Over the last 50 years, cooperative research on planted southern pine management among SE U.S. universities, government agencies, and forest industry has developed and facilitated the widespread implementation of improved genetic and silvicultural technology. The impact of the regional research cooperatives is difficult to overstate, with current members managing 55% of the privately owned planted pine forestland, and producing 95% of the pine seedlings planted each year. Our team includes the eight major forestry cooperative research programs, scientists from nine land grant and three 1890s institutions, the US Forest Service, and climate modeling and adaptation specialists associated with the multi-state SE Climate Consortium and state climate offices. Our goal is to create and disseminate the knowledge that enables landowners to: harness planted pine forest productivity to mitigate atmospheric CO_2; more efficiently use nitrogen and other fertilizer inputs; and adapt their forest management to increase resilience in the face of changing climate. We will integrate our team's infrastructure and expertise to: 1) develop breeding, genetic deployment and innovative management systems to increase C sequestration and resilience to changing climate of planted southern pine forests ; 2) understand interactive effects of policy, biology, and climate change on sustainable management; 3) transfer new management and genetic technologies to private industrial and non-industrial landowners; and 4) educate a diverse cross-section of the public about the relevance of forests, forest management, and climate change. These efforts will enable our stakeholders to enhance the productivity of southern pine forests, while maintaining social, economic, and ecological sustainability.

INTRODUCTION

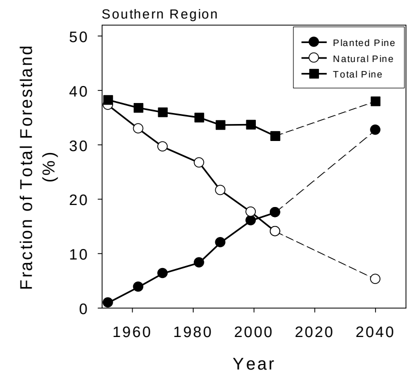

Figure 1. Actual and projected trends in the proportion of total southern forestland occupied by planted pine and naturally-regenerated pine stands (Conner and Hartsell 2002, Wear and Greis 2002, Smith *et al.* 2009).

In the southeastern U.S., forests occupy 60% of the land area, with a large fraction dominated by the genus *Pinus*, about half naturally regenerated and half planted with genetically improved seedlings (Figure 1). Because of their large area and high productivity, southern forests are a significant portion of the U.S. carbon budget, containing 12 Pg of C, 36% of the sequestered forest carbon (C) in the conterminous United States (Turner *et al.*, 1995). Forests in the region annually sequester 76 Tg C, equivalent to 13% of regional greenhouse gas emissions, and have the potential to sequester more through reforestation, afforestation, and improved forest management (Johnsen *et al.* 2001, Han *et al.* 2007). Southern pine forests are also central to the economic vitality of the nation: the forest products industry is responsible for 5.5% of the jobs and 7.5% of total industrial output in the region (Wear & Greis 2002). Nationally, this industry employs more people than the automotive, chemical or plastics industries. In the SE U.S., ~85% of all forestlands are privately owned, and planted pine forests will remain important for the foreseeable future (Figure 1).

Over the past 50 years, the productivity of planted pine has tripled (Fox *et al.* 2007, Jokela *et al.* 2010), enabling southern forests to produce about 16% of global industrial wood, more than any other *country* (Prestemon & Abt 2002). These productivity gains are attributable to widespread implementation of improved genetics, seedling culture, and nutrient and competition management technology developed and deployed by university-led cooperative research programs involving forest industry, federal and state forestry agencies, forest management consulting firms and state extension services (Stanturf *et al.* 2003, Fox *et al.* 2007; Table 1). The research infrastructure established by SE U.S. forestry research cooperatives is singular, and includes thousands of progeny trials and other genetics experiments, thousands of permanent plots and experiments designed to parameterize statistical growth and yield models, and hundreds of replicated experiments testing the effects of diverse silvicultural treatments on pine productivity, all of which provide cooperative members with vital information and approaches on which their decision systems are built. This substantial infrastructure investment, intended initially for creation of applied knowledge, has been leveraged by scientists in the region to further our fundamental understanding of the biological and genetic controllers of tree and forest productivity (e.g., Jokela *et al.* 2004, Emhardt *et al.* 2007, Samuelson *et al.* 2008), disease and insect resistance (e.g. Strom *et al.* 2002, Kayihan et al. 2005, Isik *et al.* 2008), and C sequestration (e.g., Tyree *et al.* 2008, Radtke *et al.* 2009, Gonzalez-Benecke *et al.* 2010, Noormets *et al.* 2010), among others. Taken as a whole, the accumulated data, germplasm, research trial base, and scientific expertise associated with SE U.S. forestry research cooperatives is unmatched, and has made the southern pine plantation system arguably the best understood production forestry system in the world.

The impact of cooperative research on SE U.S. forest management is difficult to overstate, as members of the cooperatives in Table 1 manage > 20 million acres of planted forests in the region (about 55% of the total privately owned planted pine forestland), and produce 95% of the pine seedlings planted in the region each year (McKeand *et al.* 2003). Because research cooperatives include scientists and land managers from member organizations, research innovations from the cooperatives are translated seamlessly and rapidly into practice on both lands managed for industrial wood production, as well as to non-industrial private forestland (NIPF) owners by major forestry consulting companies and state agency members. Because these cooperatives are based in land-grant universities, the research findings are easily conveyed to private forest landowners and extension agents.

Table 1. University – forest industry research cooperatives participating in this proposal.

Industrial Research Cooperative	Host University (yr founded)	# Members
Cooperative Forest Genetics Research Program http://www.sfrc.ufl.edu/cfgrp/ourweb.html	University of FL (1953)	8
Cooperative Tree Improvement Program http://www.treeimprovement.org/	NC State University (1955)	25
Forest Biology Research Cooperative http://www.sfrc.ufl.edu/fbrc/	University of FL (1996)	8
Forest Modeling Research Cooperative http://www.forestry.vt.edu/ForestModelingResearchCooperative/	VA Polytechnic Institute and State Univ. (1979)	21
Forest Nutrition Cooperative http://www.forestnutrition.org/	VT / NC State Univ. /Universidad de Concepción (1969)	52
Plantation Management Research Cooperative http://warnell.forestry.uga.edu/pmrcpub/	University of GA (1975)	17
Southern Forest Resource Assessment Consortium http://cnr.ncsu.edu/fer/research/sofac/whoweare.html	NC State University (1994)	22
Western Gulf Forest Tree Improvement Program http://www.ars-grin.gov/misc/wgftip/about.html	TX A&M Univ. / TX Forest Service (1969)	13

RATIONALE AND SIGNIFICANCE

Climate change will likely have important impacts on planted southern pine systems. A 2009 summary from the U.S. Global Change Research program (Karl *et al.* 2009) indicates that the SE U.S. will experience continued increases in the rate of warming through the end of the century, with a rise in average temperature of 2.5 to 5^{o} C by the 2080s, a magnitude of temperature increase that is predicted to decrease loblolly pine productivity by at least 10% (Schmidtling 1994). The greatest temperature increases are expected to occur in the summer, with the number of very hot days to increase faster than the rise in average temperature. Precipitation predictions for the region are less certain, but generally indicate that summertime precipitation will decline by 10% to 30% (Karl *et al.* 2009, Christensen *et al.* 2007). Decreased precipitation and expected elevated temperatures will increase vapor pressure deficits, making it more likely that soil water deficits will negatively impact southern pine C sequestration (Noormets *et al.* 2010). The physiological response to soil water and vapor pressure deficits varies with genetics (Gonzalez-Benecke & Martin 2010) suggesting negative impacts may be mitigated by changing genetic deployment. Increased sea surface temperatures are predicted to increase hurricane intensity, leading to greater windstorm damage, which has great potential to impact regional C balance (Chambers *et al.* 2007). Susceptibility to wind damage varies among species and may be under genetic control (Johnsen *et al.* 2009).

The overarching goal of this proposal is to create, synthesize, and disseminate the knowledge necessary to enable southern pine landowners to harness forest productivity to mitigate atmospheric CO_2 and to more efficiently utilize nitrogen and other fertilizer inputs, and to adapt their forest management approaches to increase resilience in the face of changing climate. Our focus is on planted pine forests in the Atlantic and Gulf coastal states from Virginia to Texas, plus Arkansas and Oklahoma, managed by industrial and non-industrial private landowners. Our primary focus will be on loblolly pine, the dominant commercial species in the region (Schultz 1997). The economic, environmental and social benefits of our efforts will be rapid and maximized with a focus on these landowner/producer groups because (1) technology transfer connections are well established and efficient between cooperative research programs and all major industrial forestland owners in the region, as well as many private non-industrial owners through consulting firms, (2) non-industrial entities own 58% of all forestland in the region (Smith *et al.* 2009), so even incremental changes in this group will have substantial cumulative regional benefits, and (3) regional Extension and education programs are well-connected through the Southern Regional Extension Forestry Office and national Project Learning Tree network. Our approach will build trans-disciplinary research, education and outreach capacity aimed at mitigating climate change impacts through an understanding of adaptation and management potential in the region. We will integrate disciplinary expertise from all major regional university forestry cooperative programs, as well as accumulated data, germplasm, and infrastructure, with outreach and education specialists from major research universities and minority-serving institutions in the region, the USDA Forest Service, and climate scientists associated with the multi-state SE Climate Consortium and state climate offices.

The project goals will be accomplished by completing the following aims:

(1) Establish a regionwide three-tiered monitoring network based on existing cooperative research trials, and develop standardized methods to quantify C, water, and nutrient storage and flux baselines and responses to climate and management.

(2) Apply a multi-scaled modeling program incorporating data from the monitoring network, empirical growth and yield models, stand-level biophysical C balance models, and watershed to regional scale C and water models driven by remote sensing to assess alternative forest management systems for sustainably increasing mitigation of greenhouse gases while adapting to changing climate and associated disturbances.

(3) Analyze genetics of breeding and natural populations to discover alleles in genes controlling important adaptation and mitigation traits that enable future tree breeding strategies, and deliver deployment guidelines for genotypes suited for varied climatic conditions to maximize resiliency and reduce adverse impacts of climate change on productivity.

(4) Conduct comprehensive life cycle analyses of regional forest management systems and multi-scale policy and economic analysis of market and non-market forest benefits and services to evaluate regional tradeoffs and interactions among policy, climate scenarios, C/water/nutrient/energy footprints, forest management, and genetic deployment, and assess adoption of alternative approaches by private landowners.

(5) Create educational resources and training programs for teachers and extension agents to convey the value and relevance of southern forests and climate change impacts, engage undergraduate interns in research and teaching activities, and contribute to an existing national educational network in the development and delivery of inquiry-based middle and high school lessons that feature our research strategies and tools. Prepare graduate students to address climate change mitigation and adaptation issues.

(6) Develop Extension programming that combines regional climate expertise and forest management outreach to deliver knowledge and state-of-the-art information, resources and management decision support tools to forest landowners, resource managers and policy makers.

APPROACH

Aim 1**:** *Establish a regionwide three-tiered monitoring network based on existing cooperative research trials, and develop standardized methods to quantify C, water, and nutrient storage and flux baselines and responses to climate and management.*

Monitoring network establishment: We will use existing regionwide cooperative field trials as the backbone of a three-tiered monitoring network. **Tier I** will use the existing network of several thousand growth and yield cooperative (*e.g.*, Shiver & Martin 2002, Russell *et al.* 2010) and US Forest Service Forest Inventory and Analysis (FIA) permanent plots which blanket the region to provide extensive, spatially-explicit information on regional variability in productivity. Most of these plots have repeated measurements over time and thus provide excellent information on spatial and temporal variability in productivity in relation to geographic and climate factors.

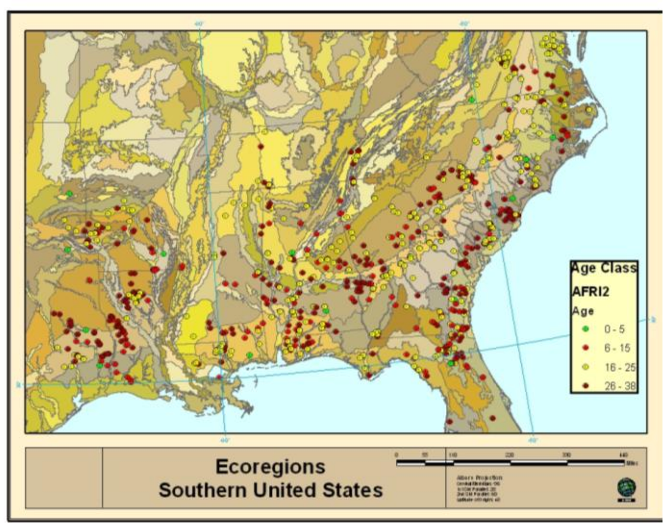

Figure 2. Locations and ages of existing cooperative field trials from which Tier II monitoring network sites will be chosen. The map is divided into U.S. EPA Level IV Ecoregions which delineate areas with similar geology, physiography, vegetation, climate, soils, land use, and hydrology (Gallant *et al.* 1989, Griffith *et al.* 1994, Omernik 1995, Omernik *et al.* 2000).

Tier II will contain sites chosen from existing cooperative field studies and planted forest AmeriFlux installations (Noormets *et al.* 2010, Gonzalez-Benecke *et al.* 2010) which cover the full range of climate and soils in the region, and most of which include replicated silvicultural treatments (Figure 2). All of these trials have multiple historical tree inventory (typically survival, trees/acre, tree height and diameter) measurements. Tier II sites will be chosen to optimize variation in geography, soils, climate, stand age, and treatment (focusing on nutritional, competition control, and thinning or planting density treatments), as well as the strength of existing data for each trial. New, more intensive measurements on Tier II sites will enable standardized quantification of C pools and fluxes, including soil heterotrophic respiration, the key link between net primary production (NPP) and net ecosystem production (NEP). In a subset of Tier II sites these and other trait measures will be associated with genetic diversity information to discover genes and alleles that control important productivity, sustainability and adaptive traits important for ecosystem function and tree breeding in the context of climate change (see Aim 3). Included in the Tier II sites will be installations of a study currently being established by the Forest Nutrition Cooperative with support of the NSF Center for Advanced Forestry Systems that will use ^{15}N to investigate the uptake efficiency and ecosystem fate of applied N fertilizer in loblolly pine plantations. A minimum of 20 loblolly pine stands across the South will be included in this study which will compare ^{15}N labeled urea and three types of controlled release N fertilizers.

Finally, **Tier III** will consist of experiments established in four key locations at the edges of the loblolly pine range chosen to span the full range of potential productivity of the species, with manipulative treatments designed to elucidate interactions among genetics, nutrition, and precipitation (Figure 3). Tier III sites will be located approximately as indicated in Figure 3, with the exact locations chosen from the best combination of available genetics trials (with genetic commonality across the Tier where possible), age (approximately 6 years, which is just past canopy closure in most southern pine stands), plot size, and number of replicates available for treatments. At each site, we will establish on top of the existing study a factorial combination of fertilization (2 levels) and precipitation (2 levels) treatments. Fertilization treatments will include a control and an "optimum" nutrition treatment similar to the regime described by Albaugh *et al.* (2004). Precipitation treatments will consist of a control (rainfed) and a ~30% reduction treatment (corresponding to the driest predictions for the region, Christensen *et al.* 2007) imposed by installing fiberglass throughfall diversion panels in the forest understory. Similar systems have been used successfully in several forest types (Nepstad *et al.* 2002, Wullschleger and Hanson 2006, Stape *et al.* 2009; Figure 4) but to our knowledge have not been deployed in a coordinated manner across the entire range of a species. Sites will be instrumented with cellular networked weather stations and with automated soil CO_2 efflux measurement systems.

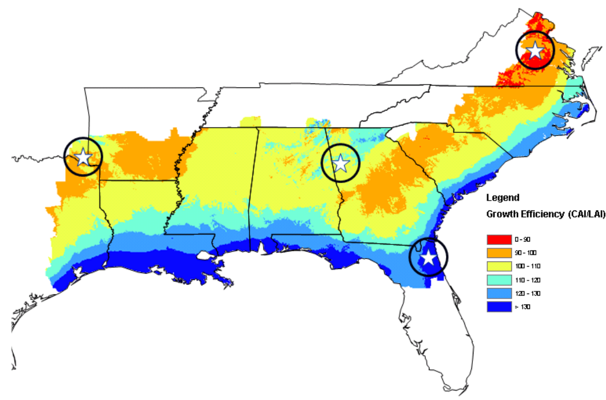

Figure 3. Potential Tier III site locations overlaid on 3-PG predictions of loblolly pine canopy growth efficiency (F. Flores *et al.*, unpublished).

Figure 4. Rainfall exclusion treatment in *Eucalyptus* plantations in Brazil (Stape et al. 2009).

Tier II and Tier III vegetation and soil sampling: Vegetation sampling will follow the international protocol for C accounting described by Law *et al.* (2008), modified for the relatively homogeneous structure of planted southern pine stands (Vogel *et al.* 2010). This protocol is in wide use by investigators in programs such as the AmeriFlux network and North American Carbon Program. Sampling will occur on previously-established inventory measurement plots for each site, which typically range from 0.01 to 0.10 ha, and will include replicate plots at each site. This protocol includes measurements of standing live and dead trees, understory vegetation, coarse and fine woody detritus, forest floor, and soil organic matter, roots, and chemical and physical properties collected at 0-5, 5-10, and 10-20 cm depths, then additional 20 cm depth intervals to 1 m, or as deep as possible. We will archive all sieved, air dried soils following the methods being developed by the USDA supported National Soil Carbon Network (www.soilcarb.net).

