

**THE EFFECTS OF FERTILIZATION AND COMPETITION CONTROL ON
CARBON AND NUTRIENT ALLOCATION AND PHYSIOLOGY IN LOBLOLLY
PINE PLANTATION**

Quarterly Report for the Period July – September, 1999

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PREPARED FOR THE UNITED STATES DEPARTMENT OF ENERGY

Under Cooperative Agreement
No. DE-FC36-98GO10363

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1. Status of Work

All of our plots have been established, all monitoring equipment has been installed, and we are making good progress on our field and laboratory measurements. Analysis is proceeding on relevant datasets.

Our progress on the specific tasks under each objective listed in our Statement of Work can be summarized as follows:

Objective #1: Understand the mechanisms by which fertilization and competition control affect the growth, development and productivity of loblolly pine stands by determining fluxes and allocation of carbon and nutrients.

1. Quantify biomass and nutrient (esp. N and P) allocation to leaf, stem and roots of individual loblolly pine within the plots.

Litter collections continue on a monthly basis from all Waycross, BF Grant and Whitehall plots. Litter has been sorted and weighed through the May collection. Soil cores for determination of root mass were collected in January, and are still being processed. One-half of our oldest stands (Waycross) were harvested this winter. Stem, branch, foliage and bark samples were taken for determination of nutrient content.

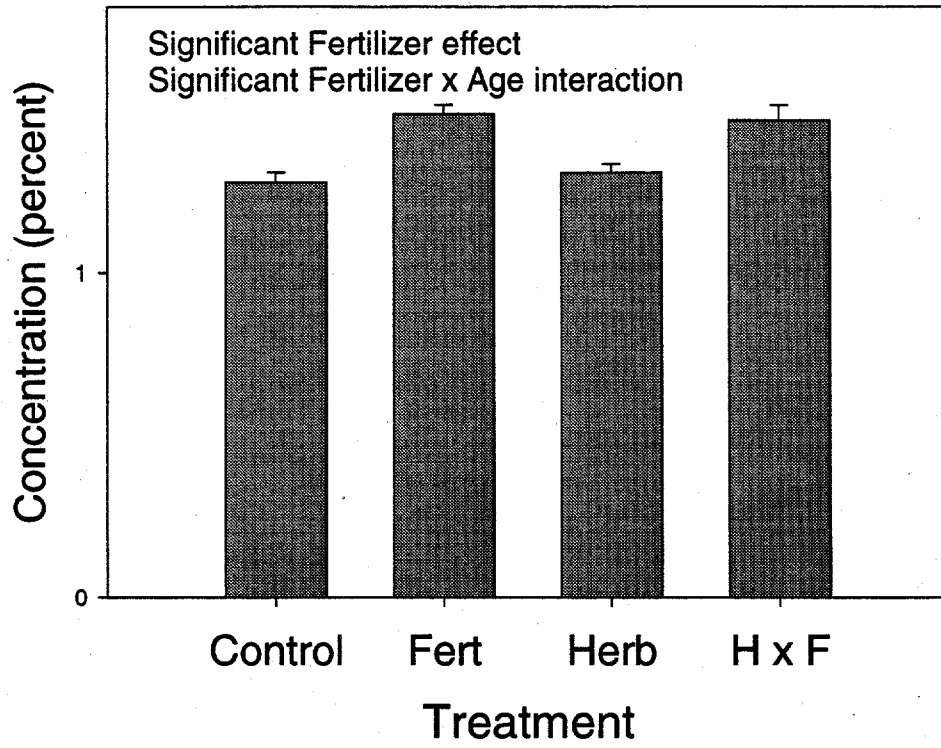
Upper canopy, middle canopy, branch bark, stem bark and wood samples were taken from three trees per plot at Waycross in the winter of 1998-99 to determine nutrient concentrations. Measurements of the major cations have been completed. Foliar nitrogen concentrations have been completed. Foliar data have been analyzed and treatment effects are presented graphically on the following pages. To summarize, nitrogen, phosphorus, and potassium concentrations were greater in the upper canopy than in the lower canopy, while calcium and manganese concentrations were higher in the mid canopy. However, canopy position did not affect the treatment-related trends in nutrient concentration. Fertilization increased nitrogen and potassium, but decreased calcium and magnesium. Phosphorus and manganese were not significantly affected by fertilization. In general, competition control had no effect on nutrient concentrations.

For nitrogen concentration in both the mid and upper foliage, there was a significant fertilizer x age interaction. This interaction occurred because the positive effect of fertilization increased with stand age. Nitrogen concentration decreased with stand age in the unfertilized stands, but increased with stand age in the foliage of the fertilized stands.

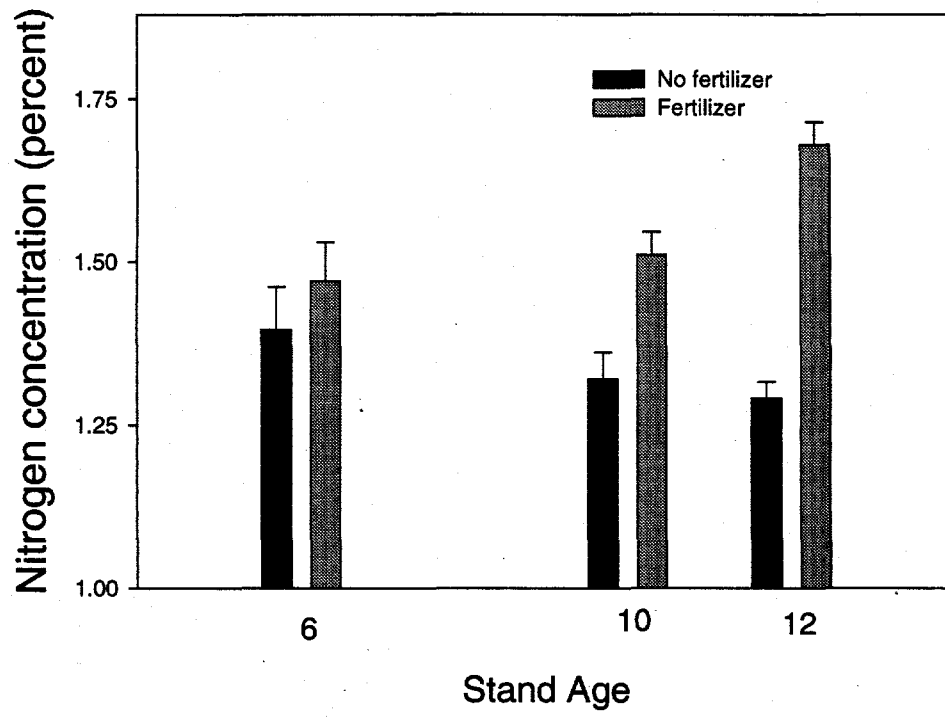
Diameter growth is being monitored on five trees per plot from two blocks of each age at Waycross and BF Grant. We finished installing minirhizotron observation tubes in the oldest plots for monitoring patterns of root production and mortality, and will take our first images during the first week of August, 1999.

