Center for Advanced Forestry Systems (CAFS)

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Refinement of Growth and Yield Models for Naturally-Regenerated, Mixed-Species Stands

Forest growth models are widely used by forest managers and researchers to forecast future growth, update forest inventory information, and assess alternative forest management strategies. Currently used computer simulation models across the Northeastern US typically show significant biases. Because of these biases improved growth and yield tools have recently become a top research priority by Maine's industrial forest landowners. This CAFS project has developed a computer simulation tool that better reflects present-day forest conditions and can more accurately represent alternative forest management regimes across the Northeast.

A naturally-generated mixed species forest.

Compared to plantations, growth and yield models for naturally-regenerated, mixed-species stands have received relatively little attention. This project also provides a tool that can be used by forest managers in a variety of settings. First, model uses data generated from diverse sets of stand conditions and forest management regimes (>3 million observations are typical). Second, it is specific enough to predict individual tree growth in the complex mixed-species stands that comprise much of the Northeast. As a result, outputs are flexible enough to account for varying forest types and stand histories. Third, this project uses model-fitting techniques that are capable of flexibly accounting for dynamic growth patterns. At the same time, alternatives measures of site productivity are being tested to find out which measures best correlate to and model forest growth. Finally, similar models are being developed to accurately represent common forest management practices such as thinning; an attribute that existing models lack.

Economic Impact: This work will have significant economic impacts not only on the forestry industry generally, but on regional, state and the national economy as well. A properly developed growth characterization and forecasting tool such as this CAFS's work produces will produce more refined regional growth and yield estimates for determining future forest attributes. For forest managers, the net present value of carrying out various types of silviculture, such as pre-commercial and commercial thinning, can be quantitatively assessed prior to treating a stand. For the center's pulp and paper industry sponsors, wood supply analyses are being conducted on ownership and regional scales. For wildlife managers and those interested in biodiversity issues, suitable habitat is being more accurately assessed. Landowners can accrue significant savings and higher yields by calculating annual forest property carbon sequestration, which is becoming a valuable commodity itself. Finally, policy makers can assess the consequences of various forest policy measures.

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Predicting the Quality Value of Fast Grown Wood from Advanced Forestry System

Over the last two decades foresters have dramatically increased growth rates and yields of the South's forests through intensive plantation management (advanced forestry systems). What is the quality of this fast grown wood compared to historic wood products? Until now that question has either been avoided or addressed with very limited data and a good bit of speculation. Forest landowners rely on long term forecasting models of forest growth and yield as they plan these intensive management regimes. Traditional forecasting models predict the timber volumes but have not taken into account the quality of the wood produced, such as lumber stiffness and strength. Yet wood quality is directly affected both positively and negatively by intensive plantation management. Wood growers currently do not have good understandings of the quality of the wood they are growing. There has been no region wide consensus among wood growers on how to manage for wood quality, nor is there a broad understanding among wood products manufacturers about the value of trees grown in different ways.

A managed planation forest.

CAFS researchers at the University of Georgia have been dissecting trees and analyzing the wood grown throughout the South under the range of forest management intensities and have put their findings into prediction models that can future wood density, stiffness and strength. Most importantly, they have integrated these wood quality predictions into the growth and yield models foresters use for evaluating volume gains from advanced genotypes and intensive silvicultural treatments such as weed control, thinning, and fertilization. This allows wood growers, for the first time, to incorporate the quality of wood in their planning along with the quantity of wood. Results are helping sponsors to better understand wood quality impact on forest product mix. Large timberland owner such as Plum Creek need to understand value of wood that is grown as it relates to their customers' needs. This work is a breakthrough because it enables direct predictions of value along with volume, linking the tree grower with the wood buyer and the lumber manufacturer.

> **Economic Impact:** This outcome of this project will improve how timber is grown and marketed, because it will allow wood quality and value to be factored into the long term forest management decisions. This in turn will help manufacturers better market their products to end-users. It will result in more competitive pricing for timber based on wood quality. It should also dispel myths about plantation grown wood that have negative market impacts and could improve sales of the products. By factoring wood quality into silvicultural decisions, growers may increase the proportion of high quality sawtimber by 25% or more. This could mean gains in value at harvest of $1000 or more per acre; that could easily reach $1 billion in new value annually across the South.

