The objective of the Southern Forest Carbon Research Inventory is to gain insights on the strengths, weaknesses and scope of forest carbon-related research in the South and to provide a resource to assess priority research needs and opportunities for collaboration across research institutions, research programs, and scientists. This inventory represents a wealth of information on southern forest sector carbon dynamics and controlling factors with topics ranging from controls over carbon acquisition at the leaf level and fine root responses to soil resource gradients to assessments of how land use change and socioeconomic factors may influence for carbon fluxes and sequestration for the region as a whole.

The Southern Forest Carbon Research Inventory represents a snapshot of current and recent research on carbon storage, fluxes, and sequestration in the southern forest sector and how management, biological, and socioeconomic factors influence carbon dynamics. The inventory is based on the USDA’s Current Research Information System (CRIS) database, on U.S. Department of Energy and the National Science Foundation project descriptions, and on a survey distributed in the region.

The inventory consists of a one-page description of each project divided into (a) principal investigators, institutions, and primary contact information, (b) scope and objectives, (c) site locations, (d) timetable and funding sources, (e) remaining gaps/opportunities, (f) project description, and (g) key publications. Project descriptions were edited in some cases to maintain a one page length and to improve consistency across categories for the projects. Some broader research programs that represent multiple projects were allotted more than one page. An Excel project matrix is lists the projects and notes the subjects addressed in each (i.e., tree, stand, ecosystem/landscape, and region (scales), remote sensing, belowground, physiology, elevated CO₂, water, nutrients, management, genetics, economics, wood/products, bioenergy, and forest sector). The intent of both the inventory project descriptions and the matrix is to highlight the most important features of each project and to provide a starting point, with more complete and up to date information available from project web sites and from contacting investigators.

This inventory does not capture all relevant projects, such as some projects that contain carbon as a minor component or others that may be indirectly relevant to carbon, such as some forest productivity studies. Other projects not captured include some that have a site located in the South as one of multiple sites and those funded by sources not reviewed. Some forest bioenergy/biofuel projects are included in the inventory but these projects were not a primary focus and most were not captured and the inventory should not be considered a good source of information on such projects.

**Priority Research Needs**

The inventory reveals many innovative research projects that are addressing critical needs. It also reveals weaknesses and areas where improvement is needed. Research integration and application are two areas where substantial improvement is needed:
Integration

Despite substantial advances in the forest carbon sciences, the array of projects identified in the inventory remain largely fragmented and not integrated across scales or disciplines. For example, there is a focus on on-site carbon sequestration and fluxes while the fate of post-harvest carbon residing in other forms such as products and landfills is largely ignored. Because some post-harvest carbon forms have longer residence times than carbon stored in trees subject to management and disturbance, conclusions drawn about management implications based solely on the latter can be misleading. In addition to improving integration across the forest sector, research designs and data standards that more consistently provide inputs to scaling models and assessments are needed. Process studies also need to more consistently integrate forest responses to multiple limiting factors and to integrate above- and belowground dynamics. Some of these integration issues has been addressed in individual studies but they remain more the exception than the rule.

Application

Research data gathered are of little use unless they are eventually applied to address the real-world issues faced by forest managers and policymakers. There have been significant advances in the development and application of models but a more formal and consistent collaboration among modelers and experimental scientists is needed if those models are to be used in problem solving across multiple sites. Basic questions concerning the effects of changes in management and land use as well as ongoing management on carbon sequestration also remain unanswered, which calls for closer cooperation between forest managers and scientists in formulating research questions and designing studies to address them. The use of process-level understanding accumulated by scientists for the development of tools for forest managers has been inconsistent, in part because models are usually not based on standard or easily obtained inventory data. One example is the need for models that can be used to rapidly assess carbon inventories and changes in carbon pools over time with reasonable accuracy. Because it is not economically or logistically feasible for managers to conduct comprehensive carbon assessments for every site-management combination, research that can be used to develop scientifically credible default values is needed.

Contact

If you have a project that you would like to add to the inventory, or if you have comments or find errors or omissions please contact Dr. Eric Vance, National Council for Air and Stream Improvement (NCASI), P.O. Box 13318, Research Triangle Park, NC 27709-3318 (Phone (919) 941-6415; Fax (919) 9412-6401; Email evance@ncasi.org).
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<td>Carbon and Water Flux in Eastern Forests: Data Collection, Model Development, and Application of Spatially-Explicit Models (C)</td>
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<td>Restoring Sustainable Forests on Appalachian Mined Lands for Wood Products, Renewable Energy, Carbon Sequestration, and Other Ecosystem Services (D)</td>
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<td>National Carbon Sequestration Database and Geographical Information (D)</td>
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**Tree**

**Stand**

**Ecosystem/Landscape Region**

**Remote Sensing**

**Belowground Physiology**

**Elevated CO₂**

**Water**

**Nutrients**

**Management**

**Genetics**

**Economics**

**Wood/Products**

**Bioenergy**

**Forest Sector**
<table>
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<td>16</td>
<td>Coupling the Effects of Management and Climate on Carbon and Water Fluxes in the Forests of Eastern U.S. and P.R.C. (S)</td>
<td>Chen X X X X</td>
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<td>Dynamic Sensor Networks - Enabling the Measurement, Modeling, and Prediction of Biophysical Change in a Landscape (N)</td>
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<td>Short Rotation Woody Crops Cooperative Research Program, Experiment A: Fundamental Controls of Growth and Productivity (S)</td>
<td>Coleman X X X</td>
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<td>Modeling Selected Soil Processes in Forested Soils of Florida (C)</td>
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<td>Floodplain Forests and Water Quality: Influence of Ecosystem Type and Biogeochemistry (C)</td>
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<td>Controls on the Isotopic Composition of Fixed CO₂ and Ecosystem-respired CO₂ in Southeastern Pine Forests (N)</td>
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<td>Effects of Whole-Tree Harvesting and Site Preparation on Production of Loblolly Pine Plantations (C)</td>
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<td>23</td>
<td>The Ameriflux Network (D)</td>
<td>Drake et al. X X X X</td>
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<td>24</td>
<td>Response of Southern Pine Wood to Elevated CO₂ (C)</td>
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## Southern Forest Carbon Research Inventory Matrix

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| 3 | | | | | | | | | | | | | | | | | | |
| 4 Project Title | Investigator |
| 25 Remote Sensing of Forest Resources (C) | Evans | X | X | X | X | |
| 26 Maintaining and Enhancing Forest Soil Productivity in the MidSouth (C) | Farrish | X | X | X | X | X | X |
| 27 Interactions of Arkansas Forest Vegetation With Soils Relative to Forest Productivity and Value (C) | Ficklin | X | X | X | X | X | X |
| 28 Environmental Physiology of Tennessee Tree Species (C) | Franklin | X | X | X | X | X |
| 29 Forest Soil Carbon Dynamics in the Southern Appalachian Mountains (D) | Garten | X | X | X | X |
| 30 Competitiveness of Mississippi’s Forest Resources in the Global Marketplace (C) | Grebner | X | X | X | X | X | X | X | |
| 31 Effects of Loblolly Pine Plantation Re-establishment on Nitrogen and Phosphorus Pools: An Approach to Quantifying Sustainability (C) | Gresham | X | X | X | X |
| 32 Enriched Background Isotope Study (D) | Hanson | X | X | X | X | |
| 33 The Impact of CO₂ Fertilization on Soil Carbon Storage Below a Forest (C+B40) | Harrison | X | X | X | X | X | X |
|   | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S |
| 2 | Southern Forest Carbon Research Inventory Matrix |
| 3 | Project Title | Investigator |
| 4 | Southern Appalachian Forests: Belowground Processes in a Diverse and Changing Landscape (C) | Hendrick |
| 5 | Nitrogen Controls on Belowground Carbon Allocation and Fates at Ecosystem Scales (C) | Hendricks |
| 6 | Investigation of Ecophysiological Processes Determining Productivity of Loblolly Pine (C) | Hennessey |
| 7 | Wood Utilization Research Program 2005 (C) | Hopper |
| 8 | Forest Inventory and Analysis Using GIS and Geospatial Systems (C) | Hung |
| 9 | Effects of Elevated CO2 on Forest N Cycling: Assessment with Large-Scale 15N Tracers and Modeling (N) | Jackson |
| 10 | Understand and Quantify the Above and Below-Ground Processes, Their Governing Factors, and Their Control of Forest Productivity and Sustainability (C) | Johnsen |
| 11 | Carbon and Nutrient Accumulation in Loblolly Pine Plantations over 75 Years on a Severely Eroded Agricultural Field (Potential Remeasurement) (S) | Kapeluck |
| 12 | Development of a Biorefinery Process for Energy Production, Value Added Products, and Advanced Catalysts (C+B73) | Kastner |</p>
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<td>Linking Remote Sensing with the Ecology of Forest Succession in Regional Carbon Cycle Modeling (C)</td>
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<td>Arkansas Forest Resource Center: A Continuing Program, Phase IX (C)</td>
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<td>Enhancement of Terrestrial Carbon Sinks Through Optimal Forest Management (S)</td>
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<td>Enhancement of Terrestrial Carbon Sinks Through Reclamation of Abandoned Mine Lands in Appalachia (D)</td>
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<td>Assessing Carbon Balance of Farming Systems Constituting Agricultural Crops and Forest Ecosystems (C)</td>
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<td>Gene Expression in Forest Trees (C)</td>
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<td>A Dynamic Stochastic Analysis of Global Warming, Forest Carbon Flux, and Timber Harvests (C)</td>
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<td>Application of Low-Cost Digital Elevation Models to Detect Change in Forest Carbon Sequestration Projects (D)</td>
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<td>Invasion of North Temperate Forest Soils by Exotic Earthworms (N)</td>
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<td>Quantifying Genotype x Silviculture Interaction Impacts on Productivity and Carbon Sequestration by Manipulating Soil Organic Matter, N Supply and Demand (S)</td>
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<td>Carbon Sequestration and Enhanced Wildlife Habitat Resulting From Bottomland Hardwood Afforestation Activities in the Lower Mississippi Alluvial Valley (S)</td>
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<td>Consortium for Accelerated Pine Productivity Studies (S)</td>
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<td>Southlands Experiment Station (S)</td>
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<td>Impact Analysis and Decision Strategies for Agricultural Research (C)</td>
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<td>Coupling the Effects of Management and Climate on Carbon and Water Fluxes in the Forests of Eastern U.S. and P.R.C. (S)</td>
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<td>The Competition Omission Monitoring Project (COMP): Soil Nutrient Response 15 Years after Competing Vegetation Control and their Correlation to Growth for 13 Loblolly Pine Plantations (S)</td>
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<td>Carbon Fine Root Allocation and Transfer at Ecosystem Scales: Root Architecture, Mycorrhizae and Stored Carbon Regulation and Belowground Dynamics (C)</td>
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<td>Carbon Sequestration and Nutrient Conservation of 16-Yr-Old Naturally Regenerated Loblolly Pine (C)</td>
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Letter in parentheses indicates information source: S=survey; C=CRIS; D=DOE, N=NSF
ANALYSIS OF PRIVATE TIMBER SUPPLY BEHAVIOR
IN THE UNITED STATES

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Scope and Objectives: This study aims to improve and extend the major types of models of private timber harvest and investment behavior to allow better predictions of likely future harvests and to better understand private response to policy changes. Objectives are to 1) develop models of timber harvest and forest management investment decisions by private owners in the U.S. at the regional (multi-state) level, recognizing major economic and social determinants of behavior; 2) examine the performance of these timber supply models in projections of timber markets (including representations of timber demand) using larger models of timber and secondary forest products markets; and 3) develop estimates of the private harvest response to commonly advocated changes in forest policies and management regulations, including limitations on access to some portion of the timber inventory (mandated reserves) minimum harvest ages and/or harvest sizes, minimum post-harvest residual stocking, and monetary incentives for prolonging rotations.

Timetable and Funding Sources: CSREES OREZ
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: NEW
START: 01 MAR 2002 TERM: 01 MAR 2007 FY: 2004

Project Description: Private timberlands have become the primary source of all wood products in the U.S. Work will proceed by updating existing econometric models developed as part of the Forest Service's national timber assessment program and a linked set of regional intertemporal optimization models developed for USEPA's forest carbon sequestration analyses. Project activities include 1) improve and extend historical timber harvest data series for use in econometric analyses, 2) employ a common initial timber inventory database for both models, 3) compare projections from the two approaches under comparable input conditions over a fixed future period, 4) extend the economic model by adding explicit relations for management investment, and 5) develop hybrid models using the management investment projections of the intertemporal optimization model in the econometric system and the econometric investment equations to constrain the intertemporal optimization model.

Key Publications:
BIOFUELS PRODUCTION FROM COTTON GIN WASTE AND RECYCLED PAPER SLUDGE

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Scope and Objectives: The purpose of this project is to develop an in situ detoxification process for the bioconversion of cotton gin waste and recycled paper sludge mixtures into ethanol in high yields. The specific objectives of this project are 1) collect and fractionate cotton gin waste from cotton gins in five states to access the impact of harvesting method on the quality of the feedstock, 2) characterize recycled paper sludge and cotton gin waste from various states to assess impact of ginning on feedstock composition, 3) investigate the in situ detoxification of cotton gin waste/recycled paper sludge during steam explosion pretreatment, 4) investigate the bioconversion of steam exploded cotton gin waste/recycled paper sludge mixture to ethanol, and 5) analyze biomass-to-ethanol fermentation residue to assess the nature of the unhydrolyzed residual cellulose.

Timetable and Funding Sources: CRIS AGENCY: CSREES VA.
PROJ TYPE: HATCH PROJ STATUS: NEW
START: 01 OCT 2005 TERM: 30 SEPT 2010

Project Description: Cotton gin waste (CGW) is an agro-industrial residue which could be potentially used for ethanol production. Unlike other lignocellulosic feedstocks, this material is concentrated at the processing sites; therefore, harvesting and transportation costs could be considerably less than those for agricultural and forestry residues and dedicated biomass feedstocks. Recycled paper sludge is a short fiber cellulosic feedstock, which could also be potentially used for ethanol production. Similar to the CGW, this material is concentrated at processing sites, so transportation costs could be considerably reduced. By combining these feedstocks, ethanol in high yields can be produced for fuel applications and waste disposal problems in these industries can be solved simultaneously. The overall goal of this project is to develop an in situ detoxification process for the bioconversion of cotton gin waste and recycled paper sludge mixtures into ethanol using steam explosion, enzyme hydrolysis, and fermentation technologies. The process has the potential of solving a waste disposal problem while simultaneously generating a new product stream for the cotton and paper and pulp industries. This technology could be applied to other biomass feedstocks and thus eliminate the extra processing step required for the bioconversion of biomass to fuels and chemicals. This will obviously improve the biomass-to-ethanol process economics. The processing of cotton gin waste and recycled paper sludge to ethanol will reduce greenhouse gas emissions, and replace petroleum products.
FOREST NUTRITION COOPERATIVE (FNC)

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Scope and Objectives: Our program goal is to provide innovative solutions to enhance forest productivity and value through sustainable management of site resources.

Site Location(s): Over 100 active study locations in plantations throughout the southeast United States with loblolly and slash pine, in Argentina with loblolly pine, in Colombia with E. grandis, and Chile with Radiata pine.

Timetable and Funding Sources: FNC has been operation for 35 years on an annually renewable basis. Support through industry members, NCSU, and VA Tech.

Remaining Gaps/Opportunities:
- Quantify soil nitrogen supply and how it is affected by carbon forms and fluxes.
- Understand how silvicultural practices interact to influence carbon cycling including carbon gain, loss, sequestration, forms, and fluxes.
- Develop decision support models that accurately reflect silvicultural treatment impacts on carbon cycling across a range of site/stand conditions.