Nitrogen use efficiency: In the SE, chronically low levels of available soil N limit growth in most planted pine forests (Jokela & Martin 2000, Fox *et al.* 2007). Forest fertilization can significantly increase the productivity of most planted pine forests in the region, and consequently over 400,000 ha/yr are fertilized with N (Albaugh *et al.* 2007). Unfortunately, only 10-25% of the applied N is taken up by crop trees (Mead & Pritchett 1975, Blazier *et al.* 2006). Most of the fertilizer N is tied up in other ecosystem components or lost to volatilization (Will *et al.* 2006). Improving the tree uptake efficiency of applied fertilizer N could significantly reduce the amount of fertilizer needed to increase the productivity of existing and future southern pine plantations. Most of the existing studies that will be used as Tier II sites include N fertilization as one of the treatments. Combining existing growth response data at these sites with the new data on below ground and above ground C and N pools will enable us to determine nitrogen use efficiency and how it varies by soil and climate across the South. The data from the network, combined with ongoing regionwide cooperative research on N use efficiency, will guide creation of alternative fertilization and management regimes designed to improve N use efficiency, which will be assessed and scaled to the region in the modeling program in Aim 2.

Ecophysiology measurements: Several ecophysiological parameters will be measured on the Tier III sites and on a subset of Tier II sites to (1) parameterize key model inputs and (2) characterize regional variation in important biological functions related to C cycling.

The stand scale Physiological Principles in Predicting Growth (3-PG) model that will be used in Aim 2 is particularly sensitive to two parameters, canopy quantum efficiency (α_c) and fertility rating (FR) (Landsberg & Waring 1997, Landsberg *et al.* 2001). To characterize variation in α_c across the plot network, maximum intercepted photosynthetically active radiation will be measured as in Will *et al.* (2001), and will be combined with productivity data. The FR is a relative index of soil nutrient availability, and is more difficult to estimate. We will test three methods of predicting FR. The first is the technique in which FR was found to be well correlated with soil attributes of the A horizon in a group of stands in Brazil (chemical attributes) (Stape *et al.* 2004) and Virginia (physical attributes) (Sampson *et al.* 2008). The second will estimate FR from early stand height growth (up to year 5), analogous to an early site index estimate. The third method predicts FR from other soil chemical, structural and/or biological properties.

Understanding stomatal conductance is critical because it controls transpiration and is tightly linked to C assimilation (Franks & Farquhar 1999). To analyze stomatal response to vapor pressure deficit and soil drying, we will use the approach of Oren *et al.* (1999) applied to estimates of whole-crown stomatal conductance derived from sap flow measurements. These measurements and analysis will enable us to (1) provide important water relations parameters for the 3-PG and WaSSI models; (2) measure actual tree water use to compare with 3-PG and **Wa**ter **S**upply and **S**tress **I**ndex (WASSI) model outputs; (3) use measurements of wood stable isotope ratios of O and C ($\delta^{18}O$ and $\delta^{13}C$) to quantify the amount of C biomass produced per unit water transpired (transpiration efficiency) by the trees and attribute water stress to physiological or environmental constraints; (4) characterize variation in tree water use efficiency by genotype, tree age, and region; and (5) provide a physiological understanding of underlying regulatory mechanisms of water use efficiency differences between regions and among genotypes under changing climatic conditions. Transpiration and whole-tree water use will be determined by measuring sap flow as described by Granier (1987) and stomatal conductance terms will be calculated as in Domec *et al.* (2009a) and Gonzalez-Benecke & Martin (2010). In all Tier III rainfall exclusion experiments and a subset of Tier II plots, all trees with sap flow measurements will be cored and $\delta^{13}C$, $\delta^{18}O$, and wood density will be measured.

Because the soil's capacity to sequester carbon depends on the rate of input of new litter exceeding the rate of decay of existing C pools, we will measure soil CO_2 efflux on Tier II and III sites (Li-Cor portable CO_2 flux systems, Lincoln, Nebraska). Heterotrophic and autotrophic respiration will be separated using a modified root exclusion core that will sever roots from tree carbohydrate inputs, analogous to stem girdling (Hogberg *et al.* 2001, Kuzyakov 2006). A comparison of total soil CO_2 efflux before and after girdling is used to partition the heterotrophic (rate after girdling) and autotrophic components (difference of before and after girdling). Similar to previous studies (Vogel *et al.* 2005, Lalonde & Prescott 2007), we have found that severing roots in a small plot area results in a rapid decrease in total root respiration similar to that seen in girdling studies (Figure 5). Comparing CO_2 efflux from the severed and undisturbed root zones allows partitioning of total efflux into heterotrophic and autotrophic components. This information is necessary to establish (1) a minimum allowable fraction of GPP allocated to support root development, and (2) the rate of decay of old soil carbon. Comparison of this partitioning approach with root respiration estimates derived from the radiocarbon partitioning method of Schuur & Trumbore (2006) are in progress (Jokela & Vogel 2010).

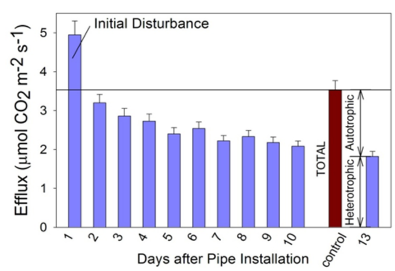

Figure 5. Decline in soil CO_2 efflux following root severing using a pipe driven into the ground. (J. Seiler, unpublished).

Subregion measurement teams: Four geographic sub-groups (1: VPI & NCSU; 2: UGA & Auburn; 3: FL; 4: OSU & TAMU) will be assigned responsibility for the Tier II and III measurements in their subregion. This approach, rather than a single investigator measuring a single characteristic at all sites, was selected because it more efficiently uses resources, fosters collaboration among researchers, and builds institutional capacity. Subregional groups will be required to use the same base standards for vegetation and soil analysis, publish standard analyses online, and cross-check chemical analyses among groups. At annual meetings, collection methods will be discussed and cross-lab comparisons will be evaluated. This effort will lead to the regional standardization of the measurements needed to accurately estimate C and nutrient pools and fluxes across the region. Data will be archived and shared among project investigators in a centralized C information system described in the Management Plan.

<u>Aim 2</u>: *Apply a multi-scaled modeling program incorporating data from the monitoring network, empirical growth and yield models, stand-level biophysical C balance models, and watershed to regional scale C and water models driven by remote sensing to assess alternative forest* *management systems for sustainably increasing mitigation of greenhouse gases while adapting to changing climate and associated disturbances.*

The existing inventory data from our very extensive Tier I network, as well as existing inventory and new C/nutrient dynamics data from our Tier II and III networks and experimental manipulations will be used to parameterize and validate a coordinated series of open-source models ranging in complexity and scale from tree-level to regional (Figure 6). If necessary, network data will be supplemented by data from Phase 3 FIA plots in the region. These models will in turn be used to design and test novel genetic and forest management systems focused on greenhouse gas mitigation, enhanced resource use efficiency, and resilience to climate change. The larger-scale models, coupled with remote sensing, will provide the framework for region-wide bioeconomic assessment of the response of forests and forest management systems to climate change and policy scenarios (see Aim 4). Models and model output will be used to help develop the open-source decision support system that will serve as a primary outreach tool, and as a hub for interaction between the research and extension teams (see description under Aim 6).

Growth and yield and empirical C balance modeling: Baseline biomass estimates will come from the most appropriate growth and yield models by timber type and physiographic region. These models will be updated through the course of the project with data shared from the participating cooperatives and new C pool measurements on the Tier II and III networks. Models such as FastLOB (from the participating Forest Modeling Research Cooperative) and Gonzalez-Benecke *et al.* (2010) already have complete C allometry validated against field data, and will be extended in a robust way through the datasets generated from the network.

3-PG: Stand-level carbon balance modeling will be carried out with 3-PG (use of Physiological Principles in Predicting Growth; Landsberg & Waring 1997). 3-PG is a hybrid between detailed physiological process and statistical growth and yield models that incorporates easily obtained weather and site conditions and can be used to simulate growth and yield of forest stands and the effects of environmental factors. It can also be used as an analytical tool to evaluate the probable effects of altering, by breeding or selection, the physiological processes that govern tree growth. 3-PG has several important advantages for this project: (1) it allows us to predict forest productivity under changing management and environmental conditions; (2) changing management practices and genotypes can be easily incorporated into it by creating modifiers to key biological parameters; and (3) it has been shown to accurately predict productivity in a variety of forests world-wide (e.g., Zhao *et al*. 2009, Coops *et al*. 2010, Rodriguez-Suarez *et al.* 2010). The successful use of the 3-PG model for both stand-level and regional C and water budgets predictions (Feikema *et al.* 2010, Waring *et al.* 2010) suggest that it is an excellent tool for regional integration and assessment. Tier II network productivity, C and nutrient pool, and ecophysiological measurements will enable cross-regional parameterization of the model, while parallel measurements plus additional water relations measurements from Tier III will provide data necessary for extending the model to conditions likely to occur under altered climate scenarios.

NASA CASA: Capacity for watershed-scale decision support for forest C management will be added through CASA (Carnegie Ames Stanford Approach; Potter *et al.* 1999) Express, an ArcGIS based version of CASA designed for use in southeastern forests. The CASA model predicts terrestrial ecosystem fluxes using satellite inputs at a maximum geographic resolution of 30 meters to estimate daily or monthly patterns in C fixation, plant biomass increments, nutrient allocation, litter fall, soil C/nitrogen and CO_2 exchange, and soil nutrient mineralization. CASA

Express will be used for scaling -up tract-level predictions made through growth and yield and 3-PG modeling (Feikema *et al.* 2010).

Use of LANDSAT data within NASA-CASA: To increase the spatial specificity of the model predictions over small areas (e.g., select forest stands), Landsat scenes from recent years will be used to downscale the model results. Within each Worldwide Reference System frame, all available cloud-free scenes within at least a two-year period will be converted to surface reflectance using the Landsat Ecosystem Disturbance Adaptive Processing System (Masek *et al.* 2006). If sensor issues or cloud cover limit temporal resolution, the Spatial and Temporal Adaptive Reflectance Fusion Model (Gao *et al.* 2006) will be used to increase resolution with Moderate Resolution Imaging Spectroradiometer platform products.

WaSSI-CB: To assess the modulating effects of alternative land and resource use demands on forest productivity, we will use the extended version of the regional scale ecosystem model **Wa**ter **S**upply and **S**tress **I**ndex (Sun *et al.* 2008a, 2008b) - WaSSI-Carbon Biodiversity (WaSSI-**CB**) to calculate water balance (ET and water yield) and carbon cycle components. WaSSI-CB allows spatially explicit assessment of competing demands on water resources, as it considers stream network data for flow routing on watershed and basin scales across the study area. Ecosystem gross productivity (GPP) is estimated through ecosystem type-specific WUE (McNulty *et al.* 2010), which will be obtained from Tier II and III sites as well as literature (Law *et al.* 2002).

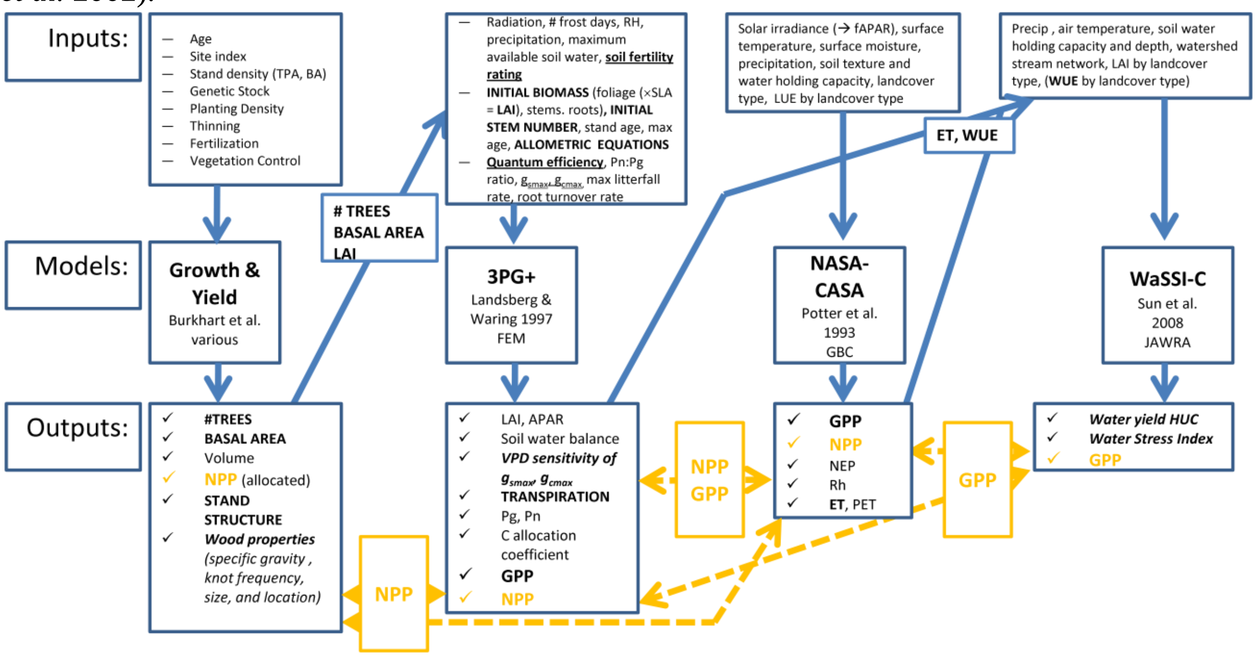

Figure 6. Schematic depiction of the inputs, outputs, and interactions among the four primary models. Solid blue arrows indicate data flow between models, yellow dashed arrows and variable names indicate cross comparison of common model outputs, **BOLD CAPS** input & output parameters indicate variables transferred among models, underlining indicates key sources of stand-level variability, and *italics* indicates terminal outputs unique in scale.

Model simulations and regional optimization: The suite of models described above will be used to analyze a range of management, climate and disturbance scenarios. Future monthly mean temperature and total precipitation scenarios for the region will be obtained from the National Center for Atmospheric Research GIS Climate Change Scenarios (www.gisclimatechange.org). While regional climate model outputs are not appropriate for direct input into the forest system models, the relative changes are appropriate. To obtain these relative changes, scenarios will be calibrated with historical observations, with the model difference (delta) over time used to adjust historical data and provide reasonable, bias corrected future scenarios of climate for forest system model input (Hijmans *et al.* 2005, Ines *et al.* 2006). Nested model runs will include simulation of baseline C estimates, the interaction of climate and C, the impacts of alternative national or regional C mitigation polices, effects of altered disturbance regimes associated with climate change, and how alternative silvicultural and management scenarios affect regional C, water, and nutrient balances.

Effective mitigation and adaptation to climate change in forests requires a large-scale approach that explicitly considers trade-offs between different goals. We will evaluate climate change mitigation and adaptation trade-offs so that optimal management strategies can be developed at the landscape to regional level. This strategy will include a genetic algorithm optimization framework (Cropper & Anderson 2004, Cropper & Comerford 2005, Holzkamper & Seppelt 2007) for assessing tradeoffs among managing large-scale C sequestration, pulp and solid wood production, and maintenance of other ecosystem services. Regional outputs will also be used in regional economic modeling efforts (see Aim 4).

Aim 3: *Analyze genetics of breeding and natural populations to discover alleles in genes controlling important adaptation and mitigation traits that enable future tree breeding strategies, and deliver deployment guidelines for genotypes suited for varied climatic conditions to maximize resiliency and reduce adverse impacts of climate change on productivity.*

For over 50 years, university-industry tree improvement cooperatives and the USFS have conducted extensive genetic analyses and breeding with loblolly and slash pine. Large breeding populations have been established and evaluated in extensive regionwide replicated field tests. Using recurrent selection for growth, stem form, and disease resistance, 3rd generation loblolly and slash pine seedlings yield ~30% more wood compared with unimproved material, and essentially all of the ~1 billion southern pine seedlings planted annually have been through at least one generation of genetic improvement (McKeand *et al.* 2006, Vergara *et al.* 2007).

Seed deployment decisions are crucial for achieving high productivity and depend on matching genetic material to planting environments. Current deployment guidelines for southern pines (Schmidtling 2001) are based primarily on survival and growth data from the Southwide Southern Pine Seed Source Study (SSPSSS) conducted from 1950 to 1980s with wild seed, under historical weather conditions. In these guidelines, minimum winter temperature is a key factor with both benefit and risk of moving southern or coastal material northward or inland to colder environments (Schmidtling 1994, Schmidtling 1997). Since the SSPSSS, the tree improvement cooperatives have conducted more extensive, large-scale provenance, family and clone tests across the physiographic regions (e.g., Sierra-Lucero *et al.* 2002). Provenance trials have demonstrated that loblolly pine from the east grows faster than the interior western material, which is better adapted to a more continental climate with more extreme temperatures and precipitation. This knowledge has led to widespread planting of field-tested Atlantic Coastal Plain (ACP) families on industry lands in AR, MS and OK rather than locally adapted stock (Lambeth *et al.* 2005).

