PINEMAP

2012 Annual Meeting
Poster Titles

1 Joseph E. Clark, Stan Bartkowiak, and Lisa J. Samuelson. *Impact of rainfall manipulation on light use and water use efficiency in 6-year-old loblolly pine*.

2 Wen Lin, Asko Noormets, and Jean-Christophe Domec. *Unraveling a quasi-industrial new approach for pine mapping of wood stable isotope ratio*.

3 Cody M. Luedtke, Madison K. Akers, and Robert O. Teskey. *Soil CO_2 efflux and tree carbon relations in a loblolly pine plantation*.

4 Adam O. Maggard. *Interaction between fertilizer and drought on leaf area dynamics and tree water use and their relationship to stand growth of loblolly pine* (*Pinus taeda* L.).

5 Jay Raymond, Thomas Fox, and Brian Strahm. *Use of stable isotopes to trace the fate of applied nitrogen in forest plantations*.

6 Rodney Will, Duncan Wilson, Tom Hennessey, Jason Vogel, Jason West, and Bob Heinemann. *Description of the Oklahoma Tier III site*.

7 Brett Heim, John R. Seiler, and Brian D. Strahm. *Heterotrophic and autotrophic soil respiration in response to fertilization and reduced throughfall at the Virginia Tier III site*.

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10 Maxwell Wightman and Timothy Martin. *The impact of artificial drought conditions on parameterization of 3-PG for Pinus taeda*.

11 Eric Ward, Asko Noormets, Jean-Christophe Domec, John King, Steve McNulty, and Ge Sun. *Integrating measurements and models of carbon and water cycling at Tier II and III PINEMAP sites*.

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17 Ross Whetten and Laura Townsend. *Identifying genetic variation in site adaptability in loblolly pine*.

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19 Puskar N. Khanal and Donald L. Grebner. *A preliminary effort to evaluate the willingness of nonindustrial private forest land owners to practice optimum carbon sequestration regimes in Mississippi*.

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21 Melissa M. Kreye, Damian C. Adams, Tatiana Borisova, and Francisco Escobedo. *Valuing forest conservation and water quality protection programs: A meta-analysis of willingness-to-pay scenarios*.

22 Nilesh Timilsina, Wendell P. Cropper, Jr., and Francisco Escobedo. *Assessing trade-offs among different ecosystem services in pine flatwoods of southeastern coastal plain*.

23 Annie Oxarart, Martha Monroe, Stephanie Hall, Jie Li, and Al Stenstrup. *Project Learning Tree Secondary Module: Southern Forests and Climate Change*.

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PINEMAP

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Poster Abstracts

1 **Joseph E. Clark, Stan Bartkowiak, and Lisa J. Samuelson.** ***Impact of rainfall manipulation on light use and water use efficiency in 6-year-old loblolly pine*****.**

Objectives
Aim 1 goals are to establish a region wide three-tiered network system based on existing research cooperatives trials, develop standardized methods to quantify C, water and nutrient storage and flux baselines and responses to climate and management. A goal of Aim 1 is to test loblolly pine response to nutrition and artificial drought. Our project deals specifically with the tier III site located in Taliaferro, GA and will investigate the influence of a 30% reduction in ambient precipitation combined with varying nutrient availability on the mechanisms controlling growth of loblolly pine. Our objectives were evaluate how changing precipitation and nutrient availability influence relationships among LAI, IPAR, photosynthetic capacity and growth efficiency, determine whether soil nutrients or water availability had more of an influence on Asat, gs, and Fv/Fm, and canopy stomatal conductance in response to vapor pressure deficit and soil moisture. These measurements will be used to help parameterize and validate the many models being used in PINEMAP.

Methods
Four replicates of a randomized 2 x 2 factorial experimental design were installed in a 6-year-old loblolly pine plantation. Treatments are two levels of precipitation, ambient and a 30% reduction, and two levels of fertilization, operational and none. Precipitation is reduced by rainfall interception troughs. Growth and physiology are being studied by examining leaf area index, intercepted radiation efficiency, photosynthetic capacity and tree and stand level transpiration and water use efficiency. Leaf area will be measured with litter traps along with LAI 2000. Photosynthesis measurements will examine light saturated photosynthesis (Asat), stomatal conductance (gs), chlorophyll fluorescence (Fv/Fm) and also recovery of Asat and Fv/Fm following frost events. Stand level transpiration will be measured using heat dissipation probes.

2 **Wen Lin, Asko Noormets, and Jean-Christophe Domec.** ***Unraveling a quasi-industrial new approach for pine mapping of wood stable isotope ratio*****.**

No abstract provided.

3 **Cody M. Luedtke, Madison K. Akers, and Robert O. Teskey.** ***Soil CO_2 efflux and tree carbon relations in a loblolly pine plantation*****.**

Through The Pine Integrated Network: Education, Mitigation and Adaptation Project, we are able to address two research questions at a young Loblolly Pine plantation in Washington, Georgia (a Tier III site). First, what are the relative contributions of heterotrophic and autotrophic respiration to soil respiration? This question will be approached at this, and other Tier III sites within the natural range of Loblolly Pine using a 2 × 2 factorial treatment of natural rainfall and 30% rainfall exclusion combined with low and high nutrient application on 16 plots segregated into 4 blocks. Measurements of heterotrophic respiration will be taken using a modified root exclusion core, which will sever roots and prevent influx of carbohydrates from the tree. These measurements will be subtracted from measurements of total soil respiration to calculate autotrophic soil respiration. We have gathered preliminary CO2 efflux data from the site, which indicate that efflux rates are significantly different between some study plots and blocks. Our second research question focuses specifically on the Washington, Georgia site: do trees experiencing water and/or nutrient stress increase partitioning of carbon to storage or allocation of carbon to root growth? To investigate this question, total carbon content, carbohydrate, and lipid content will be measured on a subset of trees within each treatment in addition to above and belowground biomass. These measurements will be used to test the functional equilibrium hypothesis.

