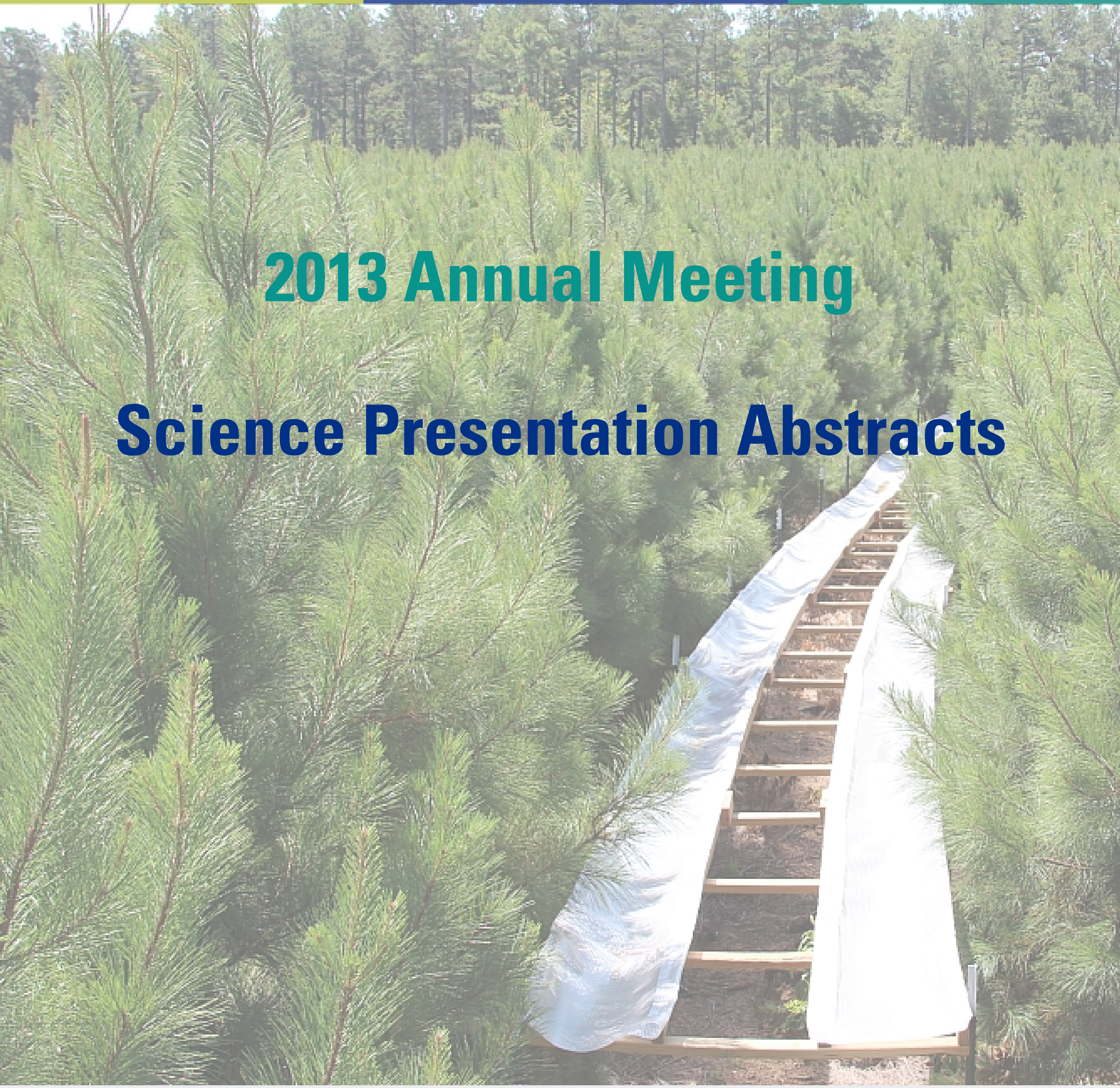
PINEMAP

Mapping the future of southern pine management in a changing world



2013 Annual Meeting

Science Presentation Abstracts

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Preliminary Results From Tier III Studies:

Effects of Lower Precipitation and Fertilization on Loblolly Pine Plantation Growth and Physiology