Begin and completion dates: Oct. 1, 1998 - August 31, 2001

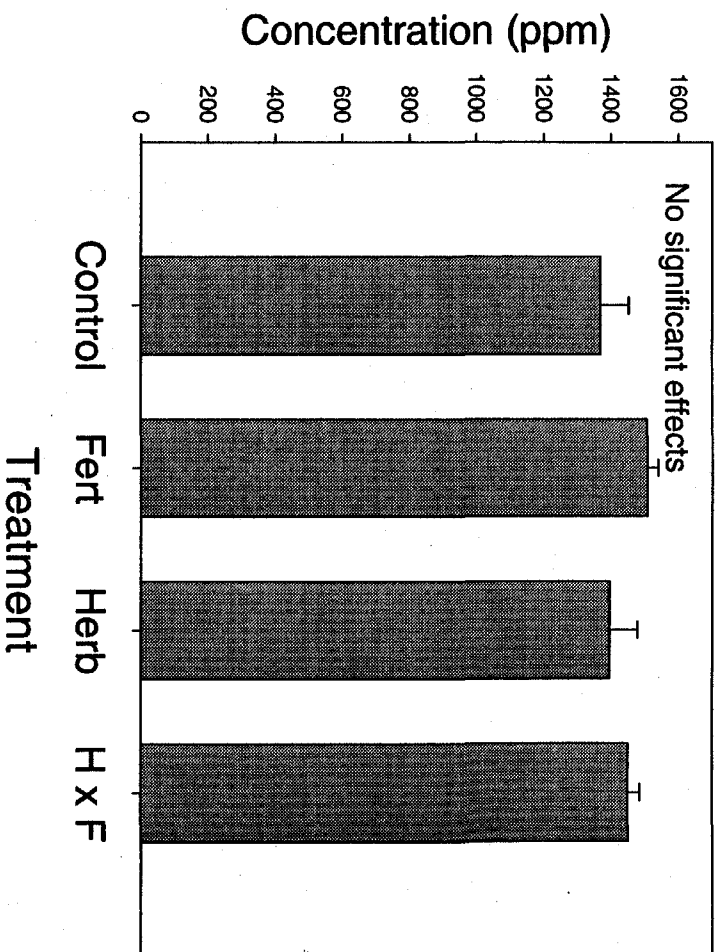
Foliar Nitrogen Concentration - Mid Canopy



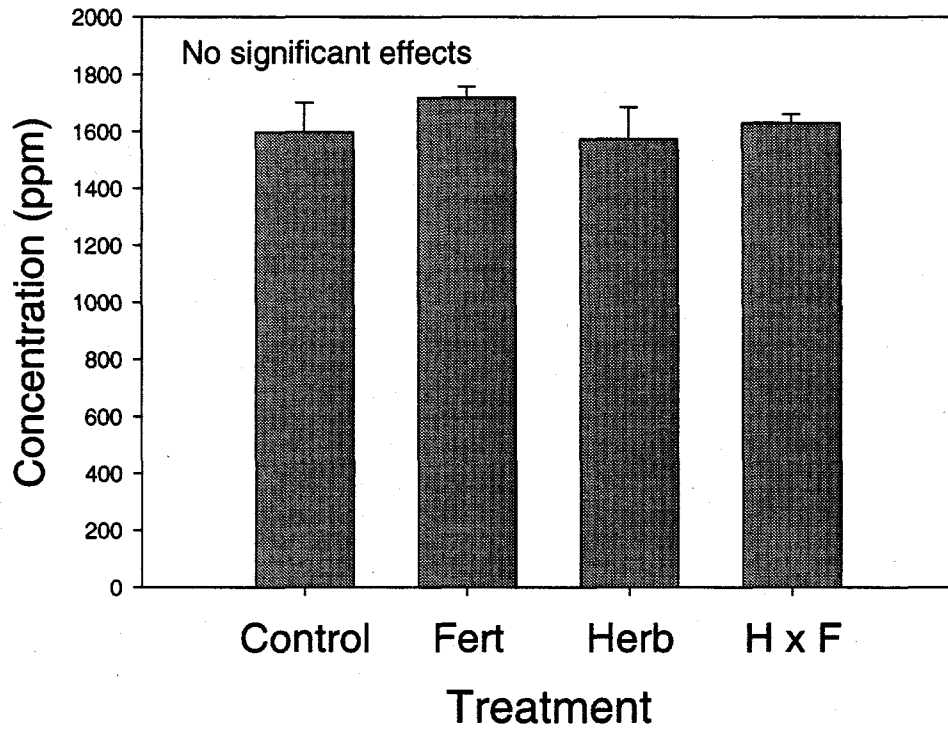
Foliar Nitrogen Concentration



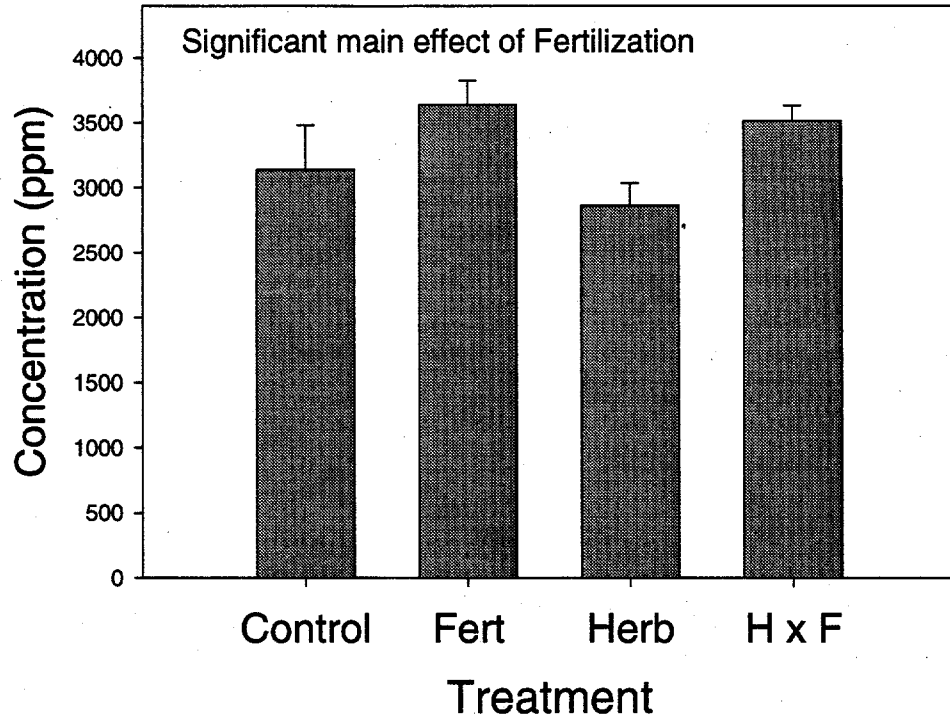
Foliar Phosphorus Concentration - Mid Canopy



