PINEMAP Year 2 Interim Report 2
November 2012
Aim 2—Modeling

Outcomes/Impacts

Describe how Aim-level activities, results, findings, techniques, or products contribute to project-level outcomes and impacts.

Aim 2 activities contribute to project-level outcomes and impacts by assessing and analyzing 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. Potential current and future stress impacts on forest productivity and carbon sequestration will be assessed using scaled ecosystem models, as will tradeoffs between maximizing forest productivity and other ecosystem services such as recreation, biodiversity, and water yield.

Outputs

Aim 2 Peer-reviewed publications (January-November 2012)

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 form fertilization of pine in the southeastern United States. *Forest Science* 58(5): 419-429. doi: http://dx.doi.org/10.5849/forsci.11-050

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* 31, advance access. doi: http://dx.doi.org/10.1093/treephys/tps082

Amateis, R. L. and H. E. Burkhart. Relating quantity, quality and value to planting density for loblolly pine plantations. Southern Journal of Applied Forestry, in press.

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

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

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.

Burkhart, H. E. Comparison of maximum size-density relationships based on alternate stand attributes for predicting tree numbers and stand growth. Forest Ecology and Management, in press.

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.

Campoe, O.C., J.L. Stape, T. J. Albaugh, H. L. Allen, T.R. Fox, R. Rubilar, and D. Binkley. 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

Domec, J.C., G. Sun, A. Noormets, M. Gavazzi, E. Treasure, E. Cohen, J.J. Swenson, S. McNulty, and J. King. 2012a. 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* 58(5): 497-512. doi: http://dx.doi.org/10.5849/forsci.11-051

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* 58(5): 457-471. doi: http://dx.doi.org/10.5849/forsci.11-072

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* 58(5): 430-445. doi: http://dx.doi.org/10.5849/forsci.11-069

Marion, D. A., Sun, G., Caldwell, P. V., Ford, C. R., Ouyang, Y., Amatya, D. M., Clinton, B. D., Conrads, P. A., Gull-Laird, S., Dai, Z., Clingenpeel, J. A., Liu, Y., Roehl, E. A., Moore Meyers, J. A., and Trettin, C.: Managing forest water quantity and quality under climate change in the Southern US, in: Climate Change Adaptation and Mitigation Management Options, edited by: Vose, J., CSC Press, Boca Raton, FL, in press, 2012.

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 CO2 in Southeastern U.S. pine forests. *Journal of Geophysical Research*, in review.

Noormets, A., S.G. McNulty, J.C. Domec, M.J. Gavazzi, G. Sun, 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

Noormets et al. 2012. Forest rotation length impacts on ecosystem carbon balance. *Forest Ecology and Management*, in review.

Peduzzi, A. R.H. Wynne, V.A. Thomas, R.F. Nelson, J.J. Reis, 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*, 36(4):198-203.

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. 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. Genetic effects on height-age relationships in clonal loblolly pine. *Forest Science*, in revision.

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

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

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

Sun, G., Caldwell, P.V., Georgakakos, A.P., Arumugam, S., Cruise, J., McNider, R.T., Terando, A., Conrads., P.A., Feldt, J., Misra, V., Romolo, L., Rasmussen, T.C., McNulty, S.G., and Marion, D.A. Impacts of Climate Change and Variability on Water Resources in the Southeastern US, in: Southeastern Regional Technical Report to the National Climate Change Assessment, Water Resources, in review, 2012.

Tavernia, B.G., M.D. Nelson, P.V. Caldwell, and G. Sun, 2012, Water Stress Projections for the Northeastern and Midwestern United States: Anthropogenic and Ecological Consequences, *Am. Water Resour. As.*, in revision.

Worsham, L., D. Markewitz, N.P. Nibbelink, L.T. West. 2012. A comparison of three field sampling methods to estimate soil carbon content. *Forest Science* 58(5): 513-522. http://dx.doi.org/10.5849/forsci.11-084.

