PROJECT NARRATIVE

USDA National Institute of Food and Agriculture
Climate Change: Regional Approaches to Climate Change, Program Code A3101
Continuation Application—2012

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

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

NIFA Award number 2011-68002-30185

Team Plan-of-Work (Year 3)

Preliminary year 3 (March 1, 2013-February 28, 2014) work plans for each PINEMAP Aim group are outlined in Table 1. Milestones anticipated to be delivered and/or completed during year 3 are outlined in Table 2.

Table 1. Preliminary year 3 (March 1, 2013-February 28, 2014) work plans for each PINEMAP Aim group.

Aim	Task
Aim 1 (Silviculture & Ecophysiology)	Measure Tier 2 and 3 sites (vegetation and soil sampling, growth response data combined with carbon and nitrogen pool data, and ecophysiological measurements)
	Collect additional data on water and carbon fluxes at subset of Tier 2 sites previously identified
	Develop regional C, H_20 baseline with Tier 2 data
	Conduct quantification of regional variation in soil respiration
	Conduct initial regional quantification of cross-region fertility rating and stomatal response functions
	Measure $\delta^{18}O$ & $\delta^{13}C$ from Tier 2 wood samples
	Refine regional stomatal response and transpiration functions based on clonal and regional $\delta^{13}C$ data
	Characterize tree water use efficiency (WUE) of different provenances and clones
	Regionalize estimates of WUE for application in 3-PG and WaSSI
	Assess genotypic and treatment differences in carbon use efficiency (NPP:GPP) and regional variation in carbon sequestration efficiency (NEP:GPP)
	Develop improved method to evaluate stomatal response functions to update 3-PG
	Develop improved method to evaluate fertility rating (FR) in 3-PG
Aim 2 (Modeling)	Develop improved process and hybrid models parameterized from network measurements
	Predict C pool dynamics at varying scales for alternative land use, management, and climate scenarios
	Develop improved growth and yield models with climate inputs & C balance (initial prototype)
	Develop a regional map of potential climate or anthropogenic limitations to productivity (nutrients)
	Refine climate scenario modules for integration into DSS
	Develop prototype of carbon management decision support tools to solicit structured feedback - climate scenarios
	Begin developing prototypes of modules for decision support system (genetics, 3-PG, pest/fire risk, fertilizer, and nutrient genetics); refine modules
	Begin scaling-up of prototype of growth and yield components
	Conduct modeling of soil C—forest dynamics (G-Day Model)
	Incorporate competing vegetation into 3-PG
Aim 3 (Genetics)	Develop version 2 of genetic deployment tool with progeny information
	Assess regional variation in tree water use efficiency by genotype and age from Tier 2 data
	Continue genotyping of ADEPT2, CCLONES, and PSSSS populations
	Continue phenotyping insect and disease resistance
	Continue phenotyping response to fertilizer
	Discover alleles associated with nitrogen responsiveness
	Discover and validate alleles and genes associated with growth and adaptive traits in 3 populations (new markers)

Table 1. Preliminary year 3 (March 1, 2013-February 28, 2014) work plans for each PINEMAP Aim group.

Aim	Task
Aim 4 (Economics & Policy)	Conduct assessment of policies and programs that may affect C mitigation in planted pine forests
	Conduct analysis of NPV and regional market impacts of adaptive management
	Document landowner adoption of mitigation and adaptation strategies
	Conduct cradle-to-gate life cycle inventory for wood and pulp and paper products
	Conduct bioeconomic modeling of nontimber market ecosystem services
	Assess tradeoffs between regional C sequestration, forest products, and maintenance of ecosystem services
	Assess landowner and regional economic losses from altered disturbance risks
	Implement landowner survey to assess willingness of landowners to adopt adaptation and mitigation strategies
Aim 5 (Education) **Undergraduate Internship Program**	Announce winners of 2013 intern micro-grant program
	Facilitate undergraduate intern transitions to host universities
	Maintain the intern program web site and update as needed with information for internships and the undergraduate distance course
	Revise, finalize syllabus for undergraduate teaching and communication distance course
	Conduct monthly online meetings with interns and graduate student mentors
	Conduct undergraduate communication and teaching distance course on education
	Promote 2014 summer undergraduate internship program
	Interns deliver inquiry-based educational presentations
	Evaluate goals, objectives, structure, and format of summer internship program and modify as necessary
	Conduct follow-up evaluation with teachers, mentors, and interns and modify as necessary
	Conduct selection process for winners of 2014 intern micro-grant program and undergraduate internship program
Distance Graduate Course	Obtain, compile, and review course evaluation input from students and faculty
	Write final course evaluation report
PLT/PINEMAP Secondary Module	Obtain expert review of module
	Develop formative evaluation tools
	Develop training workshop for teachers (online and in person)
	Finalize revisions to draft module and workshop plans
	Conduct training workshops for formative evaluation
	Formative evaluation in schools across Southeast
	Develop supplemental resources for module (videos, web site, etc.)
Aim 6 (Extension)	Compile and analyze audience needs assessment results
	Develop and pilot test DSS user interface
	Begin rollout of DSS to landowners and consultants
	Assess and refine DSS based on pilot test
	Develop and implement Extension products for educators, Extension professionals, and practitioners (fact sheets, webinars, workshops, eXtension modules, etc.)
	Conduct evaluation to assess impact of outreach
	Continue development of state teams to deploy outreach materials and programs
	Strengthen forestry Extension/climatologist partnerships

Table 2. Anticipated year 3 milestones (March 1, 2013-February 28, 2014).

	2013										2014	
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Aim 1: Silviculture & Ecophysiology												
Assessment of Tier 3 treatment effects												
Assessment of climate, soil, and management impacts on soil GHG flux												
Regional C, nutrient, H_2O baselines and responses to management from measured Tier 2 data												
Regionalize estimates of water use efficiency for application in 3-PG and WaSSI												
Aim 2: Modeling												
Improved growth and yield models with climate inputs and C balance (initial prototype)												
Improved growth and yield models with climate inputs and C balance (for regional simulations)												
Regional map of potential climate or anthropogenic limitations to productivity (nutrients)												
Modules for integration into DSS: Fertilizer: Tier 1 data for first version												
Aim 3: Genetics												
Version 2 of genetic deployment tool with progeny information												
Aim 4: Economics & Policy												
Assess policies and programs that may affect C mitigation in planted pine forests												
NPV analysis and regional market impacts of adaptation strategies												
Document landowner adoption of mitigation and adaptation strategies												
Bioeconomic modeling of nontimber market ecosystem services												
NPV and regional market impacts of altered disturbance risks												

Table 2. Anticipated year 3 milestones (March 1, 2013-February 28, 2014).

	2013										2014	
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Aim 5: Education												
Draft PLT Secondary Module and training ready for formative test												
Web-based course in multidisciplinary research for graduate students completed												
Undergraduate research internships completed												
Undergraduate teaching and communication distance course completed												
Aim 6: Extension												
Implement and Strengthen forestry Extension/climatologist partnership (ONGOING)												
Extension programs delivered (ONGOING)												
Extension program evaluation (ONGOING)												
Decision Support System pilot												
Decision Support System development (ONGOING)												
Decision Support System training (ONGOING)												

Outcomes/Impacts

Aim 1 (Silviculture and Ecophysiology)

Activities of the Aim 1 (silviculture and ecophysiology) group contribute to project-level outcomes and impacts primarily through the establishment and measurement of carbon and nutrient pools and fluxes on a three-tiered monitoring network. The data generated from this network will quantify climatic, soils, and management impacts on carbon sequestration in planted pine ecosystems and provide data necessary for the Aim 2 (modeling) group to build and verify stand- to regional-level models that simulate pine forest dynamics under varying climate. These data and simulations will form the core of the PINEMAP Decision Support System which will provide landowners and managers the tools necessary to make decisions about managing planted pine for increased carbon sequestration, enhanced fertilizer efficiency, and resilience to altered disturbance regimes.

Aim 2 (Modeling)

Activities of the Aim 2 (modeling) group contribute to project-level outcomes and impacts through the assessment and analysis of how changing management and climate will impact stand and regional carbon sequestration, productivity, and resilience to disturbance. Because climate and management effects on forests span such large spatial and temporal scales, modeling approaches remain the only method available to assess outcomes and impacts for the entire region. Fine scale measurements are transferred using multiple scale models to extrapolate to the region.

Aim 3 (Genetics)

Activities of the Aim 3 (genetics) group contribute to project-level outcomes and impacts by providing a genetic deployment tool necessary for stakeholders to make sound genetic deployment decisions under changing climatic conditions and by discovering genes and markers associated with important mitigation and adaptation traits that can be incorporated into future breeding programs. The genetics group will work closely with the Aim 1 (silviculture and ecophysiology) and Aim 2 (modeling) teams to provide input and benefit from insights gleaned from the stand-level studies and modeling to make tree improvement more efficient. Simultaneously, knowledge of traits varying at the gene level should contribute to the ecophysiology studies.

Aim 4 (Economics and Policy)

Activities of the Aim 4 (economics and policy) group contribute to project-level outcomes and impacts by providing the economic analysis that will underpin land manager decision-making in future management and climatic conditions. From stand- to regional-scale, economic impacts of disturbance, climate, management, and policy alternatives must form the basis of any viable and sustainable management change. Policy analysis will enable PINEMAP stakeholders to

better assess management responses to future policy changes. Quantification of different ecosystem services will lead to a better understanding of tradeoffs among carbon, timber, and biodiversity. Finally, the life cycle assessment (LCA) carried out by the economics and policy group will provide the framework necessary to analyze the stand to regional carbon sequestration implications of changes in management regimes.

Aim 5 (Education)

Activities of the Aim 5 (education) group contribute to project-level outcomes and impacts through educating graduate and undergraduate students, along with high school teachers and students, on climate science, forestry, and interdisciplinary research. The PINEMAP distance graduate course, *Climate and Forests*, was offered for the first time during the spring 2012 semester (January-May). The course provides a platform for faculty, students, and staff to interact and better understand the variety of interdisciplinary research, education, and outreach elements within the PINEMAP project. The PINEMAP Undergraduate Internship Program was launched in May 2012 as undergraduate interns began working with PINEMAP graduate students at host institutions. This internship experience will be used in fall 2012 to educate public secondary school students about forest resources and climate change. Seven activities for the Project Learning Tree/PINEMAP secondary module have been developed and reviewed by the Education Advisory Committee; five additional activities are being developed.

Aim 6 (Extension)

Activities of the Aim 6 (Extension) group contribute to project-level outcomes and impacts through development and dissemination of informational products and tools which provide stakeholders with knowledge and skills needed to address planted pine climate change mitigation and adaptation issues. PINEMAP Extension efforts include outreach and technology transfer to both non-industrial private and corporate forestland owners.

Outputs

Aim 1 (Silviculture and Ecophysiology)

<u>Products</u>

Peer-reviewed Publications

Albaugh, T.J., E.D. Vance, C. Gaudreult, T.R. Fox, H.L. Allen, J.L. Stape, and R.A. Rubilar. Carbon emissions and sequestration from fertilization of pine in the southeastern United States. *Forest Science*, in press.

Albaugh, T.J., H.L. Allen, J.L. Stape, T.R. Fox, R.A. Rubilar, and J. Price. Intra-annual nutrient flux in *Pinus taeda*. *Tree Physiology*, in press.

Blinn, C.E., T.J. Albaugh, T.R. Fox, R.H. Wynne, J.L. Stape, R.A. Rubilar, and H.L. Allen. 2012. A method for estimating deciduous competition in pine stands using Landsat. *Southern Journal of Applied Forestry* 36(2):71-78. http://dx.doi.org/10.5849/sjaf.10-034

Bracho, R.G., G. Starr, H.L. Gholz, T.A. Martin, W.P. Cropper, and H.W. Loescher. 2012. Controls on carbon dynamics by ecosystem structure and climate for southeastern U.S. slash pine plantations. *Ecological Monographs* 82: 101-128. doi: http://dx.doi.org/10.1890/11-0587.1

Campoe, O.C., J.L. Stape, T. J. Albaugh, H.L. Allen, T.R. Fox, R. Rubilar, and D. Binkley. 2012. Fertilization and irrigation effects on tree level aboveground net primary production, light interception and light use efficiency in a loblolly pine plantation. *Forest Ecology and Management*, in press. doi: http://dx.doi.org/10.1016/j.foreco.2012.05.026

Jones, P.D. and T.R. Fox. Stem sinuosity in *Pinus taeda* stands: Is it a problem we need to be concerned with? *Forest Products Journal*, in press.