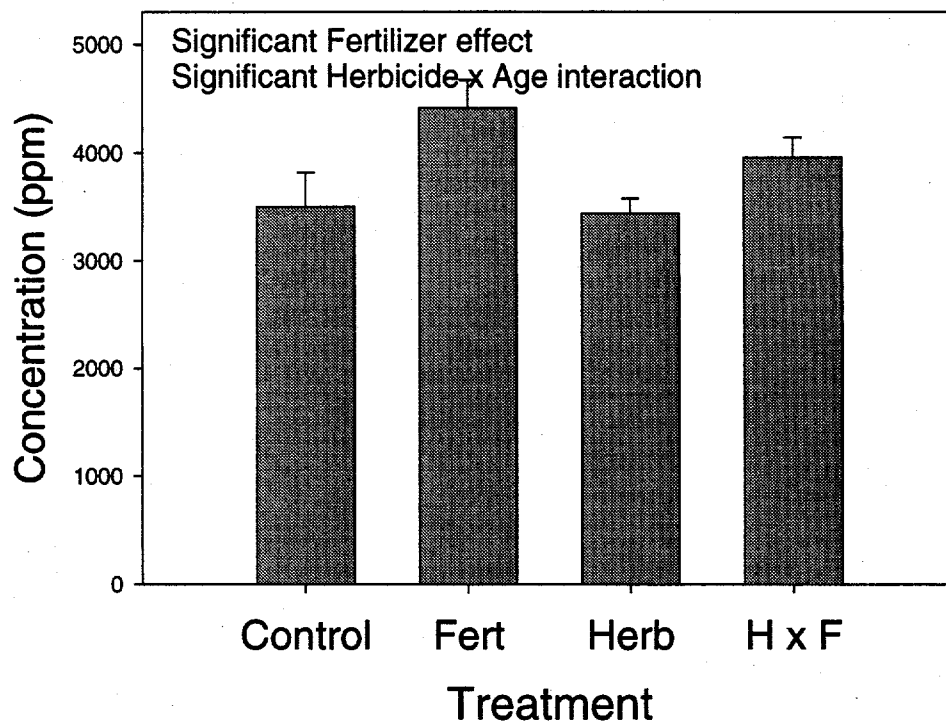
Foliar Phosphorus Concentration - Upper Canopy



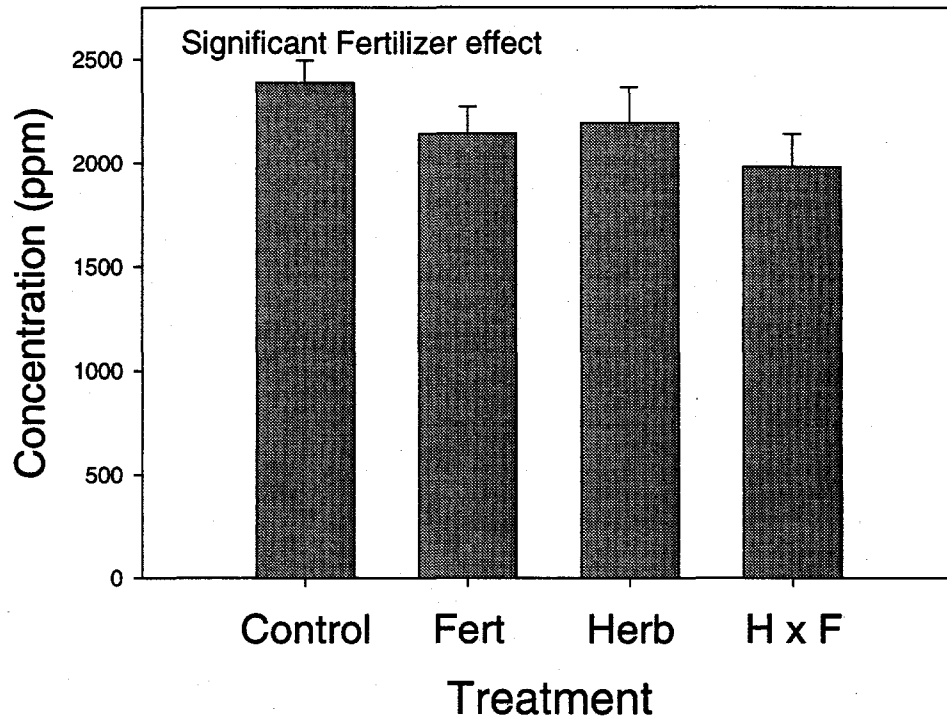
Foliar Potassium Concentration - Mid Canopy



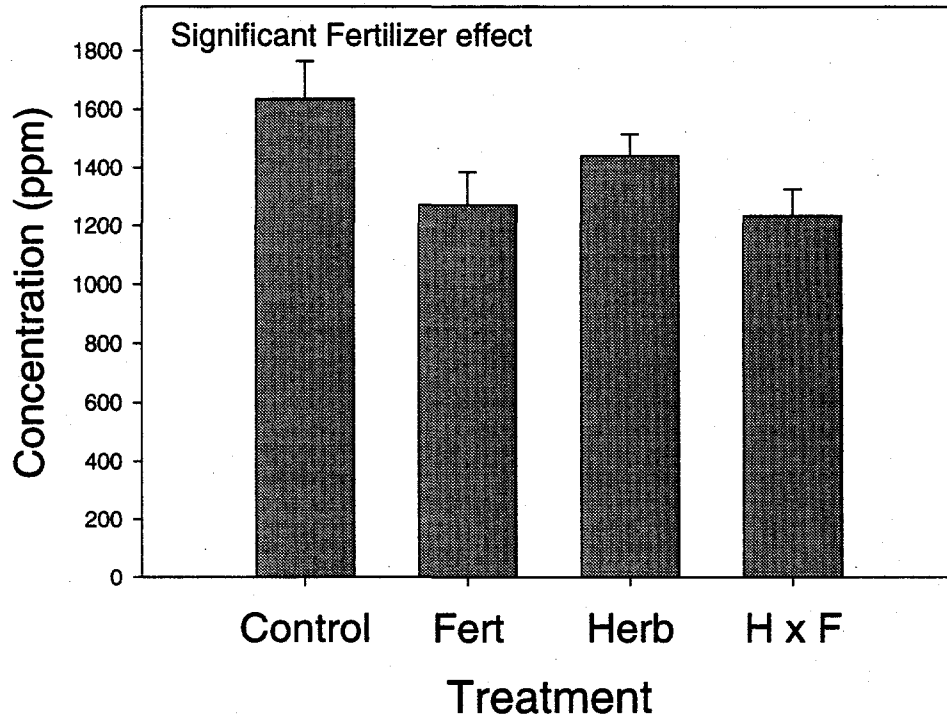
Foliar Potassium Concentration - Upper Canopy