VanderSchaaf, C.L. and H.E. Burkhart. 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

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.

Summarize ***Events/Activities*** (January 2012-current) as follows:

→ Provide a bulleted list of presentations (oral and poster) given at meetings or conferences. The format for citing presentations is as follows: Presenter(s)/Author(s). Date. Name/title of meeting/conference, location.

- Burkhart, H. E. Planning initial spacing and thinning to optimize value. Presented on March 13, 2012. Lexington County Forestry Association meeting, Batesburg-Leesville, SC.
- Burkhart, H. E. Initial tree spacing and thinning impacts on pine wood quality. Presented on June 6, 2012. North Carolina Society of American Foresters meeting, Rocky Mount, NC.
- Burkhart, H. E. and R. L. Amateis. Plot installations for modeling growth and yield of loblolly pine plantations. Presented on September 20-21, 2012. International Workshop at Beijing Forestry University, Beijing, China. Caldwell, P.V., G. Sun, S.G. McNulty, E.C. Cohen, and J. A. Moore Myers, Modeling the individual and cumulative impacts of anthropogenic activities and climate change on water resources in data-rich and data-poor regions, Presented at the HydroPredict 2012 International Interdisciplinary Conference on Predictions for Hydrology, Ecology, and Water Resource Management, Vienna, Austria, September 2012.
- Caldwell, P.V., G. Sun, S.G. McNulty, E.C. Cohen, and J. A. Moore Myers, Potential Impacts of Water Withdrawals, Impervious Cover, and Climate Change on River Flows Across the Conterminous United States, Presented at the EcoSummit 2012 - Ecological Sustainability: Restoring the Planet's Ecosystem Services, Columbus, OH, September 2012.
- Caldwell, P.V., G. Sun, S.G. McNulty, E.C. Cohen, J. A. Moore Myers, and Bhattarai, R., Predicting the impact of global change on water supply stress in the conterminous U.S., Presented at the 2012 ASABE Annual International Meeting, Dallas, TX, July 2012.
- Fang, Yuan, Ge Sun, Asko Noormets, John King, and Steve McNulty. Modeling Evapotranspiration with Global Eddy Flux and MODIS Data. Presented on March 27-28, 2012. NC Water Resource Research Institute Annual Conference, Raleigh, NC.
- Ford, C.R., Laseter, S.H., Caldwell, P., Sun, G., Vose, J.M., Drought, exurban expansion, and water yield in southern forest ecosystems. (Published abstract, http://eco.confex.com/eco/2012/webprogram/Paper33288.html). Organized oral presentation at the 2012 Ecological Society of America Annual Meeting in Portland, OR.
- Gyawali, N. and H. E. Burkhart. General response functions for silvicultural treatments and genetic improvement. Presented October 1-2, 2012. Northeast Mensurationists Organization meeting, State College, PA.
- Sabatia, C. S. and H. E. Burkhart. Tree size-based competition indices for modeling individual tree basal area growth in genetically enhanced loblolly pine. Presented October 8-9, 2012. Southern Mensurationists meeting, Jacksonville, FL.
- Poster: Ward, E.J., A. Noormets, J.-C. Domec, J. King, G. Sun, S. McNulty. October 10, 2012. Data-model integration in the PINEMAP project. RCN FORECAST Conference 2012, Woods Hole, MA.

/AN note: Eric's attendance at this Research Coordination Network workshop was supported by a competitive travel award from the same./

→ Provide a short narrative describing any workshops, courses, and/or trainings conducted.