Kiser, L.C. and T.R. Fox. Nitrogen and phosphorus pools in fertilized loblolly pine and sweetgum. *Soil Science Society of America Journal*, in press.

Kiser, L.C. and T.R. Fox. Short Rotation Woody Crop Biomass Production for Energy. Chapter 6. In B. Singh (Ed.). *Biofuel Crop Sustainability*. John Wiley and Sons, in press.

Maier, C.A., K.H. Johnsen, P. Doughterey, D. McInnis, P. Anderson, and S. Patterson. 2012. Effect of harvest residue management on tree productivity and carbon pools during early stand development in a loblolly pine plantation. *Forest Science*, accepted. Fast track link: http://www.ingentaconnect.com/content/saf/fs/pre-prints/forsci11069

Mortazavi, B., M.H. Conte, J.P. Chanton, T.A. Martin, T. Teklemariam, J.C. Weber, and W.P. Cropper, Jr. Carbon isotopic composition of assimilated and respired CO_2 in southeastern U.S. pine forests. *Journal of Geophysical Research*, in review.

Samuelson, L.J., T.A. Stokes, and K.H. Johnsen. 2012. Ecophysiological comparison of 50-year-old longleaf pine, slash pine and loblolly pine. *Forest Ecology and Management* 274:108-115. doi: http://dx.doi.org/10.1016/j.foreco.2012.02.017

Stovall, J.P., J.R. Seiler, and T.R. Fox. Allometry varies among six-year-old *Pinus taeda* (L.) clones in the Virginia Piedmont. *Forest Science*, in press.

Stovall, J.P., T.R. Fox, and J.R. Seiler. 2012. Short-term changes in biomass partitioning of two full-sib clones of *Pinus taeda* L. under differing fertilizer regimes over four months. *Trees: Structure and Function* 26(3):951-961. doi: http://dx.doi.org/10.1007/s00468-011-0673-4

Worsham, L., D. Markewitz, N.P. Nibbelink, and L.T. West. 2012. A comparison of three field sampling methods to estimate soil carbon content. *Forest Science*, in press. http://dx.doi.org/10.5849/forsci.11-084.

Zhang, F., J.M. Chen, J. Chen, C.M. Gough, D. Dragoni, and T.A. Martin. Evaluating spatial and temporal patterns of MODIS GPP over the conterminous U.S. against flux measurements and a process model. *Remote Sensing of Environment*, in review.

Events/Activities

Presentations

- Clark, J.E., S. Bartkowiak, L.J. Samuelson. *Impact of rainfall manipulation on light use and water use efficiency in 6-year old loblolly pine*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Fox, T.R. *PINEMAP Overview Presentation*. Forest Productivity Cooperative Annual Contact Meeting, Alexandria, LA, June 13-14, 2012.
- Heim, B. J.R. Seiler, and B.D. Strahm. *Heterotrophic and autotrophic respiration in response to fertilization and reduced throughfall at the Virginia Tier III site*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Laviner, A. and T. Fox. *Stand level water relations at the Virginia Tier III site*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Lin, W., A. Noormets, and J.C. Domec. *Unraveling a quasi-industrial new approach for pine mapping of wood stable isotope ratio*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Luedtke, C.M., M.K. Akers, and R.O. Teskey. *Soil CO_2 efflux and tree carbon relations in a loblolly pine plantation*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Maggard, A.O. *Interaction between fertilizer and drought on leaf area dynamics and tree water use and their relationship to stand growth of loblolly pine (Pinus taeda L)*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Raymond, J., T. Fox, and B. Strahm. *Use of stable isotopes to trace the fate of applied nitrogen in forest plantations*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Shrestha, R. and B. Strahm. *Soil greenhouse gas fluxes in response to fertilization across gradients in soil moisture*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Wightman, M. and T. Martin. *The impact of artificial drought conditions on parameterization of 3-PG for Pinus taeda*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Will, R., D. Wilson, T. Hennessey, J. Vogel, J. West, and B. Heinemann. *Description of the Oklahoma Tier III site*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].

Meetings/Workshops/Courses

- Workshop conducted for PINEMAP industry members on June 12, 2012 in Alexandria, LA. Workshop focused on the impacts of the 2011 drought on growth of loblolly pine in the South.
- An Aim 1 team meeting was conducted April 3-5, 2012 in Athens, GA to discuss Tier 2 measurement protocols and prepare for the PINEMAP annual meeting.
- Aim 1 members participated in 3-PG modeling meeting organized by Aim 2 on July 2, 2012 in Charlotte, NC.

Experiments/Surveys/Data Collection

1. Tier 1 (Legacy Experiments): Industry/University Cooperative Research installations have been identified for inclusion in the Tier 1 (Legacy Experiments); archived data from these sites has been transferred to PINEMAP for uploading into the PINEMAP/TerraC database.
2. Tier 2 (Active Experiments): Industry/University Cooperative Research installations have been identified for inclusion in the Tier 2 (Active Experiments); archived data from these sites has been transferred to PINEMAP for uploading into the PINEMAP/ TerraC database. Studies of N fertilizer uptake efficiency using ^{15}N labeled enhanced efficiency fertilizers were established at 28 sites in the South associated with Tier 2 (Active Experiments) in 2011 and 2012.
3. Tier 3 (Throughfall Exclusion and Fertilization Experiments) were installed at sites in Taliaferro County, Georgia, Taylor County, Florida, McCurtain County, Oklahoma, and Buckingham County, Virginia. Studies of N_2O and NO_x emissions following nitrogen fertilization were established at a subset of the Tier 3 sites in 2012.
4. Microclimate and sap flow data collection has been automated and data are posted daily at http://www4.ncsu.edu/~anoorme/PINEMAP/index.html.

Aim 2 (Modeling)

Products

Peer-reviewed Publications

Amateis, R. L. and H. E. Burkhart. 2012. Rotation-age results from a loblolly pine spacing trial. *Southern Journal of Applied Forestry* 36(1):11-18. doi: http://dx.doi.org/10.5849/sjaf.10-038

Antón-Fernández, C., H.E. Burkhart, and R.L. Amateis. 2012. Modeling the effects of initial spacing on stand basal area development of loblolly pine. *Forest Science* 58(2):95-105. doi: http://dx.doi.org/10.5849/forsci.10-074

Blinn, C.E., T.J. Albaugh, T.R. Fox, R.H. Wynne, J.L. Stape, R.A. Rubilar, and H.L. Allen. 2012. A method for estimating deciduous competition in pine stands using Landsat. *Southern Journal of Applied Forestry* 36(2): 71-78. doi: http://dx.doi.org/10.5849/sjaf.10-034

Bryars *et al.* 2012a. A single physiological parameter set for the 3-PG model produced accurate estimates of loblolly pine growth in stands in the Coastal Plain and Piedmont Provinces of Georgia, USA. *Forest Ecology and Management*, in review.

Bryars *et al.* 2012b. Parameterization of the 3-PG model for use with two contrasting clonal loblolly pine genotypes and their simulated performance under altered climate regimes. *Southern Journal of Applied Forestry*, in review.

Domec, J.C., G. Sun, A. Noormets, M. Gavazzi, E. Treasure, E. Cohen, J.J. Swenson, S. McNulty, and J. King. 2012. A comparison of three methods to estimate evapotranspiration in two contrasting loblolly pine plantations: Age-related changes in water use and drought sensitivity of evapotranspiration components. *Forest Science*, in press.

Domec, J.C., J. Ogee, A. Noormets, J. Jouangy, M. Gavazzi, E. Treasure, G. Sun, S.G. McNulty, and J.S. King. 2012. Interactive effects of nocturnal transpiration and climate change on the root hydraulic redistribution and carbon and water budgets of southern United States pine plantations. *Tree Physiology* 32: 707-723. doi: http://dx.doi.org/10.1093/treephys/tps018.

Gonzalez-Benecke, C.A., E.J. Jokela, and T.A. Martin. 2012. Modeling the effects of stand development, site quality, and silviculture on leaf area index, litterfall, and forest floor accumulations in loblolly and slash pine plantations. *Forest Science*, in press.

Noormets A., S.G. McNulty, J.C. Domec, M.J. Gavazzi, G. Sun, and J.S. King. 2012. The role of harvest residue in rotation cycle carbon balance in loblolly pine plantations. Respiration partitioning approach. *Global Change Biology*, in press. doi: http://dx.doi.org/10.1111/j.1365-2486.2012.02776.x

Peduzzi, A., R.H. Wynne, V.A. Thomas, R.F. Nelson, J.J. Reis, and M. Sanford. 2012. Combined use of airborne lidar and DBInSAR data to estimate LAI in temperate mixed forests. *Remote Sensing* 4(6): 1758-1780. doi: http://dx.doi.org/10.3390/rs4061758

Peduzzi, A., R.H. Wynne, T.R. Fox, R.F. Nelson, and V.A. Thomas. 2012. Estimating leaf area index in intensively managed pine plantations using airborne laser scanner data. *Forest Ecology and Management* 270: 54-65. doi: http://dx.doi.org/10.1016/j.foreco.2011.12.048

Russell, M.B., H.E. Burkhart, R.L. Amateis, and S.P. Prisley. 2012. Regional locale and its influence on the prediction of loblolly pine diameter distributions. *Southern Journal of Applied Forestry*, in press.

Sabatia, C.O. and H.E. Burkhart. 2012. Competition among loblolly pine trees: Does genetic variability of the trees in a stand matter? *Forest Ecology and Management* 263(1):122-130. doi: http://dx.doi.org/10.1016/j.foreco.2011.09.009

Sabatia, C.O. and H.E. Burkhart. 2012. Height and diameter relationships and distributions in loblolly pine stands of enhanced genetic material. *Forest Science*, in press.

Sabatia, C.O. and H.E. Burkhart. 2012. Genetic effects on height-age relationships in clonal loblolly pine. *Forest Science*, in revision.

Sabatia, C.O. and H.E. Burkhart. 2012. Modeling height development of loblolly pine genetic varieties. *Forest Science*, in press.

Sabatia, C.O., T.R. Fox, and H.E. Burkhart. 2012. A model system for predicting biomass in mixed-species Southern Appalachian forests. *Southern Journal of Applied Forestry*, in press.

VanderSchaaf, C.L. and H.E. Burkhart. 2012. Development of planting density-specific density management diagrams for loblolly pine. *Southern Journal of Applied Forestry* 36(3): 126-129. doi: http://dx.doi.org/10.5849/sjaf.10-043

Events/Activities

Presentations

- Fang, Y., G. Sun, A. Noormets, J. King, and S. McNulty. *Modeling Evapotranspiration with Global Eddy Flux and MODIS Data*. North Carolina Water Resource Research Institute Annual Conference, Raleigh, NC, March 27-28, 2012.
- Gopalakrishnan, R., R.H. Wynne, and V. Thomas. *Projecting the impact of climate change on future southeastern forest fire regimes*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Ross, C.W. and S. Grunwald. *Modeling biogenic carbon dynamics across the southeastern U.S*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Wang, Y. and R.O. Teskey. *3-PG simulation of loblolly pine growth and yield*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Ward, E., A. Noormets, J.C. Domec, J. King, S. McNulty, and G. Sun. *Integrating measurements and models of carbon and water cycling at Tier II and III PINEMAP sites*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].

Meetings/Workshops/Courses

Aim 2 organized and conducted a 3-PG modeling meeting on July 2, 2012 in Charlotte, NC. This full day meeting focused on the 3-PG model and included discussion of the following: 1) identifying gaps in reaching PINEMAP objectives; 2) determining if research objectives overlap and identifying and resolving any conflicts; 3) criteria for selecting evaluation data sets; 4) 3-PG platform/software to be used; 5) model management when changes are made to functions in

3-PG; 6) use of PINEMAP web site as depository for parameterization and references; 7) how to best document improved parameter estimates; 8) moving from point to spatial modeling; and 9) additional ways to collaborate.