4 **Adam O. Maggard.** ***Interaction between fertilizer and drought on leaf area dynamics and tree water use and their relationship to stand growth of loblolly pine* (*Pinus taeda* L.).**

The objective of this study is to determine if the positive effects of fertilizer on the growth of loblolly pine plantations can compensate for decreased water availability or whether fertilization increases susceptibility to water stress. The central hypothesis is that fertilizer added to a loblolly pine plantation experiencing reduced water availability will increase the negative effects of drought such that the effects of nitrogen fertilizer are largely negated. I hypothesize that increased leaf area due to fertilization causes a greater reduction in leaf-level and whole-tree use when water availability is limited and causes greater water stress and earlier leaf abscission. To meet the objective, a variety of foliar, soil moisture and ecophysiological measurements will be conducted. Specific measurements will include leaf area dynamics using litter trap samples, whole-tree water use measured with thermal dissipation probes, leaf-level water use estimated using a LI-6400 portable photosynthesis system, and water use efficiency estimated by a combination of leaf-level gas exchange measurements and carbon isotope discrimination. Understanding the interaction between fertilizer and drought is essential to understand the effects climate change will have on loblolly pine management throughout the southern United States. The outcome of this proposed study is expected to leaf to knowledge of how the benefits of nitrogen fertilizer are affected by water stressed conditions and how decreased water availability may alter nitrogen use in future forest management.

5 **Jay Raymond, Thomas Fox, and Brian Strahm.** ***Use of stable isotopes to trace the fate of applied nitrogen in forest plantations*.**

One of the primary objectives of the PINEMAP program is to increase the efficiency of nitrogen (N) fertilizer inputs in loblolly pine (Pinus taeda) systems. Fertilizer studies in forest plantation systems across the Southern United States indicate 10-25% of N applied during fertilization is incorporated into crop trees while the remainder is retained in different components of the ecosystem, volatilized or leached. A comprehensive understanding of the movement of N in these systems is critical due to financial costs associated with fertilization, and an environmental awareness of the potential negative impacts from improper fertilizer application. Our primary research objective is to improve the fundamental understanding of N dynamics in forested systems by 1) determining the fate of applied fertilizer N in mid-rotation loblolly pine stands (8-25 years) across the entire plantation range in the Southern United States using 15N enriched fertilizers (0.5 atom %;~370 ‰), and 2) compare N dynamics following fertilization with conventional (urea) and enhanced efficiency (polymer coated urea, urea+NBPT, monoammonium phosphate coated urea) fertilizers enriched with 15N. Five 100 m2 circular plots were installed at each of the 20 study sites across the entire range of loblolly pine plantations from 2011-2012 in a wide range of soil and stand conditions. During the late winter months, 224 kg ha-1 of total N was applied to treatment plots. The rate of N uptake from different fertilizers is being evaluated by periodic foliage sampling in 2011. Total N uptake in the growing season is being determined by biomass sampling of trees separated into individual components (foliage, fine branches, coarse branches, stem) to determine the mass and concentration for each. Additional ecosystem components are also being analyzed to determine N uptake (understory vegetation, forest floor, mineral soil, roots). N volatilized following fertilization was also measured using a static chamber method and a microcosm experiment.

6 **Rodney Will, Duncan Wilson, Tom Hennessey, Jason Vogel, Jason West, and Bob Heinemann.** ***Description of the Oklahoma Tier III site*.**

No abstract provided.

7 **Brett Heim, John R. Seiler, and Brian D. Strahm.** ***Heterotrophic and autotrophic soil respiration in response to fertilization and reduced throughfall at the Virginia Tier III site*.**

Climate change predictions in the southeastern US expect up to a 30% decrease in annual precipitation in some areas. This may lead to declines in productivity and as a result may change the net carbon balance of forests in the southeast which are presently large carbon sinks. Estimating net ecosystem productivity (NEP) to quantifying the net carbon balance of a forest requires partitioning soil respiration (RS) into components of heterotrophic (RH) and autotrophic (RA) respiration. Working within Aim 1 at the VA Tier III site in the Appomattox–Buckingham State Forest (Buckingham County) on the Piedmont, soil CO2 efflux measurements will be taken in fertilized and ~30% reduced throughfall plots in a 2x2 factorial design with four replicates. Root severing collars (10 cm diameter x 35 cm deep) will be installed seasonally to drive RA to 0, providing an estimate of RH. This RH coefficient can then be used in models to better predict the net carbon balance of southeastern pine plantations under varying climate change scenarios and nutrition regimes.

8 **Andy Laviner and Thomas Fox.** ***Stand level water relations at the Virginia Tier III site*.**

The PINEMAP Tier III sites offer a unique opportunity to examine the effects of water stress in pine plantations at the stand level. The study design is a two by two factorial of fertilization (200N, 25P, 50K plus micro-nutrients) and drought (30% throughfall removal) with four replications. In the main study area, hardwood and volunteer pine competition was removed mechanically and chemically so we also installed plots adjacent to the study where this competition was not removed. This combination of treatments in a loblolly pine plantation that is just reaching crown closure should create a wide range of leaf area, water demand and water availability. Hypotheses to be tested include:

1. Stem volume growth of fertilized stands will be maintained under drought conditions (Treatment rank F > FD = C > D),
2. Root allocation will be shifted deeper in the soil as result of imposed drought,
3. Planted pine experiences equal water stress due to hardwood and volunteer pine competition as planted pine with 30% throughfall removal.

We will also be exploring the relationships between and variability of leaf area, throughfall, and soil moisture through the profile.

