












## Poster Summaries



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## Poster Abstracts



*Increased carbon (C) sequestration from silvicultural and genetic enhancement of productivity and efficiency of fertilizer use, and resilience to climate variability and disturbance.*

1. Santosh Subedi and Thomas R. Fox.

### **Baseline Fertility Rating Assessment in the 3-PG Model for Loblolly Pine Plantations Across the Southeastern United States**

We developed a method to predict the soil fertility rating (FR) used in the model 3-PG for loblolly pine plantations based on the relationship between stand productivity and site index. Then we used FR in 3-PG to predict loblolly pine yield and mortality on 21 sites across the southeastern United States. 3-PG predicted yield on 16 sites and mortality on 18 sites reasonably well. Largest discrepancies in stand volume simulation were observed in some of the sites in the Lower Coastal Plain and the Gulf Coastal Plain. On sites located in Piedmont and the Upper Coastal Plain yield simulation matched well. When observed stand volume and basal area at age 10 and stem number before thinning were compared against the simulated values, 77% of the variation in stand volume, 52% of the variation in basal area, and 86% of the variation in stem number were explained by simulated values.

*Linkage to outcome theme: This research attempted to develop an independent estimate of fertility rating based on plant productivity for the loblolly pine plantation in the Southeastern United States. The outcome of this research is expected to enhance the predictability of the process model 3-PG.*

2. Jill (Ji) Qi and Daniel Markewitz

### **Effect of Wetting/Drying Cycles on Deep Soil Carbon in a Southeastern US Loblolly Pine Plantation**

In the Southeast US, changing climate conditions are predicted to be warmer and more severe drought in the summer. The largest pool of carbon on land is contained in soils and it can change in response to changing climate. Many studies have shown priming effect of soil carbon in top soils, however, little is known about deep soil carbon. The aim of this paper is to study the effect of wetting/drying cycles on deep soil carbon in a southeastern US loblolly pine plantation. A carbon incubation experiment with three wetting/drying cycles was established using soil samples taken from Taliaferro, GA. Soil were sample in 8 depths: 0-10, 10-20, 20-50, 50-100, 100-150, 150-200, 200-250 and 250-300 cm. Results show that top soil has high carbon mineralization peak in response to wetting/drying cycles, however, deep soil carbon mineralization rate changed significantly. Water-extractable organic carbon was also analyzed. Comparing CO<sub>2</sub> loss in incubation with water-extractable organic carbon shows interesting pattern. In consideration of soil moisture, this study indicates that total soil carbon would decrease under more severe wetting/drying cycles and release more CO<sub>2</sub> into the atmosphere, which could aggravate climate change.

*Linkage to outcome theme: This research focus on soil carbon storage, especially deep soil carbon. It looks into possible mechanisms that affect soil carbon sequestration.*

3. 🌟 Adam O. Maggard, Rodney E. Will, Cassandra R. Meek, Casey Ausmus, and Duncan S. Wilson  
**Physiological mechanisms related to drought mortality of mid-rotation loblolly pine (*Pinus taeda* L.)**

Climate predictions across the southeastern United States are variable. However, parts of this region are likely to experience a warmer and drier climate due to increased temperature and decreased or more variable precipitation events. How these changes will impact southern pine plantations, specifically loblolly pine (*Pinus taeda* L.), are unclear because of the lack of knowledge regarding the physiological mechanisms causal to drought associated mortality. A better understanding of the physiology of drought stressed trees will improve predictions of loblolly pine potential growth and improve management under different climate scenarios. In this study we are comparing loblolly pine physiology of seven-year-old loblolly pine trees located in McCurtain County near Broken Bow, OK in response to complete rainfall exclusion. This study is comprised of six blocks, each containing two trees, one a control (ambient throughfall) and one that has 100% of throughfall excluded. The objective of this study is to measure physiological attributes until trees in the 100% diversion treatment die and relate these changes to mortality. We have been measuring leaf gas exchange, pre-dawn and mid-day leaf water potentials, soil CO<sub>2</sub> efflux, sap flow, volumetric soil water content, and height and diameter growth. Preliminary results indicate that 100% throughfall exclusion causes a reduction in net photosynthesis and stomatal conductance, more negative leaf water potential, and decreased water use. After an entire year under treatment, drought stressed trees remain physiologically active and are not yet showing signs of severe drought stress.

*Linkage to outcome theme: How climate change predictions will impact southern pine plantations, specifically loblolly pine (*Pinus taeda* L.), are unclear because of the lack of knowledge regarding the physiological mechanisms causal to drought associated mortality. A better understanding of the physiology of drought stressed trees will improve predictions of loblolly pine potential growth and improve management under different climate scenarios.*

4. 🌟 Alfredo Farjat, Fikret Isik, Steven McKeand, and Ross Whetten  
**Modeling Growth Performance of Loblolly Pine Families Under Differing Climate Conditions**

Previous studies and modeling efforts have focused on the characteristics and response behavior of seed sources of loblolly pine (*Pinus taeda* L.) from the southeastern United States. Genetic differences among families within the same seed source exist and cannot be ignored for making informed deployment decisions. Empirical evidence indicates that families from the same seed source can have very different responses to environmental factors. In this work, we first propose a formal method of statistical inference for testing whether the relative performance across test sites of two different families differ significantly from each other. Then we propose a statistical model to predict the relative performance of different families under a given climate scenario using climate variables as predictors. To adjust for differences in site index and overall performance, family performance is expressed relative to locally adapted families (checklots) at each site. The model was developed and tested using data from the Plantation Selection Seed Source Study, a large replicated test of loblolly pine composed of 140 families planted on 25 sites throughout the southeastern United States. We will test the predictive power of this model by cross-validation, then look for ways to generalize the model to predict family performance based on data from a more limited geographic range of test sites.

Application examples of the proposed methodology are presented and discussed using hypothetical future climate scenarios drawn from historical data. The presented statistical model can be used as a quantitative tool to model the effects of climatic variables on the performance of specific families. Furthermore, these modeling methods can be used to identify superior performing families, and to estimate their growth potential for a given planting site under a given future climate.

*Linkage to outcome theme: The poster links best to the first two themes listed in the above menu. Below brief descriptions of the connection of the poster with each theme are provided. The ability to predict which families will be most productive and resilient in specific sites will increase productivity and therefore carbon sequestration, as well as increasing the resilience of plantations to climate change (theme 1).*

*The availability of tools to predict family performance will equip land owners and managers with the information they need to make informed decisions about how best to balance risk and potential productivity on specific sites (theme 2).*

5. 🌟 Andy Laviner and Thomas R. Fox

### **Litter Decomposition and Nitrogen Fluxes Following Fertilization and Rainfall Exclusion Treatments**

Forest litter has been shown to be both a source and sink for carbon and nitrogen in pine plantations at different points within a rotation. Major factors that have been correlated to litter decomposition include sun light, temperature, moisture, and litter nutrient status. In this experiment, three meter by three meter throughfall excluders were constructed using ten centimeter wide troughs evenly spaced to cover thirty percent of the ground area. These excluders were installed in the treated buffer of the control and fertilized treatments of the Virginia Fertilization by Throughfall Exclusion Experiment. Under each excluder and in the adjacent buffer area, twenty-one 10 cm by 25 cm litter bags were filled with 14g each of both brown litter collected in litter traps during the Fall of 2013 and green litter collected from live branches from each treatment in the main experiment. Three litter bags with each tissue type will be collected at installation, 2, 4, 6, 8, 12 and 18 months. Mass loss and nutrient content will be determined after each collection. In addition, brown litter and green foliage from trees that were grown after fertilization with  $^{15}\text{N}$  enriched urea fertilizer were placed in one meter square sub-plots adjacent to the litter decomposition bags. We will sample soil 0 - 5 cm and 5 - 10 cm depths as well as litter and duff after one year to attempt to track where  $^{15}\text{N}$  enriched nitrogen is being transported. Our hypotheses include:

- 1) Green foliage will decompose at a faster rate due to more favorable C:N ratio.
- 2) Decomposition rates will be slower under throughfall exclusion due to lower moisture and light levels.
- 3)  $^{15}\text{N}$  enriched tissue will provide a viable means for tracking nitrogen dynamics in this system.