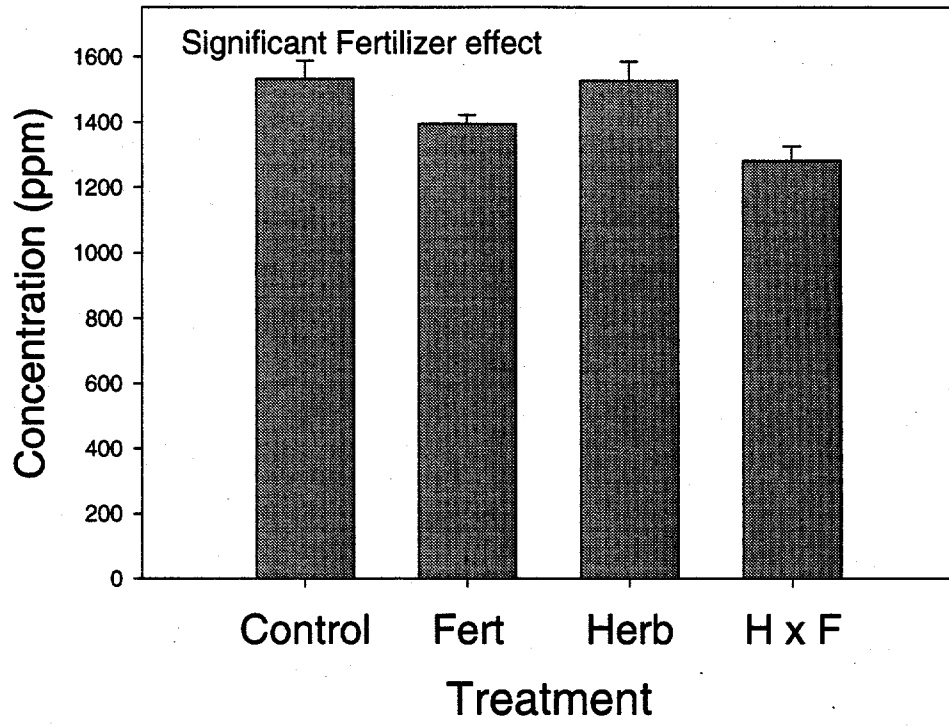
Foliar Calcium Concentration - Mid Canopy



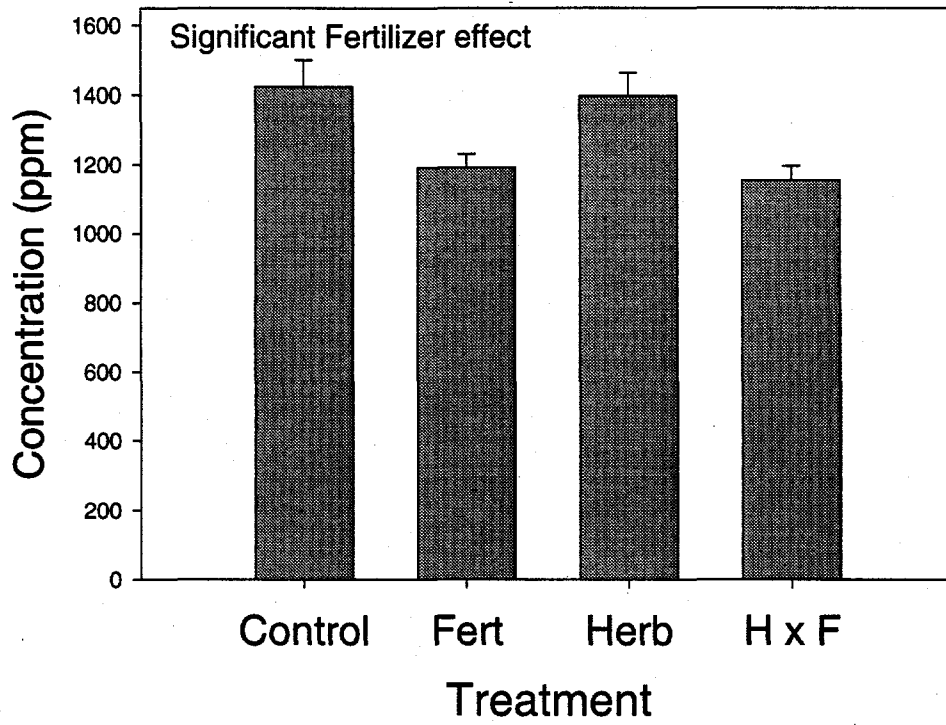
Foliar Calcium Concentration - Upper Canopy



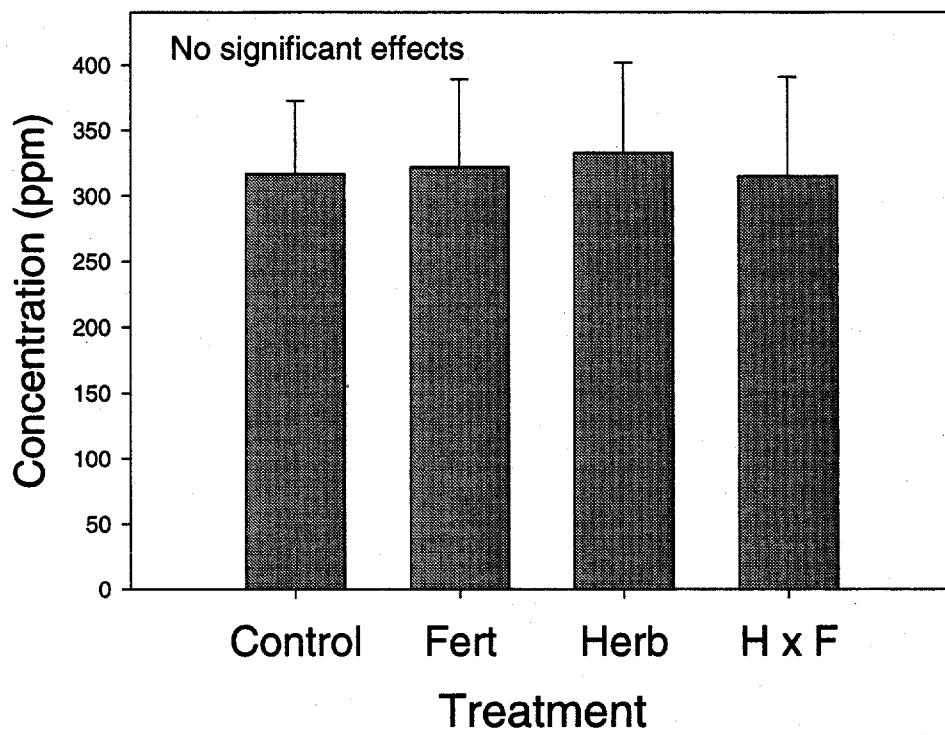
Foliar Magnesium Concentration - Mid Canopy



