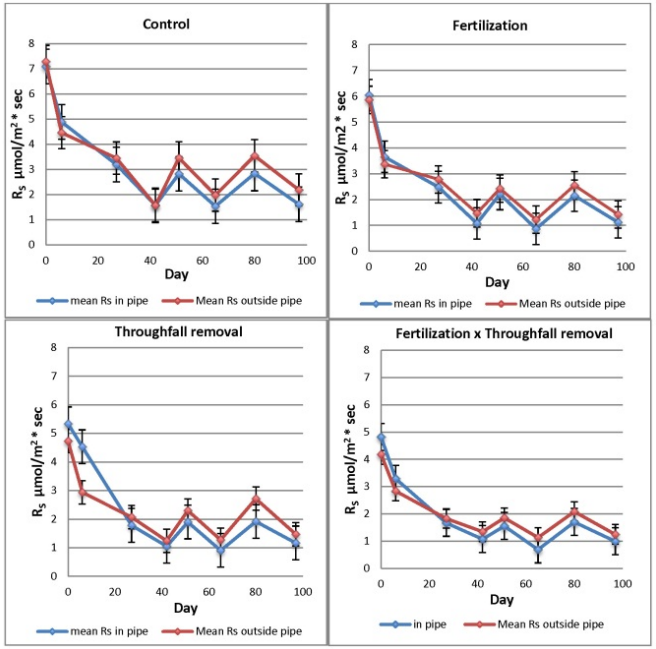
PINEMAP Year 2 Interim Report 2 (Compiled & Condensed Version)
November 2012

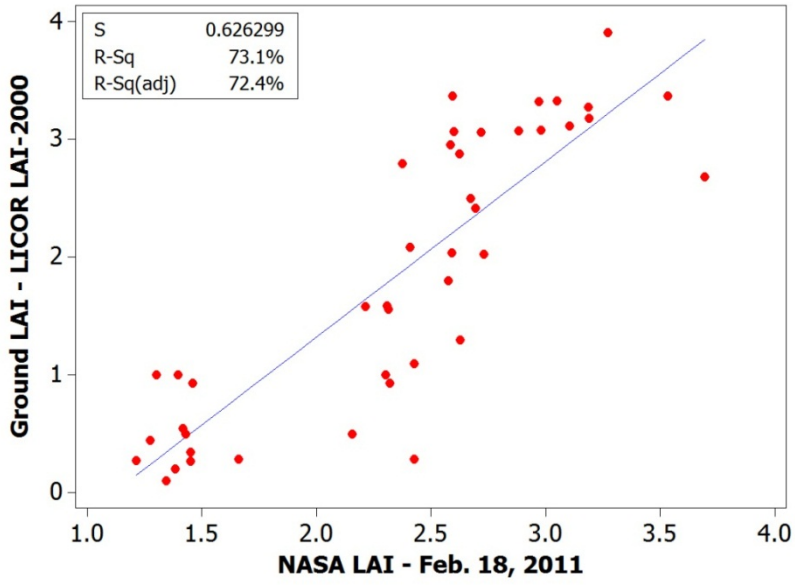
Milestones and Work Plan Progress

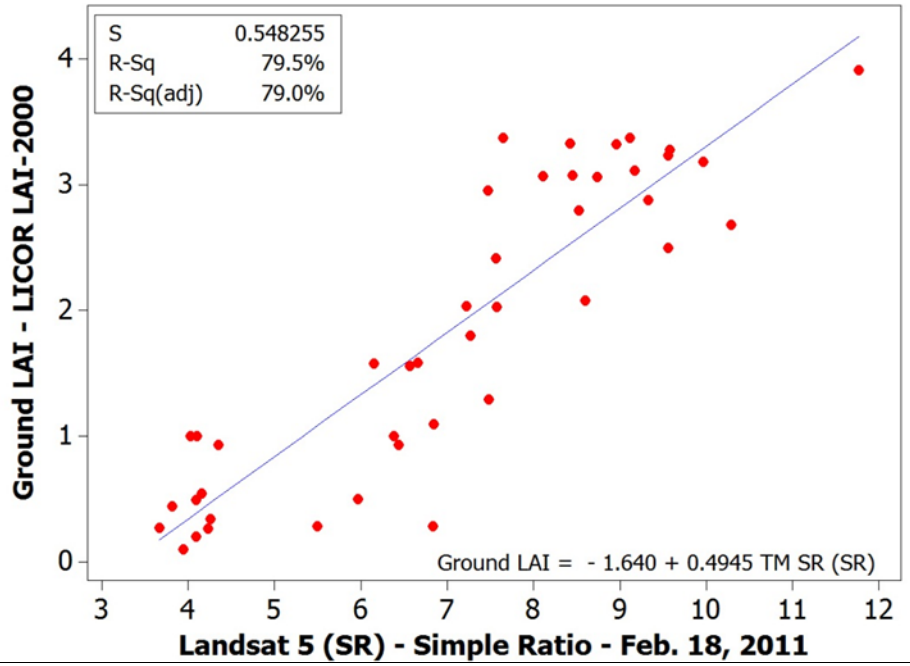
Aim 1	
Milestone	**Progress**
Assessment of Tier III treatment effects	• Leaf gas exchange, chlorophyll fluorescence, and leaf water potential were measured from July through October 2012 at the Georgia Tier III installation. Rainfall exclusion has had a significant effect on light-saturated photosynthesis, leaf conductance, leaf water use efficiency and predawn water potential. Photosynthesis was reduced on average by 11% and leaf conductance by 22% in response to rainfall exclusion. Predawn leaf water potential was also lower and leaf water use efficiency was higher with rain exclusion. Preliminary sap flow data indicate a 22% reduction in total daily transpiration in response to the rain exclusion treatment, from 1.8 to 1.4 mm/day in October, which was due to a reduction in midday maximum sap flux density. • Fertilization increased Fv/Fm, most likely from increasing foliar N, but had no other significant effect on leaf or whole tree physiology. No interactions between treatments have been detected thus far. • Stand level LAI and IPAR have been monitored since May 2012. Fertilization increased average LAI from 1.56 to 1.83 and average IPAR from 57% to 63%. A trend towards an interaction between month and fertilization indicated a greater effect of fertilization on LAI and IPAR beginning in July. Rainfall exclusion had no significant effect on LAI or IPAR. • At the GA site we measured baseline soil CO_2 efflux on Feb. 9, 2012, and have been measuring soil CO_2 efflux according to protocols since June 6, 2012.
Assessment of climate, soil, and management impacts on soil GHG flux	Belowground Carbon Allocation of Two Loblolly Pine Varieties with Contrasting Aboveground Growth Efficiencies: Soil CO_2 efflux (Sf), microbial biomass carbon (MBC), and nitrogen (MBN) were measured in the spring and summer at the Cross Carbon Study near Cross, SC. The effects of clone (high and low growth efficiency) and silviculture (addition of logging residues (LR) to the soil at planting) on Sf, MBC, and MBN were examined using a 2x2 factorial treatment structure. Initial Sf measurements were made in the spring (March) and summer (July). Immediately after the initial measurement, a 10.7 cm diameter by 20 cm long pipe was installed in one of the two spots to exclude root respiration form Sf (pipe-exclusion method). The other spot served as the 'no-pipe' control. Soil CO_2 efflux was measured again in June and October 94 and 92 days, respectively after pipe installation. Following the final Sf measurement, the soil was collected from the 20 cm pipe and the adjacent control spot. Soil was brought back to the lab where soil organic matter, live and dead roots were sieved (>2 mm). A subsample of soil was process for chloroform fumigation and assayed for microbial biomass carbon (MBC) and nitrogen (MBN).