- Aim 1 team met in Athens, GA on April 3-5, 2012 to discuss Tier 2 measurement protocols and prepare for the PINEMAP annual meeting.
- PINEMAP annual meeting in Atlanta, GA on May 14-16, 2012.
- Presentation on PINEMAP to members of the Forest Productivity Coop at the annual Contact Meeting in Alexandria, LA on June 13-14, 2012
- Workshop for PINEMAP industry members on the impacts of the 2011 drought on growth of loblolly pine in the south was held in Alexandria, LA on June 12, 2012.
- 3PG Modeling meeting held July 2 in Charlotte, NC. This full day meeting focused on the 3PG model and included discussion of topics that included; Identify gaps in reaching PINEMAP objectives; If research objectives overlap, identify and resolve any conflicts; Criteria for selecting evaluation data sets; 3PG platform/software to be used; Model management when changes are made to functions in 3-PG; Use of Pinemap Web as depository of parameterization and references; How to best document improved parameter estimates; Moving from point to spatial modeling; and Additional ways to collaborate.

→ Provide a short narrative describing experiments or surveys conducted and/or analyzed.

- Risa Patarasuk, GIS Specialist working for Sabine Grunwald at UF working on reprojections, extractions, and consolidation of various spatial data sets (GIS data) for regional wide modeling including climate data (PRISM and Idaho sets). Service work (spatial extractions) for various PINEMAP project participants on specific site locations (experimental data). Climate data (1970 to present) were extracted to tier 1 site locations. Harmonization and standardization of gridded climate change projections from NARCCAP into ArcGIS by Risa Patarasuk. The NARCCAP data were previously extracted by the VT team. A QA/QC of the extracted spatial climate change data by UF team revealed inconsistencies and about half of the data had to be re-compiled by VT (work in progress).
- Ranjith Gopalakrishnan, graduate student with Randolph Wynne, acquired a large collection of LIDAR data (from USGS), covering a substantial amount of the PINEMAP region of interest. This enabled us to get LIDAR profiles for over 6000 FIA plots, distributed over several southern states (collaborating with USFS SRS, Knoxville). These LIDAR profiles (over the FIA plots) are being analyzed, to correlate them with (known) factors such as ecoregions, management practices and fuel load.
- Brandon Hoover, Database Manager working on harmonization of Tier 1 data (about 700+ records) including all available attributes and meta data into a relational database (SQL).
- Eric Ward, Postdoctoral Associate with Steve McNulty, has finished compiling and processing sap flux data for the Parker Tract Tier II site (US-NC2) for 2010-2012. Analysis of these data for stomatal responses to environmental drivers has begun. This analysis will form the basis for further analyses of Tier III data as it

becomes available and may be used to update related functions in 3PG and other models.

- Tier 1 – Legacy Experiments: Industry/University Cooperative Research installations to include in the Tier 1 – Legacy Experiments have been identified. Archived data from these sites has been transferred to PINEMAP for uploading into TerraC.
- Tier 1 – Active Experiments: Industry/University Cooperative Research installations that will be included as Tier 2 – Active Experiments have been identified. Archived data from these sites has been transferred to PINEMAP for uploading into TerrC. One half of the sites have been selected where tree cores will be collected in 2012 for $^{13}C/^{14}C$ analysis to determine water use efficiency. The other half of the sites will be sampled in 2013. The sites where samples will be collected in 2012, 2013, 2014 and 2015 have been identified. Field work to collect the tree cores and the inventory biomass samples started in June 2012.
- The four Tier 3 – Throughfall Exclusion and Fertilization Experiments were installed. Throughfall collectors were completed and the plots were fertilized. 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 2 and Tier 3 sites. The soil procedure for measuring soil respiration and separating heterotrophic and autotrophic respiration are being tested.
- Microclimate and sapflow data collection has been automated data are posted daily at http://www4.ncsu.edu/~anoorme/PINEMAP/index.html
- Studies of N fertilizer uptake efficiency using ^{15}N labeled enhanced efficiency fertilizers were established at 28 sites in the South associated with Tier II Active Experiments in 2011 and 2012. Samples of ^{15}N in ecosystem components (trees, understory vegetation, forest floor, and soil) were collected and are being analyzed using IRMS.
- Studies of N_2O and NO_x emissions following nitrogen fertilization were established at a subset of the Tier III sites in 2012. Trace gas estimation for N_20 was completed 1 week prior to fertilization, 3 weeks and 8 weeks after fertilization. All gas samples have been analyzed.
- 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.

a. 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 and average of 17% and that total soil CO_2 efflux during this period was correlated with microbial biomass carbon.