9 **Raj Shrestha and Brian Strahm.** ***Soil greenhouse gas fluxes in response to fertilization across gradients in soil moisture*.**

Although southern pine forests represent potential C sinks, the role of forest management in mitigating other greenhouse gases (GHG) is less familiar. The objective of this study is to provide an understanding on the impacts of forest fertilization on GHG fluxes in managed loblolly pine ecosystems across gradients in soil moisture. The studies were conducted in the Coastal Plain of North Carolina and PINEMAP Tier III site in the Piedmont of Virginia. In North Carolina, three landscape positions (i.e., flat, terrace, and upland) were selected to provide gradients in soil moisture and drainage. The fertilization treatments in each landscape position included control (no fertilization), urea, and Arborite® applied in spring, summer, and fall seasons. Nitrogen-fertilizers were applied at the rate of 168 kg N ha-1 in all three seasons. GHG sampling started immediately after fertilizer application and continued every six weeks for one year. The treatments in the PINEMAP site at Virginia were control, fertilization (optimal nutrition), drought (~30% throughfall reduction), and fertilizer plus drought. GHG sampling at the PINEMAP site occurs quarterly. GHG measurement was done using vented static chambers in both studies.

10 Maxwell Wightman and Timothy Martin. ***The impact of artificial drought conditions on parameterization of 3-PG for Pinus taeda*.**

The impact of climate change on temperature and precipitation patterns in the southeast U.S. are likely to have an important impact on southern pine systems. The southeast U.S. is predicted to experience an increase in average temperature of 2.5 to 5°C by the 2080s. Predictions for changes in precipitation for the southeast, although less certain, generally indicate a 10% to 30% reduction in summertime precipitation. Increased average temperature and decreased precipitation will increase vapor pressure deficits (VPD).

The Physiological Principles in Predicting Growth (3-PG) model uses physiological process data, statistical growth and yield models, and easily obtained weather and site conditions to simulate the growth of forest stands. The ability of this model to predict forest productivity under a variety of management and environmental conditions makes it an especially useful tool for predicting the impact of climate change scenarios on forest stands. The sensitivity of stomatal conductance to VPD and the impact of soil moisture on growth are important components of 3-PG. The objective of this research project is to parameterize the 3-PG model for both fertilized and unfertilized loblolly stands under conditions of extended artificial drought.

11 Eric Ward, Asko Noormets, Jean-Christophe Domec, John King, Steve McNulty, and Ge Sun. ***Integrating measurements and models of carbon and water cycling at Tier II and III PINEMAP sites*.**

One of the goals of PINEMAP is improving predictions of monthly time step models of forest carbon and water cycling (such as 3PG and WaSSI-C) with data from the Tier II and III sites. This poster presents possible methods for integrating data from sap flux sensors, leaf-level gas exchange, micrometeorology towers and stand structural characteristics into estimates of absorbed radiation, transpiration and photosynthesis that can be used to calibrate 3PG and WaSSI-C. These methods include a Bayesian state-space model of canopy conductance and a one-dimensional radiative transfer model that incorporates crown and shoot structure. The outputs of both of these models are used in estimating monthly gross primary productivity (GPP) in a canopy conductance constrained carbon assimilation (4CA) framework. This method can also provide estimates of conductance and assimilation responses to soil moisture, light, vapor pressure deficit and canopy structure that could be utilized in interpreting projections of 3PG and WaSSI-C for future climate scenarios.

12 C. Wade Ross and Sabine Grunwald. ***Modeling biogenic carbon dynamics across the southeastern U.S*.**

Global warming has been well documented and there is concern that continued increases in anthropogenic greenhouse gas (GHG) emissions will continue to increase global temperatures, and may alter regional climate patterns and carbon (C) pools. Increasing the capacity of the terrestrial biosphere to act as a “C sink” has been suggested as a means for mitigating anthropogenically induced global warming.
The terrestrial biosphere stores substantial amounts of C in both aboveground biomass (650 Pg C) and soils (3,150 Pg C); approximately 6 times more than the atmospheric C pool (750 Pg C). As such, relatively small changes in terrestrial C (TerraC) pools could have a significant effect on the atmospheric concentration of CO2, and therefore affect temperature and climate. In the Southeastern U.S., nearly 1/3 of all forest C is stored within privately owned pine forests. These forests supply 16% of global industrial wood and 7.5% of industrial economic activity in the region. These forests can help offset anthropogenic GHG emissions by increasing the C sink capacity through proper land management.

The objectives of this project are to i) investigate soil C dynamics along various trajectories of soil moisture/hydrology and fire regimes, and develop and validate a soil C submodel that simulates belowground processes governing soil C dynamics, ii) investigate the effects of fire disturbance on the structure and function of TerraC stocks in Southern pine ecosystems, and iii) develop a model to upscale site-specific changes in TerraC stocks and budgets under various disturbance and climate change scenarios to the regional scale.
Results from this project will improve the understanding of TerraC dynamics and potential effects of climate driven changes on soil moisture and fire regimes and allow land managers to implement best management practices to increase C sequestration while increasing forests resilience to climate change stressors.

13 Ranjith Gopalakrishnan, Randolph H. Wynne, and Valerie Thomas. ***Projecting the impact of climate change on future southeastern forest fire regimes*****.**

Possible changes in wildland fire regimes caused by climate change are becoming a concern for south-eastern and southern US forest stakeholders. For example, in 2011, the state of Texas faced the worst forest fire season in the history of the state, with fires burning over 1.6 million hectares of forest land and destroying over 3000 homes. Hence, it is of extreme importance to project the evolution of fire regimes for a landscape or a region for the long-term, so that forest managers can be best prepared.

