

5. Regionalization of Growth and Yield Models

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Predicting future tree growth with growth and yield modeling systems is central to forest management planning and to PINEMAP's research goal of understanding how forest carbon sequestration responds to forest management and climate. We are using PINEMAP datasets to develop a new, region-wide growth and yield modeling system that incorporates the effects of advanced genetics, more intensive silviculture, and changing climate. From a research perspective, this system will enable us to test a range of modern management scenarios under predicted future climate conditions. In addition, this system will be a useful tool for corporate and noncorporate forest landowners.

Accurately predicting productivity of southern pines is essential for determining sustainability of the resource under various management options and future climate conditions. Management practices—such as developing genetically improved planting stock, controlling competing vegetation, thinning, and applying fertilizers—are commonly employed when growing southern pines. While a number of growth and yield models have been developed for specific physiographic areas and management practices, a region-wide modeling system is needed when projecting future productivity that will involve advanced genotypes, more intensive silvicultural inputs, and changing climate.

Stand-level Modeling

Our approach for developing a modeling system for long-term predictions of productivity for future southern pine stands has three components. These are (1) developing baseline, stand-level growth models; (2) formulating general response functions for silvicultural practices, including thinning, vegetation management, and fertilizer applications; and (3) relating exhibited site index (a standardized measure of growth potential of a particular site and management combination) to biophysical factors (soils and climate variables) so that, in concert with information on performance of present and anticipated genotypes, pine productivity can be estimated for various management inputs and climate scenarios.

Baseline models of stand dominant height growth, basal area, and tree survival of loblolly pine plantations were fitted using the Tier I network, region-wide data from permanent sample plots that were installed across the region and measured on multiple occasions (see Chapter 1, page 6). Response functions were then fitted to data from broad-scale studies of thinning treatments, competing vegetation control, and fertilizer applications. Stand productivity for various levels of silvicultural options is estimated by multiplying the baseline growth models with the modifier response functions. Effects of multiple silvicultural inputs are assumed to be additive.

We fitted and evaluated different types of statistical models for predicting loblolly pine plantation site index from biophysical variables. Tree and stand location data came from region-wide plot installations of the Virginia Tech Forest Modeling Research Cooperative (Figure 5.1). Climate data for each stand location were computed using the Oakridge National Laboratories' daily surface weather prediction models, while soils data were extracted from the USDA Natural Resource Conservation Service Soil Survey Geographic (SSURGO) database. Separate models were fitted for non-intensively managed and intensively managed loblolly pine plantations. Variable selection methods in both modeling approaches showed that the number of biophysical variables that were important in predicting site index of intensively managed loblolly pine was smaller than the number for non-intensively managed stands. Appropriate statistical models were selected based on both their fit to the input data, as well as their ability to produce consistent and reasonable predictions when used for extrapolation.



Photo by Larry Korhnak.

Baseline stand-level growth models, coupled with general response functions for thinning, competing vegetation control, and fertilizer applications, provided accurate estimates of pine plantation productivity for varying levels of management intensity.

Scaling Up

In order to extrapolate the stand-level parametric models to the regional level along historical and future timelines, we used regional-based climate and soil data. In particular, the Multivariate Adaptive Constructed Analogs (MACA) downscaled climate model outputs yielded temperature and precipitation data at 1/16 degree grid cells (areas of no more than 16 square miles for each cell), and the SSURGO database yielded water holding capacity and soil physical properties along polygons of varying size. In order to match these data efficiently, we intersected the soil polygons with the grids for the climate variables as polygons to produce “wall to wall” polygons containing both climate and soils data across the 15 states that encompass the PINEMAP study region. These polygons were then used as input to the stand-level models to produce site quality estimates for the different management conditions. An example of baseline site quality classes for a portion of Virginia is shown in Figure 5.2. We are in the process of producing region-wide site index maps, specific to each management scenario, for each year of available climate data.

We will use these site index maps in conjunction with stand age information from sources such as the Vegetation Change Tracker and reasonable assumptions about the level of management intensity to arrive at growth and yield estimates for each cell in the region. Results can be re-averaged, if necessary, to produce outputs at larger levels of aggregation for comparison to output from other PINEMAP modeling efforts.

Conclusion

Baseline stand-level growth models, coupled with general response functions for thinning, competing vegetation control, and fertilizer applications, provided accurate estimates of pine plantation productivity for varying levels of management intensity. A function that relates pine site index to biophysical variables (soils and climate) allows the model to incorporate the effects of climate on tree growth. These growth and site quality relationships provide a basis for scaling up from stand- to regional-level productivity under varying assumptions of silvicultural inputs and climatic influences.

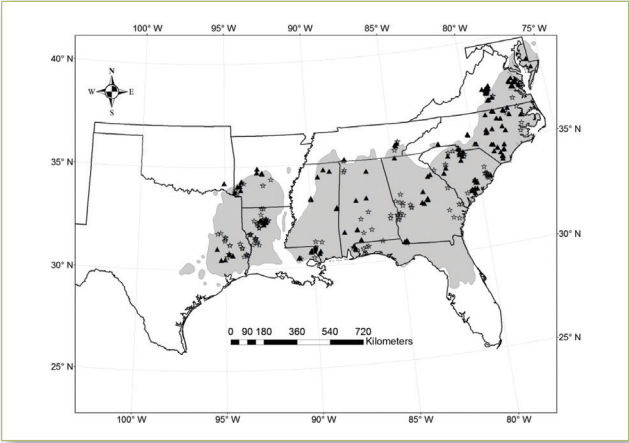


Figure 5.1. Location of Virginia Tech Forest Modeling Research Cooperative loblolly pine permanent research plots (186 non-intensively managed locations are represented by triangles and 170 intensively managed locations are represented by stars). The portion of the map shaded in gray is the natural range of loblolly pine.

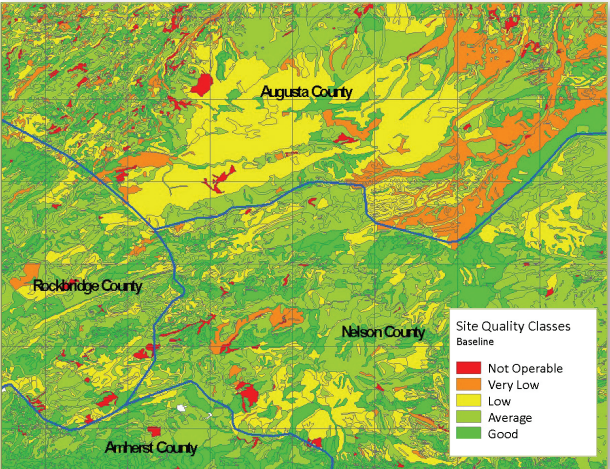


Figure 5.2. Baseline site quality classes for loblolly pine in a portion of four counties in Virginia.