Experiments/Surveys/Data Collection

- Reprojections, extractions, and consolidation of various spatial data sets (GIS data) conducted for regional wide modeling including climate data.
    - Spatial extractions conducted on specific site locations (experimental data).
    - Climate data (PRISM and Idaho sets, 1970 to present) were extracted to Tier 1 site locations.
    - Harmonization and standardization of gridded climate change projections from NARCCAP into ArcGIS.
    - QA/QC of the extracted spatial climate change data identified some inconsistencies; data is being re-compiled.
- Tier 1 data including all available attributes and metadata (about 700+ sites) has been uploaded into a spatially-explicit, relational database.

Aim 3 (Genetics)

Products

Peer-reviewed Publications

Aspinwall, M.J., S.E. McKeand, and J.S. King. 2012. Carbon sequestration from 40 years of planting genetically improved loblolly pine across the Southeast United States. *Forest Science*, in press. Fast track link: http://www.ingentaconnect.com/content/saf/fs/pre-prints/forsci11058

Holliday J.A., T.L. Wang, and S.N. Aitken. 2012. Predicting adaptive phenotypes from multilocus genotypes in Sitka spruce (*Picea sitchensis*). *G3: Genes, Genomes, Genetics*, in press.

Events/Activities

Presentations

- Aspinwall, M.J., S.E. McKeand, and J.S. King. *Carbon sequestration from 40 years of planting genetically improved loblolly pine across the Southeast United States*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Bawa, R. and J. Holliday. *Signatures of natural selection and local adaptation in Populus trichocarpa and Populus deltoides along latitudinal clines*. Joint Congress on Evolutionary Biology, Ottawa, Ontario, Canada, July 6-12, 2012.
- Chhatre, V. *Evolutionary and population genetics of the Lost Pines: Lessons from history*. Western Gulf Forest Tree Improvement Contact Meeting, Bastrop, TX, May 22-23, 2012.

- Farjat, A. *Climate variables and height growth in the Plantation Selection Seed Source Study field trials*. North Carolina State University Cooperative Tree Improvement Program Advisory Board Meeting, Raleigh, NC, May 10, 2012.
- Farjat, A., F. Isik, R. Whetten, and S. McKeand. *The effect of minimum winter temperatures on pine growth*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Holliday, J.A. and L. Zhou. *Toward whole-genome association mapping and landscape genomics in trees*. Botany 2012 – The Next Generation (Annual Meeting of the Botanical Society of America), Columbus, OH, July 7-11, 2012.
- Krutovsky, K. *How genomics can help restore the Lost Pines*. Western Gulf Forest Tree Improvement Contact Meeting, Bastrop, TX, May 22-23, 2012.
- Whetten, R. *Preliminary results from Genotyping-By-Sequencing experiments in loblolly pine*. North Carolina State University Cooperative Tree Improvement Program Advisory Board Meeting, Raleigh, NC, May 10, 2012.
- Whetten, R. and L. Townsend. *Identifying genetic variation in site adaptability in loblolly pine*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Zhang, J., S. Gezan, and G.F. Peter. *Integrating climate and genetic effects of southeastern loblolly pine by Universal Response Functions*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].

Meetings/Workshops/Courses

Fikret Isik of the North Carolina State University Cooperative Tree Improvement Program co-taught a week-long workshop entitled “Genetic Data Analysis: Applications in Plant and Animal Breeding” at the Czech University of Life Sciences in Prague, Czech Republic, June 11-15, 2012. The course covered statistical methods for analysis of field trials, including methods appropriate for trials planted at multiple sites to estimate impacts of climate variation on forest productivity. The course was jointly organized by North Carolina State University Forestry Education and Outreach Program and forestry faculty from the Czech University of Life Sciences.

Experiments/Surveys/Data Collection

Working under the supervision of Ross Whetten at North Carolina State University, Will Kohlway (Undergraduate Research Intern) and Laura Townsend (new M.S. student), prepared samples for genotyping-by-sequencing of 90 progeny and two parent trees and submitted the samples to a sequencing service provider for analysis. Results are expected by early August.

Aim 4 (Economics and Policy)

Products

Peer-reviewed Publications

Abt, K., R. Abt, and C. Galik. Effect of bioenergy demands and supply response on markets, carbon and land use. *Forest Science*, accepted. Fast track link: http://www.ingentaconnect.com/content/saf/fs/pre-prints/forsci11055.

Gan, J., C.T. Smith, and J.W.A. Langeveld. Effects of considering greenhouse gas consequences on fertilizer use in loblolly pine plantations. *Journal of Environmental Management,* in revision.

Susaeta, A.I., C.A. Gonzalez-Benecke, D.R. Carter, T.A. Martin, and E.J. Jokela. 2012. Economical sustainability of pinestraw raking in slash pine stands in the southeastern United States. 2012. *Ecological Economics* 80: 89-100. doi: http://dx.doi.org/10.1016/j.ecolecon.2012.05.010

Susaeta, A.I., D.R. Carter, S.J. Change, and D.C. Adams. The impact of hurricane risk on optimal forest management in southern U.S. pine plantations: Application of a generalized Reed model. *Canadian Journal of Forest Research*, in review.

Timilsina, N., W. Cropper, Jr., F. Escobedo, and J. Tucker. Predicting species richness in forest inventories using regression tree analyses: Implications for assessing ecosystem service trade-offs (to be submitted to *Journal of Forestry*).

Timilsina, N., F. Escobedo, W. Cropper, Jr., T. Brandeis, S. Delphin, and S. Lambert. A framework for identifying carbon hotspots and forest management drivers. *Journal of Environmental Management*, in review.

Events/Activities

Presentations

- Adams, D.C. *Economic Values of Environmental Services: Water in Florida*. University of Florida Water Institute Symposium, Gainesville, FL, February 15-16, 2012.
- Adams, D.C. *Integrating Biophysical and Economic Values of Wetlands: Recent Advances in Ecosystem Service Valuation*, 9th INTECOL International Wetlands Conference, Orlando, FL, June 4, 2012.
- Khanal, P.N. and D.L. Grebner. *A preliminary effort to evaluate the willingness of nonindustrial private forest land owners to practice optimum carbon sequestration regimes in Mississippi*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].

- Kreye, M.M., D.C. Adams, T. Borisova, and F. Escobedo. *Valuing forest conservation and water quality protection programs: A meta-analysis of willingness-to-pay scenarios*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Kreye, M.M., D.C. Adams, T. Borisova, and F. Escobedo. *Willingness to Pay to Protect Well-Conserved Aquatic Systems: A Meta-Analysis*. University of Florida Water Institute Symposium, Gainesville, FL, February 15-16, 2012.
- Nettleman III, C.A., A. Abd-Elrahman, D.C. Adams, G. Barnes, T. Ruppert, B. Dewitt, and T. Fik. *Modeling Policy Solutions to coastal climate change in Florida*. International Federation of Surveyors Working Week – Territory, environment, and cultural heritage, Rome, Italy, May 6-10, 2012.
- Soto, J.R. and D.C. Adams. *Attitudes and Willingness to Accept Compensation for Carbon Offset Production in Florida: Application of Best-Worst Choice Modeling*, Western Agricultural Economics Association Meeting, Park City, Utah, June 20-22, 2012.
- Soto, J.R., D.C. Adams, and F. Escobedo*. Estimating the supply of forest carbon offsets: A comparison on best-worst and discrete choice valuation methods*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Timilsina, N., W. Cropper, Jr., and F. Escobedo. *Assessing trade-offs among different ecosystem services in pine flatwoods of the southeastern coastal plain*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].

Experiments/Surveys/Data Collection

- D.C. Adams (Co-PI), M.M. Kreye (Ph.D. student), and Justin Soto (undergraduate PINEMAP intern) are conducting pilot tests of our survey on willingness to pay for forest-based water quality improvement which will inform the bioeconomic modeling non-market ecosystem services.
- D.C. Adams (Co-PI) and Jose Soto (Ph.D. student) have finished the first wave of surveys to estimate non-industrial private forest landowners' willingness to accept carbon offset payments. A second wave of the survey will be conducted this summer. The results of this survey will inform landowner adoption of mitigation and adaptation strategies and our assessment of policies and programs that affect C mitigation in planted pine forests.

Aim 5 (Education)

Products

Peer-reviewed Publications

Monroe, M.C. 2012. Enhancing both Cooperative Extension and national environmental education resources. *Journal of Extension*, in press.

Research Summaries

Monroe, M.C., A. Oxarart, and R. Plate. 2012. *Understanding Southeastern Science Teachers' Interest in Climate Change Education*.

Events/Activities

Presentations

- Fowler, S., J. Munsell, and J. Seiler. 2012. *High school science teachers and forestry education: How are they connected?* 9th Biennial Conference in University Education in Natural Resources, Fort Collins, CO, March 23-24, 2012.
- Hall, S. and M. C. Monroe. 2012. *Climate change education for secondary students*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].
- Kidd, J.B., J.R. Seiler, M.C. Monroe, and S. Sriharan. 2012. *The PINEMAP Intern Program: Integrating undergraduates into forest resource and climate change research and education*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].

- Kidd, J.B., J.R. Seiler, M.C. Monroe, and S. Sriharan. 2012. *The PINEMAP Intern Program: Integrating undergraduates into forest resource and climate change research and education*. Biennial Conference on Undergraduate Education in Natural Resources, Fort Collins, CO, March 23-24, 2012.
- Oxarart, A., M. C. Monroe, S. Hall, J. Li, and A. Stenstrup. 2012. *Project Learning Tree Secondary Module: Southern Forests and Climate Change*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster].

Meetings/Workshops/Courses

- PINEMAP Distance Graduate Course, *Climate and Forests*, spring 2012: Twenty-two PINEMAP students from 8 universities participated in the course. Additional details on the course are provided in the Milestones section of this narrative.
- PLT activities with the Center for Precollegiate Education and Training, University of Florida
    - We conducted a half-day program with 48 high school students in two Science Quest programs (July 11 and 18, 2012), a week-long residential science camp program at UF. Students explored the carbon cycle and measured carbon stored in trees at the Austin Cary Memorial Forest. This activity enabled us to pilot test two PLT activities.
    - We worked with 90 high school students to provide basic information about climate change and to help them understand why people have different perceptions on the issue in two sessions, July 16 and 20. This enabled us to pilot test one PLT activity.
- We have conducted 4 conference calls with the Education Advisory Committee to review activity drafts and concepts. Seven activities have been developed and revised based on Advisory Committee Feedback.

Experiments/Surveys/Data Collection

- Undergraduate Internship Survey: John Kidd and John Seiler leveraged the opportunity to survey undergraduate interns to examine intern attitudes toward research before and after a 12 week internship in PINEMAP-related research. Interns were asked to complete a pre-internship survey on their attitudes toward research. Pre-internship results will be compared with those from a post-internship survey as an attempt to detect changes in attitudes. This study will be conducted over the length of the Undergraduate Internship Program and has a potential maximum sample size of 50 interns.
- High School Educators Forest Management Survey: A web-based survey of high school science teachers in the 5 state southern Piedmont region of the United States was conducted to study their knowledge, attitudes, and teaching practices with regard to forest management. A total of 1,024 surveys were successfully delivered with 324 returned for an adjusted response rate of 32%. Results indicate that most teachers (82%) agree forestry should be taught in high schools and most frequently present forestry concepts in the context of ecosystem services, followed by concepts related to physical and physiological characteristics of trees. Concepts related to products, uses, and management are taught least frequently. Variables that predict teaching frequencies for each of these three concept groups include classes taught in the last five years, environmental education program training, and childhood location in addition to attitudes toward and knowledge of forest management. Also, it was found that over half (57%) of the teachers surveyed do not take field trips to forests and less than 25% do so multiple times per year. Variables that predict whether or not teachers take forest field trips include confidence to teach forestry concepts, involvement in school natural resources related extra-curricular activities such as 4-H and Envirothon, and the presence of a forest within walking distance of the school. The most widely reported constraints to teaching forestry concepts and taking field trips to forests are mandated standards or curriculum (60%), money (40%), time (32%), mandated testing (19%), and training, interest, and infrastructure (19%).
- Educator Needs Assessment: A needs assessment survey was distributed throughout the region in May 2012 to enable secondary science teachers to provide input to the PLT module. The results of this survey are described in the Milestones section of this narrative.