	Sf was greater on average 19% in LR treatments compared to Control (p=0.013). There was also a significant treatment effect on the reduction of Sf in the root exclusion pipes. Approximately 90 days after pipe installation, Sf was reduced by 38.3% in the Control treatment compared to only 15.3% in the LR treatments (C vs LR: p=0.02). In the spring, MBC and MBN in the LR treatments were 27% (p=0.02) and 31% (p=0.03), respectively greater than in Control treatments. Pipe insertion reduced MBC by 20% (pipe vs no-pipe: p=0.007), but had no effect on MBN. These measurements will continue quarterly in year 3.
Regionalize estimates of WUE for application in 3-PG and WaSSI	Wood cores from a subset of the Tier II sites have been collected for C13 isotope analysis to determine WUE in the PINEMAP region.
Work Plan Task	**Progress**
Develop standardized methods for baseline C inventory, baseline soil characterization, and baseline ecophysiology measures	• 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. • Sap flow monitors to measure evapotranspiration rates were installed at each site. Protocols for tree core collection, soil sampling, and biomass sampling have been finalized and uploaded to the PINEMAP website where they will serve as a reference for field work on the Tier II and III sites. • General IPAR-LAI sampling methods for Tier II and III sites have been uploaded to the intranet site.
Develop standardized methods for separating soil heterotrophic and autotrophic respiration	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. Tests to evaluate the protocols for separating heterotrophic (Rh) and autotrophic (Ra) components of soil respiration have been installed at the Virginia Piedmont Tier 3 site. Results of the summer installation are shown in figure x. Respiration initially increased inside the collars but then became consistently lower than outside collars. Maximum reduction of R_A occurs approximately 65 days after root collar installation. Over time Rs rates decreased inside collars presumably due to a decrease in autotrophic respiration (R_A) due to a diminished C supply. It appears that this method works well for the partitioning of R_S needed to calculate C sequestration in managed pine forests. The percent decrease in R_A (1 - inside collar/adjacent to collar) across all treatments ranged from 20% - 40%, leaving R_H to account for 60 – 80% of R_S. Additionally at this early stage in the experiment there does not appear to be treatment or interaction effects on the partitioning of R_S. Average R_A across all treatments is 26%.

	 Figure 1. Soil CO_2 efflux over time during the summer of 2012 in all four treatments of the Virginia Piedmont Tier 3 PINEMAP installation as influenced by 35 cm deep collar (pipes) installation
Collect soil baseline data on Tier III sites	• Forest floor and mineral soil samples were collected from the four Tier III research sites and is being processed. Forest floor and soil sampling (0-10, 10-20, 20-50, 50-100) and analysis prior to Exclusion x Fertilization treatment installation have been completed. Sampling included 8 points per plot that were composited to two points for per plot for analysis. Analysis have included digests of forest floor for C, N, Ca, Mg, K, Al, and trace metals and pH water and salt, total C and N, extractable cations (Ca, Mg, K, Al) as well as trace metals for all mineral soil horizons. • GA Site - We have installed TDR rods at 0-15, 0-30, 0-60, and 0-100 cm in two locations within each of the PINEMAP Exclusion x Fertilization study plots. Regular measurements were initiated in September 2012. We are currently constructing TDR cables for installation at 2 and 3 m depth.
Install studies to measure N fertilizer uptake efficiency using 15N labeled fertilizer at Tier II and Tier III sites	Studies of N fertilizer uptake efficiency using 15N labeled enhanced efficiency fertilizers were established at 28 sites in the South associated with Tier II Active Experiments in 2011 and 2012. Samples of 15N in ecosystem components (trees, understory vegetation, forest floor, and soil) were collected and are being analyzed using IRMS.