The best planting decisions are based on growth and survival data obtained from genetic tests that are 10-20 years old; however, such information is available for only a limited set of environments, and the impacts of changing climate during the rotation are rarely taken into account. Thus, our goal is to inform future deployment decisions with projected climate change scenarios taking into account uncertainty and risk introduced by performance instability. To accomplish this goal, available growth, survival, genetic and environmental data from our participants' and cooperators' provenance, family, and clone trials will be used to parameterize uniform response functions (Wang, *et al.* 2010). We will integrate response functions with geospatially specific climatic predictions in a dynamic model to estimate the relative productivity and adaptation of genetic material to specific climatic conditions analogous to that developed for Douglas fir (Howe *et al.*, 2010). This analysis will be conducted by all three breeding cooperatives and climatologists to provide guidance for seed deployment.

Seed sources of loblolly pine differ in growth rate, drought and cold tolerance, and insect and fungal resistance (Wells & Wakeley, 1966, Wells, 1983, Schmidtling 1994, 2007). Pine productivity and adaptive traits are controlled by many genes, but their number and identity are unknown (Gonzalez-Martinez *et al.* 2006, Neale & Ingvarsson 2008). We will investigate the genetic basis of these traits in loblolly pine by conducting linkage and association mapping (Myles *et al.* 2009, Myles *et al.* 2010) to identify alleles that can be screened in breeding populations, helping to accelerate improvement of productivity and adaptive traits. Mapping studies will be done in three complementary populations: Plantation Selection Seed Source Study (PSSSS), Comparing Clonal Lines ON Experimental Sites (CCLONES) and Allele Discovery of Economic Pine Traits2 (ADEPT2). In addition, we will develop a new population for a Southwide field test that includes region-wide crosses and material from extremes of the natural range to capitalize on anticipated decreases in DNA sequencing costs. PSSSS was planted in 1994-96 on 23 sites across the region and contains 140 polymix families, 20 families from each of seven physiographic regions in the Southeast. PSSSS was designed to test for growth stability. Breeding values for various growth and stem quality traits are available for years 4 and 8 (Chamblee 2010). CCLONES was planted in 2002 on seven sites, including two outside the physiographic region of the parental ACP and Florida provenances, and contains 62 full sib families (Baltunis *et al.* 2007). CCLONES was designed to compare rooted cutting and seedling performance under operational and intensive fertilization, and dissect the genetic architecture of productivity and adaptive traits. Extensive phenotype data are available from years 1-8, including various growth (Baltunis *et al.* 2007, 2008; Gezan *et al*. 2010), stem and wood quality (Li 2009), and adaptive traits (Kahiyan *et al.* 2005, 2010, Parisi 2006, Baltunis *et al.* 2008, Westbrook *et al.* 2010). ADEPT2 was planted in 2010 on three sites and contains 420 unrelated genotypes selected to represent much of the geographic diversity of the region and was designed for association genetic analyses of productivity and adaptive traits (Cumbie 2010, Eckert, *et al.* 2010).

We will continue measuring productivity traits, including response to N fertilization in CCLONES and will also phenotype additional adaptive traits, such as cold hardiness (Hannerz *et al.* 1999), budset and budflush in CCLONES and ADEPT2 and needle $\delta^{13}C$, oleoresin flow a measure of resistance to southern pine beetle (SPB) (Strom *et al.* 2002), wood density and lignin content in ADEPT2. In addition to the available phenotypic data on these two populations, ~4000 single nucleotide polymorphisms in 3800 genes have been genotyped in ~1500 individuals with the Illumina Infinium assay. Association tests between SNPs and fungal disease resistance (Quesada *et al.* 2010, Quesada 2010), wood properties (Li 2009), needle $\delta^{13}C$ (Gonzalez-Martinez *et al.* 2008, Cumbie 2010), aridity index (Eckert *et al.* 2010) and needle N content (Cumbie 2010) and xylem gene expression (Palle *et al.* 2010) in CCLONES and ADEPT2 have identified >200 significant SNPs. We will leverage existing data by dramatically expanding the amount of genetic variation surveyed in these three populations to discover genes and alleles controlling productivity and adaptive traits.

Loblolly pine gene coding regions have high nucleotide diversity and linkage disequilibrium decays rapidly (Brown *et al.* 2004). Hence genetic polymorphism coverage limits genome wide association experiments. We will use next generation sequencing to greatly expand the variation analyzed in all three study populations. In a parallel project, NIFA anticipates funding development of a draft sequence of the loblolly pine genome. We expect the first assembly of the sequence to be available in year 2 or 3 of our project, and we will work closely with the awarded group to share sequence information to strengthen both projects. However, because of the size of the loblolly pine genome, cost effective genotyping still requires reducing the complexity of the genome component to be genotyped by sequencing. To reduce library complexity, three methods will be compared to determine relative merits and costs: RNA-seq (Mortazavi *et al.* 2008) as recently modified by Illumina to include normalization with duplex-specific nuclease (Zhulidov *et al*. 2004), solution hybridization capture and sequencing of specific genomic sequences (SureSelect) (Gnirke *et al.* 2009), and reduced representation genomic libraries prepared with restriction enzymes (Baird *et al*. 2008; Fellers 2008; Gore *et al*. 2009; Miles *et al.* 2010). For these tests a sample of diploid vegetative tissue from a single tree, and eight haploid megagametophytes obtained from seeds of the same tree will be used for each method to objectively distinguish allelic sequence variants from paralogous variants. The criteria used to choose a genotyping method will include the cost per sample, the recovery of polymorphic SNPs, and the ability to distinguish paralogous variants from allelic variants based on sequence characteristics. Because it may be advantageous to use different strategies, these criteria may differ depending on the population and goal. Experimental design considerations for high-throughput sequencing will be incorporated (Auer & Doerge 2010).

We expect to identify alleles in genes controlling growth, nitrogen responsiveness, cold hardiness, water usage, resistance to SPB and fungal diseases. Of particular interest are alleles that influence adaptive traits because these will enable screens of fast growing material in breeding programs for adaptability to changing pest, disease and climate conditions.

Aim 4: *Conduct comprehensive life cycle analyses of regional forest management systems and multi-scale policy and economic analysis of market and non-market forest benefits and services to evaluate regional tradeoffs and interactions among policy, climate scenarios, carbon/water/nutrient/energy footprints, forest management, and genetic deployment, and assess adoption of alternative approaches by private landowners.*

Well accepted financial models based on discounted cash flow analysis are used for evaluating the returns of investing in silvicultural practices such as mechanical and chemical site preparation, fertilization, thinning and harvesting of planted southern pine forests (e.g., Klemperer 2003). However, the impacts of silvicultural practices on C mitigation are less well understood (Markewitz 2006, Gonzalez-Benecke *et al.* 2010). To fill this gap we will conduct a comprehensive life cycle analysis (LCA) to quantify global warming impacts of various silvicultural practices and systems typical of non-industrial private forestland (NIPF) and industrial private forest landowners (Curran, 2006). This LCA will provide critical information for comparing C inputs and outputs in planted pine forests with growth and yield simulations for selected regimes using well accepted forest simulators. This information will be used to calculate environmental and financial criteria to determine optimal management regimes and rotation ages.

Federal and state policies and programs that incentivize C sequestration and climate change mitigation are expected to significantly influence management choices, afforestation of agricultural lands, landowner profitability, and other important aspects of planted southern pine forests (e.g., Alig, 2003, Gillig *et al.* 2004). The economics team will provide critical support throughout the project, assessing the current and expected features of policies and programs anticipated to significantly impact climate change mitigation efforts in planted pine forests. A white paper summary and regular updates will be available on the CAP website to support team members and serve as an important outreach/extension resource.

Building on the LCA, we will explore how C sequestration and mitigation efforts will affect ecological functions, goods and services (EFGS) (Alig, 2003). We will construct an empirical bio-economic model with joint provision of EFGS and forest products from planted pine, with the goal of generating a parsimonious empirical model that can be generalized to other areas using available silviculture and LCA data. With this model, we will evaluate and simulate changes to forest production, land use and management due to C sequestration and climate change mitigation policies.

The degree to which planted southern pine forests can help adapt to and further mitigate climate change will largely depend on the behavior of private landowners altering planting and harvesting decisions and adopting improved southern pine feedstocks and silvicultural systems, which will be affected by government and market incentives. In coordination with project Extension efforts, we will evaluate the expected adoption of altered silvicultural practices for private industrial and non-industrial private forest (NIPF) management activities. For adoption on industrial lands we will survey our cooperative members. For NIPF landowners, we will conduct a survey to quantify the adoption of specific management practices such as altered planting density or rotation length, regeneration methods used, herbaceous weed control, or thinning, and willingness to accept alternative regimes.

Disturbances such as wildfire and SPB outbreaks have emerged as a major threat to the productivity and health of US southern forest ecosystems (Wear & Greis 2002). Climate change is likely to intensify the risk of these disturbances (Dale *et al.* 2001; Gan 2004); and the risk to some extent can be mitigated through adaptation (Nabuurs *et al.* 2007). Yet the impact of climate change on this risk, particularly its economic consequences and the role of adaptation in mitigating the risk are relatively unexplored. We will assess and compare the risk and economic consequences (i.e. the impact on timber and C values) of forest fire and SPB outbreaks under climate change with and without adaptation. At the landowner level, options analysis (e.g., Yin & Newman 1996; Susaeta *et al.* 2009) coupled with dynamic optimization under risk (e.g., Amacher *et al.* 2005) will be used to model investment and management decision making behavior. At the regional level, panel data modeling with historical data on forest fires, SPB infestations, and climate along with forest stand information will be used to establish the relationships between the risk of forest fire or SPB infestations and explanatory climate, site and management factors. The models will reveal (1) the impact of climate change on the risk of the disturbances and (2) the contributions of adaptations to mitigating the risk under climate change. Risk estimates will further be converted into economic losses in terms of timber and C values based on timber and C prices and projected future forest areas in the South under climate change.

The impact of climate change and markets for C on SE regional wood supplies are vital but not well understood. Regional product market and C consequences of business-as-usual and potential new silvicultural management regimes will be modeled using the SubRegional Timber Supply (SRTS) model (Abt *et al.* 2009). This model uses empirical product supply and demand relationships to project changes in inventory characteristics (forest type, age class structure, product inventories, harvest, and growth) at a survey unit level (58 subregions in the U.S. South). STRS was recently updated to incorporate C accounting and bio-energy demand (Galik *et al.* 2009, Abt *et al.* 2010).

Aim 5: *Create educational resources and training programs for teachers and extension agents to convey the value and relevance of southern forests and climate change impacts, engage undergraduate interns in research and teaching activities, and contribute to an existing national educational network in the development and delivery of inquiry-based middle and high school lessons that feature our research strategies and tools. Prepare graduate students to address climate change mitigation and adaptation issues.*

Two education activities will link the research process and findings to college students and K-12 educators, as well as provide resources for Extension faculty to use with the public. Both projects will be guided by an advisory committee that will meet in-person in Years 1 and 3 to help development, implementation, and evaluation. Electronic meetings will be conducted more frequently as needed. The advisory committee will include forest science researchers, extension specialists, Project Learning Tree coordinators, teacher educators, and teachers from across the 10-state region. Both activities will undergo formative evaluation to improve the project and summative evaluation to assess impacts (Ernst *et al.* 2009).

Forest Climate Change Undergraduate Researchers and Educators: Modeled after the highly successful "Forestry OutReach Site (FORSite)" Program at Virginia Tech (VT), we will provide undergraduate students with a research experience and prepare them to successfully assist in middle school science classes (Kirwan & Seiler 2005, Seiler 2010). Undergraduate students from 1890 and other teacher preparation and natural resource institutions will be selected for a summer internship (Southern Conifer Climate Change Intern Program) to work with a forest science researcher and participate in data collection and hypothesis testing. They will return to their institution to enroll in a fall distance education course in inquiry teaching from VT and work with their classmates to develop and refine engaging activities for secondary school life science and biology classes (Jacobson *et al.* 2006). They will visit science classrooms in their community to lead these activities and help younger students explore the C in the trees on their school grounds, understand the C cycle and role of trees in mitigating climate change, and compare the life cycles of products made from southern pine to comparable items made from non renewable resources (*e.g.*, rayon *vs.* nylon, wood *vs.* concrete and steel, paper bags *vs.* plastic bags). School site measurements will use GLOBE science education network protocols (www.globe.gov) so that teachers have the option of entering their data into this international database and comparing their C sequestration with others. The experience will include a journal writing assignment enabling undergraduates to reflect on the process of teaching and their own learning. Internship applications will be widely circulated at community colleges and universities with natural resources, forestry, and science education programs throughout the region.

PLT Secondary Module on Southern Pine and Climate: Project Learning Tree (PLT) is a national network of state coordinators, facilitators, and educators who use supplemental curriculum resources to convey concepts about forest ecosystems, forest products, and environmental issues. Secondary modules are focused on specific topics to help middle and high school students understand the environmental, economic, and social ramifications of issues such as biodiversity and solid waste. We will create a secondary module on the potential role of managed southern pine forests in climate change mitigation and the role consumers play in making that potential a reality based on carbon life cycle analyses of consumer products.

Activities adapted and pilot tested in our program will subsequently be enhanced, reviewed, and tested by the PLT network of coordinators, facilitators, and educators across the South. New activities will help complete the program using the U.S. Climate Literacy guidelines (www.globalchange.gov). An online training module will be developed to supplement state coordinators' training programs (McConnell 2010). Graduate students will be engaged in conducting needs assessments: designing, testing and revising activities; and evaluating impacts, helping them to better understand how to share information about climate change with others.

Taken together, these projects will educate undergraduate students and enable secondary teachers and students to better understand climate, the role of forests in climate mitigation, forest adaptations to climate change, and the role of consumers in selecting products that enable southern pine to mitigate climate change. Questions answered by a consumer product life cycle analysis can help guide the public toward better decisions with a host of sustainable products as they think about resources, production processes, transportation, and waste disposal.

Graduate student and postgraduate trans-disciplinary education: This project will engage and train seven postdoctoral associates and twenty-nine graduate students. The existing cooperative structure has been effective at engaging groups of students in projects involving multiple investigators and complex field trials, but the current project will facilitate greater levels of integration across disciplines. The project structure is designed to enhance communication, cooperation, and collaboration among disciplines and among research, education, and Extension functions, and students and postdoctoral associates will be encouraged to engage in these processes to the greatest extent possible. Mechanisms for specifically enhancing student interactions within the project will be developed, including student-focused workshops and social programs at the annual project meetings; young scientist wikis and message boards on the project's web portal; and opportunities for student presentations to stakeholders in cooperative meetings and other venues. This large group of students working in a common framework provides us with an unparalleled opportunity to advance our understanding of social learning and capacity building of teams of scientists and students that are working together. We intend to identify indicators of trans-disciplinary perspectives and track their change among participants, especially young scientists, across the five year project.

Aim 6: *Develop Extension programming that combines regional climate expertise and forest management outreach to deliver knowledge and state-of-the-art information, resources and management decision support tools to forest landowners, resource managers and policy makers.*

Our Extension goal is to demonstrate and disseminate emerging knowledge, practices, and tools developed by the CAP to influential educators who will share this information with landowners and resource managers, enabling them to make informed decisions. For industrial forest landowners, our primary method of information delivery will be through existing research cooperative structures, which have connected researchers with industrial scientists, land managers and state agencies for the past five decades (Table 1). The NIPF population is much larger and more diverse (Hughes *et al.* 2005, Butler 2008) requiring a wider range of approaches, which regional Extension professionals have also been developing for decades. Efforts will include a focus on underrepresented and underserved landowner populations, with leadership from and participation by 1890's minority-serving institutions. The following activities will link research and education activities and integrate climate science with forestry perspectives to create a robust and comprehensive Extension program.

Climatologist/forest Extension partnership: The Extension goals will require substantial interaction between climate scientists and forestry specialists. Unlike forestry Extension, there is not a widely developed *climate* extension program in the United States. However, state climatologists exist in each state (many at land-grant universities) and have a common mission for climate science outreach and Extension. We propose an innovative team approach where Extension foresters partner with state climatologists to: learn from each other and collaborate to build a regional network of climate Extension/outreach specialists; collectively develop and review materials and a decision support system (see below); provide oversight and advice to research and education activities; and collaborate in training and regional support for workshops.

Strengthening interaction and involvement with research efforts: Regular communication with research teams is required not only to discuss new knowledge gained from research, but also to convey practitioner needs and lessons learned from field application. This communication will continue through the project with both face-to-face and virtual meetings. Extension representatives will be assigned to each of the specific aim teams to ensure effective development of the materials and decision support system (DSS) tools. In addition, Extension team members will regularly participate in annual meetings of the regional research cooperatives (Table 1) to learn about research advances. At the first annual meeting, a research-extension-educator workshop will develop and enhance collaborative working relationships.

Engaging stakeholders and assessing audience types, needs, and preferred methods of communication: Because we will target a diversity of landowners (industrial, NIPF, and underserved), we will assess their perceptions, information, and decision-making needs, as well as their current practices, and determine their preferred and most cost effective methods of communication, education, and evaluation. The assessment will help segment these audiences and help to develop audience-specific, field-tested, educational materials such as fact sheets, newsletters, brochures, circulars, videos, slide presentations, and online learning tools and technologies (such as DSS) that will be available through the online portal.

Stakeholders will be engaged at annual cooperative meetings and across the region to help refine priorities for research and education as well as provide a test bed for evaluating decision support information and tools that can be used in Extension programs throughout the region. As such, the Extension component provides an effective link with decision makers that will help ensure relevance and benefits to society through a co-learning process that integrates research and education components of the CAP. This activity will be accomplished by the researchers, Extension professionals and state climatologists working together, and will also provide key information for helping formulate effective mitigation and adaptation DSS tools and information.

