

PROJECT NARRATIVE

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No Cost Extension Application - 2015

Integrating Research, Education, and Extension for Enhancing Southern Pine Climate Change Mitigation
and Adaptation

Pine Integrated Network: Education, Mitigation, and Adaptation Project (PINEMAP)

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No Cost Extension Justification Narrative

The Pine Integrated Network: Education, Mitigation and Adaptation Project (PINEMAP) engages approximately 50 co-PIs from eleven southeastern U.S. universities and the U.S. Forest Service to create, synthesize, and disseminate knowledge that enables southern pine landowners to: manage forests to increase carbon uptake and storage (sequestration) by 15% by 2030; increase the efficiency of nitrogen and other fertilizer inputs by 10% by 2030; and adapt forest management approaches and plant improved tree varieties to increase forest resilience and sustainability under variable climates. To accomplish these outcomes, the project leverages relationships with existing networks including the Southern Regional Extension Forestry network; Project Learning Tree, and the eight major regional forestry research cooperatives. The project was funded by NIFA for a five-year period: March 2011 – February 2016. We are requesting a one-year no-cost extension for a revised end date of 2/28/2017 for two compelling reasons: administrative delays, and creating and capitalizing on opportunities for improved project outcomes. These justifications are described below.

Administrative Delays

In most research projects, there is a lag time between the funding of the project, and achievement of full effort on the project. This lag occurs primarily because hiring and purchasing processes take time, but cannot start until funding is in hand. This lag is exacerbated in a complex project like PINEMAP, which was a larger project than NIFA had typically funded, and where the majority of participants were funded through subcontracts that had to be executed at the University of Florida (UF) after receiving the initial letter of award. As an example, UF received the first increment of funding from NIFA on April 27, 2011 (almost two months after the official start date of March 1), and issued the first subcontracts on May 4. In addition, building project teams across disciplines and institutions necessarily takes additional time compared to single-discipline efforts involving only one or a few universities. While the team did everything possible to get a running start (the first all-hands-on-deck, in-person project meeting took place in Atlanta on May 2, 2011, using “borrowed” money), these largely unavoidable administrative lags delayed full project deployment by at least six months.

Creating and Capitalizing on Opportunities for Improved Project Outcomes

Across the project, teams have found a variety of ways to create and capitalize on opportunities to improve scientific, educational, and outreach outcomes relative to original plans. In the final analysis, this entrepreneurial approach will result in a substantially larger return on investment for NIFA, and more effective progress toward the 2030 project outcomes, but in most cases the improved approaches require additional time to implement. In addition, in a networked project like PINEMAP, delays associated with improving one step of a process (e.g. improved climate projections) propagate to delays in dependent, downstream parts of the network (e.g. model runs dependent on climate projections). Here we briefly summarize a range of examples of opportunities for improved outcomes that will require additional time to implement.

Adopting State-of-the-Art Climate Projections

At the 2013 annual project meeting, we determined that the North American Regional Climate Change Assessment Program (NARRCAP) climate projection dataset would not meet the needs of all regional modeling efforts. Substantial effort and time went into creating a new dataset that would meet those needs.

- The new dataset, Multivariate Constructed Analogs (MACA) was created using a statistical downscaling method with 20 global climate models from IPCC’s 5th Assessment Report across a baseline period (1950-2005) and future period (2006-2100) for two different future pathways. While no technique is perfect, this state of the art method offers unique features (the daily time step and meteorological variables: wind speed, specific humidity, shortwave radiation, temperature, and

precipitation) that are required for ecological applications at a fine resolution of 6 km. This dataset was created in 2014, and its use in PINEMAP improves both the coordinated modeling and DSS efforts. We generated grids of all parameters required by the regional modeling group and computed HUC12 weighted averages. The ability for PINEMAP to compare model outputs from 20 projection inputs is unprecedented for this ecosystem.

- Additional efforts included debugging data from the source dataset, and hosting it on our THREDDS Data Server, which both improves data delivery and allows for the manipulation and subsetting of the gridded data by PINEMAP colleagues.
- We have created projection grids for the entire US for the nine parameters required by modelers, as well as for variables required by the DSS tools. These projections provide future value for modelers of other ecosystems who require fine scale climate projections, and will allow the modeling output from PINEMAP to have national impact. WaSSI has been used in nationwide analyses, and HUC12 averaged projections represent an opportunity to analyze future water availability on a national scale. 3-PG is expanding their analysis to the entire East Coast region based on stakeholder feedback.

Modeling

- Regional-scale parameterization of the 3-PG and WaSSI models for loblolly pine has taken longer than anticipated, and the necessary downscaled regional climate model data were not available until March of 2015. In addition, a range expansion (3-PG only) has been requested by project stakeholders.
- Recent incorporation of the Community Land Model into the PINEMAP model suite more tightly links our work to global model community and adds a new dimension to model output/intercomparison, but will take additional time to fully implement.
- WaSSI synthesis of data from Tier III sites will provide more data on fertilization and drought effects on WUE. The use of a common descriptive modeling framework should greatly facilitate this process.

Genetics and breeding

- Although not an explicit original objective, NIFA funding of the loblolly pine genome sequences (PineRefSeq CAP) enabled us to coordinate to improve our outcomes. PineRefSeq information was used to expand the number of coding and potential regulatory regions for analysis with exome capture, one of the two methods used for genome enrichment prior to sequencing to identify genetic variants for association genetic analyses. During the wait for PineRefSeq information, the costs for genotyping were reduced due to improvements in sequencing technology and exome capture, giving more genetic variants at similar costs, yielding a greater return on investment.
- The DNA sequencing cost reductions of 75% from April 2011 to April 2015 (NHGRI report <http://www.genome.gov/sequencingcosts/>) allows us to better characterize genetic variation in pine populations and test hypotheses relating genetic variation to resilience and adaptability of trees in field trials.
- The group at NC State will continue sequencing through the end of the project to maximize the number of different parents for which seedling gene expression measurements are available. These seedling gene expression measurements can expand the scope of the seed deployment guidelines during a no-cost extension. Additional sequencing experiments will map regions of the pine genome that may be involved in gene regulation. Such data will add significant value to the PineRefSeq draft genome assembly and to future efforts to use molecular genetic markers in the context of applied breeding programs.

Silviculture and Field Ecology

- In 3.5 years the Tier II network of researchers collected 1420 bulk density, soil C and N observations from 491 pedons covering 23 different soil Great Groups. By comparison over a ~30 year period for

the same Great Groups, the National Resources Conservation Service (NRCS) collected 2770 bulk density samples from 825 pedons across the SE US. The NRCS database is the foundation for regional and global modeling efforts. We have created a merged dataset of both PINEMAP and NRCS soils data to improve estimates of soil carbon for forests in the region. This is a significant value-added component of PINEMAP that is beyond what was originally proposed.

- The work on the PINEMAP objectives related to improving nutrient use efficiency is a joint effort between PINEMAP and the NSF Center for Advanced Forestry Systems. Under the auspices of the NSF project, ¹⁵N labelled fertilizers were used to determine N uptake by loblolly pine crop trees and the environmental fate of the fertilizer N at 24 locations across the range of loblolly pine in the South, and were co-located with selected PINEMAP Tier II and Tier III installations. Sampling of loblolly pine, other vegetation, forest floor and the mineral soil was completed in each plot and analysis of ¹⁵N in each ecosystem component will be completed by December 31, 2015. A no-cost extension of the PINEMAP project will provide the time needed to integrate the Tier II and Tier III data with the ¹⁵N data and provide a comprehensive synthesis of the results.
- A no cost extension would allow the sap flux group to measure hydraulic conductivity and cavitation vulnerability of loblolly branches and small coarse roots for all Tier III sites and to link to results from cross-site sap flux analyses.
- The sap flux group also plans to characterize loblolly pine needle water potential, terminal stem hydraulic conductance and foliar stable carbon isotope ($\delta^{13}\text{C}$) discrimination at the VA Tier III site, detail the effect of throughfall treatment on fine root distribution to 15 cm, and improve needle level gas exchange measurements in response to VPD at VA Tier III site.
- Tier III is a cross-site installation (Virginia, Georgia, Florida, Oklahoma) that is measuring the interactive effects of throughfall reduction and fertilization on loblolly pine stand growth and physiology. These sites required a significant initial expense. A no-cost extension will allow us to monitor and maintain baseline measurements at the sites for an additional year for relatively little expense compared to the initial investment.
- Accurate estimation of heterotrophic respiration (R_H) is essential for quantifying net ecosystem production (NEP). R_H has been measured along with total soil CO₂ efflux (R_S) at Tier III and Tier II sites, and a consistent partitioning coefficient ($R_H:R_S=0.84$) was found. However, with an additional year of measurements collected since then, we find growing evidence of systematic variability in the $R_H:R_S$ partitioning as a function of factors including time of year, stand age, fertilization, competition control, and water availability. Additional time is needed to consolidate this information to a form that would be usable by the PINEMAP modeling team, and thus allow a fully dynamic estimation of ecosystem carbon balance.

Economics and policy

- This group's work is probably most dependent on output from the regional biophysical model runs, which were delayed as described above.
- We are collecting additional datasets and leveraging additional funding that will increase the final value of their regional analyses:
 - Leveraging efforts under another funded study with PINEMAP outputs to better understand the dynamic relationship between loblolly pine management, climate change, and invasive species impacts. Our goal is to develop a pre-invasion trade-based stand-level model of disturbance risk from invasive species in the Southern US. The model will use the most recent empirical inputs from historical insect incursions data and merchandise imports to estimate the likelihood of establishment.
 - New transportation and PestID data that will become available later this year, and used to inform the trade-based stand-level disturbance risk model for invasive species. We have approval to access the updated Forest Service PestID database that will be used to filter insect identifications by family name. We are also acquiring the latest insect establishment data through 2010 and

seeking warehouse data to improve the accuracy (10x10km) of the final import destination estimates of goods associated with forest pest vectors.

- The recent availability of new data critical to the stand-level water-C tradeoff simulations will enable us to correctly determine the different options for forest landowners under contrasting management objectives being considered under PINEMAP scenarios.

Education

- Three regional training workshops and state implementation grants have energized the Project Learning Tree Coordinator network and they are beginning to use the module. Additional time will allow us to provide support for additional workshops, thus magnifying our impact. It will also enable us to market the resource to AP Environmental Science teachers who are very excited about it.
- We have launched a comprehensive project to explore how to assess systems thinking, and how to build systems thinking into our materials. This activity arose with the advent of the Next Generation Science Standards and was not built into the original module. Additional time will enable us to pursue this critical component of science and environmental education.
- We have been asked to contribute to a systematic literature review on climate adaptation education in collaboration with the North American Association for Environmental Education. This activity will be a key resource for assisting Extension agents plan climate programs that help communities respond appropriately.
- The undergraduate fellowship project is ongoing in year 5 (2015). Full assessment and analysis cannot begin until after completion of year 5. An additional year will enable us to fully incorporate outcome assessment data of the undergraduates and mentors from year 5.
- We are conducting a comprehensive review and comparison of natural resource undergraduate research experiences and participant outcomes from these programs. This summary will provide valuable information to all federal programs that encourage undergraduate students to partake in research activities.

Extension

The Extension teams' products and outreach work is integrally tied to the findings, outputs, and discovery from all PINEMAP research teams. Thus, our long-term impacts can be greatly enhanced by a no cost extension.

- We are currently in the depths of beta testing tools for the PINEMAP Decision Support System (DSS), which is a critical but time intensive step for incorporating professional feedback and stakeholder review to improve the quality and usefulness of the user interface.

A no cost extension would allow for integration and synthesis of research findings into outreach products, including:

- Stakeholder-specific products, trainings, and outreach (including regional adaptation conferences, webinars, training modules, and handbooks)
- Development and delivery of industry (TIMO and REIT) stakeholder outreach resources linked to the Sustainable Forestry Initiative certification requirements
- Integrative papers that synthesize lessons learned through PINEMAP research related to audience, needs, and observations on climate resilient southern pine management activities.

Critical resource leveraging that will come to fruition during a no cost extension period:

- The Forest, Climate and Woodlands Community of Practice (CoP) (www.eXtension.org) is a 2 year funded project which includes PINEMAP Extension personnel. The CoP provides a platform for engaging the Extension community and increases the availability of PINEMAP adaptation materials. A NCE allows for greater overlap with the CoP grant activities.
- The USDA Southeast Climate Hub (SERCH, <http://globalchange.ncsu.edu/serch/>) includes many PINEMAP participants (especially those associated with the USFS and NC Climate Office). SERCH has partnered with PINEMAP to jointly promote sustainable forestry practices. SERCH will

distribute materials and host our virtual presence after the completion of our project. A no cost extension will improve the logistics involved in the handoff of materials and resources.

- The Climate Learning Network (CLN) Forestry and Agriculture online resources and learning modules for Extension is being led by Southern Region Extension Forestry Staff (also PINEMAP personnel), and lessons learned and materials are being used for development and furthering of this network. This work extends through the NCE timeframe and would widen the audience for PINEMAP outreach products.

Funding to be carried forward:

Based on funds remaining as of June 30, 2015 and projected costs for the remaining 8 months of year 5, we anticipate approximately \$2,500,000 will be carried forward into a No Cost Extension period. Of that total, approximately \$1,200,000 is for direct costs and \$400,000 for associated indirect costs at the University of Florida. The remaining \$900,000 is for both direct and indirect costs for subcontracts to other institutions.

Team Outcomes/Impacts

Pine Integrated Network: Education, Mitigation, and Adaptation Project (PINEMAP) focuses on the 20 million acres of planted pine forests managed by private landowners in the Atlantic and Gulf coastal states from Virginia to Texas, plus Arkansas and Oklahoma. These forests provide critical economic and ecological services to U.S. citizens.

PINEMAP's overall goal is to create, synthesize, and disseminate knowledge that enables southern pine landowners to

- manage forests to increase carbon sequestration by 15% by 2030;
- increase the efficiency of nitrogen and other fertilizer inputs by 10% by 2030;
- adapt forest management approaches and plant improved tree varieties to increase forest resilience and sustainability under variable climates.

NIFA funded PINEMAP to produce and disseminate the knowledge necessary to better manage planted southern pine forests in a changing world. PINEMAP is charged with producing real-world outcomes, and, accordingly, our research and deliverables are structured around a set of outcome themes and associated activities, outputs, and outcomes which are described below.

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

Planted southern pine forests already contribute to climate change mitigation by taking up and storing (sequestering) enormous amounts of atmospheric CO₂ in trees, soil, and long-lived wood products. PINEMAP produces knowledge necessary to increase the amount of CO₂ sequestered through enhancement of forest productivity, more efficient use of fertilizers, and management of forests for resilience to climate variability and disturbance.

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

In a democratic society, rational public policy and decision making depend to a large extent on public understanding of and engagement with societal problems. PINEMAP's education programs are designed to help nonscientists better understand and grapple with the complex issues surrounding climate and forest management.

Outcome theme: Public policy that supports sustainable management of planted pine under future climate scenarios.

The biophysical and human dimensions research produced by PINEMAP provides information critical for guiding the development of rational natural resource policy.

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

PINEMAP's unprecedented coalition of over 120 forestry researchers, educators, Extension professionals, and students is building new networks and new infrastructure for cutting-edge, collaborative, outcome-based science.

Outcome theme: Enhanced connections between corporate and non-corporate forest landowners and forestry and climate researchers and education and outreach professionals.

PINEMAP strives to strengthen existing and build new connections to on-the-ground forest management so that the science can be quickly translated to outcomes that benefit society.

Outcome theme: A more robust and resilient forest-based economy in the Southeast U.S.

PINEMAP research enables pine landowners in the Southeast U.S. to continue producing economic and ecological services that benefit society.

Executive Summary of Progress

PINEMAP's research focuses on current and future effects of climate, soils, management and genetics on planted pine productivity and resilience. Central to this effort is a three-tiered monitoring network that leverages historical and current experiments established by the forest science research co-ops mentioned above. Tier I consists of previously unshared data from about 700 legacy studies completed before PINEMAP began; Tier II consists of previously unshared data plus new PINEMAP measurements on 125 active experimental sites; Tier III consists of four sites at the edges of the natural range of loblolly pine with new experiments begun as part of PINEMAP.

PINEMAP's Research Program: though intentionally fluid to maximize the opportunity for interdisciplinary approaches research efforts in PINEMAP can be categorized into four main areas:

1. **Silviculture and Ecophysiology:** To examine the combined impacts of climate, soils, nutrient availability and drought, PINEMAP personnel established Tier III sites, to compare stand growth and physiology in different geographic locations, and to determine how fertilization and rainfall diversion influence stand growth and physiology. With PINEMAP standardized methods, we have quantified total carbon, water and nutrient storage, flux baselines and tree response to climate and management in Tier II and Tier III sites across the region, providing one of the largest assessments of soil carbon of any terrestrial ecosystem.
2. **Modeling:** Using four complementary models that were developed and tested with data from the three-tiered monitoring network, we are predicting the long-term effects of soils, management, climate and disturbance scenarios on planted pine, at scales ranging from a single tree to the southeastern region.
3. **Genetics:** Developed quantitative guidelines to help landowners understand where to plant specific southern pine varieties in anticipation of future climate scenarios. Identified genes controlling traits such as growth, nitrogen responsiveness, water usage, etc., to accelerate breeding programs to improve productivity and resilience.

4. **Economics and Policy:** Analyzed the benefits of the market and non-market products and services provided by planted pine trees. Developed projections of the economic and environmental consequences resulting from interactions of management practices, environmental conditions and policy decisions. Completed life-cycle analyses of planted pine growth and wood utilization which demonstrate the strong net positive carbon sequestration benefits of utilizing wood and residues from fast-growing planted pine.

PINEMAP's Extension Program: The overall goal of PINEMAP's extension effort is to disseminate emerging knowledge, practices and PINEMAP decision-support tools to enable corporate landowners and smaller producers to increase forest carbon sequestration, nitrogen fertilizer efficiency and forest resilience under varied environmental conditions.

Extension successes and initiatives underway:

- Developed highly effective partnerships between extension foresters and state climatologists, resulting in production of instructional materials and workshops.
- Assessed stakeholder perceptions and needs to help PINEMAP extension personnel communicate with stakeholders.
- Created a web-based PINEMAP Decision Support System that includes the results from models assessing the influence of genetics, management practices and economics; beta testing is in progress.
- Developed online learning modules, webinars, fact sheets and other products.
- Trained county and state employees regarding climate change mitigation and adaptation.
- Assessing impacts of adoption of alternative management techniques promoted by PINEMAP, engagement of smaller landowners in the carbon-trading markets, changes in forest carbon sequestration and nitrogen use efficiency resulting from adoption of PINEMAP recommendations, and clients' understanding of interactions between climate and forests.

PINEMAP's Education Program: The PINEMAP education team created and evaluated programs and resources to educate students and teachers about the relevance of forests, forest management and climate impacts. The team mentors and engages college students in collaborative, interdisciplinary research aimed at solving complex societal problems.

Education successes and initiatives underway:

- Conveyed the significance of Southeastern pine forests and future climate change impacts with teaching strategies that engage youth and build hope.
- Engaging undergraduate interns in research and teaching.
- Preparing graduate students to address climate change mitigation and adaptation issues and engage in interdisciplinary research.
- Created, tested and distributed a learning module for high school students that introduces climate change and includes selected PINEMAP research findings.

Evaluating impact: Research impacts are evaluated relative to pre-determined measurement goals and creation of outputs for extension programs. Extension impacts are evaluated via event attendance and survey data revealing land-management impacts and changes. Education impacts are evaluated through written assessments, interviews, and observations of participating students and teachers.

Examples of measurable research outcomes realized to date:

- Comprehensive assessment of climate-related research and technology transfer needs of Southeastern forest managers.
- Coordinated and standardized procedures for field ecology measurements across >125 locations from Virginia to Texas.

- Developed region-wide, fine-scale projections of pine forest carbon sequestration, productivity, and timber supply under future climate scenarios using newly developed or enhanced statistical growth and yield, process-based, and bio-economic models, driven by state-of-the-art MACA downscaled climate projections.
- Developed full life-cycle assessment of carbon sequestration associated with production and use of wood products from planted pine systems.
- Analyzed genetic variation relative to climate adaptation and productivity traits to accelerate breeding of future generations and improve seedling deployment decisions.
- Incorporated state-of-the-art climate projections and genetic deployment tools into our PINEMAP Decision Support System.

Examples of measurable Extension outcomes realized to date:

- In 2014, PINEMAP training events reached 175 industry professionals who manage 16.4 million acres of forest; other efforts reached 9,600 small-acreage landowners who own 16.2 million acres. Surveys have indicated that the majority of these individuals plan to implement PINEMAP recommendations.
- PINEMAP partnered with other CAPs to provide education on climate change and its ramifications to more than 100 extension agents and specialists from across the South.
- PINEMAP will continue disseminating actionable knowledge to producers and industry professionals through the Southeast Regional Climate Hub after PINEMAP funding ends in February 2016.

Examples of measurable education outcomes realized to date:

- From 2012 to 2014, the PINEMAP undergraduate fellow program trained 26 university undergraduates to develop and present lessons on natural resources and climate change issues, and those fellows made a total of 233 presentations to 5,043 secondary school students.
- In partnership with Project Learning Tree, PINEMAP personnel developed an educational module, Southeastern Forests and Climate Change, designed for middle- and high-school science programs; 2,700 copies of the module have been distributed to teachers in 12 states and it is being requested by educators outside PINEMAP's geographic region.
- PINEMAP surveyed about 250 educators in five states, to gauge their opinions about climate change; the results may help PINEMAP connect with teachers more effectively.

Team Outputs

PINEMAP developed and published an annual report containing 24 articles by 60 authors summarizing preliminary research results and education and Extension programs during funding year 4 (http://www.pinemap.org/reports/annual-reports/PINEMAP_AnnualReport_press4v2.pdf). Hard copies were distributed to partners and stakeholders, and the report is available for download via the PINEMAP web site. The PINEMAP web site (<http://www.pinemap.org>) continues to be a valuable outreach tool, and provides project updates, research results, and outreach materials.