Install studies to measure N_2O and CH_4 emissions following N fertilization	Studies of N_2O and NO_x emissions following nitrogen fertilization were established at a subset of the Tier III sites in 2012. At the GA Tier III Site - Trace gas sampling at the Exclusion x Fertilization experiment has been completed 4 times once prior to fertilization (Mar) and three times post fertilization (Apr, June, and Oct). We have also completed a denitrification and nitrification assay for soils from this site. Rates of N_2O efflux were very small and there were not significant differences by treatment. As part of the trace gas sampling for N_20 in Tier II locations two additional sites were sampled in October 2012. These sites are 22 and 18 years old managed pine. We measured paired plots that included control and HF plots that had received fertilizer annual for the duration of stand development. Surprisingly no difference in N_2O efflux was observed between these plots.
Develop improved method to evaluate fertility rating (FR) in 3-PG	A method to determine FR rating based on the relationship between site index and modeled stand biomass production was developed and is being validated using data from Tier II sites.
Ongoing measures of carbon, nutrient pools and fluxes, and water flux at Tier III sites (i.e., soil respiration, soil nutrient availability, leaf level PD and respiration, etc.)	Forest floor and soil samples were collected at all four Tier III sites and analyses are underway. Soil moisture is being monitored. Trace gases and CO_2 soil efflux are being measured. Litter traps were installed and crown and foliar attributes are being assessed and sapflow is being monitored. A study of through fall as a proportion of total rainfall was installed at the VA Tier III site.
Identify subset of Tier II sites for additional ecophysiology measures	Half of the sites have been selected where tree cores will be collected for 13C/14C analysis to determine water use efficiency. Field work to collect the tree cores and the inventory biomass samples is ongoing. Studies of N fertilizer uptake efficiency using 15N labeled enhanced efficiency fertilizers were established at 28 sites associated with Tier 2 Active Experiments. Samples of 15N in ecosystem components (trees, understory vegetation, forest floor, and soil) were collected and are being analyzed using Isotope-ratio mass spectrometry (IRMS).
Wood samples for O and C isotope analysis from Tier II sites	Half of the sites have been selected where tree cores were collected for 13C/14C analysis to determine water use efficiency. Field work to collect the remainder of the tree cores will be completed in 2013.
Collect baseline data at Tier II sites to evaluate treatment effects on C and nutrient pools and fluxes	Measurements and samples (soil, forest floor) have been collected from a subset of the Tier II sites and the samples are in various stages of being processed.

Aim 2	
Milestone	**Progress**
Improved process and hybrid models parameterized from network measurements	This is a major milestone within AIM 2. Several separate but integrated components and steps are required to fully complete this milestone as listed below. The published papers represent a compilation of component research progress in this area. Additionally, 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 H2O 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.
Work Plan Task	**Progress**
Start evaluation of initial growth and yield fitting using Tier 1 data.	Underway
Preliminary assessment of potential effects of climate change on loblolly water/C manuscript submitted	Caldwell, P.V., G. Sun, S.G. McNulty, E.C. Cohen, and J.A. Moore Myers. 2012. Impacts of impervious cover, water withdrawals, and climate change on river flows in the conterminous U.S., *Hydrol. Earth Syst. Sc.* 16:2839-2857. doi: http://dx.doi.org/10.5194/hess-16-2839-2012
Evaluation of Ames RT LAI product	Complete and presented. Blinn, C.E., R.H. Wynne, S. Ganguly, and T.R. Fox. 2012. Sensor intercomparison for the estimation of LAI in loblolly pine stands. ASPRS 2012, Sacramento, CA. Summary graphic is below. 

Initial modeling of Tier I sites using 3-PG, 3-PGS, and CASA (latter two using Landsat data)	Complete for 3-PG. Delays in processing of the Landsat-derived LAI chronosequences by NASA Ames have hindered the satellite-based big leaf model deployments.
Initial empirical LAI modeling	Complete and presented in Blinn et al. 2012 (see above). Summary graphic is below. 
Incorporate climate variables in growth and yield components	Random Forests modeling is complete and will be presented at the Forest Modeling cooperative meeting.
Assessment of Tier I big leaf modeling completed; models reparameterized	See above; complete for 3-PG, delayed for satellite-based big leaf models.
Climate scenarios added to Ames System Regional baseline big leaf models runs using Landsat LAI (3-PGS and CASA)	Awaiting availability of Landsat LAI data.
Improved process model (3-PG) parameterization from network measurements	New allometric functions developed by Carolos Gonzales and Chris Maier are being added to 3-PG.
Completed prototype of growth and yield components; start of scale-up	On track for June deadline

Modeling soil C—forest dynamics (G-Day Model)	Wade Ross (and Risa Patarasuk, GSI Specialist) have assembled a variety of input data (spatial environmental data, such as topography, MODIS-derived properties, soil types, etc.) for the Pinemap study area. In addition he is mining existing pedon-specific soil carbon data into a geodatabase. The soil carbon observations and spatial environmental covariates will then be used to upscale soil carbon to the regional scale using stochastic/deterministic modeling techniques and a mechanistic model (GEFSOC) [next year].
Aim 3	
Milestone	**Progress**
Version 1 of genetic deployment tool with provenance information	1) Texas A&M: Analysis of 73 tests of the WGFTIP Seed Source Study of 43 selected families (divided into two series) has been conducted with focus on using 1) minimum temperature of the coldest month (MMIN) and 2) summer heat/moisture index (SHM) as dependent variables and 1) height growth, 2) diameter and 3) volume as independent variables. MMIN corresponds to the most extreme event, and strongly correlates with the other minimum temperature variables investigated ($P < 0.0001$). The trend for MMIN was clearly linear and closely related to latitude. SHM showed a relationship with longitude that could be interpreted as curvilinear or perhaps indicating a threshold between two different distributions occurring at approximately 93.5° W. Highly significant response surface models have been developed; however, they pose further questions regarding the large portion of variation that is not explained by the weather explanatory variables alone. All raw progeny test data from this study has been supplied to University of Florida for the Tier 1 database. 2) NC State University: Growth (height at age 8) and climate data were analyzed for 19 field test sites of the Plantation Selection Seed Source Study using a multiple regression approach that tested a total of 68 climate variables and interaction terms for significance, to create a Uniform Response Function for the NCSU pine breeding populations. After refinement the model included 19 variables and interaction terms, and explained almost 68% of the variation in height growth in the dataset. Cross-validation to test the predictive accuracy of the model found predictive power was low, indicating that the problem is ill-conditioned due to co-linearity in the climate variables. Further refinement of the statistical model will use regularization or dimensional reduction methods to deal with the co-linearity in explanatory variables in an attempt to increase the predictive power of the model. Including additional independent variables related to site quality in the modeling effort is likely to increase the predictive accuracy of the model, provided that suitable data can be obtained for the test sites. The progeny test data from the 19 field sites used in this analysis have been provided to University of Florida for the Tier 1 database.