Training and supporting educators: The Southern Regional Extension Forester (SREF) trains forestry extension personnel in the 13 southern states. The SREF will train educators from a variety of agencies, county Extension agents, state forestry and natural resource professionals and others with outreach responsibilities in climate change mitigation and adaptation. This training will include face-to-face and technology assisted sessions (webinars, Moodle® courses, etc.) with project Extension and state climatologist personnel (Hammett *et al.* 2009, Hubbard & Biles 2009, Londo *et al*. 2009). Train-the-trainer materials will be developed to support this effort and be made available online in various formats. Newly trained trainers will be supported by project Extension and climate educators to provide support and assistance for regional training of practitioners (professional, natural resource managers, teachers, community-based leaders, and the general public) on various aspects of climate change and planted pine forest responses to climate change. Training programs will instruct users on the DSS, how to implement management options, economic and financial aspects, and awareness training for policy makers. A certificate or recognition program is proposed for professionals and practitioners.

Website and web-based decision support system: The Extension and climate educator team will provide oversight to the development of the project website that will serve as a focal point for research, education, outreach, and decision support tools for planted southern pine forests. In addition, we will develop web-based interactive demonstrations to reach more people through other popular social media platforms. The team will also work with the researchers to develop an open-source decision support system (DSS) that will include the results of the genetics, silvicultural and economic models resulting from project research. The DSS will be a web-based, open-source set of current and future decision support tools directed to the innovative management of southern pine forests. Development of the DSS is expected to focus and integrate research, education, and Extension functions through discussions about research needs (from the science and stakeholder communities) and development and evaluation of the DSS with stakeholders. The DSS will be compatible with the DSS for agriculture that was developed by the Southeast Climate Consortium (www.AgroClimate.org). All of these tools will be incorporated into the project website, ensuring their utility and availability during and after the end of this project. The Extension team will develop the surrounding interface to explain to forester managers and landowners why the models are important, how to use the models, how to interpret the results and use the information to make decisions. A variety of products, delivery mechanisms, and result demonstrations will emerge from the DSS and be applied toward Extension and outreach efforts.

eXtension community of practice*:* A rapidly growing outreach technology of the land-grant universities is eXtension. The Extension and climate educator team will support existing eXtension Communities of Practices (Climate, Forests, & Woodlands; Wood Energy; etc) by contributing articles and training modules to this rapidly growing, nationally recognized extension delivery tool, which will also be accessible through the project's web portal.

Impact analysis: In collaboration with the Aim 4 team, we will develop formative and summative impact assessments regarding: (1) the adoption of alternative planted pine forest management systems designed to enhance climate change mitigation and adaptation; (2) the engagement of NIPF landowners in active planted pine management and carbon markets; (3) quantitative changes in regional planted pine forest carbon sequestration and nitrogen use efficiency resulting from adoption of alternative management systems; and (4) clientele understanding of the interaction between climate and forests.

Extension infrastructure: A regionally coordinated effort will be necessary to effectively deliver the products and programs. Each state Extension service professionals within the planted southern pine region will be invited to participate, including 1890 and 1862 land grant universities. A regional advisory committee with forest management, climatology, social science, and extension expertise will provide oversight to regional specialists. These specialists will work closely with the advisory committee to develop and deliver programming and evaluate outcomes. Project leaders will organize task forces based on stakeholder interactions to develop information that is requested or to conduct outreach activities that address the need, and to develop and test DSS tools, with stakeholder participation. State climatologists will be fully integrated into the Extension team, providing unprecedented coordination of climate science and forest management outreach efforts.

Table 2. Overview of major project deliverables.

Aim 1. Establish monitoring network & develop standardized methods…	
1	Standardized methods for estimating C, N & H_2O footprints; Initial regional C, nutrient baselines from Tier I data; Install Tier III trials; Start measurements on Tier II & III sites;
1-2	$\delta^{18}O$ & $\delta^{13}C$ from Tier II wood samples;
2	Initial quantification of cross-region fertility rating & stomatal response functions
2-5	Regional C, H_2O, nutrient baselines & responses to field manipulations; quantification of regional variation in soil respiration
Aim 2. Develop multi-scaled modeling program to assess forest management systems…	
1	Develop & assess management alternatives w/ Tier I data & existing models of C seq.
3	Predict C pool dynamics at varying scales for alternative land use, management, & climate scenarios
2-4	Improved process & hybrid models parameterized from network measurements
4-5	Improved growth & yield models with climate inputs & C balance; Regional map of potential climate or anthropogenic limitations to productivity; Assessment of tradeoffs among regional C sequestration, forest products, & maintenance of ecosystem services
Aim 3. ***Analyze productivity & adaptive traits in breeding and natural populations …***	
1	Complete needle $\delta^{13}C$ on ADEPT2 population; Determine appropriate genome reduction methods; Develop uniform response functions with provenance trial data;
2	Version 1 of genetic deployment tool (GDT) based on provenance data;
2-4	Discover alleles and genes associated with productivity and adaptive traits in 3 populations; Version 2 of GDT with progeny data; Regional variation in tree water use efficiency by genotype & age from Tier II data
4-5	Discover alleles and genes associated with growth, wood and insect resistance traits; altered breeding strategies
Aim 4. Conduct life cycle, policy & economic analyses of regional forest management…	
1	Assessment of policies & programs anticipated to impact climate change mitigation efforts in planted pine forests; Regional market impacts modeled on business-as-usual assumptions; LCA for current management regimes
2-4	LCA of alternative management scenarios under varying sub regional, ownership & climate conditions; NPV analysis & forecast of adaptive management impacts; Document landowner adoption of mitigation & adaptation strategies;
3-5	Estimates of landowner and regional economic losses from disturbance risks; Regional market impact of alternative mitigation & adaptation strategies
Aim 5. Create educational resources & training programs…	
1-2	PLT module & Roll out K-12 Research and teaching internship program
2-5	Deliver internship program, deliver distance class on climate change education
3-5	Conduct training programs on PLT module; Complete study of graduate student trans-disciplinary training; Trained graduates in forest & climate science
Aim 6. Extension programming combining climate & forest management expertise to deliver	
1	Rollout comprehensive website on planted pine climate change mitigation & adaptation; Establish extension/climatologist partnership; Assess audience needs;
2-4	Develop materials; Educator & Extension professionals trained in train-trainer workshops
3-5	Roll out open source decision support system & train users; eXtension modules delivered; Assess impacts of outreach

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Overview of Organization and Management: The CAP is organized and will be managed to facilitate communication and collaboration among project scientists across the region, to foster integration across disciplines, to establish accountability, to guarantee deliverables, and to maintain two-way information flow with stakeholders. These structures are in place to meet project goals and milestones in a timely fashion, assure that project direction remains relevant to stakeholders, and allocate resources appropriately. Elements of this plan include scientific leadership associated with aims, integration leaders for mitigation, adaptation, and climate education /extension goals, institutional coordinators for those with multiple investigators, a cooperative-industrial advisory council, a project Executive Committee and an External Advisory Board (Figure 1).

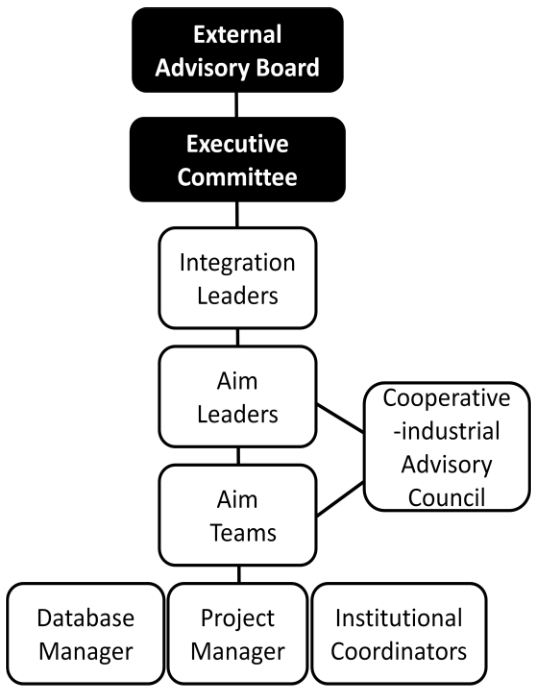

Figure 1. Organizational Chart

Structure and Integration: Accomplishing the long-term outcomes, goals and general milestones laid out in the RFA requires a strong team conducting disciplinary and trans-disciplinary research. The nucleus of our team is the eight long-standing university-industry forest research cooperatives, most of which were founded to provide deep disciplinary expertise. However, the applied nature of their research and demands from industry members for integrative knowledge and practical solutions has meant that cooperative scientists have also conducted trans-disciplinary research. The NIFA funds for this CAP provide a strong incentive and focus for strengthening trans-disciplinary research among all cooperative research programs. To best leverage our strong disciplinary expertise and existing cooperative infrastructure, teams of university-industry cooperative and associated scientists are organized around specific aims to meet the general milestones. Aims will be coordinated by two or more leaders distributed across institutions to promote integration among regional cooperatives. Aim leaders have written this proposal and will be responsible for meeting milestones and reporting deadlines. Achieving many of the milestones within aims requires integrative research which will be fostered by resource and data sharing. Working with these aim leaders will be three Integration Leaders who will assure that we achieve the broader goals of adaptation, climate education/extension and mitigation. These leaders will facilitate the flow of information, needs and outcomes among the researchers, education and extension specialists. Refer to the "Key Personnel" document for details regarding leadership.

Governance: Project-wide governance involving progress and performance, major changes to budgets or scientific direction will rest with the Project Director, who will chair an Executive Committee consisting of the integration leaders and the Aim team leaders. The Executive Committee will formulate bylaws and operating procedures at the beginning of the project, including guidelines that explicitly indicate how the Executive Committee will provide input to Project Director decision making. The Executive Committee will meet at the Annual Project

Meeting, and will have quarterly meetings throughout the year at regional conferences, annual cooperative meetings and by conference or video calls as needed. In addition to project wide governance, each institution with multiple co-project directors will have one person who will coordinate the budgets, paperwork, etc. for their institution.

External Advisory Board: The External Advisory Board will provide guidance on program development, implementation, and evaluation from project stakeholders. About fifteen people will be chosen who represent education, extension and research stakeholders. The board will include forest science and climate researchers from industry and government, extension professionals, a Project Learning Tree coordinator, teacher educators, industrial and NIPF forest managers and representatives, state climatologists and state agency representatives. The Board will elect chairs who will each serve 2.5 year terms. The External Advisory Board will discuss progress with the project Executive Committee four times a year and meet in person at the annual project meeting.

Cooperative-Industrial Advisory Council: The university-industry cooperatives (co-ops) will continue their normal industry-directed research simultaneously with conducting activities within the CAP project if funded. The co-ops are organized with a director or team of co-directors who take advisement from the industrial members often through an industrial advisory committee. Within the co-ops the advisory committee/council is chaired by an industry member who coordinates with all members, where full members of the co-op rotate in this function. The cooperative-industrial advisory board will be composed of the directors or a designee of each cooperative and the current chair of the industry advisory committee/council for each cooperative. The role of this committee is to work with the CAP team to insure that existing and newly collected co-op specific data are made available so as to strengthen the science of the CAP but not undermine the ability of cooperatives to best serve their current and future members. In addition, this board will serve to vet tools and facilitate transfer of knowledge to their organizations.

Enhancing Communication, Interaction and Integration through Data Sharing, Presentation, and Common Deliverables: Most investigators are familiar with the cooperative research programs and some have worked together for years on joint experiments and large federally funded research projects. With this familiarity as a base, a number of mechanisms will enhance communication and interaction among all project participants. First, a full time project manager will be hired who will facilitate coordination and communication. Second, annual meetings will bring together all project participants to report on progress and plan for the upcoming year, in conjunction with the External Advisory Boards. The first annual meeting will occur in January, 2011 to initiate the project, build connections, prioritize goals, and complete project planning and coordination. A key objective is to enable extension stakeholders to help prioritize researchable questions. Third, the project website will serve as a focal point for enhancing communication and coordination among CAP participants and with external constituencies, and will be the central point for data storage and retrieval and the public face of the project. Fourth, sub-group and disciplinary communication will be facilitated by secure wiki-type message boards and customized e-mail listserves. Fifth, quarterly newsletters will be disseminated to project members and stakeholders to inform them of project progress and findings.

The project website will interface with the Terra Carbon Information System (http://terrac.ifas.ufl.edu/) that has been developed to enable the analysis and synthesis of carbon science data at scales ranging from the stand to the region, and will make it possible to incorporate and synthesize data layers that were previously not easily accessible, such as climate, soil morphology, soil carbon, land use class, land cover class, and biodiversity status. As datasets publicly funded through this project become available, they will be shared with the wider carbon science community through additional public network archives such as the Oak Ridge National Laboratory Distributed Active Archive Center for Biogeochemical Dynamics (ORNL DAAC, http://daac.ornl.gov/). Gene sequence and/or polymorphism data will be made available to members of the NIFA funded loblolly pine genome project and deposited at the National Center for Biotechnology Information for public access.

A project-wide deliverable is the open source decision support system (DSS). Development and deployment of the DSS will catalyze interactions and integrate researchers, educators, extension professionals, and project stakeholders. DSS will be developed iteratively with feedback and input from all groups at each stage. A similar approach proved very effective at enhancing research-extension collaboration in agricultural climate change response research (http://AgroClimate.org), and key personnel involved in the development of AgroClimate.org (R. Boyles, J. Jones) will guide the development of our system.

Outreach to the Broader Scientific Community: We will reach other forest, agricultural and climate scientists, educators, and extension specialists by participating in international, national and regional conferences. Traditionally, cooperative leaders organize regional biennial silviculture and genetics meetings at which mini symposia will be used to present results. In addition, a national meeting will be organized near the end of the project as required that showcases findings from the CAP and brings together the wider global change community. We will coordinate with investigators awarded standard grants that complement this project and with the PI of the loblolly genome sequencing project. In addition, we will coordinate with directors of the two other CAP projects and those expected to be funded in following years, particularly with those focused on western conifers (2011) and deciduous hardwoods and mixed forests (2012). Finally, we will reach out to international scientists working on forest climate mitigation and adaptation.

Plan for Sustaining Project beyond the Funding Period: This project builds on and benefits from existing institutions and structures, including land-grant universities spread across the region, the long-term regional forestry research cooperatives and their connection to industrial southern pine forest landowners, the Project Learning Tree network, the Florida Climate Institute, the SE Climate Consortium, and the UF Carbon Resources Science Center. All of these organizations will provide continuity and support as this project starts up, develops, and leverages new funding and research, and will serve as bridges as the project funding period ends and new, related projects are developed to expand and capitalize on the accomplishments of the CAP.

KEY PERSONNEL ROLES

Project Director: Tim Martin, Professor of Tree Physiology in the School of Forest Resources and Conservation (SFRC), University of Florida (UF), will be the project director (PD). Dr. Martin co-directs the multidisciplinary Forest Biology Research Cooperative (FBRC) and directs the UF Carbon Sciences Resource Center, a component of the UF and Florida State University's Florida Climate Institute. The PD will coordinate the program to insure that the long-term outcome, goals and milestones are achieved on time while using resources efficiently and effectively. To reflect his commitment he will also serve integration and Aim leadership roles [R – 60%, Ed – 20%, Ex – 20%].

- **Program Manager:** The PD will hire a full time program manager who will be housed at UF to help coordinate project activities, develop and maintain the website, facilitate communication among participants, and assist with budgets, paperwork, and reports.
- **Database Manager:** This individual will work under the direction of Sabine Grunwald, UF Professor of GIS and Land Resources who created and will maintain the TerraC project databases and facilitate data sharing and analysis among project participants.

Co-Project Directors: Co-project directors are organized into Integration Leaders, Aim Leaders and Aim Team members. Each broad goal, Adaptation, Climate Education/Extension, and Mitigation have a single leader, while Aims have two or more leaders distributed across institutions (Table 1).

- **Integration Leaders:** These leaders will facilitate integration across aims to insure delivery of knowledge, information and materials that will help agriculture and forestry achieve adaptation, climate education/extension and mitigation goals.
  - Gary Peter, Associate Professor of Forest Genetics and Genomics, UF, will lead the adaptation goal. Dr. Peter co-directs the FBRC and the Cooperative Forest Genetics Research Program, and is Director of the UF Plant Molecular and Cellular Biology Graduate Program. [R – 60%, Ed – 10%, Ex – 30%]
  - Martha Monroe, Professor of Environmental Education and Extension, UF, will lead the Education/Extension goals. Dr. Monroe directs Florida Project Learning Tree and was President of the North American Association for Environmental Education. [R – 10%, Ed – 65%, Ex – 25%]
  - Tim Martin will lead the mitigation goal (see project director above).

- **Aim Leaders:** The Aim leaders are responsible for coordinating the research, education, and extension activities to insure delivery of the information and materials for each Aim. The Aim leaders were selected to facilitate cross university collaborations. Table 1 identifies the leaders of each Aim.

- **Aim Team Members**: The PD, co-directors and collaborators are all members of teams designed to deliver and transfer the information and tools needed to foster increased mitigation, improve forest resilience and train more scientists, educators and extension professionals across the region. Table 1 identifies team members for each Aim.