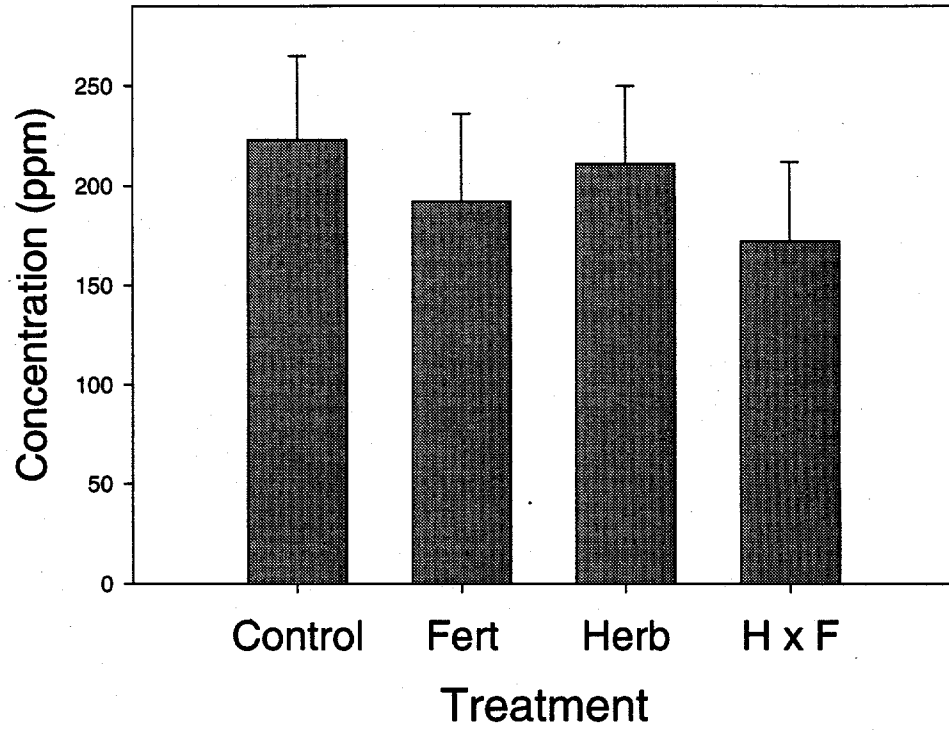
Foliar Magnesium Concentration - Upper Canopy



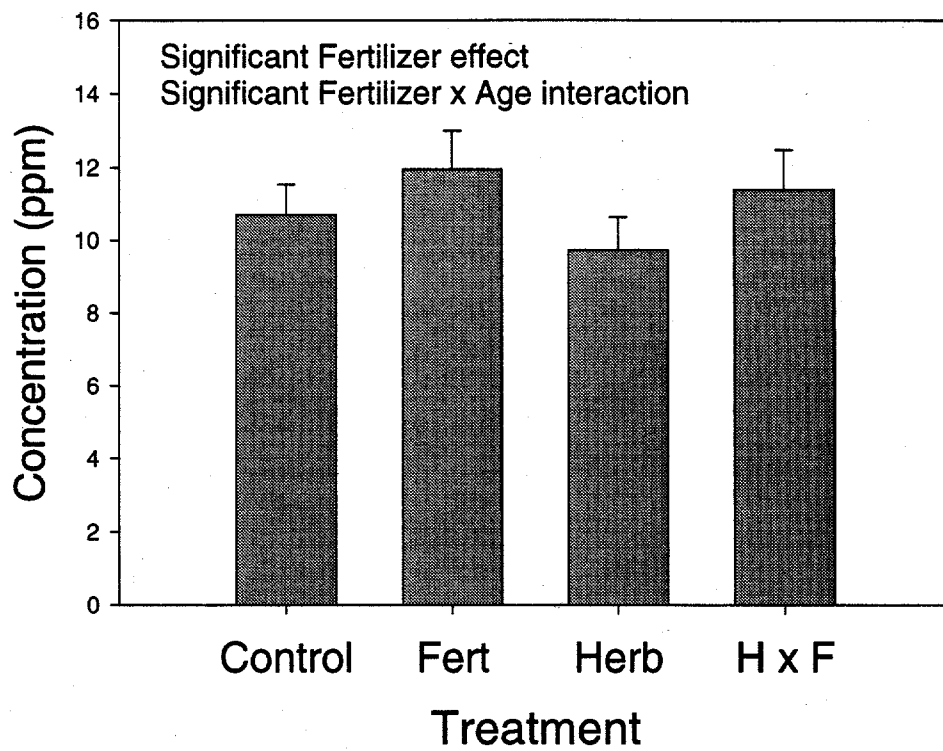
Foliar Manganese Concentration - Mid Canopy



Foliar Manganese Concentration - Upper Canopy



Foliar Boron Concentration - Mid Canopy



2. Quantify how biomass and nutrient content of above and below ground components of loblolly pine stands change with time by examining the growth of different-aged stands.

The data collected under in association with the preceding task will be used for this purpose.

Begin and completion dates: Oct 1, 1998 - August 31, 2001

3. Quantify rates of carbon flux, i.e. net photosynthesis, foliar respiration, root respiration and soil respiration.

Photosynthesis was measured during three separate sampling periods in two blocks of each age at both Waycross and BF Grant. The first flush of 1998 and the first flush of 1999 were measured on three trees in each plot. Measurements from the three trees were averaged and serve as the experimental unit. Measurements will continue approximately every six weeks. The needles used in the measurement of photosynthesis were collected, are currently being ground, and will be analyzed for nitrogen concentration.