Project Description: The core of our research effort is the establishment, maintenance, and measurement of uniform field trials by full members. These “region-wide” studies address silvicultural options for improving productivity (carbon gain) and value at stand establishment (e.g., site preparation, competition control, and fertilization) and in established stands (e.g., thinning, fertilization, woody vegetation control). In addition, FNC scientists are partners in several long term studies focused on understanding and quantifying the genetic, ecophysiological, and soil process that affect productivity, carbon cycling, and nutrient cycling in loblolly pine plantations. These studies include SETRES1, SETRES2 in North Carolina and the IP-FNC long-term site productivity studies in the North Carolina Piedmont and Alabama upper coastal plain.

Key Publications related to carbon:

DISTURBANCE AND RECOVERY PROCESSES IN WETLAND AND RIPARIAN FORESTS

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Scope and Objectives: Forest operations in wetlands may result in decreased water quality or decreased long-term site productivity. The purpose of this study is to develop operational forestry practices or best management practices (BMPs) that will minimize or prevent water quality or site productivity declines.

This study aims to evaluate and quantify the effects of existing or potentially useful silvicultural forest operations on wetland and riparian sites and to use such results to develop environmentally benign operational methods.

Timetable and Funding Sources: SUBFILE: CRIS  AGENCY: CSREES VA.
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: TERMINATED

Project Description: Quantify the effects of harvesting, site preparation, and intermediate silvicultural operations on soils, hydrology, and vegetation in wet pine flats, pocosins, black river riparian areas, and red river riparian areas.

As expected, carbon storage in above- and belowground pools increased as the stands aged, but particulate carbon export values to the streams stabilized within the 12-16 year age classes. Large woody debris did not stabilize before age 60, and this suggests that streamside management zones should be managed for older age classes if addition of large woody debris is a management objective.

Key Publications:
LINKING LANDSCAPE-SCALE CARBON MONITORING WITH FOREST MANAGEMENT

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Scope and Objectives: Our research project consists of the following three linked objectives: (1) develop a consistent set of landscape-scale estimates of carbon stocks and productivity (NPP, NEP) for stands at various stages of succession following land management activities and natural disturbances, and evaluate their uncertainty; (2) develop and validate two compatible process models to simulate (a) effects of natural disturbances on carbon stocks and productivity at the ecoregion scale, and (b) effects of forest management activities on carbon stocks and productivity at the forest stand scale; and (3) develop and evaluate two decision support tools for estimating and reporting carbon stocks and changes in carbon stocks for use by forest carbon managers. Achieving these objectives will constitute a significant advance in availability of relevant and useful ecosystem data for broad application by the scientific, policy, and land management community, and lead the way toward implementation of landscape monitoring on a much broader scale than currently possible.

Site Location(s): Marcell Experimental Forest, Minnesota; Bartlett Experimental Forest, New Hampshire; Weyerhaeuser Parker Tract, Washington County, North Carolina; Fraser Experimental Forest, Niwot Ridge, and Glacier Lakes Ecosystems Experiment Site, Colorado

Timetable and Funding Sources: FY2003 – FY2008; NASA/DOE/USDA, Carbon Cycle Science, plus substantial base program funding and in-kind resources from USDA Forest Service

Remaining Gaps/Opportunities: Existing databases of model drivers and validation measurements document both the need for land data, and the gaps in data availability. For example, as of 2002, there were just 12 sites in North America where intensive measurements of NPP were sufficiently documented and passed a quality assurance check to be included in the global database.

Project Description: The USDA Global Climate Change Program has recently funded several pilot projects to examine the potential of sites with intensive ground-based measurements to aid in the development of landscape-level carbon flux estimates. The sites, termed “Tier 3” sites in the North American Carbon Program, are intended to tie the spatially extensive, but coarsely resolved, measurements made through remote sensing and forest inventory to the spatially intensive and highly resolved measurements made at AmeriFlux sites. To more fully develop the potential of connecting intensive and extensive monitoring, and increase our ability to develop accurate terrestrial carbon budgets for various forest management and disturbance scenarios, we propose to expand upon this effort by extending our ground-based measurements across additional levels of forest management intensity, by adding Lidar measurements, by developing ecosystem process models at two distinct scales, and by linking landscape monitoring to carbon management at a scale relevant to land managers. The main products of this research include precise statistical estimates and maps of carbon stocks and productivity for a variety of forest
landscape conditions; improved process models at ecoregion and stand scales; and decision-support tools for land managers interested in carbon management.

Key Publications:


INFLUENCES OF TIMING OF FERTILIZATION IN CONJUNCTION WITH MID-ROTATIONAL THINNING ON NUTRIENT AND CARBON DYNAMICS OF LOBLOLLY PINE PLANTATIONS IN LOUISIANA

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Scope and Objectives:  Stand conditions that optimize mid-rotation loblolly pine fertilizer uptake efficiency, soil C and nutrient dynamics that underlie crop tree nutrient uptake, and growth responses to fertilization and thinning will be studied. Objectives are 1) determine how stand conditions associated with three mid-rotation thinning-fertilization options will affect loblolly pine fertilizer accumulation efficiency, understory vegetation nutrient sequestration, soil nutrient cycling; and 2) determine the effects of understory vegetation suppression treatments applied in conjunction with three mid-rotation thinning-fertilization options on loblolly pine fertilizer accumulation efficiency, understory vegetation nutrient sequestration, soil nutrient cycling, and soil microbial biomass and activity across a gradient of soil conditions in Louisiana.

Timetable and Funding Sources:  2003-2006, Agenda 2020

Project Description:  Forests of the southeastern U.S. are among the world’s most productive, and increased usage of fertilizer has contributed to this productivity. In the 1990s, the area of fertilized forests in the region increased 184%. Despite the productivity increases often yielded by fertilization of southern pine forests, crop tree uptake efficiencies in response to nitrogen additions are often relatively low; only ~10% of applied nitrogen is readily sequestered by crop trees. Errant fertilizer-derived nutrients reduce investment returns, increases potential nitrate leaching into groundwater, and constitute lost fossil fuel energy used in fertilizer manufacturing. Interactions between pine, understory vegetation, and microbial responses to vegetation removals and nutrient additions could influence fertilizer use efficiency. Four study sites were established in mid-rotation loblolly pine stands across a gradient of soil drainage classes in Louisiana with the following treatments: 1) untreated control; 2) fertilizer (NP) applied 6 months pre-thinning, 6 months after thinning, or 1.5 years after thinning; and 3) fertilizer + vegetation control (NPVC) (a) at the same rates and timing as NP treatment or (b) applied as needed to reduce woody and herbaceous vegetation. Loblolly pine N accumulation efficiency is being characterized by measuring variables that account for nutrient supply (soil N, retranslocated N, fertilizer N) and demand (aboveground biomass N content).
CARBON AND WATER FLUX IN EASTERN FORESTS: DATA COLLECTION, MODEL DEVELOPMENT, AND APPLICATION OF SPATIALLY EXPLICIT MODELS

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Scope and Objectives: This work will help us quantitatively identify the impacts of human action on forest growth, water yield, and water quality in the eastern United States. Our overall goal is to better quantify how carbon and water are captured, stored, and leave forest and agricultural ecosystems, and how natural environmental variation and human-caused changes in land use affect carbon and water cycling. The primary objectives are to measure and model carbon and related water cycles in natural and human-modified ecosystems.


Project Description: Humans impact water and carbon cycles in important forest ecosystems. Land use change and human manipulations of forest ecosystems, and how these actions and natural climatic variability affect forest growth, respiration, photosynthesis, and water use need to be quantified and measured in the field. We propose to develop spatially-explicit measurements for important environmental parameters. We will perform a series of studies to characterize the accuracy and efficiency of portable field systems in collecting point, line, and area data, and associated attribute information. We also propose to measure forest carbon and water flux through a series of component and whole-ecosystem measurements.

Key Publications:


Principal Investigator(s), Institution(s), Primary Contact Information:
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Scope and Objectives: Objectives are to 1) reduce the cost of harvesting, handling, storing and transporting biomass increasing the competitiveness of biomass as a feedstock for biofuels, biomaterials and biochemicals; 2) expand the scientific knowledge leading to significant economic improvements in biofuel production processes; and 3) develop, evaluate and optimize integrated processes to convert biomass resources into biomaterials with commercial applications. A database will be assembled to evaluate the potential of using agricultural wastes to produce biomass crops, and develop a model of an energy farm that would include animal production, manure treatment to mineralize organic nutrients (i.e., anaerobic digestion), utilization of plant nutrients to produce biomass energy crops, and dewatering and drying of indigestible solids for biomass energy recovery.

Timetable and Funding Sources: AGENCY: CSREES SC.
PROJ TYPE: HATCH PROJ STATUS: NEW MULTISTATE PROJ NO: S-1007
START: 01 OCT 2002 TERM: 30 SEPT 2007 FY: 2004

Project Description: Recent work at Clemson University indicates that using the plant nutrients in animal manure for Loblolly pine plantations in South Carolina increased biomass production per acre by 31% on the average assuming a constant number of trees per acre. If similar results could be obtained for tree or grass biomass energy crops then the energy production per acre that can be produced on a farm could be increased by a factor of 10 using anaerobic digestion to generate biogas. Using the plant nutrients in the effluent from the anaerobic digester to grow terrestrial biomass would require about 280 acres of biomass crops fertilized at 120 lb PAN/ac. The annual net energy production would be on the order of 44,744 Mbtu/year (43.83 Mbtu/AU-yr) or 6.8 times the net energy produced by anaerobic digestion. It is believed that using animal and municipal waste to produce biomass energy feedstock can help reach the Department of Energy goal of obtaining a significant portion (30 to 49%) of the U.S. energy needs from renewable sources. Anaerobic co-digestion of waste paper with algal sludge produced a dramatic increase in methane production rate from less than 200 cm3 CH4/l day (at 2 g VS/l day, 100% algal loading) to over 1600 cm3 CH4/l day (at 5 g VS/l day, 60% paper fraction). A database will be assembled to evaluate the potential of using agricultural wastes to produce biomass crops, and develop a model of an energy farm that would include animal production, manure treatment to mineralize organic nutrients (i.e., anaerobic digestion), utilization of plant nutrients to produce biomass energy crops, and dewatering and drying of indigestible solids for biomass energy recovery. The model will determine the economically and energetically optimum agricultural waste manure handling and treatment system design and utilization options for energy biomass production on swine, dairy, and poultry farms.

Key Publications:
RESTORING SUSTAINABLE FORESTS ON APPALACHIAN MINED LANDS FOR WOOD PRODUCTS, RENEWABLE ENERGY, CARBON SEQUESTRATION, AND OTHER ECOSYSTEM SERVICES

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Scope and Objectives:  Carbon sequestration potential of grassland and reforested grassland will be estimated on three 30- to 40-hectare sites in West Virginia and Virginia. A carbon inventory has already been made for 14 mined and 7 non-mined forests across an age and site quality gradient. The mine soil properties that influenced the amount of carbon sequestered will be determined as part of this project.

Timetable and Funding Sources:  START:  30 SEPT 2002 TERM:  31 JAN 2006, DOE Carbon Sequestration

Project Description:  Carbon sequestration potential of grassland and reforested grassland will be estimated on three 30- to 40-hectare sites owned by MeadWestvaco Corporation and Plum Creek Timber Company in West Virginia, and Pittston Coal Company in Virginia. A GIS-based map of each of the three sites will be developed and used to delineate forest site quality classes. Site quality classes I to V will be mapped based on criteria found to be influencing carbon accumulation. A 3 x 3 factorial experiment with three forest types consisting of mixed native hardwoods, alkaline-tolerant hardwood plantations, and pine plantations, and three levels of forest management intensity will be installed in each of three site quality classes at each location. Carbon accumulation projections for each treatment combination will be made based on estimated improvement in site quality class and site index. Cost-benefit analyses will be done for each management approaches. The stream of benefits and costs over time will consider soil quality, as well as the silvicultural management regime applied to each treatment.
SUSTAINABLE MANAGEMENT OF TREE PLANTATIONS
FOR WOOD AND FIBER PRODUCTION

Principal Investigator(s), Institution(s), Primary Contact Information:
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Virginia Polytechnic Institute and State University, Department of Forestry
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Scope and Objectives: Pine plantations of the southern U. S. contribute most of the commercial timber used in the region, and their value is critical to local and regional economies. A factor that limits our ability to increase plantation yield is our lack of understanding of the site-specific mechanisms and interactions among silvicultural practices. Accordingly, the overall objective of this research is to better understand the principles and properties of forest soil productivity, determine how to increase soil productivity using management practices, and develop methods for restoring soil ecosystems damaged by forestry operations. Specific objectives are to 1) determine forest response to several intensive management scenarios used to establish pine plantations; 2) determine the effects of forest management practices on soil and hydrologic properties; 3) determine the relationships between soil properties and pine growth; and 4) develop forest management guidelines that ensure sustainable forest management.

Timetable and Funding Sources: SUBFILE: CRIS AGENCY: CSREES VA.
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: NEW
START: 01 JAN 2001 TERM: 31 DEC 2005 FY: 2005

Project Description: A long-term field study established in 1981 is being used to test plantation response to treatment. Six mechanical site preparation treatments were applied to 5-acre plots to create a 30-acre plantation. This installation was replicated 12 times in a two-state region. The treatments involved different combinations of residue removal, weed control, and soil tillage. These loblolly pine plantations are now approaching harvest age. We will measure total wood volume and nutrient content of the foliage to determine how treatments influenced tree growth and soil productivity. The strong experimental design, the operational scale, and the age of the study make it unique and important to the forestry community. A second study, begun in 1992, will test the effects of harvesting disturbances on soil and forest productivity. Two 8-acre forest tracts were harvested under wet conditions, and two harvested under dry conditions. Prior to harvest, tree volume was measured at each intersection of a 20 by 20-m grid superimposed across each 8-acre plot. One wet and one dry tract were harrowed and bedded. This factorial treatment design was replicated 3 times. Results from our reforestation research have been incorporated into land reclamation plans used in a multi-state area of the Appalachian region. Carbon sequestration accounting protocols have been developed for mined land. Mined lands are now more productive for forests, more native forests are being restored, and there is greater economic potential on mined land.

Key Publications:

NATIONAL CARBON SEQUESTRATION DATABASE
AND GEOGRAPHICAL INFORMATION SYSTEM (NATCARB)

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Scope and Objectives: The objectives of this project are to 1) expand the database originally designed to assess the geological CO₂ storage potential of five Midwestern states (Indiana, Illinois, Kansas, Kentucky, and Ohio) to include the entire U.S.; 2) link terrestrial/agricultural and geologic sequestration databases through Kansas State University; 3) develop a national Carbon Sequestration Geographic Information and Relational Database Management System covering the U.S. and operating through a portal under the aegis of the National Energy Technology Laboratory website; 4) develop improved online tools to provide real-time display and analysis of CO₂ sequestration data; and 5) enhance the current webpage by making it more user friendly with more advanced query capabilities and more options.

Timetable and Funding Sources: START: 01 OCT 2000 TERM: 30 JUNE 2008, DOE Carbon Sequestration

Project Description: The National Carbon Sequestration Database and Geographical Information System (NATCARB) started as a joint project between the Geological Survey's of Illinois, Indiana, Kansas, Kentucky, and Ohio, with funding from the Department of Energy National Energy Technology Laboratory. Later, the project was expanded to include the seven regional partnerships established by the Department of Energy and a prototype to integrate databases for terrestrial sequestration with databases on geologic sequestration. The purpose of NATCARB is to assess the carbon sequestration potential in the United States and to develop a national Carbon Sequestration Geographic Information and Relational Database Management System covering the entire U.S. When completed, the digital spatial database will allow users to estimate the amount of CO₂ emitted by sources (such as power plants, refineries and other fossil fuel consuming industries) in relation to geologic reservoirs that can provide safe, secure sequestration sites over long periods. NATCARB is organizing and enhancing the critical information about CO₂ sources and developing the technology needed to access, query, model, analyze, display, and distribute natural resource data related to carbon management. Large stationary CO₂ emission sources are identified, located, and characterized. Potential CO₂ sequestration sites, including producing and depleted oil and gas fields, unconventional oil and gas reservoirs, uneconomic coal seams, abandoned subsurface mines, and saline aquifers, will be characterized to determine quality, size, and geologic integrity. All information will be available online through user query and will be provided through a single interface that will access multiple servers in various locations. This is one of the first demonstrations of a large-scale distributed database of natural resources and geological information.
COUPLING THE EFFECTS OF MANAGEMENT AND CLIMATE ON CARBON AND WATER FLUXES IN THE FORESTS OF EASTERN U.S. AND P.R.C.