In June 2015 over 100 PINEMAP team members assembled in Athens, GA for our annual meeting. The group discussed our plan of work for the final year of the project, shared research through big science talks and more than 40 poster presentations, improved the coordination of our research and outreach efforts with a new consideration on reaching additional stakeholder audiences, discussed how to leverage our networks into the future, and gained consensus on the process of planning our final research and ultimate stakeholder meetings.

The research, education, and Extension efforts of PINEMAP team members resulted in an impressive array of outputs since August 2014, including products (peer-reviewed publications, fact sheets, white papers,

research summaries, and audio/video products) and events/activities (oral and poster presentations, workshops/trainings/courses, and experiments, data collection, and surveys). A complete summary of team outputs produced and disseminated from August 2015 to present can be found in Appendix A.

Detailed Progress Report on Team Milestones and Deliverables

Aim 1 (Silviculture/ Physiology) Milestones/ Deliverables:

Net ecosystem productivity group

Net primary productivity of 125 Tier II sites was calculated using measured diameter and heights and allometric equations. Calculation of net ecosystem productivity awaits final development of robust models of soil heterotrophic respiration.

Sap flux regional analysis group

TerraC has been redesigned to make it more user-friendly and allow easy download of data to PCs of members of Pinemap. Data and metadata sheets including templates for tier 1, 2 and 3 sites have been uploaded into TerraC. The datasets contain: (1) Ecosystem measurements (observations) representing soil, vegetation (trees), atmosphere, (2) Estimated (calculated) data (such as net primary productivity), and (3) extracted environmental covariates from geospatial layers (e.g., climate data, soil and topographic data). Sap flux data through 9/30/2013 has been uploaded to TerraC. Tier III meteorological and biometric data are currently in template development and will be uploaded no later than 5/31/15, as well as sap flux data through 9/31/2014. An additional year of data will be added this fall. LAI phenology data derived from remote sensing are being analyzed.

GA and VA analyses were completed and manuscripts are in preparation for FL and GA. VA and GA manuscripts were accepted for publication in June 2015, and FL analyses are to be completed by August 2015. We used continuous half-hourly sap flux measurements of 80 trees from June, 2012 until March 2014 (>32,000 data points) and associated stand-level biometric data and meteorological data.

Protocols for carbon sampling, tree core collection, biomass sampling, precipitation collection for isotopes, GHG flux, and heterotrophic and autotrophic soil respiration, and IPAR-LAI protocols have been finalized and uploaded to the PINEMAP intranet site where they will serve as a reference for field work and data collection on Tier II and III sites. Standardized metadata and spreadsheets have been created. Radial corrections were estimated for Florida in M. Wightman's M.S. thesis. Data collected in one tree per plot for other sites in growing season 2014, will be analyzed for cross-site analyses.

Data are being analyzed and a manuscript prepared on OK gas exchange, growth, and daily eddy covariance, anticipated completion 9/31/15. OK sap flux x VPD relationship is being analyzed.

Soil moisture assessment and standard index data are being analyzed.

Independent estimates from GA and VA sites' E_c are being used to develop models. Standardized estimates for cross site analysis awaiting all relevant data streams to be available in TerraC. Modeling framework and base code for final cross-site analysis of E_c , G_s has been published in Ward et al. (2015) and Bell et al. (2015).

Should a no cost extension be granted, hydraulic conductivity and cavitation vulnerability of loblolly branches and small coarse roots will be measured for all Tier III sites and linked to results from cross-site sap flux analyses.

Additional outputs that would be completed during a no cost extension include the characterization of loblolly pine needle water potential, terminal stem hydraulic conductance and foliar stable carbon isotope ($\delta^{13}\text{C}$) discrimination at the VA Tier III site. Characterization of fine root distribution to 15 cm in response to throughfall treatments is ongoing and additional time would allow for improved data. Preliminary analysis indicates a strong redistribution of fine roots into open areas and away from throughfall exclusion zones. Similarly, needle level gas exchange in response to VPD is being studied at VA Tier III site. It requires more time for completion, but would inform interpretations of sap flow data.

Soil respiration regional analysis group

We have transferred the completed R_s dataset to modeling group (via Templeton et al. (2015) paper). Validation of Templeton's R_s model with continuous observations will be completed with paper submission planned in September 2015.

A region-wide dataset of R_s has been reanalyzed. A four-parameter model (temperature, temperature x moisture, bulk density, soil nitrogen) explains 56% of the variance in R_s . A simple one-parameter model (temperature) explains 48% of the variance in R_s . Multiple datasets from across the region are being combined and analyzed to validate and further current models.

We completed sampling and analysis of R_H/R_S for the VA, OK, and FL Tier III sites and delivered data to the modeling group. Additional validation work at Tier III sites is ongoing. We completed additional sampling of R_H/R_S across the Tier II network to validate and inform observations from the Tier III synthesis; planned delivery of preliminary results to modelers is expected by September 2015.

The comprehensive synthesis of sources of variability in R_H/R_S ratio is ongoing, with delivery to modelers expected by Dec 31, 2015. Dan Markewitz is leading the group processing the R_H/R_S Tier II synthesis, and Brian Strahm and John Seiler have completed the Tier III R_H/R_S synthesis; the associated manuscript is in draft.

A study to further investigate how R_H/R_S changes with stand age and season was completed in central Virginia within the Appomattox-Buckingham State Forest (close to the Tier III installation). Three replications of four loblolly pine age classes (2-3, 7-9, 16-18, and 23-25 years-old) were measured using established PINEMAP protocols. Preliminary analysis indicates a significant stand age effect, with annual R_H/R_S decreasing with age.

At the GA Tier III site, measurements were made of soil CO_2 efflux and its components—autotrophic CO_2 efflux, heterotrophic CO_2 efflux and CO_2 efflux from the ectomycorrhizal hyphae. At least three Tier II sites in each sub-region were identified for R_H vs. R_A measurements using the established PINEMAP protocol and equipment has been installed for data collection during late summer 2015.

A study to investigate how soil microbial processes and litter chemistry are linked to decomposition established at the Virginia Tier III site has been completed. Data collected from this study include soil CO_2 efflux, leaf litter structural carbohydrate and lignin content, soil (0-10 cm) nutrient content, litter and soil microbial and extracellular enzyme activity, and macroinvertebrate abundance and diversity. Carbon degrading enzymes activity increased while nitrogen and phosphorus mineralizing enzymes decreased with fertilization and throughfall reduction. Other measured variables are currently being analyzed.

A study investigating the contribution of forest floor CO_2 efflux to R_s has been established using forest floor collected Virginia Tier III site. This study will be completed in August, 2015.

We are currently synthesizing soil health and R_h data, which will be incorporated into a factsheet outlining

flexible forest management for multiple ecosystem services and soil health led by Chris Maier. Kristin McElligott will lead development of additional fact sheets and case studies detailing each forest management option outlined in the multiple ecosystem services and soil health factsheet.

Tier II regional analyses group

Extractions of soil properties (n=18) from the Soil Survey Geographic (gSSURGO) Database and climate data (PRISM and Idaho Geospatial) has been completed for tier I and II sites. Extractions of MACA climate data are also complete. Tier II field sampling is complete.

Field-measured aboveground data are ready for entry into Terra C, and output to modeling groups is expected over summer 2015.

More than 1200 direct observations of soil bulk density (Db) from the PINEMAP Tier II Network have been combined with more than 2700 direct observations in the southeastern United States from the National Cooperative Soil Survey. This extensive database is being used to create pedotransfer functions using Random Forest models with two goals in mind: (1) to predict missing Db values that are needed to estimate soil C and N contents of the Tier II installations, and (2) to understand the nature of variation and depth dependence of Db in forest ecosystems. Results from this modeling exercise will be compiled as a manuscript that will be submitted for publication by June of 2015.

A study designed to quantify the depth dependence and actual variability of Db at the plot level was established in North Florida in Dec 2014 and was completed in May 2015. Soils from different taxonomic Orders (Spodosols and Ultisols) are being intensively sampled for Db (n=100) at each of four depths corresponding to the PINEMAP Tier II sampling depths (0-10; 10-20; 20-50; and 50-100 cm). A combination of traditional statistics and geostatistics are being conducted to quantify Db uncertainty and our ability to accurately measure elemental contents of forest soils.

This fall, Jason Vogel and Allan Bacon will lead the C analysis of existing data. Jason Vogel and Tom Fox will lead the incorporation of aboveground and soil forest floor carbon and nitrogen use efficiency and trace gas data into the DSS. The life cycle analysis of carbon emissions from practice and the carbon upscaling kriging is also expected to be completed this fall.

Aim 2(Modeling) Milestones and Deliverables:

Regional modeling: 3-PG group

The initial comparison of two models for taking SI to FR suggested a need to recalibrate other parameters in 3-PG. Because of this recalibration, additional parameter sets and SI-FR models were considered. The common validation dataset, and climate & scenarios for the all models were agreed upon in May 2015. The effect of CO₂ on photosynthesis and stomatal conductance has been incorporated into 3-PG. Initial regional runs were used to compare pre-determined combinations of parameter sets and models, with emphasis on comparison to existing WaSSI and G&Y baseline results.

Region-wide soil and site index inputs have been extracted and aggregated to the HUC-12 level. 3-PG can now be run across the PINEMAP region for any year between 1950 and 2100, with likely emphasis being on comparing 1980-1990 with 2060-2070 to facilitate model comparisons between 3-PG, WaSSI, and G&Y. An assessment of the ability of 3-PG to predict stand growth has been made on sites across the loblolly pine region and a manuscript (Gonzalez-Benecke et al.) been submitted.

This summer, we will finish work on MCMC parameter estimation, complete a second inter-comparison of 3-PG “flavors”, refine the SSURGO SI map, and expand the SSURGO SI map range where feasible.

This fall, we will provide county-level outputs to the economics group. This winter we will work with the DSS group to incorporate 3-PG final outputs into the DSS interface, and complete work on our manuscript detailing the process of regionalizing 3-PG.

Regional modeling: Growth and Yield group

Climate data from 20 models is pending has allowed for estimates of variability in G&Y predictions. Scenarios were agreed upon to allow model output comparisons with 3-PG and WaSSI. Baseline runs for 1980-1990 and 2060-2070 for 2 management scenarios and 2 climate scenarios have been made and presented. Runs for the remaining management scenarios and climate scenarios will be complete this fall

This summer we will finalize incorporation of the CO₂ fertilization effect and the dynamic site index model, compare results to validation dataset.

This fall we will provide output to DSS. A manuscript on the PINEMAP growth and yield model regionalization is expected to be completed this winter.

Regional modeling: WaSSI group

We developed an ecosystem respiration (ER) model for Loblolly Pine (LP) plantation using 8-years data collected from a drained wetland site on the eastern North Carolina coastal plain. The model can be used to simulate ecosystem respiration with air temperature and soil moisture. We found monthly mean ER is highly correlated with evapotranspiration. The scaling of the transpiration numbers for FACE with the full ET balance is complete. We will use the 3-PG generated NPP/GPP ratio to get an improved WUE for WaSSI.

We have tested several ecosystem respiration models developed from Fluxnet. Improved ER models will be implemented in WaSSI for use in PINEMAP project to understand the tradeoffs between carbon and water.

WaSSI baseline runs using the MACA climate data (20 GCMs at two RCPs scenarios) from 1951-2099 are complete. Maps of climate change impacts on water yield and GPP have been made. Next step is incorporating CO₂ effects on water use efficiency and forest leaf area index to project how climate change and CO₂ concentrations change affect water yield and GPP.

CO₂ fertilization (i.e. NPP) impacts from the literature are being incorporated into WaSSI. These will be combined by Ge Sun, Eric Ward and Steve McNulty with new analyses by Ward of total ET from Duke FACE, themselves based on the same descriptive modeling framework as the Tier III sap flux. The combination of this information will allow the evaluation of long-term impacts of experimental elevated CO₂ on WUE. This may be contrasted with the lack of 'direct' short-term effects in the same experiment (Tor-ngern et al. 2015) or weak effects noted with change of ambient CO₂ in the control (Novick et al. 2015). We expect completion of this task this fall. We will provide WaSSI results to the DSS this fall, with a manuscript this winter.

Model synthesis of data from Tier III sites will provide more data on fertilization and drought effects on WUE. This work is expected to continue after PINEMAP's official end date or during the no-cost extension year, if granted. The use of a common descriptive modeling framework should greatly facilitate this process.

Regional modeling: SRTS group

We have worked out the protocol and code to implement growth changes by age, region, and age class and completed baseline runs with WaSSI.

We have worked with 3PG to refine protocols. Bob Teskey et al. have created the 3PG+ model with an accompanying algorithm to estimate FR, the 3PG soil fertility factor that serves to mimic an index of site productivity. David Arthur Sampson created an original version code set using 3PG+ as the starting point. This 3PGs base model was parametrized using the VPI FMC stand data set (using the Santosh FR algorithm) and validated using the FBRC IMPAC control sites.

As model productivity output change with climate becomes available from 3-PG this fall, we will aggregate results, incorporate disturbance scenarios from economics, and provide soil C estimates to the life cycle analysis. We will create a region-specific life cycle analysis factsheet covering policy making, forest industry models, and market solutions. We plan to complete work on a CO₂ policy and life cycle analysis impact manuscript this fall.

Regional modeling: Community Land Model group

The Community Land Model (CLM) Version 4.5, the land model in the Community Earth System Model, has been added to the PINEMAP suite of models. We are using the version that includes the CENTURY model as the soil biogeochemistry model, which is also the same soil model in the DAYCENT model that was previously associated with this task. We are running the CLM at the 1 x 1 degree spatial resolution because that is the spatial scale of climate inputs.

We created a PINEMAP grid that replaces the global grid in the CLM. A grid is the spatial extent and resolution used in the simulation. The PINEMAP grid was used to resample the global input datasets that describe soil physical properties. Currently we are using the default parameterization for a needleleaf evergreen temperate tree to represent a loblolly tree (future work can better parameterize the loblolly tree). The weather inputs used output from Community Climate System Model (a precursor to the CESM) RCP 8.5 scenario simulation. This includes historical output (1850-2005) that used historical data on forcing agents (CO₂, land-use, N deposition, solar) and future output (2006-2100) based on the RCP 8.5 scenario. Weather inputs from a RCP 4.5 are also available.

To create a map of initial soil organic carbon stocks, we ran the CLM for 1000 years using climate from 1850-1880 and other forcings from 1850 (CO₂, N deposition, and land-cover) until an equilibrium was reached. This is a standard modeling protocol for the CLM. No calibration was performed for this project. The CLM was used with default parameterizations except for changing the tree annual mortality rate from 2% to better match the lower mortality in plantation forests (1%). We also modified how harvests are simulated in the CLM by removing all tree boles at harvest and replanting seedlings instead of the default where harvests are a set percentage of existing biomass. Using the equilibrium 1850 initial conditions, we simulated 1850 to 1970 where potential vegetation was replaced with needleleaf evergreen trees and harvested occurred every 25 years. Next we simulated from 1970 to 2100 with harvested every 25-years and wild-fire excluded.

We have modeled output from 1970 to 2100 from RCP 8.5, and plan to simulate RCP 4.5. Key variables in the the output are the change carbon (vegetation and soil) stocks over each 25-year harvest cycle and the average NPP, GPP, NEP, and Rh over each harvest cycle.

This summer we will use the common validation datasets to allow for model result inter-comparisons, run 1970-1993 CRUNCEP, calculate absolute C stocks by adding delta to baseline. This fall, we plan to compare the model simulated Rh to the observations to better understand whether the model captures the general patterns in the observed Rh.

Since the CLM requires subdaily weather inputs of many variables, the daily output of the MACA can not be used in the CLM. However, the CCSM input data used in the CLM is the data that the MACA used for the downscaled CCSM data. Since the other models (G&Y, 3PG, and Wassi) will also use CCSM data as

one of the MACA inputs, we can directly compare the CLM output to the output from other model simulations that use the CCSM MACA inputs. We expect a CLM regionalization manuscript to be complete this winter

Regional modeling: DayCent group

Wade Ross is applying DayCent at a finer spatial resolution than CLM to improve characterization of processes and assessment of soil C – climate interactions. The model has been parameterized and calibrated at Tier III sites using NPP and soil carbon data. It is now regionalized using space-time inputs, such as climate data, soil, etc. for this model that uses daily time steps. DayCent will be calibrated and validated at tier II sites summer/fall 2015 because tier II soil carbon and forest floor measurements were not complete until July 2015. After completion of calibration and validation DayCent will be used to simulate carbon dynamics into the future using MACA projections.

Aim 3(Genetics) Milestones and Deliverables:

Genotyping group:

The positive preliminary results obtained from analysis of seedling gene expression analysis results in conjunction with field trial data suggests that it may be possible to predict which families within a specific provenance or seed source will show above-average resilience to variation in environmental conditions. This possibility will be explored in further experiments with germplasm for which both seed samples and field test data are available.

This summer, we plan to upload the ADEPT2 phenotypes in TerraC, discover genetic variant data (SNPs in VCF files), and upload that variant data into TreeGenes.

Mengmeng Lu (TAMU) and PINEMAP intern Nathalie Reiley collected tissue samples and data from the ADEPT2 clonal trial planted near Saucier MS in May and June, 2014. The phenotypic data available include: specific leaf area, branch angle, crown width, total height, growth height, diameter, and number of fusiform rust galls. Measurements of carbon isotope discrimination and stomata density of foliage are complete and will be used to test hypotheses about the relationship of water use efficiency and growth under field conditions. These phenotypic measurements will be used in conjunction with genotypes obtained from the same cloned individuals to test for associations between genetic and phenotypic variation.

In collaboration with Dana Nelson (USFS), Virginia Tech researchers are measuring cold hardiness for the ADEPT2 population at Saucier, MS.

The group at Texas A&M has done exome capture on 384 ADEPT2 clones using approximately two million Roche Nimblegen baits covering 38,000 genes. The results from the first 20 trees were very promising, with approximately 3 million SNPs detected in regions sequenced at least five times in all 20 trees. DNA sequencing is complete or underway for all 384 clones, but analysis is not yet complete.

Dana Nelson and the USFS group at Saucier collected additional tissue samples and phenotypic measurements from the ADEPT2 clonal planting at the Harrison Experimental Forest. The tissue samples were collected to provide DNA for other researchers interested in analysis of this experimental population.

The Virginia Tech group is using an electrolyte leakage test to measure cold hardiness in the ADEPT2 population at both Gainesville, FL, and Saucier, MS. Preliminary results show extensive genetic variation in freeze tolerance both within- and among-population, and greater damage in the southern provenances. These data will be employed to seek genotype-phenotype relationships using data generated by the Florida group

(led by Gary Peter). Because freeze tolerance is a primary determinant of the suitability of loblolly pine for a given site, these data will provide insights into possible expansion of the planting range of the species under climate change, and allow for the selection of both families and allelic combinations that are favorable for a given site under future predicted climatic regimes.

The Virginia Tech group used genotyping-by-sequencing to genotype the Plantation Selection Seed Source Study (PSSSS) trial located in Appomattox County, Virginia. Genotyping of this study is of interest due to its location at the northern edge of the current loblolly pine range, and will complement co-PI Whetten's sampling/genotyping of the same families planted in Georgia. DNA was extracted from 960 individuals chosen to maximize overlap with families present at sites being genotyped by the NC State group. Once bioinformatics tasks are complete, these data will be coupled with growth data available NC State (co-PI McKeand) to conduct marker-trait association mapping and genomic selection. These data on the associations of specific genes or genomic regions with height growth in the same families grown in contrasting sites (Appomattox County Virginia versus Screven County, Georgia) will allow tests of the hypothesis that different genes are involved in adaptation to different environmental conditions.

The NC State group has begun to test the relative value of estimating genetic covariance separately for genetic variants that may affect gene function versus genetic variants that affect gene regulation. The 42 parent trees used in this experiment are from the Lower Gulf Elite Population, a collaborative experiment among the Cooperative Forest Genetics Research Program at UF, the Cooperative Tree Improvement Program at NC State, and the Western Gulf Forest Tree Improvement Program of the Texas Forest Service. Field trials of progeny from a partial diallel mating design have been established and measured, so phenotypic data are available to test the relative accuracy of statistical models using genetic covariance matrices based on pedigree, on genetic variants in gene coding regions, on covariance of gene expression patterns, or some combination. A second set of 40 parent trees with progeny test results in hand is also available, so results from the initial first experiment can be verified in a second population.

RNA-Seq data have been obtained for 3-month-old seedlings of parent trees of the Lower Gulf Elite population, and gene expression measurements and analysis of coding sequence variation is underway. Preliminary results indicate that evaluation of differential gene expression will be possible for about 25,000 transcripts, and that over 1 million single-nucleotide polymorphisms (SNPs) are detectable within those transcripts. Modeling of field performance at age six years using the covariance patterns of gene expression levels and coding sequence variation will continue, and additional sequence data will be collected from more samples of independent parents in order to extend the analysis to a broader range of germplasm. Preliminary results suggest that patterns of gene expression covariance alone can account for about half the observed variation in genetic values among full-sibling families based on age six field measurements, and the expectation is that including covariance of coding-sequence variation will further increase the fraction of variation explained.

Sequencing data collection is largely complete for the groups at Texas, Florida, and Virginia Tech; the group at NC State will continue sequencing through the end of the project to maximize the number of different parents for which seedling gene expression measurements are available. These seedling gene expression measurements will then be utilized during the no-cost extension to expand the scope of the seed deployment guidelines. Additional sequencing experiments will also be undertaken at NC State to map regions of the pine genome that may be involved in gene regulation, as such data will add significant value to the PineRefSeq draft genome assembly and to future efforts to use molecular genetic markers in the context of applied breeding programs.