Aim 6 (Extension)

<u>Products</u>

Peer-reviewed Publications

Monroe, M.C. and D.C. Adams. 2012. Increasing response rates to Web-based surveys. *Journal of Extension*, in press.

Research Summaries

Adams, D.C. M.C. Monroe, R. Plate, and D. Wojcik. 2012. *The Six Americas of Climate Change: Perceptions of Southeast Extension Professionals*.

Fact Sheets

The following list summarizes fact sheets currently under development.

- *To Plant or Not To Plant: New Timber Stand Drought Risk Assessment,* Eric Taylor, Matthew Bonham, and others
- *What can TACCIMO / CACCIMO tell us?*, Mark Megalos
- *Obstacles to Delivering Climate Variability Programming to Traditional Audiences,* Mark Megalos
- *Frequently Asked Questions about Climate Projections,* Heather Dinon and Ryan Boyles
- *Water Cycle in Forested Lands with Emphasis on Silvopasture Systems,* Shareika Williams and Gwendolyn Boyd
- *Invasive Plants and Your Forest*, Christina Temple and Mark Megalos
- *Forest Land: Health and Resiliency*, Christina Temple and Mark Megalos
- *Climate change: Opportunities for Adaptation and Mitigation,* Joshua Idassi
- *Glossary of Climate Terms*, Mark Megalos and Heather Dinon
- *Assessing Forest Vulnerability*, Mark Megalos and Heather Dinon
- *Southern U.S. Drought,* Ryan Boyles and Heather Dinon
- *Climate Oscillations: Impacts to Forestry,* Heather Dinon and Ryan Boyles
- *Introduction to Weather and Climate,* Heather Dinon and Ryan Boyles
- *What's Under the Umbrella that is Climate?,* Heather Dinon and Ryan Boyles
- *Misconceptions about Global Warming and Climate Change,* Heather Dinon and Ryan Boyles
- *Climate Change and Forestry,* Leslie Boby and Heather Dinon
- *Interpreting Uncertainty of Climate Model Projections,* Heather Dinon and Ryan Boyles
- *Herbicide Use Considerations,* Eric Taylor
- *Minimizing Forest Insect/ Disease Risk: A Practical Landowner Guide,* Mark Megalos

Internal Webinar Series

Aim 6 organized and hosted internal webinars for integration of all PINEMAP members. Webinar presentations were given by Aim 6 members, other PINEMAP members, and additional external lecturers.

- Boyles, R. and H.A. Dinon. *Misconceptions about Global Warming and Climate Change*, March 16, 2012 (17 attendees).
- Domec, J.C. *The effect of soil texture and nocturnal transpiration on root water uptake and consequences for the future carbon and water budgets of Southern U.S. pine plantations*, February 3, 2012 (25 attendees).
- Dwivedi, P. *Assessing impact of bioenergy production on the age structure of surrounding forest plantations*, July 27, 2012 (20 attendees).

- Grunwald, S. and B. Hoover. *TerraC/PINEMAP Data Res*ources, July 13, 2012 (20 attendees).
- Keim, B. (Louisiana State Climatologist) and R. Boyles. *Basic Climate Change Concepts and Definitions*, January 20, 2012 (21 attendees).
- Konrad, C. (Southeast Regional Climate Center). *Historical climatology and future projections in the Southeast U.S.*, April 20, 2012 (20 attendees).
- Monroe, M.C., D.C. Adams, and R. Plate. The Six Americas of Climate Change: Perceptions of Southeast Extension Professionals, August 17, 2012 (23 attendees).
- Zierden, D. (Florida State Climatologist). *The Drivers of Climate and Climate Variability*, February 17, 2012 (21 attendees).

Presentations

- Adams, D.C., M.C. Monroe, D. Wojcik, and R. Plate. *Extension Perceptions of Climate Change*. Livestock and Poultry Climate Change Adaption and Mitigation Workshop, Southeast Climate Consortium Meeting, Auburn, AL, April 9, 2012.
- Bardon, R., E.L. Taylor, W. Hubbard, and M. Bonham. *Where are we going with Technology Assisted Extension Programming: A Roundtable to Discuss the Future*. ANREP Biannual Conference, Hendersonville, NC, May 20-23, 2012 [poster].
- Boby, L.A. and W.G. Hubbard. *PINEMAP Overview*. Southern Group of State Foresters Meeting, Louisville, KY, June 13-15, 2012 (17 attendees).
- Boby, L.A. and W.G. Hubbard. *PINEMAP Overview*. Webinar meeting with state Extension foresters, February 7, 2012 (14 attendees).
- Boby, L.A. and W.G. Hubbard. *A Regional Approach to Climate Variability Extension Delivery*. Southeastern Society of American Foresters, Jekyll Island, GA, February 19-21, 2012 [poster].
- Boby, L. A. and W.G. Hubbard. *PINEMAP Overview*. Southern Regional Extension Forestry's Annual Unit Leaders Meeting, Athens, GA, February 23-24, 2012 (25 attendees).
- Boby, L.A. and W.G. Hubbard. *PINEMAP: Extension Delivery*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster] (80 attendees).
- Boby, L.A. and W.G. Hubbard. *PINEMAP: Extension Delivery*. ANREP Biannual Conference, Hendersonville, NC, May 20-23, 2012 [poster].
- Boyles, R. and H.A. Dinon. *PINEMAP Decision Support System (DSS).* PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 (80 attendees).
- Boyles, R. and H.A. Dinon. *PINEMAP Decision Support System (DSS) Group Activity.* PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 (80 attendees).
- Boyles, R. *Misconceptions about Global Warming and Climate Change.* Texas Annual Coop Meeting (WGFTIP) [online webinar] (40 attendees).
- Boyles, R. and H.A. Dinon. *Misconceptions about Global Warming and Climate Change*. Southern Region Extension Forestry Webinar, April 25, 2012 (210 attendees).

- Dinon, H.A., L.A. Boby, M.L. Bonham, G. Boyd, R. Boyles, W.G. Hubbard, J. Idassi, T. Martin, M.A. Megalos, M.C. Monroe, and E. Taylor. *A Regional Approach to Addressing Impacts of Climate Variability and Climate Change on Forest Production in the Southeast U.S.* Seventh Symposium on Policy and Socio-Economic Research as part of the 92nd American Meteorological Society Annual Meeting, New Orleans, LA, January 25, 2012 (50 attendees).
- Dinon, H.A., L.A. Boby, M.L. Bonham, G. Boyd, R. Boyles, W.G. Hubbard, J. Idassi, T. Martin, M.A. Megalos, M.C. Monroe, and E. Taylor. *PINEMAP: Progress and future plans*. Southeast Climate Consortium 2012 Spring Program Review, Auburn, AL, April 11, 2012 [poster].
- Embrey, M., R. Boyles, P. Knox, S. Schulze, and H.A. Dinon. *Climate Education Materials with Sector-Focused Context.* 21st Symposium on Education as part of the 92nd American Meteorological Society Annual Meeting, New Orleans, LA, January 24, 2012 (50 attendees).
- Hubbard, W.G., L.A. Boby, R. Sheridan, and S. Ashton. *Serving Today's Agents and the Forestry Community with eTechnology- A Summary of Southern Regional "eXtension" Forestry Activities*. University of Georgia, College of Agriculture Extension Winter Conference, Eatonton, GA, January 18-20, 2012 [poster].
- Hubbard, W.G. *Update on PINEMAP Activities*. Association of Southern Regional Extension Directors (ASRED), Nashville, TN, April 10, 2012 (20 attendees).
- Krantz, S., M C. Monroe, and W.-L. Bartels. *Climate change perceptions of Florida forest landowners*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster] (80 attendees).
- Krantz, S., M C. Monroe, and W.-L. Bartels. *Climate change perceptions of Florida forest landowners*. ANREP Biannual Conference, Hendersonville, NC, May 20-23, 2012 [poster].
- Megalos, M.A. *Variability in Climate: What Should Landowners Do?* Robeson County Landowners Association, Lumberton, NC, February 2, 2012 (18 attendees).
- Megalos, M.A. *Variability in Climate: What Should Landowners Do?* Cumberland County Landowners Association, Fayetteville, NC, February 12, 2012 (26 attendees).
- Megalos, M.A. *Introduction to Climate Vulnerability*. PINEMAP Online Graduate Class presentation, March 27, 2012 (28 attendees).
- Megalos, M.A. *Weather and climate variability: What should foresters do?* Southern Pines, NC Sandhills Society of American Foresters and Forestry Club, April 10, 2012 (36 attendees).
- Megalos, M.A. and H.A. Dinon. *How Do We Manage Risks Related to Extreme Weather? Introduction to Weather and Climate Change in North Carolina.* Harnett County Forestry Association, Lillington, NC, April 17, 2012 (18 attendees).
- Megalos, M.A. *Forest Climate Variability: What Should Landowners Do?* North Carolina Chapter of Association of Consulting Foresters, Holly Springs, NC, May 3, 2012 (50 attendees)
- Monroe, M.C., D.C. Adams, and D. Wojcik. *Southeast Extension Faculty Perceptions of Climate Change*. Forestry PINEMAP Webinar, February 7, 2012 (9 attendees).

- Monroe, M. C., D. C. Adams, R. Plate, and D. Wojcik. 2012. *The Six Americas of Climate Change: Perceptions of Southeast Extension Professionals*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster] (80 attendees).
- Monroe, M. C., D. C. Adams, R. Plate, and D. J. Wojcik. *Perceptions of climate change among southern Extension professionals: Survey results and a comparison to "Six Americas."* ANREP Biannual Conference, Hendersonville, NC, May 20-23, 2012 [concurrent session] (40 attendees).
- Monroe, M. C., D. C. Adams, R. Plate, and D. Wojcik. *The Six Americas of Climate Change: Perceptions of Southeast Extension Professionals*. Florida Extension Administration Meeting, Gainesville FL, June 14, 2012 [invited presentation] (15 attendees).
- Nielsen-Gammon, J. (Texas State Climatologist). *Weather Trends and Long Term Forecast.* Forest Pest Seminar, Lufkin, TX, February 10, 2012 (73 attendees).
- Nielsen-Gammon, J. (Texas State Climatologist). *Texas Drought; 2012 and Beyond.* Texas Society of American Foresters Annual Meeting, Huntsville, TX, April 18, 2012 (80 attendees).
- Taylor, E.L. *Climate Basics and Impact to Forest & Woodlands*. Master Naturalist, Gideon Lincecum Chapter, January 21, 2012 (67 attendees).
- Taylor, E.L. *Improving Forest and Woodlands Resiliency*. Master Naturalist, Gideon Lincecum Chapter, January 21, 2012 (67 attendees).
- Taylor, E.L. *Health and Vigor in Shade Trees and Woodlands*. Harrison County Landowners Meeting, January 24, 2012 (18 attendees).
- Taylor, E.L. *Strategies for Forest Management in Time of Pervasive Change*. Marion County Landowner Meeting, January 26, 2012 (21 attendees).
- Taylor, E.L. *Strategies for Forest Management in Times of Pervasive Change*. Forest Drought Symposium, Dibol, TX, February 8, 2012 (200 attendees).
- Taylor, E.L. *Forest Pest Application Safety*. Forest Pest Seminar, Lufkin, TX, February 10, 2012 (73 attendees).
- Taylor, E.L. *Stand Establishment Strategies in Light of an Uncertain Future*. Harrison County Landowner Meeting, Marshall, TX, February 17, 2012 (23 attendees).
- Taylor, E.L. *Improving Forest and Woodlands Resiliency*. Central Texas Forest, Woodland and Drought Meeting, Cat Springs, TX, February 25, 2012 (160 attendees).
- Taylor, E.L. *Strategies for Improving Forest Management in Time of Pervasive Change*. Smith County Farm and Ranch Meeting, Tyler, TX, March. 8, 2012 (18 attendees).
- Taylor, E.L. *Timber Management Strategies*. 1890's Small Scale Producer Conference, Texarkana, TX, April 26, 2012 (8 attendees).
- Taylor, E.L. M. Bonham, and Y. Li. *A Framework for the Economic Valuation of Forest Ecosystem Cultural Services in Texas*. ANREP Biannual Conference, Hendersonville, NC, May 20-23, 2012 [poster].
- Vuola, A.J. *North Carolina Cooperative Extension Perceptions and the Six Americas of Climate Change. Presentation to Atlantis Program faculty and students*. United States/Europe graduate Exchange Program, NC State University, Raleigh, NC, June 6, 2012 (30 participants).

