PINEMAP

AUBURN UNIVERSITY

Early Impacts of Rainfall Manipulation and Fertilization Treatments on the Ecophysiology of Loblolly Pine in the Georgia Tier III Installation

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Background

A central goal of the PINEMAP project is to quantify climate, soils, and management impacts on carbon sequestration in planted pine ecosystems and provide data on these impacts to build and verify models that simulate pine forest dynamics under varying climate. To help achieve this goal, we are studying the interactive effects of a 30% reduction in rainfall and nutrient availability on the ecophysiology of loblolly pine. This field experiment is part of the PINEMAP Tier III "Throughfall Exclusion x Fertilization" network, in which nutrients and water are manipulated at four sites situated at the edges of the native loblolly pine range (Figure 1).

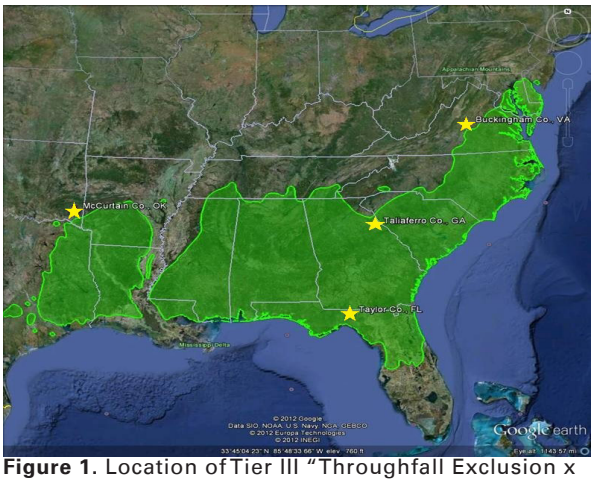

Figure 1. Location of Tier III "Throughfall Exclusion x Fertilization" research sites.

Methods

The Georgia Tier III site is located in the Piedmont physiographic region in Taliaferro County. At this site, seedlings were planted in 2006 and treatments consisting of two levels of rainfall (ambient or 30% reduction in ambient rainfall) and two levels of fertilization (none or 224 kg N ha-1, 28 kg P ha-1 and 56 kg K ha-1) were initiated in spring 2012. The 30% reduction in ambient rainfall was achieved using exclusion troughs covering 30% of the land area in a plot (Figure 2). From July through November 2012, we examined leaf physiological characteristics such as net photosynthesis, stomatal conductance, and leaf water potential. In addition, sap flow measurements began in October 2012 and will be used to estimate stand level water use and canopy level stomatal conductance. Leaf area index (LAI) and intercepted radiation (IPAR) have been monitored since May 2012.

Figure 2. Throughfall exclusion structures at the Tier III site in Taliaferro County, Georgia. Photos by Madison Akers.

Results

Initial studies indicate that the 30% rainfall exclusion treatment has a significant effect on leaf physiology. Across all measurement months, rainfall exclusion reduced net photosynthesis by 12% on average and stomatal conductance by 27% (Figure 3). Predawn leaf water potential was reduced by rain exclusion, but midday leaf water potential was not affected. Preliminary sap flow data indicates a 20% reduction in total daily transpiration in response to the rain exclusion treatment, from 1.5 to 1.2 mm day-1 over a 7-day period in October, which was due to a reduction in midday maximum sap flux density. As of yet, fertilization has not had a significant effect on these variables.

In comparison, fertilization has affected LAI, with changes detected as early as June 2012 (Figure 3). Peak LAI increased from 1.7 with no fertilization to 2.1 with fertilization. At peak LAI, IPAR increased from 70% to 80%. Thus far, rainfall exclusion has not had a significant effect on LAI or IPAR and interactions between the rainfall exclusion and fertilization treatments have not yet been detected.

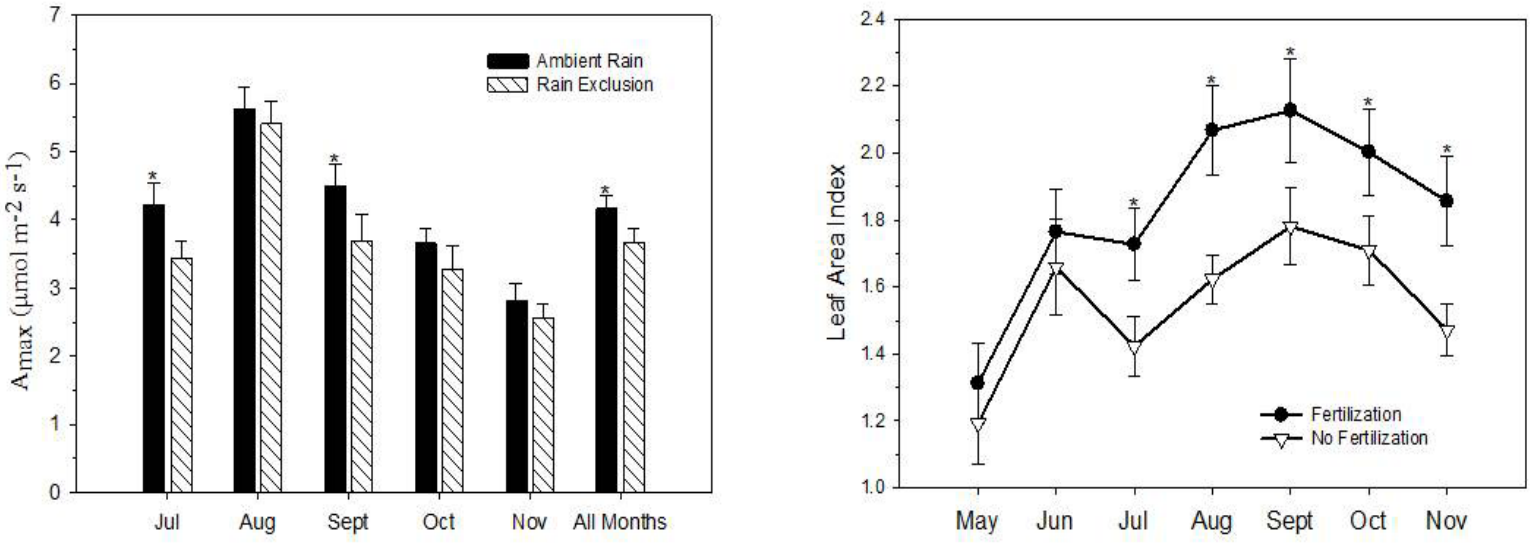

Figure 3. Influence of the rainfall exclusion treatment on leaf light-saturated net photosynthesis (A_{max}) and influence of fertilization on leaf area index (LAI) of loblolly pine at the Georgia Tier III research installation. Asterisks indicate a significant difference between treatments.

Implications

These results indicate early responses to changes in the availability of water and nutrients. To date, net photosynthesis, stomatal conductance, and predawn water potential have been sensitive to water availability, and leaf area production has been responsive to nutrient availability. A key question to be answered is whether, over time, interactions will develop between water and nutrient availability. For example, increased leaf area production in response to fertilization may also increase tree susceptibility to drought events. Results from this study will contribute to the PINEMAP Decision Support System which will provide landowners and managers the tools necessary to make decisions about managing planted pine for increased carbon sequestration, enhanced fertilizer efficiency, and resilience to altered disturbance regimes.

For additional information on this research,
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USDA United States Department of Agriculture National Institute of Food and Agriculture

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