Rod Will and Aim 1 researchers

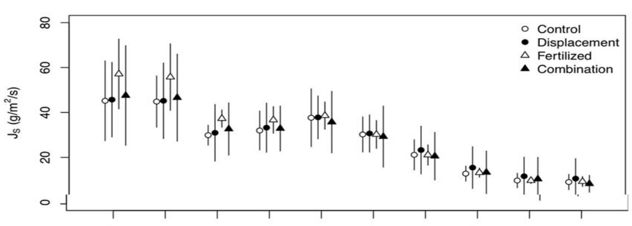
To determine the effects of a drier climate and increased nutrient availability on loblolly pine plantation growth, carbon accumulation, and physiology, PINEMAP installed the Tier III study at four locations across the commercial range of loblolly pine. The four sites capture the current range-wide variability of climate, precipitation, and productivity. Initiated in 2012, treatments at all four sites consist of a factorial combination of rainfall exclusion (30% reduction in throughfall) and fertilization with a complete suite of essential nutrients. This South-wide study is answering questions central to PINEMAP and is serving as a research platform to address a number of additional questions relevant to carbon sequestration and loblolly pine productivity.

Measurements of sap flux are being used to estimate tree water use of five trees per plot. Preliminary estimates from the Virginia site indicate increased sap flux associated with fertilization. Preliminary findings from the Georgia site are that sap flux is higher due to fertilization and lower due to rainfall exclusion.

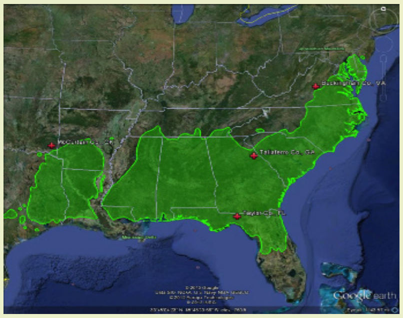
Soil CO_2 efflux includes respiration from the tree roots (autotrophic; Ra) and from soil heterotrophs (Rh). Separating the two is essential to understand carbon cycling and the effects of the imposed treatments on productivity. At all four sites, we are separating Ra and Rh using root exclusion plots. Preliminary work for the Virginia site indicates that Rh accounts for 60-80% of soil CO_2 efflux.

Increasing the uptake of fertilizer by pine trees will increase growth per amount of fertilizer applied thereby decreasing fertilizer cost and reducing possible offsite movement of nutrients. PINEMAP scientists from Virginia Tech are measuring the effects of season of treatment and understory vegetation on fertilizer uptake of loblolly pine trees using ^{15}N labeled urea at 18 locations across the Southeast. Preliminary data from the Year 1 winter application indicate that, depending on fertilizer type, between 23 and 48% of the nitrogen applied as fertilizer could be found in the aboveground biomass of pine trees.

The data from these studies and other ongoing and planned research at Tier III sites will allow us to better understand how loblolly pine plantations grow and function so that we can better predict growth, assess risk, and ultimately alter management to increase productivity and carbon sequestration.



Sap flux density from the Virginia Tier III site showing greater values for the fertilized stands in the summer.



Pictures shown from top to bottom are:

1. Location of Tier III sites.
2. Brett Heim measuring soil CO_2 efflux.
3. Rainfall excluders in action.
4. Adam Maggard measuring the radius of a pine needle.

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Regional Carbon Sequestration and Climate Change: It's All about Water

Steve McNulty, Ge Sun, Peter Caldwell, Eric Ward, Jean-Christophe Domec, and Asko Noormets

Forest productivity is highly dependent on leaf area, light, and nutrient availability. Southern forests are the most productive in the nation due to plentiful rainfall and abundant sunlight. Within these forests, carbon and water cycles are highly coupled. Water stress in some parts of the South occurs only periodically; therefore water is a minor environmental control to southern pine productivity. However, projected drought frequency, duration, and severity are on the rise compared to the past decades. Thus, there is a possibility that water stress can become the top limiting factor for some forests such as loblolly pine (*Pinus taeda* L.), especially near the western edge of the native range of loblolly pine where climate is in transition from humid to arid.