*Linkage to outcome theme: This project will inform forest managers on the timing and release of nutrients and carbon from normal forest litterfall and green foliage that is lost due to thinning or storm damage. We will be tracking litter decomposition and nitrogen dynamics over 18 months in the Virginia Fertilization by Rainfall Exclusion Experiment.*

6. 🌟 Benjamin J. Ahlswede and R. Quinn Thomas

### **Biophysical Climate Effects of Sub-biomes within the Temperate Forest; Implications for Plantation Forestry and Urban Expansion in the Southeastern United States**

Forests are the primary terrestrial carbon sink, but forests also affect local climate through biophysical processes. Relative to other types of land cover, boreal forests have a warming effect by reducing albedo while tropical forests have a cooling effect due to increased evapotranspiration. Based on previous model experiments, temperate forests have been thought to have a weak warming effect on climate. However, this contradicts data from satellites and eddy flux towers that indicate a latitudinal gradient of biophysical effects; with low latitude temperate forests trending towards a cooling effect. We hypothesize that the overall effect of the entire temperate biome does not accurately reflect the conditions and feedbacks of regional processes. We will be using the Community Earth System Model (CESM) at two degree grid cell resolution with an active land and atmosphere model (CLM 4.5, CAM 5) to simulate deforestation of 4 sub-biomes within the temperate biome. We hypothesize that relatively warm-wet temperate forests, such as those in the South Eastern United State (SEUS), will have a local cooling effect. These results could indicate another benefit of southern forests in addition to carbon sequestration that was previously masked by the overall effect of temperate forests.

*Linkage to outcome theme: This project seeks to look at the balanced effect of temperate forests. All forests sequester carbon but the biophysical effects of forests may enhance or offset this benefit. We are examining these effects to determine what overall effects we may expect from expanding urban and forest land cover.*

7.  C. Wade Ross, Sabine Grunwald, Leda Kobziar, and Stefan Gerber  
**Using DayCent to model ecosystem dynamics in managed pine**

Terrestrial ecosystems store substantial amounts of carbon in biomass and soils, approximately five times more than presently observed in the atmosphere. Because of this magnitude, relatively small changes to terrestrial carbon pools could significantly affect atmospheric concentrations of CO<sub>2</sub>, and therefore alter temperature and climate patterns. In the Southeastern U.S., forested ecosystems are currently a large sink for atmospheric CO<sub>2</sub>. This sink can be increased by improving forest productivity through management activities, such as the use of nitrogen fertilizers.


However, there are many gaps and uncertainties in the current understanding of the combined effects of future climate conditions and management activities on terrestrial carbon dynamics.

Improving our understanding of these relationships and processes requires a mechanistic understanding. To achieve this, we will apply DayCent, a process-based (mechanistic) model which has been developed and applied to simulate ecosystem processes for agricultural, grassland, savanna, and forested ecosystems. DayCent is capable of simulating productivity, decomposition, soil temperature, greenhouse gas (GHG) emissions, and carbon dynamics.

Our objectives are to use DayCent and 1) simulate GHG emissions from managed soils of southern pine under multiple scenarios of climate change, 2) investigate the individual and combined effects of increased CO<sub>2</sub>, temperature, and drought on net primary productivity NPP and carbon dynamics using multiple scenarios of climate change, and 3) investigate the effects of increased fire return intervals on carbon dynamics and NPP under warmer, dryer climate scenarios. Model simulations will be verified using measurements at tier sites of the Pinemap project and other miscellaneous observations.

Results from this project will improve the understanding of terrestrial carbon dynamics and the potential effects of climate change in managed pine ecosystems in the Southeastern US. This information will aid foresters and land managers in implementing best management practices to sustain productivity while increasing the carbon sink capacity of pine ecosystems.

*Linkage to outcome theme: This research will improve our understanding of carbon dynamics in managed southern pines under multiple scenarios of climate change. Improved understanding will allow land managers to make informed decisions regarding best management practices.*

8.  Casey J. Ausmus, Adam O. Maggard, Rodney E. Will, Duncan S. Wilson, Thomas C. Hennessey, and Cassandra R. Meek  
**Response of soil CO<sub>2</sub> efflux in a mid-rotation loblolly pine (*Pinus taeda* L.) exposed to extreme drought conditions**


A likely future scenario for the Southeast United States is that climate will become warmer and drier. Therefore, the need to understand the biological response to warmer and drier conditions is crucial. The response of the below ground component, due to its important role in the carbon cycle and carbon sequestration, is especially important. Loblolly pine (*Pinus taeda* L.) plantations are an economic staple and provide numerous ecosystem services to the Southeast United States. The objective of this study was to measure soil CO<sub>2</sub> efflux in response to 100% rainfall exclusion until tree mortality. This study consists of seven-year-old loblolly trees in Broken Bow, OK exposed to 100% rainfall exclusion (six replications 100% exclusion vs control). Measurements of soil temperature, soil moisture and soil respiration (Li-Cor 6200) have been conducted throughout the past year. Preliminary results indicate there is no significant effect of the rainfall exclusion treatment through the first growing season of treatment. However, the trees are still alive and measurements are continuing into the second season (2014).

*Linkage to outcome theme: This study monitors soil respiration under extreme drought conditions. This is valuable information in regards to carbon sequestration, carbon cycling, and below ground response to very stressful and possible climate conditions.*

9. Cassandra R. Meek, Rodney E. Will, Duncan S. Wilson, and Jason Vogel  
**Fertilization decreases soil CO<sub>2</sub> efflux of mid-rotation loblolly pine (*Pinus taeda* L.) stands in southeastern Oklahoma**

Managing pine forests across the southeastern US will likely become more challenging as temperature increases and precipitation becomes more variable. Understanding the interaction between soil nutrient and water availability will improve management in response to climate changes and lead to increased carbon sequestration. As part of PINEMAP, a Tier III installation was established in Broken Bow, OK (McCurtain County) to determine the effects of fertilization and ~30 % reduction in throughfall on stand growth and physiology. Soil CO<sub>2</sub> efflux was measured with a LI-COR 6200 portable photosynthesis system every four to six weeks from May 2012 through August 2013. Fertilizer significantly reduced ( $p = 0.003$ ) soil CO<sub>2</sub> efflux, while throughfall exclusion did not have an effect. The mean soil CO<sub>2</sub> efflux of the fertilized treatment was 2.37  $\mu\text{mol m}^{-2} \text{sec}^{-1}$  while the unfertilized treatment mean was 2.84  $\mu\text{mol m}^{-2} \text{sec}^{-1}$ . The difference between the fertilized and unfertilized stands has been increasing with time (time x fert interaction;  $p 0.008$ ). These results indicate that in addition to increasing stand growth, fertilization may be increasing soil carbon by reducing respiratory losses (depending on how fertilization also affects autotrophic respiration and allocation to belowground biomass).

Linkage to outcome theme: Soil CO<sub>2</sub> efflux was significantly reduced in fertilized treatments. These results indicate that fertilization may be increasing soil carbon by reducing respiratory losses.

