4. Physiological Principles in Predicting Growth (3-PG) Regional Analysis

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The regional biomass and carbon estimates resulting from the Physiological Principles in Predicting Growth (3-PG) regional analysis will inform economic models of product availability and will provide forest land managers with knowledge and tools necessary to make informed management decisions to ensure sustainable yield and increased carbon sequestration. Given that these models are being integrated into the project's decision support system, this information will also be useful to Extension specialists as they reach out to stakeholders.

Modeling is an essential component of PINEMAP activities, and there are several models being used in the project including Physiological Principles in Predicting Growth (3-PG) (Landsberg and Waring 1997). This process-based model uses mathematical representations of tree physiological processes such as carbon gain and loss, water use, and nutrient uptake, coupled with weather and soil information, to predict tree growth and stand productivity. 3-PG has been used by other research groups to predict plantation productivity of several *Eucalyptus* and conifer species with success. We have made several modifications to 3-PG to increase the model's accuracy in predicting productivity of loblolly pine plantations, including refinements in how it calculates leaf area index, basal area, and stem volume. Because we have optimized the model specifically for loblolly pine plantation growth, we call our modified version 3-PG_{lob}.

This year, using Tier I datasets (see Chapter 1, page 6), we tested the ability of 3-PG_{lob} to predict historical growth of loblolly pine plantations at sites in 10 southeastern states: Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas, and Arkansas. For these simulations, we used the unique weather and soils information of each site. Figure 4.1 shows examples of the model's prediction of stem biomass growth compared to actual measured growth at three sites. We found that a single set of physiological model settings specific to loblolly pine was sufficient to estimate stand biomass and stem volume across the region. There are likely two main reasons for the robustness of these physiological settings. The first is that, due to many years of research by university, government, and corporate scientists, there is a wealth of information about the physiology of loblolly pine with which to determine the settings or parameter values needed in the model. The second is that maximum rates of physiological processes that are critical to growth, such as photosynthesis and respiration, change little across a wide range of soil fertility and climatic conditions. Our results give us confidence that the model can be used for more extensive regional assessments of plantation growth and productivity.

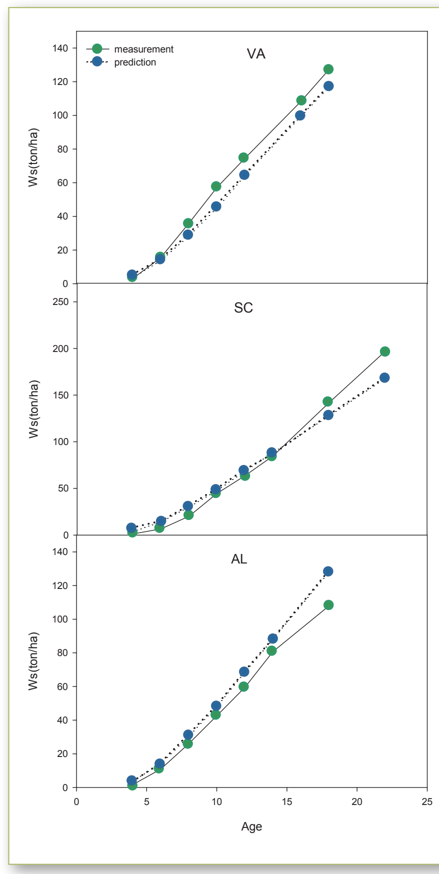

Figure 4.1. Physiological Principles in Predicting Growth (3-PG) simulations of stem biomass growth (blue circles) in loblolly pine plantations in Virginia (VA), South Carolina (SC), and Alabama (AL) compared to biomass estimated from measurements made at each site. Each green circle represents a year in which biomass was estimated from volume and wood density measurements.

Photo by Steve McKeand.