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Scope and Objectives: To assess the causal relationships between management or disturbance regimes and the environmental controls of biosphere-atmosphere exchange of carbon and water. Our overall objective is to measure and model the coupling effects of forest management and changing climate on CO₂ and H₂O fluxes of the eastern forests of U.S.A. and P.R.C.

Site Location(s): Coastal North Carolina, northwest Ohio, northern Wisconsin, eastern China

Timetable and Funding Sources: 5/1/2003 – 5/30/2006

Remaining Gaps/Opportunities: To expand the study from ecosystem to regional scales by including landscape heterogeneity, management alternatives, and age structure would be key for regional implications.

Project Description: In collaboration with researchers from the Southern Global Climate Change Program of the USDA Forest Service and seven institutions from P.R. China (USCCC: US-China Carbon Consortium), this proposal is developed to understand the roles of managed ecosystems and human influences on global carbon budget within the context of global climate change and carbon management. The primary goal of this study is to assess the causal relationships effects of natural and anthropogenic disturbance on the environmental controls of biosphere-atmosphere exchange of carbon and water. An integrated ecosystem approach, centered on eddy-covariance flux measurements, will be used to directly measure and model (PnET family) the fluxes of CO₂, H₂O, and energy in three managed forests in North Carolina and Ohio. A coordinated effort will be made to share our data collections and publications with three flux measurement sites (10 in the U.S. and 18 in China) through USCCC. The use of numerous sites will allow the comparison of regulatory mechanisms of C and water cycles at different land use practices. Exchanges of scholars and students with Chinese institutions will be of additional benefit for both U.S. scientists and students.
COLLABORATIVE RESEARCH: DDDAS-TMRP: DYNAMIC SENSOR NETWORKS - ENABLING THE MEASUREMENT, MODELING, AND PREDICTION OF BIOPHYSICAL CHANGE IN A LANDSCAPE

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Scope and Objectives: The focus of this project is the dynamic sensor network application involving understanding how biodiversity and carbon storage are influenced by global change. Specifically, this project is designed to learn how the growth, survival, and reproduction of forest trees are influenced by changes in climate, CO2 and disturbance, in the context of these and other variables that can fluctuate rapidly. This goal involves models of how tree growth and resource allocation are influenced by variables that can be understood through adaptive sampling across diverse scales in both time and space. Specific goals are to 1) construct a wireless sensing and networking infrastructure that supports a new paradigm of joint in-network and supervisory measurement, modeling, and prediction; 2) develop the modeling strategy needed to combine system understanding with costs for efficient wireless sensing of the environment; 3) make significant progress in understanding the maintenance of biodiversity and in measuring ecosystem properties; and 4) improve collaboration between computer sciences, engineering, statisticians and environmental scientists.

Timetable and Funding Sources: NSF. START: 15 JAN 2006; TERM: 31 DEC 2006

Project Description: The next generation of wireless sensor networks will be dynamic systems with the potential to revolutionize understanding of environmental change, provided they can assimilate large amounts of heterogeneous data in real time, rapidly assess (optimize) the relative value and costs of new data collection, and schedule subsequent measurements accordingly. Thus, they are Dynamic Data Driven Application Systems that integrate sensing with modeling in an adaptive framework. Keen interest in broad application of wireless sensing of the environment, as in NEON and CLEANER, awaits DDDAS technology that can estimate the value of future data in terms of its contribution to understanding against the costs of deployment, acquisition, transmission, and storage. This balance is especially important for environmental data, because networks will typically be deployed in remote locations without access to infrastructure (e.g., power), and sampling intervals will range from meters and seconds to landscapes and years, depending on the process, the current state of the system, the uncertainty about that state, and the perceived potential for rapid change. Network control must be dynamic and driven by models capable of learning about both the environment and the network. The focus of this project is the dynamic sensor network application involving understanding how biodiversity and carbon storage are influenced by global change. Specifically, this project is designed to learn how the growth, survival, and reproduction of forest trees are influenced by changes in climate, CO2 and disturbance, in the context of these and other variables that can fluctuate rapidly. This goal involves models of how tree growth and resource allocation are influenced by variables that can be understood through adaptive sampling across diverse scales in both time and space. The project will enable a general framework for dynamic data-driven wireless network control that combines environmental modeling and sensor network modeling both in and out of the network. Out of the network, environmental modeling entails full assimilation of all information, with exploitation of computing resources available there.
SHORT ROTATION WOODY CROPS COOPERATIVE RESEARCH
PROGRAM, EXPERIMENT A: FUNDAMENTAL CONTROLS OF GROWTH
AND PRODUCTIVITY

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Scope and Objectives: Our goal is to determine how belowground responses in planted
cottonwood, sycamore, sweetgum, or loblolly pine change with fertilization and irrigation and
with stand development.

Site Location(s): Savannah River Site, New Ellenton, SC

Timetable and Funding Sources: In 6th growing season expect to complete rotation.
Funding from DOE Savannah River and the US Forest Service

Remaining Gaps/Opportunities: Eddy flux, soil microbes, canopy physiology, partitioning
heterotrophic and autotrophic respiration

Project Description: We’re monitoring growth and yield on 95 half-acre plots planted with
cottonwood, sycamore, sweetgum or loblolly pine. Treatments include fertilization and irrigation
in a 2 x 2 factorial as well as unreplicated plots that receive a range of annual fertilizer inputs.
Our focus is on belowground responses including fine root turnover and coarse root biomass.
We’re assembling a belowground carbon budget that includes soil respiration, fine root turnover
and soil carbon pools.
MODELING SELECTED SOIL PROCESSES IN FORESTED SOILS OF FLORIDA

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Scope and Objectives: This project investigates the amount and stability of soil organic carbon in sandy soils. Objectives are to 1) use soil characteristics, soil processes and models of processes to develop and apply soil quality indicators in order to index changes in forest ecosystems due to disturbance as well as the need for forest management practices such as fertilization; 2) investigate and model aspects of soil C cycling in forest ecosystems in order to understand its control on nutrient bioavailability, as well as the potential for C sequestration in these landscapes; and 3) continue developing the SSAND model to meet the above objectives.

Timetable and Funding Sources: AGENCY: CSREES FLA PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: NEW START: 01 OCT 2004 TERM: 30 SEPT 2009

Project Description: This project investigates the amount and stability of soil organic carbon in sandy soils and develops soil nutrient bioavailability indices. Models of soil processes are useful in 1) evaluating soil fertility, 2) optimizing fertilization practices, 3) understanding soil-root interactions and 4) developing and employing soil quality indicators. This project’s first approach is to continue development of the SSAND model and use the output as soil quality indicators for nutrient bioavailability. This provides a mechanistic approach to synthesize a wide range of soil information into a single indicator. It should be useful in evaluating soil degradation, both its presence and degree. The second approach is to investigate soil carbon in forest soils in order to better understand its control on nutrient bioavailability, and better estimate or predict carbon sequestration in soils. The proposal intends to use existing studies to better understand how carbon is stored and protected in the sandy soils of the coastal plain, as well as in tropical soils. Soil carbon investigations assist in not only indexing soil degradation, but soil carbon also has its own economic value.

Key Publications:


FLOODPLAIN FORESTS AND WATER QUALITY:  
INFLUENCE OF ECOSYSTEM TYPE AND BIOGEOCHEMISTRY

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Scope and Objectives:  
1) Determine the degree of nutrient exchange between the floodplain and the floodwater column of a riverine ecosystem in coastal South Carolina.  
2) Determine the amount of P retention associated with sedimentation in this system.  
3) Determine the capacity of the vegetation to assimilate waterborne N and P inputs.  
4) Establish the relative magnitude of nutrient loading that can be filtered by this system.  
5) Determine the relative fates of waterborne nutrients which enter this riverine forest.

Timetable and Funding Sources:  
SUBFILE: CRIS  
AGENCY: CSREES SC.Z  
PROJ TYPE: MCINTIRE-STENNIS  
PROJ STATUS: TERMINATED  
START: 01 JUL 2001  
TERM: 30 JUN 2004  
FY: 2004

Project Description:  
Three transects will be established on Bull Island (Waccamaw/Pee Dee River watershed) running roughly east-west. Sediment detention, organic carbon export, and biogeochemical balance in sheetflow across the island will be measured during individual flood events. Total tree biomass (stem, branch, and bark) for each year will be estimated from dbh using general allometric equations.

Key Publications:  

COLLABORATIVE RESEARCH: CONTROLS ON THE ISOTOPIC COMPOSITION OF FIXED CO₂ AND ECOSYSTEM-RESPired CO₂ IN SOUTHEASTERN PINE FORESTS

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Scope and Objectives: The study will look at how climate variability affects the 13C/12C ratio of the CO₂ that plants absorb and release during their respiration in southern pine forests. The result may yield a significant recalculation of how important land plants are as a “sink” for human-produced CO₂. The study will look at carbon isotope composition in leaf waxes and respired CO₂. This will be used to improve estimates of the distribution and magnitude of the terrestrial carbon sink, a step in further understanding the importance of land plants as absorbers of CO₂ produced by humans.

Timetable and Funding Sources: NSF Ecosystem Studies. START: 01 APR 2004; 01 SEPT 2005; TERM: 31 MARCH 2007 (Estimated)

Project Description: Ever since scientists linked human production of carbon dioxide with global warming, they have sought to quantify how much impact humans have had on climate. Half the CO₂ produced by humans—mainly from the burning of fossil fuels—remains in the atmosphere. The other “missing half” is either adsorbed by the oceans or taken up by terrestrial plants during photosynthesis. Knowing how much goes where is a crucial link in understanding how human activity affects global climate and the global carbon cycle. A useful marker to trace the destination of CO₂ is the ratio of 13C to 12C in CO₂ in the air. Land plants preferentially take up 12C, enriching the air in 13C. The oceans don’t discriminate when they take up CO₂. By measuring the ratio of 13C to 12C, scientists can tell whether the CO₂ is going into land plants or into the ocean. But there is variation in how much 13C to 12C land plants take up, so the models that predict where human-produced CO₂ winds up can have significant error. To limit the error, and develop better estimates of the fate of CO₂, a new study will be conducted to examine southern pine forests, one of the largest carbon sinks in North America. The study will look at how climate variability affects the 13C/12C ratio of the CO₂ that plants absorb and release during their respiration. The result may yield a significant recalculation of how important land plants are as a “sink” for human-produced CO₂. The study will look at carbon isotope composition in leaf waxes and respired CO₂. This will be used to improve estimates of the distribution and magnitude of the terrestrial carbon sink, a step in further understanding the importance of land plants as absorbers of CO₂ produced by humans.
EFFECTS OF WHOLE-TREE HARVESTING AND SITE PREPARATION ON PRODUCTION OF LOBLOLLY PINE PLANTATIONS

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Timetable and Funding Sources: SUBFILE: CRIS AGENCY: CSREES LA.B
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: TERMINATED
START: 01 JAN 1999 TERM: 31 DEC 2004 FY: 2005

Scope and Objectives: Project objectives are 1) determine the impact of whole-tree intensive harvesting on the production of loblolly pine plantations, 2) compare the effect of various site preparation treatments on the productions of loblolly plantations established on intensively harvested sites, and 3) monitor changes in biomass, nutrients, and selected chemical and physical properties of the soil following various harvesting and site preparation treatments.

Project Description: The objectives of this research will be accomplished through periodic measurements of tree size and soil properties on four newly established plantations subjected to two types of harvesting and a variety of site preparation techniques that vary by installation. Changes in stem and crown dimensions will be measured annually for the next 5 years. The quantity and size of competing woody vegetation will also be measured. Once during the duration of the project, average nutrient content of the competing vegetation and soil to a depth of 1.5m will be measured to ascertain temporal changes in site resource availability as a result of different harvesting and site preparation practices.

Key Publications:


THE AMERIFLUX NETWORK

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**Scope and Objectives:** The AmeriFlux network, established in 1996, includes more than 120 independently funded sites operating across North, Central, and South America. AmeriFlux sites include tundra, grassland, agricultural crops, tropical forests, and temperate coniferous and deciduous forests. AmeriFlux sites have provided a sustained set of detailed observations of ecosystem-level exchanges of CO₂, water, energy and momentum on an hourly basis, spanning diurnal, synoptic, seasonal, and interannual time scales. Contributions to carbon cycle science include understanding variation in net carbon uptake with inter-annual variation in climate, and the influence of disturbance on carbon storage and fluxes. Objectives are to 1) quantify spatial and temporal variation in carbon storage in plants and soils, and exchanges of carbon, water and energy in major vegetation types across a range of disturbance histories and climatic conditions in the Americas; 2) advance understanding of processes regulating carbon assimilation, respiration, and storage, and linkages between carbon, water, energy, and nitrogen through measurements and modeling; and 3) produce high quality data for site-level analyses, synthesis activities, and the data archive.

**Timetable and Funding Sources:** Ongoing, funded through the Department of Energy and competitive grants

**Project Description:** The goal of AmeriFlux is to develop a coordinated research network of long-term flux sites in the Americas for quantifying and understanding the role of the terrestrial biosphere in global climate change. Specifically, we aim to provide reliable estimates of carbon storage, carbon dioxide and water vapor exchange, and improve our description and understanding of variation, and its causes at relevant temporal and spatial scales. We expect to provide the quantitative information to adequately predict large-scale long-term responses to changing environmental conditions. This will be accomplished using micrometeorological and biological measurements at the intensive flux sites coupled with extensive measurements (e.g., surveys and remote sensing) and modeling. AmeriFlux has a pivotal role in development, testing, and application of ecosystem, atmospheric, and weather models. The network can conduct in situ experiments, gradient studies, and comparative studies to improve understanding of plant and microbial processes contributing to fluxes, and the effects of vegetation type, climate, and disturbance on pools and fluxes. Major products include 1) quantification of regional NEP and carbon storage; 2) Elucidation of controls on NEP and carbon storage; 3) development of a database of meteorological, biological, site history, remote sensing products, and model outputs; and 4) web-based and on-site training in micrometeorological and biological measurements.
RESPONSE OF SOUTHERN PINE WOOD TO ELEVATED CO₂

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Scope and Objectives: This project has two objectives: 1) to determine anatomical changes in cell wall thickness, growth ring thickness, and fiber length of Pinus palustris grown under ambient vs. twice ambient CO₂ concentrations, and 2) to examine anatomical changes in wood of three genotypes of Pinus elliottii grown under different CO₂ concentrations and two different N-fertilization regimes.

Timetable and Funding Sources: HATCH PROJ STATUS: NEW
START: 01 OCT 2004 TERM: 30 SEPT 2007

Project Description: Wood disks from pines growing under appropriate CO₂ and nitrogen regimes have been collected and preserved. Sections and macerations will be made from each disk, and appropriate cell measurements will be taken. The data will be used to characterize the response of wood to changing climate.
REMOTE SENSING OF FOREST RESOURCES

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Scope and Objectives: This study examines uses of remote sensing in forest inventory and management. Objectives are to 1) investigate uses of satellite remote sensing to identify, characterize, and monitor changes in forest resource distributions at regional and continental scales; 2) develop and test uses of high-resolution aerial imagery and LiDAR, either separately or in combination, for detailed forest resource assessments at local to regional scales; 3) design and evaluate methods of stand visualization that incorporate inputs from spatial technologies for support of management decisions.