10.  Charles J. Pell and Lisa J. Samuelson  
**Long-term interactive effects of throughfall exclusion and fertilization on physiology of loblolly pine (*Pinus taeda* L.)**

Future climate models for the southeastern U.S. project increases in annual temperature and decreases in summertime precipitation. This variability in climate may impact the productivity of loblolly pine (*Pinus taeda* L.). The objective of this project is to quantify the main and interactive effects of throughfall exclusion and fertilization on factors that affect the productivity of loblolly pine including: leaf area (LAI), intercepted photosynthetically active radiation (IPAR), and leaf physiology. The experimental design is a 2x2 factorial combination of throughfall exclusion and fertilization treatment replicated in four blocks at the Tier III site located in Taliaferro County, Georgia. The throughfall exclusion treatment includes ambient throughfall and a 30% reduction in throughfall while fertilizer treatment includes an unfertilized control and fertilization. Previous research conducted the first two years after treatment initiation indicated that loblolly pine growth was influenced primarily by fertilization in 2013 and that fertilization increased LAI in 2012 and 2013 as well as IPAR in 2013. Throughfall exclusion reduced net photosynthesis and leaf water potential in 2012 but not 2013. In 2012 the weather was unusually dry and 2013 was wetter than normal. Due to annual variability in climate, continued investigation is needed in order to quantify the underlying conditions leading to variations in growth and examine possible limitations to photosynthesis. Leaf physiology including A:Ci curves, leaf water potential, LAI, and IPAR will be studied from March 2014 through August 2015.

*Linkage to outcome theme: Fertilization can increase loblolly pine productivity by increasing photosynthesis and leaf area index (LAI). However, high LAI in response to fertilization may increase severity of drought effects which may limit photosynthesis and growth. The interactive effects of throughfall exclusion and fertilization will be studied to better understand how the physiology and productivity of loblolly pine are affected by drought.*

11. Chris A. Maier, Daniel McInnis, and Kurt H. Johnsen  
**Partitioning root and heterotrophic respiration from soil CO<sub>2</sub> efflux in two a loblolly pine clones that differ in growth efficiency and carbon allocation**

Partitioning soil CO<sub>2</sub> efflux is important for understanding how forest management affects net ecosystem productivity. We measured Sf, microbial biomass carbon (MBC), and root biomass in two loblolly pine clones and partitioned Sf into root (Ra, root and symbiotic mycorrhiza) and heterotrophic (Rh) respiration. Clones had similar stem growth rates; however, the broad-crown ideotype (BC) had greater canopy biomass (15-20%) than the narrow crown ideotype (NC). Soil organic matter treatments consisted of no addition (-LR) and addition of 25 Mg ha<sup>-1</sup> comminuted logging debris (+LR) incorporated into the soil at planting. A 10.7cm diameter by 20cm root exclusion pipe was used to halt Ra. Ra was estimated as the difference in Sf measured prior to pipe installation and after, when Sf had stabilized (80-95 days). We hypothesized that 1) because of greater canopy biomass, the BC clone would have greater Sf, Rh, and MBC, and 2) incorporation of LR would increase Sf, MBC, and Rh.

Sf ranged from 3.4 μmol m<sup>-2</sup> s<sup>-1</sup> in March to greater than 15 μmol m<sup>-2</sup> s<sup>-1</sup> in July. Logging residues (+LR) increased Sf by 19% (p=0.006). Clone had no effect on Sf and there was no clone x LR interaction; however, there was a clone x season interaction (p=0.01), where BC Sf was 17% greater than NC Sf during the growing season. Root exclusion pipes significantly reduced live root biomass (52%, p<0.0001), MBC (13%, p=0.007), and Sf (p<0.0001). Ra averaged 21% of Sf, but ranged from 3% to 32%, depending on time of year. There were no treatment effects on Ra. The +LR treatments increased MBC (19%, p<0.0001) and Rh (25%, p=0.0001). These results suggest that genotype and management can have significant effects on Sf, Ra, and Rh. However, because there was considerable live root biomass in the root exclusion pipes, Ra/Sf was probably underestimated.

*Linkage to outcome theme: Improved genetics and intensive silviculture have the potential to increase forest carbon sequestration by greatly increasing net primary productivity (NPP). However, knowledge of the mechanisms controlling soil carbon loss from the soil surface particularly from heterotrophic respiration is essential for quantifying the impact climate change and forest management on net ecosystem productivity (NEP).*

12. 🌱 Elizabeth S. Wilson, Jason B. West, Jason G. Vogel, Astrid Volder, Madison Wigley, and JC Domec  
**The drought response of physiological and structural traits in loblolly pine (*P. taeda* L.) clones with a focus on mesophyll conductance to CO<sub>2</sub>**

Climate change will likely affect the productivity of forests through changes in precipitation and moisture availability. An important measure of a plant's ability to assimilate carbon in photosynthesis with limited water loss, water use efficiency (WUE), is assessed through the use of carbon stable isotopes by the Farquhar model. However, recent work has shown that mesophyll conductance to CO<sub>2</sub> (gm) changes in response to environmental conditions, and the simplified model does not take into account this variability. Variation in this parameter could decrease the effectiveness of the stable isotope tool. This study, conducted in a greenhouse, examined the effects of drought on gm and other physical and biochemical traits in three clones of loblolly pine (*P. taeda* L.).

The three clones exhibited plasticity in stomatal conductivity and hydraulic conductivity in response to drought. There was some evidence for an interaction between clone and drought such that one clone exhibited higher photosynthetic capacity and gm in response to drought but there were not significant differences between all other treatments. We report on the relationship between the carbon isotopic composition of soluble sugars and a set of other physiological traits in the three clones studied that are evidence for patterns of plant response to drought and the implications for management of pine forests in a changing climate.

*Linkage to outcome theme: Mesophyll conductance (gm) may respond to drought and limit photosynthesis. Variability in gm also decreases the effectiveness of stable isotopes as a proxy of water use efficiency. Genetic control over stomatal conductance, mesophyll conductance, and hydraulic conductivity in loblolly pine can be leveraged in breeding for higher productivity.*

13. 🌟 Jianxing Zhang, Salvador A. Gezan, and Gary F. Peter  
**Integrating Climate and Genetic Effects of Loblolly Pine by Universal Response Functions**

Genetic improvements in forestry dramatically increase the productivity of planted pine in the southeast US over the last 50 years. Climate is a key environmental factor affecting the phenotypes and genotypes of trees. New deployment strategies are required to satisfy the rapidly changing climate to make genetic materials to adapt the future climates. We created a new statistical model by universal response function with different variable selection methods. Significant provenance and site climate variables were detected.

*Linkage to outcome theme: Create a more robust set of seed deployment guidelines by creating universal response functions with different variable selection methods, and generate maps for matching optimum genetic materials with appropriate planting sites.*

14. 🌟 Jinyan Yang, Cody M. Luedtke, Katherine M. Akers, Mary Anne McGuire, and Robert O. Teskey  
**Effects of throughfall exclusion and fertilization on soil CO<sub>2</sub> efflux in a loblolly pine (*Pinus taeda*) plantation**

Soil CO<sub>2</sub> efflux ( $R_s$ ) is an important component of forest ecosystem carbon budgets and net ecosystem CO<sub>2</sub> exchange, but little is known about  $R_s$  and its components responding to throughfall exclusion and optimal fertilization. The experiment design was a 2 X 2 factorial combination of fertilization (2 levels) and precipitation (throughfall exclusion, 2 levels) replicated in four blocks. We measured  $R_s$  along with soil temperature ( $T_s$ ) and soil moisture ( $W_s$ ) at a 10 cm depth from 2012 to 2013 in a loblolly pine plantation in Washington, GA. Our objectives were to (1) quantify impacts of throughfall exclusion and fertilization on  $R_s$  and (2) determine soil CO<sub>2</sub> efflux individually response to environmental factors and biological factors in throughfall exclusion and fertilization treatments.