- Vuola, A.J. *North Carolina Cooperative Extension Perceptions and the Six Americas of Climate Change*, Master's Thesis presentation to faculty and staff. North Carolina State University, Raleigh, NC, March 30, 2012 (20 attendees).
- Vuola, A.J. and M.A. Megalos. *Climate Variability Programming Limitations among north Carolina Cooperative Extension Professionals & North Carolina Cooperative extension Perceptions and the Six Americas of Climate Change*. PINEMAP Annual Meeting, Atlanta, GA, May 15-16, 2012 [poster] (80 attendees).

Meetings/Workshops/Courses

- Jennings, L.J., E. Taylor, V. Simone-Brown, H. Dinon, R. Boyles, E.A. Treasure, S.G. McNulty, M. Bonham, C. Liggett, M. Megalos, L.A. Boby, W.G. Hubbard, J.A. Moore Myers, R.L. Herring, D. Merriweather, P. Arndt, M. Monroe, and G. Boyd. *It's Getting Hot Out Here: An Interactive Workshop Focused on Communicating Climate Change for Natural Resource Professionals*. ANREP Biannual Conference, Hendersonville, NC, May 20-23, 2012 [concurrent session/workshop] (50 attendees).
  In this workshop, participants explored the daunting and divisive task of teaching about climate change, as well as the natural resource impacts of climate variability and tools that can be used to address its effects. As extension professionals, it is crucial that we incorporate the best science-based knowledge and understanding about all factors that impact natural resource management into our educational programs. Our goals for this workshop were comprehensive and included understanding taboos and barriers that make climate change conversation difficult; a primer on climate, climate variability, and climate change related to natural resource management; and management tools that will help natural resource managers deal with climate change effects.

- Taylor, E., W.G. Hubbard, M. Megalos, H.A. Dinon, L.A. Boby, and others. *CSI: Climate Science Initiative*. ANREP Biannual Conference, Hendersonville, NC, May 20-23, 2012 [concurrent session/workshop] (24 attendees).
  In this workshop, ANREP conference attendees with an interest in projects on climate change education and effects met to discuss efforts based on educating extension agents and the general public on the importance of climate science, climate change information, and strategies they (and we) can use to educate the public.

- We organized and implemented a forest landowner meeting in Tallahassee with county agent Stan Rosenthal, inviting 325 landowners in the five county regions currently on the Forest Stewardship mailing list. Fifteen landowners, 2 agents, 4 specialists, 2 staff, and 3 students attended. The Florida State Climatologist, David Zierden, oriented the group to climate change and seasonal variation due to El Niño and La Niña and responded to questions. Three University of Florida School of Forest Resources and Conservation professors provided short presentations connecting their work to climate changes and the panel responded to questions. Dr. Tim Martin (forest disturbance), Dr. Jason Smith (forest health), and Dr. Patrick Minogue (forest management) helped landowners think about management options that increase forest resilience given

expected fluctuations in precipitation and temperature and impacts such as wildfire and insect pests. A pre/post survey helped measure participants' opinions and interest in adopting management changes.

Experiments/Surveys/Data Collection

In 2011-2012, M.C. Monroe and D.C. Adams conducted a study of extension professionals in the southeast to assess their perceptions of climate change and global warming as 'Six Americas'. The survey included 2,418 responses from extension professionals in eight southern states. Results are being analyzed.

Milestones

Aim 1 (Silviculture and Ecophysiology)

Milestone: Tier 3 rainfall exclusion sites installed

The four Tier 3 (throughfall exclusion and fertilization) experiments were installed at sites in Taliaferro County, Georgia, Taylor County, Florida, McCurtain County, Oklahoma, and Buckingham County, Virginia. Throughfall diverters were completed, plots were fertilized, and sap flow gauges to measure evapotranspiration rates were installed at each site. Microclimate and sap flow data collection has been automated, and data are posted daily on a data web site. Initial soil sampling has been completed at all four of the sites. Studies of N_2O and NO_x emissions following nitrogen fertilization were established at a subset of the Tier 3 sites. Trace gas estimation for N_2O was completed 1 week prior to fertilization and 3 weeks and 8 weeks after fertilization; all gas samples have been analyzed.

Milestone: Finalize standardized measurement protocols

Standardized measurement protocols for tree core collection, soil sampling, and biomass sampling have been finalized and uploaded to the PINEMAP Intranet site where they will serve as a reference for field work on the Tier 2 and Tier 3 sites. In addition, protocols for separating heterotrophic (Rh) and autotrophic (Ra) components of soil respiration are being tested in order to determine the final methods that will be used in remainder of the project. Preliminary results on an ancillary research site where total soil CO_2 efflux was measured before and after root girdling using a 20 cm. pipe suggest that pipes installed in the spring (March-May) reduced total soil CO_2 efflux an average of 17% and that total soil CO_2 efflux during this period was correlated with microbial biomass carbon. Sampling protocols are being beta tested on Tier 2 sites currently being sampled and will be modified to fix any problems that we find.

In addition to progress on the milestones listed above, Aim 1 made progress on the Tier 1 (Legacy Experiments) and Tier 2 (Active Experiments) as described below.

Industry/University Cooperative Research installations have been identified for inclusion in the Tier 1 (Legacy Experiments) and archived data from these sites has been transferred to PINEMAP for uploading into the PINEMAP/TerraC database.

Industry/University Cooperative Research installations have been identified for inclusion in the Tier 2 (Active Experiments). Archived data from these sites has been transferred to PINEMAP for uploading into the PINEMAP/ TerraC database. Half of the sites have been selected where tree cores will be collected for $^{13}C/^{14}C$ analysis to determine water use efficiency. Field work to collect the tree cores and the inventory biomass samples started in June 2012, and the sites where samples will be collected in 2012, 2013, 2014, and 2015 have been identified.

Studies of N fertilizer uptake efficiency using ^{15}N labeled enhanced efficiency fertilizers were established at 28 sites associated with Tier 2 Active Experiments. Samples of ^{15}N in ecosystem components (trees, understory vegetation, forest floor, and soil) were collected and are being analyzed using Isotope-ratio mass spectrometry (IRMS).

Aim 2 (Modeling)

Milestone: Improved process and hybrid models parameterized from network measurements.

Several separate but integrated components and steps are required to fully complete this milestone. The published papers represent a compilation of component research progress in this area.

These individual papers are now being used as the base for synergistic discussions of model integration. The assessment of management and climate effects on loblolly pine C and H_2O budgets over a rotation cycle was completed using the Physiological Principles in Predicting Growth (3-PG) (Landsberg & Waring 1997) model and is reported in Bryars *et al.* 2012a and 2012b. An assessment of alternative methods for quantifying forest water use has also been completed and a paper has been accepted with minor revisions (Domec *et al.* 2012a).

Finally, to predict C pool dynamics for alternative land use, management, and climate scenarios at the stand level, we are exploring linking 3-PG and Century models to examine forest ecosystem carbon sequestration.

Aim 3 (Genetics)

Milestone: Version 1 of genetic deployment tool with provenance information

Texas A&M University is developing a Universal Response Function based on analysis of 73 tests of the Western Gulf Forest Tree Improvement Program Seed Source Study of 43 selected families (divided into two series). Initial analysis is focused on using 1) minimum winter temperatures and 2) summer heat/moisture index as dependent variables and height growth as the independent variable. All raw progeny test data from this study has been supplied to University of Florida for the Tier 1 database.

North Carolina State University is retrieving climate data for 19 field test sites of the Plantation Selection Seed Source Study for analysis with height growth data to create a Universal Response Function for the North Carolina State Cooperative Tree Improvement Program germplasm database. The growth data from these sites have also been provided for the Tier 1 database.

Milestone: Determine appropriate genome reduction methods for genotyping by sequencing.

Texas A&M University used the Agilent SureSelect Target Enrichment System to select exon regions in loblolly pine. 647,634 baits were designed using 35,550 unigenes and the Agilent's eArray software. The total capture library size was approximately 78 MB. Subsequently, genomic DNA of a haploid megagametophyte and a diploid embryo from the same seed from the reference tree 20-1010 were isolated. After fragmenting the total genomic DNA into 150 to 200 bp long fragments, two sequencing libraries were built, one from each source of genomic DNA, and then hybridized with the capture library. After hybridization, the captured DNA was isolated using magnetic beads and amplified with index primers. The amplified selected sequences are currently being sequenced using Hiseq 2000 sequencer.

North Carolina State University used a published a procedure for Genotyping-By-Sequencing using two restriction enzymes to fragment genomic DNA (Poland *et al*., PLoS One 7: e32253, 2012) to prepare DNA samples from two parents and 90 progeny of loblolly pine. The samples were submitted to a sequencing service provider, and results are expected by August 2012. A tissue storage solution has been developed and tested that allows collection of tissue samples in the field and storage at ambient temperature for days to weeks before DNA extraction, with good preservation of DNA quality.

Virginia Tech completed genome complexity reduction by the 'RAD-seq' approach for 10 haploid megagametophyte and two diploid needle samples, and the libraries are awaiting sequencing on an Illumina Hi-Seq instrument.

Aim 3 also made progress on a number of work plan tasks related to overall milestones as described below.

Task: Obtain appropriate weather data for each of the entries in the progeny test database.

Texas A&M University downloaded provisional weather data from NOAA National Climatic Data Center (http://www.ncdc.noaa.gov/cdo-web/search).

In collaboration with the TerraC database staff, North Carolina State University has defined GIS coordinates for test sites and county-level regions of interest defined and climate data has been recovered from the PRISM dataset for a subset of the locations of interest. Additional PRISM data will be retrieved to provide the complete dataset for future analyses; additional data retrievals will be made as alternate datasets become available.

Task: Reduction of genome complexity for generating molecular markers/gene discovery

1. Texas A&M University :
    a. Sequence data captured through the SureSelect enrichment process have been retrieved. The procedure will be evaluated for effectiveness and efficiency and metrics tabulated for comparison to other techniques under development by the group. The sequences will be assembled into contigs and mapped to the unigenes, and then SNP discoveries will be conducted. We will try to identify alleles in adaptive trait related genes that could be involved in response to climate change via association mapping.
    b. Foliage samples will be collected from the ADEPT II population located at the Harrison Experimental Forest, Southern Institute of Forest Genetics. DNA extraction will begin as time allows. This will support gene discovery through the analysis of the geographical distribution of alleles.
2. Virginia Tech: Results from the RAD-seq libraries are available as of August 2012, at which time we will align them to the reference genome and assess various parameters such as depth of coverage, coverage heterogeneity, missing data, etc. These data will be integrated with those from other genetics groups to determine the relative merits and drawbacks of each technique and to identify one or more that will be used in the various trials to be genotyped across the southeast.
3. North Carolina State University: The protocol reported by Elshire *et al.* was tested with loblolly pine samples in a preliminary experiment conducted by Will Kohlway and Ross Whetten between January and March 2012. The analytical software of Elshire *et al.* was used to analyze the preliminary data, and results of this analysis were presented at the PINEMAP annual meeting and reported to stakeholders at the Advisory Board Meeting of the North Carolina State Cooperative Tree Improvement Program. The reproducibility of genotyping the same loci in multiple individuals was too low in this preliminary experiment to provide confidence in the technique. A second trial was conducted using the modified protocol reported by Poland *et al.* Data analysis of those results will use both the software described by Elshire *et al.* and new software described by Peterson *et al.* (PLoS One 7:e37135, 2012), which is reported to have some advantages. Identified genetic loci will be compared to the draft loblolly pine reference genome assembly produced by the PineRefSeq genome sequencing project to determine the extent to which the GBS marker loci are located in or near genes identified by the genome sequencing project.

Aim 4 (Economics and Policy)

Milestone: Assess policies and programs that may affect C mitigation in planted pine forests

We have completed a draft summary of market-based programs and policies that are likely to impact C mitigation and have started work summarizing federal and state programs and policies.