Table 1. Aim Leaders and Team Members

Aim #	Leaders (University)	Team Members
1	Tom Fox (VT), Mike Kane (UGA), Tim Martin (UF), Jose Stape (NCSU)	L. Samuelson (Aub), A. Noormets, J.-C. Domec, J. King (NCSU); R. Will, T. Hennessey, D. Wilson (OSU); J. Vogel (TAMU); R. Teskey, D. Markewitz (UGA);S. Grunwald, E. Jokela, (UF), K. Johnsen (USFS); B.Strahm, J. Seiler (VT)
2	Randy Wynne (VT), Steve McNulty (USFS)	R. Boyles, J. King, S. McKeand (NCSU); T. Byram (TAMU); M. Kane, R. Teskey (UGA); W. Cropper, S. Grunwald, T. Martin (UF); G. Sun (USFS); H. Burkhart (VT)
3	Ross Whetten (NCSU), Tom Byram (TAMU)	F. Isik, S. McKeand (NCSU); C. Loopstra, K. Krutovsky (TAMU); J. Davis, G. Peter (UF); D. Nelson, K. Johnsen (USFS); J. Holliday (VT)
4	Robert Abt (NCSU), Douglas Carter (UF)	J. Gan (TAMU); D. Grebner (MSU); D. Adams, G. Peter (UF); M. Kane (UGA); T. Fox (VT)
5	Martha Monroe (UF), John Seiler (VT)	S. Sriharan (VSU)
6	Bill Hubbard (SREF), Eric Taylor (TAMU)	G. Boyd (Alcorn St); J. Idassi (NCAT); R. Boyles, M. Megalos, S. McKeand, J. Stape (NCSU); T. Byram, (TAMU); J. Davis, E. Jokela, J. Jones, M. Monroe, G. Peter, T. Martin (UF); M. Kane (UGA); H. Burkhardt, T. Fox (VT)

Institutional Coordinators: M. Kane, UGA; T. Fox, VT; T. Martin, UF; S. McNulty, USFS; R. Whetten, NCSU; R. Will, OSU; J. Vogel, TAMU will coordinate co-PDs at their institutions.

Senior Advisor: Jim Jones, Distinguished Professor of Agricultural and Biological Engineering, UF, co-directs the Southeast Climate Consortium and the Florida Climate Institute. He will advise the PD and integration leaders.

Directors of University-industry Cooperative Research: Most of the biologists on the project work with the co-op programs, and co-op directors are integrated across the Aims and included on the extension team, because of their role in knowledge transfer to their members.

Table 2. University-industry Cooperative Research Directors

Cooperative	Director(s)
Cooperative Forest Genetics Research Program	Matias Kirst (UF), Dudley Huber (UF), Gary Peter (UF), Greg Powell (UF)
Cooperative Tree Improvement Program	Steve McKeand (NCSU)
Forest Biology Research Cooperative	John Davis (UF), Eric Jokela (UF), Tim Martin (UF), Gary Peter (UF)
Forest Modeling Research Cooperative	Harold Burkhart (VT)
Forest Nutrition Cooperative	Tom Fox (VT), Jose Stape (NCSU), Rafael Rubilar (UC, Chile)
Plantation Management Research Cooperative	Mike Kane (UGA)
Southern Forest Resource Assessment Consortium	Robert Abt (NCSU), Fred Cubbage (NCSU)
Western Gulf Forest Tree Improvement Program	Tom Byram (TX Forest Service, TAMU)

Logic Model: Regional Approaches to Climate Change: Southern Conifer CAP

SITUATION	INPUTS	ACTIVITIES
Protecting planted southern pine forests from losses due to changing climate is vital to the economic, social and environmental health of the region & nation Private forest owners need knowledge & options to make informed management decisions that increase resilience & mitigation potential of planted southern pine forests Scientists need trans-disciplinary research to develop new options that increase resilience & C mitigation potential of planted southern pines Foresters, county Extension agents, & other natural resource professionals need training on management practices that address climate change risks to help private owners maintain productive planted southern pine forests Community leaders need knowledge about potential climate change mediated economic & environmental impacts to planted southern pine & concomitant effects on resources (e.g., water) K-12 students need exposure to this important career option, knowledge about changing ecosystems, & tools to participate in consumer decision making regarding climate change & pine systems	Federal, state & private funds Faculty, staff, & students at southern 1862 & 1890 Land Grant institutions. Climate & forest scientists with federal, state, industry, NGO & other agencies Research facilities, regionwide trial network, southern pine germplasm, equipment, & supplies Industrial cooperator expertise, historical soils & productivity data & existing decision support systems such as growth & yield, climate models Traditional & new technology transfer & science delivery systems for disseminating knowledge & decision-making tools Land-grant extension network (e.g. county agents) K-12 education networks (e.g. PLT), public schools Industrial and non-industrial private planted southern pine forestland owner opinions Needs assessment to efficiently guide technology transfer material development and grant resources	Establish regionwide monitoring network based on existing cooperative field trials of planted southern pines Measure C, water & nutrient baselines using standardized methods Apply multi-scaled modeling to assess forest management alternatives under climate change Analyze genetics of breeding & natural populations to ID genes controlling mitigation & adaptation traits Integrate genotype performance with climate records to develop response functions Conduct LCA and multi-scale economics and policy analyses to evaluate tradeoffs and interactions among management and climate Assess audience needs Develop audience-based educational materials & programs for education & extension use (traditional & new technology) Integrate forestry & climate science research, education & extension professions that can be sustained after project completion Conduct train-the-trainer workshops for key educators Implement undergraduate research & teaching internship program Evaluate impact of education materials & training efforts (e.g., K-12 & extension)

ASSUMPTIONS – Understanding climate change factors will affect adaptation, mitigation & other activities *(see narrative for more details). Best science transferred to owners/educators/students in a usable form will lead to adaptive management*

OUTPUTS	OUTCOMES		
	Knowledge	Actions	Conditions
Regional C, H_2O, & N baselines	Audiences learn new feedstock selection, moisture & nutrient management strategies, & market options	Practitioners adopt new guidelines, techniques, & technologies & disseminate these to clientele	Improved economic return or reduction of loss from catastrophic events, and/or conservation of planted pine forests
Improved growth & yield models with climate variables, C balance	Stakeholders learn new DSS & stand level management strategies	Private forest owners establish & manage using new guidelines, technologies, & adaptive strategies for short- and long- term , which in-cludes enhanced management, species selection or better adapted germplasm	Increased forest carbon sequestration and N use efficiency
Improved process & hybrid models parameterized from network measurements	Leaders learn new life cycle analyses & the economic, social, & resources compromises associated with climate change & southern pine management policies & practices.	Teachers increase their competence & teaching related to climate, carbon & planted southern pine ecosystems	Enhanced capacity for regional, trans-disciplinary collaboration among climate and forest scientists, extension & education professionals
Regional market impacts modeled based on business-as-usual assumptions with risks of increased disturbance and altered management that increases mitigation and resilience	Youth (via informed teachers) learn new climate science, planted southern pine adap-tation/mitigation information & how consumers affect forests & climate.	Community leaders & consumers utilize LCA, economic analyses & other research results in decision making	Increased capacity for NIPF participation in C markets or to deploy adaptive strategies to insure the sustainability of planted southern pines in advance of climatic changes
Complete LCA of C, H_2O, nutrient, & energy footprint of alternative management scenarios under varying sub regional, ownership & climate conditions	Educators gain competence in climate & forest science & LCA	Southern planted pine & climate science research, education & outreach professionals & communities become integrated	Climate-smart audiences making informed decisions relating to the planted southern pine system & consumption of forest products
Open source decision support system with C management, economics, genetics res. results	Scientists learn important details about the planted southern pine ecosystem from field application & experiences	Teachers/environmental educators deploy new materials related to climate adaptation & mitigation in the region	Landowners/K-12 Teachers/students have a clearer idea of adaptive strategies and their role in climate change mitigation in the southeastern US
"One stop" web presence for info. on southern pine climate change mitigation & adaptation	Scientists learn how to better conduct trans-disciplinary research		
Graduated students & postdocs prepared to address trans-disciplinary forestry & climate sciences issues			
Environmental ed. curriculum provides accessible info. to teachers, youth and general public			

<u>EXTERNAL FACTORS –</u> Availability & interest of key participants who are not directly funded by the project *(see narrative for more details) Unforeseen geo-political events that may advance or diminish the goals of this effort.*

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Letters from Industry-University research cooperative advisory council chairs

Rayonier

Value From The Ground Up™

U.S. Forest Resources
Forest Research Center

July 9, 2010

Dr. Timothy A. Martin
Professor, Tree Physiology
School of Forest Resources and Conservation
University of Florida / IFAS
PO Box 110410 (mail), 134 Newins-Ziegler Hall (courier)
Gainesville, FL 32611-0410

Dear Dr. Martin,

As current chair of the Executive Committee of the Cooperative Forest Genetics Research Program at the University of Florida, and on behalf of all the members, I want to express our enthusiastic support for your AFRI CAP proposal "*Integrating research, education and extension for enhancing southern pine climate change mitigation and adaptation*". Breeding slash and loblolly pine with improve disease resistance and growth rate that is adapted to a broad range of environments has been and will continue to be the focus of the Cooperative efforts. The approaches, methods and breeding strategies are an essential part of our ability to establish more resilient planted southern pine forests. We also recognize the need for incorporating molecular markers into pine breeding to more rapidly develop fast growing, well adapted germplasm.

The Cooperative members have extensive regional genetic trials that will be used by the scientists in the research, and we are happy to provide this resource for the various experiments. We also appreciate that existing safeguards for cooperative specific data and germplasm will remain in effect.

Again, on behalf of all 8 corporate and state members of the Cooperative, I wish you success in this endeavor, and please let any of us know how we can be of help with this research.

Sincerely,

Josh Sherrill
Manager, Genetic Resources

P. O. Box 819 Yulee, FL 32041
Telephone (904)548-9016
Fax (904)225-0370

Rayonier

Eastern Forest Resources

Forest Research Center

Dear Tim,

On behalf of the members of the Forest Biology Research Cooperative (FBRC), I am pleased to provide this letter in support of the National Institute of Food and Agriculture / Agriculture and Food Research Intiative Coordinated Agricultural Project that you are leading entitled "Integrating research, education and extension for enhancing southern pine climate change mitigation and adaptation". This project will provide important and groundbreaking research that will enable both industrial and non-industrial landowners to better manage their forests for climate change mitigation, and for resilience in the face of changing climate.

As you are aware, the FBRC has numerous experimental trials across the region, and extensive measurement data from these trials, both of which can contribute to the success of this project. I am pleased to note that your approaches capitalize on using region-wide cooperative trials and data, while still following existing cooperative guidelines and safeguards regarding genetic material and proprietary information.

I and the other cooperating industry scientists in the FBRC look forward to working with you on this project.

Best regards,

Ben Cazell
Manager Silviculture Research & Operations
FBRC Advisory Council Chair

851582 U.S. Hwy. 17
P.O. Box 819
Yulee, FL 32041
Phone: 904.225.5393 <> Fax: 904.225.0370

Weyerhaeuser
The future is growing™

810 Whittington Ave.
Hot Springs Ar 70901

June 21, 2010

To whom it may concern:

I am writing to express support from the members of the Forest Modeling Research Cooperative (FMRC) for the AFRI southern conifer CAP proposal prepared by Dr. Timothy A. Martin of the University of Florida in collaboration with a host of top scientists, including the directors of the major industry-funded research cooperatives in the region. This project is relevant to non-industrial private forest land owners, managers of publically-held forests, and corporate owners of forest land such as Weyerhaeuser Company.

Weyerhaeuser Company was a founding member of the Forest Modeling Research Cooperative (originally named the Loblolly Pine Growth and Yield Research Cooperative), which was initiated by Virginia Tech in 1979. During its 31-year history, the forest modeling coop has established two region-wide sets of permanent growth plots, installed and measured spacing trials through a 25-year rotation, initiated trials on pruning, and analyzed data and incorporated results in stand models in collaboration with cooperatives focused on genetics, forest fertilization, and vegetation control. Data bases collected by the various cooperatives, and the modeling experience gained from them, provide a sound platform for initiating the work of the southern conifer CAP project. Members of the FMRC support the further use of coop measurement data and plot installations for pursuing the goals of the AFRI southern conifer proposal, provided, of course, that proprietary uses of the coop's data base and the original purpose of the trial installations are not compromised.

While much progress has been made over the past three decades in modeling response of southern conifers to genetic improvement and silvicultural treatments, we still lack reliable predictions of how this valuable resource might respond to climate change. Thus, we are pleased to strongly and enthusiastically endorse this AFRI CAP proposal.

Sincerely,

Mike R. Strub

Advisor, Weyerhaeuser Southern Forest Production Research

Carl E. Garrison III
State Forester

COMMONWEALTH of VIRGINIA

DEPARTMENT OF FORESTRY
900 Natural Resources Drive, Suite 800
Charlottesville, VA 22903
www.dof.virginia.gov
(434) 977-6555
Fax: (434) 296-2369

June 28, 2010

Dr. Timothy A. Martin
Associate Professor, Tree Physiology
School of Forest Resources and Conservation
University of Florida / IFAS
PO Box 110410
Gainesville, FL 32611-0410

Dear Dr. Martin:

Thank you for the opportunity for the members of the Forest Nutrition Cooperative to voice their strong support for the proposal "Integrating Research, Education and Extension for Enhancing Southern Pine Climate Change Mitigation and Adaptation". This is an outstanding effort by a transdisciplinary team of scientists at the elite forestry programs in the South that will provide the information forest landowners need to help them develop management regimes that will enable them to adapt to and mitigate potential climate change. The outreach and education component of the proposal will enable this information to reach all landowners, including underrepresented groups, throughout the region. Therefore, the members of the Forest Nutrition Cooperative strongly support this proposed research and stand ready to assist the co-investigators wherever possible to accomplish the objectives.

The Forest Nutrition Cooperative is an international partnership committed to creating innovative solutions to enhance forest productivity and value through the sustainable management of site resources. The partnership is lead by faculty within the Forestry Departments at N.C. State (Dr. Stape), Virginia Tech (Dr. Fox), and the University of Concepcion in Chile (Dr. Rubilar). Additional faculty at these three universities work collaboratively in the Forest Nutrition Cooperative. Therefore, the coop has a wide range of expertise including silviculture, forest nutrition, ecophysiology, soils, plant community ecology, growth and yield modeling, GIS, and remote sensing, that can be brought to bear on pertinent research questions. The Forest Nutrition Cooperative is one of the world's largest cooperative forest research, outreach and education programs; its 52 current members include forest industry, forest management consultants, state agencies and others interested in sustainable plantation management. Collectively the members manage over 20 million acres of pine plantations in the southeastern USA.

The Cooperative's approach includes a mix of applied research, fundamental research, graduate education, technology transfer, continuing education, and consulting. This mix provides an excellent environment for addressing pertinent questions and immediately incorporating research results into appropriate silvicultural practices. The close linkages between research and application are a hallmark of the Cooperative, and coupled with our extensive field trial base, uniquely position us to continue a leadership role in developing silvicultural prescriptions to help adapt to and mitigate the potential effect of climate change in the South. Additional information on the Forest Nutrition Cooperative can be found at www.forestnutrition.org.

We are excited about the opportunity to participate in this project. Please feel free to contact me if you need additional information about the Forest Nutrition Cooperative.

Sincerely,

Jerre L. Creighton

Applied Research Program Manager
Virginia Department of Forestry
Chair, FNC Advisory Council

June 16, 2010

Dr. Timothy A. Martin
Associate Professor, Tree Physiology
School of Forest Resources and Conservation
University of Florida / IFAS
PO Box 110410 (mail), 134 Newins-Ziegler Hall (courier)
Gainesville, FL 32611-0410

Dear Dr. Martin;

As current chair of the Executive Committee of the NC State University Cooperative Tree Improvement Program, and on behalf of all the members, I want to express our enthusiastic support for your AFRI CAP proposal "*Integrating research, education and extension for enhancing southern pine climate change mitigation and adaptation*". Breeding loblolly pine that is adapted to broad ranging environments has been the focus of the Cooperative for 54 years, and breeding for future climates is the most effective mitigation approach in forestry. The decisions, approaches, and methods that breeders use today will have impact on our southern forests for decades and centuries to come. I can think of few research foci that are more critical for our continued success under future climates.

The Cooperative members have extensive regional genetic trials that will be used by the scientists in the research, and we are glad to provide this resource for the various experiments. We also appreciate that existing safeguards for proprietary data and germplasm will remain in effect.

Again, on behalf of all 25 corporate and state members of the Cooperative, I wish you success in this endeavor, and please let any of us know how we can be of help with this research.

Sincerely,

Bob W.

Robert J. Weir, Ph.D.
Vice President, Product Development
CellFor
51 Great Heron Drive
West Bath, Maine 04530

Hancock
Forest
Management

An MFC Global Investment Management Company

Jim Boyd, RF, PMP
Senior Planner

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704-540-4113 office 803-984-2277 cell
704-405-4943 fax 617-210-8677 computer f
jboyd@hnrg.com
www.hancocktimber.com

Date: July 2, 2010

To Whom It May Concern:

As 2010 Chair of the Plantation Management Research Cooperative (PMRC), Warnell School of Forestry and Natural Resources, University of Georgia, I write in support of the proposal, "Integrating Research, Education, and Extension for Enhancing Southern Pine Climate Change Mitigation and Adaptation" led by Dr. Timothy Martin at the University of Florida. This proposal is in response to AFRI Program Area A3101 and addresses science, technology, education, and extension needed to manage southern conifer forests to mitigate and adapt to potential climate change. The PMRC and the Warnell School of Forest Resources are participants in the grant proposal.