Annual mean  $R_s$  were 2.11, 1.73, 2.09 and 1.92 for control, fertilization, throughfall exclusion and combination between fertilization and throughfall exclusion, respectively from 2012 to 2013. The apparent  $Q_{10}$  for  $R_s$  was 2.26, 2.25, 2.12 and 2.35 in four treatments, respectively. There were no significant differences for  $R_s$  and  $T_s$  in all treatments except  $W_s$ . In all treatments,  $T_s$  explained more than 80% of variation in  $R_s$ . There was a weak relationship between  $R_s$  and  $W_s$ .  $R_s$  was better predicted by  $T_s$  in the dormant season than the growing season, indicating that additional factors such as root growth, photosynthesis became more important contributors to  $R_s$  during the growing season. The nonsignificant throughfall exclusion effects due to the abnormal precipitation in 2013. We concluded that aboveground carbon assimilation, root growth should be considered in assessing and modeling  $R_s$  and its components.

*Linkage to outcome theme:  $R_s$  is a part of component of calculation for NEP and NPP. The exact estimation of  $R_s$  and its components is helpful to evaluate the carbon sequestration of southern pine forest ecosystem with intensive management under the future climate scenario.*

15. 🌟 Kristin M. McElligott, John R. Seiler, and Brian D. Strahm  
**Fertilization and Throughfall Reduction Effects on Soil Respiration as Mediated by Extracellular Enzyme Activity and Litter Decomposition**

Heterotrophic soil respiration is one of the largest fluxes in the terrestrial carbon (C) cycle and ultimately constrains ecosystem carbon storage. Forest management and altered precipitation regimes are expected to influence extracellular enzyme activity, decomposition, and soil respiration, thereby ultimately affecting the net C balance of forest ecosystems. Extracellular enzymes produced by soil microorganisms control nutrient cycling and litter decomposition by hydrolyzing polymeric compounds, yet enzyme production and activity is partially dependent on N availability. Forest fertilization will alter litter quality and decomposition dynamics while simultaneously increasing litter C inputs; however, the mechanisms of decomposition responses from increased nutrient availability remain ambiguous and the combined effects of fertilization and reduced precipitation are unknown. The objectives of this study are to evaluate the interactive effects of fertilization and throughfall reduction on extracellular enzyme activity and litter quality that ultimately control litter decomposition, and understand the contribution of this flux to total soil respiration. Litter and soil samples will be collected from the VA PINEMAP Tier III treatment plots, and assayed for enzyme activity using fluorometric and colorimetric microplate analysis. Litter exclusion treatments will be used to measure total soil respiration, and by difference, litter respiration. Litter quality will be evaluated using litter nutrient content and carbon chemistry. We expect that (1) fertilization will increase the abundance of C-degrading enzymes but decrease the abundance of N- and P-degrading enzymes and (2) reduced throughfall will inhibit potential enzyme activities in unfertilized, and to a lesser extent, fertilized plots. Results from this study could be used to infer shifts in decomposition dynamics, total soil respiration, and ecosystem C sequestration.

*Linkage to outcome theme: Understanding shifts in decomposition dynamics and microbial nutrient demand as a result of forest management and altered precipitation regimes is important for understanding ecosystem C storage potential. Increased decomposition could negate C sequestration potential of loblolly pine plantations, yet greater decomposition could enhance nutrient availability and improve productivity.*

16. 🌟 Laura Townsend and Ross Whetten  
**Identifying Genetic Variation in Loblolly Pine**

Loblolly pine is the leading southern pine species produced in the U.S. The projected increase in severe weather events due to climate change has potential to impact the forest industry. Loblolly pine has a diverse gene pool, is adapted to various environments, and is thus a good candidate to breed for adaptation to climate change. An ideal way to accomplish this is to identify associations of individual genetic marker loci with growth/quality characteristics using climate factors as covariates. To accomplish this, a cost effective, easily implemented, and high-throughput genotyping method is needed. To identify the appropriate genetic markers, a set of phloem tissue samples will be collected from a study consisting of 140 pollen mix families representing the entirety of the loblolly range. Phenotypic data at ages 4 and 8 years are available to be used in genetic marker analysis. The DNA will be extracted using cost effective buffers adapted from the Canadian Center for DNA Coding protocol. Genotyping-by-sequencing will be employed using methylation-sensitive enzymes to enrich gene regions. 1471 individual tree samples were sequenced and unique polymorphic SNP counts on 94% of them was detected with an average count of 5,562 SNPs per sample. Further analysis is underway using the newly published loblolly pine genome to perform genotype calling. A relationship matrix will be built and combined with the phenotypic data to perform BLUP analysis to derive estimates of the proportion of phenotypic variance associated with certain haplotypes. How associations vary among the 7 different seed sources will also be investigated. These determined haplotypes can provide a good idea of the full allelic diversity of loblolly pine, and can potentially be used for screening of future offspring in breeding.

*Linkage to outcome theme: We hope to identify associations of individual genetic marker loci with growth/quality characteristics using climate factors as covariates. From this we will be able to breed trees for adaptation to climate change.*

17. 🌟 Maxwell Wightman, Timothy Martin, and Carlos Gonzalez

**The Impact of Fertilization and Throughfall Exclusion on loblolly pine (*Pinus taeda*) Growth and Water Use**

The influence of climate change on temperature and precipitation patterns in the Southeast U.S. will likely have an important impact on southern pine systems. A 2009 summary from the U.S. Global Change Research Program indicates that the Southeast U.S. will 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 percent reduction in summertime precipitation. Increased average temperature and decreased precipitation will increase vapor pressure deficits (VPD). Potential increases in VPD will likely impact forest tree water use. The objective of this study is to quantify the impact of fertilization and throughfall exclusion on loblolly pine (*Pinus Taeda*) water relations and productivity. The study utilized a randomized complete block design containing two levels of fertilization and throughfall exclusion in a 2x2 factorial arrangement. Treatments include: fertilization with 224N, 28P, 56K (kg/ha) and micronutrient blend as to eliminate any nutrient deficiencies, and an exclusion of 30 percent of incoming throughfall. The specific objectives are to: 1) quantify the impact of both 30 percent throughfall exclusion and fertilization treatments on loblolly pine productivity, whole-crown stomatal conductance, and whole tree hydraulic conductivity, and 2) investigate the relationship between vapor pressure deficit, soil moisture, and stomatal conductance.

*Linkage to outcome theme: My poster will discuss the potential impacts of future drought conditions on pine productivity, water use, and resiliency. It will also illustrate the impact of fertilization on pine productivity.*

18. 🌟 Mengmeng Lu, Konstantin Krutovsky, C. Dana Nelson, Tom Byram, and Carol Loopstra

**Phenotyping environmental adaptation and stress mitigation traits in the clonal loblolly pine association mapping population ADEPT2**

We search for the alleles that are associated with environmental adaptation and stress mitigation traits in loblolly pine, and would like to develop guidelines for selecting loblolly pine trees that would be more resilient to the altered climatic conditions. Single nucleotide polymorphism (SNP) discovery is being conducted using a target sequence capture method. This summer, we will utilize the PINEMAP undergraduate fellowship program to collect and analyze phenotypic data at one field site in southeast Mississippi. These SNP genotypes and field phenotypes will be used in association genetic analyses to discover alleles affecting the measured traits. The major goals are as follows: 1) to measure adaptation, mitigation and productivity traits in the clonal ADEPT2 population trees; and 2) to conduct mixed model analyses on the phenotypic traits, laying a basis for the association genetic analyses. The plant materials and experimental methods consist of the following: Rooted cuttings from 384 unrelated trees (i.e., clones) sampled across a natural range of loblolly pine were established at Harrison Experimental Forest (Southern Institute of Forest Genetics) in southeast Mississippi during the spring of 2011. A randomized incomplete block alpha lattice design ( $r=3$ ,  $s=24$ ,  $k=16$ ) was used, with 3 replications of 24 incomplete blocks of size 16 (4 trees  $\times$  4 trees). Clones were represented as single tree (i.e., ramet) plots. Specific leaf area (SLA), stomata density (SD), wood density (WD), branch angle (BA), carbon isotope discrimination (CID) and leaf nitrogen (LN) will be measured. A mixed model analysis utilizing spatial autocorrelation will be used to assess the genetic effects for the measured traits.