Our research question here is: **"What will be the trend in the wildfires regimes in managed loblolly ecosystems in the south-eastern US region in the future?"** The objectives of this work are: 1) To enhance current remote sensing methods for fuel load characterization in managed loblolly pine plantations; 2) To identify the relations between fuel load and management practices, in such plantations; 3) To estimate future fuel load trajectories, in the face of climate change and planned management strategies

For the first objective, we primarily plan to use LIDAR data collected over loblolly pine plots established by the Forest Inventory and Analysis Program to understand and improve characterization of fuel loads. To tackle the 2nd objective, we plan to use the methods developed from our work on objective 1 to quantify fuel loads across industry stands, with known management practices. This would allow us to understand and describe the link between the current fuel load and the previous management practices followed. The third objective will be addressed by using parameters simulated by the forest stand model 3PG, and understanding how its outputs (eg, biomass) correlate to fuel load.

14 Ying Wang and Robert O. Teskey. ***3-PG simulation of loblolly pine growth and yield*****.**

Loblolly pine is one of the most important timber species in the United States, which makes important contributions to the economy and the global carbon cycle. As a result, methods to enhance forest productivity and carbon sequestration have become important, particularly in regard to climate change impact. One method to derive new understanding into these areas is to apply model simulation to loblolly pine growth and yield under various climate and soil conditions. In this study, we will use the 3-PG model to predict the loblolly pine productivity in the southeastern region. In addition, we will choose and link a soil carbon model to 3-PG model in order to simulate the carbon sequestration regionally.

15 Alfredo Farjat, Fikret Isik, Ross Whetten, and Steve McKeand. ***The effect of minimum winter temperatures on pine growth*****.**

Loblolly pine (*Pinus taeda* L.) is the major timber species in the Southeastern United States, with almost 1 billion seedlings produced annually. Genetic improvement through breeding and selection of loblolly pine since the 1950's has improved the productivity, form, and disease resistance in the species. The Plantation Selection Seed Source Study (PSSSS) was initiated in 1994 by the NCSU Cooperative Tree Improvement Program to determine the patterns of geographic variation in plantation selections and to understand pine genotypes by environment interactions. Pine families were initially selected from pine plantations for phenotypic indicators, such as height, stem form, and disease resistance. Seedlings from 180 families were planted at 22 test locations throughout the southeastern US. Growth, stem quality and fusiform rust disease were measured at tree ages 4 and 8 years. Previous studies indicate that minimum winter temperature was the primary adaptability factor for loblolly pine seed source movement in the southern US. The NCSU Cooperative Tree Improvement Program uses the county level temperature information to guide deployment of specific families of loblolly pine. In this work, a geo-spatial statistical model is presented to estimate the effect of average minimum temperatures on pine performance throughout the southern US. The average minimum temperatures, along with the corresponding measures of uncertainty, are estimated using data from weather stations throughout the southeastern US from 1994 to 2005. The interactions between pine families and the average yearly minimum temperature will be estimated to identify the norm of reaction of families and draw guidelines for future deployment of loblolly pine varieties under different minimum temperature scenarios.

16 Michael J. Aspinwall, Steven E. McKeand, and John S. King. ***Carbon sequestration from 40 years of planting genetically improved loblolly pine across the Southeast United States*****.**

Highly productive, widely deployed genetically improved loblolly pine (*Pinus taeda* L.) may play an important role in mitigating rising atmospheric CO2 via carbon (C) sequestration. To understand the role of loblolly pine genetic improvement in future C sequestration strategies, we examined the historical (1968 –2007) impact of operationally deploying improved families of loblolly pine on productivity and C sequestration across the southeast United States. Since 1977, nearly 100% of loblolly pine plantations in the southeast United States have been established with genetically improved loblolly pine. In recent years, more than 400,000 ha of genetically improved loblolly pine are planted annually. Between 1968 and 2007, we estimate that genetically improved loblolly pine plantations have produced a total of 25.6 billion m^3 of stemwood volume and have sequestered 9,865 Tg C in live and dead biomass. Our estimates also indicate that genetic improvement has resulted in an additional 3.7 billion m^3 (17% increase) and 1,100 Tg C (13%) of volume production and C sequestration, respectively, relative to volume production and C sequestration with no genetic improvement. We expect that loblolly pine plantation C sequestration will increase as more productive families and clones are deployed and as currently deployed genetic material continues to mature. Together, genetic improvement, intensive silvicultural, and longer rotations aimed at producing long-lived wood products will be important tools for maximizing C sequestration in loblolly pine plantations.

Aspinwall, M.J., S.E. McKeand, and J.S. King. 2012. Carbon sequestration from 40 years of planting genetically improved loblolly pine across the southeast United States For. Sci. (published online April 12, 2012; http://dx.doi.org/10.5849/forsci.11-058.).

17 Ross Whetten and Laura Townsend. ***Identifying genetic variation in site adaptability in loblolly pine*****.**

The objectives of Aim 3 are to develop deployment guidelines for existing pine planting stock, to identify alleles in pine populations that influence tree growth, development, or responses to environmental signals, and to characterize the frequency and distribution of those alleles in deployment populations. A key requirement to accomplish the second and third objectives is a cost-effective high-throughput genotyping method for loblolly pine. An important deliverable for the first two years of the project is to develop such a method and provide convincing evidence of its quality, reproducibility, and cost-effectiveness. Four groups in Aim 3 are working to test different alternative approaches that may help to achieve this key milestone. This poster presents an outline of experiments to test the Genotyping-by-Sequencing (GBS) method in loblolly pine, and an overview of some preliminary results. The pilot experiment used a single restriction enzyme, PstI, to create a library of small fragments of genomic DNA from a set of four diploid and 14 haploid loblolly pine DNA samples. Those samples were sequenced, along with samples from other conifer species that are part of a separate experiment, on a single lane of a flowcell on an Illumina HiSeq2000 instrument. Almost 150 million paired-end DNA sequences were obtained; almost 95% of those contained barcode information allowing assignment of the sequence to a specific sample within the pool of 93 different DNAs analyzed. The reproducibility of sampling the same loci across individual DNA samples was unsatisfactory, so a second experiment is underway to prepare sample libraries using a two-enzyme variant of the GBS protocol.