NC State University researchers have continued to explore refinements in statistical modeling approaches to build predictive models suitable for incorporation into the web-based DSS. Recent efforts have focused on

Bayesian non-parametric methods that are more flexible than the multiple regression approach used in the first round of analyses. The Bayesian method provides a description of the uncertainty of outcomes as well as the expected outcome, which would allow land owners and managers to incorporate those uncertainties into their own risk-benefit analysis to determine the most favorable course of action given their own financial situations.

Feedback on the prototype Decision Support System website was provided to the DSS development team, and ongoing conversations with the DSS developers and outside stakeholders continue to maximize the value of the DSS to stakeholders. More information is available below in the Extension – DSS group progress report.

Each of the southern pine breeding cooperatives (Cooperative Forest Genetics Research Program, UF; Cooperative Tree Improvement Program, NC State; and Western Gulf Forest Tree Improvement Program, TAMU/Texas Forest Service) communicates regularly with cooperative member organizations about appropriate seedling deployment guidelines for germplasm developed by the respective breeding programs. In addition, presentations at public meetings such as the Forest Landowners Association inform stakeholders who are not cooperative members about the importance of appropriate seedling deployment.

Aim 4 (Economics and Policy) Milestones and Deliverables:

We are completing one manuscript assessing the attitudes and willingness to accept compensation for carbon offset production in. The results from this study will also be used for a subsequent publication that compares two survey choice elicitation models (Best Worst Choice and Discrete Choice Experimentation), which produce similar estimates of willingness to accept payments for ecosystem services using different choice tasks. This comparison study will be useful to scientists interested in stated preference survey methods, particularly the use of the relatively new tool called Best Worst Choice. Our goal is to finish this latter publication by November 2015.

We are currently analyzing the data collected from our regional survey of non-industrial private forest landowners across the southern United States. Within this study Nonindustrial Private Forest (NIPF) landowners are segmented in the southern US on the basis of their attitudes toward climate change and carbon sequestration. A k-means cluster analysis was used to segment their climate change and carbon sequestration attitudes into three broad clusters: skeptic, supportive, and undecided landowners. The results indicated that a majority of the southern landowners (40%) held undecided attitudes while the proportion of supportive and skeptical clusters was 33% and 27%, respectively. These attitude clusters differ with respect to landowner income and education as well as their land ownership and management characteristics. Results of this study provide insights on current attitudes of NIPF landowners toward climate change and carbon sequestration as well as strategies for effectively communicating climate change and carbon sequestration information to them. Other manuscripts are in development.

We are in the process of completing a publication assessing the distributional effects of socio-economic and ecological determinants of forest carbon stocks in Florida. Our results provide evidence of heterogeneity in the effects of important determinants, which highlights the limitations of conventional mean based regression results, and the advantage of using quantile regression analysis. Our goal is to submit by the end of July 2015.

We have completed a publication in which we determined the efficiency of loblolly pine forest plots in the provision of timber, carbon sequestration and species richness under climate change. We are also assessing the profits foregone due to inefficiency in loblolly pine forest management with increased level of temperatures and precipitation using a non-parametric economic optimization approach. This manuscript is under collegial review and will be sent for a special issue of Forest Policy Economics.

We are developing an economic forest stand level model in which we will determine the impacts of increased temperatures and precipitations on the optimal forest management for southern pines using the 3-PG model. We will apply this model in different locations throughout the U.S. South to ascertain the economic rents, optimal rotation age and C sequestration in situ. Our goal is to have preliminary results by October-November 2015.

Aim 5 (Education) Milestones and Deliverables):

PLT secondary module group

The module was printed and website is complete. The module is in the process of being revised for a second printing in fall 2015.

The student pre and post knowledge survey, systems survey, and hope surveys have been developed, tested, and finalized for both formative and summative evaluations. A workshop pre/post survey was developed, pilot tested, and finalized. We are in the process of finalizing the overall Web survey for all users. An application was distributed across the Southeast in December 2014. Of the 160 applicants, 45 teachers were invited to participate in the evaluation. All materials and instructions have been sent to the participants. Observations and student interviews were conducted in four classrooms in spring 2015. Data are being analyzed this summer.

Suggestions from summative evaluation have been compiled for the revision; we requested feedback from state coordinators and facilitators for changes in June 2015. Summative evaluation responses are also being analyzed to help us know how best to revise the research questions and data collection on systems thinking.

Three regional workshops were completed.

- September 19, 2014: 6 hour workshop for educators from NC and facilitators from KY, VA, NC, TN, and GA in Asheboro, NC. 39 participants.
- November 13-15, 2014: Two day workshop for educators from AK and facilitators from AR, MS, NC, OK, GA, TX, TN, and SC in Little Rock, AR. 22 participants.
- January 23-24, 2015: 6 hour workshop for educators and facilitators from FL, AL, MS, TX, GA, and SC in Jacksonville, FL. Facilitators also participated in an extra session the evening of January 23. 37 participants.

We worked with National Project Learning Tree staff to develop an application form for state grants to implement workshops that distribute the SFCC module to educators. Applications were received and grants were processed by 2/1/15. We also developed a series of reporting forms to help track the results of the state workshops.

To better support state PLT coordinators and market the secondary module to more educators, we plan to work with the national community of AP Environmental Science teachers, provide states a second round of small grants, provide guest speakers to support state workshops, and develop a series of webinars to support educators. The website will be modified to include background information that is typically offered in workshops. These new tasks will help state PLT programs reach new audiences, as many states have not yet developed a strong secondary program.

Data on climate change and hopefulness, systems thinking, teacher efficacy, and teacher worldviews are currently being analyzed; an extension would be useful for this task.

We launched a literature review of climate education for community adaptation project in June 2015 and plan to continue through the extension period. This should serve as a resource for improving the efficacy of future Extension programs and educational materials.

Undergraduate fellowship program group

Nine undergraduate students from the 3rd undergraduate fellowship cohort completed their fellowships in December, 2014 and the remaining three completed their fellowships during spring of 2015.

Interview protocols for interviewing undergraduate and graduate student participants are in development.

Twelve PINEMAP graduate students, post-doctoral researchers or faculty submitted proposals for hosting undergraduate students through the PINEMAP Undergraduate Fellowship. Additionally, two faculty members from non-PINEMAP institutions working on southeastern forest ecophysiology were invited to host additional undergraduate fellows as needed. These positions include four of PINEMAP disciplinary aims: silviculture, modeling, education, and extension. Fourteen undergraduate students from 10 North American universities were provided with fellowships to work with 13 mentors at 8 universities.

Preliminary analysis of student intern attitudes toward research has been conducted on all but the current (2015) cohort. Tasks relevant to the PINEMAP fellowship evaluation remaining are: developing the interview protocol and interviewing undergraduate and mentor participants, and examining student feedback on the fall distance education course.

This integration paper between the PLT module, graduate student course, and undergraduate fellowship groups is currently being discussed. Writing will depend on the journal, but the focus will be on useful ideas for other projects integrating research and education.

Due to the inclusion of a fourth cohort of undergraduate students that will complete the fellowship in December, 2015, the evaluation report is expected to be pushed beyond a February 2016 timeline. An extension would allow a more thorough and accurate report on the fellowship program's activities, participants, and outcomes. Additionally, research examining other REU programs will be conducted during a potential no-cost time extension that will allow a comparison of the PINEMAP fellowship to other programs within natural resources disciplines.

Aim 6 (Extension) Milestones and Deliverables:

Corporate outreach group

The corporate outreach group has been attending coop meetings to disseminate PINEMAP research as results come in. This summer we are continuing to develop presentations, trainings, as well as begin work on a journal special issue. Over the next year, we will plan and deliver a stakeholder virtual meeting and an in person wrap up symposium.

Extension outreach group

Discussions of next steps for PINEMAP materials and the Decision Support System have been ongoing. The Extension team is partnering with the Southeast Regional Climate Hub (SERCH), the Climate, Forest and Woodlands Community of Practice (eXtension), and the Climate Science Learning Network to create a comprehensive resource for educational and Extension resources on climate and forestry. This effort will help leverage and share PINEMAP resources with wider audiences, and extend the availability of results beyond the initial funding of the PINEMAP project.

Southern Regional Extension Forestry (Bill Hubbard and Leslie Boby), annually host a meeting for Extension Foresters at the different southern land grant universities, called the Unit Leaders meeting, and have solicited feedback and ideas from the group, as an ad-hoc regional advisory board. Since these leaders are engaged in extension forestry with similar work, their feedback has been valuable towards improving products and direction of work.

Over the past few years, we have produced 14 webinars for professional foresters using PINEMAP researchers and other professionals to present. We worked closely with them to guarantee the quality and relevance of their presentations. 739 people viewed the webinars for an average attendance of 53 per webinar. As the Decision Support System nears completion, we will develop a webinar series/e-learning modules/videos to demonstrate how to use the DSS tools.

Eight landowner factsheets have been completed and more than 18 are in progress. Two factsheets designed to serve as companion pieces for the DSS are currently in development.

Extension personnel developed two adaptive silviculture workshops that trained 300 foresters and landowners. Approximately 45 other extension foresters were trained in adaptive forest management at 3 additional workshops. Nearly ten other workshops have been delivered training and are listed in the outputs section. Group members have facilitated workshops and developed guidelines for presentations. PINEMAP researchers have attended the workshops to speak to foresters about their work with a focus on management applications of research results.

Decision Support System (DSS) group

The Multivariate Adaptive Constructed Analogs (MACA) climate projection dataset has been averaged over HUC12 regions for variables required by 3-PG, Growth & Yield, and WaSSI. MACA was created using a statistical downscaling method with 20 global climate models from IPCC's 5th Assessment Report and two different emission scenarios across a model baseline period (1950-2005) and future period (2006-2099).

The way we were previously creating spatial averages for HUC12 scales could possibly cause problems for some modelers, so we had to re-tool our analysis software. We used this opportunity to create additional efficiencies, and we were able to reprocess all the MACA projections at HUC12 with output now available for:

- 9 PINEMAP modeling variables: growing season days, total annual precipitation, summer dryness index, monthly min and max temp, monthly total precipitation, mean incoming radiation, frost days, and monthly mean temp
- all 20 global climate models
- all climate model scenarios (baseline, RCP4.5, RCP8.5)
- all HUC12s within the PINEMAP region (exception: WaSSI data is CONUS)

This has created ~ 6TB worth of new output for folks to use both at HUC12 and as gridded data. Daily extractions have also been completed at a daily time step for Tier I (~749 sites), Tier II (~100 sites), Tier III (4 sites), and 36 3-PG validation (36 sites) sites.

HUC12 averages for the remaining East Coast states (defined as -98.5 longitude and eastward; amounts to 25 additional states) has also been processed for all parameters required by 3-PG and G&Y. This allows for projections of pine productivity beyond the current loblolly range.

The initial webpage has been designed, and a third iteration of the full website was completed. The Extension group provided feedback on the look, feel and language of the website and also solicited

feedback from other foresters. The DSS menu structure has been updated again so users can navigate to their desired tool in fewer steps. We have worked with a NCSU Technical Communication graduate student to refine some technical language with the climate risk and seedling deployment tools, and based on her feedback, we have begun adding tooltips to define unfamiliar terms and provide navigational assistance. Additional refinements to the DSS design and language are expected by collaborating with the Extension group during Summer 2015.

The DSS team has refined 3-panel display for the climate data tools. For the DSS analysis, we generate multi-model mean changes as well as multi-model mean changes +/-2 standard deviation changes for all variables across 20-year future time periods (2020-2039, 2040-2059, 2060-2079, 2080-2099). These change maps are complete for the seedling deployment tools (see below for more details), and the change maps for the climate risk/opportunities tools are being completed.

The seedling deployment tools have the ability to show a 5 degree range in temperature isotherms which mimics the recommended “safe zone” by Schmidting 2001. We have obtained feedback on the web interface from the beta testers and DSS subcommittee.

Two climate risk and opportunity tools have been developed and are undergoing internal alpha testing: extreme minimum temperature risk, which displays average number of days < 32F and how that is expected to change in the future, and average summer precipitation and how that is expected to change in the future. The next step is to complete the alpha version of the average summer temperature (and how that is expected to change in the future). Other thresholds (28F, 25F, 20F, and 15F) are also being generated for the extreme minimum temperature risk tool. Beta testing on these three climate risk and opportunity tools will occur during Summer 2015.

We have worked closely with Gary Peter on the seedling deployment tools, which have gone through several revisions. The tools initially display a map of shaded 5°F isotherms (lines of constant or equal temperature) corresponding to the historical average January minimum temperatures from 1986-2005, which closely mimic the USDA Plant Hardiness Zones and the current seed transfer guidelines of Schmidting (2001). When a user clicks a location of interest on the map, the specific historical isotherm associated with that location (e.g., the 33.4°F isotherm for Athens, Georgia) is highlighted, along with several other isotherms based on future projections from a suite of climate models.

The tool went through “pre-beta” testing (Mark Megalos and his student John Hastings) and full beta testing with a team consisting of several industry stakeholders, a consultant, a TIMO/REIT representative, and several PINEMAP team members. Many changes to the tools have been implemented based on our beta tester feedback. The two seedling deployment tools are now finalized.

We are in the process of identifying beta testers for the climate risk and opportunity tools. We have identified individuals to help assess tools for market change inclusion: ecosystem services, timber yields, and bioenergy. Much of the work will be done small pieces at a time through web meetings.

Work continues on several additional tools, including:

- A fire risk tool using Keetch-Byram Drought Index and Energy Release Component (two commonly used fire weather monitoring indices) calculated with the MACA projections.
- A web-based Biological Optimum Thinning Key that will guide land managers to better, proactive management and improved thinning regiments that promote pine forest health, resiliency, and resistance to climate driven environmental stressors; and
- An Herbicide Decision Key that will guide land managers in making herbicide prescriptions at the stand level.

The DSS team has been working closely with Evan Brooks to identify how to best visualize and incorporate PINEMAP's multiple modeling outputs. We have planned a December 2015 summit on tool development to speed up the tool development process. We hope to have the final modeling tools developed before the end of year 5, but additional time would allow for further refinement and feedback from stakeholders to improve the final disturbance/ resilience and change in productivity tools.

This winter, we will work with the Tier II regional analysis team to incorporate their region-wide information on aboveground biomass, forest floor carbon, and nutrient availability.

The DSS will be rolled out at regional Society of American Foresters (SAF) meetings across the PINEMAP region during Fall 2015.

Enhanced Connections to Other Networks and Projects

Connections with existing networks such as the regional forestry research cooperatives and Regional Extension Forestry are central to this project's success and are incorporated into the preceding narrative. However, additional linkages are constantly being leveraged, and some are detailed here.

Close ties are maintained between PINEMAP researchers and the PineRefSeq CAP, also funded by the bioenergy component of the CAP program, to fully exploit the value of the draft loblolly pine genome sequence for the breeding and genetic analysis objectives of the IBSS and PINEMAP research efforts. Texas A&M University applied the results of the draft loblolly pine reference genome assembly and annotation from PineRefSeq team for designing the capture probes used in the Nimblegen hybrid-capture sequencing experiment now being analyzed. The SNPs discovered from the captured exome sequences will be a supplement for the current pool of molecular markers which could be used in screening for better-adapted genotypes. The Genetics and Breeding group is discovering genes and markers associated with important mitigation and adaptation traits that can be incorporated into future breeding programs. Integration of the genetic data collected on pine populations during PINEMAP research with the draft genome sequence assembly of loblolly pine produced by the PineRefSeq project will continue to be an important aspect of Aim 3 efforts. Though this integration effort was not part of the original proposal objectives because the PineRefSeq project was funded in the same funding cycle as the PINEMAP project, it both adds value to the genome assembly and leverages the power of the genome sequencing project for applied breeding efforts.

The NCSU Cooperative Tree Improvement Program is also part of the Integrated Biomass Supply System (IBSS) project funded at University of Tennessee-Knoxville under the bioenergy component of NIFA'S CAP program. The IBSS research conducted by NCSU CTIP is focused on chemical and physical properties of loblolly pine biomass, with a strong focus on wood. These properties are relevant to PINEMAP objectives because they affect the market for southern pine forest products, including solid wood products, pulp and paper as well as potential bioenergy markets that may develop.

We have strengthened our relationship with Project Learning Tree and between Extension and PLT across the South. State coordinators are working with PINEMAP researchers and Extension faculty to plan and conduct teacher workshops in several states. This effort has also increased educators' likelihood to talk about climate change, as evidenced by workshop comments such as, "I really learned something here." And "This curriculum is an excellent resource and provides educators tools to introduce discussions about climate change or dive into investigations."

We have been able to involve many people representing a variety of expertise areas in our PLT module development process through the advisory committee, expert review, pilot test, and incorporating student projects into undergraduate environmental education courses. These connections have provided

opportunities to introduce PINEMAP research and to build relationships that will help us distribute and train educators to use the final module.

PINEMAP has collaborated with similar projects focused on different natural resource sectors. PINEMAP partnered with an animal livestock and climate change project (Animal Agriculture and Climate Change Project) as well as an agriculture and climate change project (Southeast Climate Extension), in order to collectively train approximately 100 extension agents on climate science/change and tools for their resource areas.

We have also engaged with multiple partners concerned with education related to climate change and natural resource management. The Extension team is working closely with the new leading team of the Climate, Forests and Woodlands Community of Practice (co-PI Mark Megalos is part of this team), the staff and leadership of the Southeast Regional Climate Hub (SERCH), which includes co-PI Steve McNulty, and the new Climate Science Learning Network (an eXtension initiative being led by co-PI Bill Hubbard and Leslie Boby). The timing of these collaborations has been excellent, since one of the key discussions within the project and within the group is how to ensure that results, materials, and resources from the PINEMAP effort continue to be utilized and will have a “home” as the project finishes. Because PINEMAP members are involved with these other projects we have been able to collaborate and leverage PINEMAP resources for these efforts. These three additional projects will help provide continuity for PINEMAP Extension resources and the DSS, and collective planning will help avoid replication of efforts and more relevant, robust, and streamlined resources.

We have developed partnerships among state climatologists and Extension foresters and established a PINEMAP Extension network in the Southeast. These partnerships and networks are critical to the efficient and effective dissemination of PINEMAP Extension programs and products. Programs and products being developed include a Decision Support System (DSS), a web-based, open-source set of current and future decision support tools directed at the innovative management of southern pine; eXtension modules for the Climate Science and Forests Interaction Community of Practice (CoP); and additional resources such as fact sheets and web-based education modules; engagement with the USDA Climate Hubs (specifically the Southern Region one), joint work with the Climate Science Learning Network; and promotion of other mitigation and adaptation programs through the Southern Region Extension Climate Academy (SRECA) graduates.

The PINEMAP Extension team has been involved with the Extension efforts with the International Union of Forest Research Organizations (IUFRO) and the National Adaptation Forum.

- PINEMAP information has reached 72 Silviculturists through the Western Gulf Silvicultural and Technology Meeting representing 9 million acres- 5 of those million in pine. Based on what they learned from this effort, changes will be made to management plans covering at least 250,000 acres. An additional 80 foresters were educated on climate change and forest management in Tifton, GA in April 2015.
- Texas Forestry Agency Training- 16 foresters participated in the initial run, representing around 200,000 northeast Texas landowners. They have incorporated PINEMAP strategies into their forest management plans and landowner outreach efforts. This group represents roughly 4 million acres across the Western Gulf region.
- 150 southeastern extension agents (ranging from foresters to agriculture and natural resource agents) have been trained on climate science, change and mitigation efforts through three different workshops (Huntsville, AL May 2013; Wilmington, NC January 2014; and Athens, GA September 2014).

- Western Gulf workshop and Woodlands Owner workshop August- 150 attendees (Diboll, TX). Wilmington, Workshop, Agency foresters-15. Spring 2015 herbicide training on adaptive silviculture (northeast TX region).
- Multi-state SAF meeting (250)- “Reflections on Water” adaptive silviculture, and workshops with minority landowners and forestry extension.

Training

As of July 2015, 62 graduate students, 44 undergraduate students, 16 postdoctoral research associates, and 26 professional and technical staff have been trained under the PINEMAP project. Names and roles of these individuals are listed in Appendix B.

Concluding Statement

The southern pine ecosystem is one of the most economically and ecologically important forest ecosystems in North America. The PINEMAP project is integrating key research, education, and outreach networks to create and disseminate the knowledge that enables landowners to harness planted pine forest productivity to mitigate atmospheric CO₂, more efficiently use nitrogen and other fertilizers, and adapt forest management approaches to increase resilience in the face of climate variability and change. In the first half of the fifth year of the project, we produced key products and results that will support these outcomes as described below.

Our focus on integration across disciplinary groups positions us to deliver real-world outcomes:

- Increased carbon sequestration from silvicultural and genetic enhancement of productivity and efficiency of fertilizer use, and resilience to climate variability and disturbance.
- Engaged and literate public with the capacity to make informed, practical decisions related to climate, forest ecosystems, and forest management.
- Public policy that supports sustainable management of planted pine under future climate scenarios.
- Enhanced capacity for regional, interdisciplinary collaboration among climate and forest scientists and Extension and education professionals.
- Enhanced connections between corporate and non-corporate forest landowners and forestry and climate researchers and education and outreach professionals.
- A more robust and resilient forest-based economy in the Southeast U.S.