*Linkage to outcome theme: The adaptation, mitigation and productivity traits in the clonal loblolly pine population ADEPT2 will be measured and used in our association mapping study. We search for the molecular markers that will help us select loblolly pine trees more resilient to the climate change.*

19. 🌟 Ranjith Gopalakrishnan, Valerie A. Thomas, John Coulston, and Randolph H. Wynne  
**Producing a canopy height map over a large region using heterogeneous lidar datasets**

Accurate and unbiased wall-to-wall canopy height maps for large regions are useful to forest scientists and managers for several reasons such as carbon accounting and wildfire fuel-load monitoring. Airborne lidar is establishing itself as the most promising technology for this. However, mapping large areas often involves using lidar data from different projects executed by different agencies, involving varying acquisition dates, sensors, pulse densities, etc. In this work, we address the important question of how accurately one can predict and model canopy heights over large areas of the Southeastern US using a heterogeneous lidar datasets (with more than 90 separate lidar projects). A unique aspect of this effort is the use of extensive and robust field data from the Forest Inventory and Analysis (FIA) program of the US Forest Service.

We construct a simple linear model to predict canopy height at plots from distributional lidar metrics. Preliminary results are quite promising: over all lidar projects, we observe a correlation of 81.8% between the 95th percentile of lidar heights and field-measured height, with an RMSE of 3.66 meters ( $n=3078$ ). We further estimated that  $\sim 1.21$  m (33%) of this RMSE could be attributed to co-registration inaccuracies. The RMSE of 3.66 m compares quite well to previous efforts that used spaceborne lidar sensors to estimate canopy heights over large regions. We also identify and quantify the importance of several factors (like point density, the predominance of hardwoods or softwood) that also influence the efficacy of our prediction model.

*Linkage to outcome theme: A key requirement of this theme is to have good ways to understand baseline pine (and forest) productivity, on a region-wide basis. Also, baseline maps are key for modeling exercises that would project many forest parameters (eg:biomass) into the future.*

20. Ross W. Whetten  
**Testing gene expression patterns as predictors of pine family performance**

The ability to predict how well a specific pine family will perform under specific climate conditions is essential to achieving increased carbon sequestration and resilience to climate variability in future pine plantations. Unfortunately, performance data are not available for all trees in current breeding populations across a wide range of climate conditions, and good performance under one climate regime does not guarantee good performance under other regimes. PINEMAP research to date has focused on identifying DNA sequence variation associated with specific characteristics using data from past field trials, with the hope that these sequence variants will have power to predict the performance of the same families, or even unrelated families, in new field plantings established in the future. Data from genetic studies of humans and model organisms suggest that the predictive power of DNA sequence variants may be relatively low for complex quantitative traits such as growth rate or responses to changes in temperature or water availability.

A more comprehensive approach to predicting family performance is to use patterns of gene expression in addition to DNA sequence variation. Several recent reports have described successful prediction of performance of the same, related, or even unrelated individuals in a variety of different environments using patterns of gene expression measured in a single environment on young healthy individuals. One hypothesis to explain this success is that gene expression measurements capture integrated information from many different genetic variants, even those interacting in complex ways. Genetic differences among individuals in these patterns of gene expression are hypothesized to be consistent enough across developmental stages and environmental conditions that measurements made at one age in a single environment have power to accurately predict performance at other ages in different environmental conditions. A pilot experiment is proposed to test this hypothesis.

*Linkage to outcome theme: Current methods for prediction of pine family performance in a particular region are based on progeny test data from that region, but unfortunately progeny test data are not available for all families from all regions of the southeastern US. Patterns of gene expression measured in all tissues of young healthy seedlings may provide information useful for prediction of genetic value, even in environments for which test data are not yet available. A pilot experiment is needed to determine the value of gene expression data in increasing predictive accuracy of models to project the genetic enhancement of productivity, resilience, and carbon sequestration of individual pine families deployed in specific sites across the southeastern US.*

21. 🌟 Stan M. Bartkowiak and Lisa J. Samuelson

**Interactive Effects of Throughfall Exclusion and Nutrient Availability on Sap Flux and Hydraulic Properties of 7-Year-Old Loblolly Pine**

Future climate projections indicate that the duration and intensity of summertime droughts are expected to increase with the rate of warming in the southeastern United States, which may impact loblolly pine (*Pinus taeda* L.) plantation productivity. As part of PINEMAP, the objective of this study is to examine the interactive effects of throughfall exclusion and nutrient availability on water use and hydraulic properties of 7-year-old loblolly pine to better understand potential impacts of climate change on productivity. The Tier III experimental design is a 2x2 factorial combination of throughfall manipulation (ambient and throughfall exclusion) and fertilization (control and fertilized) treatments replicated in four blocks in the Piedmont physiographic region near Washington, GA. Sap flux measurement was initiated in November 2012 and is being monitored continuously to determine sap flux density (JS), whole tree transpiration per unit ground (EG) and leaf area (EL), and canopy stomatal conductance (GS). We hypothesized that greater leaf area index (LAI) in response to fertilization would (1) increase susceptibility to drought (induced by a 30% reduction in throughfall implemented using throughfall exclusion troughs) and cause reductions in GS and EL to limit whole tree water loss, or (2) cause changes in hydraulic properties to avoid drought stress. In 2013, fertilization increased LAI (see poster by C. Pell) and growth but increased JS and EG only in the ambient throughfall treatment and not throughfall exclusion treatment. In the throughfall exclusion treatment, fertilization reduced GS and EL which limited EG with increased LAI. These results indicate that a conservative water use strategy at the whole tree level in loblolly pine may facilitate continued productivity under drought conditions associated with climate variability.

*Linkage to outcome theme: Analysis of whole-canopy transpiration and stomatal conductance estimated from sap flux measurement provide (1) essential water relation parameters to the Physiological Principles to Predict Growth (3-PG) and Water Supply and Stress Index (WASSI) models, and (2) physiological understanding of underlying regulatory mechanisms controlling productivity.*

22. Tomasz E. Koralewski, Hsiao-Hsuan (Rose) Wang, and Thomas D. Byram

**In search of optimal strategies for delineating assisted migration guidelines as applied to loblolly pine families from the Western Gulf region of the USA**

The Universal Response Function (URF) developed for lodgepole pine populations in the Pacific Northwest (Wang et al. 2010), when applied to loblolly pine helped confirm the importance of minimum winter temperatures for optimizing seed movement guidelines on the N-S transect. It was also instrumental in identifying variation in water availability as a major limiting factor when recommending movement on the E-W transect. However, substantial amount of variance remains unexplained by this approach. Some of the most likely sources of this unexplained variation are the local growing conditions (e.g. soil type, site preparation, drainage, competition) and genetic variation between families within a population. The differences in the land form, past and present climate conditions of the Western Gulf vs. the Pacific Northwest, and the recent migratory and evolutionary history of loblolly pine make direct application of the URF to our species challenging. Therefore, we propose a novel approach using the Generalized Linear Model that may be seen as an alternative with the potential to account for a proportion of the local variation unexplained by the URF model.