Regional scale models with interlinked carbon and water cycles have the capacity to simulate the sensitivity of forest productivity and water yield to multiple stressors over a large geographic region. Most importantly, a model can predict what will happen in the future to forests under different climate change and forest management scenarios. We used the Water Supply Stress Index (WaSSI) model to identify 'hot spot' watersheds that are most vulnerable to droughts in the loblolly pine range. At the spatial scale of a watershed, WaSSI simulates monthly evapotranspiration, stream flow, and carbon balances (i.e., gross ecosystem productivity [GEP], ecosystem respiration, and ecosystem net carbon exchange). The basic assumption of the WaSSI model is that water availability is the dominant driver of ecosystem productivity. A series of hypothetical climate scenarios were developed to study how droughts may affect GEP and water yield (Q) across the 9,283 watersheds in the study region. We modeled monthly forest water and carbon balances using 20 years (1990 to 2009) of historic climate data (PRISM database). We examined two levels of hypothetical precipitation reduction (15% and 30% reduction below latest 20 year means) and two stand ages (7 and 17 years) to represent climate impacts on GEP and Q for two stages of forest development (Figure 1).

Our simulations indicate that when precipitation is reduced by 30%, loblolly pine forest productivity and water yield is dramatically reduced compared to current conditions. The reduction can be as high as 400 g C/m^2/yr or 22% reduction from baseline (Regional mean= 200 ± 145 g C/m^2/yr or 10 ± 7%) and water yield is expected to decrease even more, 320 mm/yr or 65% reduction from baseline on average. Conversely, a moderate reduction of 15% of rainfall may result in only marginal reduction in GEP (3.4± 6%), but still significant reduction in water yield, with regional average of 172 mm/yr or 35% reduction from current baseline. The preliminary results suggest that the effect of the two drought scenarios on the productivity of young stands (7 years old in our simulations) would be similar in magnitude for late-rotation stands (17 years old). Such simulations provide a predictive framework that can readily assimilate data from other PINEMAP Aims, such as transpiration and growth estimates from the Tier III sites.

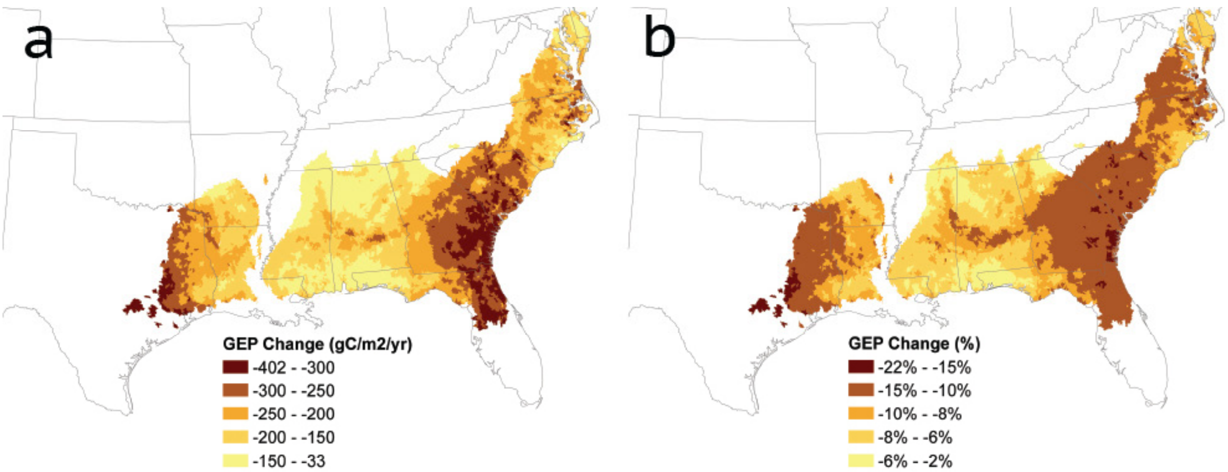

Figure 1. WaSSI model simulated drought (30% rainfall reduction year round) impacts on annual gross ecosystem productivity of watersheds covered by mid-rotation loblolly pine plantations (age 17) a) Absolute change and b) Relative change compared to historic climate.

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Strengths and Weaknesses of Universal Response Function Approaches for Support of Deployment Decisions

Thomas D. Byram, Tomasz E. Koralewski, and Earl M. (Fred) Raley

The Universal Response Function (URF) approach to supporting seedling deployment decisions relies on historical results from common garden seed source or provenance tests to construct deployment guidelines. If these progeny tests are widely scattered across a range of climatic conditions, the weather at the test sites combined with the climate at the seed source can be used as dependent variables to predict future performance of seed sources under similar conditions, current or future. There are three components to this modeling approach and underlying assumptions inherent in each component that limit the scope of the possible conclusions.