Appendix A: Team Outputs

Peer-reviewed publications

Aim 1 (Silviculture and Physiology) Peer-reviewed publications

- Albaugh, T.J., L.C. Kiser, T.R. Fox, H.L. Allen, R.A. Rafael, and J. L. Stape. 2014. Ecosystem nutrient retention after fertilization of *Pinus taeda*. *Forest Science*. <http://dx.doi.org/10.5489/forsci.13-159>.
- Bartkowiak, SM, Samuelson, L., McGuire, MA and Teskey, R. *In press*. Fertilization increases sensitivity of canopy stomatal conductance and transpiration to throughfall reduction in an 8-year-old loblolly pine plantation. *Forest Ecology and Management*.
- Bell, DM, Ward, EJ, Oishi, AC, Oren, R, Flikkema, PG and Clark, JS. *In press*. A state-space modeling approach to estimating canopy conductance and associated uncertainties from sap flux density data. *Tree Physiology*.
- Domec, J-C, Ward EJ, Oishi AC, Palmroth S, Radecki A, Bell DM, Miao G, Gavazzi M, Johnson DM, King JS, McNulty SG, Oren R, Sun G, Noormets A. 2015. Conversion of natural forests to managed forest plantations impacts tree response to climatic variable and affects negatively tree resistance to prolonged droughts. *Forest Ecology and Management*: In press. doi:10.1016/j.foreco.2015.04.012
- Noormets A, Epron D, Domec JC, McNulty SG, Fox TD, Sun G, King JS. *In press*. Effects of forest management on productivity and carbon sequestration: a review. *Forest Ecology and Management*: <http://dx.doi.org/10.1016/j.foreco.2015.05.019>
- Noormets, A., Nouvellon, Y. *In press*. Introduction for special issue: Carbon, water and nutrient cycling in managed forests. *Forest Ecology and Management*.
- Reinhardt K., M. Germino, L. M. Kueppers, J.C. Domec, J. Mitton. *In press*. Linking carbon and water relations to drought-induced mortality in *Pinus flexilis* seedlings. *Tree Physiology*.
- Templeton, B.S., J.R. Seiler, J.A. Peterson, M. Tyree. 2015. Environmental and stand management Influences on Soil CO₂ Efflux across the Range of Loblolly Pine. *Forest Ecology and Management*. doi:10.1016/j.foreco.2015.01.031
- Tian, S., Youssef, M.A., Sun, G., Chescheir, G.M., Noormets, A., Amatya, D.M., Skaggs, R.W., King, J.S., McNulty, S., Gavazzi, M., Miao, G., Domec, J.-C., 2015. Testing DRAINMOD-FOREST for predicting evapotranspiration in a mid-rotation pine plantation. *Forest Ecol Manag*, In press. <http://dx.doi.org/10.1016/j.foreco.2015.03.028>
- Vogel, J.G., He D., Jokela E.J., Hockaday W., and Schuur E.A.G. 2015. The effect of fertilization levels and genetic deployment on the isotopic signature, constituents, and chemistry of soil organic carbon in managed loblolly pine (*Pinus taeda* L.) forests. *Forest Ecology and Management*.
- Ward EJ, Domec JC, Laviner MA, Fox TD, Sun G, McNulty SG, King JS, Noormets A (2015) Fertilization simulates drought. Water use and stomatal conductance of loblolly pine (*Pinus taeda*) in a factorial fertilization and throughfall reduction experiment. *Forest Ecology and Management*: In press. doi:10.1016/j.foreco.2015.04.009
- Will, R.E., T.R. Fox, M. Akers, J-C Domec, E. Jokela, M. Kane, M.A. Laviner, G. Lokuta, D. Markewitz, M.A. McGuire, C. Meek, A. Noormets, L. Samuelson, J. Seiler, B. Strahm, R. Teskey, J. Vogel, E. Ward, J. West, D. Wilson, T. Martin. 2015. A Range-wide experiment to investigate nutrient and soil moisture interactions in loblolly pine plantations. *Forests* 6: 2014-2028; doi:10.3390/f6062014

Aim 2 (Modeling) Peer-reviewed publications

Tor-ngern, P., Oren, R., Ward, E. J., Palmroth, S., McCarthy, H. R. and Domec, J.-C. 2015. Increases in atmospheric CO₂ have little influence on transpiration of a temperate forest canopy. *New Phytologist* 205: 518–525. doi: 10.1111/nph.13148

Novick, K. A., Oishi, A. C., Ward, E. J., Siqueira, M. B. S., Juang, J.-Y. and Stoy, P. C. 2015. On the difference in the net ecosystem exchange of CO₂ between deciduous and evergreen forests in the southeastern United States. *Global Change Biology* 21: 827–842. doi: 10.1111/gcb.12723

Aim 3 (Genetics) Peer-reviewed publications

Egbäck, S., B.P. Bullock, F. Isik, and S. McKeand. 2015. Height-diameter relationships for different genetic planting stock of loblolly pine at age six. *Forest Science* 61(3): 424-428.

Kim, T.J., B.P. Bullock, and S.E. McKeand. 2015. Spatial autocorrelation among different levels of genetic control and spacings in loblolly pine. *Forest Science* 61(3): 438-444.

Koralewski, T. E., H.-H. Wang, W. E. Grant, and T. D. Byram. 2015. Plants on the move: Assisted migration of forest trees in the face of climate change. *Forest Ecology and Management* 344: 30-37.

Farjat, A.E., Isik, F., Reich, B.J., Whetten, R.W., McKeand, S.E. 2015. Modeling Climate Change Effects on the Height Growth of Loblolly Pine. *Forest Science* 61 (4, 5): 703-715.

Smith, B.C., B.P. Bullock, F. Isik, and S.E. McKeand. 2014. Modeling genetic effects on growth of diverse provenances and families of loblolly pine across optimum and deficient nutrient regimes. *Canadian Journal of Forest Research* 44: 1453–1461.

Westbrook J. W., V. E. Chhatre, L-S. Wu, S. Chamala, L. G. Neves, P. Muñoz, P. J. Martínez-García, D. B. Neale, M. Kirst, K. Mockaitis, C. D. Nelson, G. F. Peter, J. M. Davis, and C. S. Echt. *In press*. A consensus genetic map for *Pinus taeda* and *Pinus elliottii* and extent of linkage disequilibrium in two genotype-phenotype discovery populations of *P. taeda*. G3 (Bethesda). Available online at <http://www.g3journal.org/content/early/2015/06/11/g3.115.019588.abstract>

Yeaman S, Hodgins KA, Suren H, Nurkowski KA, Rieseberg LH, Holliday, JA, Aitken SN. 2014. Conservation and divergence of gene expression plasticity following ~140 million years of evolution in lodgepole pine (*Pinus contorta*) and interior spruce (natural hybrid populations of *Picea glauca* and *Picea engelmannii*). *New Phytologist* 203(2):578-91.

Zapata-Valenzuela, J., F. Ogut, A. Kegley, W.P. Cumbie, F. Isik, B. Li, and S.E. McKeand. 2014. Seedling evaluation of Atlantic Coastal and Piedmont sources of *Pinus taeda* L. and their hybrids for cold hardiness. *Forest Science* 61(1):169–175.

Aim 4 (Economics and Policy) Peer-reviewed publications

Gan, J. (Guest Editor). 2015. Special Issue of *Forests*: Climate change and forest fires. http://www.mdpi.com/journal/forests/special_issues/forest_fire.

Gan, J., A. Jarrett, and C. Johnson Gaither. 2015. Landowner response to wildfire risk: Adaptation, mitigation or doing nothing. *Journal of Environmental Management* 159: 186-191.

- Gan, J., A. Jarrett, and C. Johnson Gaither. 2014. Wildfire risk adaptation: Propensity of forestland owners to purchase wildfire insurance in the southern U.S. *Canadian Journal of Forest Research* 44: 1376-1382.
- Grebner, D.L., R.K. Grala, O. Joshi, and G. Perez-Verdin. *In Press*. Physical and economic aspects of assessing woody biomass availability for bioenergy production. *In: Handbook of Bioenergy*. Eds. Sandra Eskogilu. Revised and resubmitted on October 3, 2014.
- Joshi, O. Grebner, D.L., and P. N. Khanal. 2015. Status of urban wood waste and their potential use for bioenergy in Mississippi. *Resources, Conservation & Recycling*, 102(2015): 20-26.
- Joshi, O., Grebner, D.L., Henderson, J.E., and S.R. Gruchy. 2015. Landowners, bioenergy, and extension strategies. *Journal of Extension* 53(2). Available online at: <http://www.joe.org/joe/2015april/a3.php>.
- Joshi, O., Grebner, D.L., Munn, I.A., and R.K. Grala. 2015. Issues Concerning Landowner Management Plan Adoption Decisions: A Recursive Bivariate Probit Approach. *International Journal of Forestry Research*, vol. 2015, Article ID 926303, <http://dx.doi.org/10.1155/2015/926303>.
- Kabli, M., J. Gan, and L. Ntaimo. 2015. A stochastic programming model for fuel treatment management. *Forests* 6(6): 2148-2162; doi:10.3390/f6062148.
- Susaeta, A., Carter, D.R., Adams, D.C. 2014. Impacts of climate change on economics of forestry and adaptation strategies in the Southern United States. *Journal of Agricultural and Applied Economics* 46(2): 257-272.
- Susaeta, A., Carter, D.R., Adams, D.C. 2014. Sustainability of forest management under changing climatic conditions in the southern United States: Adaptation strategies, economic rents and carbon sequestration. *Journal of Environmental Management* 139: 80-87.

Aim 5 (Education) Peer-reviewed publications:

- Monroe, M. C., J. Ireland, and T. A. Martin. 2015. Integration of forestry research and Extension in an Online Graduate Course. *Journal of Forestry*. 113(2): 240-247.
- Monroe, M.C., R.R. Plate, L. Colley. 2015. Assessing an Introduction to Systems Thinking. *Natural Sciences Education*, 44(1): 11-17.

Aim 6 (Extension) Peer-reviewed publications:

- Boby, L.A., Hubbard, W.G., Megalos, M.A. and Morris, H.L.C. *In submission*. Climate Change Observations, Perceptions and Concerns of Southern United States Forestry Professionals. *Journal of Extension*.
- Burnett, R. E., Vuola, A. J., Megalos, M. A., Adams, D. C., & Monroe, M. C. 2014. North Carolina Cooperative Extension professionals' climate change perceptions, willingness, and perceived barriers to programming: An educational needs assessment. *Journal of Extension* [On-line], 52(1) Article 1RIB1. <http://www.joe.org/joe/2014february/rb1.php>
- Morris, H.L.C. Megalos, M.A., Vuola, A.J., Adams, D.C., Monroe, M.C. 2014. Cooperative Extension and Climate change: Successful Program Delivery. *Journal of Extension* 52 (2). <http://www.joe.org/joe/2014april/comm3.php>
- Morris, H.L.C. Megalos, M.A., Boby, L.A. and Hubbard, W.G. *In Revision*. Climate Change Attitudes of Southern Forestry Professionals: Outreach Implications. *Journal of Forestry*.

Theses/ Dissertations

Aim 1 (Silviculture/ Ecophysiology) Theses/Dissertations

Bartkowiak, S.M. 2015. Fertilization effects on water use of 8-year-old loblolly pine (*Pinus taeda* L.) vary with throughfall treatment. M.S. Thesis, Auburn University, Auburn, AL.

Aim 4 (Economics and Policy) Theses/Dissertations

Kreye, M. 2014. Public Preferences and Willingness to Pay for Forest Conservation Programs that Protect Water Quality. Doctor of Philosophy Dissertation. University of Florida. 212 p.

Aim 5 (Education) Theses/Dissertations

Kunkle, K.A. (2015). *Cultural Cognition and Climate Change Education: Why Consensus is Not Enough*. Gainesville, FL: University of Florida, School of Forest Resources and Conservation.

Aim 6 (Extension) Theses/Dissertations

Morris, Hilary Lynn Cole. 2013 Climate Change Attitudes of Southeast Forestry Professionals: Implications for Outreach. Master of Science Thesis, NC State University, <http://www.lib.ncsu.edu/resolver/1840.16/9225>

Audio/ video products

Aim 6 (Extension) Audio/video products

Density Management: How to make decisions about planting density and thinning given uncertain future markets. Presented by Jeremy Stovall at the 2014 Western Gulf Silvicultural Technology Exchange (<http://wgste.org>) in Shreveport, LA. Stovall is Assistant Professor of Silviculture, Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University. <https://youtu.be/i43cOKuj6U8>

Bringing it Together: How to think about the timing and application. Presented by Jason Vogel at the 2014 Western Gulf Silvicultural Technology Exchange (<http://wgste.org>) in Shreveport, LA. Vogel is Assistant Professor of Ecosystem Science, Department of Ecosystem Science and Management, Texas A&M University

Unmanned Aerial Vehicles (UAVs) for Forest Applications. Presented by Wesley Palmer at the 2014 Western Gulf Silvicultural Technology Exchange (<http://wgste.org>) in Shreveport, LA. Palmer is Spatial Data Lab Supervisor, GIS/GPS Instructor, GIS Program Coordinator, School of Forestry, Louisiana Tech University. <https://youtu.be/LKcZ6xOZwqA>

On the Horizon: the South East Research Climate Hub. Presented by Steven McNulty at the 2014 Western Gulf Silvicultural Technology Exchange (<http://wgste.org>) in Shreveport, LA. McNulty is Director, USDA South East Regional Climate Hub (SERCH), Raleigh, NC. <https://youtu.be/f-gbbqh6Jx8>

Stand Establishment Strategies. Dr. Michael Blazier - Associate Professor and Forestry Research Project Leader at Louisiana State University. <https://youtu.be/kPAUWhqwTo0>

Tree Physiological Responses to Extreme Stress. Presented by Dr. Michael Tyree - Assistant Professor and Homer T. Rogers professorship of Eco-physiology at Louisiana Tech University. https://youtu.be/1Kf4qAfY_0g

Nutrient Cycling and Nutrient Deficiencies in Production Forests. Presented by Dr. Jeremy Stovall - Assistant Professor of Silviculture at Stephen F. Austin State University. <https://youtu.be/baOi3i5ZUNk>

Climate Resources Hal Needham - Department of Geography and Anthropology at Louisiana State University. Web-based climate tools and resources helpful to natural resource managers. <https://youtu.be/Y6BQ1sRicfo>

Hurricanes in a Changing Climate. Presented by Dr. Barry Keim - Louisiana State Climatologist and LSU Professor of Geography and Anthropology. <https://youtu.be/y0HfkQJEDnY>

Climate Prediction Made Difficult. Presented by Dr. John Nielsen-Gammon - Texas State Climatologist & Regents Professor of Atmospheric Sciences at Texas A&M University. <https://youtu.be/l43d4zrNB1w>

Unmanned Aerial Vehicles (UAVs) for Forest Applications. Presented by Wesley Palmer at the 2014 Western Gulf Silvicultural Technology Exchange (<http://wgste.org>) in Shreveport, LA. Palmer is Spatial Data Lab Supervisor, GIS/GPS Instructor, GIS Program Coordinator, School of Forestry, Louisiana Tech University. <https://youtu.be/LKcZ6xOZwqA>

Other publications

Aim 1 (Silviculture and Physiology) Other publications:

Maggard, A., Bobby, L., Megalos, M. 2014. *Southern Pine Plantations Store Carbon: Insights for Forest Landowners*. SREF Publication Series. SREF-FM-0019.

Noormets, A., 2015. Trade-off between forest productivity and carbon sequestration in soil. In *18th Biennial Southern Silviculture Research Conference*, Knoxville, TN.

Subedi P., Jokela E.J., Martin T.A., and Vogel J.G. 2015. Effects of fertilization and weed control on second rotation growth and soil nutrient availability in juvenile loblolly pine plantations in North Florida. pp 249-251. In Holley, A. G.; Connor, K. F.; Haywood, J. D., eds. 2015. *Proceedings of the 17th biennial southern silvicultural research conference*. e-Gen. Tech. Rep. SRS-203. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 551 p.

Aim 4 (Economics and Policy) Other publications

Grebner, D.L. and P. Khanal. 2014. Non-industrial private forest landowners' willingness to sequester forest carbon in the Southern United States. *In: Pine Integrated Network: Education, Mitigation, and Adaptation Project (Pinemap) Year 3 Annual Report*, March 2013-February 2014: 32-22.

Khanal, P. and D.L. Grebner. 2015. Nonindustrial private forest (NIPF) landowner attitudes toward climate change and forest carbon sequestration in the Southern United States. *In: Book of Extended Abstracts, International Scientific Conference: Forestry a bridge to the future and 90 years of higher forestry education in Bulgaria*. Sofia, Bulgaria, May 6-9, 2015.

Khanal, P. and D.L. Grebner. 2015. What characteristics affect non-industrial private forest (NIPF) landowner attitudes towards climate change and forest carbon sequestration in the United States South. *In: Book of Abstracts, International Union of Forestry Research Organizations (IUFRO) Symposium Cross-sectoral policy impacts on managerial economics and accounting in forestry*, Joint Units 4.05.00 and 9.05.03. Sarajevo, Bosnia-Herzegovina, May 4-6, 2015.

Khanal, P. N., T.J. Dean, S.D. Roberts, and D.L. Grebner. 2015. Evaluating First-Year Pine Seedling Survival Plateau in Louisiana. *In: Proceedings, 18th Biennial Southern Silvicultural Research Conference*, Knoxville, Tennessee March 2-5, 2015.

Khanal, P.N. and D.L. Grebner. 2014. Factors Affecting NIPF Willingness to Defer Final Harvest for Forest Carbon Sequestration in the Southern U.S. *In: Proceedings, 2008 International Society of Forest Resource Economics Annual Meeting*, St. Louis, Missouri, March 17-18, 2014.

Aim 5 (Education) Other publications

Monroe, M. C., & Oxarart, A. (Eds.). 2014. *Southeastern forests and climate change: A Project Learning Tree secondary environmental education module*. Gainesville, FL: University of Florida and American Forest Foundation.

Oxarart, A. and M. C. Monroe. 2015. A cognitive approach to environmental education. *Across the Spectrum: Resources for Environmental Educators*. Washington DC: North American Association for Environmental Education. Pages 93-106.

Kunkle, K. and M. C. Monroe. 2015. Addressing Misconceptions and Understanding the Psychological Mechanisms of Climate Change Communication. *Across the Spectrum: Resources for Environmental Educators*. Washington DC: North American Association for Environmental Education. Pages 147-167.

Li, J. & Monroe, M. C. 2014. *Measuring the effectiveness of educational materials on climate change and forests*. <http://www.pinemap.org/publications/research-summaries>

Aim 6 (Extension) Other publications

Fact sheets: published (cumulative)

To Plant or Not to Plant: New Timber Stand Drought Risk Assessment	Eric Taylor and Sean Burns
Drought and Southern Forests: The Importance of Forest Health and Resilience	Rachel Burnett, Heather Dinon, Ryan Boyles, Mark Megalos, Eric Taylor, and Sean Burns
Climate Communication Series V3: Obstacles to Delivering Climate Variability Programming to Traditional Audiences	Mark Megalos, Martha C. Monroe, and Claire Layman Bode
Climate Communication Series V2: Communicating through Climate Change Challenges	Claire Layman Bode, Martha C. Monroe, and Mark Megalos
Climate Communication Series V1: Challenges in Communicating Climate Change to Extension Audiences	Martha C. Monroe, Claire Layman Bode, Mark Megalos
Southern Pine Plantations and the Carbon they store: Important Information for the Forest Landowner	Adam Maggard and Leslie Boby
The Role of Woodlands in Climate Regulation	Eric Taylor and Sean Burns
The Role of Woodlands in the Bio-based Industry: Woody Biomass for Power and Products	Eric Taylor and Sean Burns
Climate Change Attitudes of Southeastern Foresters	Leslie Boby, William Hubbard, and Shafkat Khan
Drought and Southern Forests: The Importance of Forest Health and Resiliency	Heather Dinon, Rachel Burnett, Eric Taylor, Ryan Boyles, William Hubbard, Mark Megalos, Sean

	Burns, Leslie Boby
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Fact sheets: in development

<i>Assessing Forest Vulnerability</i>	Mark Megalos and Heather Dinon
<i>Climate Oscillations: Impacts to Forestry</i>	Heather Dinon and Ryan Boyles
<i>Ecophysiological Effects of Temperature and Moisture Stress on Trees in the Southern U.S.</i>	Evelyn Denzin, Tim Martin, Leslie Boby, Jeremy Stovall and Eric Taylor
<i>Fertilizer Application Guidelines for Southern Forests</i>	Evelyn Denzin, Tim Martin, Leslie Boby, Jeremy Stovall and Eric Taylor
<i>Frequently Asked Questions about Climate Projections</i>	Heather Dinon & Ryan Boyles
<i>Glossary of Climate Terms</i>	Mark Megalos, Heather Dinon and John Hastings
<i>Interpreting Uncertainty of Climate Model Projections</i>	Heather Dinon and Ryan Boyles
<i>Introduction to Weather and Climate</i>	Heather Dinon and Ryan Boyles
<i>Managing for Temperature and Moisture Stress in Forests in the Southern U.S.</i>	Evelyn Denzin, Tim Martin, Leslie Boby, Jeremy Stovall and Eric Taylor
<i>Minimizing Forest Insect / Disease Risk: A Practical Landowner Guide</i>	Mark Megalos
<i>Misconceptions about Global Warming and Climate Change</i>	Heather Dinon and Ryan Boyles
<i>Pine Seed Sources: what you need to know to select the best seeds for your site</i>	Katherine Sanders, Leslie Boby and Brhan Eskinder
<i>Thinning Recommendation Key</i>	Eric Taylor
<i>Nutrient Cycling in Forests under Variable Environmental Conditions</i>	Evelyn Denzin, Tim Martin, Leslie Boby, Jeremy Stovall and Eric Taylor
<i>Schmidling's Rule- A guide to the 5 degree rule</i>	Brhan Eskinder, Leslie Boby, Katherine Sanders
<i>Water Cycle in Forested Lands with Emphasis on Silvopasture Systems</i>	Shareika Williams and Gwendolyn Boyd
<i>What's Under the Umbrella that is Climate?</i>	Heather Dinon and Ryan Boyles
<i>Seedling Selection Tool Factsheet</i>	Eric Taylor