18 Jianxing Zhang, Salvador Gezan, and Gary F. Peter. ***Integrating climate and genetic effects of southeastern loblolly pine by Universal Response Functions*****.**

Genetic improvements in forestry dramatically increase the productivity of planted pine in the southeast US. Climate is a key environmental factor affecting the phenotypes and genotypes of trees. In 1982-1983, seven provenance-progeny tests were established in Alabama, Florida, Georgia and Mississippi and tree height, stem diameter and volume and disease traits were measured at years 5, 10, and 15. Based on the tests, universal response functions will be constructed to understand the climate and genetic effects influencing growth and adaptation, and develop a genetic deployment tool to help forest managers target appropriate seedlots and families to specific planting sites based on climate and predictions of climate change.

19 **Puskar N. Khanal and Donald L. Grebner.** ***A preliminary effort to evaluate the willingness of nonindustrial private forest land owners to practice optimum carbon sequestration regimes in Mississippi*.**

Intensive forest management is one of the strategies to sequester atmospheric carbon in terrestrial ecosystems. Few studies have evaluated maximum carbon sequestration strategy for nonindustrial private forest (NIPF) lands in Mississippi. The study will evaluate optimum carbon sequestration strategies ideal for NIPF lands. The data will be derived from a review of the literature and NIPF mail survey. Results will report landowners willingness to implement practices that maximize carbon sequestration. Initial findings from the literature have shown that joint production of timber and carbon requires relatively longer rotation lengths.

20 **Jose R. Soto, Damian C. Adams, and Francisco Escobedo.** ***Estimating the supply of forest carbon offsets: A comparison of best-worst and discrete choice valuation methods*.**

A recent national survey revealed that 75% of U.S. voters favor regulating carbon dioxide as a greenhouse gas (GHG pollutant. One way to mitigate climate change is to create a market that pays land owners to sequester GHG, for example by planting trees, increase efficiency of nitrogen and other fertilizer inputs, or improving forest management techniques. Pine flatwood forests are common throughout Florida, but the state has yet to take advantage of vast public and private forestlands (over 16 million acres of forest, representing nearly half of the state's land area) to participate in carbon markets. The same may be true of other southeastern states.

This study conducted an electronic survey of one of the most comprehensive lists of non-industrial private landowners in Florida to explore their attitudes towards offsets, and estimate the supply of carbon. Preliminary results indicate that non-industrial private forest landowners in our study would need between $20 and $30 per-acre-per-year to participate in a representative carbon offsets program. These results will be used to estimate a supply curve for carbon offsets in the Southeast as part of the PINEMAP project.

21 **Melissa M. Kreye, Damian C. Adams, Tatiana Borisova, and Francisco Escobedo.** ***Valuing forest conservation and water quality protection programs: A meta-analysis of willingness-to-pay scenarios*.**

Conserved forest ecosystems are effective at protecting water quality by reducing soil erosion, sedimentation, and nutrient loading and pollution. However, there is little information about the ecosystem services and economic benefits associated with specific forest conservation and water quality protection programs. We conducted a meta-analysis of (n=43) willingness-to-pay (WTP) studies from the economic literature that estimate the public's WTP for water quality protection and related forest-water resource conservation programs that protect "well conserved" rivers, lakes and wetlands. Our econometric model revealed important drivers of WTP for water quality protection programs, including the type of conservation tool, type of aquatic resource, geographic context, scale of the conservation program (e.g. watershed scale), and household income. When applying this model to a representative watershed in Florida, the average household's annual WTP was $2.29 for programs that use land acquisition or easement strategies, and $43.79 for programs that do not. This suggests an important relationship between characteristics of forest conservation-related water quality protection programs and individual welfare, and suggests that program design may have a large influence on WTP and on public support for such programs.

22 Nilesh Timilsina, Wendell P. Cropper, Jr., and Francisco Escobedo. ***Assessing trade-offs among different ecosystem services in pine flatwoods of southeastern coastal plain*****.**

Forest ecosystems provide a variety of ecosystem services. Interactions (trade-offs and synergies) occur between these different ecosystem services, and management and environment can influence the interactions. Our objective is to develop a framework to assess the interactions between carbon, timber, and biodiversity in longleaf, loblolly, and slash pine ecosystems in Florida. This framework will use optimization techniques to address these ecosystem services and their interactions with forest management. Finally, we are also interested in evaluating these interactions in the context of a changing climate. For this purpose, we are using plot level data from USDA Forest Service Forest Inventory and Analysis data. We have already estimated plot level carbon and timber values from FIA data. We are using species richness as a measure of biodiversity. Unfortunately, data on herbaceous richness are not available in FIA data; therefore, we developed a model to predict species richness from richness data collected from an extensive literature review. Our regression tree model showed that forest type, stand age, and time since last fire are important predictors of herbaceous richness in pine flatwoods. In future we will be using these data to assess trade-offs. We plan to use a genetic algorithm to identify management choices that optimize these different ecosystem services.