The first component is the choice of response variables. This includes both the trait and the measurement age. Some variables, such as height at early ages, may be predictive of future production. Other traits, such as older volume per planted tree or basal area, which incorporate survival, may be more informative about adaptive resiliency. The second component is the assumption that seed sources from a provenance have genetic components that reflect their evolutionary response to common selection pressures. Many factors including mutation, migration, and heterogeneous environments effect selection. In wind-pollinated outcrossed species like loblolly pine, these factors result in tremendous amounts of tree-to-tree genetic variation that are at least as important as the provenance variation. Finally, the weather variables at the test site represent only a small portion of the site-specific variables that determine productivity. Much information on site quality such as the impact of soil fertility, drainage, and management history are completely ignored. Furthermore, the decision space is limited to the conditions tested and to the measurement ages evaluated. Progeny tests are rarely established on land deemed marginal for commercial forestry.

Josh Sherrill and Steve McKeand measuring a genetic test on Rayonier property in Atkinson County, GA. Photo courtesy of Steve McKeand.

Nevertheless, there are useful insights that have been obtained from this approach:

1. Local seed is seldom optimal and gain in production can be made from transferring seed from warmer to slightly cooler climates.
2. The further a seed source is moved to cooler or drier climates, the more important tradeoffs between production and adaptation become.
3. Tree-to-tree variation is large and should be captured through continued progeny testing and family deployment.
4. Productivity and resiliency can both be improved to the degree that aridity can be ameliorated by proper silvicultural practices.

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Carbon Consequences of Changes in Wood Supply and Product Demand from Pine Plantations: Preliminary Results from Market and Life Cycle Analysis

Robert Abt and Puneet Dwivedi

There are several important factors that will determine ultimate carbon outcomes associated with future pine plantation management. Increased growth and resilience of the pine resource is the focus of PINEMAP biological research and the forcing agent for many downstream effects. The focus here is on how regional market interactions and accounting for product life-cycles affects the carbon story associated with pine plantations. We offer two examples. In the first, Abt explores the price, landuse, and forest carbon consequences of increases in supply from plantations and the sensitivity to future demand. Given the disproportionate market impacts from plantations relative to their role in the landscape, price effects from plantation supply changes can influence timberland trends and dampen net carbon gains. This type of market "leakage" is a key factor in carbon accounting and we provide preliminary estimates of the welfare and market adjusted carbon consequences (Figure 1). In the second example the focus is on one source of potential future demand, the use of pulpwood for manufacturing wood pellets. Dwivedi et al. adopted an integrated life-cycle approach to analyze overall carbon savings related to the utilization of pulpwood and logging residues for electricity generation relative to their current usage. Dwivedi et al. found that the use of pulpwood for bioenergy development reduces carbon sequestered in wood products and wood present in landfills relative to a baseline where pulpwood is used for paper making and logging residues are used for manufacturing wood pellets. However, this reduction was fully compensated by the additional carbon credits generated due to displacement of fossil fuels electricity (Figure 2). Future efforts will integrate life cycle analysis into regional scale simulations.

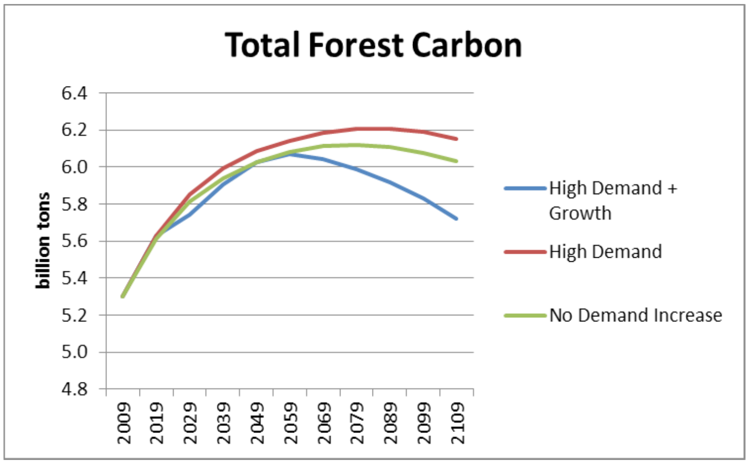

Figure 1. Total carbon sequestered in forestlands under selected scenarios.