The PMRC has conducted research in southern pine silviculture and growth and yield research for over 35 years. Currently, PMRC has 17 private sector members who own or manage more than 50% of the commercial pine plantation resource in the southern U.S. Hancock Timber Resource, a PMRC member, alone manages approximately 2 million acres of southern pine plantations.

The proposed project is highly relevant to future forestry practices in the U.S. South. We support the use of targeted historical PMRC data to develop regional analysis and decision support tools and welcome additional measurements of carbon and nutrient pool data on targeted, existing PMRC trials.

Best Regards,

James H. Boyd jr RF
Inventory and Systems Manager, Southern Divisions
Hancock Forest Management Inc.

2.337

June 3, 2010

Dr. Tim Martin
359 Newins-Ziegler Hall
P.O. Box 110410
University of Florida
Gainesville, FL 32611-0410

Dear Dr. Martin,

This letter is to confirm our intent to participate in the USDA/AFRI Coordinated Agricultural Product grant proposal entitled "Integrating research, education and extension for enhancing southern pine climate change mitigation and adaptation" directed from the University of Florida, School of Forest Resources and Conservation. Specifically our institution will provide the following:

1) Plant material for genotyping from loblolly pine parents as required to support the research objectives of the project.
2) Progeny test measurements to support characterizing and monitoring climate change.
3) Data analysis to support the development of selection and deployment models.

Project Director: Tom D Byram

Authorized Organizational Representatives: Tom Boggus

Western Gulf Forest Tree Improvement Program
Forest Science Laboratory
Building 1042 Agronomy Rd. TAMUS 2585
College Station, TX 77843-2585
TEL 979-845-2523 FAX 979-845-3272
http://texasforestservice.tamu.edu

Letters from state climatologists

The Alabama Office of the State Climatologist

29 June 2010

Dr. Tim Martin
School of Forest Resources and Conservation
University of Florida
Box 110410 (mail), 134 Newins-Ziegler Hall
Gainesvile, FL 32611-0410

Dear Dr. Martin

By this letter I wish to inform you that the Alabama Office of the State Climatologist expresses interest and support for your proposal "Integrating research, education and extension for enhancing southern pine climate change mitigation and adaptation" of which you are Principal Investigator. I understand the participation should the proposal be secured will lead to engagement as a local climate expert in the planning and implementation of local workshops and decision support systems.

Sincerely

John R. Christy
Alabama State Climatologist
University of Alabama in Huntsville

Administered by The University of Alabama in Huntsville
John R. Christy, State Climatologist, Earth System Science Center
Huntsville, Alabama 35899
Phone: 256-961-7763, 256-961-7771   Fax: 256-961-7751
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South Carolina Department of

Natural Resources

DNR

John E. Frampton
Director

Ken Rentiers
Deputy Director for
Land, Water and Conservation

July 2, 2010

Tim Martin, Ph.D.
P.O. Box 110410
University of Florida
Gainesville, FL 32611-0410

REFERENCE: Integrating research, education and extension for enhancing southern pine climate change mitigation and adaptation proposal

Dear Dr. Martin,

The South Carolina Department of Natural Resources-State Climatology Office (SCDNR-SCO) supports the proposal to integrate research, education and extension to enhance southern pine climate change mitigation and adaptation. We would be willing to engage cooperatively with the forestry extension team in the planning and implementation of local workshops. We can also provide input into the development of decision support tools that will integrate climate science and climate data into forestry management and planning tools.

The SCDNR is working on a state plan focusing on the natural resource impacts related to climate change as well as updating the South Carolina Comprehensive Wildlife Conservation Strategy, a document which also will address climate change and adaptation. We would benefit from and be willing to cooperate with your team's efforts to develop science-based information and tools to evaluate how the region's climate is changing as well as explore strategies for responding to climate change. Please contact me if you have any additional need regarding your proposal.

Sincerely,

Hope P. Mizzell

Hope Mizzell, Ph.D.
S.C. State Climatologist
S.C. Department of Natural Resources

cc:// Ken Rentiers

Rembert C. Dennis Building • 1000 Assembly St • P.O. Box 167 • Columbia, S.C. 29202
EQUAL OPPORTUNITY AGENCY www.dnr.sc.gov PRINTED ON RECYCLED PAPER

Texas A&M University Department of Atmospheric Sciences

John W. Nielsen-Gammon

Professor of Meteorology Texas State Climatologist

n-g@tamu.edu Ph: 979-862-2248 Fax: 979-862-4466

3150 TAMU College Station, TX 77843-3150 O&M Building, Room 1210F

June 28, 2010

Dr. Tim Martin
University of Florida

Dear Dr. Martin,

I am the Texas State Climatologist, and am interested in participating in your proposed project entitled "Integrating Research, Education and Extension for Enhancing Southern Pine Climate Change Mitigation and Adaptation", being submitted to the United States Department of Agriculture. I would be happy to assist with the preparation and conduct of workshops on climate change and their impact on southern conifer forests in my area. I would also be willing to provide input for online decision support tools for the forestry community involving climate.

Climate variability and climate change are particularly important issues in the Piney Woods, because the region has been somewhat shielded from climate change over the past century by the regional effects of sea surface temperature anomalies, and because there are no good present geographical analogues to future climates in the area. These factors make sector-specific research, extension, and education crucial so that forest managers may make the proper long-term planning decisions. I look forward to helping with this effort.

Sincerely,

John Nielsen-Gammon
Professor and Texas State Climatologist

The University of Georgia
Office of the State Climatologist
Driftmier Engineering Center
Athens, Georgia 30602

28 June 2010

Dr. Tim Martin
School of Forest Resources and Conservation
University of Florida
Gainesville, Florida 32611

Tim,

I am confirming my involvement as the State Climatologist of Georgia in the AFRI grant for "Integrating Research, Education and Extension for Enhancing Southern Pine Climate Change Mitigation and Adaptation."

If you are successful in obtaining this grant, my office will engage the forestry extension team involved with this project by participating as a local climate expert in the planning and implementation of local workshops and decision support systems.

Through the Southeast Climate Consortium, my office has worked with the forestry industry in the use of seasonal climate outlooks for seasonal forestry planning and management. I am looking forward to extending this work to longer time frames.

Sincerely,

David Emory Stooksbury, Ph.D.
State Climatologist of Georgia and Associate Professor
Biological and Agricultural Engineering and Atmospheric Sciences

Driftmier Engineering Center • Athens, Georgia 30602-4435 • (706) 542-8855 • FAX (706) 542-8806
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29 June 2010

Dr. Tim Martin
School of Forest Resources and Conservation
University of Florida
Box 110410 (mail), 134 Newins-Ziegler Hall
Gainesvile, FL 32611-0410

Dear Dr. Martin

The Mississippi Office of the State Climatologist expresses interest in and support for your proposal "Integrating research, education and extension for enhancing southern pine climate change mitigation and adaptation" of which you are Principal Investigator. If the proposal is granted, I understand that I will be expected, as a local climate expert, to help plan the one or two workshops each year and to participate in these workshops with presentations on climate, especially as it might impact forest systems. I will also provide input into the development of the online decision support tools that will integrate climate science and climate data into forestry management and planning tools.

Sincerely

Charles L. Wax

Charles L. Wax
Mississippi State Climatologist

Letters from state forestry associations

ALABAMA FORESTRY
ASSOCIATION

June 28, 2010

Dr. Tim Martin
Associate Professor
School of Forest Resources and Conservation
University of Florida
IFAS P.O. Box 110410
Gainesville FL 32611-0410

Dear Dr. Martin

I am writing in support of a proposal submitted by a consortium of southern research institutions including Auburn University, University of Florida, NC State, VPI, University of Georgia, Texas A&M and Oklahoma State to USDA / AFRI Climate Change Program.

As you may be aware, forests are the largest land use in Alabama. Approximately 2/3rds of Alabama (22 million acres) are covered in forests. Almost 93% of those forests are owned by private landowners and the trees harvested from those forests support Alabama's largest manufacturing industry. To say that forests are an integral part of Alabama's economy is a gross understatement. Almost 1 in 10 jobs are tied to forestry and forestry-related activities including manufacturing and recreation related to Alabama's forests contribute more than $27 billion in economic activity. Given the importance of our forests to Alabama's economic health and well-being, anything that might affect our forests or our ability to manage those forests could have far-reaching impacts. Further, anything that affects markets for our forest products or creates new markets can have an equally dramatic impact.

Information is one key to better managing and protecting our forest assets. This is where we rely heavily on our research institutions to provide information, not only about how to better manage what we have, but to anticipate how changing conditions may require adapting current practices to maintain the health and productivity of those forests. As climate changes, temperatures vary and rainfall patterns are altered, forest landowners and forestry practitioners (my members) need to understand how they can change and adapt to protect their assets and ensure their livelihoods. This is the first reason that we support the collaborative approach proposed by the consortium of southern research universities.

This consortium has as wealth of existing research plots, institutional knowledge, and faculty expertise that will create the kind of broad-based, multi-disciplinary team that can deliver the kind of information needed. By leveraging the SE US cooperative forestry research infrastructure, we believe that this proposal will be able to provide the maximum results for minimum investment.

The second reason we support this project relates to the potential new markets that exist for forest landowners in monetizing the sequestration of carbon. Current economic conditions have resulted in depressed markets for many forest products, especially higher value sawtimber. While most forest landowners have experienced short term market fluctuations, over the long term reliable markets for forest products are essential to offset the pressure to convert forests to non-forest uses. Further, landowners in the South have historically responded to more economic incentives (better markets) by growing more trees. In today's carbon economy, this positive correlation between economic incentive and increased growth creates a win-win.

This project should provide information and technology to southern landowners that will help them not only to maintain current levels of productivity, but also to enhance that productivity so more volume will be grown and more carbon sequestered. As markets for carbon storage develop, this will provide additional income to forest landowners, it will boost the incentive to grow more and all of the benefits that come from forests: clean water, clean air and forest-based recreation will continue. This is a win for forest landowners who can receive additional revenue both from carbon sequestration as well as harvesting for forest products, it's a win for forest products companies whose business is dependent on having a long term, reliable supply of timber, and a win for the public in general who will enjoy the benefit forests provide as well as the tax revenue that comes from forest-based economic activity.

Please accept this letter as our hearty endorsement of this project and we look forward to working with these institutions in the dissemination of the results.

Sincerely,

Chris Isaacson
Executive Vice-President

FLORIDA FORESTRY ASSOCIATION

Jeff G. Doran
Executive Vice President

Michael L. Gaff
President

P.O. Box 1696
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Promoting the responsible and sustainable use of Florida's forest resources since 1923.

June 29, 2010

Timothy A. Martin
Associate Professor, Tree Physiology
School of Forest Resources and Conservation
University of Florida / IFAS
PO Box 110410
Gainesville, FL 32611-0410

RE: Request for funding from the USDA / Agricultural and Food Research Initiative (AFRI) Climate Change program

Dear Dr. Martin:

This letter is to express the support of the Florida Forestry Association for your team's request for funding from the USDA / Agricultural and Food Research Initiative (AFRI) Climate Change program. Our Association currently represents approximately 1600 members of Florida's forestry community, ranging from owners of small tracts of forested lands to the largest forest products companies and many others involved in the forestry profession.

We believe the concept of bringing together all the major southern pine research cooperatives to develop approaches for using southern pine management for mitigation of, and adaptation to climate change is both timely and necessary. This proposal will benefit not only industrial forest management, but also the small, non-industrial segment of the forestry community as well.

We fully recognize the importance and potential of pine management in addressing climate change issues our nation is facing. This five-year project, which includes research, education, and extension elements, will be of major importance to our members.

We appreciate the important work you are doing.

Sincerely,

Philip Gornicki, Director of Responsible Forestry
Florida Forestry Association

TEXAS FORESTRY
ASSOCIATION

President
Beverly Lindsey Peoples,
Bullard, TX

President-Elect
Thom Karels, Oakwood, TX

Vice President
Bob Harper, Conroe, TX

Executive Vice President
Ronald H. Hufford, Lufkin, TX

July 1, 2010

Timothy A. Martin
Associate Professor, Tree Physiology
School of Forest Resources and Conservation
University of Florida/IFAS
P.O. Box 110410 Mail, 134 Newins-Ziegler Hall (courier)
Gainesville, FL 32611-1410

Dear Mr. Martin:

The Texas Forestry Association (TFA) is supportive of the proposed USDA/Agricultural and Food Research Initiative (AFRI) Climate Change project.

TFA supports forestry research projects that provide information which allow professional foresters and private landowners to make informed management decisions. TFA has reviewed the background information on this specific project and feel that it would be most valuable to our members. The future forest management decisions that will be affected by anticipated climate changes need to be better understood and communicated to private landowners, forestry professionals and manufacturing mills. The better the forestry community is prepared to address the anticipated changes to the forest resource the better everyone will be to implement necessary and timely land management decisions.

TFA has an outstanding working relationship with Texas AgriLife Extension Service and the association is willing to assist Texas AgriLife Extension Service with the coordination and dissemination of information to the East Texas forestry community. This can be accomplished through articles in the association's monthly paper, webinars, and County Forest Landowner workshops.

Sincerely,

Ronald H. Hufford
Executive Vice President

cc: Beverly Peoples

P.O. Box 1488 · Lufkin, Texas 75902-1488
936/632-TREE · FAX 936/632-9461
tfa@texasforestry.org · www.texasforestry.org

VIRGINIA FORESTRY ASSOCIATION

Virginia Forestry Association

3808 Augusta Avenue ⬩ Richmond, Virginia 23230-3910
Phone 804/278-8733 Email: vfa@vaforestry.org
Web site: www.vaforestry.org

PAUL R. HOWE, EXECUTIVE VICE PRESIDENT

July 2, 2010

Dr. Timothy A. Martin
Associate Professor, Tree Physiology
School of Forest Resources and Conservation
University of Florida / IFAS
PO Box 110410
Gainesville, FL 32611-0410

Dear Dr. Martin:

I am writing on behalf of the 1400 members of the Virginia Forestry Association (VFA) and the broader forestry community in Virginia in support of the exciting research proposal entitled "Integrating research, education and extension for enhancing southern pine climate change mitigation and adaptation."

The proposed effort includes an impressive group of forest scientists at Virginia Tech who I have worked with on numerous occasions. They are joining forces with many other forest researchers from around the South to address how best to sustain the health and productivity of southern pine forests against potential climate change-induced threats to the southern region's continued economic, ecological and social well-being. Their overall goal of integrating current Southeast US cooperative forestry research expertise and leveraging their infrastructure to support a coordinated program of experiments, measurements, modeling, extension and education is bold and necessary.

We are counting on the research results to enable forest landowners, managers, policymakers, and the public to successfully expand the role of southern pine forests for such vital purposes as greenhouse gas mitigation and the continued productivity of southern pine forests.

In short, this is an outstanding opportunity for practical forestry research in Virginia and the Southeast, and VFA urges all potential funding sources and supporters to join in the cause.

Sincerely,

Paul R. Howe

Letters from complementary AFRI research proposals

The University of Mississippi

Oxford • Jackson • Tupelo • Southaven

June 29, 2010

Dr. Timothy A. Martin
Associate Professor, Tree Physiology
University of Florida

Dear Dr. Martin,

I am writing in support of your Regional Coordinated Agriculture Project research proposal to the AFRI Climate Change panel, entitled “Integrating research, education and extension for enhancing southern pine climate change mitigation and adaptation.” The proposed CAP promises to make great progress towards improving Adaptation and Mitigation in response to climate change, in the context of southern conifers.

As you are aware, I am the project director on a research proposal entitled “Management Of Southern Pine Forests - The Role Of Genetic Variation, Fungal Communities, And Hurricane Damage In Soil Carbon Sequestration” with co-PDs Aimee Classen and C. Dana Nelson. We plan to submit this proposal to AFRI Climate Program Area: Climate Change Mitigation and Adaptation in Agriculture. As we have discussed, the research you are proposing is complementary to the work we are planning, and we look forward to working and coordinating with you should both of our projects be funded.

best wishes,

Jason Hoeksema
Assistant Professor
Department of Biology
University of Mississippi
hoeksema@olemiss.edu
662-915-1275

NC STATE UNIVERSITY

NC State University Cooperative Tree Improvement Program
1019 Biltmore Hall
Campus Box 8002
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Tree improvement program NC STATE UNIVERSITY

Department of Forestry & Environmental Resources

DEPARTMENT of FORESTRY and ENVIRONMENTAL RESOURCES NC STATE UNIVERSITY

July 1, 2010

Timothy A. Martin,
Associate Professor, Tree Physiology
CAP Project Leader
School of Forest Resources and Conservation,
University of Florida / IFAS
PO Box 110410 (Mail)
Gainesville, Florida 32611-0410

Dear Dr. Martin,

I am the lead PI for a research project called '**Rapid Breeding and Disease Management for Climate Adaptation in Southern Pines**'. The proposal will address AFRI Climate Change program area priority Climate Change Mitigation and Adaptation in Agriculture (Program Area code A3141), Forest Systems, southern conifers. Our research proposal will focus on shortening the breeding cycles of southern pines using genomic tools. We will also determine the genetic basis of disease and insect resistance, and model how pest incidence will change by climatic variables. With this information, conifer breeders in South will be better prepared to meet the challenges of climate change.