23 Annie Oxarart, Martha Monroe, Stephanie Hall, Jie Li, and Al Stenstrup. ***Project Learning Tree Secondary Module: Southern forests and climate change*****.**

In partnership with Project Learning Tree, a widely-recognized environmental education program of the American Forest Foundation, PINEMAP's Education Aim 5 is creating a set of hands-on activities to help educators teach about climate change and southern pine forests. This secondary module is being developed for use in life science, environmental science, and agriculture courses in grades 9-12, with potential use in middle school or community college. The activities will be connected to PINEMAP topics and research, including climate change and its impact on forests; carbon cycle and carbon sequestration; alternative viewpoints; forest management strategies; and consumer choices, life cycle analysis, and product comparisons. Activities will contain teacher background information and instruction; student readings and handouts; media and technology connections; extensions; assessment ideas; and additional resources such as slide presentations and videos. We will evaluate whether completing the activities in this module enables students to meet the following objectives:

- Gain an appreciation for the role of forests in models of climate change.\
- Increase understanding of climate and change, carbon cycle, and carbon sequestration.
- Increase understanding of how forest management can remove carbon dioxide from the atmosphere and improve resilience of southern pine forests.
- Explore the role of consumer choices in climate change mitigation through life cycle analysis and product comparisons.

To guide module development, an online needs assessment is currently being conducted for middle and high school science educators in the Southeast. In addition, an Education Advisory Committee is helping to ensure the development of high-quality, relevant, and useful materials. As we draft activities, PINEMAP team members are needed to provide expert content review and help us develop activity ideas based on PINEMAP research. A complete draft of the module will be pilot tested in 2013. The final product will be released in 2015, with in-person workshops and online trainings.

24 Stephanie Hall and Martha C. Monroe. ***Climate change education for secondary students*****.**

Education in the classroom is necessary to overcome the knowledge gap about climate change and develop environmentally literate citizens with the skills, knowledge, and attitudes to develop climate change solutions. The public perception of climate change as a controversial issue makes it more difficult to design successful curriculum on the topic. The objective of this research is to investigate how to teach students about a controversial topic such as climate change. Several research questions will be addressed.

- What factors (ex. Political orientation) influence students' opinions on climate change?
- Is the scientific misconceptions framework or the anchoring framework more successful at addressing climate change misconceptions?
- To what extent does social learning make students more open to the climate change opinions of others?

The study sample will consist of students participating at two University of Florida science camps. Rising 10th grade students will participate in activities to learn about the global carbon cycle and carbon sequestration in trees. Rising 11th and 12th grade students will learn about multiple perspectives on climate change. There will be two treatment groups for both age levels; each treatment group will receive the same content in a different format. Through interviews and surveys, both groups of students will be asked their opinions about climate change, knowledge of climate change, and opinions on the lesson. This research will be useful to the development of a PLT secondary module and to climate change educators.

25 John B. Kidd, John R. Seiler, Martha C. Monroe, and Shobha Sriharan. ***The PINEMAP Intern Program: Integrating undergraduates into forest resource and climate change research and education*****.**

The PINEMAP Intern Program is part of the Pine Integrated Network: Education, Mitigation, and Adaptation Project and uses educational projects to both integrate the scientific disciplines and expand the science to students and educators. Our broad goal is to develop a program that engages undergraduate students in interdisciplinary research, education and, potentially, future graduate studies. Principle investigators and their graduate students from across PINEMAP's 6 disciplinary areas will briefly train undergraduate researchers from universities across the southeastern US who will later return to their home institutions and share internship experiences and knowledge with public school students. In its first year, the program is funding 6 interns, and funding will scale up to 18 interns over the following 3 years. From December to February, graduate students and undergraduates submitted, respectively, proposals for micro-grants (a proxy for intern stipends) and applications for internships. Interns were paired with graduate student mentors based on interest in PINEMAP disciplinary areas. Undergraduate interns must participate in a distance education course the following fall semester. This course functions as a public communication class with a focus on creating inquiry-based lessons on forest resources and climate change targeting secondary public school students. Interns may present their experiences with other colleagues and mentors at the next spring PINEMAP annual meeting. Expected outcomes for interns are: increased understanding of and ability to conduct scientific research, improved communication skills, and an appreciation for professional interdisciplinary research. Graduate students selected to the program will: learn to be mentors, build interns' research skills, and be better prepared for other post-graduate work. The intern program is currently under evaluation to determine where improvements can be made. Potential changes include directly marketing to a greater number of colleges and opening the program to other southern conifer research studies.

26 Martha C. Monroe, Damian C. Adams, Richard Plate, and Deborah J. Wojcik. ***The Six Americas of Climate Change: Perceptions of Southeast Extension Professionals*****.**

Perceptions on climate change vary dramatically in the United States, with the general public forming six coherent categories from alarmed through dismissive (Leiserowitz et al. 2010, Maibach et al. 2009). Understanding Extension professionals' perceptions can help PINEMAP create programs that are more likely to be used because they resonate with their values.

Since Extension agents are in the business of conveying science-based research findings to adult learners, one might expect them to fall on the "concerned" side of the spectrum. However, if they represent their audiences, they might reflect the full range of six categories.

Our study used a 56-item web-based survey to collect data from all Extension agents and state specialists in eight southeastern states. The survey was developed, pilot tested and implemented in summer and fall, 2011. Our response rate averaged 68% and no non-response bias was detected.

Respondents mirror the national pattern of Six Americas with a slight skew to the right. Demographic factors are strongly associated with these perceptions, such as:
Location: Florida, Virginia and North Carolina respondents are more likely to be more concerned and alarmed than Gulf state respondents and those from coastal counties are more likely to be alarmed and concerned than inland counterparts.
Political Leaning: Conservatives are more likely to be doubtful and dismissive; Liberals are more likely to be alarmed and concerned.

Respondents also vary by their major program area, with agriculture agents being more doubtful and dismissive. Natural resource agents divided into two groups, with forestry and wildlife agents less alarmed and concerned than environmental education agents. In addition, the position that respondents have in Extension correlates to perceptions of climate change, with agents being the least concerned.