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Ultimately, the 3-PG_{lob} model will be scaled up, or applied across the region, to thousands of individual grid cells so that we can predict variation in response specific to particular areas in the range. The regional scaling up of 3-PG_{lob} will mirror as closely as possible the scaling up of other models being used in PINEMAP to facilitate comparisons among the models' outputs. While the same set of physiological parameters will be used across the PINEMAP study area, the climate and soils data will vary by location. Accordingly, we will use the USDA Natural Resource Conservation Service Soil Survey Geographic (SSURGO) database and Multivariate Adaptive Constructed Analogs (MACA) climate model data as location-specific inputs into 3-PG_{lob}. We will also input the same site index (a measure of site quality) estimates derived from the process described in the growth and yield model report (see Chapter 5, page 14). By keeping the input variables as congruent as possible, we expect to be better able to compare the resulting model outputs.

In order to simplify data processing, the SSURGO soil inputs will be aggregated to a coarser scale associated with 12-digit hydrological unit code (HUC-12) features, a standardized unit often used in large-scale analysis. These HUC-level soil aggregates will be intersected with the 1/16 degree climate data grid to produce uniquely indexed features (in soil and climate values) with areas of no more than 16 square miles, sufficiently fine for subcounty analysis. This approach allows for more efficient construction of the climate-based input files used to drive the 3-PG_{lob} model. Within this framework, we will generate monthly outputs from 3-PG_{lob} for each feature, each available year, and each emissions scenario in the projected climate dataset (1950 to 2100). The results can then be displayed as a map of each 3-PG_{lob} model output, either at the finer level or re-aggregated to the HUC-12 level. A visual representation of this approach is shown in Figure 4.2.

The regional 3-PG_{lob} model represents an important synthesis of many aspects of PINEMAP. The revised model and parameter estimates use field data from PINEMAP. The model and parameter changes reflect our current understanding of the ecophysiological processes important to pine productivity in the Southeast. These processes are affected by changing carbon dioxide concentrations, climate, silvicultural practices, and growing stock improvements. The resulting regional biomass and carbon estimates will inform economic models of product availability and will be very helpful to Extension specialists as they reach out to stakeholders. Given that these models are being integrated into the project's decision support system, forest land managers will have the latest research results available as they make management decisions to ensure sustainable yield in a changing world.

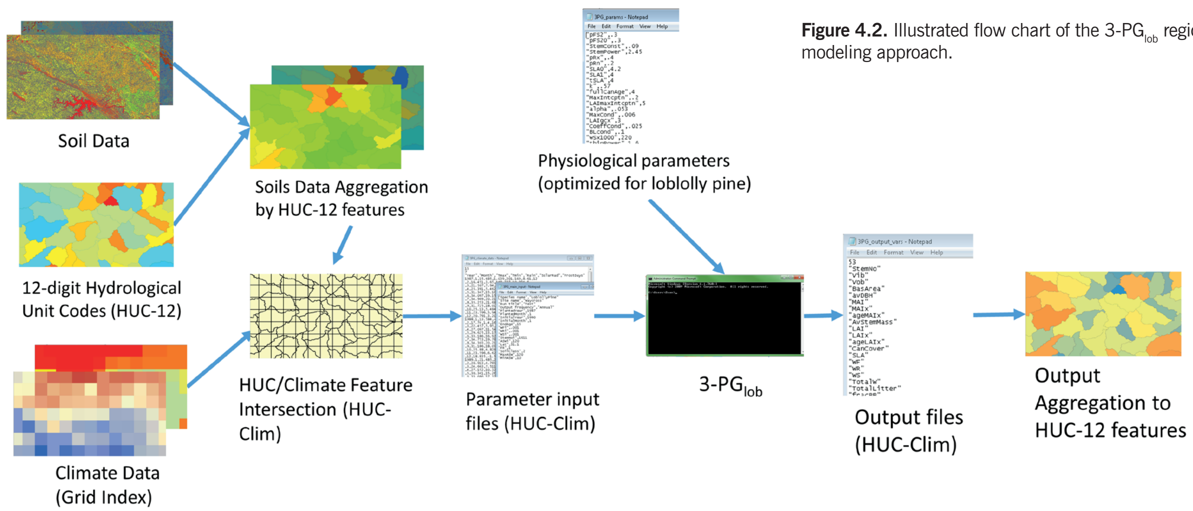

Figure 4.2. Illustrated flow chart of the 3-PG_{lob} regional modeling approach.