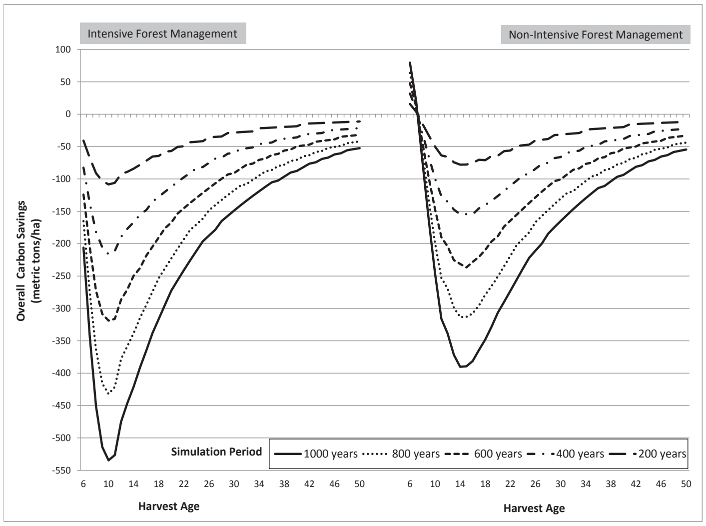

Figure 2. Results of simulations of two scenarios for two management intensities and a range of simulation lengths. For baseline case ENE-LR, harvested trees are used to produce lumber, OSB, and paper, and logging residues are used for manufacturing wood pellets for energy production. In case ENE-LR&PW, both pulpwood and logging residues are used for wood pellets. The graph shows the difference in total carbon savings saved or sequestered between the two scenarios (ENE-LR minus ENE-LR&PW), with more negative values indicating greater carbon sequestered in the ENE-LR&PW scenario.

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Incorporating Climate Change into Biology Concepts

Stephanie Hall and Martha Monroe

Climate change is recognized by a majority of climate scientists as a critical issue that will affect the planet for many years. To help them become knowledgeable citizens, high school students should obtain the background needed to make informed decisions about potential strategies for mitigation and adaptation. While both students and teachers are interested in addressing climate change in the science classroom, determining exactly how this should be accomplished raises several interesting questions.

Because every science course already takes a full year, adding a unit on climate means finding content to remove, which is not easily done. Educators have long known, however, that applying basic scientific principles to real world issues can improve student interest in science. Some teachers may find it easier to integrate climate concepts into their current framework rather than making room for a climate unit. The carbon cycle and carbon sequestration, for example, are often covered in a biology class and are fundamentally important to understanding climate change and mitigation. However, this issue is controversial, and students may bring preconceptions and attitudes about climate to the classroom. If students do not believe climate change has anthropogenic causes, their attitudes could be a barrier to learning and a disruption to small group discussions. This study explored if teaching the biological concepts of the carbon cycle and carbon sequestration in an integrated manner with climate change increased or decreased student interest in the activities and knowledge about these carbon concepts.

Data were collected from rising high school sophomores participating in a summer science program at the University of Florida. Two versions of a half-day program on the carbon cycle were offered to 47 youth. One version introduced climate change as a consequence of increasing atmospheric carbon dioxide and sequestration as a potential solution. The other version refrained from mention of climate until after the posttest. There was a significant increase in knowledge only among students who participated in activities connecting carbon cycle concepts and climate change. Almost all of the students (44 out of 47) stated that they felt knowing that the carbon cycle and carbon sequestration are an important part of climate change made the activities more interesting because it made the activities more relevant and important to them. This suggests that incorporating climate change into biological concepts, such as the carbon cycle, could increase student knowledge gain by making the lesson more interesting to students, helping them learn more about biological concepts and climate change.

Students expressed a variety of attitudes about climate change, some of which are strongly associated with their perception of their parents' attitudes about climate and their political preference. These attitudes did not affect students' level of interest in the activities and increased knowledge.

Pictures shown from top to bottom are:

1. Showing the connection between the carbon cycle, the greenhouse effect, and climate change.
2. Students moving through the biological portion of the carbon cycle.
3. Students mapping the entire carbon cycle.
4. Students measuring trees to determine their carbon storage.