Events/ Activities: Presentations

Aim 1 (Silviculture/Ecophysiology) Presentations

Author(s)/Presenter(s)	Title	Type	Date	Venue/Location
Albaugh, T.J. and T.R. Fox	Improving our understanding of growth differences of <i>Pinus taeda</i> in the United States and Brazil: A common garden experiment	Oral Presentation	June 10, 2015	33rd Southern Forest Tree Improvement Conference Meeting, Hot Springs, AR
Albaugh, T.J. and T.R. Fox	Growth of <i>Pinus taeda</i> in the US and Brazil: Understanding growth and carrying capacity differences	Oral Presentation	May 12, 2015	Forest Productivity Cooperative US Pine Working Group Contact Meeting, Florence, SC
Albaugh, T.J., T.R. Fox, M. Sumnall, R.A. Rubilar, C.A. Alvares, J.L. Stape	Growth of <i>Pinus taeda</i> in the US and BR: Will crown ideotype help determine optimum varietal silviculture?	Oral Presentation	March 4, 2015	18th Biennial Southern Silvicultural Research Conference, Knoxville, TN
Akers, M., Will, R., Samuelson, L., Fox, R., Jokela, E., Gonzalez, C., and Zhai, D.	Early growth results from the PINEMAP loblolly pine throughfall manipulation x fertilization study.	Poster Presentation	March 4, 2015	18th Biennial Southern Silvicultural Research Conference, Knoxville, TN
Ausmus, C.J., A.O. Maggard, R.E. Will, D.S. Wilson, T.C. Hennessey, and C.R. Meek	Response of soil CO ₂ efflux in a mid-rotation loblolly pine (<i>Pinus taeda</i> L.) exposed to extreme drought conditions	Poster Presentation	May 14-16, 2014	PINEMAP Annual Meeting, Athens, GA
Bartkowiak SM, Samuelson LJ	Impacts of reduced precipitation and nutrient availability on loblolly pine	Oral Presentation	October 8-11, 2014	2014 SAF National Convention, Salt Lake City, UT
Bartkowiak SM, Samuelson LJ, Akers M, McGuire MA, Teskey RO	The Impact of Fertilization on Canopy-Level Processes of 9-Year-Old Loblolly Pine Varies With Throughfall Treatment	Poster Presentation	March 3-5, 2015	18th Biennial Southern Silvicultural Research Conference, Knoxville, TN
Bartkowiak SM, Samuelson LJ, McGuire MA, Teskey RO	The Effect of Throughfall Reduction and Fertilization on Water Use in Loblolly Pine Over Two-Years at the Georgia Tier III Installation	Poster Presentation	June 3, 2015	PINEMAP Annual Meeting, Athens, GA
Bruce B. Souza; Eric Ward, Lisa Samuelson, Stan Bartkowiak, Carlos Gonzalez Benecke, Robert O. Teskey	Estimating transpiration and growth efficiency in loblolly pine <i>Pinus taeda</i>) plantations using the 3-PG model	Poster Presentation	March 2-5, 2014	18th Biennial Silvicultural Research Conference
Bruce B. Souza; Eric Ward, Lisa Samuelson, Stan Bartkowiak, Carlos Gonzalez Benecke, Robert O. Teskey	Estimating transpiration and growth efficiency in loblolly pine (<i>Pinus taeda</i>) plantations using the 3-PG model	Poster Presentation	June 3, 2015	PINEMAP Annual Meeting, Athens, GA
Domec, J-C, Noormets, A, King, JS, McNulty, SG, Sun, G, Palmroth, S, Radecki, A, Ward, EJ, Oishi, AC, Johnson, D, and Bell, D.	Conversion of natural forests to managed forest plantations decreases tree resistance to prolonged droughts.	Poster Presentation	April 28, 2015	Dept. of Energy Terrestrial Ecosystem Science Meeting. Potomac, MD
Domec, J-C, Ward EJ, Oishi AC, Palmroth S, Radecki A, Bell DM, Miao G, Gavazzi M, Johnson DM, King JS, McNulty SG, Oren R, Sun G, Noormets A	Conversion of natural forests to managed forests and its effect on water balance, transpiration and resistance to drought across different scales	Oral presentation	March 4, 2015	18 th Biennial Southern Silvicultural Research Conference, Knoxville, TN

Events/Activities: *Presentations*

Laviner, A. and T.R. Fox	Litter Decomposition Following Fertilization and Throughfall Exclusion Treatments in Loblolly Pine	Poster Presentation	November 2-5, 2014	Soil Science Society of America Annual Meetings, Long Beach, CA
Laviner, A. and T.R. Fox	Six Month Litter Decomposition Following Fertilization and Throughfall Exclusion Treatments in Loblolly Pine	Poster Presentation	March 2-5, 2015	18 th Biennial Southern Silvicultural Research Conference, Knoxville, TN
Maggard, A.O., R.E. Will, C.R. Meek, C. Ausmus, and D.S. Wilson	Physiological mechanisms related to drought mortality of mid-rotation loblolly pine (<i>Pinus taeda</i> L.)	Poster Presentation	May 14-16, 2014	PINEMAP Annual Meeting, Athens, GA
Maggard, A.O., R.E. Will, C.R. Meek, C. Ausmus, and D.S. Wilson	Physiological mechanisms related to drought mortality of mid-rotation loblolly pine (<i>Pinus taeda</i> L.)	Poster Presentation	October 8-11, 2014	Society of American Foresters Annual Meeting, Salt Lake City, UT
Maggard, A.O. and R.E. Will	Tier III. Methods and findings for the PINEMAP Oklahoma Site	Oral Presentation	November 14, 2014	Southeastern Forest and Climate Change Workshop, Little Rock, AR
Markewitz, D.	Drought experiments in the Amazon and USA Southeast.	Presentation	June 4, 2014	Universidade Federal Rural de Amazonas and Embrapa Amazonia Oriental, Belem, Brazil.
McElligott, K.M., B.D. Strahm, and J.R. Seiler	Fertilization and Throughfall Reduction Effects on Soil CO ₂ Efflux and Litter Decomposition as Mediated by Extracellular Enzyme Activity	Poster Presentation	November 2-5, 2014	Soil Science Society of America Annual Meetings, Long Beach, CA
Meek, C.R., R.E. Will, D.S. Wilson, and J. Vogel	Fertilization decreases soil CO ₂ efflux of mid-rotation loblolly pine (<i>Pinus taeda</i> L.) stands in southeastern Oklahoma	Poster Presentation	October 8-11, 2014	Society of American Foresters Annual Meeting, Salt Lake City, UT
Noormets A, Epron D, Domec JC, McNulty SG, Fox TD, Sun G, King JS.	Trade-off between forest productivity and carbon sequestration in soil	Presentation	March 3-4, 2015	18 th Biennial Southern Silvicultural research Conference. Knoxville, TN
Noormets A, Epron D, Domec JC, McNulty SG, Fox TD, Sun G, King JS	Effects of forest management on productivity and carbon sequestration: a review	Presentation	Jan 26-30, 2015	NACP and AmeriFlux Joint Meeting. Washington D.C
Pell, C.J. and L.J. Samuelson	Long-term Effects of Throughfall Reduction and Fertilization on Leaf Physiology of Loblolly Pine	Poster Presentation	October 8-11, 2014	2014 SAF National Convention, Salt Lake City, UT
Pell, C.J., L.J. Samuelson, M.K. Akers, M. Kane, M. McGuire, R.O. Teskey	Effects of Fertilization and Three Years of Throughfall Reduction on Leaf Physiology of Loblolly Pine	Oral Presentation	March 3-4, 2015	18 th Biennial Southern Silvicultural research Conference. Knoxville, TN
Pell, C.J., L.J. Samuelson, M.K. Akers	Preliminary Three Year Analysis of Throughfall Reduction and Fertilization on Leaf Physiology of Loblolly Pine in Georgia	Poster Presentation	June 3, 2015	PINEMAP annual meeting, Athens GA
Qi, J. and D. Markewitz.	Drier Summers: Effects on Deep Soil Carbon	Poster Presentation	October 8-11, 2014	2014 SAF National Convention, IUFRO World Congress, Salt Lake City, UT
Qi, J., Markewitz, D., and Radcliffe, D	Modeling the effect of throughfall reduction on soil water content in a loblolly pine plantation of the southeast US	Poster Presentation	Feb 23-24, 2015	SSSGA annual meeting, Guyton, GA
Qi, J., Markewitz, D., and Radcliffe, D	Modeling the effect of throughfall reduction on soil water content in a loblolly pine plantation of the southeast US	Poster Presentation	June 3, 2015	PINEMAP annual meeting, Athens GA
Vogel, J.G.	Bringing it together: how to think about the timing and application of technologies to optimize pine productivity	Presentation	Dec 12, 2014	Western Gulf Silvicultural Technology Exchange, Louisiana Technological University, Shreveport, LA.
Vogel, J.G.	Carbon and Nitrogen Pool Estimates from the Tier II Network	Presentation	June 3, 2015	PINEMAP annual meeting, Athens GA
Vogel, J.G.	'Getting there from here': Better forest growth predictions using PINEMAP data and modeling"	Presentation	May 19, 2015	Western Gulf Tree Improvement Program, College Station, TX.
Vogel, J.G., Markewitz D., Amateis R., Laviner M.,	The Carbon Measurement Protocol of the Pine Integrated Network: Education, Mitigation, and Adaptation Project	Poster presentation	October 10, 2014	2014 SAF National Convention, IUFRO World Congress, Salt Lake City, UT

Events/Activities: *Presentations*

Jokela E.J., Grunwald S., Sun G., Noormets A., Akers M., Strahm B., Bacon A., Fox T., Gonzalez-Benecke C., Kane M., West J., Meek C., Will R., Wilson D., Samuelson L.				
Ward, E.J. JC Domec, MA Laviner, TR Fox, S McNulty, G Sun, JS King, DM Bell, and A Noormets	Imagining future forests: what models can learn from field data	Poster Presentation	Dec 18 2015	American Geophysical Union Fall Meeting, San Francisco, CA
Ward, E.J. JC Domec, MA Laviner, TR Fox, S McNulty, G Sun, JS King, A Noormets	Transpiration and Canopy Conductance of Loblolly Pine with Fertilization and Throughfall Exclusion: Early Results from PINEMAP.	Oral presentation	March 4, 2015	18th Biennial Silvicultural Research Conference, Knoxville, TN
Will, R.E., Meek, C., Maggard, A.	Field tour of Oklahoma PINEMAP Tier III site	Field Tour	January 27, 2015	Four state SAF meeting, Texarkana, TX
Yang, J., C.M. Luedtke, M.K. Akers, M. McGuire, Doug P. Aubrey and R.O. Teskey	Soil CO ₂ efflux and its components responded differently to throughfall exclusion and fertilization in a loblolly pine (<i>Pinus taeda</i>) plantation	Poster Presentation	Dec 15-19, 2014	American Geophysical Union Meeting, San Francisco, CA
Yang, J., C.M. Luedtke, M.K. Akers, M. McGuire, L. Samuelson, C. Pell, D.P. Aubrey, M. Kane and R.O. Teskey	Fertilization decreases soil CO ₂ efflux and total belowground carbon flux in a loblolly pine plantation	Oral Presentation	March 3-4, 2015	18 th Biennial Southern Silvicultural Research Conference. Knoxville, TN
Yang Jinyan, C M. Luedtke, K. M. Akers, Mary Anne McGuire, C. Pell, D. P. Aubrey, M. Kane, Robert O. Teskey	Fertilization decreases soil CO ₂ efflux and total belowground carbon flux in a loblolly pine (<i>Pinus taeda</i>) plantation	Poster Presentation	June 3, 2015	PINEMAP annual meeting, Athens GA
Zhao, D., M. Kane, R. Teskey, T.R. Fox, T.J. Albaugh, H.L. Allen, J. Stape, R. Rubilar	Why should we develop site-specific silvicultural management for loblolly pine plantations?	Oral presentation	March 4, 2015	18th Biennial Silvicultural Research Conference

Aim 2 (Modeling) presentations

Author(s)/Presenter(s)	Title	Type	Date	Venue/Location
Souza, B and R.O. Teskey	Estimating transpiration in loblolly pine (<i>Pinus taeda</i>) plantations using the 3-PG model	Presentation	March 3-4, 2015	18 th Biennial southern Silvicultural research Conference, Knoxville, TN
Souza, B, R. Teskey, C Gonzalez, L. Samuelson, E. Ward, S. Bartkowiak, and E. Jokela	Estimating transpiration and growth efficiency in loblolly pine plantations using the 3-PG model	Poster Presentation	June 3, 2015	PINEMAP annual meeting, Athens GA
Ross, C. W., S. Grunwald, S.J. del Grosso, W. Cropper, S. Gerber, L. Kobizar	Daycent calibration at the PINEMPA tier III monitoring network	Poster Presentation	June 3, 2015	PINEMAP annual meeting, Athens GA
Sun, G., S. Sun, P. Caldwell, S. McNulty, Y. Zhang	Modeling the impacts of historic climate change and extreme droughts on water yield and	Poster Presentation	June 3, 2015	PINEMAP annual meeting, Athens GA

Events/Activities: *Presentations*

	productivity of the national forest system			
Gopalikrishnan, R., V. Thomas, and R. Wynne	Producing and understory cover map over a large region using hereogeneous lidar datasets	Poster Presentation	June 3, 2015	PINEMAP annual meeting, Athens GA
Domec, J-C, J King, E Ward, AC Oishi, S Palmroth, A Radecki, D Bell, G Miao, M Gavazzi, D Johnson, S McNulty, G Sun, A Noormets	Conversion of natural forests to managed plantations decreases tree resistance to prolonged droughts	Poster Presentation	June 3, 2015	PINEMAP annual meeting, Athens GA

Aim 3 (Genetics) presentations

Author(s)/Presenter(s)	Title	Type	Date	Venue/Location
Casola, C.	Genomics research at Texas A&M	Presentation	May 19-20, 2015	WGFTIP Contact Representatives meeting, College Station, TX
Farjat, A., B. Reich, F. Isik, R. W. Whetten, S. E. McKeand	Bayesian spatial modeling for loblolly pine seed source movements	Poster Presentation	June 3 – 4, 2015	PINEMAP Annual Meeting (presented by Ross Whetten)
Festa, A. R. and R. W. Whetten	An alternative approach to selection within families	Poster presentation	June 3 – 4 and June 9 – 10, 2015	PINEMAP Annual Meeting, Athens GA, and Southern Forest Tree Improvement Conference, Hot Springs AR
Gonzalez-Ibeas D., Martinez-Garcia P.J., Famula R., Loopstra C., Puryear J., Neale D., Wegrzyn J.	Survey of the sugar pine (<i>Pinus lambertiana</i>) transcriptome by deep sequencing.	Poster Presentation	January 2015	Plant and Animal Genome, San Diego, CA
Holliday JA, Suren H	Association mapping of climate-related traits in spruce and pine	Presentation (meeting)	June 9, 2014	Forest Genomics Symposium, Vancouver, BC, Canada
Koralewski, T.E., T.D. Byram, H.-H. Wang and W.E. Grant	Deployment and procurement of loblolly pine (<i>Pinus taeda</i> L.) seed sources guided by the application of categorical universal response function (CURF)	Presentation (Meeting and extended abstract)	June 9-10, 2015	Southern Forest Tree Improvement Conference, Hot Springs, AR
Koralewski, TE, M Mateos, and KV Krutovsky	Phylogeny of major southern pines (subsection Australes, genus <i>Pinus</i> , family Pinaceae)	Poster Presentation	June 9-10, 2015	Southern Forest Tree Improvement Conference, Hot Springs, AR
Koralewski, T.E., T.D. Byram, H.-H. Wang and W.E. Grant	Supporting loblolly pine deployment and procurement decisions: A modeling approach	Poster Presentation	June 3-4, 2015	PINEMAP Annual Meeting Athens, GA
Koralewski, T.E.	Where from and where to: Using climate models to guide deployment	Presentation (Meeting)	May 19-20, 2015	WGFTIP Contact Representatives Meeting College Station, TX
Krutovsky, K., V. Chhatre, M. Lu, T. Byram, J. Wegrzyn, D. Neale, C. Loopstra	Population and landscape genomics to study local adaptation in loblolly pine (<i>Pinus taeda</i>) populations and to breed more climate change resilient trees.	Oral Presentation	October 5–11, 2014	XXIV IUFRO World Congress, Salt Lake City, USA
Krutovsky, K. V.	Genome study of Siberian stone pine (<i>Pinus sibirica</i>) and Siberian larch (<i>Larix sibirica</i>).	Oral Presentation	June 26-28, 2014	Third meeting of the Alpine Forest Genomics Network (AForGeN), Fafleralp, Lötschental (Canton of Valais), Switzerland
Krutovsky, K. V., V. E. Chhatre, M. Lu, T. D. Byram, J. L. Wegrzyn, D. B. Neale, C. Loopstra	High-Throughput Genome-Wide Genotyping, Targeted Sequencing and Association Mapping of Adaptive and Breeding Traits in Loblolly Pine (<i>Pinus taeda</i> L.) Populations.	Oral Presentation	January 11-15, 2014	Plant & Animal Genome XXII. The International Conference on the Status of Plant and Animal Genome Research, San Diego, CA
Krutovsky, K., V. Chhatre, M. Lu, T. Byram, J. Wegrzyn, D. Neale, C. Loopstra	Population and landscape genomics to study local adaptation in loblolly pine (<i>Pinus taeda</i>) populations and to breed more climate change resilient trees.	Oral Presentation	October 5–11, 2014	XXIV IUFRO World Congress, Salt Lake City, USA

Events/Activities: *Presentations*

Author(s)/Presenter(s)	Title	Type	Date	Venue/Location
Krutovsky, K. V., N. V. Oreshkova, Yu. A. Putintseva, D. A. Kuzmin, V. V. Sharov, V. V. Biryukov, S. V. Makolov, K. O. Deych, E. I. Bondar, O. A. Ushakova, and E. A. Shilkina	De novo sequencing of conifer megagenomes.	Oral Presentation	June 17–21, 2015	The 3rd International Conference “Plant Genetics, Genomics, Bioinformatics and Biotechnology”, Novosibirsk, Russia
Loopstra, C.	What can you do with a million molecular markers?	Presentation	Loopstra, C.	What can you do with a million molecular markers?
Lu M, Krutovsky K, Nelson CD, Koralewski T, Byram T, Loopstra C.	Genome Wide Association Study and Exome Capture in <i>Pinus taeda</i> L.	Poster Presentation	December 4, 2014	Texas A&M University, MEPS/Horticulture Fall Poster Symposium
Lu, M., K. Krutovsky, C.D. Nelson, T. Koralewski, T. Byram, C. Loopstra	Exome capture in a population of <i>Pinus taeda</i> L.	Poster Presentation	June 3-4, 2015	PINEMAP Annual Meeting, Athens, GA
Nelson CD, Abbott AG	Alternative approaches to tree breeding for no-analog physical and fiscal environments	Presentation	August 25 – 29, 2014	IUFRO Forest Tree Breeding Conference, Prague, Czech Republic
Paul R., Kuruganti S., Stevens K., Gonzalez-Ibeas D., Martinez-Garcia P.J., Liechty J., Vasquez-Gross H., Grau E., Loopstra C., Zimin A., Holtz-Morris A., Koriabine M., Yorke J.A., Crepeau M.,	Genome annotation and repeat sequence characterization in sugar pine (<i>Pinus lambertiana</i>)	Poster Presentation	January 10 – 15, 2015	Plant and Animal Genome, San Diego, CA
Wegrzyn J., Stevens K., Paul R., Gonzalez-Ibeas D., Martinez-Garcia P.J., Liechty J., Vasquez-Gross H., Kuruganti S., Grau E., Loopstra C., Zimin A., Yorke J.A., Crepeau M., Puiu D., Holt C., Yandell M., Salzberg S., deJong P.J., Mockaitis K., Main D., Langley C.H., Neale D.	Sugar pine annotation	Oral Presentation	January 10 – 15, 2015	Plant and Animal Genome, San Diego, CA
Westbrook JW, Chhatre VE, Wu LS, Chamala S, Neves LG, Muñoz P, Martínez-García PJ, Neale DB, Kirst M, Mockaitis K, Nelson CD, Peter GF, Davis JM, Echt CS	An annotated consensus genetic map for <i>Pinus taeda</i> L. and extent of linkage disequilibrium in three genotype-phenotype discovery populations	Poster Presentation	June 3-4, 2015 presented by Echt; and June 8-9, 2015 presented by Nelson	PINEMAP Annual Meeting, Athens, GA; and Southern Forest Tree Improvement Conference, Hot Springs, AR
Whetten, R.W, Lu, M., Krutovsky, K., Palle, S.R., Seeve, C.M., Loopstra, C.A.	Predictive Accuracy of Models Based on Multiple Genomic Attributes in Loblolly Pine (<i>Pinus taeda</i> L.)	Poster Presentation.	January 10 – 15, 2015	Plant and Animal Genome, San Diego, CA

