Impact of Rainfall Manipulation and Fertilization on Light and Water Use Efficiency in 6-Year-Old Loblolly Pine

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AIM 1

Goals of Aim 1:

- Test loblolly pine plantation response to nutrition and artificial drought around the fringe of the natural range of the species.
- Create a platform where ecophysiological measurements can be made that will aide process model parameterization.
- Determine C, N and H_2O fluxes and pools under drought conditions that could exist in the future.
- Provide educational opportunities for graduate education.
- Test loblolly pine resilience under extreme conditions.

Objectives & Hypotheses

Our research is associated with the Tier III site located in Taliaferro, GA and will contribute to each of these goals, with the main focus being on the physiological and growth responses of loblolly to nutrition and drought. Our objectives are to:

1.Evaluate how changing precipitation and fertility influence relationships among leaf area index (LAI), intercepted photosynthetically active radiation (IPAR), growth efficiency, and photosynthetic capacity.

We hypothesize based on Figures 1 and 2 that treatments will not have an impact on growth efficiency through photosynthetic capacity, rather increases in LAI will affect growth through increases in IPAR.

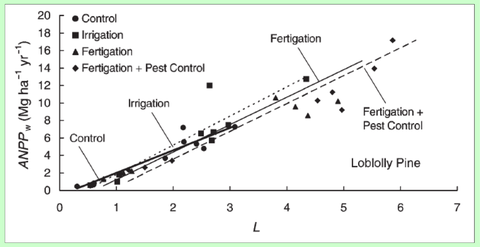

Figure 1 illustrates that intensive management has little affect on growth efficiency and that annual net primary productivity (ANPP) is more a function of LAI (L) (Samuelson et al. 2001).

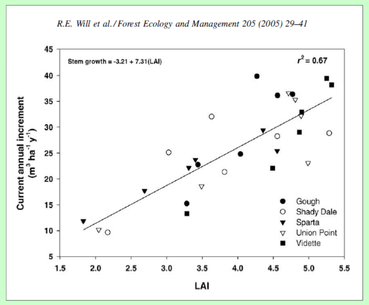

Figure 2 shows the relationship between current annual increment and LAI across various sites with densities from 740 to 4440 trees ha^{-1} (Will et al. 2005).

2.Measure canopy stomatal conductance (Gs) in response to vapor pressure deficit, soil moisture and fertilization.

We hypothesize that high vapor pressure deficit and low soil moisture will have a negative impact on Gs.

3.Determine whether water or soil nutrient availability has a greater effect on LAI, IPAR, light saturated net photosynthesis (A_{sat}), stomatal conductance (gs) and chlorophyll fluorescence (Fv/Fm).

We hypothesize that soil nutrient availability would have a greater effect than water availability on LAI, IPAR, A_{sat}, gs, and Fv/Fm.

In addition will also be investigating the recovery of A_{sat}, gs, and Fv/Fm following frost events.

Methods

- Tier III sites are located at the edge of the loblolly pine range and were chosen for the best combination of genetics, age, and plot size.

Figure 3 shows the locations of all Tier III sites with our site in Taliaferro, GA.

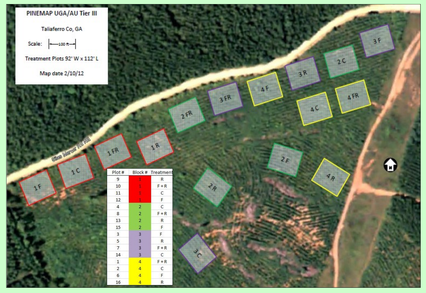

Figure 4 is a map of the GA Tier III site with plots indicated and labeled with appropriate block and treatment.

- The study is designed as a 2x2 factorial design with four blocks.
- Each block consist of two levels of fertilization (none and operational) and two levels of precipitation (ambient and 30% reduction).
- Rain exclusion trays for GA site have been installed between rows.

Rain exclusion trays that have been installed on the GA Tier III site.

Figure 5 shows the layout of each plot on the Tier III site. Measurement plot (21.3 x 14.0 m) treatment plot (34.1 x 28.0 m) and buffer (6 m wide on all sides).

Leaf Area Index

- LAI will be measured using LAI 2000 and litter traps.
- 15 litter traps will be placed in each plot.
- Traps will be 0.5 m^2 in size and assigned an unique position within the tree spacing (3.5 m x 2.13 m).
- Traps will be randomly assigned to trees.
- LAI 2000 measurements will be made by walking diagonal transects randomly selected between rows as depicted in Figure 6.

LAI 2000 in an open area taking automatic readings.

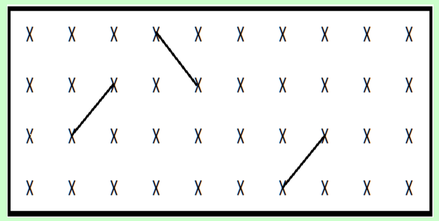

Figure 6 is a map showing the diagonal transects that will be walked between rows when measuring LAI.

Intercepted Photosynthetically Active Radiation (IPAR)

- Permanent sample points will be established along transects running between rows.
- All points will be located in the center of the inter-row space.
- Measurements will be made walking transects in between rows, stopping at 10 randomly selected points along transects and taking readings that allow for coverage across the entire inter-row space (Figure 7).

Measuring IPAR using ceptometer.

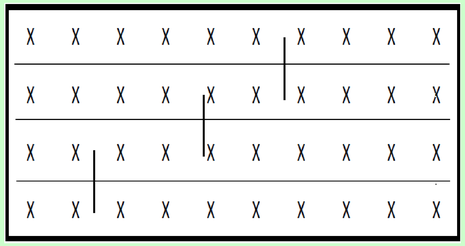

Figure 7 illustrates the transects with examples of the entire inter-row space used for measuring IPAR.

Photosynthetic Capacity

Measurements will consist of :

- Mid-day light-saturated photosynthesis (A_{sat}), stomatal conductance (gs), and chlorophyll fluorescence (Fv/Fm) will be measured monthly.
- Pre-dawn and mid-day leaf water potential measured monthly.
- A_{sat}, gs, Fv/Fm will also be measured following frost events.

Pressure chamber used to measure water potential.

Measuring gas exchange with LICOR 6400.

Sap Flow and Transpiration

- Measurements of sap flow and transpiration will be conducted using thermal dissipation probes in 5 trees per measurement plot.
- Sap flow measurements will help to characterize variation in water use efficiency among genotypes, across the region and under variable climate.

Thermal dissipation probes (photo by Geoff Lokuta).

Applications to Aims

1.Sap flow and transpiration measurements will provide important parameters for the 3-PG and WASSI models and also be used in comparing actual measured tree water use to outputs from the models 3-PG and WASSI in Aim 2.

2.Recovery of A_{sat}, Fv/Fm, and gs will be used to parameterize and validate 3-PG (Aim 2).

3.The 3-PG model is sensitive to canopy quantum efficiency (α_c) and IPAR measurements will characterize the variation in α_c across the region for 3-PG in Aim 2.

References

Samuelson L. J., Stokes, T, Cooksey, T, McLemore III, P. 2001. Production efficiency of loblolly pine and sweetgum in response to four-years of intensive management. Tree Physiology 21, 369-376.

Will R. E., Narahar, N. V., Shiver, B. D., and Teskey, R. O. 2005. Effects of planting density on canopy dynamics and stem growth for intensively managed loblolly pine stands. Forest Ecology and Management 205, 29-41.