Milestone: Regional market impacts based on business-as-usual assumptions

We have assessed the effect of bioenergy demands and supply response on markets, carbon, and land use in a three-state region. BAU and biomass demand scenarios were evaluated for AL, FL, and GA. The findings have been accepted for publication in *Forest Science*.

Milestone: NPV analysis & regional market impacts of adaptation strategies

We have developed the potential future productivity scenarios in light of climate change. In addition, we have defined some mitigation strategies to reduce the negatives effects of disturbances and climate variations (if applicable) on forest productivity. Such strategies could be incorporated into forest management practices.

Milestone: Document landowner adoption of mitigation and adaptation strategies

We have completed a first wave of surveys to estimate willingness to accept carbon offset payments by non-industrial private forest landowners in the Southeast.

Milestone: NPV & regional market impacts of altered disturbance risks

We will use the Reed model to quantify the effect of expected increased disturbances due to climate change on the economic rents for nonindustrial private forest landowners. Current rates of returns of wildfires, storms, and pest outbreaks will be increased and compared to current levels to determine the impact on profitability of forestlands.

Aim 4 also made progress on a number of work plan tasks related to overall milestones as described below.

Task: Develop and validate herbaceous richness model

We have developed a model to predict forest understory herbaceous richness using the existing literature and available USDA Forest Service Forest Inventory and Analysis Data. The model has been validated using an independent data set from pine flatwood sites in Georgia and Florida. Validation statistic such as mean prediction error, percentage error, and mean absolute difference have been used to assess model predictions. The manuscript describing this model will be submitted to the *Journal of Forestry*.

Task: Complete the assessment of implications of carbon sequestration on economic rents for southern forestland owners

We have completed the first draft of a manuscript in which we developed an economic model that incorporates the effect of fluctuating carbon prices, conversion factors to forest products, and proportion of wood that permanently sequester carbon on optimal harvest decision of southern pines.

Task: Conduct trade-off analysis and optimization

We are finalizing a literature review on genetic algorithm methods and the interactions among ecosystem services, specifically biodiversity (i.e. species richness), carbon storage and timber production in forested ecosystems of Florida's coastal plain. Results will be used to develop tradeoff analyses for ecosystem services and optimization of management regimes/ecosystem service provision scenarios using genetic algorithms.

Aim 5 (Education)

Milestone: Report of audience assessment for PLT module

An online survey was developed and pilot tested in SurveyMonkey®. Based on comments and pilot test results from 14 educators and 7 curriculum or climate experts, the 28-question survey was revised to improve clarity, reduce length, and include appropriate wording. Invitations to complete the survey were distributed through 13 email lists of science coordinators and teachers from April 30 through July 8, 2012. Because we did not have access to the email lists, it is not possible to know the population size or to assess non-response bias. This is a significant limitation to generalizing these results to the population of secondary science educators. We suspect that the results over-report educators who are interested in teaching about climate because of their interest in responding to the survey. The findings are useful, however, in guiding the development of the curriculum, since we want to learn what teachers who might use these materials will find helpful.

A total of 746 surveys were received; 675 of those were fully completed. Most respondents teach 11th and 12th grades (61% each); 57% teach 10th graders and 48% teach 9th graders. As with the Wise study (2010), fewer middle school teachers responded; 16%, 21%, and 21% teach 6th, 7th, or 8th grades, respectively. More than 75% of the respondents came from FL, NC, OK, and VA with the remainder from AL, AR, LA, SC, and TX. Most respondents (77%) already cover climate change in their secondary science courses. In agriculture, chemistry, and physical science courses, the largest percentage of respondents do so with informal discussions. Planned lessons lasting one week or less are used by the largest percentage of respondents teaching biology, AP biology, earth science, integrated science, and marine science. Teachers use planned lessons lasting more than a week in ecology, environmental issues, environmental science, and AP environmental science classes. A large majority (82%) of the respondents are interested in continuing to cover climate change in future courses.

Only 2% of respondents believe they have little understanding of the issue; 28% report having a basic understanding; 46% have a moderate understanding; and 24% report having a detailed understanding. Because some students and parents may disagree with climate change science, only 37% of the respondents are very comfortable teaching about climate change; 35% are somewhat comfortable, 15% are neutral, 9% are somewhat uncomfortable, and 5% are very uncomfortable.

Regarding teaching strategies, over 85% of the respondents believe it is appropriate or very appropriate to: explain scientific uncertainty; present the rationale for how people interpret climate change differently; discuss advantages and disadvantages of climate related policies, and discuss the history of climate change science. One item—presenting all perspectives as valid—evoked the greatest disagreement, with 36% viewing this strategy is very inappropriate or inappropriate and 41% as appropriate or very appropriate.
Just over half of the respondents are most interested in covering climate change impacts related to their local area (50.5%), their state (54%), and the nation (50%). Most, however, would like to cover climate change as it relates to the world (81%).

All of the supplemental resources listed in the survey will be very useful to the largest percentage of respondents with hands-on student activities (80%) and lab exercises (76%) collecting the most votes. Background information, data sets to analyze, short videos of scientists, and photographs were also marked as very useful resources.
It is very or somewhat important to the largest percentage of respondents for the module to help them meet the following goals:

Connecting science to students' everyday lives	98%
Emphasizing critical thinking	98%
Developing data analysis skills	94%
Emphasizing choices that affect sustainability	92%
Emphasizing systems thinking	92%
Enabling students to use technology	88%
Connecting science issues with policy	83%
Exploring careers	83%
Building group skills	82%
Implementing action projects	74%
Teaching about technology	72%

Comparing the responses of biology (n=246), AP biology (n=57), environmental science (n=138), AP environmental science (n=108), and agriculture (n=131) teachers highlighted several significant differences among teachers. Regarding self-reported level of knowledge, about 80% of the biology and AP biology teachers and 90% of the environmental science and AP environmental science claim to have a moderate or detailed knowledge of climate change; only 50% of the agriculture respondents make the same claim (Figure 1, $p<0.01$). Similarly, where 80% of the biology and environmental science teachers (regular and AP) are somewhat to very comfortable teaching about climate change, only 54% of agriculture educators are ($p<0.01$). Responding to the question "at what scale would you like to teach about climate?" agriculture educators had no strong preference, considering the state level to be slightly more interesting than the world. All others strongly favored the world scale over local, state, regional, and national levels.

These results suggest that life science and environmental science educators in the southeastern U.S. could be interested and willing to teach about climate and climate change in their high school classes. These respondents are willing to address multiple perspectives through the lens of science, allowing students to critique the data and come to their own conclusions. Lesson

plans that actively engage students in exploring the concepts are desired. Since these respondents are likely more knowledgeable and interested in teaching about climate, new resources should provide sufficient background information as well as data sets and sample discussion questions to assist teachers who are less familiar with the topic. Despite the media-based rhetoric about conveying all perspectives as valid, these respondents are comfortable standing on the science.

These results do not speak for all teachers, however. Those teaching agriculture were less willing to teach about climate change and less knowledgeable. Much like the general population, there are a variety of opinions among educators, and resources developed for educators need to be cognizant of this diversity of perspectives.

Milestone: Web-based course in multidisciplinary research for graduate students completed

A distance graduate course, *Climate and Forests*, was launched in the spring of 2012. The course goals were to: 1) prepare graduate students to address climate change mitigation and adaptation issues in southern pine forests; 2) facilitate greater levels of integration by encouraging students to engage in processes designed to enhance communication, cooperation, and collaboration among disciplines and across research, education, and Extension functions; and 3) build interdisciplinary research, education, and outreach capacity. Twenty-two students (16 Ph.D. and 6 M.S.) from 8 southeastern universities participated in the course, and an interdisciplinary team of 15 PINEMAP faculty members assisted with course instruction.

Students registered for 2 credits of independent study or special topics at their home institution. All course materials (readings, archived webinars, online discussion threads, and additional resources) were hosted on a course web site, the PINEMAP Education Portal. Throughout the semester, students participated in live webinars and reviewed narrated PowerPoint presentations covering topics including impact of climate change on forest ecosystems, climate model projections in the southern U.S., southern forest futures, carbon scoring and policy, Extension programming, challenges to communicating about climate, decision support system, and interdisciplinary research. In addition, students completed readings related to each topic and participated in online discussion.

Students completed two group assignments during the course. For the research assignment, students in each PINEMAP Aim group worked with a faculty member to understand their research foundations and questions. In working with fellow students and faculty in their disciplines, students learned about existing disciplinary knowledge, why research is proposed, and what questions the research is designed to answer. Student groups developed presentations to explain their Aim research to the other students. All students reviewed other groups' presentations and answered questions during a live webinar. For the interdisciplinary outreach assignment, students worked in groups to develop an extension product (fact sheet, web site, presentation, or action plan) for a target audience (limited resource landowner, private landowner, industrial/corporate landowner, or state forest agency) on the topic of southern pine forest vulnerability to climate change or management practices to enhance

forest resilience. Groups created an evaluation form, sent their product to a team of reviewers, synthesized evaluation comments, and presented a brief report on their product and what they learned from this experience.

At the conclusion of the course, students completed an online evaluation survey and offered feedback on a webinar. Twenty students completed the survey which included 14 questions (3 closed-ended and 11 open-ended). Furthermore, a discussion activity regarding the course was conducted at the 2012 annual meeting to garner additional feedback from graduate students, faculty, postdocs, and staff.

Quantitative survey responses indicate that the course did a fairly good job at facilitating learning about climate change in the Southeast and climate change mitigation and adaptation in southern pine forests. Respondents also indicated that the course did a fairly good job at instilling a better understanding of integration among the PINEMAP Aims. Students indicated that the course aided them in better understanding PINEMAP objectives and strategies, and the majority of students felt that the course content was well organized. In addition, respondents indicated that the assignments were effective mechanisms for learning about Aim research goals and about Extension product development.

Qualitative responses gathered from the survey and the annual meeting activity indicate that students enjoyed interacting, collaborating, communicating with, and getting to know other graduate students and found that the course provided a great deal of useful information. Students thoroughly enjoyed the presentations and felt that they were informative and that the speakers were knowledgeable. The course could do better at promoting discussion, both online prior to the webinars and also during live webinars.

Students also indicated that the workload may have been too much for a 2-credit course and that some readings should be designated as supplemental. Students and faculty indicated that there needs to be more uniformity in grading—all students should receive a letter grade and there should be a standardized system for assigning grades. Students thought the assignments were useful but consistently noted that distance group work is difficult and tedious. Students also indicated that more detail and direction for assignment 2 would be helpful and make the assignment more useful.

Students and faculty alike overwhelmingly agree that the course should be conducted in subsequent years of the project. We will utilize the evaluation results to: 1) guide revisions to the course structure and format for a two-credit graded course; 2) revise assignments to provide better detail and instructions as well as opportunity for feedback, and 3) review assigned readings. In addition, we will work closely with course instructors to clearly explain their role in the course. We will ask instructors to be engaged in online discussion during their topic week and to develop specific points/questions to guide student discussion and input.

Milestone: Undergraduate research internships completed

Undergraduate interns relocated to their mentors' host universities in mid- to late-May and will remain at host universities throughout the course of the 12 week internships. After internships conclude in early August, students will return to their home universities to participate in the fall teaching and communication distance course. The syllabus for the undergraduate teaching and communication course was completed in June. Other course materials such as assignment handouts and class notes are being drafted and finalized.

Aim 6 (Extension)

Milestone: Implement and strengthen forestry Extension/climatologist partnership.

Aim 6 has identified three strategies within this milestone (local training, climate expertise to support research, and integrating climate and forestry research with extension expertise). Progress on these items is described below.

1. Local training: State climatologists have been approached singly and as a group and invited to become members of the PINEMAP delivery teams to help plan and execute local workshops and distance education training programs. Additionally, Aim 6 members have established individual relationships with their respective state climatologists and engaged with them on development of workshops as well as the review of materials. A conference call with the state extension team was held in February 2012. Another round of joint calls between the two groups is being planned for August 2012.
2. Climate expertise to support research: Aim 6 members have surveyed climatologists to learn more about their backgrounds and specialties and to use them as resources for PINEMAP research and products.
3. Integrating climate and forestry research with extension expertise: AIM 6 members (including climatologists) are developing the Decision Support System (DSS) to utilize climate and forestry data, including PINEMAP research for dissemination. This DSS will utilize climate and forestry research and use an extension approach to reach stakeholders and design a user-friendly interface.