Events/Activities: *Presentations*

Aim 4 (Economics and Policy) presentations

Author(s)/Presenter(s)	Title	Type	Date	Venue/Location
Adams, D.C., A. Susaeta, and D.R. Carter	Economics of Forest Management with Climate Change Risks.	Presentation	April 21, 2015	Growing Pines in Changing Times, Tifton, GA
An, H., J. Gan, and S.J. Cho	Assessing climate change impacts on wildfire risk in the United States	Poster Presentation	June 3-4, 2015	PINEMAP Annual Meeting, Athens, GA
Gan, J., H. An, K. Clifton	Climate change impact on southern pine beetle infestations	Presentation (Conference)	October 11, 2014	2014 SAF Convention, Salt Lake City, UT
Grebner, D.L.	Research update	Presentation (Conference)	November 12, 2014	MSU Department of Forestry Annual Advisory Committee Meeting, Mississippi State University
Grebner, D.L., Henderson, J.E., Grala, R.K., and D.G.Hodges	The role of bioenergy as an ecosystem service.	Presentation (Conference)	October 5-11, 2014.	IUFRO World Forestry Congress, Salt Lake City, Utah
Henderson, J., J. Gordon, S. Dicke, G. Hughes, J. Kushla, B. Self, C. Siegert, D. Grebner, and P. Khanal.	Climate change related extreme weather events and risk management options for family forests.	Presentation	October 8-11, 2014	Society of American Foresters National Convention, Salt Lake City, Utah
Khanal, P. and D.L. Grebner	Factors Affecting Non-industrial Private Forest Landowner Decision to Manage Forest for Carbon Sequestration.	Presentation (Conference)	June 13-18, 2015	21 st International Symposium on Society and Resource Management, Charleston, South Carolina
Khanal, P. and D.L. Grebner	Nonindustrial private forest (NIPF) landowner attitudes toward climate change and forest carbon sequestration in the Southern United States.	Presentation (Conference)	May 6-9, 2015	International Scientific Conference: Forestry a bridge to the future and 90 years of higher forestry education in Bulgaria. Sofia, Bulgaria
Khanal, P. and D.L. Grebner	What characteristics affect non-industrial private forest (NIPF) landowner attitudes towards climate change and forest carbon sequestration in the United States South?	Presentation (Conference)	May 4-6, 2015	International Union of Forestry Research Organizations (IUFRO) Symposium Cross-sectoral policy impacts on managerial economics and accounting in forestry, Joint Units 4.05.00 and 9.05.03. Sarajevo, Bosnia-Herzegovina
Khanal, P. and D.L. Grebner.	Characterizing nonindustrial private forest landowner attitudes toward climate change and carbon sequestration in the Southern US	Presentation (Conference)	November 14, 2014	PINEMAP Webinar
Khanal, P.N. and D.L. Grebner.	NIPF willingness to sequester forest carbon in the southern United States	Presentation (Conference)	October 8-11, 2014	Society of American Foresters National Convention, Salt Lake City, Utah
Khanal, P. and D.L. Grebner.	Characterizing NIPF attitudes toward climate change and carbon sequestration in the southern United States	Presentation (Conference)	October 5-11, 2014	IUFRO World Forestry Congress, Salt Lake City, Utah
Khanal, P.N., Abdollahi, K., Legiandyeni, T., and D.L. Grebner.	Identifying urban forest status and obstacles to earn offset credits under California carbon trading in Baton Rouge, Louisiana.	Poster Presentation	October 8-11, 2014	Society of American Foresters National Convention, Salt Lake City, Utah,
Khanal, P.N. and D.L. Grebner.	Identifying nonindustrial private forest landowners obstacles to manage forests for carbon sequestration in the Southern U.S.	Poster Presentation	October 8-11, 2014	Society of American Foresters National Convention, Salt Lake City, Utah,
Susaeta, A., Carter, D.C., Adams, D.	Sustainability of slash pine forest stands in the southern United States with climate change	Presentation (Conference)	October 10, 2014	IUFRO World Congress

Events/Activities: *Presentations*
Aim 5 (Education) presentations

Author(s)/Presenter(s)	Title	Type	Date	Venue/Location
Bass, A.	Potato Head: DNA the Traits They Code For	Presentations (2) (Education)	Dec. 12, 2014	Trask Middle School, Wilmington, NC
Cheek, M.	Forests, the Land, and You	Presentations (2) (Education)	Dec. 10, 2014	Fuquay-Varina Middle School, Fuquay Marina, NC
Cheek, M.	Forests, the Land, and You	Presentations (2) (Education)	Dec. 17, 2014	Garner Magnet High School, Garner, NC
Cheek, M.	Forests, the Land, and You	Presentation (Education)	Dec. 11, 2014	Centennial Campus Magnet Middle School, Raleigh, NC
Cheek, M.	The Real Cost	Presentations (2) (Education)	Dec. 17, 2014	Garner Magnet High School, Garner, NC
Cheek, M.	Forests, the Land, and You	Presentation (Education)	Dec. 18, 2014	Neighborhood Ecology Corps, Raleigh, NC
Cheek, M.	The Real Cost	Presentation (Education)	Dec. 18, 2014	Neighborhood Ecology Corps, Raleigh, NC
Cheek, M.	Tree Introduction	Presentation (Education)	Dec. 18, 2014	Neighborhood Ecology Corps, Raleigh, NC
Donner, I.	If a Tree Grows, Will 'Yew' Know?	Presentations (3) (Education)	Nov.5, 2014	Twin Springs High School, Twin Springs, VA
Donner, I.	If a Tree Grows, Will 'Yew' Know?	Presentations (7) (Education)	Nov., 2014	Blacksburg Middle School, Blacksburg, VA
Forrester, Bryce and Lori Haynes	Introduction to Southeastern Forests and Climate Change	Presentation	March 21, 2015	League of Environmental Educators in Florida 2015 Conference, Venus, Florida
Hamill, A.	Photosynthesis: The Breath of Life	Presentations (4) (Education)	Nov 5, Dec. 8, 2014	Blacksburg High School, Blacksburg, VA
Hamill, A.	Photosynthesis: The Breath of Life	Presentation (Education)	Nov.3, 2014	Auburn High School, Riner, VA
Hamill, A.	Photosynthesis: The Breath of Life	Presentations (3) (Education)	Dec. 15, 2014	Pulaski Middle School, Pulaski, VA
Hardison, H.	Forest Growth and Climate	Presentation (Education)	Nov.12, 2014	Owasso 7th Grade Learning Center, Owasso, OK
Hardison, H.	A Comparison of Soil CO2 Efflux of Mid-rotation Loblolly Pine (<i>Pinus taeda</i> L.) and the Partitioning of Heterotrophic and Autotrophic Respiration	Presentation (Scientific)	Sept. 27, 2014	Oklahoma Louis Stokes Alliance for Minority Participation (OK-LSAMP) 20th Annual Research Symposium, Stillwater, OK
Hardison, H.	A Comparison of Soil CO2 Efflux of Mid-rotation Loblolly Pine (<i>Pinus taeda</i> L.) and the Partitioning of Heterotrophic and Autotrophic Respiration	Presentation (Scientific)	Oct. 16-18, 2014	Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) 2014 National Conference, Los Angeles, CA
Kidd, J. and J. Seiler	Attitudes Toward Research After Participation in an Undergraduate Research Internship	Poster Presentation	Oct. 8-11, 2014	Society of American Foresters National Convention, Salt Lake City, UT
Kidd, J.	Forest Resources Education and Communication in the PINEMAP Undergraduate Fellowship Program	Presentation	Nov. 3, 2014	Department of Forest Resources and Environmental Conservation Seminar, Blacksburg, VA

Events/Activities: *Presentations*

Kunkle, K.A. and Monroe, M.C.	Applying a Motivated Reasoning Framework to Climate Change Education Development	Poster Presentation	September 19, 2014	3 rd Annual Southeastern EE (SEEA) Alliance Conference Research Symposium, Asheboro, NC
Kunkle, K. and M. Monroe	Evaluating Web Tools in Environmental Education and Extension	Poster Presentation	May 14-16, 2014	PINEMAP Annual Meeting, Athens, GA
Kunkle, K. and M. Monroe	Evaluating Websites and Web Tools in Extension Education	Poster Presentation	March 22, 2014	League of Environmental Educators in Florida (LEEF) Conference, Altoona, FL
Kunkle, K. and M. Monroe	Applying a Motivated Reasoning Framework to Climate Change Education	Poster Presentation	April 4, 2014	SFRC Graduate Student Symposium, University of Florida, Gainesville, FL
Kunkle, K. and M. Monroe	Integrating Motivated Reasoning into Climate Change Education	Poster Presentation	October 8, 2014	North American Association for Environmental Education Research Symposium Ottawa, Canada
Kunkle, K. and M. Monroe	Cultural Cognition and Climate Change Education: Why Consensus is Not Enough	Oral Presentation	April 10, 2015	SFRC Graduate Student Symposium University of Florida Gainesville, FL
Kunkle, K. and M. Monroe	Cultural Cognition and Climate Change Education: Why Consensus is Not Enough	Poster	June 3-4 2015	PINEMAP Annual Meeting Athens, GA
Laguer, D. M.	The Effects of Drought and the Need to Educate About Conservation Agriculture	Presentations (10) (Education)	Nov.17-Dec 11, 2014	Juana Rosario, Aguada, PR
Li, J. and M. Monroe	Uncovering Teens' Misconceptions About Climate Change	Poster Presentation	March 22, 2014	League of Environmental Educators in Florida (LEEF) Conference, Altoona, FL
Li, J. and M. Monroe	Climate Change in the Classroom	Presentation	March 22, 2014	League of Environmental Educators in Florida (LEEF) Conference, Altoona, FL
Li, J. and M. Monroe	Uncovering Teens' Misconceptions About Climate Change	Poster Presentation	March 28, 2014	9 th Annual Conference of the Social Sciences, Gainesville, FL
Li, J. and M. Monroe	Uncovering Teens' Misconceptions About Climate Change	Poster Presentation	April 4, 2014	Graduate Student Symposium, University of Florida, Gainesville, FL
Li, J. and M. Monroe	Uncovering Teens' Misconceptions About Climate Change	Roundtable Presentation	October 11, 2014	North American Association for Environmental Education Ottawa, Canada
Li, J. and M. Monroe	Effective Climate Change Education: Making Hope Happen	Presentation	October 8, 2014	North American Association for Environmental Education Research Symposium Ottawa, Canada
Li, J. and Monroe, M.	Effective Climate Change Education: Making Hope Happen	Poster Presentation	September 19, 2014	3 rd Annual Southeastern EE (SEEA) Alliance Conference Research Symposium, Asheboro, NC
Li, J. and M. Monroe	Exploring Characteristics of Educative Curriculum	Poster Presentation	October 8, 2014	North American Association for Environmental Education Research Symposium, Ottawa, Canada
Li, J. and M. Monroe	Understanding, Measuring and Cultivating Hope about Climate Change	Oral Presentation	April 10, 2015	SFRC Graduate Student Symposium University of Florida, Gainesville, FL
Li, J. and M. Monroe	Understanding, Measuring and Cultivating Hope about Climate Change among High School Students	Poster	June 3-4, 2015	PINEMAP Annual Meeting Athens, GA
Mitchell, S.	Forest Management and Water Quality	Presentation (Education)	Nov.11, 2014	Timber Academy High School, College Station, TX
Mitchell, S.	Forest Management and Water Quality	Presentations (2) (Education)	Dec. 2, 2014	Carl Wunsch High School, Spring, TX

Events/Activities: *Presentations*

Mitchell, S.	Forest Management and Water Quality	Presentations (5) (Education)	Nov.14, 2014	Bryan High School, Bryan, TX
Mitchell, S.	Forest Management and Water Quality	Presentation (Education)	Nov.21, 2014	Klein Collins High School, Spring, TX
Monroe, M, A. Oxarart, J. Li, T. Ritchie, K. Kunkle, and S. Krantz	Southeastern Forests and Climate Change	Presentation	March 22, 2014	League of Environmental Educators in Florida (LEEF) Conference, Altoona, FL
Monroe, M. C. and J, Li	Climate Change in the Classroom	Presentation	September 20, 2014	3 rd Annual Southeastern EE (SEEA) Alliance Conference, Asheboro, NC
Monroe, M	Regional Climate Module from PINEMAP and PLT	Presentation	Feb 25, 2015	Southern Region Extension Forestry Meeting, Athens GA
Monroe, M. Ardoin, N	Measuring Our Impact: Environmental and Sustainable Literacy	Presentation	Feb 6, 2015	Green Building Coalition Meeting to establish goals to measure impact, Washington DC
Monroe, M and Stallard, J	How PLT Supports STEM Instruction and Systems Thinking	Presentation	June 11, 2015	Project Learning Tree Annual Conference, Saratoga Springs NY
Monroe, M., Oxarart, A., Ritchie, T., Li, J., Kunkle, K.	Using Climate Change Curriculum to Improve Systems Thinking and Hope	Poster	July 2, 2015	World Environmental Education Congress, Gothenberg Sweden
Monroe, M.	Framing Science-based Issues for Community Discussions	Presentation	July 15, 2015	Kettering Foundation, Dayton OH
Oxarart, Monroe, Ritchie, Li, Kunkle	Linking Educators and Students to Forests in a Changing Climate	Poster	June 3, 2015	PINEMAP Annual Meeting, Athens GA
Oxarart, A. and M. Monroe	Building Innovative Climate Curriculum: Highlights from a New PLT Secondary Module	Poster Presentation	October 10, 2014	North American Association for Environmental Education Ottawa, Canada
Reilly, N.	How Do Pine Trees Wear Their Jeans?	Presentations (2) (Education)	Nov.12, 2014	Pender Early College High School, Burgaw, NC
Reilly, N.	How Do Pine Trees Wear Their Jeans?	Presentation (Education)	Nov.13, 2014	Trask Middle School, Wilmington, NC
Reilly, N.	How Do Pine Trees Wear Their Jeans?	Presentation (Education)	Nov.18, 2014	E. A. Laney High School, Wilmington, NC
Reilly, N.	How Do Pine Trees Wear Their Jeans?	Presentations (2) (Education)	Nov.6, 2014	New Hanover High School, Wilmington, NC
Ritchie, T. and M. Monroe	Can Using Systems Thinking Improve Student Success with Climate Change Education?	Poster Presentation	April 4, 2014	Graduate Student Symposium, University of Florida, Gainesville, FL
Ritchie, T.R. and Monroe, M.C.	Assessing Students' Systems Thinking Skills	Poster Presentation	September 19, 2014	3 rd Annual Southeastern EE (SEEA) Alliance Conference Research Symposium, Asheboro, NC
Ritchie, T.	Using Systems Thinking to Improve Student Achievement in Environmental Education	Poster Presentation	March 22, 2014	League of Environmental Educators in Florida (LEEF) Conference, Altoona, FL
Ritchie, T. and M. Monroe	Systems Thinking in Environmental Education: The Big Picture	Poster Presentation	October 11, 2014	North American Association for Environmental Education Research Symposium Ottawa, Canada
Ritchie, T. and M. Monroe	Methods for Measuring Systems Thinking in High School Students	Poster	April 10, 2015	SFRC Graduate Student Symposium University of Florida Gainesville, FL
Ritchie, T. and M. Monroe	Methods for Measuring Systems Thinking Skills of High School Students	Poster	June 3-4, 2015	PINEMAP Annual Meeting Athens, GA

Events/Activities: *Presentations*

Seiler, J., J. Kidd, M. Monroe, and S. Sriharan	Reflections on the PINEMAP Undergraduate Fellowship Program	Presentation	October 11, 2014	Society of American Foresters National Convention, Salt Lake City, UT
Vial, S.	What Causes Trees to Grow?	Presentations (3) (Education)	Nov.14, 2014	Blacksburg Middle School, Blacksburg, VA
Vial, S.	What Causes Trees to Grow?	Presentations (3) (Education)	Nov.7, 2014	Pulaski Middle School, Pulaski, VA
White, A.	The Real Cost: Raw Environmental Expenses Challenge	Presentations (2) (Education)	Nov.22, 2014	VSU Kids Tech University, Petersburg, VA
White, A.	The Real Cost: Raw Environmental Expenses Challenge	Presentation (Education)	Nov.25, 2014	Swift Creek Middle School, Midlothian, VA
White, A.	The Real Cost: Raw Environmental Expenses Challenge	Presentations (2) (Education)	Dec. 8, 2014	Essex Intermediate School, Tappahannock, VA
White, A.	The Real Cost: Raw Environmental Expenses Challenge	Presentation (Education)	Dec. , 2014	Colonial Heights High School, Colonial Heights, VA

Aim 6 (Extension) presentations

Author(s)/Presenter(s)	Title	Type	Date	Venue/Location
Boby, L., Taylor, E., Hubbard, W. and Megalos, M.	Outreach Efforts: Educating Foresters and Influencing Change on the Ground	Poster Presentation	June 3, 2015	PINEMAP Annual Meeting 2015 Athens, GA
Boby, L.	Survey Results: Southern Foresters and Climate change	Presentation	May 28, 2015	Climate Learning Network Advisory Board meeting Tampa, FL
Boyles, R.	Climate Risks for Forests	Presentation	September 4, 2014	Piedmont SAF
Boyles, R.	Climate outreach and extension	Webinar	November 20, 2014	National Park Service Climate Ready Parks
Boyles, R.	Climate change in NC	Presentation	December 2, 2014	NC Ag/Forest Adaptation Workgroup
Boyles, R., Davis, C. and Dinon Aldridge, H.	Decision Support System	Presentation	June 3, 2015	PINEMAP Annual meeting 2015
Clifford, M., Monroe, M.	Understanding the Needs and Perceptions of Extension Agents for Climate-related Professional Development	Poster	June 3-4, 2015	PINEMAP Annual Meeting, Athens, GA
Davis, C.	Teaching the Basic Weather Processes unit of the S-290 (Intermediate Wildland Fire Behavior) training course	Presentation	September 15, 2014	S-290 Training for NC Forest Service
Davis, C.	Fire Weather Portal	Presentation	October 9, 2014	Triangle Climate and Landscaper Researchers Brown Bag
Davis, C., Dinon Aldridge, H.	Climate-Based Decision Support for Foresters	Web Presentation	January 28, 2015	Multi-state SAF meeting
Davis, C., Dinon Aldridge, H.	MACA updates	Webinar	January 23, 2015	PINEMAP ATP meeting
Dinon Aldridge, H., Boyles, R., Davis, C.	Decision Support System/MACA updates	Presentation	June 3, 2015	PINEMAP Annual meeting 2015
Dinon Aldridge, H., Boyles, R., Davis, C.	DSS “poster”/live demo	Poster Presentation	June 3, 2015	PINEMAP Annual meeting 2015
Dinon Aldridge, H.	PINEMAP DSS Updates	SCO Summer Seminar	May 28, 2015	NCSU

Events/Activities: *Presentations*

Dinon Aldridge, H., Davis, C., Boyles, R.	PINEMAP DSS & MACA updates	Webinar	December 5, 2014	PINEMAP ATP meeting
Greene, R.E. and Megalos, M.A.	Southern foresters' Observations of Climate Change: What, Where, and Implications for Continuing Education	Poster presentation	June 3, 2015	PINEMAP Annual Meeting, Athens, GA
Hastings, J., Megalos, M., Jetton, R., Potter, K. and Koch, F.	Using Climate and Genetic Diversity Data to Prioritize Conservation Seed Banking	Poster Presentation	June 3, 2015	PINEMAP Annual Meeting, Athens, GA
Hubbard, W., Bartels, W., Boby, L., Clifford, M., Dourte, D., Fraisse, C., Gambill, J. Knox, P., Monroe, M., Ortiz, B., Risse, M. and Megalos, M.	Southern Region Extension Climate Academy	Presentation	April 14, 2015	Public Issues Leadership Development Forum
Hubbard, W., Boby, L., Megalos, M. and Moore, S.	Land Grant Activities in Climate Science Education/Extension Arena	Presentation	May 28, 2015	Climate Learning Network Advisory Board meeting Tampa, FL
Megalos, M.A.	Climate Tools For Forestry	Presentation	9/5/2014	Inaugural SREC Academy
Megalos, M.A.	PINEMAP PLT Train the Trainer workshop	Presentation	9/19/2014	Regional teacher training for PINEMAP PLT MODULE
Megalos, M.A.	Considering Climate as an Additional Management Risk	Presentation	11/20/2014	NCSUTIP PINEMAP Workshop - Savannah
Megalos, M.A.	Ag/For Adaptation	Presentation	12/2/2014	NCAdapatation Team (25x25 Grant)
Megalos, M.A.	Southern Foresters Survey: Observations (climate& weather)	Presentation	12/11/2014	SALCC Roundtable
Megalos, M.A.	Southern Foresters Survey: Observations (climate& weather)	Presentation	Jan.22, 2015	APSAF Annual Meeting
Megalos, M.A.	Southern Foresters Survey: Observations (climate & weather)	Webinar	3/19/2015	National Forestry Webinar.net
Will, Rodney, Monroe, M.C. and others	Oklahoma Tier III Site field trip for the Four-State Society of American Foresters meeting	Field Trip	1/27/15	Oklahoma, Arkansas, Texas and Louisiana Society of American Foresters
Knox, P.	Recent Climate Trends in the Southeast and their Impact on Trees	Presentation	October 23, 2014	Georgia Urban Forest Council Annual Conference 2014
Taylor E.L.	Strategies for Forest Health and Resiliency	Presentation	March 18, 2014	Multi-County Extension Program
Taylor E.L.	Biological Optimum Thinning Schedules	Presentation	March 25, 2014	Intra-Agency Natural Resource
Taylor E.L.	Strategies for Forest Health and Resiliency	Presentation	April 12, 2014	Community meeting
Taylor E.L.	Strategies for Forest Health and Resiliency	Presentation	April 24, 2014	Multi-County Extension Program
Taylor E.L.	Strategies for Forest Health and Resiliency	Presentation	April 26, 2014	Tree Farm Tour
Taylor E.L.	Biological Optimum Thinning Schedules	Presentation	May 6, 2014	WGFTIP Meeting
Taylor E.L.	Strategies for Forest Health and Resiliency	Presentation	May 31, 2014	Intra-Agency Landowner Workshop
Taylor E.L.	Biological Optimum Thinning Schedules	Presentation	June 5, 2014	Texas SAF chapter meeting
Taylor E.L.	Biological Optimum Thinning Schedules	Presentation	August 14, 2014	Landowner Workshop
Taylor E.L.	Strategies for Forest Health and Resiliency	Presentation	August 14, 2014	Landowner Workshop
Taylor E.L.	Biological Optimum Thinning Schedules	Presentation	August 27, 2014	Professional Conference
Taylor E.L.	Biological Optimum Thinning Schedules	Presentation	September 4, 2014	SRECA
Taylor E.L.	Biological Optimum Thinning Schedules	Presentation	September 20, 2014	Multi-County Extension Program
Taylor E.L.	Biological Optimum Thinning Schedules	Presentation	September 27, 2014	Multi-County Extension Program
Taylor E.L.	Incorporating Climate and Resilience Concepts into Forest Management Outreach Programs	Presentation	October 11, 2014	National SAF

Events/Activities: *Presentations*

Taylor E.L.	Biological Optimum Thinning Schedules	Presentation	November 20, 2014	Texas SAF chapter meeting
Taylor E.L.	Biological Optimum Thinning Schedules	Presentation	November 21, 2014	In-service training
Taylor E.L.	Stand Establishment Strategies	Presentation	November 21, 2014	In-service training
Taylor E.L.	Stand Establishment Strategies	Presentation	February 3, 2015	County Program
Taylor E.L.	Strategies for Forest Health and Resiliency	Presentation	February 13, 2015	Multi-County Program

Trainings, workshops, and courses

Aim 3 (Genetics) Trainings, workshops, and courses

Krutovsky, K. V., 2014. Sequencing and conservation genomics. ProCoGen Dissemination Workshop “Genomics and the conservation of conifer genetic resources”, September 1-3, 2014, Kámoni Arboretum Szombathely, Hungary. (<http://www.procogen.eu>)

Krutovsky, K.V., 2014. Importance of genetic studies for understanding of structure, function and adaptation of the forest ecosystems and for Siberian boreal forest management. The Training Workshop for Young Scientists “Problems and prospects of the forest ecosystem studies”, September 15-19, 2014, Krasnoyarsk, Russia. (http://forest.akadem.ru/Konf/2014/IF/Program_school.pdf)

Aim 4 (Economics and policy) Trainings, workshops, and courses

Andres Susaeta attended the course *Economics of Forest Resource Management*, Faculty of Forest Sciences, Swedish University of Agricultural Sciences, March 9-20, 2015, Umea, Sweden.