*Linkage to outcome theme: The model will help develop guidelines for seed deployment strategies, given projected future climate changes. It will help maximize production gains and minimize risks of loss through identification of best-adapted material for a given climate scenario.*

23. 🌟 Wen Lin, Asko Noormets, JC Domec, John King, Ge Sun, and Steve McNulty  
**Isotopic estimates of water use efficiency: a high-throughput  $\alpha$ -cellulose extraction method for softwood and its application**

Wood stable isotope ratios ( $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$ ) offer insights about plant water source, water availability and water use efficiency (WUE), which are informative for predicting the sensitivity of plants to projected future precipitation patterns. We recently developed a new and more time-efficient method for high-throughput  $\alpha$ -cellulose extraction from resinous softwood for the purposes of PINEMAP-wide application. Here we tested the method on wood from loblolly pine trees coming from 5 geographic locations in SE US and from 5 other wide-spread coniferous species (black spruce, Fraser fir, Douglas-fir, Norway spruce, and ponderosa pine) that bear contrasting resin profiles. The results indicate that the difference between the new and traditional  $\alpha$ -cellulose extraction method are within the precision of the isotope ratio mass spectrometry method used:  $\pm 0.2\text{‰}$  for carbon and  $\pm 0.3\text{‰}$  for oxygen. The technique was equally effective for most species tested, although some unanticipated results were observed. For example, our initial hypothesis that the effectiveness of the extraction method may change in proportion with the number of xylem resin canals present was not supported by the outlying data from Fraser fir, the single resin-free species in our study.

The values of intrinsic WUE (iWUE) calculated from  $\delta^{13}\text{C}$  values of latewood produced in wet and dry years differ significantly ( $\Delta = 25.0 \mu\text{mol/mol}$ ,  $p < 0.001$ ,  $n = 10$ ). The iWUE of loblolly pine from 5 locations across SE US correlated with annual temperature and precipitation, and the iWUE of the 6 tested species exhibited good correlation with the Palmer Drought Index during the year of interest ( $R^2 = 0.69$ ).

In summary, the resolution of the modified method is accurate enough and sufficient for quantifying the expected changes in tree water use under the ranges of natural rainfall variability and the drought effects imposed in the Tier III installations.

*Linkage to outcome theme: Wood stable isotope ratios ( $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$ ) offer insights about plant water source, water availability and water use efficiency (WUE), which are informative for predicting the sensitivity of plants to projected future precipitation patterns. We recently developed a new and more time-efficient method for high-throughput  $\alpha$ -cellulose extraction from resinous softwood for the purposes of PINEMAP-wide application. Here we tested the method on wood from loblolly pine trees and 5 other wide-spread coniferous species, as well as its application on intrinsic WUE.*

24. 🌟 Wen Lin, Asko Noormets, JC Domec, John King, Ge Sun, and Steve McNulty  
**Seasonality of soil respiration partitioning coefficient at different Tier II sites**

The magnitude and temporal variability of the balance between autotrophic and heterotrophic respiration ( $R_h$ ) in total soil  $\text{CO}_2$  efflux ( $R_s$ ) is one of the key parameters required for estimating ecosystem net carbon balance (NEE) for PINEMAP. Yet, information on the partitioning constant is scarce, making any estimates of NEE subject to large uncertainties. The small sample size of results to date has not allowed resolving consistent site or treatment differences at the Tier 3 sites, yet there is evidence of temporal and spatial structure in the data, varying about the global mean of  $R_h:R_s = 0.84 \pm 0.03$ .

Here we report evidence of higher dormant season partitioning coefficient, and of stimulated dormant season  $R_h$  in the fertilized than control plots at the Tier 2 sites in the northern subregion of PINEMAP. The seasonal installations of new sets of deep root exclusion collars show increased contribution of  $R_h$  in winter particularly at coastal plain site, where the ratio changed from  $79 \pm 2\%$  (mean  $\pm$  se) in June to September to  $91 \pm 5\%$  from January to April. The effect was similar in both the control and fertilized treatments ( $180 \text{ lb N ha}^{-1}$  every 4 years). The seasonality was not apparent at the Sandhills and Piedmont sites. The Piedmont site exhibited  $R_h:R_s > 1$  frequently, which could be caused by higher soil moisture or different microbial community composition in the root exclusion collars. It is clear, however, that accumulating data will allow us to better elucidate the spatial and temporal controls of the partitioning constant, and tighten the confidence bounds on estimates of NEE. Renewed PINEMAP-wide focus on this issue is warranted, particularly with regard to effective sampling designs that span the spectrum of underlying environmental controls.

*Linkage to outcome theme: The study is about changes of carbon sequestration of loblolly pine plantation under the different climate change scenarios. It is also trying to explore the silvicultural (e.g. fertilization, irrigation) impacts on soil carbon dynamics.*

25. 🌟 Yang Zhang, Jason Vogel, and Jason West

**Effect of climate change and forest management on wood mass loss in a southeastern US loblolly pine forest**

The productivity of managed pine forests in the southeastern US has been improved in part through nutrient management over the past 50 years. Although significant uncertainty exists, climate change may drive a reduction of rainfall of 10%-30% by 2080 for the region. This reduced precipitation may interact with fertilization to affect forest productivity and carbon balance. In this study, we analyzed the mass loss of southern pine wood and the accumulation of soil  $\text{NH}_4^+$  and  $\text{NO}_3^-$  under a factorial combination of two treatments: soil moisture (30% throughfall removal) and nutrient addition (224 kg/ha N, 64 kg/ha P and 67 kg/ha K). Our results showed that after 6 months the substrate mass loss by microbes under throughfall removal, irrespective of fertilization treatment, was lower compared to the wood mass loss under control. After one year, both fertilization and throughfall removal decreased microbial decomposition (decreased  $k$  value). Increased N pools, primarily  $\text{NO}_3^-$ , corresponded to decreased microbial decomposition. Our results indicate that future drought and fertilization may cause slower substrate decomposition by microbes but higher substrate mass loss by termites.

*Linkage to outcome theme: We analyzed the wood substrate decomposition respond to fertilization and drought treatments. The purpose is to test if fertilization and drought would increase carbon sequestration by decreasing the wood mass loss. However, we found different response of decomposition rate contributed by microbes and termites under fertilization suggesting that termites may eliminate the carbon sequestration caused by microbes under fertilization.*

26. 🌟 Zachary Clark, Michael Kane, Dehai Zhao, Daniel Markewitz, and Madison Akers

**Effects of stand density, management intensity, and site preparation technique on non-planted vegetation growth and developmental patterns in loblolly pine plantations**

The abundance and developmental patterns of non-planted vegetation in loblolly pine (*Pinus taeda*) plantations contribute to ecosystem carbon and nitrogen budgets and may affect pine productivity and vigor. The objective of this research is to quantify the effects of stand density, management intensity, and site preparation techniques on non-planted vegetation in loblolly pine plantations. Final results will include: 1) non-planted vegetation cover, carbon and nitrogen pools and biomass from a one-time PINEMAP Tier II sampling and 2) non-planted vegetation cover from PMRC repeated measures over multiple years. Preliminary results for Upper Coastal Plain/Piedmont sites show that planting density does not affect non-planted vegetation growth at age 16; however cultural intensity has a significant effect on non-planted attributes at midrotation. Significant correlations were found between age 16 herbaceous biomass estimates and herbaceous cover at ages 6, 8, and 12. The final results of non-planted vegetation attributes as affected by silvicultural treatments and stand development stage will be useful for evaluating implications for pine plantation ecosystem carbon and nitrogen budgets and stand productivity.

*Linkage to outcome theme: My project relates to the above outcome theme through the estimation of carbon and nitrogen pools in non-planted pine vegetation. Estimates of percent cover and biomass for non-planted vegetation is also presented to determine the effects of silvicultural treatments on non-planted vegetation.*



*Engaged and literate public with the capacity to make informed, practical decisions related to climate, forest ecosystems, and forest management.*

27. ✪ Jie Li and Martha Monroe

### **Effective Climate Change Education: Making Hope Happen**

Why do some people more actively engage in climate change and work toward solutions? Perhaps it is because they have greater hopefulness. So, what exactly is hope and how can we nurture it through education and extension programs?