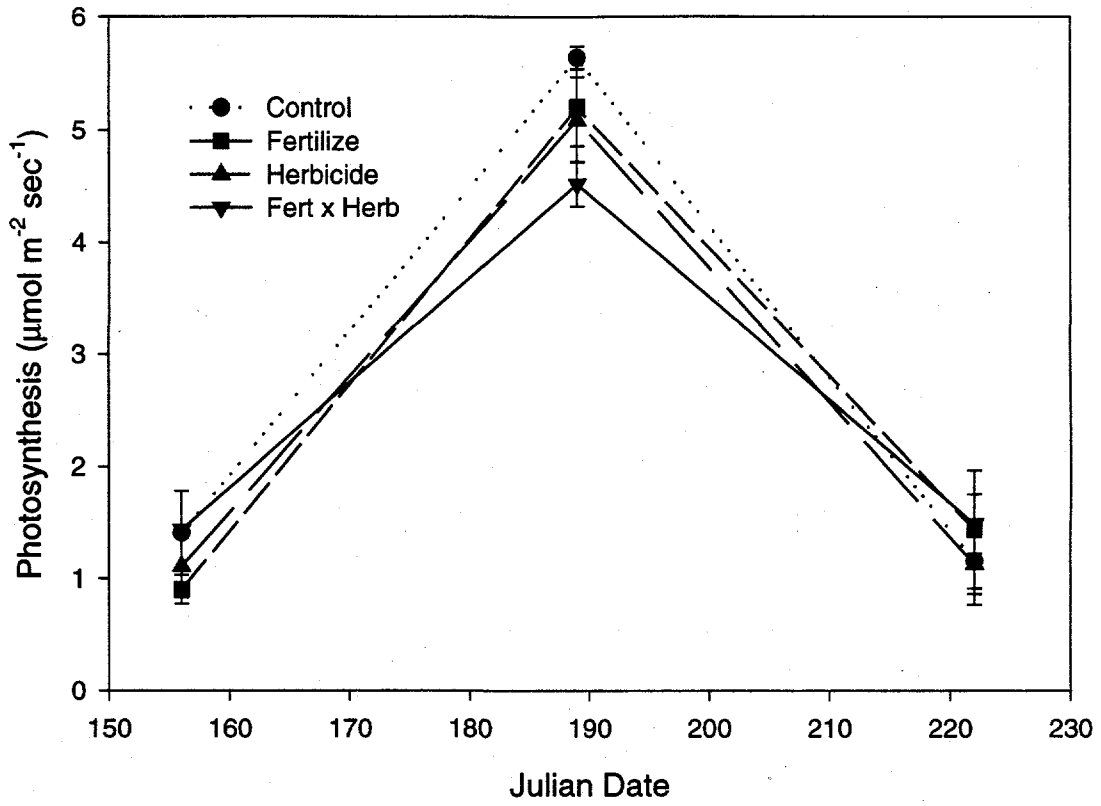
Photosynthesis data from the first three sampling rounds are shown graphically on the following pages. Because there were significant differences between Waycross and BF Grant as well as between the 1998 and 1999 flushes, data were further analyzed and are presented by location and flush.

Photosynthetic rates at both Waycross and BF Grant increased between the first and second sampling rounds. Rates at BF Grant decreased between the second and third sampling rounds while rates at Waycross were similar between the sampling rounds. This may be associated with the extremely dry conditions at BF Grant. For both Waycross and BF Grant, the current-year flushes had higher rates of photosynthesis than the one-year-old flushes.

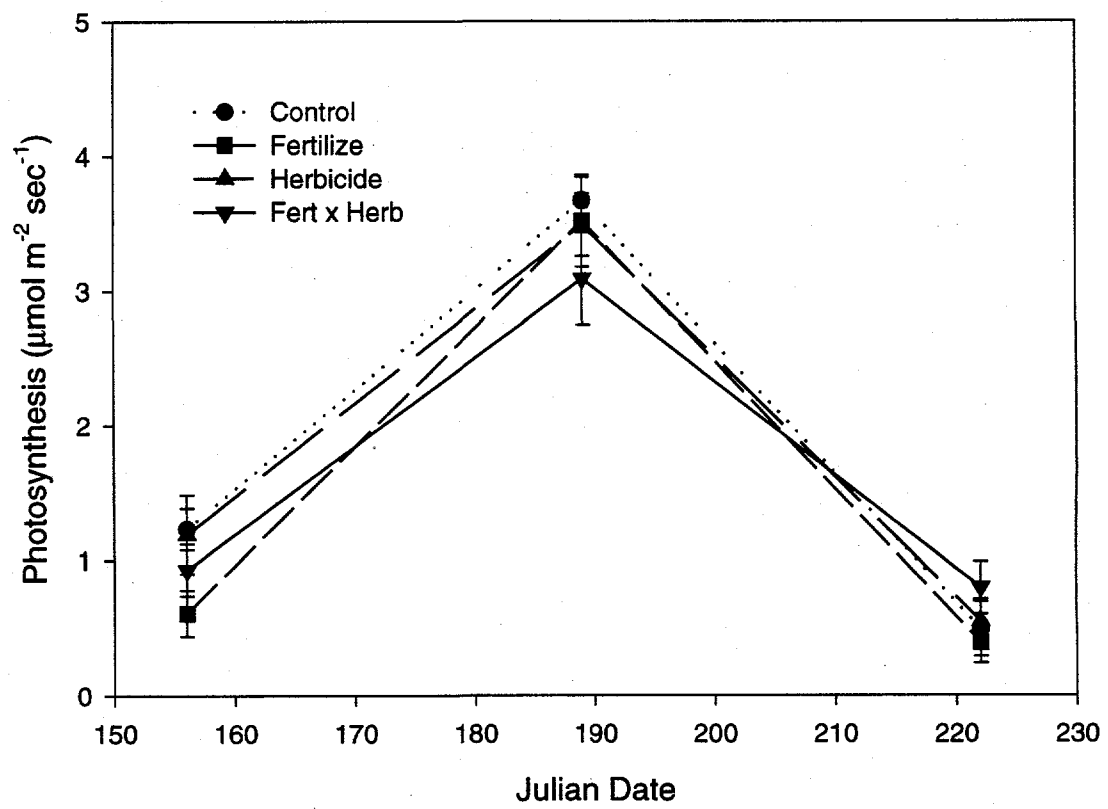
Through the first three sampling rounds, there was not a consistent effect of either competition control or fertilization on photosynthetic rate. If anything, the control treatments, i.e., no fertilizer and no weed control, tended to have higher rates of photosynthesis than the other treatments. As more data becomes available, we will examine the data with repeated measures analyses. This will result in a more powerful test of treatment effects.