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Exponential Nutrient Loading

A new approach referred to as “exponential nutrient loading” has been developed by researchers at the Center for Advanced Forestry Systems (CAFS) to pre-condition black walnut grafts in the greenhouse for field planting. The technique increases the morphological and nutritional quality of grafted plants, as well as store nutrients in root plugs for later utilization to benefit early plantation establishment success. This protocol, allows for a higher growth rate of the grafts in their first year after planting in the field. Black walnut grafts that have been grown exponentially will be used in intensively cultivated plantings. In intensive cultivation, this is important because the response to fertigation and weed control is higher and rotation age will be decreased, which brings substantial financial benefits. In extensive cultivation, the rapid growth and competitiveness exhibited by exponentially nutrient loaded grafts will accelerate plantation growth to reach free to grow status sooner, which increases the chances of crops to escape damage from animal browsing and weed competition. Intensively cultivated clonal black walnut plantings under are currently being offered as a financial opportunity for long-term investors.

> **Economic Impact:** This method makes possible a two-year reduction in the long term production cycle. Based on today’s prices for black walnut timber, this new method of tree production is increasing the profitability of one CAFS corporate partner by an estimated 8 million USD over expected the production rotation period. Our corporate partner employs over 50 staff annually. This increased profitability allows the company to maintain its current level of employment. This method has also been adopted by public nurseries and increases their competitiveness by allow-

ing them to sell a higher quality product and thus stay more competitive in the current recessionary market.

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Precocious Flowering in Populus

Trees have not been domesticated to the same extent as agronomic row-crops because of their extended juvenile periods. Moreover, significant amounts of sugars fixed as a result of photosynthesis are diverted away from vegetative growth (e.g., stems, branches, roots, and leaves) to form reproductive structures (e.g., cones, flowers, seeds, etc.) after trees have undergone the transition to maturity.

Federal regulators have made it clear that a transgene confinement system is likely to be needed before genetically engineered trees can be deployed commercially. CAFS researchers are attempting to genetically engineer flowering control as a way to satisfy this requirement. In order to test the efficacy of the genetic constructs inserted in the poplar genome for their ability to affect floral development, researchers must wait for plants to acquire the competence to produce flowers. The long delay before the onset of flowering in poplars (they have a juvenile period of five to seven years) and their resistance to various conventional flower-induction treatments have been serious impediments to engineering sterility. CAFS researchers obtained a genotype of *Populus alba* from the University of Tuscia (Viterbo, Italy) that flowered nine months from when the seed was sown. Vegetative propagules from this line remained true to type (i.e., they flowered in nine months). However, this genotype had to be regenerated in vitro and grown under aseptic conditions before it could be imported into the U.S. The regeneration process caused this genotype to lose its ability to flower early. CAFS researchers experimented with a variety of inductive treatments and discovered one that restored the early-flowering phenotype. Center researchers have also obtained a genotype of *Juglans regia* that is capable of producing flowerings on nine-month-old plantlets and have identified conditions required to induce flower formation on *Prunus serotina* grown in vitro. Thus, CAFS scientists now have a variety of effective model systems for testing flower-control constructs, without having to conduct lengthy, expensive field trials.

Economic Impact: Through better understandings of the process by which trees control the onset of flowering, it may be possible switch flowering on or off at will, through genetic engineering. Shortening breeding cycles will allow for more rapid selection of trees that produce more biomass and are resistant to various biotic and abiotic stresses, thus minimizing economic losses. Preventing flowering will allow more photosynthate to be used for vegetative growth. Because there are so many tree species grown for a diverse range of products, it is difficult to quantify the benefits associated with this technological advance. Poplars are grown for fiber to manufacture paper, but increasingly for window and door casings, moldings, pallets, core stock for plywood, and, increasingly, as a feedstock for biofuel production and it is estimated that the yearly value of the U.S. poplar industry alone is about $300 million USD.

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