Milestone: Audience needs assessments

Audience needs assessments are critical for better understanding stakeholders themselves as well as determining their needs and, thus, the direction of PINEMAP extension programs and products.

- Extension staff: Aim 6 staff conducted an audience assessment survey of all Extension staff throughout 8 states in the southeastern U.S. This survey was designed to determine attitudes, beliefs, practices, and interest in global warming and climate change programs and programming. Results of that survey have been presented at many regional and national conferences as summarized in the "Outputs" section of this report.

- Forestry Professionals: Aim 6 recently completed the development of a survey instrument for professional foresters (includes consulting foresters, extension foresters and others); the survey will be distributed in the next few months. This needs assessment will examine forester and natural resource professionals' needs for continuing education programs on increasing forest productivity (particularly pine plantation productivity) and resilience to extreme weather, climate variability, and climate change. Specifically, participants will be questioned on their personal experiences and understanding of current and future effects of climate change on forestry management. Questions also aim to glean attitudes and knowledge about climate change, climate variability, etc., with a focus toward developing the best approach for meeting perceived and actual needs. We will also query professionals on climate resiliency and forest "weather-proofing" areas they are interested in learning more about.

- The Aim 6 team also recently deployed the Texas FRESH (Forest Resources, Ecosystem Services and Health) survey, both in hard copy and web versions. The intent of the survey is to get a better feel for the benefits that Texans associate with forests and eventually use this data to support incentive programs to improve the management of Texas forests and woodlands. Data will be collected and analyzed in the second half of 2012. Analyzed data from this survey will be used to direct and support PINEMAP outreach programs.

Milestone: Extension programs delivered

Numerous fact sheets are currently in draft form with expected publication in the second half of this year. Fact sheet review guidelines have been established and will be used to vet all PINEMAP publications. Additionally, official formats and templates for PINEMAP factsheets have been selected. All publications will be submitted to the Climate, Forest and Woodlands Community of Practice on eXtension. Web-based climate education materials are being adapted for forestry, with a goal of creating a certificate program through another agency (such as Society of American Foresters) in Climate Smart Forest Management. Contextual examples are being developed for the topics that are most important to our target audience(s). We are also planning four regional workshops on forest resiliency which will incorporate PINEMAP information and will be supportive of PINEMAP goals. We will include feedback from completed audience assessments and evaluations as we continue to develop these workshops and more extension programs.

Milestone: Extension programs evaluated

It is important to develop evaluation instruments that will be used across the region to provide consistency with questions asked, etc. The following survey items are currently under development.

- Retrospective Post – Family Forest Landowners: This retrospective-post evaluation allows the host to select/modify the types of question asked depending upon the topics of the training event.

- Retrospective Post – Natural Resource Manager: This survey allows respondents to select questions from a pool of allowable questions designed to measure the impact of PINEMAP outreach programs.
- Follow-up surveys for family forest landowners and natural resource managers are also under development.

Milestone: Decision Support System development

A subcommittee composed of at least one PINEMAP member from each Aim has been developed to provide guidance on the Decision Support System (DSS). So far, this subcommittee has provided a list of existing tools and inputs/outputs from each aim that are relevant to/will be useful for the DSS. A presentation and group activity at the annual meeting identified different ideas for the design of the DSS. Meetings with the DSS subcommittee will continue on a bi-monthly basis.

Broad Impacts

Aim 1 (Silviculture and Ecophysiology)

The Forest Productivity Cooperative and PINEMAP organized a workshop for forest industry on the effects of drought on the growth and productivity of loblolly pine in the Western Gulf region of the South. The workshop presented data from empirical field trials that are part of the Tier 2 network, remote sensing approaches, and process modeling. This workshop was attended by over 75 industry foresters. This workshop demonstrated the key role that the field trial network established by PINEMAP coupled with the modeling work of PINEMAP has on our ability to understand the impacts of climate variability on growth and sustainable management of loblolly pine.

Aim 2 (Modeling)

Many agencies (e.g. EPA, USGS, and USDA Forest Service) would like to be able to better quantify carbon sequestration estimates and projections. The PINEMAP Aim 2 modelers are receiving queries about the extent and timing of model outputs. Although the exact use of these deliverables is not yet clear, agency interest appears to be increasing. We are also collaborating with NASA Ames on regional modeling using the NASA Earth Exchange.

Aim 3 (Genetics)

The PineRefSeq CAP funded to obtain reference genome sequences for loblolly pine, sugar pine, and Douglas fir has been generous in releasing a draft loblolly pine genome sequence assembly for use in analysis of genotyping data generated by PINEMAP. PINEMAP researchers will continue to collaborate with the PineRefSeq project team to coordinate storage and analysis of genotype and phenotype data obtained during the PINEMAP project, with the objective of helping to evaluate and improve the reference genome assembly produced by the PineRefSeq

project and provide additional genotypic data sampled from a diverse set of loblolly pine genotypes.

Contact is continuing between PINEMAP (represented by Ross Whetten, North Carolina State University) and FoResTTraC, a European Union project to develop coordinated research plans to study adaptation of forest trees to climate change. The name is an acronym for "Forest ecosystem genomics Research: supporTing Transatlantic Cooperation", and the objective is to coordinate activities among North American and European researchers in the fields of ecology, genetics, genomics, and evolution of forest trees. More information about FoResTTraC is available at http://www.foresttrac.eu/.

Aim 4 (Economics and Policy)

The work on the EPA Biogenic Carbon Science Advisory Board has allowed PINEMAP Co-PI Bob Abt to interact with a national group of experts and point out the importance of regional variation in markets and growth rates on the carbon consequences of using wood for energy. Active southern markets and fast plantation growth give the South a significant carbon advantage when bioenergy demand affects prices.

As forest ecosystems are being managed for multiple uses, there is a need to assess trade-offs or interactions between different ecosystem services and the influence of management regimes. Although most forest inventory data provide various tree-level parameters, they often do not provide information on understory characteristics. Biodiversity conservation, forest management, wildlife habitat analyses, and invasive species management require that we provide information on understory characteristics using existing spatial and biometric data. Our species richness model can provide a tool for managers and landowners to estimate understory herbaceous richness using available forest inventory data and can be used to analyze trade-offs among ecosystem services provided by forests.

Aim 5 (Education)

The needs assessment with high school teachers has generated interest in pilot testing the new climate change activities. We have a list of 29 volunteers who have expressed interest in the materials. The PINEMAP graduate students have expressed interest in taking additional courses offered at other universities within the project, which could challenge our institutions to allow an "exchange student" option for federally-funded multi-institution students on assistantships. Students have also offered to assist incoming graduate students with course assignments, building a more cohesive network of students.

Aim 6 (Extension)

The work of Aim 6 necessitates cultivating contacts and collaborations with outside entities in order to be successful. To this end, some of our outreach efforts are targeted towards state level forestry extension personnel who can link us with stakeholders (i.e. forest landowners,

industrial forestry members, and county level Extension agents). Aim 6 is already using the traditional forestry extension networks to reach our stakeholders, but beyond this, we have developed new contacts and collaborations through working with state climatologists and interacting with ANREP members, as well as potential regional advisory board members. Aim 6 members are partnering with other forestry extension professionals to implement a web-based 5 class series, "Natural Resources Opportunities For Landowners," which will focus on the basics of natural resources and private land and serve as an introductory course to "Master Tree Farmers," a more intensive course on forestry techniques for the private landowner.

Presentations and discussions by Martha Monroe of the results of the Six America's survey of Southeast Extension Professionals has generated interest among state leadership in Florida and Pennsylvania to carefully consider how to organize in-service training and deliver programs on climate change, and is also being used in the Association of Natural Resource Professionals (ANREP)'s Climate Science Initiative.

Training

The following lists summarize graduate students and technical staff involved in PINEMAP research.

Aim 1 (Silviculture and Ecophysiology)

- Madison Akers, Research Coordinator, University of Georgia. Madison is coordinating baseline measurements on Tier 2 sites and overseeing installation and data collection on the Georgia Tier 3 site.
- Tim Albaugh, Research Associate, North Carolina State University. Tim is evaluating impacts of weed control and fertilization on loblolly pine using the 3-PG model.
- Jose Alvarez, Postdoctoral Associate, North Carolina State University. Dr. Alvarez is evaluating changes in loblolly pine leaf area due to silvicultural treatments as a component of the 3-PG model.
- Stan Bartkowiak, M.S. student, Auburn University. Stan is measuring water fluxes at Tier 3 sites and developing improved methods to evaluate stomatal response to update 3-PG.
- Joe Clark, M.S. student, Auburn University. Joe is assessing relationships among intercepted radiation, LAI, photosynthetic capacity, phenology, and productivity in loblolly pine.
- Andrew Faison, Undergraduate Intern, Virginia State University. Andrew is assisting Jay Raymond at Virginia Tech with investigating the mechanisms of nitrogen dynamics and uptake efficiencies of N containing fertilizers in loblolly pine plantations using stable isotope (^{15}N) techniques.
- Sam Frye, Research Technician, Virginia Tech. Sam is assisting with soil CO_2 efflux and N_2O measurements and installation and data collection on Tier 2 and Tier 3 sites.
- Bethany Gregory, Undergraduate Intern, Virginia Tech. Bethany is helping Andy Laviner with a study on environmental manipulation of fertilization, drought, and thinning in loblolly pine plantations.

- Amanda Hancock, Undergraduate Assistant, Texas A&M University. Amanda is assisting with carbon monitoring protocol implementation for Tier 2 sites.
- Brett Heim, M.S. student, Virginia Tech. Brett's research focus is separating heterotrophic and autotrophic respiration components of soil CO_2 efflux.
- Rebecca Jarvis, Undergraduate Intern, Virginia Tech. Rebecca is assisting Wen Lin at North Carolina State University with quantifying the growth rate of loblolly pine and analyzing its sensitivity to temperature and precipitation dynamics.
- Will Kennerly, Undergraduate Intern, Virginia Tech. Will is assisting Brett Heim with experimental manipulations of belowground metabolic activity in order to separate microbial respiration from plant respiration.
- Andy Laviner, Research Coordinator, Ph.D. student, Virginia Tech. Andy is coordinating baseline measurements on Tier 2 sites and overseeing installation and data collection on the Virginia Tier 3 site; his research focus is water use efficiency in loblolly pine.
- Wen Lin, Ph.D. student, North Carolina State University. Wen's research focus is water use efficiency in loblolly pine using $^{12}C/^{13}C$ ratios in wood.
- Geoffrey Lokuta, Research Coordinator, University of Florida. Geoff is coordinating baseline measurements on Tier 2 sites and overseeing installation and data collection on the Florida Tier 3 site.
- Cody Luedtke, Ph.D. student, University of Georgia. Cody's research focus is soil CO_2 efflux.
- Adam Maggard, Ph.D. student, Oklahoma State University. Adam's research focus is ecophysiology on Tier 2 and Tier 3 sites.
- Casey Meek, Research Associate, Oklahoma State University. Casey is assisting with ecophysiological and process measurements on Tier 2 and Tier 3 sites.
- Greg Nagel, Undergraduate Assistant, Texas A&M University. Greg is assisting with carbon monitoring protocol implementation for Tier 2 sites.
- Josh Parisher, Undergraduate Assistant, Texas A&M University. Josh is assisting with carbon monitoring protocol implementation for Tier 2 sites.
- Jason Pike, Research Technician, Oklahoma State University. Jason is assisting with installation, maintenance, and data collection on Tier 3 sites.
- Jill Qi, Ph.D. student, University of Georgia. Jill's research focus is soil water and deep soil carbon responses under rain throughfall treatment at Tier 3 sites.
- Jay Raymond, Ph.D. student, Virginia Tech. Jay's research focus is N uptake efficiency of enhanced efficiency N fertilizers using ^{15}N stable isotopes.
- Rachel Ryland, Summer Undergraduate Research Assistant. Rachel has received training in field sampling of trace gases at the Georgia Tier 3 installation and has been trained in laboratory techniques for soil gas analysis on the gas chromatograph.
- Charles Allen Sherrod, Summer Undergraduate Research Assistant. Allen has received training in field sampling of soil at the Georgia Tier 3 installation and has been trained in laboratory techniques for soil sample preparation and analysis.
- Elaine Stebler, Research Technician, Oklahoma State University. Elaine is coordinating baseline measurements on Tier 2 sites and overseeing installation and data collection on the Oklahoma Tier 3 site.