Hope is characterized by an expectation that the future will be better than present and that you have the power to make it so (e.g., Averill, Carlin, & Chon, 1990; Bruininks & Malle, 2005; Farran, Herth, & Popovich, 1995; McGreer, 2004; Pettit, 2004; Stotland, 1969). According to hope theory, proposed by Snyder (2000), hope includes two types of thinking: agency thinking, or willpower and pathways thinking, or waypower. Agency thinking refers to the appraisal that one is capable of executing the means to attain certain goals; pathways thinking refers to the appraisal that one is capable of generating those means. From his perspective, high-hope individual can clearly conceptualize the goals, envision one major pathway to a desired goal and generate alternative pathways, and perceive that they will actively employ pathways in pursuit of the goals.

Can hope concerning climate change be nurtured and enhanced with educational programs? What are the key predictors of hope concerning climate change among high school students? To what extent does knowledge of climate change increase or decrease hope concerning climate change? Do proximity and familiarity with working forests affect hope? In order to answer these research questions, a scale was developed to measure and predict American teens' level of hope concerning climate change. Pre and post surveys were administered and data were obtained from more than 600 students across the southeastern United States during fall 2013. Evidence of reliability and validity of this new scale will be presented. Preliminary results regarding the research questions will be presented. Limitations and recommendations for future research will be discussed.

*Linkage to outcome theme: This poster discusses the role of hope in promoting public climate literacy and insights on how to engage public effectively through education and extension programs.*

28. ✪ Jie Li and Martha Monroe

### **Evaluating the Effectiveness of PLT Secondary Module**

A new secondary module, Southeastern Forests and Climate Change, has been developed with the collaboration between PINEMAP and PLT. An evaluation and research team based at the University of Florida's School of Forest Resources and Conservation conducted a formative evaluation of these draft materials with secondary more than 40 educators in the Southeast in fall 2013.

The formative evaluation answered the following questions: 1) What are teachers' perceptions of the secondary module? 2) How can the activities be improved? 3) To what degree did students meet the activity objectives? 4) What are teachers' perceptions of the online training resources and module website? 5) How can the online training resources be improved to increase educators' abilities and confidence to teach about climate change and forests?

Data were collected from 24 schools and dependent t-tests suggest that students' knowledge, skills, and hopefulness concerning climate change were significantly increased after they participated the module activities. Our teacher and online training materials build teachers' confidence and competence in teaching about new research-based topics and complex issue as climate change. Limitations of this evaluation study and recommendation for future evaluation study will be discussed.

*Linkage to outcome theme: This poster will present the evaluation questions, data collection procedure, tools, and preliminary findings from the formative evaluation for the new PLT secondary. It helps answer questions about how can we effectively evaluate the effectiveness of our program and the lessons learned from our study.*

29. ✪ Kristen Kunkle and Martha Monroe

### **Evaluating Web Tools in Environmental Education and Extension**

PINEMAP has partnered with Project Learning Tree (PLT) to develop, test, and implement a new secondary environmental education module, Southeastern Forests and Climate Change. A supplementary module website was designed to equip teachers with readily accessible resources and materials that provide support and improve their confidence and competence implementing the module in their classrooms. The website is currently being pilot tested by teachers throughout the Southeast who are integrating the module into their curriculum. It is important to consider the adequacy of web-based educational training as Internet resources play an increasingly crucial role in shaping the attitudes and perspectives of educators. This research is an overview of the processes and importance of collaborative efforts within environmental education and extension. A formative evaluation of the module website was conducted through individual interviews with teachers who are critically engaged in the Southeastern Forests and Climate Change module and supplementary website. The qualitative data revealed a generally positive response to websites as teacher training tools, and the teachers' feedback addressed strengths and potential improvements of educative websites and their accessibility, visual logistics, and incorporation of useful teaching tools and exercises. Relevant conclusions offer suggestions for maintaining and improving educative websites to better meet the needs of educators.

*Linkage to outcome theme: This poster outlines the evaluation of the website and web tools that supplement the PINEMAP/PLT secondary education module. The training tools on the PINEMAP/PLT module website seek to increase secondary educators' capacity, competence, and confidence implementing education related to PINEMAP's research connections in their classrooms. The evaluation investigates how to effectively engage secondary educators in online professional development in preparation for implementing the module in their classrooms.*

30. ✪ Kristen Kunkle and Martha Monroe

### **Applying a Motivated Reasoning Framework to Mitigate Cultural Conflict in Climate Change Education**

Integrating climate change into secondary science education can be difficult, as the issue remains controversial and highly politicized among parents, educators, and administrators. There is currently no standard climate change education in the United States' secondary science curricula, leading many young audiences to form perceptions and opinions about climate change based on various media sources or advocates with their own agendas in mind. While support for integrating climate change into traditional science curricula is increasing, disconnect between scientific consensus and teachers' opinions on climate change remains. This study outlines findings based on emerging psychosocial theories regarding public perceptions of climate change and details some of the biases and barriers to effective communication and information processing of the issue. The study proposes that acknowledging self-identifying values and aligning attitudes through effective communication and interpretive techniques may reduce contention among secondary educators concerned about integrating climate change into the traditional science curricula. Quantitative surveys, an experimental treatment, and qualitative interviews will be applied to evaluate secondary science teachers' values, assess the impacts of integrating information content with cultural meaning, and evaluate the efficacy of culturally decontaminated communication techniques. The processes and results of this research can be adapted and applied to diverse environmental and political issues that require a focus on effective communication strategies.

31. 🌟 Shelby Krantz and Martha Monroe

**Message Framing Matters: Communicating Climate Change with Forest Landowners**

Forest landowners in the Southeast could benefit from being aware of potential impacts of future climate changes on their forests to protect their livelihoods and important ecosystem services. Climate change communication is a difficult task because of the misconceptions surrounding it and the politicization of the issue in the United States. This study compared how 4 frames of messages in a video affect landowners' attitudes toward and intention to adopt forest management practices to adapt to potential climate changes. Videos feature interviews with forest landowners and a university researcher and manipulate two variables: forest landowners describing their management strategies and a university researcher discussing why good forest management is important. Videos were sent electronically to landowners with a pre- and post-survey to gather data. The results of the survey suggest the four videos were able to motivate intention to act, but to increase feelings of efficacy with regard to adopting these behaviors communicators must include stewardship values. Perceived similarity between the viewer and the speaker in the video was important for the viewer to trust the speaker, and when values portrayed in the video aligned with viewers' values, they were more likely to like the videos, trust the speakers, and feel an intention to act. Because there is diversity in the population, videos about forest management and climate change portraying multiple values, attitudes, and objectives may help increase feelings of efficacy and homophily, and therefore increase intention to act in the largest group of landowners.

*Linkage to outcome theme: This research project explores effective communication with noncorporate forest landowners about climate change so they can make informed, practical decisions about forest management. We forged a connection between PINEMAP biological research and forest landowners in the Southeast in a new and interesting way: video. Forest landowners who manage their property to increase resilience should be able to sequester more carbon, maintain their forest, and retain their livelihood.*

32. 🌟 Tracey Ritchie and Martha Monroe

**Can Using Systems Thinking Improve Student Success with Climate Change Education?**

The purpose of this poster is to communicate the results of a pilot test of two activities from a newly developed Climate Change Education resource. The resource development team from the University of Florida coordinated the opportunity to pilot test two activities with local high school students to determine effective strategies for teaching systems thinking in the context pine plantation management. Activities were field tested with students to establish how students will respond to and best learn the concepts. The team also developed pre and post assessment questions and worksheets to obtain student feedback and then analyzed qualitative responses to determine themes in knowledge of systems. The results showed that these high school students have a limited working knowledge of systems and easily confuse systems with cycles. There is a wealth of new research questions that can be developed from this pilot test to further the progress on incorporating systems thinking into climate change education programs.

