2. The Tier II Research Sites: A Regional Network for Understanding Loblolly Pine Plantation Carbon Dynamics

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This interdisciplinary, regional research is aimed at gaining a better understanding of how environmental factors and silvicultural treatments affect ecosystem carbon accumulation and storage, enabling us to develop a scientific analysis of the role of loblolly pine plantations in regional carbon dynamics. Research is being conducted on established research sites managed by the University-Corporate-Governmental Research Cooperatives partnering with PINEMAP, which enhances connections between researchers and corporate forest landowners.

How do environmental factors and silvicultural treatments affect ecosystem carbon accumulation and storage? This is the central question of PINEMAP'S effort to develop a scientific understanding of the role that loblolly pine plantations play in regional carbon dynamics. Forest scientists generally understand that the answer to this question depends on time and the rate of forest regrowth. After a forest is harvested, the decomposition of residual woody debris and soil organic matter causes the site to lose carbon; in other words, the ecosystem has a net loss of carbon to the atmosphere. However, as trees and understory plants regrow, the accumulation of a surface litter layer and soil organic matter eventually reverses this carbon loss. Thus, *time since harvest* is a critical component of ecosystem carbon dynamics. The rate at which trees grow is also critical, as this is the primary source of carbon accumulation in the ecosystem. Because tree growth is affected by *climate, nutrient, and soil water availability,* these dynamics are also critical to ecosystem carbon accumulation. Stand density, often expressed as number of trees per unit area, will also affect carbon inputs to the ecosystem, influencing the amount of time that a forest requires to offset the carbon lost after a harvest.

Silviculture in planted southern pine forests focuses on manipulating environmental resources and stand density to increase profitability. In most cases, increased profitability also corresponds to increased forest productivity. Greater forest productivity can be achieved through proper site preparation, fertilization, and herbaceous or understory competition control; these practices interact with stand density, as well as soil and climatic factors, to affect carbon accumulation and storage. Advanced loblolly pine genetics are also being incorporated into silvicultural systems in an effort to increase forest growth and disease resistance, which in most cases will also increase the rate of carbon accumulation and profitability. In some management systems, profitability increases by keeping stand density low so that individual trees achieve a desired size more quickly. This may mean that trees are planted at a low initial density and/or the stand is thinned to reduce the density. Making low stand density a silvicultural objective may slow the rate of ecosystem carbon accumulation as the stand may not fully occupy the site and stand-level productivity may be reduced.

The forestry research cooperatives partnering with PINEMAP selected 130 Tier II sites that represent a range of silvicultural and environmental conditions from a network of several hundred established experimental sites. The forests range from 6 to 25 years in age and are found throughout the natural range of loblolly pine (See Figure 1.2, page 6, for a map of the Tier II sites). Originally created to examine tree growth under specific silvicultural practices, the selected sites are now being sampled to estimate the carbon stored in the tree biomass, soil, forest floor, understory, and woody debris of the forests. These measurements will represent the full ecosystem carbon accumulation. Each research site will compare one or more silvicultural practices, but thinning and the level of fertilization will be the two most common practices studied.

An objective of PINEMAP is to compare estimates of ecosystem carbon accumulation at the Tier II sites with existing models of ecosystem carbon dynamics. One model currently being

Jill Qi and Aaron Joslin collect soil samples at a PINEMAP research site in Georgia. Photo by Madison Akers.

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employed is the Water Supply Stress Index (WaSSI) Ecosystem Services Model, which estimates ecosystem carbon cycling processes based on climatic factors and pine physiological processes. The model uses spatially explicit climate and soils databases as inputs to produce regional estimates of ecosystem carbon exchange. From this model's analysis of existing databases, we find that the Tier II network spans from 1077 to 1718 mm/yr in precipitation, and from 716 to 1200 mm/yr in potential evapotranspiration (a measure of annual evaporative demand) (Figure 2.1). The model also estimates a 30% range in gross ecosystem production (GEP, a measure of total plant photosynthesis) and net ecosystem exchange (NEE, a measure of net carbon accumulation) (Figure 2.2). These latter estimates are based on parameterizing the model for a 17-year old loblolly pine forest receiving very little silvicultural treatment.

A complementary objective is to compare this model parameterization to the actual field estimates of carbon pools collected under a range of silvicultural prescriptions. Using this approach, we will be able to develop a spatially explicit estimate of carbon accumulation across the range of managed loblolly pine ecosystems. Gradients in existing climate variables will provide insight into how carbon dynamics in different regions might respond to climate change and silvicultural prescriptions, providing regional modelers with validation for predictions of regional carbon balance.

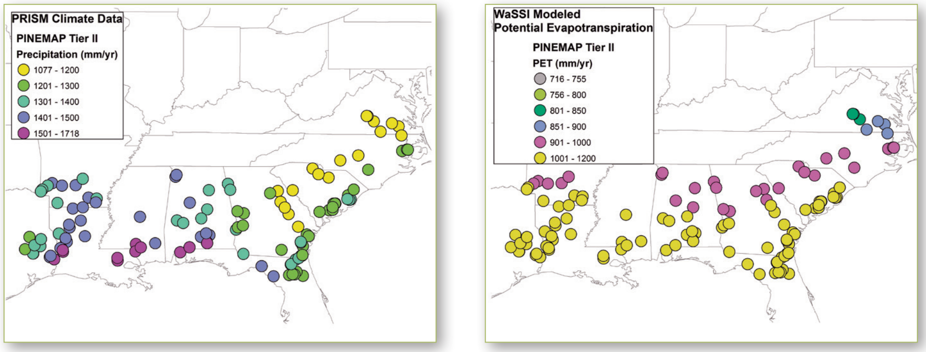

Figure 2.1. Precipitation estimated from PRISM historic climate data (left) and potential evapotranspiration estimates with the Water Supply Stress Index (WaSSI) Ecosystem Services Model (right) across the range of Tier II sites. Each dot represents a site, and the color of the dot relates to the amount of precipitation or potential evapotranspiration.

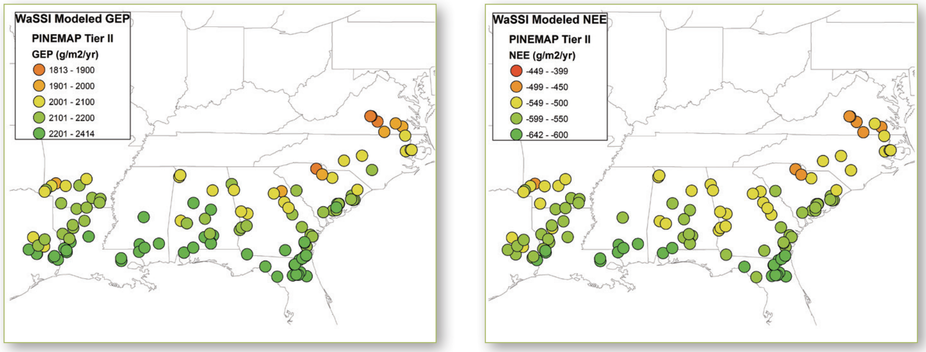

Figure 2.2. Potential gross ecosystem production (GEP) (left) and net ecosystem exchange (NEE) (right) from the Water Supply Stress Index (WaSSI) Ecosystem Services Model parameterized for a 17-year old loblolly pine forest across the range of Tier II sites. Each dot represents a site, and the color of the dot relates to the relative amount of GEP or NEE compared to the rest of the sites. For the NEE figure (right), larger negative NEE values correspond to greater rates of carbon accumulation.