Determine appropriate genome reduction methods for genotyping by sequencing	1) Texas A&M: Agilent's SureSelect Target Enrichment System was used 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 78MB. 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 were sequenced using a Hiseq 2000 sequencer. After trimming and discarding low quality reads, sequences of 6.4 Gbp and 5.8 Gbp were obtained for the megagametophyte and embryo libraries respectively. These were *de novo* assembled into 184,907 contigs representing 58Mb. Blastn was used to check the *de novo* assembly against the draft 18Gb loblolly pine genome with the result that only 5 contigs failed to give hits. Attempts to map the sequence to the draft genome using CLC are currently underway. After filtering, this method has identified 51,623 SNPs or approximately one SNP for every 1,119 bp. Less than 8% of the initial unigene set is not represented. Foliage samples were collected from 397 individuals represented in the ADEPT II Association mapping population for the next part of the project. 2) NC State University: A published procedure for Genotyping-By-Sequencing using two restriction enzymes to fragment genomic DNA (Poland et al, PLoS One 7: e32253, 2012) was used to prepare DNA samples from two parents and 90 progeny of loblolly pine. Results were good - each of two Hiseq lanes yielded 175 million paired-end 100-nt sequencing reads, and analysis using the Java-based GBS tools in the TASSEL software package yielded from 47,131 to 103,669 candidate marker loci depending on software parameters. These candidate loci have been compared to the draft loblolly pine reference genome assembly produced by the PineRefSeq genome sequencing project to estimate the proportion of single-copy sequences. About 70% of the candidate loci mapped to the draft genome assembly, and of those, about half mapped to a single location, yielding over 16,000 candidate single-copy genetic markers. A linkage map with 12 linkage groups, containing 529 markers distributed over a total map distance of 1281 cM, was constructed to confirm the Mendelian segregation of a sample of these candidate markers. An additional cluster of markers is found in a small linkage group that is not yet connected to one of the 12; addition of more marker loci to the mapping dataset is expected to allow this fragment to converge with one of the 12 larger groups. 3) Virginia Tech: Genome complexity reduction by the 'RAD-seq' approach was tested for 10 haploid megagametophyte and two diploid needle samples. An initial test was completed in an attempt to optimize the stoichiometry between adapter sequences and available genomic DNA fragments from

	the restriction digest. Specifically, the P1 adapter was titrated between 0.01 and 1x relative to the protocol modified from Miller et al (2007) (https://www.wiki.ed.ac.uk/display/RADSequencing/Home). Once we were satisfied based on the bioanalyzer results of these titrations, we completed library preparation of the indexed samples were sequenced on a single lane of an Illumina MiSeq instrument (2x100 PE format). Results from this sequencing run were not encouraging – much of the data generated was from adapter sequences, indicating an excess of concatenated adapters with no genomic DNA inserts. Discussions with a variety of colleagues revealed that this is a common issue with RAD-seq, and due to the success of the two-enzyme GBS approach being employed at NC State University, we decided to discontinue efforts to optimize RAD-seq, and due to the success of the two-enzyme GBS approach being employed at NC State University, we decided to discontinue efforts to optimize RAD-seq and re-direct our efforts to the two-enzyme method described in (2) above.
Comparison of methods	1. As noted above, the RAD-Seq method was dropped from further consideration. No data have been obtained for DArT-seq, but that procedure differs only minor respects from the two-enzyme GBS protocol tested, so the key comparison to be made is between SureSelect and double-digest GBS. 2. Cost per sample for the SureSelect method as implemented was about ten-fold more than for GBS 3. Recovery of polymorphic SNPs was comparable; SureSelect identified about 8% more total SNPs than GBS identified candidate markers (51,623 total vs 47,131 candidates) 4. Ability to distinguish paralogous variants from allelic variants has not yet been tested for SureSelect; 35% of GBS candidate marker sequences map to single locations on the draft genome assembly 5. Suitability for high-throughput sequencing is similar for both methods, although SureSelect is more technically complex 6. The degree of focus on transcribed regions is greater for SureSelect; virtually all candidate SNPs are in or very near transcribed regions or sequences similar to transcribed regions, while 17.4% (8199) of the GBS candidate markers align to sequences in the reference pine transcriptome assembly.
Work Plan Task	**Progress**
Agree to standardized traits for analysis and a methodology for stratifying locations	Analyses to date for development of Uniform Response Functions have been carried out independently by the three tree breeding programs, to avoid infringement on the rights of cooperators to the proprietary datasets held by those breeding programs. Discussions are needed among the project investigators to decide if a joint analysis of all data together would be beneficial. If so, then consultation with cooperative directors and advisory board representatives will be essential to develop a mechanism for merging data across cooperatives for a region-wide analysis while maintaining the intellectual property rights of cooperative members.

Reduction of Genome Complexity for generating molecular markers 1. Test of genotyping-by-sequencing protocol and data analysis pipeline reported by Elshire et al., PLOS One 6(5): e19379, 2011 2. SureSelect 3. DaRT libraries 4. RAD-seq libraries	1) Texas A&M: a. Attempts to map the sequence reads to the 18 Gb draft loblolly pine genome will continue. Protocols to maximize efficiencies will continue to be refined through 1) redesigning baits and 2) improved multiplexing of samples. DNA will be extracted from the 397 individuals in the ADEPT Association mapping population in preparation for genotyping. This is to support gene discovery through the analysis of the geographical distribution of alleles. 2) NC State University: Additional refinement of the double-digest GBS method will include testing an automated size-selection step to increase the reproducibility of recovery of genotypes at specific loci across multiple independent library preparations. DNA extraction and genotyping of tissue samples from progeny tests will be initiated. Customization of the open-source software used to analyze GBS datasets will be undertaken to improve the efficiency of data analysis and provide better integration with breeding program data management methods. 3) Virginia Tech: As noted above, the results from the RAD-seq approach were not encouraging. With colleagues at Texas A&M and NC State, we have therefore decided to focus on the two-enzyme approach and sequence capture. To improve the genomic coverage of data obtained from GBS, we plan to complete an additional test using non-methylation sensitive enzymes. We expect this method to provide data in non-repetitive regions, without a bias with regard to gene content. This will provide complementary data to that being generated by NC State using methylation sensitive enzymes (i.e., enriching for gene regions) for the purpose of genomic selection in loblolly pine pedigrees.
Aim 4	
Milestone	**Progress**
Assess policies & 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. We have also identified and mapped forest carbon storage hotspots (areas of high carbon storage) and other forest areas with low carbon storage (i.e. coldspots) in the State of Florida and the biophysical and forest management characteristics that are driving these hot/coldspots.
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 were published in *Forest Science*.