Begin and completion dates: Oct 1, 1998 - August 31, 2001

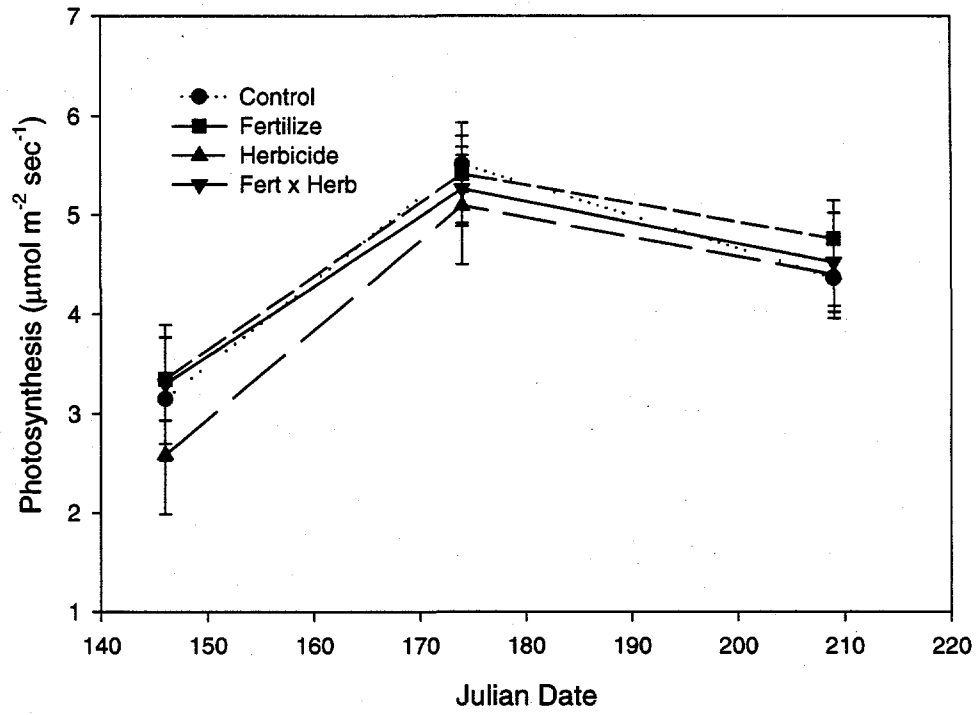
BFG '99 Flush



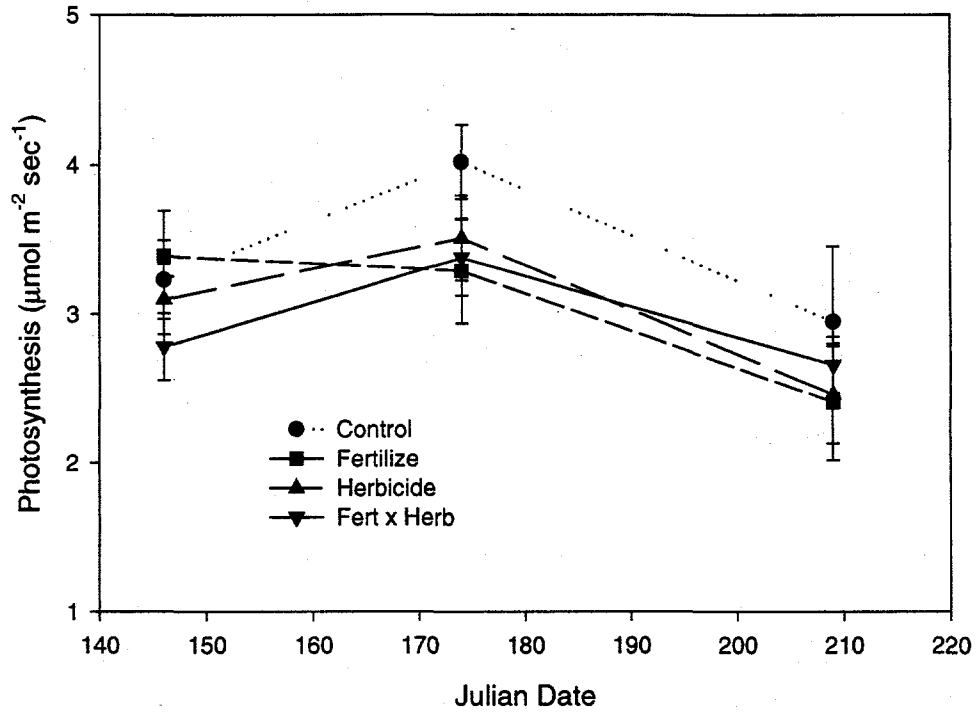
BFG '98 Flush



Waycross '99 Flush



Waycross '98 Flush



4. Determine allometric, phenological and temporal relationships between loblolly pine canopy and fine root dynamics.

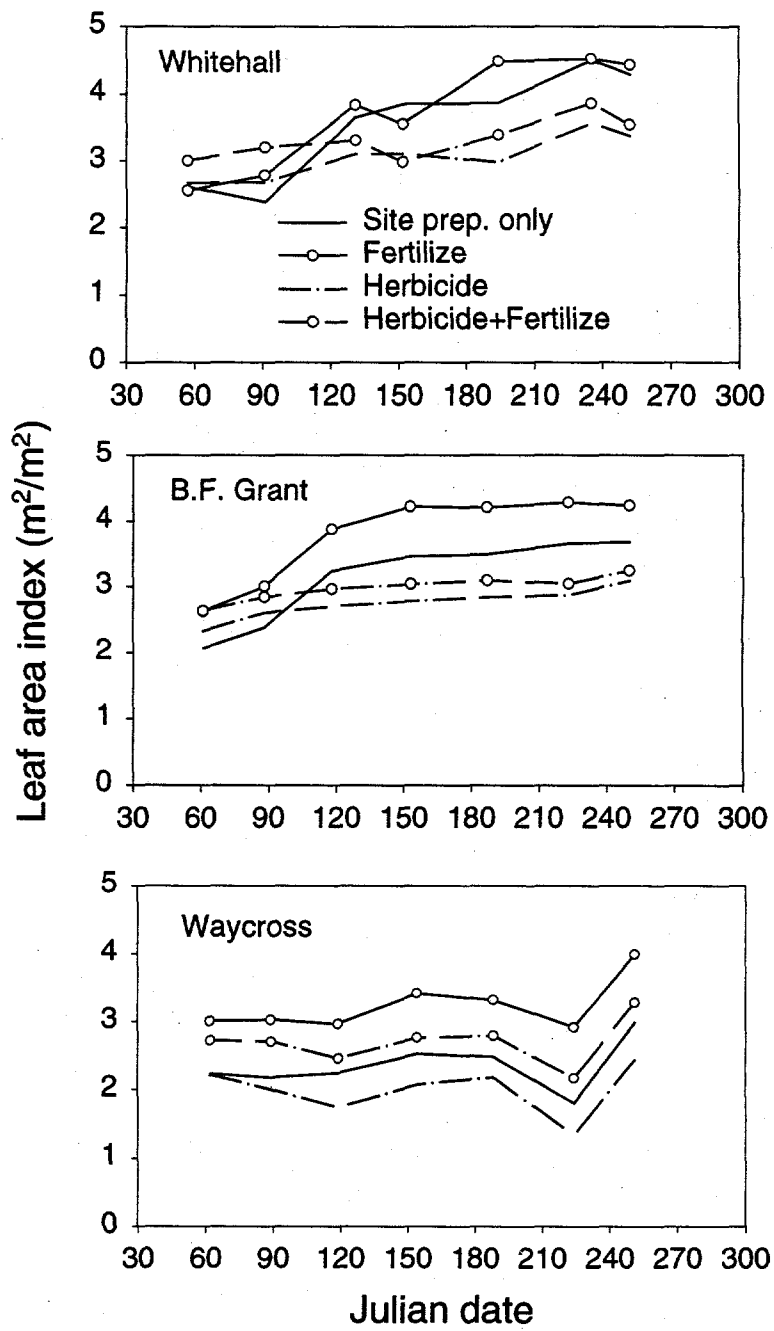
New canopy photographs are being taken to estimate leaf area and canopy structure. Indirect measurements of leaf area index (LAI, total one-sided, leaf area per unit ground area, m^2/m^2) are being taken each month in the intensively managed plantations of loblolly pine at Athens, Eatonton, and Waycross, Georgia. The LAI-2000 plant canopy analyzer (Li-Cor, Inc., Lincoln, NB) is being used. The instrument measures diffuse radiation and uses these readings to calculate LAI. A total of 12 readings are being taken on each of the 100 research plots.

