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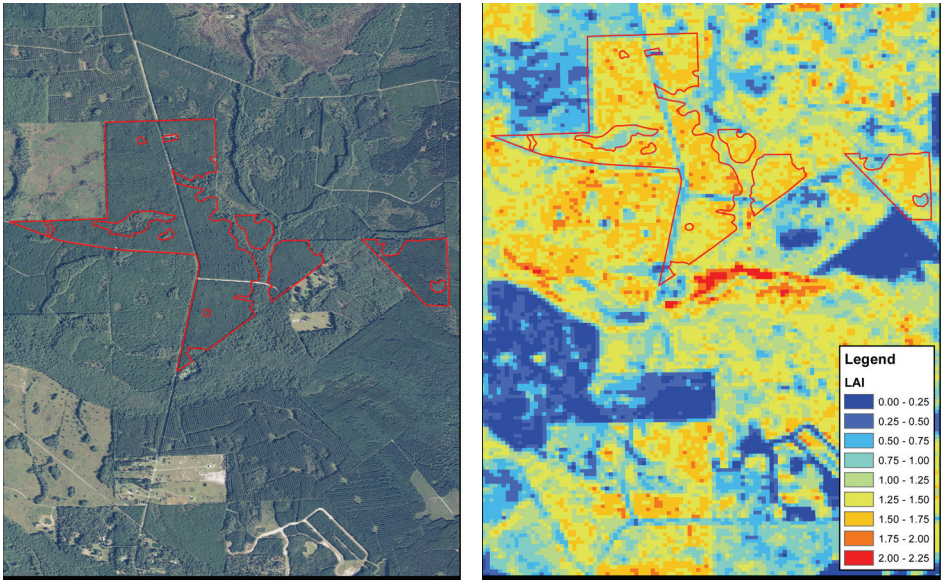
Remote Sensing for Diagnosing Nutritional Status of Forest Plantations

Over the years, on-site computations of Leaf Area Index (LAI) have been demonstrated to be the best indicators of the nutritional status of pine forest plantations and of whether they will require fertilization to achieve maximum productivity and value. Researchers at the Center for Advanced Forest Studies (CAFS) have developed techniques that use LANDSAT imagery to remotely estimate the leaf area index.



This image shows the leaf area index in loblolly pine plantations in Florida that were calculated using Landsat Imagery.

Prior to the development of this LANDSAT methodology, the only reliable way to determine leaf area index was to send field crews to visit plantations and make on-site field measurements. This was and remains very time-consuming and costly to do. That plus an obvious limitation of on-site LAI measurements has been that it can only examine small samples of the forestry stands of interest.

Satellite imagery provides a total, 100% examination of entire plantation/forest stands. One CAFS member company now collects satellite data on every one of its plantations (approximately 1.8 million acres). It calculates LAI on every plantation that is greater than 3 years old. They use it to more accurately determine the plantations that will require fertilization. This helps the firm reduce costly and wasteful fertilization of stands that will not respond to fertilization.

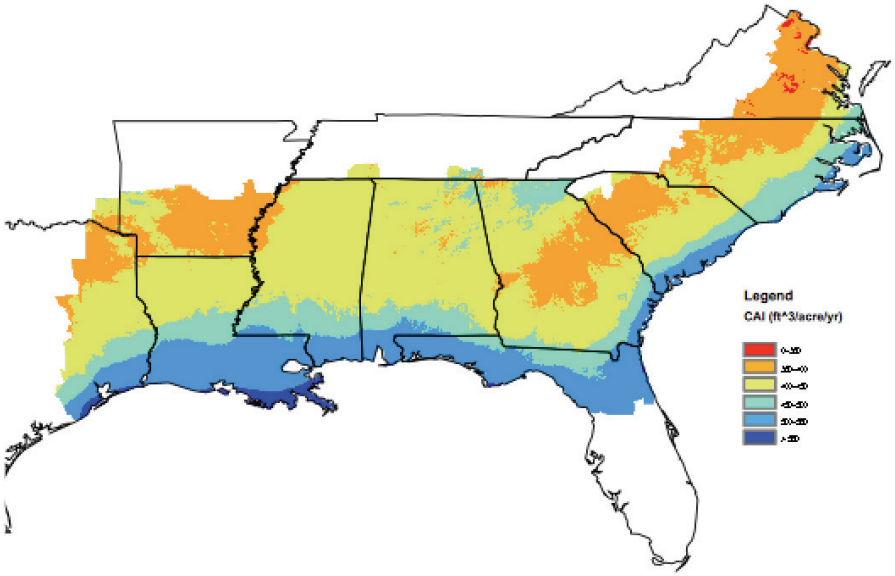
Too often, below average plantation responders to fertilizer applications are in stands that had good Leaf Area Indexes (LAIs). Taking advantage of this satellite-based LANDSAT-enhanced breakthrough, LAI technology can enable users to minimize or eliminate unnecessary fertilizing. The breakthrough has demonstrated that by using satellite enhanced LAI, average response to plantation fertilization can be maximized. With the addition of satellite-based Leaf Area Index (LAI) technology, this CAFS member company has become more capable of identifying and treating nutrient deficient stands and of better tracking the impact of fertilization applications on stands.