Timetable and Funding Sources: AGENCY: CSREES MISZ
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: NEW
START: 01 JAN 2003 TERM: 31 DEC 2007 FY: 2004

Project Description: This study examines uses of remote sensing in forest inventory and management. For Objective 1, historic and current Landsat satellite data dating to 1972 will be acquired for approximate 5-year intervals and processed to determine forest type and age classes. These results will be assessed with respect to their utility in guiding regional inventories through stratification for field plot allocations. Objective 2 will be accomplished by developing techniques to compile stand-level inventories based on LiDAR-derived individual-tree and plot-level measurements and comparing these against current field methods. Through collaborations, economic factors will be examined for commercial potential of LiDAR in the forestry sector. Objective 3 will examine the accuracy and efficiency of portrayal of stand information derived from LiDAR and viewed in a virtual environment at the MSU Engineering Research Center. Landsat TM (Thematic Mapper) satellite data have been used to map forest cover for the entire state of Mississippi in support of a statewide inventory program. Research is being conducted on use of historic satellite data to determine the changes in spatial distributions of forests and their approximate ages. Satellite data are also being used to develop a south-wide forest fire susceptibility model and to model above-ground carbon in pine stands.

Key Publications:
MAINTAINING AND ENHANCING FOREST SOIL PRODUCTIVITY 
IN THE MID-SOUTH

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Scope and Objectives: The proposed research project will examine the effects of forest management on forest soil productivity and ecosystem function in forests of the mid-south region. Some specific objectives of the research include 1) evaluating chicken litter as a soil amendment to enhance productivity of loblolly pine plantations; 2) improving early survival and growth of pine seedlings on coarse textured, droughty soils through soil management techniques; and 3) evaluating soil organic carbon sequestration in restored bottomland forests.

Timetable and Funding Sources: SUBFILE: CRIS  AGENCY: CSREES TEXY 
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: TERMINATED
START: 01 FEB 1998 TERM: 30 JAN 2004 FY: 2004

Project Description: Both stand-alone and cooperative research projects will be established to address the objectives of this work. The chicken litter amendment project will evaluate applications of chicken litter waste on recently thinned pine plantations. Growth response of crop trees to the chicken litter application will be compared to that of commercial fertilizer applications. The pine seedling survival and growth study will involve the use of various soil management techniques to maintain soil moisture availability, such as mulching and plowing techniques. The soil organic carbon sequestration study will use new and established hardwood restoration plantings to evaluate changes in soil organic carbon content.

Key Publications:
INTERACTIONS OF ARKANSAS FOREST VEGETATION WITH SOILS RELATIVE TO FOREST PRODUCTIVITY AND VALUE

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Scope and Objectives: This research will address questions relative to sustainable forest productivity as a function of soil physical and chemical properties. This project will measure soil and plant carbon/chemistry changes under different forest management regimes with greenhouse and field trials. This project will supply information on changes in forest-sequestered carbon to policy makers and landowners to achieve equitable carbon management legislation.

Timetable and Funding Sources: AGENCY: CSREES ARK PROJ TYPE: MCINTIRE-STENNIS; PROJ STATUS: NEW START: 01 JAN 2003 TERM: 30 SEPT 2007 FY: 2005

Project Description: Accurate quantification of soil organic carbon pools is confounded by spatial and temporal variability of carbon. Policies regarding carbon emissions and sequestration cannot be equitably applied without accurate carbon accounting. A new component of forest resource sustainability is the valuation of carbon sequestration. One of the specific objectives of this research is to integrate current and future research on carbon sequestration in forest soils with proposed carbon valuation and free-market trading of carbon emission/ sequestration permits. The emphasis of this research is on the accurate accounting of forest carbon storage, since equitable policies for carbon trading will require the best estimates of carbon emissions and storage. Both greenhouse and field experiments will be implemented to address the objectives of this research. Influences of fertilizer amendments, forest management practices, and timber species on soil chemical and physical properties will be measured according to standardized soil and plant analysis techniques. The results from this research will be used to assess potential changes in forest productivity resulting from changes in soil properties.

Key Publications:
ENVIRONMENTAL PHYSIOLOGY OF TENNESSEE TREE SPECIES

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Scope and Objectives: The effects of elevated temperature and of soil chemical and physical properties on the growth and physiology of tree species native to Tennessee are being studied. The objectives of this research program are to 1) identify environmental and physiological factors having the greatest effects on the survival and growth of tree species native to Tennessee, 2) modify silvicultural treatments to promote the growth of economically important tree species, and 3) predict the effects of elevated temperatures and other environmental changes to Tennessee forests through an understanding of tree physiological mechanisms.


Project Description: The approach will integrate field and laboratory studies. To meet the above objectives several studies will be undertaken.
1) Growth and physiology of native tree species on disturbed soils. Selected native tree species will be grown on mine tailings in the laboratory, and seedlings planted on mine sites, clearcuts and partial harvests to determine how soil properties affect growth and physiology.
2) Differential effects of soil nitrogen manipulation on the growth of native tree species. The effects of nitrogen level on the growth of native tree seedlings will be tested in solution culture in the laboratory. Additions of sugar and sawdust will be applied to field plots to manipulate soil nitrogen in the field, and the effects of these treatments on the growth and physiology of economically important tree species such as oak and their competitors will be measured. Silvicultural treatments will be tested based on the results of the above experiments.
3) Effects of temperature on the carbon budget of red spruce seedlings. Seedlings will be grown in chambers at current average, and elevated temperatures. Biomass accumulation, photosynthetic rate, and respiratory temperature acclimation will be measured.
FOREST SOIL CARBON DYNAMICS IN THE SOUTHERN APPALACHIAN MOUNTAINS

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Scope and Objectives: The goal of this research is to further the understanding of forest soil C and N dynamics in a changing climate, particularly the dynamics of labile soil C stocks in mountainous terrain. The research objectives are directed at supplying answers to the following questions that are relevant to DOE’s Terrestrial Carbon Processes Program. 1) How do forest soil C and N stocks vary along elevation gradients in the southern Appalachian Mountains? 2) How do different environmental factors (e.g., soil temperature and litter chemistry) affect C apportionment among different soil pools? 3) What is the effect of C apportionment on soil C dynamics (i.e., soil C turnover times)? 4) How do changes in temperature and litter chemistry interact to influence measured and predicted soil C stocks?

Project Description: Quantification of soil C stocks in mountainous areas was identified as a knowledge gap in the North American Carbon Program (NACP). In order to predict future forest soil C stocks, we must understand how different environmental factors (temperature, N availability, litter chemistry) affect input and output processes that control amounts of forest soil organic matter (SOM). This study provides empirical data, for use in mathematical models, on amounts of forest soil C in mountainous terrain and factors affecting forest soil C dynamics. The approach involves studies of amounts and forms of soil C and N at multiple forest sites along an elevation gradient, the use of $^{15}$N- and $^{13}$C-enriched isotopes as tracers, measurements of N and C isotopes at natural abundance levels, and modeling. Environmental changes along elevation gradients in the southern Appalachians include varying regimes of temperature and precipitation, N availability, and litter chemistry. Although it is widely recognized that many environmental factors vary with elevation, the use of altitudinal gradients as a resource in climate change research has not received much attention. One primary benefit of this approach is that elevation gradients reflect numerous interacting abiotic and biotic factors and, importantly, the long-term effect of climate and ecosystem processes on soil C storage. Field studies began in 1995. Past work has utilized stable C isotope techniques to ascertain differences in SOM decomposition rates and their relationship to N availability. Overall, measurements of amounts and forms of soil C have been made at ten forest sites. The data have been used in models of soil C dynamics to predict changes in labile and mineral-associated organic matter as a consequence of regional climate change.
COMPETITIVENESS OF MISSISSIPPI'S FOREST RESOURCES IN THE GLOBAL MARKETPLACE

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Scope and Objectives: This research has three objectives: 1) to identify and document competitive strengths and weaknesses of domestic and international forest resource sectors and activities; 2) to evaluate existing federal and state policies and technologies that impact production, costs, physical stocks, and efficiency of domestic and international forest resource sectors and activities; and 3) to compare and assess alternative federal and state policy mechanisms, resource stocks, and technologies that have the potential for enhancing the competitiveness of domestic and international forest resource sectors and activities. The impacts of silvicultural operations on terrestrial carbon sequestration will also be investigated.

Timetable and Funding Sources: AGENCY: CSREES MISZ
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: EXTENDED

Project Description: Increasing competitiveness of the global marketplace dictates that the competitive strengths and weaknesses be documented for the forest sector in Mississippi and the southern United States. Comparisons and assessments of existing and alternative policies will be essential in maintaining the competitive edge of the forest sector in Mississippi and the southern United States. The research approach will involve identifying and documenting costs and revenues pertinent to the forest sector. In addition, the approach will involve applied analysis of forest economics by using data from hardwood growth and yield, regeneration survival, IKONOS, primary, and secondary sources. Other components include 1) impacts of different remote sensing technologies on harvest and forest management scheduling, 2) the importance of roadway regulations on log hauling between southern states, 3) costs and benefits of the small city urban forest to develop a predictive model, 4) the commercial viability for airborne sensing of southern pine beetle damage 5) the supply and demand of bio-oil production in Mississippi, and 6) use of timber production information for engineered wood products.

Key Publications:
EFFECTS OF LOBLOLLY PINE PLANTATION RE-ESTABLISHMENT ON NITROGEN AND PHOSPHORUS POOLS: AN APPROACH TO QUANTIFYING SUSTAINABILITY

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Scope and Objectives: Forest industry and many other private forest owners practice intensive forestry. A major question of this practice is whether it is sustainable over many rotations. This project quantifies the C, N, and P pools in two loblolly pine plantations for both the first and second rotations with a gradient of site preparation intensity. Objectives of the work are 1) to evaluate changes in site C and N pools resulting from a gradient in plantation establishment intensity and 2) to determine if observed differences in plantation growth are related to differences in C and/or N pools.

Timetable and Funding Sources: SUBFILE: CRIS  AGENCY: CSREES SC.Z
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: NEW
START: 01 JUL 2003 TERM: 30 JUN 2005 FY: 2005

Project Description: This project quantifies the N and P pools that determine site productivity in the South Carolina Coastal Plain. The sustainability of these pools is essential to maintaining the fertility of the site. The unique characteristic of this study is its long-term scope: the quantification of the C, N, and P pools covered two forestry rotations on the same site over a span of 18 years. The results of this study will enable forest managers to minimize the loss of these determinants of productivity when deciding among management options and possibly avoid fertilizing similar stands to replace lost nutrients. This study is also quantifying the C pools in the two intensively managed loblolly pine plantations, which will contribute to our knowledge of carbon sequestration as a partial solution to global warming.
ENRICHED BACKGROUND ISOTOPE STUDY

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Scope and Objectives: A unique, large release of radiocarbon occurred near the Oak Ridge Reservation (ORR), Oak Ridge, TN in July/August 1999. Measurements of $^{14}$C in tree ring cellulose throughout the ORR area demonstrate that the 1999 release was unprecedented in its uptake by vegetation. We are taking advantage of the whole-ecosystem isotopic label generated by this release to address five outstanding issues in the terrestrial carbon cycle: 1) partitioning of soil respiration between autotrophic and heterotrophic sources, and quantification of that partitioning seasonally and inter-annually; 2) partitioning of heterotrophic respiration sources between aboveground litter decomposition and belowground root detritus decomposition; 3) identification of pathways leading from leaf and root detritus to long-term stabilization of soil organic matter, including the role of soil fauna; 4) the role of dissolved organic carbon (DOC) transport in distributing carbon within the soil profile; and 5) the longevity and turnover time of fine roots.

Project Description: The first four issues are being addressed through a reciprocal litter transplant experiment set up at four sites on the ORR encompassing two soil types and two levels of $^{14}$C exposure in 1999. The fifth issue, longevity and turnover of fine roots, is being addressed by tracing the radiocarbon label through the fine root pool over time. With a combination of incubation, soil surface chamber and soil CO$_2$ profiles, and continuous measurements of soil temperature and moisture controls, we are tracking changes in soil respiration partitioning over several years. The nature and source of organic matter pools that reside in soils for years to decades are being tracked with differently labeled root and surface litter, and experiments to exclude soil fauna have been initiated to elucidate their role in vertical transport. Periodic sampling of soils and soil solutions and the use of inert tracers, allow us to investigate the chemical nature and form of DOC and its transport in surface soil horizons. Results from these field observations will be used to parameterize and refine existing carbon dynamics models. Such models will then be used to quantitatively address the long-term fate of ecosystem carbon inputs and the potential for ecosystem carbon sequestration.
THE IMPACT OF CO₂ FERTILIZATION ON SOIL CARBON STORAGE
BELOW A FOREST

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Scope and Objectives: The aim of this research is to determine the amount of carbon transferred from the atmosphere to the soil because of CO₂ fertilization. Objectives are to 1) measure the difference in mineral-bound soil carbon accumulation rates between forests exposed to current ambient atmospheric carbon dioxide levels and forests exposed to elevated carbon dioxide levels; 2) determine the quantitative significance of the differences in soil carbon accumulation rates between the elevated and ambient rings; 3) measure changes in soil nitrogen inventories; 4) see if nitrogen availability influences the CO₂ fertilization response; and 5) determine the soil carbon CO₂ fertilization factor using radiocarbon, d13C, and carbon inventory measurements.


Project Description: Knowing how much additional carbon is stored in soil because of CO₂ fertilization will lead to more accurate predictions of future CO₂ levels and global warming. To see if CO₂ enrichment increases soil carbon storage, I have collected a set of unique samples and developed a method for determining the soil carbon CO₂ fertilization factor using radiocarbon, d13C, and carbon inventory measurements. The soil carbon CO₂ fertilization factor is the fractional change in soil carbon input divided by the fractional change in carbon dioxide level. It is my hope that the techniques used for this research will be applied to other CO₂ fertilization experiments and used to evaluate how much carbon might be sequestered in soil by re-vegetating abandoned agricultural land. If a type of vegetation had an unusually high soil carbon CO₂ fertilization factor, plantations of this species could be established on abandoned cultivated land to further slow the build-up of atmospheric carbon dioxide levels. Soil carbon and radiocarbon measurements will be used to determine the turnover time and inventory of soil carbon for a Free-Air CO₂ Enrichment (FACE) experiment. These measurements will be used to derive the soil carbon CO₂ fertilization factor to calculate the increase in carbon storage for this closed-canopy ecosystem using the contemporary increase in atmospheric CO₂.

Key Publications:


Harrison, K.G. 2004. The soil carbon CO₂ fertilization factor: The measure of an ecosystem’s capacity to increase soil carbon storage in response to elevated CO₂ levels. G-Cubed (Geochemistry, Geophysics, Geosystems) 5, Q05002, doi:10.1029/2003GC000686.
SOUTHERN APPALACHIAN FORESTS: BELOW GROUND PROCESSES IN A DIVERSE AND CHANGING LANDSCAPE

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Scope and Objectives: The goal of this project is to better understand the below ground impact of both past and probable future disturbance agents in southern Appalachian forests. In attempt to better understand the below ground impact of both past and probable future disturbance agents, this project will focus on two core areas: 1) simulating the belowground effects of Hemlock wooly adelgid outbreaks; and 2) the effect of land use histories and climate gradients on below ground productivity.