Aim 5 (Education) Trainings, workshops, and courses

Authors	Title	Type	Date	Location
Monroe, M. C., A. Oxarart, J. Li, T. Ritchie, K. Kunkle	Teacher Training: Southeastern Forests and Climate Change	Workshop	June 25, 2014	Center for PreCollegiate Education and Teaching (CPET) at the University of Florida
Monroe, M. C., A. Oxarart, J. Li, T. Ritchie, K. Kunkle	Facilitator and Educator Training: Southeastern Forests and Climate Change	Workshop	September 19, 2014	Southeast Environmental Education Alliance Conference Asheville, NC
Monroe, M. C., A. Oxarart	Southeastern Forests and Climate Change	Workshop	November 13-15, 2014	C.A. Vines Arkansas 4-H Center Little Rock, AR
Monroe, M. C., A. Oxarart, J. Li, T. Ritchie, K. Burja	Southeastern Forests and Climate Change	Workshop	January 23-24, 2015	Jacksonville Zoo and Gardens Jacksonville, FL
Ritchie, T., K. Kunkle, M. Cheek, and A. White	Forests, Climate Change, and You!	Student Workshop	July 31, 2014	4-H University, Gainesville, FL
Seiler, J. and J. Kidd	Effective Communication Skills	Online Course	Fall 2014	Virginia Tech, Blacksburg, VA
Marcia Bisnett	Southeastern Forests and Climate Change	Educator Workshop	October 11, 2014	Miami, Florida
Maria McDaniel	Southeastern Forests and Climate Change	Educator Workshop	January 27, 2015	A Time for Science Grifton, North Carolina
Jan Forrest Kent, Lauren Johnson	Southeastern Forests and Climate Change	Educator Workshop	February 5, 2015	Oxbow Meadows Columbus, Georgia
Karen Hargrove, Bonnie Ervin, Cindi Smith-Walters, Dave Walters	Southeastern Forests and Climate Change	Educator Workshop	March 14, 2015	Nashville, Tennessee
Carla Rapp	Southeastern Forests and Climate Change	Educator Workshop	March 24, 2015	Georgia
Lori Nicholson	Southeastern Forests and Climate Change	Educator Workshop	April 11, 2015	St. Marks National Wildlife Refuge St. Marks, Florida
John Guyton, Harold Anderson	Southeastern Forests and Climate Change	Educator Workshop	April 16, 2015	Delta State University, Cleveland, Mississippi
Ellen Powell and Bill Worrell	Southeastern Forests and Climate Change	Educator Workshop	April 16, 2015	2015 VA Forestry Summit, Charlottesville, Virginia

Authors	Title	Type	Date	Location
Hannah Thompson-Welch	Southeastern Forests and Climate Change	Educator Workshop	May 11, 2015	Granville County Expo and Convention Center, Oxford, NC
Jennifer Hubbard-Sanchez and Laura Duffey	Southeastern Forests and Climate Change: PLT Secondary EE Module Overview and Adaptations for Other Regions	Educator Workshop	June 16, 2015	2015 Summer Institute for Climate Change Education, Apple Valley, MN
Bonnie Ervin	Educator Workshop	Educator Workshop	June 18, 2015	Teacher's Forest Conservation Workshop, Knoxville, TN

Aim 6 (Extension) Trainings, workshops, and courses

Growing Pines in Changing Times Workshop, April 21, 2015

This workshop was co-organized by Aim 6 personnel with other partners (the Georgia Forestry Commission, other extension foresters) and many PINEMAP researchers were brought in as speakers. Nearly 100 people attended this one-day workshop in Tifton, GA and evaluations were very favorable with 25-70% knowledge gain depending on the topic. Respondents indicated that they owned or managed over 2,000,000 acres of planted pine, of whom 93% indicated that they would make management changes based on what they had learned at the workshop.

Adaptive Silvicultural Training: State Forestry Agency Training (ongoing)

PINEMAP is driving efforts in adaptive silvicultural training for state agency foresters. The key goal is to inform foresters of the latest research and tools so they can transfer information to their clients (primarily small-scale family forest landowners) and positively impact forest health, resilience, and productivity. To date, the program has been tested with the Texas A&M Forest Service. Sixteen foresters participated in the initial training program and have already incorporated the new strategies into their forest management plans and used new decision-support tools to guide landowners. Plans are in place to conduct four trainings of this type across the region in 2014.

Joint Texas Forest Service, Texas Forestry Association and Landowner Council Annual meeting and Workshop, August 14, 2014

This workshop included a wide audience of professional foresters and landowners and covered the bases of managing for forestry in a changing climate.

Texas Forest Service Natural Resource Conference, August 27, 2014.

This one day workshop was geared towards a range of natural resource professionals, including foresters and other land managers and included components which addressed climate change and land management.

Advanced Pine Silvicultural Concepts, November 21, 2014

This Workshop was for foresters in Texas, Louisiana and Oklahoma to learn more about the latest developments in silviculture.

Four-State Society of American Foresters Meeting (Oklahoma, Louisiana, Texas and Arkansas), January 27-30, 2015

The 4-state region of Society of American foresters hosted this three day workshop for SAF members to learn more about the latest forestry concepts. Many PINEMAP researchers spoke at this workshop in addition to Eric Taylor, Aim 6 member.

Annual Forest Pesticide Conference Workshop, February 13, 2015

This workshop for professional foresters included components on increasing threats from diseases and insects from a changing climate.

Experiments, surveys, and data collection

Aim 1 (Silviculture & Ecophysiology) Experiments, surveys, and data collection

Experiment	Time Frame	Description
Tier I Legacy Experiments	Ongoing	The Tier I legacy network consists of hundreds of existing silviculture experiments and growth-and-yield plots that blanket the region and provide extensive, spatially explicit information on regional variability and productivity. Industry/university cooperative research installations to include in the Tier I legacy experiments have been identified and archived data from these sites has been uploaded into the TerraC database.
Tier II Active Experiments	Ongoing	The Tier II active experiments network consists of 127 sites distributed throughout the Southeast. These sites were selected to represent the range of climate, geology, and soil conditions in the Southeast and span a range of plantation ages (5 to more than 25 years) covering a progression of stand development. Principle treatments represented in the network include planting density, thinning, fertilization, and competition control. Sampling on all or a subset of locations in this network include biomass and carbon inventory; soil sampling; tree canopy light interception measurements; wood core sampling for 13C/18O analysis to determine water use efficiency; and assessments of soil carbon emissions, nitrous oxide emissions, and nitrogen uptake efficiency. Data collection from Tier II sites is ongoing.
Tier III Throughfall Exclusion x Fertilization Experiments	Ongoing	The Tier III throughfall exclusion x fertilization network is made up of four research sites situated at the edges of the native range of loblolly pine. The four sites, located in McCurtain County, Oklahoma; Taylor County, Florida; Taliaferro County, Georgia; and Buckingham County, Virginia, capture the current range-wide variability of climate, precipitation, and productivity (Figure 3). The research sites range in planting date from 2003 to 2008, are unthinned, and were planted with a mix of genetic sources appropriate for each region. Treatments at the four Tier III sites consist of a factorial experiment: <ul style="list-style-type: none"> • Control (no treatment) • Fertilizer: fertilizer additions to achieve “optimum” nutrition • Throughfall exclusion: panels installed in understory to divert 30% of throughfall off the plot • Fertilizer + throughfall exclusion: combined fertilizer and throughfall exclusion treatment Researchers at each Tier III site are measuring tree and stand growth, above and below ground carbon, changes in soil nutrient and water availability, whole-tree water use, leaf area development and canopy light capture, and soil carbon dioxide (CO ₂) efflux (partitioned into autotrophic and heterotrophic respiration).

Aim 5 (Education) Experiments, surveys, and data collection

Undergraduate Fellowship Program Attitudes Survey

The objective of this survey research is to identify changes in undergraduate student attitudes toward research as a result of participating in a full time summer research internship. Three cohorts of students (n = 30) have come through the PINEMAP Undergraduate Fellowship Program from 2012-2014. The survey was presented in a pre- and post-experience format, and it consisted of 24 Likert-type items (1 represented “strongly disagree” and 5 represented “strongly agree”) that integrated 17 items from the “Attitudes Toward Research” (ATR) Scale and 7 scientific-method oriented items. Responses for both surveys were completed by 21 students. From these 21 respondents, 14% were upcoming sophomores, 29% were juniors, 48% were seniors, and 9% were returning seniors. Females (52%) were the majority of respondents. Minorities comprised 34% of the sample with 10% of respondents not reporting a racial background and 56% identifying as White or Caucasian. Approximately 62% of respondents had no previous undergraduate research experience. A Wilcoxon signed-rank analysis of data from 2012-2014 cohorts identified no significant differences for each factor (research use, negative attributes of research, positive attributes of research, and research understanding).

Formative Evaluation

To test the usefulness and effectiveness of the secondary module, Southeastern Forests and Climate Change, the team conducted a formative evaluation during fall 2013 to answer questions about how teachers perceive the module and how the activities can be improved. From 123 applicants, 64 teachers were accepted to represent regional and grade-level diversity. Twenty-eight teachers (46.4% high schools and 53.6% middle school) agreed to use two activities and complete the online teacher evaluation form. Thirty-six high school teachers agreed to use four activities, complete the online teacher evaluation form, and involve their students in pre- and post-activity surveys. Forty-four pilot testers completed their evaluation forms by January 24, 2014, and about half

(53%) of the teachers used the activities in environmental science and advanced placement (AP) environmental science classes. Participating teachers were from Florida (45%), Kentucky (16%), Virginia (14%), Arkansas (11%), North Carolina (9%), and Georgia (5%). The team obtained excellent and useful feedback from these teachers and their students which enabled us to make systematic revisions to the module (e.g., adding modifications for younger students) and editing the activities to increase clarity. We also added systems thinking connections to each activity to increase visibility for this important skill. Experts reviewed all changes to the materials to assure that no misconceptions were introduced in the revision process.

Hope Research

We developed a 14-item hope scale and administered the pre- and post- survey between September 2013 and January 2014. High school students (n=872) from 18 schools completed survey before and after their teachers conducted a package of four activities from *Southeastern Forests and Climate Change* (SFCC). Students were equally divided by gender (50% male); about 65% were 11th and 12th graders and 35% were 9th and 10th graders. Dependent t-tests were employed to understand whether or not feelings of hopefulness change after exposure to four activities from SFCC. Preliminary results suggest that engaging in the activities significantly increased students' hope about resolving climate change. In addition, we conducted a factor analysis and a path analysis to empirically explore the determinants of hope. We revised the scale based on the preliminary analysis and pilot tested with about 50 high school students in January 2015. The revised hope scale was sent out to 45 summative evaluation teachers. Nine hundred and seventy seven high school students provided parents' consent forms and completed pre- and post- surveys before and after they participated a package of five activities from SFCC between January and June 2015. Data collected from summative evaluation enabled us to further test the reliability and validity of the scale. We calculated Cronbach's alpha (.835) and conducted exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to assess the internal consistency of the hope survey. Three dominant factors delineated based on the covariance analysis. Paired t-tests were used (n=977) to compare the differences between students' pretest and posttest mean. Results suggest that hopefulness significantly increased among all packages.

Summative Evaluation

To determine the value of the final product of the secondary module, *Southeastern Forests and Climate Change*, the team began conducting the summative evaluation during spring 2015. The evaluation participants included 45 teachers and over 3,400 students from 10 southeastern states. The activities were separated into three “packages” based on thematic subject area content. Package 1 consisted of activities for biology classes related to carbon. Package 2 was designed for agriculture education courses and had content on forest management. Package 3 consisted of the systems-based activities and was best suited for environmental science courses. Pre and post content surveys for each package were used to measure student learning after completing 5 assigned activities. All students also completed a pre and post Hope survey (described above). Package 3 students received a pre and post Systems survey (described below). Teachers submitted online surveys for each activity to provide feedback on how the activities worked with their students and to offer suggestions, tips and edits that can be added to the module website and future reprints of the book, and an overall survey that evaluated their experience with the module. Teachers submitted their survey responses and student data by the end of June 2015. Thirty-two teachers successfully completed the evaluation process which included data from over 1,000 students that had signed parent consent forms. Data is currently being compiled, entered and analyzed.

Systems Research

The module emphasizes systems thinking skills to help students better understand large scale systems such as forests and climate and to increase understanding of complex environmental issues such as climate change. Each activity has a systems thinking connection section that highlights the skills, tools, and vocabulary utilized in that activity as well as systems-based discussion questions. There are also nine supplemental systems enrichment exercises available online that reinforce systems thinking skills. These activities are not directly related to the content, but offer opportunities for students to practice using

different systems thinking tools such as behavior over time graphs, stock and flow diagrams, causal loop diagrams, and computer simulations. The evaluation team developed multiple choice questions to assess the basics of system dynamics which were included on the Package 3 pre and post content surveys. In addition, each student in Package 3 completed a pre and post systems survey. This tool included three open ended questions that explored how students perceived relationships among variables in complex systems. In order to ascertain a deeper understanding of how the students were thinking about systems after completing the activities, 21 students were selected to participate in in-person interviews. The interviews asked students to explain their thought process when answering questions about systems and they also constructed a systems diagram. The interviews have been transcribed and will be analyzed to determine the level of systems complexity used as well as proper systems terminology. The data from all three survey types (content test, systems survey, and in-person interviews) will be used to develop an assessment tool to measure systems thinking skills in students as well as help determine strategies for effectively incorporating systems-based instruction into science lessons to help students better understand the complexity of large-scale environmental issues. Preliminary findings show that students were not comfortable with proper terminology. While they might have been able to explain a feedback loop in the systems survey or interview, they often did not use that vocabulary. Further analysis is needed to determine if there was consistency across classes and states of terminology used.

Cultural Cognition and Climate Change

Previous studies have shown that science educators vary in their willingness to address climate change and their self-reported knowledge of the topic. To understand if and how personal or political values play a role in their professional opinions about climate change education and willingness to use instructional materials, we developed and administered an online survey to formal and non-formal science educators in five states (Florida, North Carolina, Arkansas, Pennsylvania, and Virginia). The survey included quantitative and qualitative measures and was used to evaluate respondents' intentions to support climate change education, assess if and how those respondents' intentions and desired curriculum content vary according to their self-identified worldview, and explore the barriers and advantages of integrating climate change education into meaningful cultural narratives. Among the 251 completed surveys, the largest number of respondents identified as formal educators (55%), who teach in public schools (51%) and teach biology (41%). The results of the study suggest that worldview values and personal beliefs about climate change have a significant influence on respondents' intentions to support climate change education. These variables also exhibited a significant influence science educators' preferred curriculum content, as respondents indicated higher intentions to support lessons that reflect their personal beliefs about climate change. Respondents of diverse perspectives agreed that climate change education can provide valuable opportunities to engage students in current issues, but formal educators perceive limited ability to provide these opportunities given the time and curriculum constraints of the education system. The processes and results of this research can be adapted and applied to diverse audiences or scenarios that require targeted and effective climate change communication strategies.

Teacher Efficacy

At each facilitator and educator workshop, pre and post surveys were distributed to participants. We developed and pilot tested the educator self-efficacy survey with 15 educators in summer 2014. The reliability of the self-efficacy survey was confirmed with Cronbach alpha at .94. Paired t-tests suggest that all three workshops significantly increased participants' self-efficacy in teaching about climate change. In addition, participants (n=85) indicated that it is very likely that they will use this educational resource in their future work, recommend this educational resource to their colleagues, and expand the coverage on climate change in their work. Several participants provided open-ended comments that indicated their satisfaction with the materials and the workshop. The survey is being used by facilitators at their workshops throughout the Southeast throughout the summative evaluation period.

How Does Education Enhance Community Resilience for Climate Change?

As part of our literature review for and research with the secondary module and from our work with Aim 6 program development and evaluation, we have developed a useful perspective on the way educators can

approach the highly politicized issue of climate change with audiences that may or may not agree with foundational assumptions. We have been asked by the North American Association for Environmental Education to join their national Anecdotes to Evidence initiative (March 2015) and have launched a process to conduct a systematic review of the literature as it relates to education and outreach and community climate resilience (June 2015).

Appendix B: Training

These tables provide a comprehensive list of undergraduate and graduate students, postdocs, and technical/research personnel trained under this project, as well as their role in the project.

Project Administration/Management Training

Last name	First name	Position	University	Role
Bartels	Wendy-Lin	Assistant Research Scientist	UF	Conducting social network analysis, team science, and integration research; assisting with meeting planning and strategic project management.
Battle	Khori	Database manager	UF	Programmer for TerraC database
Crummer	Kathryn	Project Coordinator	UF	Coordinates project-wide activities; maintains the project web site and intranet site; organizes and coordinates project meetings; manages and oversees interim and annual reporting; and coordinates project communications.
Ireland	Jessica	Project Coordinator	UF	Coordinates project-wide activities; maintains the project web site and intranet site; organizes and coordinates project meetings; manages and oversees interim and annual reporting; and coordinates project communications.

Aim 1 (Silviculture/ Ecophysiology) Training

Last name	First name	Position	University	Role
Akers	Madison	Research Staff	UGA	Coordinating baseline measurements on Tier II sites and overseeing installation and data collection on the Georgia Tier III site
Albaugh	Tim	Research Staff	NCSU	Evaluating impacts of weed control and fertilization on loblolly pine using the 3-PG model
Alvarez	Jose	Postdoc	NCSU	Evaluating changes in loblolly pine leaf area due to silvicultural treatments as a component of the 3-PG model
Ausmus	Casey	M.S. Student	OSU	Research focus: determine the effects of fertilizer and water availability on tree physiological processes
Bacon	Allan	Post-Doc	UF	Modeling regional and plot level controls on the central tendencies and uncertainties of soil bulk density and their implications to the chemical budgets of soils and forest ecosystems. Assisting in the regional analysis ecosystem carbon and nitrogen budgets across the Tier II Network.
Baggett	Brittany	Undergraduate Intern	Univ. of W. FL	2013 Undergraduate Fellow; working with Adam Maggard at OSU
Barron	Stephan	Undergraduate Intern	Auburn	2014 undergraduate fellow; working with Stan Bartkowiak and Lisa Samuelson. Focus area: Sap flow and leaf/stand level physiology.
Bartkowiak	Stan	Ph.D. Student	Auburn	Research focus: measuring sap flux at the Georgia Tier III site
Bartkowiak	Stan	Research Staff	Auburn	Monitoring sap flux and canopy level processes at the Georgia Tier III site
Bass	Allison	Undergraduate Intern	UNC Wilmington/ NCSU	2014 undergraduate fellow; working with Wen Lin, and Michael Gavazzi. Focus area: Soil carbon dynamics
Bracho	Rosvel	Research Associate	UF	Carbon and biomass pool and flux measurements and calculations, sap flow dynamics, and

