Effects of a 30% Reduction in Precipitation on Transpiration and Hydraulic Properties of 7-Year-Old Loblolly Pine

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AIM I GOALS

1. Create a three-tiered platform to measure ecophysiological parameters.
2. Investigate loblolly pine responses to fertilization and artificial drought throughout the species' natural range.
3. Determine C, N and H_2O fluxes and pools under drought conditions associated with climate change.
4. Provide ecophysiological parameters for 3-PG and WaSSI models.

RESEARCH OBJECTIVES

Objective 1: Examine the effects of a 30% reduction in precipitation combined with fertilization treatment effects on the hydraulic properties of loblolly pine including: canopy stomatal conductance (G_S), transpiration (E_L, E_G), whole-tree hydraulic conductance (G), leaf specific hydraulic conductance (G_L) and the leaf area to sapwood area ratio (A_L:A_S).

Objective 2: Determine if drought influences relationships between hydraulic properties and environmental variables, specifically vapor pressure deficit.

Objective 3: Determine if nutrient availability increases drought effects or if drought limits fertilizer effects.

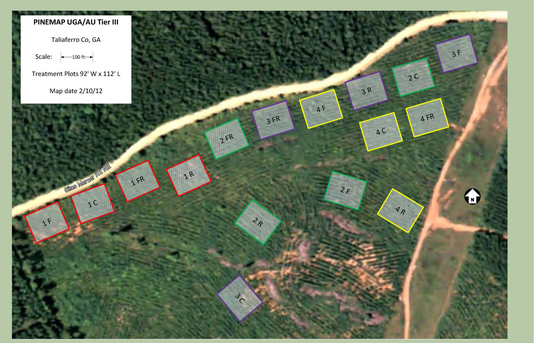
APPLICATION TO PINEMAP

The results from this research will be used by PINEMAP to:

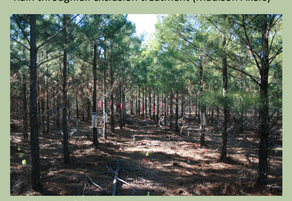
1. Provide water relation parameters for the 3-PG and Water Supply and Stress Index (WaSSI) models.
2. Determine the accuracy of the 3-PG and WaSSI model outputs.
3. Provide the physiological understanding of underlying regulatory mechanisms of water use efficiency differences between regions and among genotypes under changing climatic conditions.

EXPERIMENTAL DESIGN

- The Tier III Experimental Site is located in Taliaferro Co., Georgia, and was planted with a second generation open-pollinated family of loblolly pine in 2006.
- The experimental design is a 2x2 factorial combination of fertilization and rainfall manipulation treatments replicated in four blocks.



Rain throughfall exclusion treatment (Madison Akers)



Ambient rainfall treatment

Rainfall Manipulation Treatments

- Ambient Rainfall
- Throughfall Rain Exclusion (trays installed in understory to divert ~30% of rainfall from the treatment plots)

Fertilization Treatments

- No Fertilization
- Fertilization (224 kg N ha^{-1}, 28 kg P ha^{-1} P, 56 kg K ha^{-1} and a micro-nutrient blend; applied March, 2012)

METHODS

Thermal dissipation probe installation

Installed thermal dissipation probe

- Five trees in each measurement plot (80 trees total), absent of forks, were randomly selected based upon basal diameter distribution.
- Sap velocity was determined using 20 mm thermal dissipation probes, modified after Granier.
- Probes were inserted by removing the outer bark and drilling two small holes (2.5 and 2.0 mm in diameter) spaced 9 cm apart into the sapwood.
- Silicon was applied around the thermocouples to seal out moisture
- Stems were wrapped with porous Reflectix® insulation around the probes to reduce thermal gradients.
- Diameter at breast height (DBH) is continuously monitored using auto-mated dendrometer bands attached to each measurement tree at a height of 1.3 m.
- Leaf Area Index (LAI) is being measured monthly using the LAI-2000 plant canopy analyzer (LICOR Inc., Lincoln, NE).
- A cellular networked weather station with a data logger is collecting continuous environmental data (precipitation, wind speed, photosynthetic active radiation, global radiation, temperature and relative humidity).
- G_S was calculated following Samuelson et al. (2007).

LAI-2000 plant canopy analyzer

RESULTS

Diel Sap Flux Density

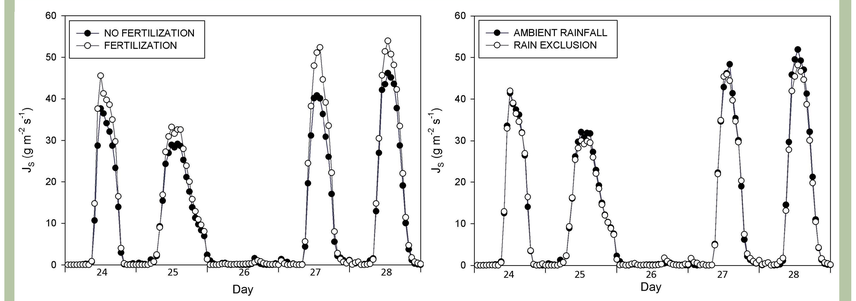


Figure 1. Example of average diel sap flux density (J_S) of 7-year-old loblolly pine in response to fertilized and rain exclusion treatments at the Georgia Tier III experiment from February 24-28, 2013.