Timetable and Funding Sources: SUBFILE: CRIS  AGENCY: CSREES GEOZ
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: NEW
START: 30 AUG 2004 TERM: 31 JUL 2009

Project Description: Southern Appalachian forests have been subject to a variety of human and non-human disturbances. Although these forests are floristically diverse, these disturbances have significantly altered forest composition and structure, as well as successional patterns. Significant historical agents of change include logging, fire (and its subsequent suppression) and Endothia parasitica (the pathogen responsible for Chestnut blight). Land use histories also have affected southern Appalachian forests, and the potential for climate change to impact forest composition, structure and function must be considered as well. Finally, recent invasive pests and pathogens, especially hemlock wooly adelgid and the fungus responsible for sudden oak death (Phytophthora ramorum), are also likely going to impact southern Appalachian forest composition and ecosystem processes. Although the aboveground effects of at least some of these disturbances have been extensively studied, we know far less about their impact on belowground processes. The Effects of Simulated Hemlock Wooly Adelgid (Adelges tsugae) Damage on Carbon Cycling experiment will consist of three treatments: a) stands with no hemlock, b) stands with 50%+ basal area in live hemlock, and c) stands with 50%+ BA in dead/dying hemlock. The Effect of Land Use Histories and Climate Gradients on Below Ground Productivity studies will be conducted in three landscapes that span a regional climate/elevation gradient: Nancytown, GA (~350 m, 34o30' N), and the Coweeta Basin (~1000 m, N35o03' N), and Mars Hill, NC (~730 m, 35o45' N).
NITROGEN CONTROLS ON BELOWGROUND CARBON ALLOCATION AND FATES AT ECOSYSTEM SCALES

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Scope and Objectives: This study will address nitrogen controls on fine roots in forests since 1) forests have large carbon storage potentials and occupy vast areas, and 2) nitrogen is generally the most limiting nutrient to plant production in forests. The primary objectives of this study are to 1) investigate nitrogen controls on fine root processes such as production, respiration, senescence, and herbivory; and 2) test competing hypotheses regarding nitrogen controls on carbon allocation and plant production.

Timetable and Funding Sources: AGENCY: CSREES GEOR
PROJ TYPE: NRI COMPETITIVE GRANT PROJ STATUS: TERMINATED

Project Description: The manner in which carbon (i.e., energy) allocation is controlled by resource (e.g., water, nutrients, and light) availability is among the most pressing questions facing terrestrial ecosystem ecologists today. Advancements in this area have been hindered primarily by a poor understanding of fine root (i.e., small feeder roots that have relatively short life spans) dynamics. A randomized factorial experimental design that manipulates carbon source to roots (via foliage removal), carbon fates in roots (via nitrogen fertilization), and root herbivory (via insecticide application) will be used to advance a more comprehensive and mechanistic understanding of the patterns and controls of production in forests. We propose a conceptual model, C-FATES (Carbon Fine root Allocation and Transfers at Ecosystem Scales), that illustrates important controls on belowground carbon pools and fluxes. The C-FATES model guides a randomized factorial experimental design that manipulates carbon source to roots (via foliage removal), carbon fates in roots (via nitrogen fertilization), and root herbivory (via insecticide application) that will be used to advance a more comprehensive and mechanistic understanding of the patterns and controls of production in forests. Also, two new techniques that avoid the major limitations of conventional approaches, the minirhizotron video image analysis system and the 15N isotope tracer technique, will be used to assess root dynamics. These investigations may provide insight into the role of fine roots in the structure and function of forest ecosystems which is critical to understanding the ecology.

Key Publications:
INVESTIGATION OF ECOPHYSIOLOGICAL PROCESSES DETERMINING PRODUCTIVITY OF LOBLOLLY PINE

Principal Investigator(s), Institution(s), Primary Contact Information:
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Scope and Objectives: Understanding processes that control forest growth and development is key to increasing productivity and creating sustainable ecosystems. The project seeks to understand and describe the physiological processes that regulate forest productivity 1) in response to moisture and nutrient limitations and 2) among genetic sources and families of loblolly pine.

Timetable and Funding Sources: SUBFILE: CRIS
PROJ NO: OKL02120 AGENCY: CSREES OKL
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: REVISED
START: 01 OCT 2001 TERM: 30 SEPT 2006 FY: 2004

Project Description: Nutrient use efficiency of loblolly pine over a wide range of soil environments, phonological stages, and growth activities will be quantified and the interaction of genotype, site resources (water, nutrients), and stand density of crown processes, biomass allocation patterns, and wood properties determined. The extent to which soil microorganisms immobilize nutrients following fertilization will also be determined. The carbon goals of the project are to understand the physiological processes and mechanisms that regulate tree and forest carbon production and distribution both 1) in response to moisture and nutrient availability and 2) among sources and families of loblolly pine.
WOOD UTILIZATION RESEARCH PROGRAM 2005

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Scope and Objectives: This research will facilitate a better understanding of the industry as it exists today and will provide a framework for future sector development. Objectives are to administer a continuing program of research and technical assistance to improve the utilization and values of southern timber resources, to strengthen existing efforts in timber harvesting and wood utilization, and to support new research initiatives in these areas.

Timetable and Funding Sources: AGENCY: CSREES MISZ
PROJ TYPE: SPECIAL GRANT PROJ STATUS: NEW

Project Description: Economic and utilization research of southern wood resources is directed at improving and extending the use of these resources, adding value and economic return to forest management, developing a better understanding of the contribution of forestry and forest products industries to our economy, improving costs of producing wood products, improving performance of wood in residential housing and furniture construction, and reducing environmental impacts of wood production. Four segments of the industry will be assessed: timberlands, harvesting and transportation, mills, and markets. Another component will assess the potential effects of using forests for carbon sequestration on timber supply.
FOREST INVENTORY AND ANALYSIS USING GIS AND GEOSPATIAL SYSTEMS

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Scope and Objectives: This project examines effectiveness of geospatial technologies such as GIS, geostatistics and remote sensing to conduct forest inventories. The purpose of this study is to learn more about effectiveness of GIS and laser technologies to estimate biomass and carbon in the forest ecosystem. There are three objectives in this project:

1) Development of digital database for forest inventory. These GIS layers include land use/land cover, digital terrain models, soil data, tree heights and diameters, canopy density, forest defragmentation, hydrologic data, and wildlife.
2) Estimation of forest ecosystem parameters, especially stems per hectare, forest biomass and above- and belowground carbon.
3) Development and testing of laser-based model for regular annual update of forest inventory in east Texas region.

Timetable and Funding Sources: CRIS AGENCY: CSREES TEXY
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: NEW
START: 01 APR 2002 TERM: 31 MAR 2007 FY: 2005

Project Description: Forest inventories will be undergoing revolutionary changes. The traditional human labor driven forest inventories will be replaced by highly sophisticated geospatial technologies in the future. FIA plot data consisting of tree heights, diameters, and density will be entered to ArcGIS 8.1 database and georeferenced. In addition, soils, hydrologic and terrain data will be acquired from USDA, STATSGO, USGS, and TNRIS sources. The digital ortho-photo quads and satellite imagery will be classified to generate land use and land cover layers for east Texas region. Ground crews to fill up the gaps between the FIA plots will provide additional measurements. In the second phase, the model of co-regionalization will be constructed using cross-variogram modeling and co-kriging of ground data. This will result in spatial estimation of total biomass, stems, wood, and carbon in the studied area. These estimates will also determine spatial variation and uncertainty of previously mentioned forest parameters. The process will be repeated using a profiling laser. The biomass equation will be developed using laser measurements and compared to estimated values based on ground measurements. The ultimate goal of this process is to determine an optimal way to conduct forest inventories faster and cheaper than before.

Key Publications:

COLLABORATIVE RESEARCH: EFFECTS OF ELEVATED CO$_2$
ON FOREST N CYCLING: ASSESSMENT WITH LARGE-SCALE $^{15}$N
TRACERS AND MODELING

Principal Investigator(s), Institution(s), Primary Contact Information:
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Scope and Objectives: There is a fundamental gap in our understanding of the coupled nature of C and N cycles in forest ecosystems, and an opportunity to expand our knowledge of ecosystem biogeochemistry. This research will have direct benefits to society by addressing a major potential limitation to C sequestration in ecosystems that cover over 24 million hectares of forest land in the southeastern U.S., ecosystems that are likely to be managed for their C-sink potential under the Kyoto Protocol.

Timetable and Funding Sources:
START: 01 MARCH 2003; TERM: 28 FEB 2007 (Estimated)
NSF ECOSYSTEM STUDIES

Project Description: Forest ecosystems exchange large amounts of carbon (C) with the atmosphere each year, an exchange that is strongly constrained by nutrient cycling. Forest productivity is anticipated to increase with the projected doubling in the concentration of atmospheric CO$_2$ over the next century. A critical area for research and synthesis concerns the feedback effects of elevated CO$_2$ on soil N cycling. Elevated CO$_2$ significantly increased plant productivity, the uptake of N from soils, and the flux of C to soil microbes but did not change litter chemistry, decomposition, the mass balance of N among ecosystem pools, gross and net N mineralization, or plant N availability. Even though plant N availability did not increase under elevated CO$_2$, there is no indication that N is progressively limiting the enhanced productivity of this ecosystem now in its sixth growing season under elevated CO$_2$. This result is surprising given that 1) Net Primary Productivity is demonstrably N limited in this ecosystem, 2) there is intense competition for available N among plants, microbes and abiotic sinks in soils, and 3) the long-term productivity of a single prototype Free-Air CO$_2$ Enrichment (FACE) plot at this research site was stimulated by elevated CO$_2$ only after the addition of N fertilizer. These results suggest a fundamental gap in our understanding of the coupled nature of C and N cycles in forest ecosystems, and an opportunity to expand our knowledge of ecosystem biogeochemistry. This research will have direct benefits to society by addressing a major potential limitation to C sequestration in ecosystems that cover over 24 million hectares of forest land in the southeastern U.S., ecosystems that are likely to be managed for their C-sink potential under the Kyoto Protocol. Given the interdisciplinary and multi-institutional nature of the Duke Forest FACE experiment, this research will have impacts that extend well beyond this collaborative team. This grant will train future scientists and recruit and retain women graduate students, and will make an effort to broaden the participation of minorities by actively participating in the SEEDS program (a joint program of ESA and UNCF). This project will enhance infrastructure for research by contributing data sets and an enhanced model to current synthesis activities at NCEAS and an international network of 15 N tracer study sites. We expect the impact of this work to continue to be high, both in advances to fundamental ecosystem science, and in the demonstrable application of ecosystem science to issues of global change, issues that will increasingly impact society over the next century.
UNDERSTAND AND QUANTIFY THE ABOVE- AND BELOWGROUND PROCESSES, THEIR GOVERNING FACTORS, AND THEIR CONTROL OF FOREST PRODUCTIVITY AND SUSTAINABILITY

Principal Investigator(s), Institution(s), Primary Contact Information:
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Scope and Objectives: The integrated approach will be focused in four major areas: above- and belowground processes, soil processes, and modeling and integration. Research will concentrate on managed stands of loblolly pine, longleaf pine, and selected commercially important hardwood species. Among the objectives are 1) determine the effects of temperature, available soil water nutrients on tree and stand growth and physiology, 2) quantify effect of whole-tree CO2 exposure on growth and physiology, 3) determine the environmental effects on fine root and mycorrhizae turnover, 4) determine the impact of fire on root pathogenic fungi dynamics in loblolly and longleaf pine stands, 5) assess feasibility of using soil carbon pool content and dynamics as an indicator of long- and short-term productivity, and 6) develop models predicting loblolly pine growth responses to climate change factors.

Timetable and Funding Sources: PROJ TYPE: USDA INHOUSE

Project Description: The integrated approach will be focused in four major areas: above- and belowground processes, soil processes, and modeling and integration. Research will concentrate on managed stands of loblolly pine, longleaf pine, and selected commercially important hardwood species. Research on aboveground processes will quantify the impact of water and nutrient availability, soil supply characteristics, rhizospheric microorganisms, woody lateral roots, and whole-tree elevated CO2. Research on belowground processes will quantify growth and developmental patterns of root systems. Research will be conducted to determine the impact of physical and chemical changes in soil conditions. Research will focus on developing models linking aboveground, belowground, and soil processes to predict tree and stand carbon allocation and accretion patterns.

Key Publications:


POTENTIAL PROJECT: CARBON AND NUTRIENT ACCUMULATION IN LOBLOLLY PINE PLANTATIONS OVER 75 YEARS ON A SEVERELY ERODED AGRICULTURAL FIELD

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Scope and Objectives: The research would examine the quantity of carbon stored in the soil beneath loblolly pine plantations during 75 years of continuous occupancy. The sites were severely eroded and nutrient depleted abandoned agricultural fields which were planted by the Civilian Conservation Corp. in the late 1930s. The objectives would be to estimate the change in carbon and nutrient stocks, if any, since the loblolly pine plantations were established on these extremely poor sites.

Site Location(s): The Clemson Experimental Forest, Clemson, SC.

Timetable and Funding Sources: No timetable or funding at present.

Remaining Gaps/Opportunities: This is an extremely valuable opportunity because of the long history of land use records and the many other research projects that have been completed on the Clemson Experimental Forest that may add to the findings.

Project Description: Above- and below-ground biomass would be estimated along with forest floor and soil to a depth of about 2 m. Carbon and nutrient stocks at the time of plantation establishment would be estimated as in Van Lear et al. (1995). Above- and below-ground biomass of second-rotation plantations would be estimated. Changes in soil carbon and nutrient stocks would be quantified and discussed.

Key Publications:
(From a similar project)

DEVELOPMENT OF A BIOREFINERY PROCESS FOR ENERGY PRODUCTION, VALUE ADDED PRODUCTS, AND ADVANCED CATALYSTS

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Scope and Objectives: Our research will focus on the development of gasification and pyrolysis processes for the production of a suite of high value products from agricultural and forest products (e.g., peanut hulls), including energy (e.g., H2), synthesis gas, solid based carbon products (e.g., carbon supported catalysts for catalytic oxidation of malodorous compounds and synthesis of fine chemicals, again from biomass derived feedstocks), and specialty chemicals from CO2. Objectives are to 1) develop a fundamental understanding of catalytic pyrolysis and gasification processes; 2) develop value added uses for solid residuals generated in pyrolysis and gasification; and 3) develop novel techniques and methods to interface and couple biological systems with chemical and physical processes.

Timetable and Funding Sources: SUBFILE: CRIS AGENCY: CSREES GEO PROJ TYPE: HATCH; START: 01 FEB 2005 TERM: 31 JAN 2010 FY: 2005

Project Description: Renewable energy derived from non-petroleum based fuels is required to break our nation’s dependence on foreign oil and energy sources. Agricultural residues and dedicated crops are large untapped sources of renewable carbon sources that can be used to develop a new biobased economy. Our research will focus on the development of a biorefinery (i.e., a suite of value-added products) based on gasification and pyrolysis of agricultural and forestry biomass. Project components include 1) feedstock, char, and catalyst characterization; 2) catalytic pyrolysis and gasification; 3) advanced catalytic material from char and ash to develop methods to generate catalyst pellets (3-10 mm) constructed of wood fly ash or magnetite to reduce pressure drop in packed bed reactors; 4) nano-scale dispersion/deposition of metals and metal oxides; 5) catalyst testing; 6) microbial synthesis of metal nanoparticles; and 7) CO2 sequestration and simultaneous synthesis of chemicals.

Key Publications:

LINKING REMOTE SENSING WITH THE ECOLOGY OF FOREST SUCCESSION IN REGIONAL CARBON CYCLE MODELING

Principal Investigator(s), Institution(s), Primary Contact Information:

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Scope and Objectives: The goal of this project is to determine and demonstrate whether individual-based models of forest succession and recovery can be effectively and efficiently linked with space-based remote sensing data. Project objectives are to 1) translate modeled forest succession and regrowth from the scale of individual-based gap dynamics to the 1-km spatial scale of space-based remote sensing data, 2) couple the rescaled individual-based forest succession model with 1-km resolution space-based remote sensing data from the MODIS and AVHRR sensors, and 3) simulate regional forest response to historical changes in land use for the forests of the eastern United States using the forest succession model coupled with remote sensing data.