Most of the PIs' from our research proposal, including myself, are also collaborators in the regional CAP proposal you are leading. I believe our research proposal will be excellent complement to your regional CAP proposal. The results from your research proposal should have high impact on solving the challenges brought by changing climate to southern conifer management systems. I am looking forward to working with you.
Sincerely,

Dr. Fikret Isik,
RapidPine Project Director
Research Associate Professor
Box 8002, Department of Forestry and Environmental Resources
North Carolina State University, Raleigh, NC 27695-8002
Phone: 919-515-6072, Fax: 919-515-3169
Email: fisik@ncsu.edu

United States Department of Agriculture **Forest Service** **Southern Research Station** **P.O. Box 12254 Research Triangle Park, North Carolina 27709**

July 1, 2010

Dr. Tim Martin
Professor, Tree Physiology
University of Florida
118 Newins-Zieglar Hall
PO Box 110410
Gainesville, FL 32611-0410

Dear Dr. Martin:

As you know, I am a principal investigator submitting a proposal entitled "Climate change mitigation and adaptation using longleaf pine "to the Agriculture and Food Research Initiative Climate Change Program Area. I have read your CAP proposal entitled "Integrating research, education and extension for enhancing southern pine climate change mitigation and adaptation". Your proposed work would be with loblolly and slash pine, the two major southern pines and those that have been the foci of decades of research by the group of Industrial Forestry Cooperative research programs that form the basis of your CAP. Our proposed work is with longleaf pine that, although is gaining popularity as a plantation species, has far less of a research history and so far less is known about its biology and management. The work in your proposed CAP will greatly pave the way for future development of climate change related research and management strategies in longleaf pine. If we are funded, I look forward to coordinating our two projects to maximize their synergy.

Sincerely,

Kurt Johnsen
Project Leader

Letter from cooperating 1890 Land Grant Institution (see subcontracts for others)

VIRGINIA STATE UNIVERSITY
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Box 9416

TEL: (804) 524-5220
FAX: (804) 524-5054

June 24, 2010

Dr. Timothy A. Martin
Associate Professor, Tree Physiology
School of Forest Resources and Conservation
University of Florida / IFAS
PO Box 110410
Gainesville, FL 32611-0410

RE: Letter of support for the proposal, "Integrating Research, Education and Extension for Enhancing Southern Pine Climate Change Mitigation and Adaptation".

Dear Dr. Martin,

Thank you for inviting me to represent Virginia State University (1890 Land Grant Institution) for collaborating on the educational component of the proposed proposal, "Integrating Research, Education and Extension for Enhancing Southern Pine Climate Change Mitigation and Adaptation". I understand that the educational component will involve my working with Dr. Martha Monroe (University of Florida) and Dr. John Seiler (Virginia Tech) and specifically with the distance education communication course that research interns will be enrolled in. I, and my colleagues at Virginia State University, will be happy to include Webinar, Videoconferencing, Discussion Board, and multi-cultural pedagogy in the distance course. As the project director of the USDA Capacity Building Grants involving Distance Education (Webinar and Videoconferencing, I have established collaborations with 1890 Land Grant Institutions (Florida A & M University, Delaware State University, and Southern University) and 1862 Institutions (Virginia Tech and University of Puerto Rico at Mayaguez, Puerto Rico (since 2005). My colleagues at Virginia State University (VSU) work closely on agricultural research and cooperative extension with 1890 Institutions in Georgia, North Carolina, and Maryland. Therefore, using the dustance education communication course, all of the 1890 Institutions will be encouraged to advertise the program and encourage promising students to apply. VSU has excellent facilities for hosting webinar, videoconferencing, discussion board, and multi-media instructional technology. My colleagues and I will be adding multi-cultural pedagogy to the distance course.

I will be happy to serve on the educational advisory committee of the above-mentioned project, if the proposal is funded. I wish you success for this proposal.

Sincerely,

Shobha Sriharan, Ph.D.
Professor of Environmental Science
Project Director, USDA Grants
Department of Agriculture & Human Ecology
Virginia State University
Petersburg, VA 23806
T: (804) 524-5220
Mobile: (804) 712-7181
E-mail: Sriharan@vsu.edu

<u>University of Florida</u>

School of Forest Resources and Conservation:

All of the wet laboratory work will primarily be carried out at the PIs' laboratory at the Genetics Institute which is well equipped for the molecular biology and genomic research required for this project. The laboratory has all equipment required for high-throughput extraction, analysis and storage of RNA and DNA, and transcript level quantification by Q-PCR. The equipments include an Olympus IX70 differential interference contrast microscope with high resolution digital camera, a Stratagene MX3000 real time PCR machine, four 96-well PCR machines, refrigerated tabletop and Superspeed centrifuge, a laminar flow hood, a Biorad Molecular Imager FX phosphoimager and laser attachment, a Kodak EDAS 290 system for gel imaging, Nanodrop spectrophotometer, Beckman Coulter P/ACE MDQ capillary electrophoresis and System Gold HPLC with scanning diode array detectors with autosamplers, tabletop, and a GenoGrinder2000 (Spex Certiprep, Inc.) for simultaneous extraction of total RNA or DNA from 96 tissue samples.

In Newins-Ziegler Hall, Dr. Peter has an x-ray Micro CT35 from Scanco Medical, equipped with an autosampler for measuring wood density and wood anatomy, a Perkin-Elmer Spectrum 400 FTIR/Near-infrared scanning spectrophotometer equipped with 96 well plate reader and ATR attachments, and ultrasonic tester from Sonisys for measuring wood mechanical properties.

In Newins-Ziegler Hall Drs. Martin and Jokela share a lab that is outfitted for conducting silviculture, production ecology, soils and plant physiological ecology studies. The lab is equipped with drying ovens, temperature controlled incubation cabinet, tissue digestion equipment, analytical balances, refrigerator/freezer, two Li-6400 photosynthesis systems, one Li-6400-09 soil respiration head, two ceptometers, LAI-2000 canopy analyzer, portable infrared gas analyzers, CE Elantech elemental analyzer, forestry biometrics equipment, multiple dataloggers, dew point generators, eddy covariance units, micro met stations, electronics fabrication tools and instruments, plus 4 vehicles to reach study areas. In addition, Martin and Jokela have a 700 ft^2 field laboratory located on the University of Florida's Austin Cary Memorial Forest which includes drying ovens, calibration gas tanks and dew point generator, a balance, refrigerator/freezer, bench space, and desk space. This climate controlled lab is used for staging field studies, equipment preparation, repair and calibration, and initial sample processing for field projects. In addition, the group maintains 3 vehicles and has access to departmental vehicles on a recharge basis.

Soils and Water Science Department:

GIS Computer Research Laboratory:
One data file server and a virtual machine (VM) with server that hosts centralized software which is remotely accessible with differential backup system; 14 PCs, 1 large format (poster) color printer HP DesignJet 2500CP), 2 color laser printers, 4 HP black/white printers and 2 HP flatbed scanner. The GIS Computer Research Laboratory provides state-of-the art workspace for computer-based research (statistical analyses; geostatistical modeling; space-time modeling; geographic information systems (GIS); remote sensing; and mechanistic simulation modeling).

Available software packages: MS Office Suite; MS SQL database; GIS software (ArcGIS Suite, ESRI and Idrisi); ERDAS IMAGINE for remote sensing analysis; S-GEMS, SAS, PC-ORD, SPSSWin, STIS and ISATIS for geostatistical and statistical analyses - annual license renewal; Adobe Photoshop; Adobe Acrobat; and Grapher; CART for tree-based analysis (Salford Systems Inc.) - annual license renewal; DreamWeaver for development of web applications; Environmental Visualization Software (EVS-PRO) and RockWorks2002 for 3D modeling and scientific visualization; Unscrambler for spectral analysis. Two sub-meter accuracy, differential GPS units (Trimble Pathfinder and Trimble GeoXT) for georeferencing of sampling locations; in addition several handheld GPS units (Garmin) are available for field navigation.

Environmental Pedology Laboratory:
The laboratory is equipped with drying oven, muffle furnace, block digester and Atomic Absorption Spectrophotometer; it has a well-equipped wet laboratory with much of the necessary experience and equipment to mount this proposal including nutrient extraction, soil texture (pipette), carbon fractionation, organic carbon quality measurements and other analysis; Shimadzu Carbon Analyzer. In addition there are available: Chemical storage cabinets, ball mills, sieve shakers, controlled temperature baths, two refrigerators, UV-visible spectrophotometers, bench space and paraphernalia for chemical analyses, and polarizing- and dissecting microscopes which can accommodate a camera for digital photographs. It houses excavation equipment (augers, shovels, probes, etc.) used for soil sampling, as well as materials (color books, clinometers, etc.) used for describing soils in the field. It is set up to perform physical and chemical soil characterization used in soil classification and interpretation. The lab also houses a spectroradiometer (QualitySpec Pro; Analytical Spectral Devices, Inc., Boulder, CO) for visible/near-infrared diffuse reflectance spectroscopic measurements of soil samples.

Auburn University

Two LI-6400 portable gas exchange systems with leaf, root and soil cuvettes, soil moisture equipment (time domain reflectometry TRACE System), root area scanning software (WHINRHIZO program), basic sap flow equipment, leaf area meters, a ceptometer, 3 scales, two pressure chambers, 3 computers and 3 ovens are available for the duration of the study and are assigned to L. Samuelson and located in the School of Forestry and Wildlife Sciences building on the Auburn University campus. A walk-in cooler is also part of the laboratory. The School of Forestry and Wildlife Sciences controls and maintains vans and trucks that will be used to travel to the study sites.

University of Georgia

Warnell School of Forestry and Natural Resources

Plantation Management Research Cooperative (PMRC) is based at the University of Georgia. The PMRC has a range of field measurement equipment including calibers, hypsometers, and handheld recording devices. Four pick-up trucks are housed in the PMRC.
Soils-Plant Laboratory:

The School provides state-of-the-art analytical chemistry and greenhouse facilities. The Phillips laboratory and greenhouse facility was built in 1993 within the Whitehall Forest. Plant, soil, and water samples are routinely analyzed following strict quality assurance and quality control protocols. A full-time research assistant employed by the Warnell School assists with laboratory management and is also available for field research assistance. Available equipment includes: CE Elantech NC 2100 is available for C and N determinations, Alpkem Flow solution 3000 from OI Analytical for wet chemical analysis, Dionex ion chromatograph DX500, Perkin Elmer ICP, Fisher Isotemp standard capacity refrigerated incubator, IEC GP8 high performance centrifuge, Equipment for particle size analysis, Controlled environment laboratory for NIRS analysis, a bench top FOSS NIRS, Unscrambler Software (Version 9.2), Field equipment includes: ASD Agrispec NIRS with contact probe, mug light, Lenovo Thinkpad, Dualem 2S – electromagnetic induction sensor, Advanced Geosciences R8 supersting, Trimble GeoXM, Hemisphere A100, Trimble Yuma, and Juniper Archer. Soil sampling equipment including AMS augers with quick connect extensions.

Ecophysiology Laboratory:
This lab is well-equipped for environmental plant physiology research, including scales, drying ovens, gas handling equipment, tools and computers. The equipment and supplies requested in the proposal has been minimized by the items for the project that the lab already possesses including: a LiCor 6400 portable photosynthesis/respiration system, four dataloggers and multiplexers (Campbell Scientific Inc., Model CR23X and AM16/32), a TDR soil water content sampling system (Moisture Point, Environmental Systems Inc.) and micro-environment sensors (quantum, relative humidity, temperature). Vehicles: Pick-up trucks are available for research at on a per-day and mileage cost basis

University of Georgia College of Agriculture and Environmental Sciences:
Southern Regional Extension Forestry (SREF) Office: The office of the Southern Regional Extension Forester has been located on the campus of the University of Georgia for over 30 years. SREF IT Laboratory: The SREF office also houses an extensive network of production computers and servers managed by an IT manager and two IT specialists. The SREF office leases secure server facilities on campus from the College of Agriculture and Environmental Sciences. These facilities are secured and temperature controlled. Several backup systems are in place and websites and associated data are backed up regularly. Due to the current state of technology within the SREF office, the amount of materials and supplies requested for this project have been minimized.

North Carolina State University

School of Forestry and the Environment

Cooperative Tree Improvement Program Laboratory equipment:

The coop manages a 1300 sq ft laboratory that is equipped primarily for the extraction of nucleic acid and DNA amplification. Equipment for nucleic acid isolation procedures includes three Fastprep (Qbiogene, Inc) and three Qiagen/Retsch Mixer Mill 301 grinders used for sample homogenization, three Sigma/Qiagen plate centrifuges with rotors capable of carrying deep-well blocks, one of which is refrigerated for protocols requiring lower temperature centrifugation, and a 96-well plate fluorometer suitable for PicoGreen fluorescent assays of DNA concentration. Equipment for nucleic acid manipulations include single channel and multi-channel manual and electric pipettors, three microcentrifuges with rotors for 1.5ml and 2ml tubes, and a plate rotor for PCR plates, and related equipment essential for standard molecular biology procedures. Equipment for PCR and analysis includes two MJR/BioRad Tetrad thermal cyclers with eight 96-well and two 384-well alpha heads, and three stand-alone 96-well thermal cycler units, and apparati for small- or large-format agarose gel electrophoresis, along with a Kodak video system for imaging stained gels and software for analyzing the resulting images. For sample and reagent storage, there are 4º C refrigerators, -20º C freezers, and a -80º C freezer. There is access to an autoclave and to walk-in size 4C refrigerators.

Computers and software:
The NC State University Cooperative Tree Improvement Program has a MacPro with dual quad-core Xeon processors and 32 Gb of RAM for analysis of large datasets. This machine also hosts virtual machines running Linux, to take advantage of open-source software for bioinformatics applications; the virtual machines are configured with dual 64-bit processor cores and 8 Gb of RAM each. In addition, multiple Windows XP or Windows 7 workstations are available for handling smaller datasets that do not require 64-bit processors and large amounts of RAM. The MacPro hosts a MySQL database that will archive data from the proposed research and help us to integrate the new data with historical records of progeny tests from current and previous breeding cycles of our loblolly pine breeding populations.

Tree Physiology Lab Equipment:

The lab is fully equipped for forest ecophysiological and ecosystem science research and investigates plant-soil relationships, gas exchange, plant growth and NPP, water relations and forest water balance, biochemistry, and carbon and nutrient cycling. Our facilities roughly break out into the following areas:

Water relations and plant gas exchange: Two Licor LI-6400 portable photosynthesis systems, one equipped for fluorescence, with standard leaf and conifer needle chambers; Dynamax hydraulic flow conductivity meter (HCFM-XP) for studying plant hydraulic conductance and cavitation; PMS Model 1000 pressure bomb for water potential; Licor LI-840 CO2/H2O gas analyzer equipped with a custom made chamber for understory respiration/transpiration/soil evaporation measurements; Licor LI-1600 porometer.

Histology and plant anatomy (xylem structure, stomatal traits, etc.): Microtome and staining equipment; Accuscope binocular light microscope (100-1000×) equipped with digital camera interfaced to computer with image analysis software; Nikon SMZ500 dissecting scope.

Soil gas exchange and roots: Two Giddings soil corers (3”×48”) equipped with polybutyrate soil sample tubes; bucket auger (6 m depth); WinRhizo root imaging software and high resolution scanner system; four PP Systems EGM-4 equipped with SRC-1 soil respiration chamber; three Licor LI-8100 soil respiration systems equipped with 6 automatic chambers and 1 survey chamber (sites US-NC1 and US-NC2 have a single autochamber, whereas the forested wetland at Alligator River NWR has 4 chambers monitoring different microsites); two PP Systems EGM-4 soil respiration systems for field measurements and one for laboratory incubation studies; various sieves and room dedicated to processing soil/root samples; three incubators with temperature control for lab incubations and analysis of microbial biomass, respiration, and decomposition.

Plant biochemistry (cellulose, hemi-cellulose, lignin, non-structural carbohydrates, soluble phenolics, condensed tannins, lipids, proteins): Beckman DU800 spectrophotometer with autosampler; Fisher Accuspin3 centrifuge; Eppendorf micro-centrifuge; various water baths, shakers, sonicators, pipetors, repipets, glassware, pH/conductivity meter, balances, Buchi rotary evaporator.

Eddy covariance towers and associated field sites: Three fully equipped eddy covariance flux towers and micrometeorology stations at Parker Tract (Washington County, NC) and Alligator River National Wildlife Refuge (Dare County, NC). The US-NC1 and US-NC2 sites have been in operation since November 2004 and have been sharing data through the Ameriflux public data server.

Texas A&M University

Ecosystem Science & Management

Konstantin V. Krutovsky has a modern molecular genetics laboratory with ~1200 sq. ft. of space and typical molecular biology equipment such as PCR machines, ultracentrifuges, electrophoresis apparatuses, etc., including a Victor-3 multitask plate reader for SNP genotyping is available.

Carol Loopstra has a laboratory that contains an ABI 7900 real-time PCR machine equipped for 384-wells, superspeed and ultracentrifuges, -80^{o}C freezers, computers and other small equipment found in a typical molecular biology laboratory. The office and lab are located in the Norman E. Borlaug Center for Southern Crop Improvement, which houses The Institute for Plant Genomics and Biotechnology (IPGB). The Center contains laboratories for faculty from seven plant-related departments, a Laboratory for Crop Transformation, a Laboratory for Crop Genome Technology, plant growth facilities and considerable shared equipment including two Illumina GAII sequencers, a Roche 454 Genome Sequencer, an ABI capillary sequencer, a robotic workstation, tissue culture hoods, centrifuges, cold rooms, a warm room, an X-ray developer, autoclaves, thermocyclers, microscopes (including fluorescence capability), an ABI 7900 real-time PCR machine, nebulizers for DNA fragmentation and other pieces of equipment.