These findings suggest PINEMAP may wish to develop program-specific messages to attract interest in climate change programming. Long term education strategies may help Extension professionals understand the consequences of projected climate changes. Focusing on impacts, not climate, should be helpful. Planning to launch programs first with those who believe there is a problem may help regional efforts gain traction.

27 Shelby Krantz, Martha Monroe, and Wendy-Lin Bartels. ***Climate change perceptions of Florida forest landowners*****.**

Climate variability and change have the potential to alter ecosystem health and productivity in Florida. While farmers have been greatly assisted by the Southeastern Climate Consortium and Florida Climate Institute, forest landowners have had fewer resources. Extension can help forest landowners: 1) manage a crop that will grow through whatever climate changes might occur, and 2) sequester carbon in considerable quantities, reducing atmospheric carbon. The goal of this project is to identify program strategies to enhance the ability of non-industrial forest landowners in Florida to adapt to changes in climate.

To explore these strategies, we began with an audience assessment. We conducted two focus groups to listen to forest landowners to identify the type and focus of Extension programs that could be useful and empowering. The focus groups were held in Leon and Madison Counties with 10 participants. Three researchers helped facilitate the discussions and asked a series of questions to understand each forest landowner's situation before exploring their concerns about climate.

The results of these focus groups told us what a climate program with forest landowners in Florida should ideally include:

- Basic information about climate and climate change.
- Management information about strategies for accommodating drought and insect pests without high costs, and that enable landowners to wait until prices rise to sell their wood.
- Practical and relevant information that can be applied to their situations.

The information should be delivered in a format that enables people to ask questions, hear new ideas, and feel respected.

Based on this information, we are developing a multi-county extension program. Because of the diversity and number of questions that small and large landowners had, it will be in a question and answer discussion format, which should help set them at ease and enable them to ask what they wish to know.

28 William G. Hubbard, Eric Taylor, Mark Megalos, Ryan Boyles, Joshua Idassi, Gwendolyn Boyd, Leslie Boby, Matt Bonham, and Heather Dinon. ***An update of the Extension activities surrounding PINEMAP*****.**

The AIM 6 Extension Team has developed a three-pronged educational strategy to ensure that PINEMAP research technology transfer on "climate smart" forest management reaches the ground. This approach includes practicing forester continuing education, train-the-trainer education, and private landowner education. The Extension Team is currently conducting needs assessments, base line fact sheets, and curricula for the various audiences we will reach in the region. Specific activities of interest in the 2012-2013 calendar years include a professional development webinar series, a landowner education webinar series, an enhanced website, eXtension products and a host of other projects. In addition, a short introductory video summarizing climate, weather and southern pine plantation management. The Extension Team will follow the Logic Model process to measure impacts of the work.

29 Aaron Vuola. ***North Carolina Cooperative Extension perceptions and the Six Americas of climate change*.**

Climate change is likely to affect agriculture and forestry in Southeastern US. Educational programs detailing climate related research of adaptation to forest landowners, resource managers and policy makers are needed. Extension professionals, as change agents, play an important delivery role for information, research, and innovations to their audiences. Change agents' opinions and knowledge will influence the development of new climate educational programs. A broad survey among cooperative extension professionals in North Carolina was conducted to understand how they perceive global warming as a part of PINEMAP project funded by USDA National Institute of Food and Agriculture. Global warming's Six Americas climate change study and audience segmentation typology provided by Yale and George Mason universities were used as main methods for analyzing survey results. The majority (63%) of NC Extension professionals believe that climate change is happening. When divided into segments, almost 70 % of the NCCE are at least "Cautious" in their perceptions about global warming. However, perceptions vary by demographic group. Liberal female respondents seem to be most concerned about global warming and its impacts. Age and work experience were not found to be a significant factor affecting the perceptions of global warming in this study, yet those professionals with less than 10 years' work experience tended to the more concerned side of the global warming spectrum. North Carolina cooperative extension does not significantly differ from the American public in perceptions of global warming. Extension agents working in the field of natural resources do show somewhat more concern than the whole population of NC extension professionals.

30 Aaron Vuola and Mark Megalos. ***Limitations and communication gaps related to climate variability programming among North Carolina Cooperative Extension*.**

A December 2011 survey of North Carolina Cooperative Extension agents and faculty revealed gaps between the agent perceptions on climate change and their landowner audiences. The survey instrument followed the Global Warming's Six Americas methodology of Yale and George Mason Universities in a time series since 2008. The effort is part of a larger, five-year, regional climate mitigation and adaptation research and extension effort for planted pines in the Southeast entitled PINEMAP. Survey responses were used to baseline the current status of extension professionals related to climate change programming. Survey results indicate that a mere 14.4 % of North Carolina Extension professionals have participated in professional development/continuing education related to climate change, while the majority were willing to participate in such training (59.3%). Similarly, only 10.2% of responding extensionists had developed programming materials related to climate change, yet over 55% were somewhat willing to develop materials, workshops or incorporate global warming information into their work. Currently extension respondents "sometimes" use the following terms in their programming efforts (by percentage): climate change (30%), climate variability (22%) and global warming (17%). Top five limitations for Extension agents to incorporate programming addressing climate change, global warming, and climate variability into their extension work are lack of audience interest, conflicting information, not enough basic and applied information, and too much information to interpret.