Project Description: Forest recovery following disturbance transfers carbon from the atmosphere and sequesters it in vegetation and soil. Accordingly, forest growth is a potentially significant factor in mitigating fossil fuel emissions and increases in atmospheric CO2. Understanding and quantifying that potential requires a fundamental understanding of processes of forest recovery following disturbance, an understanding best captured by individual-based “gap” models of forest succession. However, applying these models over large regions requires that they be linked with the spatially extensive data provided by space-based remote sensing. The size- and age-structured (SAS) approximation for the first moments of stochastic ecosystem models will be evaluated, and modified as needed, as methodology for rescaling an existing individual-based forest succession model (LINKAGES v2.2) from the gap-scale to 1-km spatial resolution. Output variables in the rescaled forest succession model, e.g., leaf area index (LAI) and net primary production (NPP), will be linked with appropriate remote sensing products, e.g., MODIS LAI and NPP. The ability of the rescaled model to accurately and efficiently predict space-based (e.g., land cover and net primary production) and ground-based (e.g., net ecosystem carbon exchange) observations in response to the disturbance of land use change is a test of the effectiveness and usefulness of the rescaled model and the linkage with remote sensing data.
ARKANSAS FOREST RESOURCES CENTER:  
A CONTINUING PROGRAM, PHASE IX

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Scope and Objectives: This project deals with emerging forest land management and water quality issues in Arkansas and associated spatial information solutions to these complex problems. A primary objective is to develop spatial tools and databases that will allow forest land managers to better plan for sustainable forest resource use.

Timetable and Funding Sources: AGENCY: CSREES ARK
PROJ TYPE: SPECIAL GRANT PROJ STATUS: TERMINATED
START: 01 SEPT 2002 TERM: 31 AUG 2005

Project Description: Greenhouse studies were conducted to determine the above- and belowground carbon sequestration effects of pine seedlings. The findings are being used to launch a much larger study into total carbon sequestration of the Arkansas forests. Carbon sequestration experiments continue and will produce a quantitative basis for carbon exchange.
THE EFFECTS OF A CARBON CREDIT MARKET ON THE MANAGEMENT AND PROFITABILITY OF PRIVATE FOREST LANDS IN THE UNITED STATES

Principal Investigator(s), Institution(s), Primary Contact Information:
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Scope and Objectives: This project will investigate the potential for storing carbon in forests, determine the optimal financial returns that forest landowners may earn by selling carbon credits and timber products, determine optimal management regimes for maximizing profitability, and determine the cost of carbon sequestration. The goals of this project are to investigate carbon sequestration in forests, calculate costs and revenues, and provide the information needed to establish a carbon credit market between landowners and utility companies and others interested in buying carbon credits.

Timetable and Funding Sources: CRIS AGENCY: CSREES TEXY
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: NEW

Project Description: Carbon dioxide can be removed from the atmosphere and stored efficiently and in great quantities in trees, with benefits to the economy, industry and landowners. This study will measure and determine the effects of various forest management activities on the regional carbon balance. In addition, the effects of carbon trading and forest management on the financially optimal management regime and the profitability of forest management will be investigated. Optimal forest management for major commercial tree species will be determined for the option of managing for timber production only, managing for carbon sequestration only, or managing for both timber production and carbon sequestration. Specific objectives are to 1) quantify and maximize the total carbon stored in the trees and other components of the forest, and determine the effects of forest management practices on carbon storage and carbon budgeting, for each of the major commercial tree species, by region; 2) conduct discounted cash flow analyses and calculate soil expectation values to predict the cost of carbon sequestration using optimal forest management methods for each major tree species and forest ecosystem, by region of the United States; and 3) determine the profitability of managing forests for timber production only, for carbon sequestration only, and for the combination of timber production plus carbon sequestration, for each major tree species and forest ecosystem, by region of the United States. The project area considered in this study will include the nine regions of the United States: Southeast, South-Central, Northeast, Mid-Atlantic, Lake States, Central States, Northern Rockies, Southern Rockies, and Pacific Coast.

Key Publications:

ENHANCEMENT OF TERRESTRIAL CARBON SINKS THROUGH OPTIMAL FOREST MANAGEMENT

Principal Investigator(s), Institution(s), Primary Contact Information
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Scope and Objectives: This project will determine the optimal forest management method to employ for each of the major commercial tree species in the U.S. so that profitability of timber production only or the combination of timber production and carbon sequestration is maximized. Because the potential of a forest ecosystem to sequester carbon depends on the species, site quality and management regimes utilized, this project will determine how to optimize carbon sequestration by determining how to optimally manage each species, given a range of site qualities and economic variables. This project also will determine the effects of a carbon credit market on the method and profitability of forest management, the cost of sequestering carbon, and the amount of carbon that can be sequestered.

Site Location(s): Entire U.S.

Timetable and Funding Sources: Three year + study, funded by U.S. DOE.

Key Publications:


ENHANCEMENT OF TERRESTRIAL C SINKS THROUGH RECLAMATION OF ABANDONED MINE LANDS IN THE APPALACHIANS

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Scope and Objectives: This project proposes to reclaim and reforest abandoned mine lands in the Appalachian region to store carbon in trees and forest ecosystems to ease the problem of global warming. The overall objective is to sequester carbon in terrestrial ecosystems (soils and vegetation) in order to achieve DOE’s long-term cost goal of $10 per ton or lower. This project will determine how to increase carbon sequestration in forests while increasing forest yields and other desirable ecosystem goods and services. Specific objectives are 1) quantify the maximum amount of carbon that can be stored in trees and forest ecosystems on abandoned mine lands in the Appalachian region, 2) calculate the per ton cost of carbon sequestration for the proposed reforestation program, 3) create a “carbon credit” market between landowners and utility companies, and 4) determine the economic impact of a carbon sequestration program on the local economy.

Timetable and Funding Sources:
START: 01 OCT 2000, TERM: 19 SEPTT 2006, DOE Carbon Sequestration

Project Description: Reforestation and forest management techniques to bring abandoned mine lands back to productiveness will remove a great amount of atmospheric CO2, a principal greenhouse gas, through carbon sequestration. This innovative approach addresses global climate issues and represents a practical and cost-effective solution to pressing environmental concerns while offering multiple benefits to all involved. Reforesting abandoned mine lands in the Appalachian region may achieve the long-term cost goal of the FETC Carbon Sequestration Program of sequestering carbon for $10 per ton or less. The results of this project will determine how to increase carbon sequestration in forests while increasing forest yields and other desirable ecosystem goods and services. In fact, carbon sequestration on these sites should earn revenue and, therefore, be costless. There are 148,500 hectares of abandoned mine lands in the Appalachian region. Reclamation and reforestation on those abandoned mine lands has a great potential to sequester carbon in terrestrial ecosystems, one of the most cost-effective ways to reduce atmospheric CO2. In addition to the benefits of carbon sequestration, it is expected that large reforestation projects will create jobs and affect the local economy through the multiplier effect. Environmental benefits from reforestation in the Appalachian region will include 1) protection of wildlife habitat, 2) increases in recreational opportunities, 3) enhancement of soil productivity and control of soil erosion, 4) reduction of stream pollution and improvement of water quality, and 5) enhancement of aesthetics. We have solved the scientifically challenging concept of determining the optimal rotations for economic returns and carbon management with the development of a dynamic computer program which allows us to investigate millions of possible combinations and derive the optimal results.
ASSESSING CARBON BALANCE OF FARMING SYSTEMS CONSTITUTING AGRICULTURAL CROPS AND FOREST ECOSYSTEMS

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Scope and Objectives: The purpose of the study is to use the properties of the nocturnal boundary layer (NBL) to estimate carbon balance of typical farming systems in Georgia constituting agricultural crops and forest ecosystems. Important objectives are to 1) quantify, using the nocturnal boundary layer measurement technique, the fluxes of carbon dioxide for typical farming systems in Georgia, 2) extend the NBL method over forest ecosystems and provide spatially integrated measurements of CO2 fluxes, 3) validate this method as a means to detect stress in crops by making nocturnal respiration measurements, 4) implement an Internet-accessible database of NBL flux estimates and ancillary data for developing and testing process-based models of carbon dioxide fluxes, 5) establish Intergovernmental Panel on Climate Change greenhouse gas emission factors for typical farming systems found in the southeastern region of the U.S., and 6) to improve the NBL budget approach of carbon dioxide fluxes measurements by the concomitant use of tethered blimp profile and SODAR techniques.

Timetable and Funding Sources: SUBFILE: CRIS  AGENCY: CSREES GEO
PROJ TYPE: HATCH PROJ STATUS: NEW
START: 30 AUG 2002 TERM: 29 AUG 2007 FY: 2005

Project Description: The CO2 exchange over farming systems constituting agricultural crops and forest ecosystems is not well understood at the farm scale. This proposal aims to assess carbon balance of farming systems constituting agricultural crops and forest ecosystems at the farm scale. The proposal also suggests a new remote sensing and non-interfering method to measure physiological stress in commercially important cash crops such as peanuts by measuring nocturnal respiration rates. This study combines SODAR and tethered blimp techniques within the nocturnal boundary layer (NBL) to measure and determine fluxes of carbon dioxide originating from several square kilometers surrounding the measuring systems. This strategy should provide knowledge of the development and structure of the NBL, and an evaluation of a methodology for determining greenhouse gas emissions/exchange at the farm scale. By extending the study over forest ecosystems, the project further contributes to the quantification of carbon sources and sinks at the forest landscape level. Furthermore, it also has practical implications for greenhouse gas policy.
GENE EXPRESSION IN FOREST TREES

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Scope and Objectives: We plan to analyze the natural variation in gene expression found in loblolly pine to help identify candidate genes important in determining wood quality and involved in adaptation to drought stress and climate change. Objectives are 1) to use natural variation in gene expression to gain a greater understanding of xylem development, and 2) to use natural variation in gene expression to gain a greater understanding of adaptation to stress and changing environments.

Timetable and Funding Sources: CRIS AGENCY: CSREES TX
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: REVISED

Project Description: A greater understanding of the genes involved in wood traits and adaptation to environmental conditions will help us develop trees to meet the needs of the future. The approach used for objective 1 will be a) determine the amount of variation in expression of genes involved in xylem development present in natural populations of loblolly pine and b) use associations between wood property traits and expression of genes involved in wood development to identify candidate genes important in determination of wood quality. The approach used for objective 2 will be a) determine the amount of variation present in natural populations of loblolly pine in expression of genes involved in responses to drought stress, elevated carbon dioxide levels, and elevated temperature, and b) determine relationships between physiological and morphological traits following environmental stresses or change and differences in gene expression.

Key Publications:
A DYNAMIC STOCHASTIC ANALYSIS OF GLOBAL WARMING, FOREST CARBON FLUX, AND TIMBER HARVESTS

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Scope and Objectives: Global warming is predicted to cause a migration of forests toward the poles. This project will study this migration using a stochastic optimal control framework augmented by a general circulation model and an ecological model.

Timetable and Funding Sources: CRIS AGENCY: SAES UTA
PROJ TYPE: STATE PROJ STATUS: REVISED
START: 01 JUL 2003 TERM: 30 JUN 2008 FY: 2005

Project Description: The research is to be an extension of previous work. The Timber Supply Model 2000 (TSM 2000) will be our starting point. TSM 2000 is an optimization model that is designed to examine theoretical and practical issues in world timber supply. The dynamic characteristics of timber supply such as aging of trees, harvesting of timber, and regenerating the forest have been modeled using discrete time optimal control theory. In this research we will identify the effects of making some elements of the model stochastic. We are in the initial stages of adding a stochastic element to the law of motion for the growing stock of timber. This will add the effects of random forest fires, and pest and disease outbreaks. This requires some restructuring of the model and some new data on the mean and variance of these events. Then the task will be to identify the solution technique and/or software to solve for the optimal path. Our current database for the resource stock and global warming will be used to implement the revised model.

Key Publications:

APPLICATION OF LOW-COST DIGITAL ELEVATION MODELS TO DETECT CHANGE IN FOREST CARBON SEQUESTRATION PROJECTS

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Scope and Objectives: The overall objective is to develop, test, and apply new low-cost technologies using 3D terrain reconstruction with multiple ranging lasers and multispectral imagery to detect carbon changes in mixed hardwood forests. This effort collaborates with ongoing research in ecosystem surveys and computer science to develop new techniques of canopy crown detection and automated delineation that currently do not exist, but are crucial in reducing costs in monitoring and estimating standing biomass in forests while maintaining known levels of precision.

Timetable and Funding Sources:
START: 02 SEPT 2005, TERM: 31 JULY 2007, DOE Carbon Sequestration
COLLABORATIVE RESEARCH: INVASION OF NORTH TEMPERATE FOREST SOILS BY EXOTIC EARTHWORMS

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Scope and Objectives: This renewal project will address how earthworm invasions affect carbon and nitrogen dynamics by altering the soil food web. Stable isotopes (13C and 15N) will be used to explore how the flow of carbon and nitrogen through different soil components is related to shifts in soil food web structure as well as to flows into the above-ground food web via woodland salamander populations.

Timetable and Funding Sources:
START: 01 MARCH 2006 TERM: 29 FEB 2008 (Estimated)
NSF Ecosystem Studies

Project Description: Biological invasions are one of great challenges currently facing environmental scientists. While most invasion research has focused on above-ground organisms (plants, animals), invasions in the soil can be equally important. Foreign earthworm species are currently invading North American forests over a wide geographic area and are causing marked changes in the soil environment. Previous NSF-funded research in two forested landscapes in New York State demonstrated that earthworm invasions had striking but complex effects on forest soils, altering the structure of soil profiles, and changing the dynamics of carbon, nitrogen and phosphorus. This renewal project will address how earthworm invasions affect carbon and nitrogen dynamics by altering the soil food web. Stable isotopes (13C and 15N) will be used to explore how the flow of carbon and nitrogen through different soil components is related to shifts in soil food web structure as well as to flows into the above-ground food web via woodland salamander populations. The research will be coupled with formal and non-formal K-12 education and outreach efforts, based on the idea that earthworm ecology is a powerful tool for engaging a broad diversity of people in thinking about soils and ecosystems.
QUANTIFYING GENOTYPE × SILVICULTURE INTERACTION IMPACTS ON PRODUCTIVITY AND CARBON SEQUESTRATION BY MANIPULATING SOIL ORGANIC MATTER, N SUPPLY AND DEMAND

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Scope and Objectives: Our goal is to investigate the potential to use forest-logging residues in combination with early rotation fertilization to enhance soil quality, promote short and long-term ecosystem productivity and sustainability and increase C sequestration in intensively managed loblolly pine plantations.

Time Table and Funding Sources: Agenda 2020, Soil Productivity and Physiology of Forest Production Research Pathways for Sustainable Forestry Research. 2005-2008

Project Description: This project is a collaborative research effort between the USDA Forest Service SRS and MeadWestvaco that examines how manipulating site organic matter, primarily logging residues, impacts soil nutrient supply, C sequestration and productivity during early stand development. Post-harvest logging debris and previous stand forest floor represent large pools of C and nutrients. Incorporating logging residues into the underlying mineral soil could potentially increase soil C and nutrient cycling and availability. We also manipulate site N demand by using two distinct loblolly pine genotypes (ideotypes). Both clones have high and similar aboveground productivity, but one produces biomass with approximately half the leaf area of the second. The mechanism(s) for this difference in growth efficiency (i.e. resource use efficiency) are unknown.