Milestones and Work Plan Progress

Provide a short narrative describing progress and accomplishments on the year 2 milestones and work plan tasks listed below. Please also describe any changes to the Aim 2 milestones and/or work plan.

Year 2 Milestones

→ Improved process and hybrid models parameterized from network measurements (October 2012).

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 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.

→ Develop improved method to evaluate stomatal response functions to update 3-PG (March 2013).

→ Collect additional data on water and carbon fluxes at subset of Tier II sites previously identified (March 2013).

Year 2 Work Plan Tasks

→ Start evaluation of initial growth and yield fitting using Tier I data.

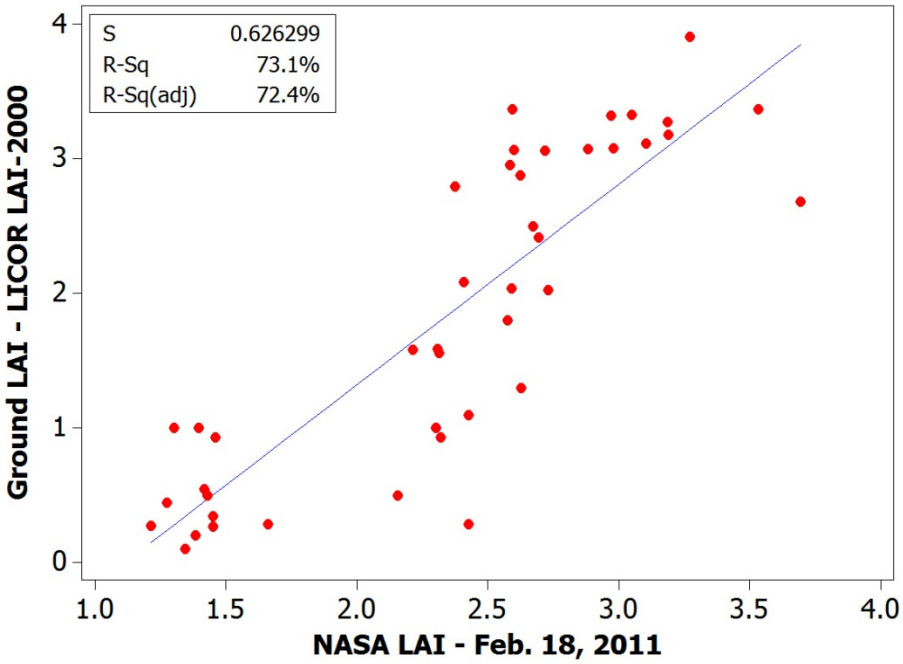
Underway.

→ Preliminary assessment of potential effects of climate change on loblolly water/C manuscript submitted.

- Caldwell et al. 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.