NPV analysis & regional market impacts of altered disturbance risks	We have completed the first draft of a paper entitled "Economics of climate change in optimal forest management in the United States South". We have assessed the economics of forestry in loblolly pine (*Pinus taeda*) stands under the risk of climate change. Specifically we have explored the following research topics: i) the effect of potential changes in forest productivity coupled with increased disturbances due to climate change on the expected economic returns and optimal rotation age for southern NIPF landowners, ii) the impact of silvicultural strategies such as managing tree density to ameliorate the impact of disturbances on optimal forest management, and iii) the effect of disturbance-resistant tree species on optimal forest management, and iv) the impact of climate change in the supply of C stored in commercial timber. This paper is under collegial review before being sent for publication.
Work Plan Task	**Progress**
Literature review and summary of ecosystem functions, goods and services	Significant progress has been made by D.C. Adams, and we have working papers that summarize ecosystem functions, good and services related to habitat, water quality, carbon sequestration, and recreation. We also finalized literature review on the effects of forest management and ecological disturbance on understory diversity of Florida pine flatwoods. Literature was compiled into a database and model.
Conduct trade-off analysis and optimization	Florida FIA data from different measurement periods has been matched at the plot and individual trees level. FIA plot data has also been matched with 2000 US Census data. Matched database can be used to determine plot-level tree carbon sequestration and other socioeconomic covariates. We are also reviewing literature to identify methods for optimization modeling and developing genetic algorithm to analyze interactions among ecosystem services (i.e. species richness, carbon storage and timber (in forested ecosystems of Florida's coastal plain. Currently, we are analyzing literature on ecosystem service tradeoffs between carbon, timber and herbaceous richness under different management and disturbance regimes, forest types, and geographic regions.
Complete modeling regional market impacts and carbon accounting under the business-as-usual scenario	We will expand from the detailed analysis of three states, to a south-wide analysis that incorporates refined land use change assumptions. The data have been updated to the most recent available (FIA 2011); the model has been updated to allow measurement of welfare impacts from interventions; and the representation of wood product demands is being improved.
Complete SPB infestation modeling	We have compiled SPB infestation data from the National Forests in the South. Modeling work is underway.
Complete wildfire data in the South for modeling	All available wildfire occurrence and extent data for all counties in all southern states has been obtained from Fire Program Analysis at NIFC. Socioeconomic data has been obtained from the Bureau of the Census, Bureau of Economic Analysis, and Bureau of Labor Statistics. Weather and climate data developed for the 2010 USDA Forest Service RPA Assessment (historical data downscaled to the county level) have been obtained. Initial econometric models that will be used to forecast wildfire occurrence and extent have been estimated. Forecast socioeconomic and weather and climate data from the 2010 RPA will be used to develop the forecasts.

Aim 5	
Milestone	**Progress**
Report of audience assessment for PLT module	We completed a survey of secondary science teachers in the Southeast. The information gleaned is providing justifications for the Project Learning Tree/PINEMAP module and helping us prioritize activities and resources. These results have been shared with the Education Advisory Committee and PINEMAP collaborators through a research summary, PINEMAP newsletter article, and PINEMAP internal webinar. A peer-review publication has been accepted in Applied Environmental Education and Communication's special edition on climate change.
Report of teachers' attitudes concerning forest management	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 1024 surveys were successfully delivered with 324 returned for an adjusted response rate of 32%.A full report of this information is contained in the thesis: Fowler, S.M. 2012. Forestry Education Attitudes and Teaching Practices Among High School Science Teachers in the Southern Piedmont. M.S. Thesis, Virginia Tech, Blacksburg, VA.
Report of research on climate change education strategies	Data were collected in July on climate change education strategies to determine whether connecting carbon lessons to climate change affects student interest and knowledge gain, whether student's attitudes about climate change are influenced by their perception of their parents' opinions of climate change, and whether a discussion or a role play is more effective in getting students to discuss the variety of opinions about climate change. The results will be used in Stephanie Hall's thesis and developed into a journal article.
Web-based course in multidisciplinary research for graduate students completed	The first offering of the PINEMAP graduate student course occurred spring term 2012 at 8 universities for 22 students.
Undergraduate research internships completed	Six interns worked at their mentors' host universities in mid- to late-May. Interns remained at their host university through the 12 week internships. After internships concluded in early August, students returned to their home universities for the fall semester and to participate in the undergraduate *Effective Communication Skills* course.
Undergraduate teaching and communication distance course completed	The undergraduate distance-delivered course, Effective Communication Skills, is scheduled to be completed the second week in December. The course is on pace to meet this milestone with five of six students earning credit for completion.
Work Plan Task	**Progress**
Announce winners of intern micro-grant program	Graduate student winners of the 6 micro-grants to host interns for summer 2012 were notified in March 2012. Official letters were attached in an email to successful applicants, and they were asked for a confirmatory response within one week.