> **Economic impact:** This CAFS research will help develop higher, more productive forest plantations that yield wood for eventual use in building materials, paper and bioenergy. Annual LAI assessments yield data that allows this firm to delay additional fertilizations and still maximize response; thus saving substantial amounts of unwarranted expenditures. Stands with low satellite LAI measurements are the ones then targeted in order to maximize responses to fertilizer applications. Fertilization is an expensive treatment ($75-$100 per acre) so postponing fertilization on stands until they will be responsive works out well economically and maximizes the response when dollars are spent. It is estimated that this CAFS sponsor alone has realized over $1,000,000 in annual savings from reduced fertilization expenses. IF LAI becomes adopted nationwide, there is potential for an estimated $18,000,000 in annual savings throughout the large pine forest plantation industry.

For more information, contact Tom Fox at Virginia Tech's Department of Forest Resources and Environmental Conservation, trfox@vt.edu, Bio http://frec.vt.edu/people/fox/, 504.231.8862.

Forest Plantation Productivity Determination: A Process-Based Modeling

The process model Physiological Processes Predicting Growth (3-PG) was used to determine potential productivity of pine and Eucalyptus plantations in the U.S. and Latin America. 3PG is a dynamic, process-based model of forest growth developed by Landsberg and Waring in 1997. It runs on a monthly time step using species specific data on physiological processes combined with site specific data on climate and soil nutrient availability. CAFS's scientists working with the Forest Productivity Cooperative refined the model by incorporating new physiological parameters for commonly planted pine and eucalyptus species and developed a better method to estimate of soil fertility. They also assembled a detailed, spatially explicit database of the climate parameters needed for the United States, Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, Uruguay, and Venezuela. With these data, they develop estimates of potential productivity of both pine and eucalyptus plantations for each country on a 1 km grid in a database accessible members of CAFS.



Potential productivity of the Loblolly Pine in the southern United Stated determined using the process model 3PG. Potential growth rates are expressed as cubic feet of wood grown per acre per year in each region. Red and orange areas have lower potential productivity than blue areas.

These breakthrough refinements improve the accuracy of estimating potential productivity of the most important forestry species in both North America and South America. This work with the 3-PG model significantly expanded the number of species and countries where estimates of potential forest productivity are available to members of CAFS to help guide decisions on forest investments. It represents a significant technological advancement that goes well beyond the previous state of technology. It provides increases

in flexibility, accuracy, precision and reliability that ultimately guide multi-million dollar investments in the forestry sector worldwide. Investors now have access to user-friendly estimates of the productivity of the forestry plantations under specific environmental conditions and how best to enhance stand growth and value.

Results using the updated 3-PG models and Geodatabases have demonstrated that the potential productivity of plantations in many areas of the Americas is much higher than previously thought. This increases opportunities for heretofore unattractive regions for timberland investment.

> **Economic impact:** GreenWood Resources business model is focused on growing higher quality trees in a more cost-efficient than other timberland managers. GreenWood relies on accurate estimates of current and potential productivity of forest plantations to guide investments in timberland and evaluate potential financial returns. The work on 3PG by CAFS is a valuable tool that can be used to evaluate alternative investment decisions. The maps of potential forest productivity in different countries enables GreenWood Resources to match species to sites to maximize productivity for selected markets.

Improved estimates of potential productivity and growth increases possible through intensive silviculture of forest plantations is leading to better forest management decisions that increases the productivity, profitability and sustainability of forest management. GreenWood Resources has used these tools in Chile to identify lands of marginal agricultural quality that can be planted with improved hybrid poplar varieties to provide a renewable source of cellulosic bioenergy feedstock. GreenWood is using these results and is working to evaluate plantation options in several other regions of the U.S. and around the world.

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