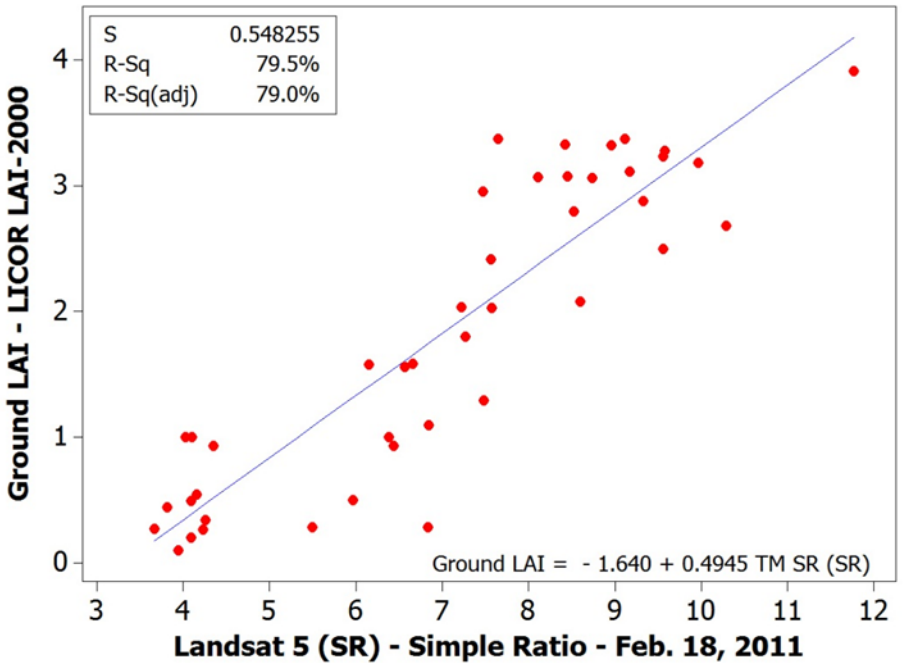


→ Initial modeling of Tier I sites using 3-PG, 3-PGS, and CASA (latter two using Landsat data).

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 the 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].

Broad Impacts & External Collaborations

Provide a short narrative describing broad impacts (i.e., far-reaching and possibly unanticipated outcomes resulting from Aim work, including contacts/collaborations with entities outside of PINEMAP).

Many agencies (e.g. EPA, USGS, Forest Service) would like to better quantifying 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.

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 II 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.

Training

Please list undergraduate and graduate students, postdocs, and technical personnel trained under this project and include a description of their research focus and/or role in the project.

- Madison Akers, Research Coordinator, University of Georgia. Madison is coordinating baseline measurements on Tier II sites and overseeing installation and data collection on the Georgia Tier III 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's research focus is measuring water fluxes at Tier III sites; developing improved methods to evaluate stomatal response to update 3-PG.
- Joe Clark, M.S. student, Auburn University. Joe's research focus is assessing relationships among intercepted radiation, LAI, photosynthetic capacity, phenology, and productivity in loblolly pine.
- Andrew Faison, Undergraduate Intern from Virginia State University. Andrew is assisting Jay Raymond at Virginia Tech with investigating the mechanisms nitrogen dynamics and uptake efficiencies of N containing fertilizers in loblolly pine plantations using stable isotope (15N) 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 II and Tier III sites.
- 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).
- 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.
- Nabin Gyawali, Ph.D. student, Virginia Tech. Nabin is utilizing Tier I 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.
- Amanda Hancock, undergraduate assistant, Texas A&M University, Carbon monitoring protocol implementation for Tier II 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 from Virginia Tech. Rebecca is assisting Wen Lin at North Carolina State University with quantifying the growth rate of loblolly pine, and analyze its sensitivity to temperature and precipitation dynamics.
- Will Kennerly, Undergraduate Intern, Virginia Tech. Will is helping 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 II sites and overseeing installation and data collection on the Virginia Tier III 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 II sites and overseeing installation and data collection on the Florida Tier III site.
- Cody Luedtke, M.S. 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 II and Tier III sites.
- Casey Meek, Research Associate, Oklahoma State University. Casey is assisting with ecophysiological and process measurements on Tier III and Tier II sites.
- Greg Nagel, undergraduate assistant, Texas A&M University, Carbon monitoring protocol implementation for Tier II sites.
- Josh Parisher, undergraduate assistant, Texas A&M University, Carbon monitoring protocol implementation for Tier II sites.
- Jason Pike, Research Technician, Oklahoma State University. Jason is assisting with installation, maintenance, and data collection on Tier III 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 III 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.
- 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.
- Rachel Ryland, summer undergraduate research assistant: Rachel has received training in field sampling of trace gases at the Georgia Tier III installation and has been trained in laboratory techniques for soil gas analysis on the gas chromatograph.
- Charles O. Sabatia, Postdoctoral Research Associate, Virginia Tech. Dr. Sabatia is investigating growth and yield response to climate and soils variables using Tier 1 data. Climate influences on tree growth and stand development, along with response functions for silvicultural treatments and genetic improvement effects, will be incorporated into empirical models for forecasting growth and yield of loblolly pine plantations.