- Tom Stokes, Research Associate, Auburn University. Tom is assisting with installation and data collection on Tier 2 and Tier 3 sites.
- Santosh Subedi, Ph.D. student, Virginia Tech. Santosh's research focus is identifying an improved method to determine fertility rating for 3-PG.
- Maxwell Wightman, M.S. student, University of Florida. Max's research focus is ecophysiology of drought response on the Florida Tier 3 site.
- Madison Wigley, Undergraduate Assistant, Texas A&M University. Madison is assisting with carbon monitoring protocol implementation for Tier 2 sites.
- Elizabeth Wilson, M.S. student Texas A&M University. Elizabeth is measuring plant physiological responses to climate manipulations (rainfall exclusion) at the Tier 3 site in Oklahoma.
- Lu Zhai, Ph.D. student, Texas A&M University. Lu's research focus is family and culture effects on ecosystem C and N dynamics.
- Yang Zhang, Ph.D. student, Texas A&M University. Yang's research focus is carbon and nitrogen cycling response to drought at the Oklahoma Tier 3 site.

Aim 2 (Modeling)

- Ranjith Gopalakrishnan, Ph.D. student, Virginia Tech. Ranjith is downloading and reformatting the NARCCAP scenarios for key climate variables from six models (GCM/RCM combinations).
- Nabin Gyawali, Ph.D. student, Virginia Tech. Nabin is utilizing Tier 1 data to develop a growth and yield model flexible enough to allow modification in diameter, height, and mortality at tree- and stand-level for diverse genotypes and silvicultural practices under varying conditions.
- Risa Patarasuk, GIS Specialist, University of Florida. Risa is working on reprojections, extractions, and consolidation of various spatial data sets for regionwide modeling.
- C. Wade Ross, Ph.D. student, University of Florida. Wade is investigating soil carbon dynamics along hydrology and fire regimes in southern pine ecosystems, as well as the effects of fire disturbance on the structure and function of soil carbon dynamics in pine and wetland ecosystems and developing a mechanistic model to upscale site specific findings to the regional scale.
- Maggie Wang, Ph.D. student, University of Georgia. Maggie is 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.
- Eric Ward, Postdoctoral Associate, North Carolina State University. Dr. Ward is 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 3 site.

Aim 3 (Genetics)

- Rajesh Bawa, Ph.D. student, Virginia Tech. Rajesh is 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.
- Alfredo Farjat, Ph.D. student, North Carolina State University. Alfredo is carrying out joint analysis of progeny test data and climate data for the Cooperative Tree Improvement Program.
- Tomasz Koralewski, Postdoctoral Associate, Texas A&M University. Dr. Koralewski is building a location database for the progeny tests and the parents represented in those progeny tests that can be linked to climatic data. This database will form the backbone of the URF analysis to optimize seedling deployment.
- Mengmeng Lu, Ph.D. student, Texas A&M University. Mengmeng is evaluating efficiency of Aglient SureSelect target gene enrichment system for Illumina GAII and HiSeq high-probe design using the Agilent eArray tool and the most recent and comprehensive unigene set consisting of 42077 sequences representing individual genes expressed in loblolly pine.
- Will Kohlway and Ben Rusche, Undergraduate Student Research Interns, North Carolina State University. Will and Ben are working on pilot scale experiments to test genotyping-by-sequencing as a cost-effective means of genotyping the experimental populations.
- Laura Townsend, M.S. student, North Carolina State University. Laura's research focus is genetic variation in loblolly pine for adaptability to climate variables.
- Jianxing Zhang, Ph.D. student, University of Florida. Jianxing is 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)

- Ernest Dixon, M.S. student, North Carolina State University. Ernest has split responsibilities between Aim 3 (genetics) and Aim 4; he is involved in discussions on market and valuation issues in estimating the benefits of genetic gain or reduction in variability. In 2012, Ernest completed a significant portion of his coursework and is currently developing a real options approach to value the flexibility inherent in genetics geared toward reducing risk from climate change.
- Puneet Dwivedi, Postdoctoral Associate, Yale University. Dr. Dwivedi is 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.
- Puskar Khanal, Ph.D. student, Mississippi State University. Puskar's primary research focus is 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.

- Melissa Kreye, Ph.D. student, University of Florida. Melissa 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.
- Jose Soto, Ph.D. student, University of Florida. Jose is assessing and summarizing competing programs and policies that incentivize carbon sequestration at the local, state, national, and international level. He has also developed, pre-tested, and implemented a survey of non-industrial private forest landowners to determine their willingness to accept payments for carbon offsets based on offset program characteristics. Results of this work will be used to predict participation rates in programs that incentivize changes in land use that increase carbon sequestration and will be integrated in a bioeconomic model of non-market ecosystem services produced under competing approaches for climate change adaptation and mitigation.
- Justin Soto, Undergraduate Intern, University of Florida. Justin is assisting with assessment of the economic value of forest-based ecosystem services under alternative management and policy regimes.
- Andres Susaeta, Postdoctoral Associate, University of Florida. Dr. Susaeta has primarily been involved in developing a forest stand-level model to assess expected economic rents for forest landowners under hurricane risks associated with future climate change conditions. He has also played a 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.
- Nilesh Timilsina, Postdoctoral Associate, University of Florida. Dr. Timilsina is working on assessing the interactions between different ecosystem services in pine flatwoods and optimizing modeling to maximize a particular ecosystem service and asses the tradeoff of the others.

Aim 5 (Education)

- Paul Decker, Undergraduate Intern from Virginia Tech. Paul is working with Stephanie Hall at the University of Florida to investigate how to teach high school students about controversial topics such as climate change.
- Stephanie Hall, M.S. student, University of Florida. Stephanie is helping to develop and pilot test activities for the PLT/PINEMAP Secondary Module and will conduct research on how to best introduce potentially divisive and contested concepts in secondary school curricula.
- John Kidd, Undergraduate Intern Program Coordinator, Virginia Tech. John is 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.
- Annie Oxarart, Environmental Education Program Coordinator, University of Florida. Annie is 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.

- Richard Plate, Postdoctoral Associate, University of Florida. Dr. Plate is assisting with the development and evaluation of activities for the PLT/PINEMAP Secondary Module and analyzing needs assessment data.

Aim 6 (Extension)

- Leslie Boby, Extension Associate, Southern Regional Extension Forestry. Leslie is assisting 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.
- Rachel Burnett, Graduate Research Assistant, North Carolina State University. Rachel is assisting with reviewing fact sheets and other PINEMAP-related publications.
- Hilary Cole, Graduate Research Assistant, North Carolina State University. Hilary is serving as a copy editor for factsheets and other PINEMAP-related publications. She is also providing guidance with contextual examples for the climate education materials in collaboration with the State Climate Office of NC.
- Heather Dinon, Applied Climatologist, State Climate Office of North Carolina. Heather is facilitating 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.
- Anslei Foster, Graduate student, North Carolina A&T University. Anslei is working on factsheets and publications for PINEMAP.
- Shelby Krantz, Undergraduate IFAS Research Intern, University of Florida. Shelby 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.
- Charlie O'Connell, Undergraduate Research Assistant, North Carolina State University/State Climate Office of NC. Charlie is reviewing the climate education materials for forestry as well as developing a tool for forestry professionals across the southern U.S. which displays historical temperature, precipitation, and drought indices.
- Richard Plate, Postdoctoral Associate, University of Florida. Dr. Plate is assisting with data analysis for the Extension climate perceptions survey.
- Christina Temple, M.S. candidate, North Carolina State University. Christina is developing two fact sheets on adaptation related to forest pests and invasive species.
- Aaron Vuola, M.S. candidate, North Carolina State University. Aaron graduated in May 2012 and is in the process of drafting two publications over the summer from his thesis work.
- Tiffany Williams, Research Assistant, Southern Regional Extension Forestry. Tiffany is developing a comprehensive list of climate education materials across the southern U.S.

- Deborah Wojcik, Postdoctoral Associate, University of Florida. Dr. Wojcik is assisting with survey development and data analysis for the Extension climate perceptions survey. Dr. Wojcik helped develop the Six Americas survey for Southeast Extension Professionals and is writing one article.

Concluding Statement

The southern pine ecosystem is one of the most widespread, economically and ecologically important forest ecosystems in North America. The PINEMAP project is working to integrate key research, education, and outreach networks to create and disseminate the knowledge that enables landowners to: harness planted pine forest productivity to mitigate atmospheric CO_2; more efficiently use nitrogen and other fertilizer inputs; and adapt forest management approaches to increase resilience in the face of climate variability and climate change. In the second year of the project, we accomplished deliverables and milestones that laid the foundation for successful completion of our mission.

- The silviculture and ecophysiology team is implementing a regionwide monitoring network to evaluate the effects of climate, soils, and management approaches on carbon sequestration rates of planted pine. The team installed four large manipulative field experiments along the edges of the native loblolly pine range to subject the species to environmental conditions that may occur in the future. The team also selected sites from existing research trials to provide regional baseline data on carbon, water, and nutrient storage rates as well as responses to climate and management. Sampling protocols for tree core collection, soil sampling, and biomass sampling have been finalized. Studies of N_20 and soil CO_2 efflux are underway.

- The modeling team is applying a multi-scaled modeling program incorporating monitoring network data with spatially-explicit historical and predicted future climate data to assess alternative forest management approaches and the impacts on carbon sequestration and resilience to disturbance. The team established a standardized set of models and climate datasets and conducted initial regional-scale assessments to guide future analyses.

- The genetics team is developing guidelines to help growers understand where to plant specific southern pine seed sources given future climate scenarios and identify genes controlling traits such as growth, nitrogen responsiveness, cold hardiness, water usage, and resistance to southern pine beetle and fungal diseases. Analyses are underway of weather and climate response of over 500 loblolly pine families in studies across the region. The team has almost completd a comprehensive assessment of current genotyping techniques.

- The economics and policy team is analyzing life-cycle carbon balance of regional forest management systems and conducting multi-scale analyses of market and non-market forest benefits and services under future management and climatic conditions. In year

2, the team completed key regional analyses of both market and non-market factors for planted pine across a range of spatial and temporal scales..

- The education team is creating resources and programs to educate high school students and teachers as well as university students about the relevance of forests, forest management, and climate impacts. The PINEMAP education program also engages university students in collaborative, interdisciplinary research aimed at solving complex societal problems. The team launched a regionwide undergraduate internship program; coordinated a distance graduate education course to prepare students to address climate change mitigation and adaptation issues in southern pine forests; and partnered with the national Project Learning Tree education network to develop a module for high school students on southern pine forests and climate change.

- The extension team is disseminating emerging knowledge, practices, and PINEMAP decision support tools to enable corporate and non-corporate landowners to increase forest carbon sequestration, nitrogen fertilizer efficiency, and forest resilience under changing climate. The team has implemented a comprehensive audience assessment program, including a survey assessing climate change perceptions of over 4,000 Extension professionals across the region. Integrating efforts with state climatologists and Extension foresters has been a key focus.

Our focus on integration across disciplinary groups positions us to deliver the real-world outcomes embedded in our mission, which include the following:

- improved economic return and reduction of loss from catastrophic events;
- increased forest carbon sequestration and fertilizer efficiency;
- enhanced capacity for regional, multi-disciplinary collaboration among climate and forest scientists, Extension and education professionals, and graduate students;
- increased capacity for non-corporate forest landowner participation in C markets;
- increased deployment of adaptive strategies to ensure the sustainability of planted southern pines in advance of climatic changes;
- climate-smart audiences making informed decisions related to the southern planted pine system and consumption of forest products;
- diverse stakeholders, including landowners, secondary school teachers, and students, with a clearer understanding of adaptive forest management strategies and their role in climate change mitigation.