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Climate Change Perceptions of Southern Foresters: Preliminary Survey Results

William Hubbard, Leslie Boby, and Hilary Cole

Professional foresters in the southeastern United States are an important stakeholder group for PINEMAP. This group, comprised of professionally trained individuals from private industry, consulting firms, public agencies, universities, and nonprofits will need to provide several critical services if PINEMAP is to accomplish its goals and objectives. Many professional foresters are in the business of serving private family forest owners. They provide oversight in the development of management plans, recommend and oversee implementation of preferred silvicultural practices, and initiate several other practices on behalf of the landowner. There is currently little to no information available regarding the receptivity of foresters to climate change (CC) concepts and their willingness to implement 'climate-smart' forest management strategies.

Methods

A team of professionals from the Extension AIM group (Aim 6) developed an online survey for professional foresters in the South. Recent surveys such as PINEMAP's Southeast Extension Professional's Climate Change Perceptions survey (Wojcik et al., in review) and a survey of farmers conducted through the 25x'25 Alliance (Fink, 2012) were reviewed to ensure consistency of questions and format. Twenty-four questions on observations, perceptions, beliefs, and continuing education needs were included in the survey in areas related to changing climatic conditions, weather, and resilient forest management strategies. Eight questions were used to collect demographic information. Most of the questions used Likert scales with open-ended options to offer participants an opportunity to provide additional information. The Tailored Design Method (Dillman, 2009) was utilized to ensure proper implementation of the Internet survey.A comprehensive working database of about 6,700 professionally trained foresters from 13 southern states was developed through Internet searches and direct contacts. The survey, which was conducted January through March 2013, was sent to all individuals in this database.

Preliminary Results

More than 1,700 foresters completed the survey by the end of the survey period (27% response rate). A few key preliminary results include the following:

- 30% of respondents believe that there is not sufficient evidence to say that climate is changing; 46% agree that CC is occurring but attribute it to unknown or mostly natural causes; and 16% agree climate is changing and caused by humans (Figure 1).
- 60% of respondents feel 'somewhat' to 'very knowledgeable' about climate and CC, and 65% are 'somewhat' to 'very interested' in learning more.
- Only 25% of respondents responded that their clients have asked about CC.
- 45% of respondents think that changes in forest management strategies are necessary to respond to climate uncertainty.
- Respondents' acceptance or doubt of anthropomorphic (human-caused) CC was a highly significant predictor of personal CC observations, concern about forestry impacts, and perceived needs for adaptive management strategies.

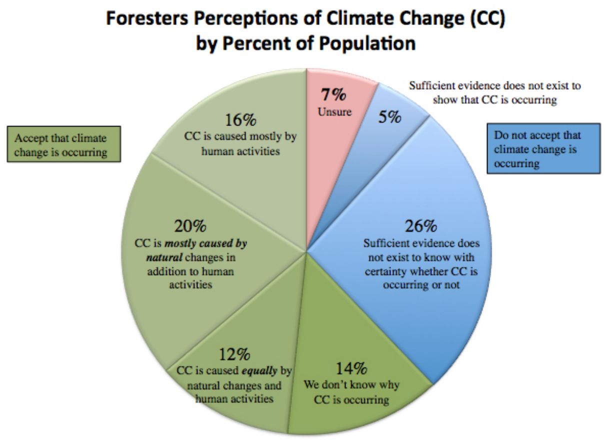

Figure 1. Foresters selected the statement that best reflected their views on climate change. About 62% agree that the climate is changing but have different notions about its cause, and only 16% think that it is mostly human-induced. 31% of foresters do not think that the climate is changing or that there is enough evidence to know with certainty.

Potential Application of Findings

Results from this survey will be used to work with forestry stakeholders on a variety of levels, including contining education and material development. It is evident from the results that many foresters are interested in educational programs that would help them increase forest resiliency on their client's properties. Results from this survey will help frame Aim 6's approach to generating and implementing better educational programs.

References

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Dillman, D., J.D. Smyth, and L.M. Christian. 2009. *Internet, Mail, and Mixed-Mode Surveys: The Tailored Design Method, Third Edition.* John Wiley and Sons, Inc. Hoboken, NJ.

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