*Linkage to outcome theme: By incorporating systems thinking into secondary curriculum, students will have a better understanding of the natural systems around them and the implications of their actions on these systems. Systems thinking is a strategy to better teach the concepts of climate change science and adaptation and mitigation strategies.*



*Enhanced capacity for regional, interdisciplinary collaboration among climate and forest scientists and Extension and education professionals.*



*Enhanced connections between corporate and noncorporate forest landowners and forestry and climate researchers and education and outreach professionals.*

33. Joshua Idassi, Gwendolyn Boyd, Leslie Boby, Mark Megalos, Heather Dinon Aldridge, Martha Monroe, and William Hubbard

**1890 Land Grant Institutions and PINEMAP Climate Change Workshops**

The 1980 Agroforestry Consortium in collaboration with the PINEMAP ([www.pinemap.org](http://www.pinemap.org)) have been charged to implement a strategic plan to train educators from a variety of agencies, including county Extension agents, state forestry and natural resource professionals and others with outreach responsibilities in forestry and natural resource-based climate change mitigation and adaptation solutions. Two in-service training workshops were organized targeting the 1890 Land Grant faculty members and selected county extension agents in the Southeast. Pre-workshop surveys were sent to registered participants asking them to send topics of interests to be included in the workshop agenda. Positive pre-workshop survey responses were received and two robust agendas were developed for the respective workshops. The expected outcomes of these workshops were that, through the training of the 1890 Land Grant faculty members and the county extension agents, PINEMAP will support climate educators who will eventually provide support and assistance for regional trainings to a wide range of practitioners. Overall the participants were very satisfied with the workshop organization. Relative to climate change issues, the field tours added value to the indoor presentations. One participant made the following comment in the evaluation form: “In the future workshops, participants should be given chance to give a short presentation on their works with respect to climate change and global warming effects.”

34. Leslie Boby, Jessica Ireland, Martha Monroe, William Hubbard, and Eric Taylor

**PINEMAP’s Cooperative Extension Forester and State Agency Needs Assessment and Extension Delivery**

PINEMAP’s overall goals require disseminating research results to the stakeholders who can either create changes on the ground directly, or educate other in best forest management techniques in a variable climate. One of those key stakeholder groups are Cooperative Extension Specialists who work within the university system and State Forestry agencies. To ensure that this group is being reached and served effectively a survey was conducted to assess their knowledge of PINEMAP, research needs, ranking of forest threats, interest in information on specific silvicultural practices and preferred information delivery format. 138 individuals were surveyed and 47% responded to questions which included indicating their awareness of the PINEMAP project and extension program (only 20% were familiar or very familiar with PINEMAP). PINEMAP’s current extension and outreach model utilizes traditional extension outreach channels and programs and about half of those surveyed felt this was an effective approach. More than 70% of the audience felt that invasive species and changes in forest management risk due to forest insects or diseases along with extreme weather events were important or very important to incorporate into their educational programming. Additionally, amongst different silvicultural practices listed in the survey, the number one issue, which 85% of foresters indicated was important or was silvicultural techniques to promote forest productivity, increase stand vigor and reduce risk from insects or diseases. Overall, extension foresters were interested in more information from the PINEMAP project and indicated that they felt the traditional extension delivery service is effective and that their top choices for information delivery included a website containing research information, in-person workshops and webinars. The PINEMAP extension team will consider these results as extension outreach programs are designed to reach these stakeholders in the final years of the project.

*Linkage to outcome theme: Cooperative Extension Specialists and State forestry Agencies are key partners for disseminating PINEMAP research and ultimately, making changes on the ground. Assessing their views and perceptions of PINEMAP, along with their interests in specific research and information delivery will enhance the PINEMAP outreach approach.*

35. Wendy-Lin Bartels, Ricardo Mello, and Jessica Ireland  
**Exploring Team Science in PINEMAP**


Project participants in PINEMAP are expected to conduct “team science” by integrating expertise across institutions, regions, and disciplines; among research, education, and outreach; and with the broader community of practitioners and managers beyond academia. As part of the project’s formative process evaluation, researchers are using surveys and social network analysis (SNA) to assess team science in PINEMAP. This poster describes current interactions among researchers and how the team evolved between 2011 and 2013. Results show the baseline social network (life before PINEMAP) as compared to the network of interactions among PINEMAP members over the first two years of the project. In 2013, the PINEMAP network consisted of 124 participants from 12 institutions and 17 disciplines, indicating a growth of 73 participants since 2011. Although the baseline network shows that some participants are not connected to others (isolates), by 2013, the network shows a relative cohesiveness and everyone is connected. Respondents identified the type of interaction they had with others in the team, and 22% of the interactions were the highest form of integration: communication, collaboration, and shared thinking.



*Public policy that supports sustainable management of planted pine under future climate scenarios.*



*A more robust and resilient forest-based economy in the Southeast U.S.*

36.  Hyunjin An, Jianbang Gan, and Kathryn Clifton

**Impact of Climate Conditions and Adaptation on Southern Pine Beetle Infestations**

This study investigates the relationship between climate factors and southern pines beetle (SPB) (*Dendroctonus frontalis* Zimmermann) risk using the Generalized Linear Model (GLM). The GLM approach alleviates some disadvantages of the traditional linear model. The estimated model is then used to predict SPB infestations under different future climate change scenarios from 2020 to 2099. The study area covers 11 southern states including Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North and South Carolinas, Tennessee, Texas, and Virginia. We find that warm spring and minimum winter temperature have a positive impact on SPB risk whereas humid spring and winter, and warm fall have a negative impact. In addition, removals of infested trees via timber salvage tend to reduce subsequent SPB risk. Because the insect life history or population level process is largely related to climate factors, global climate change could drastically alter SPB outbreak patterns. However, the risk of SPB outbreaks would not move in one direction because the SPB population largely depends on complex interactions between temperature and precipitation. Even though the mean temperature in the U.S. South in general is projected to rise by various Global Climate Models (GCMs), precipitation also is likely to increase at least in some parts of the region and/or in some time periods. Thus, in some areas, the positive impact of rising mean temperature will be compensated by the negative impact of rising precipitation on the SPB population. Overall, future SPB risk would vary with location, time, and climate conditions predicted by GCMs.

*Linkage to outcome theme: Investigates the relationship between climate factors and southern pines beetle risk using econometric model.*

37. 🌟 Puskar Khanal and Donald L. Grebner

**Non-Industrial Private Forest Landowner obstacles to Forest Carbon Sequestration in the Southern United States**

Forested lands in the Southern United States represent a significant carbon sink and play an important role in climate change mitigation. Their management has been considered to provide a lowest cost and highest volume carbon sequestration opportunity with a potential to sequester about 400 million tCO<sub>2</sub>e per year in this region. The aim of this study is to identify various underlying obstacles of Non-Industrial Private Forest (NIPF) landowners, the dominant timberland ownership group in the south, to manage their forest for carbon sequestration. A regional mail survey was sent out in Fall 2013 to 5,110 randomly-selected NIPF landowners in the 11 southern states excluding Tennessee. We used statistical factor analysis tool to identify major underlying obstacles affecting their willingness to carbon sequestration. The results indicate that landowner major obstacles to carbon sequestration could be described by four latent factors. Therefore, it is important to consider these obstacles for implementing effective carbon sequestration policies in the south.

*Linkage to outcome theme: Understanding NIPF landowner obstacles to manage their forest for carbon sequestration is important not only in making better forest management decisions, but also assisting policy makers in designing and implementing more effective policies to mitigate climate change.*