Facilitate undergraduate intern transitions to host universities	Mentors and the program coordinator assisted interns with identifying and procuring suitable housing at or near host universities for their summer internship. All interns needing housing finalized arrangements by their starting dates in May.
Maintain the intern program web site and update as needed with information for internships and the undergraduate distance course	This task is being performed as needed by the intern program coordinator. A Frequently Asked Questions (FAQ) page was uploaded to the intern program section on the PINEMAP internet site.
Continue development of undergraduate 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 were finalized in August.
Weekly monitoring of summer 2012 undergraduate intern program participants	This task is being performed on an informal basis by the intern program coordinator. Interns are contacted every other week when timesheets are due and other weeks to schedule online meetings.
Monthly online meetings with interns and graduate student mentors	We had 2 monthly meeting with program participants. Interns were able to meet each other and describe their current and projected work schedules. The program director provided additional detail about the fall distance course and how the internship fits into that half of the intern program.
Finalize undergraduate teaching and communication distance course syllabus	The final version of the undergraduate teaching and communication distance course syllabus was completed in June. The course is titled Effective Communication Skills. During the first half of the course, student interns learn public speaking skills in conjunction with some basic principles of science education. Concurrently, students identify learning content standards around which to develop their oral presentations to school students. The second half of the course requires interns to deliver their presentations, write scientific abstracts, and create professional quality scientific poster and oral presentations. These abstracts and presentations focus on work conducted and data collected during the summer internship.
Recruit secondary school teachers, 4H and Scout leaders, and introduce intern teaching activities	More than 342 public secondary school science and agriculture teachers within three hours of interns' universities were contacted. From this group, 32 teachers inquired about how to schedule students for school visits. Teachers are currently scheduling visits with interns.
Conduct undergraduate communication and teaching distance course on education	The undergraduate course, *Effective Communication Skills*, operating as part of the internship program began on September 5. Five of six interns have completed the first part of the course that focused on public presentation skills. Students each developed a 50 minute presentation that conveys PINEMAP's goals and focuses on specific work, within the broader context of climate change, each intern conducted over the summer internship. Interns began presenting their lessons to public secondary school students during the second week of November.

Promote 2013 summer undergraduate internship program	Materials for the 2013 internship program are currently being updated in preparation for promotion in late November. Furthermore, we have decided to change the titles of participating undergraduates from "Undergraduate Interns" to "Undergraduate Fellows." This change better reflects the mission of the internship program to not only train students as undergraduate research assistants, but also to have them communicate the research to a variety of audiences.
Deliver inquiry-based educational presentations	Interns began site visits to nearby secondary schools and scouting groups during mid-November. Each intern is expected to deliver at least 10 presentations. Currently, 26 biology and agriculture classes and two Boy Scouts groups are scheduled for visits. Students will continue to schedule visits and deliver presentations through the first week in December.
Obtain evaluation input from students and faculty on future graduate student interactions and next course offering	Evaluation data were collected in April and May 2012 and the course was discussed during the annual PINEMAP meeting in Atlanta. A compilation and summary report has been shared with all instructors and the course organizing team for 2013.
Compile and review evaluations and student/faculty input; plan for second version of course scheduled for spring 2013 as well as future graduate student activities and interaction within PINEMAP.	An evaluation report for the spring 2012 course was compiled. We are also exploring opportunities and mechanisms to continue to engage graduate students in interdisciplinary research and outreach activities. Specifically, we are developing a plan and process for graduate students to team up to co-author Extension fact sheets for PINEMAP. The initial plan is for student teams to start planning and discussing before the 2013 annual meeting, and at the annual meeting, we will have an activity where they will share ideas, drafts, etc. and get feedback and assistance from Aim 6 members.
Revise course syllabus, structure, themes, and overall goals/objectives based on evaluations and student/faculty input.	The syllabus for the spring 2013 course was developed after consideration of the evaluation feedback from the spring 2012 course.
Develop and revise activities, based on advisory committee feedback	We have held 5 conference calls with the Education Advisory Committee to review activity drafts and concepts. The final call is scheduled for December 2012. In addition to the feedback gathering during the call, several committee members have emailed suggestions and comments. Seven activities have been developed and revised, based on Advisory Committee Feedback. The table on pages 14-15 summarizes activities that will be included in the module and their stages of development.
Launch needs assessment with high school science teachers	An online needs assessment survey was launched in April 2012 with 4 email lists of teachers and 9 contacts who forwarded the survey link to their email lists. A total of 732 teachers completed the survey by 6/13/12.
Collect data on climate change education strategies	Data were collected in July at two summer science camps hosted by the Center for Precollegiate Education and Training, University of Florida. Both quantitative and qualitative data were collected, including pretests, posttests, interviews, and discussions. Data indicate that connecting carbon lessons to climate change increases student knowledge gain. Based on student interview responses, climate change increases student interest by making the lessons more relevant and important. There is a correlation between students' attitudes about climate change and their perception of their parents' opinions.

Needs assessment findings report	Two publications have been produced: 1) A white paper research summary that has been shared with the Education Advisory Committee and PINEMAP collaborators. 2) A peer-review publication for Applied Environmental Education and Communication's special edition on climate change (accepted Nov 13, 2013).
Research report on climate change education strategies	In progress. Stephanie Hall (UF) is analyzing data for her thesis and a journal article.
Begin plans for formative evaluation	In progress. Christine (Jie) Li (UF) is developing a plan for the evaluation as part of a fall course and will finalize the plan with input from the Advisory Committee.
Aim 6	
Milestone	**Progress**
Implement and strengthen forestry Extension/climatologist partnership	Aim 6 has identified three strategies within this milestone and progress has occurred on many aspects. 1) Local training: State climatologists have been approached singly and as a group, 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 workshops as well as to review materials. 2) Climate expertise to support research: Aim 6 members have surveyed many 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. There has been active collaboration on several workshops, presentations, and/or webinars in Texas between John Nielsen-Gammon, Eric Taylor, and Matt Bonham as well as in North Carolina between Mark Megalos, Ryan Boyles, and Heather Dinon. In addition, Georgia partnerships have been initiated between Pam Knox, David Stooksbury, Mark Riesse, Leslie Boby, and Bill Hubbard as well as Florida partnerships between David Zierden and Martha Monroe. Heather Dinon and Adrienne Wootten from the State Climate Office of NC are partnering with the Association of Natural Resource Extension Professionals (ANREP) Climate Science Initiative (CSI) group. Bill Hubbard, Mark Megalos, Leslie Boby and Eric Taylor are all members of CSI as well. We are hoping to connect CSI, a national effort, with state climatologists in the Southeast U.S.