- Charles Allen Sherrod, summer undergraduate research assistant: Allen has received training in field sampling of soil at the Georgia Tier III installation and has been trained in laboratory techniques for soil sample preparation and analysis.
- Santosh Subedi, Ph.D. student, Virginia Tech. Santosh's research focus is identifying an improved method to determine fertility rating for 3-PG.
- Elaine Stebler, Research Technician, Oklahoma State University. Elaine is coordinating baseline measurements on Tier II sites and overseeing installation and data collection on the Oklahoma Tier III site.
- Tom Stokes, Research Associate, Auburn University. Tom is assisting with installation and data collection on Tier II and Tier III sites.
- 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, Postdoc, 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 3PG and WaSSI-C across scales; assisting with data collection and analysis of water fluxes at the Virginia Tier III site.
- Maxwell Wightman, M.S. student, University of Florida. Max's research focus is ecophysiology of drought response on the Florida Tier III site.
- Madison Wigley, undergraduate assistant, Texas A&M University, Carbon monitoring protocol implementation for Tier II sites.
- Jingyan Yang, Ph.D. student, Univ. of Georgia, heterotrophic and autotrophic components of soil respiration.
- 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. Carbon and nitrogen cycling response to drought at the Oklahoma Tier III site.

Web Applications

Caldwell, P.V., G. Sun, S.G. McNulty, E.C. Cohen, and J.A. Moore Myers, 2012, WaSSI Ecosystem Services Model, Version 2.0. Available at: http://www.forestthreats.org/research/tools/WaSSI.

Fact Sheets

Caldwell, P.V., G. Sun, S.G. McNulty, E.C. Cohen, and J.A. Moore Myers, 2012, Water Supply Stress Index (WaSSI) Model, Forest Threat Factsheet no. 6, July 2012. Available at: http://www.forestthreats.org/products/fact-sheets/WaSSI_factsheet_July2012_printer-friendly.pdf.

User Guides

Caldwell, P.V., G. Sun, S.G. McNulty, E.C. Cohen, J.A. Moore Myers, R. Herring, and E. Martinez, 2012, WaSSI Ecosystem Services Model Version 2.0, User Guide Version 1.0, October 2012. Available at: http://www.forestthreats.org/research/tools/WaSSI/wassiuserguide.pdf.

Collaborations and "integrated" knowledge developed

Provide a short narrative describing new ideas, research questions, or insights that have arisen through work and discussions with colleagues, stakeholders, and others. In addition, explain the extent to which you intend to incorporate this into PINEMAP milestones and/or your Aim work plan.

With respect to stand modeling, we have identified shortcomings of 3PG for our objectives that are being addressed by the group. New elements being added include competition (Stape et al. at NCSU), changes in growing stock (Teskey et al. at UGA), and soil respiration (combination of NCSU and UGA groups). These will be subsequently called out in our work plan as details emerge on the perceived difficulty of each task.

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 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.

→ 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).

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

→ List any additional potential linkages to other Aim groups.

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

Leveraged funding/additional resources

Describe how PINEMAP funds were leveraged as well as any additional resources obtained. Please list amounts and sources.

Pending proposal to NASA and USGS for Landsat science related to PINEMAP.

- National Science Foundation, Center for Advanced Forestry Systems. $300,000 to Virginia Tech to renew NSF I/UCRC program for 2012-2017.
- Jill Qi is a PhD student *participating* in PINEMAP but is funded through a graduate assistantship from the University of Georgia.