Garrillo				interface with TerraC database
Brown	Robert	M.S. Student	UGA	Research focus: estimate proportion of heterotrophic respiration vs. autotrophic respiration of forest soils.
Clark	Joe	M.S. Student	Auburn	Research focus: assessing relationships among intercepted radiation, LAI, photosynthetic capacity, phenology, and productivity in loblolly pine
Clark	Zach	M.S. Student	UGA	Research focus: assessing developmental pattern of understory vegetation on Tier II installations
Cucinella	Josh	Research Staff	UF	Coordinating baseline measurements on Tier II sites and overseeing installation and data collection on the Florida Tier III site
Diamond	Amanda	Undergraduate Intern	VT	2013 Undergraduate Fellow; working with Madison Akers at UGA
Faison	Andrew	Undergraduate Intern	VSU	2012 Undergraduate Fellow; assisted Jay Raymond at Virginia Tech with investigating the mechanisms nitrogen dynamics and uptake efficiencies of N containing fertilizers in loblolly pine plantations using stable isotope (¹⁵ N) techniques.
Fang	Yuan	Ph.D. student	NCSU	TBCF at Bladen Lake Tier 2 site, and Rh:D analysis across Tier 3 sites
Few	John	Undergraduate Intern	VSU	2013 Undergraduate Fellow; working with Asko Noormets at NCSU
Fields	Anthony	Undergraduate Intern	VSU	2013 Undergraduate Fellow; working with Maxwell Wightman at UF
Frye	Sam	Research Staff	VT	Assisting with soil CO ₂ efflux and N ₂ O measurements and installation and data collection on Tier II and III sites.
Gonzalez Benecke	Carlos	Research Associate	UF	Ecophysiology and Carbon Balance Modeling; support of tree transpiration measurements for Tier III; use of 3PG model to assess the effect of climate change in productivity of loblolly pine plantations in SE U.S.
Gregory	Bethany	Undergraduate Intern	VT	2012 Undergraduate Fellow; helped Andy Laviner at Virginia Tech with a study on environmental manipulation of fertilization, drought, and thinning in loblolly pine plantations.
Hancock	Amanda	Undergraduate Research Assistant	TAMU	Carbon monitoring protocol implementation for Tier II sites.
Hardison	Alex	Undergraduate Intern	OSU	2014 Undergraduate Fellow; working with Adam Maggard at OSU
He	Dongmei	Visiting Chinese PhD student	TAMU	Effect of soil aggregates on soil C stabilization in different families of loblolly pine
Heim	Brett	M.S. Student	VT	Research focus: separating heterotrophic and autotrophic respiration components of soil CO ₂ efflux
Heinemann	Bob	Research Coordinator	OSU	Assists with site maintenance and data collection on Oklahoma Tier III site.
Holeman	Randy	Research Specialist	OSU	Assists with site maintenance and data collection on Oklahoma Tier III site.
Hurst	Kari	Research Technician	UF	Coordinates Tier III sap flux measurements and sap flux probe construction.
Ingwers	Miles	Ph.D. Student	UGA	Physiological and genetic effects of drought on loblolly pine clones.
Jackson	Colin	Undergraduate Intern	OSU	2013 Undergraduate Fellow; working with Jay Raymond at VT
Jarvis	Rebecca	Undergraduate Intern	VT	2012 Undergraduate Fellow; assisted Wen Lin at North Carolina State University with quantifying the growth rate of loblolly pine, and analyze its sensitivity to temperature and precipitation dynamics.
K.C.	Dipesh	Postdoc	OSU	Tier III data inventory and TerraC database management
Kinnerly	Will	Undergraduate Intern	VT	2012 Undergraduate Fellow; helped Brett Heim at Virginia Tech with experimental manipulations of belowground metabolic activity in order to separate microbial respiration from plant respiration
Laguer Martinez	Doris	Undergraduate Intern	University of Puerto Rico	2014 Undergraduate Fellow; working with (Jill) Ji Qi at UGA; learned about forest soil carbon and hydrology
Laviner	Andy	Ph.D. Student	VT	Coordinating baseline measurements on Tier II sites and overseeing installation and data

				collection on VA Tier III site; research focus is water use efficiency in loblolly pine
Lewis	Wilson	Research Technician	UF	Assists with Tier III measurements and Tier II sample collection and lab processing
Lin	Wen	Ph.D. Student	NCSU	Research focus: water use efficiency in loblolly pine using 12C/13C ratios in wood
Luedtke	Cody	Ph.D. Student	UGA	Research focus: Soil CO2 efflux
Maggard	Adam	Ph.D. Student	OSU	Research focus: ecophysiology on Tier II and III sites
McConaghy	Scott	Undergraduate Intern	Kansas State	2013 Undergraduate Fellow; working with Yang Zhang at TAMU
McElligott	Kristin	Ph.D. Student	VT	Research focus: mechanisms controlling total soil CO ₂ efflux and heterotrophic and autotrophic soil respiration
Medsker	Teresa	M.S. Student	OSU	Research focus: belowground processes affected by fertilization and water availability
McConaghy	Scott	Undergraduate Intern	Kansas State	2013 Undergraduate Fellow; working with Yang Zhang at TAMU
Meek	Casey	Research Staff	OSU	Assisting with ecophysiological and process measurements at Tier II and III sites
Meeks	April	M.S. Student	NCSU	Incorporating competing vegetation in 3-PG model
Montecinos	P	M.F. Student	Auburn	Physiology and growth of a 6-year-old loblolly pine (Pinus taeda L.) plantation in response to rainfall exclusion and fertilization treatments
Nagel	Greg	Undergraduate Research Assistant	TAMU	Carbon monitoring protocol implementation at Tier II sites
Nichols	L.K.	M.S. Student	VT	Relationships among soil properties and soil CO ₂ efflux in a loblolly pine-switchgrass intercropped system
Parisher	Josh	Undergraduate Research Assistant	TAMU	Carbon monitoring protocol implementation at Tier II sites
Pell	Charles	M.S. Student	Auburn	Research focus: ecophysiology at the Georgia Tier III site.
Pike	Jason	Research Staff	OSU	Assisting with installation, maintenance, and data collection on Tier III sites
Qi	Jill	Ph.D. Student	UGA	Research focus: soil water and deep soil carbon responses under rain throughfall treatment at Tier III sites
Raymond	Jay	Ph.D. Student	VT	Research focus is N uptake efficiency of enhanced efficiency N fertilizers using 15N stable isotopes
Russell	Ed	Ph. D. Student	VT	Research focuses on water relations at Tier III installations
Rutemiller	Paul	Undergraduate Intern	VT	2013 Undergraduate Intern; working with Chris Maier at the USFS
Ryland	Rachel	Undergraduate Research Assistant	UGA	Received training in field sampling of trace gases at the Georgia Tier III installation and has been trained in laboratory techniques for soil gas analysis on the gas chromatograph
Seyle	Jacob	Undergraduate Research Assistant	NCSU	Assists with processing soil samples from Tier2 soil respiration plots in the northern subregion, makes sapflow probes for Tier 3 installations, analyzes growth responses of trees at Tier 2 sites to historic drought events. /AN/
Sherrod	Charles Allen	Undergraduate Research Assistant	UGA	Received training in field sampling of soil at the Georgia Tier III installation and has been trained in laboratory techniques for soil sample preparation and analysis
Shrestha	Raj	Postdoc	VT	Soil greenhouse gas (CO ₂ , N ₂ O, CH ₄) flux across soil moisture and management gradients
Seyle	Jacob	Undergraduate Research Assistant	NCSU	Heterotrophic respiration, coarse woody decomposition, making sapflow probes for Tier 3 sites.
Sherrod	Charles Allen	Undergraduate Research Assistant	UGA	Received training in field sampling of soil at the Georgia Tier III installation and has been trained in laboratory techniques for soil sample preparation and analysis
Stebler	Elaine	Research Staff	OSU	Coordinating baseline measurements on Tier II sites and overseeing installation and data collection on the Oklahoma Tier III site
Stokes	Tom	Research Staff	Auburn	Assisting with data collection on Tier II and III sites
Subedi	Santosh	Ph.D. Student	VT	Research focus: identifying an improved method to determine fertility rating for 3-PG
Thompson	Ian	Undergraduate Research Assistant	NCSU	Heterotrophic respiration, coarse woody decomposition, making sapflow probes for Tier 3 sites.
Vial	Sara	Undergraduate Research Assistant	VT / NCSU	2014 Undergraduate fellow, working with Wen Lin. Focus area: Radial growth and drought

				sensitivity in Tier2 sites.
Ward	Eric J.	Postdoc	NCSU	Measuring and modeling forest water and carbon cycles, including quantifying uncertainty in key processes; working with both Aim 1 and 2 to integrate data and models such as 3PG and WaSSI-C across scales; assisting with data collection and analysis of water fluxes at the Virginia Tier III site.
Werner	A.E.	M.S. Student	VT	Nitrogen release, tree uptake and ecosystem retention in a mid-rotation loblolly pine plantation following fertilization with 15N enriched enhanced efficiency fertilizers
Wightman	Maxwell	M.S. Student	UF	Research focus: Ecophysiology of drought response on FL Tier III site
Wigley	Madison	Undergraduate Research Assistant	TAMU	Carbon monitoring protocol implementation for Tier II sites
Wilson	Elizabeth	M.S. Student	TAMU	Research focus: understanding the effects of mesophyll conductance on isotopic signatures in leaves
Yancey	Fletcher	Research Technician	UF	Coordinates Tier III sap flux measurements and assists with Tier II sample collection and lab processing
Yanez	M.A.	Ph.D. Student	VT	Management intensity effects on growth and physiological responses of loblolly pine varieties and families growing in the Virginia Piedmont and North Carolina Coastal Plain of the United States
Yang	Jinyan	Ph.D. Student	UGA	Research focus: Heterotrophic and autotrophic components of soil respiration
Zhai	Lu	M.S. Student	TAMU	Research focus: Family and culture effects on ecosystem C and N dynamics
Zhang	Yang	Ph.D. Student	TAMU	Research focus: Carbon and nitrogen cycling response to drought at the OK Tier III site

Aim 2 (Modeling) Training

Last name	First name	Position	University	Role
Barros Souza	Bruce	MS Student	UGA	Modeling loblolly pine plantation water use using 3-PG
Brooks	Evan	Postdoc	VT	Regional upscaling of growth and yield and 3-PG models for study timeframe and region, initial 3-PG parameter assessment.
Cook	Madison	Undergraduate Intern	VSU	2013 Undergraduate Fellow; working with Jose Alvarez at NCSU.
Fang	Yuan	Ph.D. Student	NCSU	Using G'DAY model to address nitrogen use efficiency in pine plantations.
Gopalakrishnan	Ranjith	Ph.D. Student	VT	Research focus: Downloading and reformatting the NARCCAP scenarios for key climate variables from six models (GCM/RCM combinations).
Gyawali	Nabin	Ph.D. Student	VT	Modeling general response to silvicultural treatments in loblolly pine stands.
Henderson	Jesse	Research associate	NCSU	Leading initial stages of integration of SRTS with regional 3P-G and WaSSI data.
Ross	C. Wade	Ph.D. Student	UF	Research focus: Investigating the response of soil carbon dynamics to changes in climate and fire disturbance in southern pine ecosystems with a process based model.
Sabatia	Charles	Postdoc	VT	Investigated growth and yield response to climate and soils variables using Tier 1 data.
Thapa	Ram	Ph.D. Student	VT	Modeling mortality of loblolly pine (Pinus taeda L.) plantations.
Wang	Maggie	Ph.D. Student	UGA	Research focus: Working on a research proposal to predict C pool dynamics for alternative land use, management, and climate scenarios at the stand level. The proposal is to link 3-PG and Century to examine forest ecosystem carbon sequestration.
Ward	Eric	Postdoc	NCSU	Measuring and modeling forest water and carbon cycles, including quantifying uncertainty in key processes; working with both Aim 1 and 2 to integrate data and models such as 3-PG and WaSSI-C

				across scales; assisting with data collection and analysis of water fluxes at the Virginia Tier III site.
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Aim 3 (Genetics) Training

Last name	First name	Position	University	Role
Bawa	Rajesh	Ph.D. Student	VT	Research focus: Conducting Phenotyping of adaptive traits (i.e., cold hardiness and bud phenology) in the loblolly pine progeny trials and working with universities across region to conduct genome-wide association mapping between these traits and the re-sequencing data.
Farjat	Alfredo	Ph.D. Student	NCSU	Research focus: Carrying out joint analysis of progeny test data and climate data for the Cooperative Tree Improvement Program.
Koralewski	Tomasz	Postdoc	TAMU	Building a location database for the progeny tests and the parents represented in those progeny tests that can be linked to climatic data, and performing URF analysis to optimize seedling deployment.
Lu	Mengmeng	Ph.D. Student	TAMU	Research focus: Evaluating efficiency of the Agilent SureSelect target gene enrichment system for Illumina GAI and HiSeq high-throughput sequencing instruments, based on capture probes designed using the Agilent eArray tool and the most recent and comprehensive unigene set consisting of 35,550 sequences representing individual genes expressed in loblolly pine.
Kohlway	Will	Undergraduate Research Assistant	NCSU	Working on pilot scale experiments to test genotyping-by-sequencing as a cost-effective means of genotyping the experimental populations.
Rusche	Ben	Undergraduate Research Assistant	NCSU	Working on pilot scale experiments to test genotyping-by-sequencing as a cost-effective means of genotyping the experimental populations.
Townsend	Laura	M.S. Student	NCSU	Research focus: Genetic variation in loblolly pine for adaptability to climate variables.
Zhang	Jianxing	Ph.D. Student	UF	Research focus: conducting analyses linking progeny test performance with climatic data and developing a database for the URF analysis to optimize seedling deployment.

Aim 4 (Economics and Policy) Training

Last name	First name	Position	University	Role
An	Hyunjin	Ph.D. Student	TAMU	Assessing climate change impact on southern pine beetle infestations and associated economic and carbon consequences.
Dwivedi	Puneet	Postdoc	University of Illinois-Urbana Champaign	Working with Dr. Gan to assess impacts of climate change on southern pine beetle infestation and exploring life cycle impacts of different wood products produced using southern pines.
Khanal	Puskar	Ph.D. Student	MSU	Research focus: Evaluating forest management practices that enhance carbon sequestration in stands and developing a survey instrument to determine small forest landowner's willingness to implement these practices and identify potential incentives that increase carbon sequestration at the stand level.
Kreye	Melissa	Ph.D. Student	UF	Completed a literature review on the economic value of forest-based changes in water quality; conducted a meta-analysis of forest-based water quality values; and specified an econometric model that predicts willingness to pay for forest-based water quality. Using a benefit transfer method, she has applied the model to two representative sites.

Last name	First name	Position	University	Role
Soto	Jose	Postdoc	UF	Postdoc research focus: 1) modeling the impacts of invasive pine beetles and ecosystem service values as a function of changing climatic conditions, management, and policy; and 2) implementing a survey of Florida household residents, Master Gardeners, and public officials, which aims at assessing the value of ecosystem services of Florida's urban forests.
Soto	Jose	Ph.D. Student	UF	Assessing and summarizing competing programs and policies that incentivize carbon sequestration at the local, state, national, and international level.
Soto	Justin	Undergraduate Intern	UF	2012 Undergraduate Fellow; assisted Melissa Kreye at University of Florida with assessment of the economic value of forest-based ecosystem services under alternative management and policy regimes.
Susaeta	Andres	Postdoc	UF	Developing a forest stand-level model to assess expected economic rents for forest landowners under hurricane risks associated with future climate change conditions. Key role in developing an economic model to analyze carbon sequestration in loblolly pine plantations under various carbon subsidies and tax rates in the context of climate change. Working on FIA plot data to analyze the efficiency in the provision of ecosystem services (C sequestration, timber production and biodiversity values) under changing climatic conditions in the U.S. South. Determining optimal forest management of southern pines under climate and economic uncertainty using 3-PG model.
Timilsina	Nilesh	Postdoc	UF	Assessing the interactions between different ecosystem services in pine flatwoods and optimizing modeling to maximize a particular ecosystem service and assess the tradeoff of the others.
Traboulsi	Mohamad	Ph.D. Student	UF	Integrating FIA plot data with hydrologic unit watersheds and subwatersheds in Florida. Watershed-level WASSI water yield outputs will then be integrated with FIA C, Timber and diversity data to identify watersheds with optimal provision levels and use/non-use values for water yield, C, timber and understory diversity.
Tucker	Joanna	Postdoc	UF	Assisting with analysis and manuscript preparation for a project involving the use of available USDA Forest Service FIA forest inventory data to estimate understory species richness (i.e. biodiversity).

Aim 5 (Education) Training

Last name	First name	Position	University	Role
Bowers	Alison	Research Staff	UF	Assisted with module development. Assisting with systematic literature review.
Burja	Kristy	M.S. Student	UF	Assisting with materials development and evaluation
Chaves	Willandia	Doctoral Student Assistant	UF	Assisting with systematic literature review.
Cheek	Morgan	Undergraduate Intern	NCSU	2014 Undergraduate Fellow assisting with module production, evaluation, and research tasks
Clifford	Margaret	M.S. Student	UF	Assisting with Extension program evaluation; assessing climate perspectives and program needs
Decker	Paul	Undergraduate Intern	VT	2012 Undergraduate Fellow; worked with Stephanie Hall at University of Florida to investigate how to teach high school students about controversial topics such as climate change.
Glover	Kristen	Undergraduate Intern	UF	2013 Undergraduate Fellow; working with Christine Li at UF. Assisted with development of slide presentations for the web; compiled teacher feedback from summative evaluation for revision of module.
Hamill	Alyssa	Undergraduate	VT	2014 Undergraduate Fellow; worked with John Kidd at Virginia Tech on a variety of projects related to undergraduate

		Intern		research experiences and secondary education.
Holmes	Tiara	Undergraduate Intern	VT	Assisted with video production for module website
Hall	Stephanie	M.S. Student	UF	Research focus: conducting research on how to best introduce potentially divisive and contested concepts in secondary school curricula; also helping to develop and pilot test activities for the PLT/PINEMAP Secondary Module.
Kidd	John	Research Staff	VT	Undergraduate Intern Program Coordinator. Developing the selection criteria, matching students, awarding proposals, developing the fall course, and working with local teachers to set up school presentations for the Undergraduate Internship Program.
Krantz	Shelby	M.S. Student	UF	Produced videos for module website
Kunkle	Kristen	M.S. Student	UF	Research focus: assessing if and how personal and political beliefs influence science educators' intentions to support climate change education and desired curriculum content
Li	Jie (Christine)	Ph.D. Student	UF	Research focus: Assessing interest in climate change based on and hopefulness and relevance of solutions; teacher self-efficacy for teaching about climate; student self-efficacy for participating in climate change solutions.
Moreno	Bianca	Undergraduate Intern	UF	2015 Undergraduate Fellow; working with Tracey Ritchie on data organization, entry, tracking, and analysis for the summative evaluation and teacher workshops.
Oxarart	Annie	Research Staff	UF	Environmental Education Program Coordinator. Working on the development of the PLT/PINEMAP Secondary Module, including assisting with the needs assessment, development and pilot testing of activities, and oversight of the Education Advisory Committee.
Plate	Richard	Postdoc	UF	Assisting with the development and evaluation of activities for the PLT/PINEMAP Secondary Module and analyzing needs assessment data; assisting with data analysis for the Extension climate perceptions survey. Assisting with systematic literature review.
Ritchie	Tracey	Ph.D. Student	UF	Research focus: Conducting summative evaluation of curriculum module and exploring how to successfully develop and measure systems thinking skills in high school students
White	Ahnaia	Undergraduate Intern	VSU	2014 Undergraduate Fellow assisting with module production, evaluation, and research tasks

Aim 6 (Extension) Training

Last name	First name	Position	University	Role
Boby	Leslie	Extension Staff	UGA/SREF	Assists with formation of regional Extension teams, and a PINEMAP Extension Advisory Board; participating in and presenting at research cooperative meetings; and facilitating internal and external PINEMAP research dissemination. Planned work includes developing and evaluating written and web-based (i.e. eXtension, webinars, etc.) educational materials and disseminating resources and materials to forestry stakeholders.
Burnett	Rachel	M.S. Student	NCSU	Assisting with reviewing factsheets and other PINEMAP-related publications; research focus: annual and decadal climate forcing of historical and current trends in fire regime in Southeast forests.
Cole	Hilary	M.S. Student	NCSU	Serves as a copy editor for factsheets and other PINEMAP-related publications, provides guidance with contextual examples for the climate education materials in collaboration with the State Climate Office of NC. Assists the SREF office with a region-wide Forest managers survey on Climate education needs that she will analyze as part of her Master's thesis.
Davis	Corey	Research Staff	NCSU	Environmental Meteorologist. Working with Heather Dinon Aldridge on DSS development.

Last name	First name	Position	University	Role
Denzin	Evelyn	Research Staff	UGA/SREF	MS Level Forester, Factsheet development and technical writing
Dinon Aldridge	Heather	Research Staff	NCSU	Applied Climatologist. Facilitates interaction between PINEMAP team members and state climatologists across the region through activities such as presentations in the internal webinar series and research cooperative meetings and weather/climate conferences. Other involvement includes development of the DSS, creation of fact sheets, and guidance on the best climate datasets for PINEMAP.
Eskinder	Brhan	PINEMAP Intern	Spellman College	PINEMAP intern for the summer of 2015, and is working on a Decision Support System companion piece.
Foster	Anslei	M.S. Student	NCAT	Working on fact sheets and publications for PINEMAP.
Hall	Megan	Research Assistant	NCSU	She is implementing contextual examples into the climate education materials for forestry in collaboration with PINEMAP colleagues.
Krantz	Shelby	M.S. Student	UF	Conducted focus groups, helped design the forest landowner Extension workshop, developed a pre/post survey and analyzed data to better understand perceptions on climate, willingness to change management strategies, and opportunities to make a meaningful difference.
Martin	Andrew	Undergraduate Research Assistant	NCSU	Developing a tool for forestry professionals across the southern US, which displays historical temperature, precipitation, and drought indices.
O'Connell	Charlie	Undergraduate Research Assistant	NCSU	Reviewed the climate education materials for forestry. Developed a tool for forestry professionals across the southern US which displays historical temperature, precipitation, and drought indices.
Sanders	Katherine	Undergraduate Research Assistant	UGA	Working on Decision Support System Companion pieces for summer 2015
Starr	Morgan	Undergraduate Research Assistant	Texas A&M U.	Assisted in planning forestry training events and researching and writing factsheets, as well as database entry.
Temple	Christina	M.S. Student	NCSU	Drafted two fact sheets on adaptation related to forest pests and invasive species. Drafts were finalized by Hilary Cole and are undergoing developing a comprehensive list of climate education materials across the southern US.
Vuola	Aaron	M.S. Student	NCSU	Successfully defended his thesis on 3/30, graduated in May 2012 . Aaron has coauthored a peer-reviewed paper and commentary from his theses with current graduates Hilary Cole and Rachel Burnett as research notes and ultimately as refereed publications. Aaron's thesis research was featured in poster during an IUFRO Small-Scale Forestry Conference in Amherst, MA fall, 2012.
Wojcik	Deborah	Postdoc	UF	Assisted with survey development and data analysis for the Extension climate perceptions survey. Dr. Wojcik helped develop the Six Americas survey for SE Extension Professionals and is writing one article.