Current results indicate that, on pine-only plots (herbicide-treated; dotted lines), average LAI increased gradually from March to September in a relatively linear fashion at Athens and Eatonton (See figure). On the non-herbicide-treated plots (solid lines) at these two sites, LAI increased rapidly from March to May (Julian dates 60-120) because of leaf area development of deciduous hardwoods, shrubs, and vines. LAI values at the Waycross site declined abruptly in August (Julian date 225), perhaps because of instrument problems associated with reflected radiation from the pine canopy.

Statistical analyses of these data indicate significant reductions in LAI from the herbicide treatment at each site because of the resulting absence of hardwoods, shrubs, and vines. LAI was significantly higher on fertilized plots than on non-fertilized plots at Eatonton and Waycross, but not at Athens. Fertilizer, in combination with complete weed control, resulted in an additive increase in pine LAI at each site, especially Waycross.

Current plans for the research are to continue taking monthly measurements through February 2001, providing two full annual cycles of LAI development. This phase of the research is now 29% complete.

Begin and completion dates: Oct 1, 1998 - August 31, 2001



5. Calculate photosynthetic nitrogen use efficiency and nitrogen productivity as well as growth efficiency on a per needle area and per unit intercepted radiation basis.

Measurements commenced June, 1999, and will incorporate the gas exchange and nutrient measurements being made under #1 and #3 above.

Begin and completion dates: Oct 1, 1998 - June 30, 2001

6. Measure uptake, retranslocation, mineralization and immobilization of nutrients within stands of different ages.

Uptake will be determined from the measures of nutrient content and distribution in association with the work performed under Task 1. Retranslocation will be determined from comparisons of litter and live canopy foliar nutrients. Soil samples were collected during the winter to determine soil nutrient concentrations.

Begin and completion dates: Oct 1, 1998 - July 31, 2001

7. Measure soil moisture and plant water status throughout the year.

All of the environmental monitoring equipment is operational. The Waycross weather station was installed in early February, and weather data from Athens and the B.F. Grant sites are being downloaded from pre-existing stations. The collected data include temperature, wind, relative humidity, solar radiation and precipitation. Our supplemental soil temperature sensors arrived the last week of March and were installed in April. All but one of our soil moisture sensors arrived from the factory with defects (11 of 12), and were not operational. We returned them for replacements, which arrived and were installed in late June. Unfortunately, they were also defective, so we have instead been using TDR measurements.

Begin and completion dates: May 31, 1999 - September 20, 2001

Objective #2: Develop a schedule of silvicultural treatments (fertilization and competition control) to maximize growth of loblolly pine stands.

1. Identifying patterns of growth response in relation to resource limitation of individual stands.

This task represents the culmination of the tasks listed under Objective #1, and awaits their completion.

Begin and completion dates: September 1, 1999 - August 31, 2001

2. Developing new process models for growth and yield that incorporate the timing of resource availability associated with competition control and fertilization.

Model construction will commence after this coming field season once we have a full year's data and the biomass and nutrient samples have been completely analyzed.

Begin and completion dates: : June 30, 2000 - September 30, 2001

3. Using (make available to industry) the process models to optimize scheduling of silvicultural treatments.

Iterative process performed in conjunction with task 2. Final version complete at termination of task 2.

Begin and completion dates: June 30, 2000 - September 30, 2001

4. Using data from the experimental portion of this study to help parameterize and calibrate existing regional assessment models in collaboration with Oakridge National Laboratory (Dr. Robert Luxmoore) and the University of Florida (Dr. Eric Jokela)

Will follow completion of task #2

Begin and completion dates: : June 30, 2000 - September 30, 2001

2. Level of Completion

Objective #1: Understand the mechanisms by which fertilization and competition control affect the growth, development and productivity of loblolly pine stands by determining fluxes and allocation of carbon and nutrients.

1. Quantify biomass and nutrient (esp. N and P) allocation to leaf, stem and roots of individual loblolly pine within the plots.

Destructive Harvests: 50%

Litter collection: 100% set-up and installation, 75% (of 1st year) collected and processed

Processing samples for biomass and nutrients: 80%

Stem biomass determination: 50%

Roots: 70%

Overall 60%

2. Quantify how biomass and nutrient content of above and below ground components of loblolly pine stands change with time by examining the growth of different-aged stands.

Same as for #1

3. Quantify rates of carbon flux, i.e. net photosynthesis, foliar respiration, root respiration and soil respiration.

Stem and Soil Respiration 80%

Roots: 0%

Overall: 35%

4. Determine allometric, phenological and temporal relationships between loblolly pine canopy and fine root dynamics.

Canopy: 30%

Roots: 0%

5. Calculate photosynthetic nitrogen use efficiency and nitrogen productivity as well as growth efficiency on a per needle area and per unit intercepted radiation basis.

Overall 0%

6. Measure uptake, retranslocation, mineralization and immobilization of nutrients within stands of different ages.

Awaiting nutrient analyses and allometric equations for tree biomass.

Overall: 70% for plants, 66% for litter and soil.

7. Measure soil moisture and plant water status throughout the year.

Climate monitoring stations (radiation, temperature, RH, wind speed/direction): 100% set-up, 50% data collection.

Plant water measurements commenced June 1999, 20% complete.

Soil moisture/temperature: ongoing.

Overall: 40%

Objective #2: Develop a schedule of silvicultural treatments (fertilization and competition control) to maximize growth of loblolly pine stands.

1. Identifying patterns of growth response in relation to resource limitation of individual stands.

Overall: 5%

2. Developing new process models for growth and yield that incorporate the timing of resource availability associated with competition control and fertilization.

Overall 0%

3. Using (make available to industry) the process models to optimize scheduling of silvicultural treatments.

Overall 0%

4. Using data from the experimental portion of this study to help parameterize and calibrate existing regional assessment models in collaboration with Oakridge National Laboratory (Dr. Robert Luxmoore) and the University of Florida (Dr. Eric Jokela)

0%

3. Significant Tests/Demonstrations Planned for Next Four Months

None

4. Upcoming Conferences at Which Work Will be Presented

None until 2000

5. Variations to Costs or Schedule

None