Jason Vogel has lab capabilities that currently include real time analysis of $^{13}CO_2$, $^{12}CO_2$, and water vapor using a Picarro G1101-i wave cavity ring-down spectroscopy system. For continuous automated measurements of these gases, the Picarro system has a multi-sampling (8 port) command and control capability through proprietary software and a Valco multi-sampler. An automated and hand held system for soil CO_2 efflux (LI-820), modeled after the system detailed in Vogel et al. (2009) and Winston et al. (1997), is currently under construction that continuously samples from eight chambers. He has a light ceptometer for LAI measurements. His laboratory includes capabilities for computing, freezer and refrigerator space for sample storage, sample drying, and sample weight collection using a number of different balances. His wet laboratory is fitted for soil analysis and root washing.

Jianbang Gan has PC computers needed for economic modeling.

Texas Forest Service and Texas A&M University

Thomas D. Byram has laboratory space hosted by the Department of Ecosystem Sciences and Management in the Forest Science Laboratory building. This space, consisting of approximately 800 square feet of laboratory space, 800 square feet of common work space and administrative area, 522 square feet of wood shop and rough storage space containing freezers, workspace, and shop tools and 2,700 square feet of greenhouse and shade house space. The Texas Forest Service has its own networked computer system for management of the extensive database compiled by the members of the Western Gulf Forest Tree Improvement Program. This system provides for data management and analysis.

Virginia Polytechnic Institute and State University

Major analytical equipment relevant to the proposed project housed in Latham Hall includes:

- Elementar Vario MAX CNS Analyzer
- Varian Vista-MPX Simultaneous ICP
- Bran+Luebbee TRAACS 2000 Autoanalyzer
- Dionex DXP 600 Ion Chromatograph
- Elementar LiquiTOC Analyzer
- 2 Licor 6400 Photosynthesis Systems
- 3 Licor 6200 Photosynthesis Systems (refitted for soil CO2 efflux)
- WinRhizo Root Scanning System
- Licor LAI 2000
- Licor Leaf Area Meter
- Ground Penetrating Radar
- TDR Soil Moisture System

The CEARS The laboratory is equipped with 25 networked (100 Mbs) workstations (each with 8GB RAM), a dedicated server with over 20 terabytes of disk storage, various printers and plotters, and a complete suite of image processing (ENVI, Merrick MARS, eCognition, Feature Analyst, ERDAS Imagine) and associated software, including compilers (IDL, Absoft Fortran 2003, Matlab, Visual Basic, and C++), statistical packages (R, SAS, CART), and GIS (ESRI products). Capability for measuring and integrating in situ measurements is provided by a RIEGL laser scanner, a full range ASD FieldSpec3 spectroradiometer, a roving GPS base station. High performance computing infrastructure (in partnership with LASCA at Virginia Tech) includes a SunFire shared memory supercluster with 32 processors and 64GB of RAM. The center maintains an extensive image archive of Landsat (>350) and MODIS scenes, most of which are made publicly available through our leadership of the VirginiaView consortium. Equipment shared with the Virginia Tech Department of Forest Resources and Environmental Conservation includes over 40 GPS receivers.

<u>US Forest Service</u>

<u>US Forest Service, RTP, NC</u>

Ground penetrating radar to estimate root biomass, identify soil attributes, and quantify tree decay – all equipment needed to process and analyze an array of attributes of large quantities of tree biomass and soils – an N and C Analyzer to measure tissue and soil samples – an ICP (Inductively Coupled Plasma) spectrometer to measure foliar macronutrient concentrations. Also includes: 21 Automated Carbon Exchange Systems - The Automated Carbon Efflux System (ACES) is a custom design multi-chambered soil and stem CO_2 efflux measurement system developed by the Southern Research Station (RWU-4160), USDA Forest Service, RTP, NC (Patent #6,692,970); 2 Licor 6400 Photosynthesis Systems; Licor LAI 2000 Plant Canopy Analyzer; Licor 610 Dewpoint Generator; ThermoFinnigan Flash EA 1112 nitrogen and carbon analyzer (Milan, Italy); Horiba Jobin Yvon JY2000 inductively coupled plasma spectrometer (Chilly Mazarin, France); WinRHIZO ProSTD 1600+

<u>US Forest Service, Saucier, MS</u>

ABI 3130XL and 3730XL DNA capillary gel electrophoresis systems for high resolution DNA fragment analysis and DNA sequencing – a Hamilton 12-channel robotic liquid pipettor with microliter capability for loading DNAs and PCRs in 96 or 384-well formats – twelve 96-well and eight 384-well DNA thermal cyclers used for PCR amplification – twelve large format horizontal agarose gel electrophoresis units for medium resolution DNA fragment analysis – 2 x 96 sample tissue grinder and centrifuge for high-throughput DNA isolation – several table-top centrifuges for small scale DNA and protein isolation – standard UV spectrophotometer and a 96-well plate reader fluorometer for DNA quantification – two ultra low temperature freezers for long-term sample and reagent storage – laminar flow and biological safety hoods and autoclave for sterile culture – four reach-in temperature and light controllable growth chambers for plant research.

University of Florida

School of Forest Resources and Conservation:

Drs. Martin, Adams, Carter, Cropper, Davis, Jokela, Monroe, and Peter reside in Newins-Ziegler Hall at the University of Florida. They have approximately 2500 ft^2 of lab and office space. In addition, Martin and Jokela have a 700 ft^2 field laboratory located on the University of Florida's Austin Cary Memorial Forest, and Davis and Peter have 2400 ft^2 of office and lab space in the new University of Florida Genetics Institute (UFGI). In the UFGI there are small conference rooms (4-6 people) as well as larger rooms (20-30) persons and an auditorium (150 persons). The UFGI also has copy, fax, and all other necessary office support. Facilities for plant propagation, growth and maintenance in the University of Florida Genetics Institute include four walk-in growth chambers. The researchers also have access to any equipment that may be available at the Interdisciplinary Center for Biotechnology Research (ICBR), also located at the Genetics Institute. This is a state-of-the-art facility that has the latest technology in DNA sequencing, microarray analysis, proteomics and metabolomics. The DNA sequencing technology available includes 454 FLX, Applied Biosystems SOLiD and Illumina GS IIx sequencers, robotic workstations, and most other equipment that may be necessary for genotyping microsatellites such as an ABI 3730. The group has access to departmentally shared research infrastructure such as station-based GPS units, walk-in drying rooms, woodworking and fabrication shop, and computer and media laboratories. In addition, we maintain over 2000 ft^2. of climate-controlled greenhouse space equipped with 30 ebb-and-flow benches that can support up to 140 plants/each.

Computers and software:
The UFGI has an HP DL585 Proliant Server with 64 Gigabytes of RAM, 2 dual core Opteron processors. The UFGI also has an IBM cluster with 11 computer nodes and 1 head node. The head node is an IBM x3650 dual quad core Xeon 5405 (2.0Ghz/1333Mhz) for a total of 8 cores 4 Gb DDR2 667Mhz ECC RAM 4 500 Gb 7200 RPM Hot Swap SATAII NCQ 3.5 drives. The 10 compute nodes are each dual quad core Xeon 5405 (2.0Ghz/1333Mhz) for a total of 8 cores/ node (80 total) 4 Gb DDR2 667 ECC RAM / node 1 74 Gb 7200 RPM SAS 2.5 drive / node. There is one compute node that is 'fat' where the configuration is: IBM x3850 quad core Xeon E7320 (2.13Ghz, 1333Mhz) for a total of 16 cores 128 Gb DDR2 667 ECC RAM 4 148 Gb 7200 RPM Hotswap SAS 2.5 drives. Rocks 5 is used as the clustering software and both machines run on a Linux platform. The two machines have ample room to expand storage and memory. Bioinformatics tools such as Bioperl, Biopython, NCBI toolbox (BLAST, etc), MrBayes are all installed and available as well. The cluster has iNquiry installed which provides an easy web based access to many of these tools. Storage for all of the UFGI is managed via a Xiotech San which is connected to the cluster via fiber. The machines are housed in the Health Sciences clean room. This temperature controlled facility is also physically secure and the nightly backups are stored in an off campus location. The server is available to all members and affiliates with the UFGI and OS maintenance and backups are provided to the UFGI. In addition, the standard statistical software used by the group, SAS, Splus, R, and Matlab will be available.

Soils and Water Science Department

Dr. Grunwald has office and laboratory space in McCarty Hall. The GIS Computer Research and Environmental Pedology labs are fully equipped for computational and soil analyses. In addition, the PI has access to the UF/IFAS clean room for server storage. This facility provides daily backup services and weekly backups to tape.

Auburn

Dr. Samuelson has laboratory and office space (total of 1950 ft^2) in which equipment is stored and any laboratory work is conducted, located in the School of Forestry and Wildlife Sciences building. A walk-in cooler is also part of the laboratory.

North Carolina State University

School of Forestry and Environment

Tree Physiology Lab:

Drs. Domec, Noormets, and King have office space and a laboratory fully equipped for forest ecophysiological and ecosystem science research that investigates plant-soil relationships, gas exchange, plant growth and NPP, water relations and forest water balance, biochemistry, and carbon and nutrient cycling.

The Eastern Forest Environmental threat Assessment Center in Raleigh (formerly USFS Southern Global Change Program):

Drs. McNulty and Sun are co-located at NCSU and operate one of the USFS climate change impacts modeling facilities and have expertise, infrastructure and support personnel to run continental-scale and regional simulations of forest hydrology and biogeochemistry at alternative climate, land use change, and population scenarios. The routinely used models include WaSSI CB, PnET CN, MIKE SHE and WETLAND DNDC. The WaSSI-CB model has been developed in-house by Sun and operates on 8-digit hydrologic unit codes (HUC) and considers downstream flow-dynamics for allocation of water resources.

Cooperative Tree Improvement Program:

Drs. Isik, McKeand and Whetten have offices in Jordan Hall, and the program manages a 1300 ft^2 laboratory that is equipped primarily for the extraction of nucleic acid and DNA amplification. In addition, the Program has a MacPro with dual quad-core Xeon processors and 32 Gb of RAM for analysis of large datasets. For larger tasks, the NC State University High-Performance Computing (HPC) facility provides state of the art support for research and academic computing. The HPC facility includes both distributed-memory and shared-memory services. Two distributed-memory Linux clusters are available, henry2 with 866 Xeon processors (a mix of single, dual, and quad core) with 2 Gb RAM per core, and Sam, with 1000 Xeon dual core processors and 4 Gb RAM per node, both with dual gigabit Ethernet interconnects. Shared-memory computing services are provided by Opteron based nodes integrated with the henry2 cluster. These nodes provide up to 16 shared memory processor cores and up to 128GB of memory accessible through a dedicated queue. Three types of storage service are available for users of the distributed memory and shared memory compute services: 1) home directory storage is shared between both distributed memory and shared memory services and provides up to about a gigabyte of backed up storage; 2) independent scratch storage services, including parallel file systems, are available for distributed memory and shared memory jobs providing up to a few terabytes of volatile storage with no backups; and 3) a shared mass storage service provides 12 terabytes of backed up storage for important files.

Drs. Abt, Boyles, Meglos, and Stape have office space and the computers required for their students and staff on the NCSU campus.

Texas A& M University

Ecosystem Science & Management

Drs. Gan, Krutovsky, and Vogel have office and lab space at Texas A&M's main campus in College Station in the Horticultural/Forest Sciences Building. Dr. Loopstra's office and lab are located in the Norman E. Borlaug Center for Southern Crop Improvement, which houses The Institute for Plant Genomics and Biotechnology (IPGB). The Borlaug Center contains laboratories for faculty from seven plant-related departments, a Laboratory for Crop Transformation, a Laboratory for Crop Genome Technology, plant growth facilities and considerable shared equipment and access to the modern genomics facilities and equipment at the Institute for Plant Genomics and Biotechnology including, two Illumina Genome Analyzers and a Roche 454 Genome Sequencer (lgt.ipgb.tamu.edu). The Supercomputing Facility (bioinformatics.tamu.edu) is available through faculty collaborators and membership in the Alliance for Bioinformatics, Computational Biology, and Systems Biology (ABCS), and provides hardware, software and technical support to the university's faculty and staff who require large-scale computing capabilities (sc.tamu.edu/resources.php). The supercomputing facility operates 1) the IBM iDataplex Cluster based on Intel's 64-bit Nehalem processor and composed of 6 head nodes, 4 storage nodes, and 314 compute nodes; 2) the IBM Cluster 1600 that based on Power5+ processors and consists of 52 p5-575 nodes, each having 16 Power5+ processors running at 1.9GHz; 3) several Linux workstations for pre- and post-processing needs, and 4) a tape based storage archive for backing up the files.

Texas Forest Service and Texas A&M University

Dr. Byram has laboratory space hosted by the Department of Ecosystem Sciences and Management in the Forest Science Laboratory building. This space, consisting of approximately 800 ft^2 of laboratory space, 800 ft^2 of common work space and administrative area, 522 ft^2 of wood shop and rough storage space containing freezers, workspace, and shop tools and 2,700 ft^2 of greenhouse and shade house space. The Texas Forest Service has its own networked computer system for management of the extensive database compiled by the members of the Western Gulf Forest Tree Improvement Program. This system provides for data management and analysis. The Western Gulf Forest Tree Improvement Staff will be involved in managing the field installation of the clonal test located at the Arthur Temple Sr. Research Area in Cherokee County that will be used in this study.

US Forest Service

The USFS Forest Service Laboratory in RTP, NC

Excellent office space is available for Dr. Johnsen's group. Desktop computers are available at all locations for technicians and PIs. These computers have software including SigmaScan, Sigma Plot, PC SAS, WinRhizo and other software packages for processing data. The Forest Service also provides a computer network for access to on-line resources. A standard size greenhouse with associated head house is available for research. The RTP lab is located 15 miles from Duke Forest.

US Forest Service Laboratory, Saucier, MS

The Southern Institute of Forest Genetics Lab in Saucier, MS is located on the Harrison Experimental Forest (HEF; 1,662 ha) and has 3000 ft^2 of lab space focused on DNA analysis of forest trees and pests. The HEF has two 1800 ft^2 greenhouses, two outdoor growing areas, four environmentally controlled growth chambers, and pollen, seed handling and storage facilities as well as onsite housing for visiting scientists and students. All research buildings on the HEF are networked with fiber-optic network at 1 Gbs and connected to the Internet through a dedicated T1 line. Two dedicated research servers and several workstation class PCs are available to facilitate bioinformatics based research and database management.

Virginia Polytechnic Institute and State University (Virginia Tech)

Department of Forest Resources and Environmental Conservation

Drs. Burkhart, Fox, Seiler, Strahm, Holliday, and Wynne have office space and fully equipped laboratories dedicated to Forest Soils, Tree Nutrition, Forest Hydrology, Forested Wetlands Forest Genomics, and Tree Ecophysiology in the newly constructed Latham Hall. In addition there are six, 20 foot tall walk in growth rooms capable of maintaining light saturated photon flux densities, humidity control (30% to 80%) and temperature control (5 to 35^oC).

All laboratories are managed by experienced laboratory technicians who are fully trained in quality assurance/quality control procedures. These laboratories have served as the basis for numerous projects involving federal agencies that require rigorous QA/QC, including the U.S. Department of Agriculture, Department of Energy, Environmental Protection Agency, and the USDA Forest Service. As an example, Virginia Tech was a major partner in the National Acid Precipitation Assessment Program (NAPAP), and labs in the Department of Forest Resources and Environmental Conservation met the exacting QA/QC requirements of that program.

The Center for Environmental Applications of Remote Sensing (CEARS) was established in 1997 as a NASA center of excellence in applications of remote sensing to regional and global integrated environmental assessments. With core faculty in both the Geography and Forest Resources and Environmental Conservation departments, it is Virginia Tech's focal point for interdisciplinary research, instruction, and outreach focused on remote sensing applications. Center researchers have extensive expertise with a wide variety of data types (i.e., active and passive microwave, multispectral, hyperspectral, lidar, aerial photographs) and application areas (e.g., temperate and tropical forestry, limnology, ecological modeling, marine biology, environmental monitoring, urban ecology, carbon sequestration, tropical biodiversity assessment, phenology studies, rangeland management, invasive species, and fire fuel loading). The CEARS laboratory is physically and administratively housed within the College of Natural Resources, but is shared with other colleagues and constituencies, both on campus and off.

University of Georgia

Daniel B. Warnell School of Forestry and Natural Resources

Drs. Kane, Markewitz and Teskey have office and lab space in Buildings 3, 4 and 5 of the Warnell School Complex. The School provides state-of-the-art analytical chemistry and greenhouse facilities. The Phillips laboratory and greenhouse facility was built in 1993 within the Whitehall Forest. Plant, soil, and water samples are routinely analyzed following strict quality assurance and quality control protocols. A full-time research assistant employed by the Warnell School assists with laboratory management and is also available for field research assistance. Vehicles: Pick-up trucks are available for research at on a per-day and mileage cost basis

University of Georgia College of Agriculture and Environmental Sciences

Southern Regional Extension Forestry (SREF) Office: The office of the Southern Regional Extension Forester has been located on the campus of the University of Georgia for over 30 years. This office houses Dr. Hubbard and a staff that supports regional and national technology transfer, Extension, professional development and science delivery to a variety of audiences. The staff includes a regional forester, an administrative assistant, an educational program specialist, three Internet technology programmers, a graphics artist and several student workers. The SREF office is supported by the 13 Southern 1862 Land Grant Universities and the USDA Forest Service Southern Region and several ongoing grants. In addition, the SREF office works closely with the 1890 Land Grant Universities, the southern state forestry agencies and associations, and several public and private environmental and natural resources agencies.