31 **Sanford Daniel Eigenbrode, John T. Abatzoglou, John Antle, Ian C. Burke, Susan Capalbo, Paul Gessler, David R. Huggins, Jodi Johnson-Maynard, Chad Kruger, Brian K. Lamb, Stephen Machado, Philip Mote, Kate Painter, William Pan, Steven Petrie, Timothy C. Paulitz, Claudio Stöckle, Von Patrick Walden, Jeffry D. Wulfhorst, and Kattlyn J. Wolf.** ***Regional Approaches to Climate Change for Inland Pacific Northwest Cereal Production Systems.***

The long-term environmental and economic sustainability of agriculture in the Inland Pacific Northwest (northern Idaho, north central Oregon, and eastern Washington) depends upon improving agricultural management, technology, and policy to enable adaptation to climate change and to help realize agriculture's potential to contribute to climate change mitigation. To address this challenge, three land-grant institutions (Oregon State University, the University of Idaho and Washington State University) (OSU, UI, WSU) and USDA Agricultural Research Service (ARS) units are partners in a collaborative project - Regional Approaches to Climate Change for Pacific Northwest Agriculture (REACCH-PNA). The overarching goal of REACCH is to enhance the sustainability of Inland Pacific Northwest (IPNW) cereal production systems under ongoing and projected climate change while contributing to climate change mitigation. Supporting goals include: - Develop and implement sustainable agricultural practices for cereal production within existing and projected agroecological zones throughout the region as climate changes, - Contribute to climate change mitigation through improved fertilizer, fuel, and pesticide use efficiency, increased sequestration of soil carbon, and reduced greenhouse gas (GHG) emissions consistent with the 2030 targets set by the USDA National Institute for Food and Agriculture (NIFA), - Work closely with stakeholders and policymakers to promote science-based agricultural approaches to climate change adaptation and mitigation, - Increase the number of scientists, educators, and extension professionals with the skills and knowledge to address climate change and its interactions with agriculture. In this poster, we provide an overview of the specific goals of this project and activities that are underway since its inception in spring of 2011. Information on the USDA, NIFA, AFRI, CAP entitled "Regional Approaches to Climate Change for Pacific Northwest Agriculture" can be found at: http://reacchpna.uidaho.edu/reacchpna

32 **Lois Wright Morton and Lori Abendroth.** ***Climate and Corn-based Cropping Systems Coordinated Agricultural Project: Overview and Flowchart*****.**

The Climate and Com-based Cropping Systems Coordinated Agricultural Project (CSCAP) is one of only three projects initially funded by the USDA to comprehensively examine strategies that will strengthen the capacity and resiliency of the US agricultural base to changes occurring in the climate. Success for US farmers, industry, and the general public relies on having a profitable and productive cropping system while employing measures that protect the environment for future generations. The CSCAP is a transdisciplinary team comprised of nearly 150 people partnering across 10 Land Grant Universities and the USDA Agricultural Research Service. The CSCAP has a research network spanning 9 states and nearly 30 field sites employing current and novel management practices to address the adaptive and mitigative potential of the Midwest's com-based cropping systems. Measurements collected during the five-year project include carbon, nitrogen, greenhouse gas, water quality and flow, pest populations, and agronomic indicators. Site data are used for systems analysis and predictive modeling based on existing physical, climate, and economic models. A life cycle analysis also provides a comprehensive view of each system's strengths and weaknesses. A comprehensive survey of farmers' behavior, knowledge, and response to climate in their farm operation will pinpoint how recommendations and strategies can be developed for greatest acceptance and incorporation. The environmental, modeling, and social-economic research drives the project's education and extension efforts as current real-world information is brought into curriculums, modules, presentations, and publications for all ages. Information will be communicated and extended outward to inform, empower and educate citizens, so they are aware of the complexities associated with producing crops in a changing climate.

33 Glenn Howe, John Abatzoglou, Darius Adams, Barbara Bentz, Mark Coleman, Nick Crookston, Steven Daley-Laurson, Gregory Ettl, Paige Fischer, James Gosz, Andy Gray, Ching-Hsun Huang, James Johnson, Olga Krankina, Dennis Lettenmaier, Jeremy Littell, Doug Maguire, Philip Mote, Elaine Oneil, Donald Robinson, Dave Turner, Tongli Wang, and Richard Waring. ***Western conifer forest systems: Strategies for climate change adaptation and mitigation*****.**

Conifer production systems in the western U.S. are expected to be adversely affected by climate change and associated increases in drought, wildfires, and pests. These prospects are alarming because western forests are among the most economically and ecologically important crops in the world. Management strategies are needed to maintain the adaptability and mitigation potential of these forests, which are important producers of wood and other ecosystem services. We propose to develop an Integrated Regional CAP project designed to develop the knowledge and decision-support tools that will allow forest managers to begin implementing effective adaptation and mitigation strategies within the next 5 years. Our large, trans-disciplinary team of scientists, extension professionals, and educators will engage stakeholders through university extension services and our existing network of university-industry forestry research cooperatives.

Our **long-term goal** is to enhance the ability of western forests to mitigate and adapt to climate change by providing forest owners, managers, policy-makers, and other stakeholders the information needed to respond to climate change by adopting new management strategies. Our objectives fall into four themes: Integration and Cyberinfrastructure, (Objectives 1-2), Research (Objectives 3-6), Extension (Objective 7), and Education (Objective 8). Our **specific objectives** are to (1) enhance regional capacity for adaptation and mitigation by (i) integrating research, extension, and education, (ii) developing strong ties with external partners, (iii) developing standardized methods, and (iv) hosting a national conference; (2) implement complete life-cycle data management and sharing in collaboration with the Northwest Knowledge Network (NKN); (3) monitor for climate-related changes in western coniferous forests and survey associated stakeholder behavior and decision-making; (4) understand the potential effects of climate change on western coniferous forests and stakeholders; (5) develop management practices, policies, economic incentives, and decision-support tools that will allow forest managers to respond to climate change; (6) integrate WC4 models and conduct scenario planning; (7) develop stakeholder partnerships that lead to changes in forest management that enhance climate change adaptation, mitigation, and production of forest ecosystem services; and (8) develop trans-disciplinary curricula and train students on the science and management of climate change adaptation, mitigation, and production of forest ecosystem services.