Audience/Needs Assessments for Extension programs	These 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: During year 1, 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 access attitudes, beliefs, practices and interest in global warming and climate change programs and programming. Results of that survey, as well as summaries were written up in 2011's annual report. Results have been presented at more than five conferences, meetings and webinars. • Forestry Professional: Aim 6 members are currently conducting a survey for professional foresters (includes consulting foresters, extension foresters and others). This survey utilizes a large database of forester contacts (5,000+) to reach as many people as possible. 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. We will also question attitudes and knowledge about climate change, climate variability, etc., with a focus towards 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 has also completed and 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 also be used to direct and support PINEMAP education programs.
Extension programs evaluated	It is important to develop evaluation instruments that will be use across the region to provide consistency with questions asked, etc. • 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 and still maintain rigidity and consistency across the region. The form is scantron to ease analyses. • Retrospective Post – Natural Resource Manager: currently under development but will be retrospective-post, scan tron form with the ability to select questions from a pool of allowable questions designed to measure the impact of PINEMAP outreach programs. • Follow-Up Surveys – Family Forest Landowners: under development • Follow-Up Surveys – Natural Resource Manager: under development

Extension programs delivered	We have ongoing extension programs as listed in the events/activities section. 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. PINEMAP AIM 6 members collaborated with Clemson University and University of Georgia's Forestry Extension Faculty to deliver a webinar based program for forest landowners this fall, titled, "Natural Resource Opportunities for Landowners." This five series course was conducted Thursday evenings from 7-8:30pm via Adobe Connect Software and ran from mid-October to early November. Topics included: 1. Introduction to Natural Resource Conservation, 2. Natural Resource Enterprise Considerations, 3. Wildlife Conservation (Introduction to Master Wildlifer), 4. Forest Management on Your Land (Introduction to Master Tree Farmer), and 5. Natural Resources Appreciative Values and Uses. Within the general course content, instructors also discussed impacts to natural resources from a changing and variable climate. Approximately 75 people attended each session, for a total count of 375 people reached, however, there were also 'viewing sites', where multiple attendees watched the webinars and we do not have final numbers from them yet. This is the link for the October 11th and 18th webinars: http://connect.clemson.edu/p891o17tl9y/ and http://connect.clemson.edu/p2maev1fj5j/.
State extension and climatologist teams organized	A conference call with the state extension team was held in February 2012. Initial conference calls with climatologists across the region were held in December 2011. Another round of joint calls between the two groups is being planned for December 2012.
Decision Support System	Ryan Boyles and Heather Dinon have developed a subcommittee composed of at least one PINEMAP member from each Aim to provide guidance for the Decision Support System (DSS). This subcommittee has provided a list of existing tools and inputs/outputs from each aim for the DSS. A presentation and group activity at the annual meeting identified different ideas for the design of the DSS. Some of these ideas are shown in the figures below. Meetings with the DSS subcommittee will continue on a bi-monthly basis. A layout and design of the PINEMAP DSS is being developed and reviewed by Aim 6 members. Also, conference calls are also being scheduled with the following goals: 1) To determine a theme for the PINEMAP DSS webpages (e.g. one similar to that of the www.pinemap.org website) and details of where it will be hosted, etc. To accomplish this task, Aim 6 is partnering with Darryl Outlaw, the PINEMAP website administrator. 2) To help build the back-end structure of the PINEMAP DSS. The data from Terra-C is very important to consider as part of this discussion so we are working with Sabine Grunwald and Brandon Hoover to accomplish this aspect of the DSS. Aim 6 is also brainstorming ideas for determining a creative name for the PINEMAP DSS.

Work Plan Task	Progress
Audience assessment—develop several "baseline" survey instruments that establish the existing knowledge levels, needs, beliefs, interests, attitudes, learning preferences, etc. regarding climate variability and forest interactions for various groups	The audience assessment has been developed and will be implemented at the end of November 2012. Additionally, we have assembled a large database of forestry professionals across the southeastern United States for distributing the survey.
Strengthen relationships with education, research, and stakeholders: State/regional advisory planning meetings	• Aim 6 members will continue outreach activities including attending Forestry Cooperative Meetings, and other forestry related workshops and conferences. We will continue to coordinate the PINEMAP internal webinar series and will have each Aim group take turns presenting monthly, as well as including presentations on new developments and other research topics. Aim 6 members have joined other Aim's listservs and will attend their in-person and virtual meetings as much as possible. • Leslie Boby has been working with Jessica Ireland to develop the *PINEMAP Press* and the *PINEMAP Gazette*. These two newsletters summarize the latest developments from PINEMAP aim groups. One newsletter is a more technical version, while the second newsletter adapts the first newsletter's articles for less of a research focus and more of a focus on knowledge application. Both newsletters will be widely distributed. *PINEMAP Press* has been emailed to all of PINEMAP, to faculty and Deans at participating universities, NIFA and others. The *PINEMAP Gazette* will be distributed through the website (there is a button for viewers to sign up for updates), through extension forester lists and to the forester database list. This newsletter will also be printed for giving out at workshops and/or training sessions. For this newsletter, each AIM group was required to submit one article, therefore, it is inclusive of the latest developments from each group. • Bill Hubbard, Eric Taylor and Leslie Boby are developing regional workshops for the late spring 2013 and into 2014. The workshop agenda and delivery of the content will be built collaboratively with PINEMAP researchers. AIM 1, 2, 3 and 4 members will be consulted for ideas for the newest developments in PINEMAP research and will also be asked to deliver presentations at these workshops. • Bill Hubbard and Leslie Boby met with Earl and Wanda Barrs (Tree Farmers of the year 2009) to film at their 1500 acre tree farm. The Barrs were recognized for their implementation of desirable forest management techniques. At this visit, the Barrs were interviewed about changes that they have witnessed on their land within the past 30 years, as well as the management techniques that they have tried to increase their forest resiliency. Footage from this visit will be turned into a PINEMAP video that can be used to advertise the PINEMAP project, as well as introduce PINEMAP concepts for foresters, landowners and extension staff.