We will quantify, via mass balance, C and macronutrient cycles by monitoring the fluxes in and between plant and soil pools including plant uptake, above- and below-ground growth, litterfall, fine root turnover, total soil nutrients, extractable N (NH$_4^+$, NO$_3^-$ and DON), microbial biomass N and C, N mineralization, leaching losses (nutrients, DON, DOC) and surface efflux (CO$_2$, N$_2$O and CH$_4$). Determine how contrasting genotypes across cultural regimes affects carbon and nutrient cycling. Examine the fate of tap-roots, coarse roots, incorporated organic matter and logging debris on soil surface as they decompose. Understanding these factors will allow management to be aimed to both promote crop tree growth and total stand C sequestration while minimizing nutrient inputs and losses out of the system.
**CARBON SEQUESTRATION AND ENHANCED WILDLIFE HABITAT RESULTING FROM BOTTOMLAND HARDWOOD AFFORESTATION ACTIVITIES IN THE LOWER MISSISSIPPI ALLUVIAL VALLEY**

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**Scope and Objectives:**
1) Determine soil and vegetative carbon storage for a number of bottomland hardwood species. 2) Evaluate the effectiveness of fertilizer application in southern bottomland hardwoods. 3) Evaluate the effectiveness of herbaceous competition control measures in early growth and survival of planted bottomland hardwoods. 4) Evaluate the costs associated with a number of hardwood establishment procedures, and the subsequent costs for sequestering carbon for each procedure. 5) Establish permanent afforestation areas that can potentially be used for long-term research and demonstration purposes. 6) Assess the potential and feasibility of application of biomineralization to increasing long-term terrestrial capture of CO₂ in terrestrial ecosystems. 7) Evaluate the economic returns for alternative hardwood establishment procedures on a before and after tax basis.

**Site Location(s):** Lower Mississippi Alluvial Valley: Greenville and Cleveland, MS

**Timetable and Funding Sources:** 2005-2007+, various funding sources

**Remaining Gaps/Opportunities:** Physiological interactions, nutrient information, soil variability

**Project Description:** This project is a joint venture between the Forest and Wildlife Research Center at Mississippi State University, Entergy Corporation and The Carbon Fund. The study is designed to evaluate different afforestation techniques in bottomland hardwoods, assess above-and belowground carbon storage, and address economic implications related to carbon storage in afforestation efforts in the Lower Mississippi Alluvial Valley. The research sites are located in two different soils and the experimental design is a completely randomized 6 x 2 x 2 factorial design with six species combinations by fertilizer/no fertilizer by competition control/no competition control. The study is in the first growing season.
CONSORTIUM FOR ACCELERATED PINE PRODUCTIVITY STUDIES

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Scope and Objectives: Forest management effects on soil carbon.

Site Location(s): Waycross, GA; Eatonton, GA; Athens, GA; Dawsonville, GA – all have soil data; Thomson, GA and Tifton, GA – unsampled

Timetable and Funding Sources: Many stands were planted between 1987 and 1992. Funding was provided by cooperators with ancillary funding from DOE and the State of Georgia.

Remaining Gaps/Opportunities: These are extremely well replicated stands throughout the state of Georgia. They focus on current operational chemical treatments. A number of stands are becoming available for a ten year re-sampling and would greatly improve our understanding of soil change over time with forest management. There are also excellent aboveground data for all these sites.

Project Description: These are stands that were established by Dr. Borders in a well planned experimental design. Excellent experimental management of these stands has been maintained over the first 15 years of the study. I have samples soils including forest floor at Waycross and Eatonton in 1998, Athens in 2001, and Dawsonville in 2003.
PREDICTING FOREST GROWTH AND SUSTAINING SOIL PRODUCTIVE CAPACITY IN MANAGED FOREST PLANTATIONS.

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Scope and Objectives: This project examines the relationship between soil N availability and pine productivity to maximize the efficient use of chemical inputs and minimize off-site environmental impacts. The general objective is to improve the predictive capacity of soil-site relationships for plantation inputs and to determine how forest plantation management will affect the long-term sustainability of soil productive capacity. Specific objectives are to quantify the effect of forest plantation treatments of complete weed control and fertilization on soil organic matter quantity and chemical attributes, and on the supply of bio-available N.

Timetable and Funding Sources: AGENCY: CSREES GEOZ
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: NEW
START: 01 JUL 2003 TERM: 30 JUN 2008 FY: 2004

Project Description: Soil suitability for fiber production is difficult to predict and affects the use of chemical inputs on forest plantations. Research will focus on quantity and characteristics of soil organic matter, and soil nutrient availability. The relationship between these attributes and observed forest productivity will be determined as will the effect of intensive management on the degradation or enhancement of these soil characteristics. This research consists of two components. The first research component utilizes long-term loblolly pine study sites established on representative soils in the Piedmont and Lower Coastal Plain of Georgia as part of the Consortium for Accelerated Pine Productivity Studies project and the Plantation Management Research Cooperative. Each site has replicated sets of treatments that include a control, herbicide for complete competition control, fertilization two or more times, and herbicide plus fertilization. For this research we have collected composite samples of surficial mineral soil that will be used for analysis of organic matter quantity and quality. The second component of this research will make greater use of the available plots in the projects listed above. In this component we will sample 30 plots across the Piedmont and Coastal Plain regions to a depth of 200 cm, where N availability and other soil and vegetation measures will be quantified and correlated with site characteristics. Measures will be used to estimate potential productivity of the stands and total N capital to help quantify the historic uptake of N.

Key Publications:

SOUTHLAND EXPERIMENT STATION

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Scope and Objectives: Forest management effects on soil carbon.

Site Location(s): Southland Experiment Station, Bainbridge, GA

Timetable and Funding Sources: Initiate in 1998 with U.S. Forest Service cost share, no current funding.


Project Description: These are second rotation stands at the Station that were originally a genetics experiment. The site was planted in three replicate blocks with herbicide+fertilizer, herbicide only, control. There is a genetics split and a high and low logging intensity split. These were sampled in 1998 (age 3) and in 2003.
IMPACT ANALYSIS AND DECISION STRATEGIES
FOR AGRICULTURAL RESEARCH

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Scope and Objectives: Here we examine the returns to the investment in agricultural research. This project investigates the potential returns to various agricultural technology development exercises. The project objective is to estimate the expected and actual flow of benefits and costs of research for agriculture, and related areas including the incidence of their distribution.

Timetable and Funding Sources: CRIS AGENCY: CSREES TEX
PROJ TYPE: HATCH PROJ STATUS: NEW MULTISTATE PROJ NO: NC-1003
START: 01 OCT 2001 TERM: 30 SEPT 2006 FY: 2004

Project Description: Social costs and benefits from public and private research will be estimated at the global, national, regional, state and sector level using new livestock and crop technologies using sectoral simulation techniques. The potential of GHG (Greenhouse Gas) emission mitigation from selected land practices: tillage systems, forestry, and pasture in Southeast Texas is assessed. The study examines carbon potential based on cost for switching: (i) to alternative tillage systems on soybean and sorghum lands; (ii) from rice lands to pasture land; and (iii) from rice lands to forest. The study develops a conceptual framework for the inclusion of discount factors such as additionality, leakage, permanence, and uncertainty into a cost of agricultural GHG offset calculation and investigates the empirical magnitude of the discounts, as well as examines the effects of discounts on the cost of an agricultural GHG offset project.

Key Publications:

COUPLING THE EFFECTS OF MANAGEMENT AND CLIMATE ON CARBON AND WATER FLUXES IN THE FORESTS OF EASTERN U.S. AND P.R.C.

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Scope and Objectives: The primary goal is to assess relationships between management or disturbance regimes and environmental controls for the biosphere-atmosphere exchange of carbon and water. Objectives are: (1) develop eddy-covariance systems to directly measure \(\text{CO}_2, \text{H}_2\text{O}\), and energy fluxes and storage in eastern US and PRC forests and explore effects of current and future climate on fluxes; (2) collect biometric data to explore the biophysical controls of each flux term; (3) parameterize and examine carbon sequestration under fire and management scenarios using PnET-II and management (e.g., LandNEP) models, and (4) establish a collaborative program with the Chinese Academy of Science (CAS) to install eddy flux towers throughout Eastern China.

Site Location(s): Weyerhaeuser Parker Tract, Washington County, Plymouth, NC.


Remaining Gaps/Opportunities: In the near future we hope to add a flux measuring system in an unmanaged deciduous wetland stand to improve our understanding of the carbon and water fluxes in these important eastern ecosystems. For more information, see Linking Landscape-Scale Carbon Monitoring with Forest Management.

Project Description: Ecosystem models must be used to quantify carbon flux for multiple ecosystems due to the difficulty in obtaining simultaneous, direct flux measurements over time. We will use a combination of direct carbon exchange measurements (e.g. NCE, respiration, and photosynthesis) from a cluster of eddy-flux towers that include measurements of NEE (eddy-covariance) and respiration (soil, live and dead stems), and models of ecosystem processes (PnET-II) and disturbances (LandNEP). Data will be used to validate the PnET and LandNEP models to extrapolate our measurements to managed stands of different ages and disturbance regimes.

Key Publications:
THE COMPETITION OMISSION MONITORING PROJECT (COMP): SOIL NUTRIENT RESPONSE 15 YEARS AFTER COMPETING VEGETATION CONTROL AND THEIR CORRELATION TO GROWTH FOR 13 LOBLOLLY PINE PLANTATIONS

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Scope and Objectives: Influences of intensive woody and/or herbaceous competition control treatments on 15-yr loblolly pine (Pinus taeda L.) plantation development and soil nutrition including total carbon were examined using a southern region dataset. The aim was to study intensifying plantation establishment practices in the region and to explore the limits of pine plantation productivity after intensive early competition control.

Site Location(s): The 13 study locations are distributed across the southern US in four physiographic provinces from Louisiana (LA) to Georgia (GA) and northward to Tennessee (TN) and Virginia (VA) on commonly occurring soil series for each province.

Timetable and Funding Sources: Initiated in 1984 and 25 yr measurements will be made in 2008 and 2009 with funding from the Southern Research Station with in kind contributions from forest industry and university cooperators.

Remaining Gaps/Opportunities: This investigation is restricted to soil C changes over fairly long periods, i.e., years 0, 15, and potentially 25.

Project Description: U.S. Forest Service, university, and forest industrial investigators established a region-wide study (the Competition Omission Monitoring Project; COMP) in 1984. Loblolly pine plantation development relative to four, near-absolute, early woody and herbaceous competition control treatments was examined. Soil macro-nutrient trends and their correlations with pine growth were examined at yr 0 and 15.

Key Publications:


NATIONAL-LEVEL CARBON AND ENERGY IMPACTS OF SUBSTITUTING WOOD-BASED BUILDING MATERIALS FOR NON-WOOD ALTERNATIVES

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Scope and Objectives: To expand the analysis done in the Consortium for Research On Renewable Industrial Materials (CORRIM) study to 1) put it in the context of other life cycle studies of building materials; 2) develop forest carbon, product carbon and end-of-life modules that were suitable for examining national-level impacts; and 3) developing national-level estimates of the carbon and energy effects of making the wood-based for non-wood building material substitutions examined in the CORRIM study.

Site Location(s): Two scenarios examined: 1) construct homes in Minnesota using wood from the Pacific Northwest vs. steel studs; and 2) construct homes in Atlanta with wood from the Carolina Piedmont vs. concrete walls.

Timetable and Funding Sources: 2004, 2005 – Information assembly and data analysis essentially complete. Funding primarily from the U.S. Forest Service.

Remaining Gaps/Opportunities: Additional wood supply regions should be included. Additional opportunities for substitution of wood-based for non-wood materials should be examined. A more quantitative approach for estimating saturation and leakage effects in the context of life cycle studies is needed.

Project Description: A review of the global literature was undertaken to identify studies that examined the life cycle impacts of using wood-based building materials vs. alternative materials. The review identified the CORRIM study as being, by far, the best suited to examining national-level substitution effects in the U.S. The data from the CORRIM reports were used to the extent possible to make such estimates. In addition, it was necessary to add forest carbon accumulation curves from COLE (carbon online estimator) and a product carbon accumulation and end-of-life modules based largely on Forest Service and EPA carbon models.

Key Publications: Most of the key data are in the CORRIM publications, available at www.CORRIM.org.
CARBON FINE ROOT ALLOCATION AND TRANSFER AT ECOSYSTEM SCALES: ROOT ARCHITECTURE, MYCORRHIZAE AND STORED CARBON REGULATION OF BELOWGROUND DYNAMICS

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Scope and Objectives: This study uses fire and N fertilization (two common forest management practices) and novel methods to assess belowground C allocation and its fates. The objectives of this project are generally to gain a more quantitative understanding of the patterns and controls of C allocation to roots and mycorrhizae, as well as the fate of that carbon, and the impact of management (fire and soil fertility) on those patterns.


Project Description: It is estimated that carbon release from the soil due to root respiration and decomposition amounts to more than 10 times the C emitted from the burning of fossil fuels. Thus, understanding soil feedbacks with atmospheric CO$_2$ is critical to issues such as global change. Measuring the pools and rates of transfer beneath the surface of the soil has proven to be difficult. Moreover, understanding the way forest management influences carbon allocation and fates belowground represents one of the largest challenges to the ecological community. We will test the effects of fire and fertility management on belowground carbon allocation and fates by using a factorial experimental design. Growth and death rates of roots and C allocated to mycorrhizae will be assessed at ecosystem scales and contrasted with aboveground C fixation and growth. In this project we will 1) test a new model of control of belowground carbon allocation and fates using branching order to link root structure with C pools and fluxes; 2) measure mycorrhizal production at ecosystems scales; and 3) experimentally manipulate management factors (fire disturbances will be done once annually instead of the two times originally proposed due to the budget cut and fertility) to test their impacts on belowground C pools and fluxes.
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Scope and Objectives: Forest management including tillage effects on soil carbon.

Site Location(s): Cuthbert and Lumpkin, GA; affiliated plots from an earlier study in Putman Co., Washington Co., Hancock Co., and Warren Co., GA

Timetable and Funding Sources: These are recently planted (2002) stands that included a diversity of tillage treatments. Funding is from the Traditional Industries in Pulp and Paper Processing program in Georgia. In-kind support provided by industrial cooperators.

Remaining Gaps/Opportunities: This is a well replicated study that focuses on the effect of upland tillage on tree growth and soil chemical and physical parameters. Upland tillage is still limited in the Southeast but growing. This study can fill a gap in knowledge regarding the effects of forest tillage operations on soil C.

Project Description: The initial study referred to above was set up by The Timber Company in collaboration with Dr. Rodney Will in 1999. There were seven sites with replicated blocks of five tillage treatments. Early growth data and soil samples were collected from all plots. A follow-up study was initiated in 2002 in Cuthbert and Lumpkin, GA on two sites (a third unsampled site also exists in Cuthbert). These sites have three replicate blocks with five tillage treatments. Early growth data and soils data are available at these two sites.
PROBING THE MECHANISMS BY WHICH SUBCANOPY EVERGREEN SHRUBS INHIBIT TREE SEEDLING RECRUITMENT

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Scope and Objectives: Commercially important canopy trees are inhibited by subcanopy evergreen shrubs. This project will determine the physiological and ecological mechanisms by which subcanopy evergreen shrubs inhibit the natural replacement of canopy trees. The main objective of this study is to determine the importance of the interaction between light limitation and mycorrhizal synthesis (as affected by evergreen subcanopy shrubs) on the growth and survival of canopy tree seedlings in the southern Appalachian forest. Specific objectives are 1) verify that resource availability above and below ground is altered by subcanopy shrub thickets; 2) examine the interaction between mycorrhizal inoculation and light limitation on the growth and survival of seedlings of two dominant tree species; 3) determine if the effect of shrubs on mycorrhizal colonization is due to changes in colonization intensity and/or diversity of mycorrhizal species and if those changes are correlated with seedling growth; and 4) determine which physiological processes of canopy tree seedlings are most associated with the demise of seedlings when they are associated with subcanopy shrub thickets.

Timetable and Funding Sources: SUBFILE: CRIS  AGENCY: CSREES VA.
PROJ TYPE: NRI COMPETITIVE GRANT PROJ STATUS: TERMINATED

Project Description: Two species will be used (Red maple, and Northern Red Oak) in two experiments designed to meet the stated objectives. Experiment 1: 100 randomly selected plots will be established in each of four sites. Within these plots, seedlings of each species with and without mycorrhizae will be planted. We will then measure survivorship, photosynthesis traits, whole plant carbon gain, water relations, and mycorrhizal colonization and diversity. Regression analysis will be used to test the effect of plot resource availability (light, water, nutrients) on the measured traits. Experiment 2: Twenty randomly selected plots that have relatively high radiation will be covered with a shade frame, and twenty randomly selected plots with relatively low light will be brightened by tying back the shrub layer. Seedlings of both tree species with and without mycorrhizae will be planted in each plot. Analysis of variance will be used to determine significant effects of light and mycorrhizae on plant performance in these plots.