Transpiration

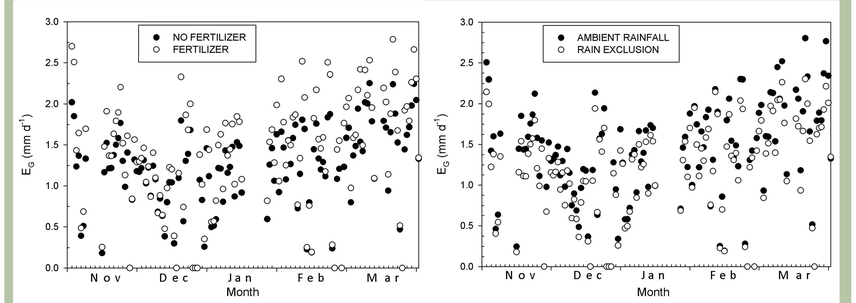


Figure 2. Average daily transpiration per unit ground area (E_G) of 7-year-old loblolly pine in response to fertilized and rain exclusion treatments at the Georgia Tier III experimental site.

Sap Flux Density

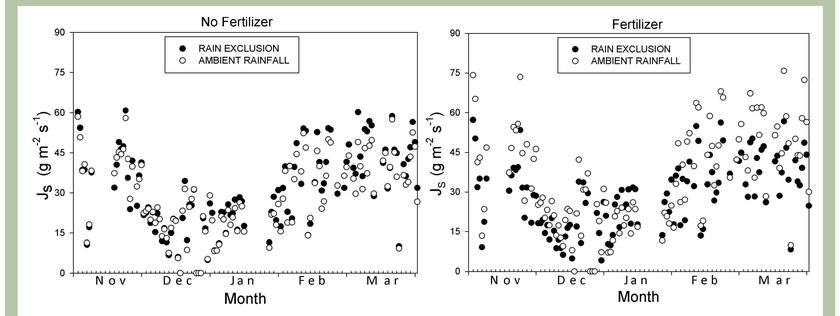


Figure 3. Average daily sap flux density (J_S) of 7-year-old loblolly pine in response to rain exclusion within non-fertilized and fertilized treatments at the Georgia Tier III experimental site. A significant fertilization x rain exclusion treatment effect was observed for daily J_S averaged by month indicating larger decreases in J_S with rain exclusion in the fertilized treatment.

Canopy Stomatal Conductance

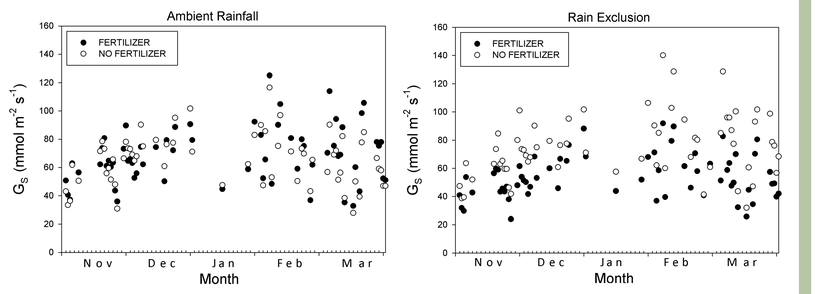


Figure 4. Average daily canopy stomatal conductance (G_S) of 7-year-old loblolly pine in response to fertilization within ambient rainfall and rain exclusion treatments at the Georgia Tier III experimental site. A significant rain exclusion x fertilization treatment effect was observed for G_S averaged by month indicating a reduction in G_S with fertilizer only in the rain exclusion treatment.

PRELIMINARY CONCLUSIONS

- An example of diel variation in J_S is shown in Figure 1.
- In general, E_G was increased by fertilization due to increased LAI (Figure 2).
- J_S and G_S were averaged by day and month. Average monthly J_S was reduced 21%, from 40.6 to 31.9 g m^{-2} s^{-1}, by rain exclusion in the fertilized treatment (Figure 3).
- A significant treatment interaction indicated a 29% reduction in average monthly G_S, from 77 to 55 mmol m^{-2} s^{-1}, in response to fertilizer only in the rain exclusion treatments (Figure 4).
- Leaf level stomatal conductance has also shown a decline with rain exclusion treatment but only trends for treatment interactions have been detected (see poster by Joe Clark and Lisa Samuelson).
- These preliminary results indicate greater sensitivity to water availability in the fertilized treatment. The increase in LAI with fertilization (see poster by Joe Clark and Lisa Samuelson) is resulting in a more conservative water use strategy at the whole plant level.

ACKNOWLEDGEMENTS

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