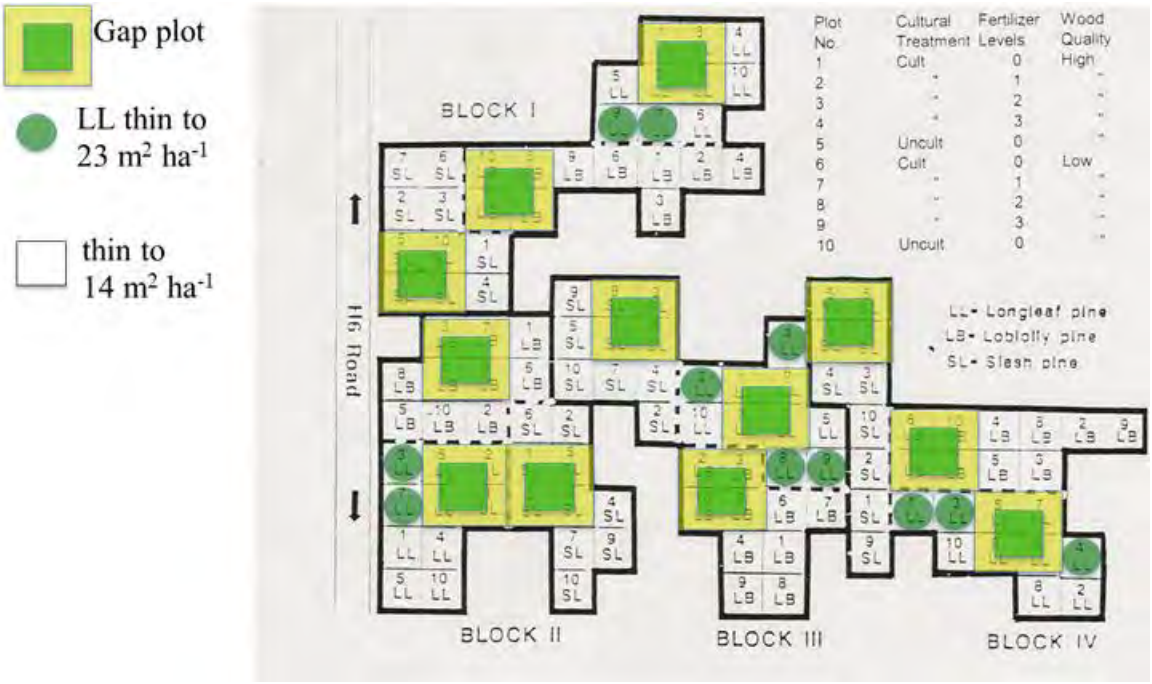

Figure 1. Map showing the location of 12 new gap plots created by combining 4 adjacent plots from the original experiment. A 5 tree buffer (yellow, light gray) will surround the new measurement area (green, darker shade). The buffer area will be thinned to14 m^2 ha^{-1} (60 ft^2 ac^{-1}) while a 55 m by 55 m (180 ft by 180 ft) area will be clear cut to create the new measurement plot. The location of 11 longleaf plots which will be thinned to 23 m^2 ha^{-1} (100 ft^2 ac^{-1}) are marked with a green (darker shade) circle, all other plots will be thinned to 14 m^2 ha^{-1} (60 ft^2 ac^{-1}).

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