Creation of regional advisory panels	Invitations to a webinar meeting about PINEMAP's regional advisory panel were sent to more than 20 state level extension foresters and 1890s University extension foresters earlier this year. About 10 foresters attended this initial meeting and expressed interest in evaluating PINEMAP extension products and plans.
External outputs (fact sheets, web-based climate education modules, complete analysis and submit articles on SE Extension perceptions of climate change, eXtension, etc.)	Numerous factsheets are currently in draft form or in review with expected publication at the end of 2012 or the beginning of 2013. Factsheet 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. The theme has been built and topics are being reviewed for relevance to our stakeholders. Contextual examples are being developed for the topics that are most important to our target audience(s). Some of these materials will be implemented into eXtension.
Administrative activities	We will continue with PINEMAP reports, monthly web conferencing meetings, and biannual in-person meetings. We will assist in the maintenance of the project website, provide content for PINEMAP Facebook page and attend monthly executive committee meetings. We are also assisting in development and writing of two different versions of a PINEMAP newsletter. Our continuing goal is to strengthen relationships with other Aim groups.

Needs from/linkages to other Aim groups

→ Provide a bulleted list outlining research results, data, products, or assistance that your Aim group needs from another Aim group.

Aim 2

- Aim 2 will need information on standard management practices across both intensively and extensively managed loblolly pine forests in the region. We will be working with the Ecosystem Ecology/Silviculture (Aim 1) group over the coming year to better define these needs.
- Aim 2 will need information on what specific attributes (e.g. increase water or nutrient efficiency) the genetics group evaluating so that these attributes can be converted into modeling coefficients.
- Aim 2 will need to work with the education Aim to learn what level of complexity and output form is most appropriate conveying modeling results to land managers and the general public.

Aim 3

- Aim 1
  - Coordination of sampling strategy, so that tissue can be collected from all individuals on which individual-tree measurements of any sort are made during the course of this project, for eventual genotyping. The storage solution developed at NC State allows ambient-temperature storage of foliage or of cambium disks taken from increment-core wood samples for periods of days to weeks, reducing the burden on field crews taking other measurements or samples.
- Aim 4
  - Information on regional changes in insect risks
  - Impact of policy changes on reforestation needs
- Aim 5
  - Course for graduate students to take on conducting trans-disciplinary research
- Aim 6
  - Information on climate science and future climate scenarios for decision support system module development
  - Presentation of state of climate science to cooperative members

Aim 4

- Changes in forest productivity in different geographical zones in the U.S South in light of elevated levels of carbon dioxide and temperatures and altered precipitation patterns.

Aim 5

- Reviewers of activities (PLT Secondary Module)
- Graduate students to apply to be a mentor for the summer 2013 undergraduate internship program.

Aim 6

- Research results and guidance is needed from Aims 1 to 4 for the DSS development. Aim 5 will also be contributing to the DSS and several other Aim 6 activities, such as workshops and survey work.
- Guidance and input for Regional Forest Workshops is needed form Aims 1-4 for both agenda development as well as personnel to deliver presentations at the workshops. The topics for these workshops will be developed collaboratively with consultation from Aims 1-4.
- Need ideas for topics and volunteers from Aims 1-4 to deliver webinars for Forestry Webinar Series targeted towards professional foresters—the purpose of these webinars is to highlight PINEMAP research developments.

→ Provide a bulleted list outlining research results, data, or products that your Aim group has compiled that have value or relevance to another Aim group (and note which Aim group).

Aim 1

- Tier II data on tree growth and carbon sequestration is being collected and will be provided to Aim 2.

Aim 2

- Updated 3PG will be of relevance to the decision support group.
- TACCIMO training will be useful for the education group as a web-based tool for relating spatially explicit climate change impacts on forests.
- TACCIMO application will be useful for the ecosystem ecology/silviculture group for examining management options for coping with climate change stress impacts.
- TACCIMO application will be useful for the extension group as a tool to examine the effects of climate change and management options for presentation to the public in a formatted pamphlet.
- WaSSI will provide projections of carbon gain to the silviculture group for use in biomass partitioning.

Aim 3

- Aim 3 inputs and outputs provided to Aim 6 group (Ryan Boyles and Heather Dinon) as part of the Aim interactions analysis for the purpose of the Decision Support System (DSS)

Aim 4

- Estimates of landowner preferences for C sequestration program features (Aim 6)
- Extension perceptions of global warming/climate change, and factors driving these perceptions (Aim 6)

Aim 5

- Aim 6 could use information about how we are communicating climate change information to youth leaders.

Aim 6

- Ryan and Heather provided guidance on pros/cons of downscaled climate projection products available for the Southeast to Alfredo Farjat, Ross Whetten, and Fikret Isik. This data is useful to their study, which attempts to test a statistical model that Alfredo and Fikret have developed to predict the performance of pine plantations in the future.
- Provided historical climate data to Jose Alvarez (Aims 1 and 2) to help him estimate potential productivity of loblolly pine in the Southeast US
- Heather Dinon, Charlie O'Connell, and Megan Hall are reviewing material for Project Learning Tree activities as related to climate and forests.
- Providing feedback to Aims 1-4 on stakeholder needs and how this may influence research choices.

→ List any additional potential linkages to other Aim groups.

Aim 1

- Links to Aim groups working on decision support efforts within PINEMAP.

Aim 6

- Aim 6 members will continue to cultivate relationships with other Aim groups to stay current on the newest developments in research and the potential for extension products developed from that research. It is critical for Aim 6 members to be knowledgeable about other Aims' research in order to successfully build the DSS.