Key Publications:
FREE-AIR CO₂ ENRICHMENT (FACE)

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(NC, loblolly pine)

Scope and Objectives: FACE field data represent plant and ecosystem responses to concentrations of atmospheric CO₂ in a natural setting possible during the next century. Unlike growth chambers and greenhouses, no containment is required with FACE designs. Previously difficult-to-study natural conditions such as temperature, precipitation, pollination, wind, humidity, and sunlight are now possible. In the South, FACE research sites have been established at a sweetgum stand in Oak Ridge, Tennessee and a loblolly pine stand at the Duke Forest in North Carolina.

Timetable and Funding Sources: Ongoing, core funding from DOE

Project Description: FACE research technology creates a platform for multidisciplinary, ecosystem-scale research on the effects of elevated atmospheric CO₂ concentrations over extended periods of time. In doing so, a large amount of high-CO₂-grown plant material can be produced, enough to support the research of many cooperating scientists. This would encourage research by teams of investigators who can study different aspects of an ecosystem’s response to CO₂ enrichment. This concurrent use by numerous independent scientists provides economies of scale and the potential to gain new insights into ecosystem responses that are difficult or impossible to obtain with smaller-scale studies.

Relevant projects associated with the Duke FACE site

Acclimation of a Forest Ecosystem to Elevated Carbon Dioxide, 2001-2004

Biogenic VOC Emissions under Present and Elevated CO₂ Conditions: Implications for Future Air Quality and Climate; National Science Foundation, 2004–2008


Forest-Atmosphere Carbon Transfer and Storage (FACTS); DOE, 2004–2007

Herbivory and Photosynthesis under Elevated Atmospheric CO₂; NSF, 2003–2006


Carbon and Nutrient Flow through Multiple Trophic Levels in CO2-Enriched Plant Communities; NIGEC, 2002–2004

Carbon Storage in CO2-Enriched Plant Systems: Belowground Processes; DOE

Effects of Elevated CO2 on Forest N Cycling: Assessment with Large-Scale 15N Tracers and Modeling; NSF, 2003–2006

CO2 Enrichment Effects on Trace Metal Uptake and Assimilation in Plants; NSF, 2004–2007


Effects of CO2 Enrichment on Ectomycorrhizal Community Diversity, Structure; NSF, 2000–2004

Quantifying the Bacterial and Fungal Contribution to C-Sequestration under Elevated Atmospheric CO2; NSF, 2003–2008

Terrestrial Carbon Sequestration under Elevated CO2 at the Duke Forest FACE Site; DOE, 2004–2007

Biocomplexity: Feedbacks between Ecosystems and the Climate System; NSF, 2001–2006


Estimating Biomass in a Combined SiB and CASA Model Using Data Assimilation; National Academy of Sciences, 2005
Innovative uses of Hyperspectral Imagery for Modeling Spatially Distributed Ecosystem Fluxes; NASA, 2002–2004


Do Internal N Pools Regulate Interspecies Difference in N Uptake Responses to Elevated CO₂?; NSF, 2002–2005

MANAGEMENT OF APPALACHIAN SOIL RESOURCES

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Scope and Objectives: To discover new information about soil components and processes that will improve pasture establishment and function in Appalachian hill-land grazing ecosystems.

Timetable and Funding Sources: SUBFILE: CRIS AGENCY: ARS 1932
PROJ TYPE: USDA INHOUSE PROJ STATUS: NEW

Project Description: 1) Determine how pasture root systems can be used to improve soil characteristics and plant response to grazing, overcome temperature, water and nutrient limitations, and promote beneficial interactions among soil biota. 2) Broaden our understanding of the relationships among the soil environment, phosphorus supply and availability, plant uptake efficiency, and pasture productivity. 3) Characterize soil organic matter in pasture ecosystems, its impact on soil characteristics, and its response to management practices. 4) Establish the basis for understanding limitations to establishment, growth, and persistence of desirable pasture species, especially legumes. 5) Develop and evaluate approaches for assessing pasture soil quality. Major forest soil types were assayed for pools and forms of soil organic matter, as total carbon and total nitrogen, and mineralizable-carbon. The effect of tree thinning on soil surface decomposition of various litter types was determined. Such information is needed to determine effects of silvopastoral management practice on important soil nutrient cycles and decomposition.
ENHANCING CARBON SEQUESTRATION AND RECLAMATION OF DEGRADED LANDS

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Scope and Objectives: This project examines the potential use of lands that have been disturbed by mining, highway construction, or poor management practices for terrestrial sequestration. The approach includes the examination of the effects of amendments with solid byproducts from fossil fuel combustion, and biosolids for enhancing carbon sequestration.

Timetable and Funding Sources:
START: 01 OCT 2003, TERM: 30 SEPT 2005, DOE Carbon Sequestration
LAND USE AND CARBON SEQUESTRATION IN EASTERN DECIDUOUS FORESTS: COMPLEX INTERACTIONS BETWEEN HUMAN ACTIVITIES AND ECOSYSTEM PROCESSES

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Scope and Objectives: The objective of this project is to investigate the role of recent past, current, and future land use change on carbon dynamics in eastern deciduous forests of North America. The project’s research questions address the interactions between human activities (forest management) and an ecosystem process (carbon sequestration) in temperate deciduous forests of West Virginia: 1) How do carbon stocks differ between forests with different land use practices? 2) How have changes in land management (1989-2000) affected carbon stocks, and what were the human drivers of this land use change? 3) How might the ability of central hardwood forests to store carbon change under future conditions?

Timetable and Funding Sources:
START: 15 AUG 2004; TERM: 31 JULY 2007 (Estimated)
NSF ECOSYSTEM SCIENCE CLUSTER, GEOGRAPHY AND REGIONAL SCIENCE

Project Description: Eastern deciduous forests may have played a major role in past carbon dioxide uptake due to regrowth following major cutting at the turn of the century. Current rates of timber harvest in eastern deciduous forests are high, so future land use and cover changes may again affect carbon cycling. These forests are managed under a diverse set of public and private management regimes, with each group possessing different motivations for land management and potentially responding differently to economic incentives. To address research questions, an ecosystem model (PnET-CN) will be calibrated and validated at two spatial scales (watershed and state). At the watershed level, PnET-CN will be calibrated for four management treatments: mature forest, young forest, and two types of diameter limit cuts. At the state level, PnET-CN will be run for 1989 and 2000 at USDA Forest Service, Forest Inventory and Analysis (FIA) plot locations classified by management strategy to match those of the experimental watersheds. This model of productivity will be linked to an econometric model that investigates correlations between land use/land management categories and their potential drivers, using FIA plot data combined with information on plot accessibility, management regime, and local hardwood timber prices. The econometric model will be coupled with the ecosystem model to conduct scenario analysis linking changes in drivers of land use and cover change to changes in carbon storage. Scenarios holding drivers of land use and cover change fixed, but varying climate parameters, will also be developed. This research addresses the important interaction between drivers of land use change, terrestrial ecosystems, and carbon balance by directly linking economic causes of timber harvest to details of forest biomass and productivity. Results from this project will help state and national agencies manage temperate deciduous forests in the context of future economic and climatic changes.
ECOLOGICAL BASIS FOR NUTRIENT MANAGEMENT FOR SUSTAINABLE FOREST PRODUCTIVITY

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Scope and Objectives: Projects will examine how materials left after forest harvesting contribute to a site's ability to provide trees with nutrients, and how atmospheric N deposition affects a site's ability to supply nutrients. Organic matter budgets will be quantified after harvesting, and this information will be used to elucidate the mechanisms controlling nutrient release from logging residues for a greater understanding of long-term site productivity, and for the identification of possible sustainable forestry practices involving logging residue manipulation. Further, the interaction of atmospheric deposition and forest management activities resulting in removal of organic matter will be addressed to increase the understanding of how current and future human impacts may affect nutrient relations in forests and in streams that drain them.

Timetable and Funding Sources: CRIS AGENCY: CSREES WVA PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: NEW START: 01 OCT 2004 TERM: 30 SEPT 2009 FY: 2005

Project Description: We do not fully understand how the materials left on site after forest harvesting affect future ability of the site to produce biomass. This problem is compounded by atmospheric deposition of nitrogen which may result in an increase in base cation losses, potentially leading to decreases in biomass production. A series of pilot studies will be performed (mostly in 2004 and 2005) to obtain data necessary for justifying project proposals for outside funding sources. These will include 1) production and field installation of 15N-labeled leaf litter to trace N movement, 2) installation of a litter-bag study and follow-up analyses, and 3) determination of feasibility of using published equations to model residue mineralization over time.
MODELING PRODUCTION AND DECAY OF COARSE WOODY DEBRIS IN LOBLOLLY PINE FORESTS

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Scope and Objectives: A significant proportion of forest biomass and sequestered carbon exists in the stems and large branches of dead trees known as coarse woody debris (CWD). We aim to quantify the rates at which CWD accumulates in southern U.S. loblolly pine plantations under different management strategies such as periodic thinning. We will also determine the rates at which the CWD buildup is reduced due to decay and decomposition. Doing so will allow us to make region-wide predictions of the amount of biomass and carbon “stored” in CWD within the vast loblolly pine forests of the southern U.S. The resulting predictions will serve private and public agencies in their efforts to make better inventories of the carbon stored in U.S. forests. Project objectives are to 1) develop mathematical models to predict stand-level volume and size-class (diameter) distributions of loblolly pine mortality, 2) develop a model to estimate the decay rate of coarse woody debris (CWD), and 3) combine the models into a projection system that predicts standing timber growth and yield along with estimates of CWD volume and carbon content.

Timetable and Funding Sources: SUBFILE: CRIS  AGENCY: CSREES VA.
PROJ TYPE: NRI COMPETITIVE GRANT PROJ STATUS: NEW

Project Description: Growth, yield, and mortality data from a long-term region-wide loblolly pine thinning study will be used as the basis for modeling. Supplementary data on CWD decay will be collected at the study sites and used to determine decay rates. Predictor variables for mortality modeling will include forest stand characteristics and time, while the CWD decay model will be based on dead tree size, decay class, position (standing or down), time since mortality, gross temperature and precipitation variables, and stand conditions such as basal area and age. Models will be implemented as stand-alone computer programs with the capacity to link to GIS databases for regional assessments.

Key Publications:
Principal Investigator(s), Institution(s), Primary Contact Information:
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Scope and Objectives: Forest management requires increasingly complex analyses of spatial data to support resource management decisions. Analyses must incorporate data over large areas and across long time spans. This project will improve the array of quantitative decision support tools available to forest managers. This effort integrates several specialty areas including Geographic Information Systems (GIS), forest inventory projection and forecasting, and timber harvest scheduling. The application focus is on the types of forest management prevalent in Virginia and the U.S. South: intensively managed pine plantations and upland hardwood managed under even-aged silvicultural systems. The project encompasses the following specific objectives: 1) to refine procedures for harvest scheduling with spatial constraints and multiple objectives; 2) to evaluate GIS data sources, applications, and algorithms for impacts and propagation of errors and uncertainty; 3) to enhance procedures for accurate modeling of forest carbon under various types of management; and 4) to develop quantitative analysis procedures to inform the forest management planning process.

Timetable and Funding Sources: SUBFILE: CRIS AGENCY: CSREES VA.
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: NEW
START: 01 APR 2003 TERM: 31 MAR 2008 FY: 2005

Project Description: A variety of modeling approaches for estimation of forest carbon are available. However, it is becoming apparent that stand-based models lead to different interpretations than forest-based models. For example, a stand-based model might lead to the conclusion that more carbon is stored in stands managed under longer rotations. However, a forest-based model may lead to the opposite conclusion, since for a given forest size, the area contained in a forest age class decreases with extended rotations, and smaller annual harvests convert less carbon to long-term storage in wood products pools. A simulation approach to stand modeling will use the STELLA simulation package, and results will be compared with a spreadsheet-based forest-level model. Using both of these tools, a deeper understanding of the carbon cycle impacts from different management regimes can be obtained.
CENTER FOR INNOVATIVE BIOMATERIAL EDUCATION AND RESEARCH

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Scope and Objectives: The activity creates a Center for Innovation for Biomaterials Education and Research that will train students both in classroom settings and using electronic technology to develop scientific and technological advances in the conversion of biomass into novel materials. The Center will serve as a clearinghouse of information to the general public and will serve as a means to create a collaborative team of national and international scientists focusing on the same problems in wood technology. Two deliverables are proposed: 1) development of new scientific and technological advances in conversion of biomass into novel materials, and (2) development of a knowledge-rich workforce skilled in these technologies.

Timetable and Funding Sources:
START Date: 22 OCT 2004; TERM: 30 SEPT 2006 (Estimated)
NSF PARTNRSHIPS FOR INNOVATION-PFI

Project Description: The proposal addresses a challenge that is important to the economy and the environment of the US and the rest of the world, i.e., how to shift to renewable, environmentally benign materials stemming from the agro/forestry sector. The move from hydrocarbon to carbohydrate technologies can have a wide variety of ancillary benefits, including enhancing rural employment and improving the environment. The proposed activity is critical to advancing our knowledge and understanding in the area of converting abundant biomass into biomaterials. The program will train students in innovative methods of converting biomass to novel biomaterials; develop a public outreach program describing the benefits of this technology; and discover new scientific processes for the efficient and practical conversion of renewable wood polymers into novel biomaterials including polyesters, nylon-4 polymers, and polycarbonate nano-cellulose derivatives. The activities will create job opportunities in rural areas of the U.S. where, during the past decade, more than 50 pulp and paper manufacturing plants have been closed and jobs are declining due changes in international markets. The partnership will enable the development of new innovative forest products technologies that will be developed with a scientifically and technologically empowered workforce. These results will improve the economic, technical, and environmental well-being of the nation. The intellectual merit of the activity lies in the creation of the science basis for conversion of the plastics industry from hydrocarbon-based technologies to carbohydrate-based technologies. This will dramatically improve rural employment opportunities, enhance national security by decreasing dependence on imported oil, and improve the environment by reducing carbon dioxide emissions. The project will educate professionals and the general public on the opportunities and science of converting biomass into innovative bio-materials, and develop new technologies that will provide valuable and practical materials for the packaging, transportation, and health care industries.
EFFECTS OF HISTORIC AND CONTEMPORARY LAND MANAGEMENT ON SOIL CARBON CHEMISTRY AND SEQUESTRATION

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Scope and Objectives: Long-term forest-carbon sequestration has been directly measured in 16 permanent plots over nearly 50 years at the Calhoun Experimental Forest. A comprehensive sampling and archiving protocol was initiated by Dr. Carol G. Wells in 1962, and has been repeated on eight subsequent occasions (1962, 1968, 1972, 1977, 1982, 1990, 1997, 2005). With this study, we have estimated total ecosystem carbon sequestration affected by reforestation of long-cultivated soils. We are preparing to clearcut and regenerate 8 of the 16 plots to test effects on soil-gas, water, and solid chemistry. We anticipate that the cutting will occur in 2005 or 2006.

Site Location(s): Calhoun Experimental Forest, Sumter National Forest, Union Co., SC

Timetable and Funding Sources: Various sources. This is the longest forest carbon study of its kind in the world.

Remaining Gaps/Opportunities: Due to the long-term archive and permanent field plots, there are many biological, chemical, and physical studies that could be conducted, all aimed at the sustainability of secondary forests.

Project Description: We initiated regular soil-gas and water collections in 2003 in preparation for harvest and pine-regeneration of half of the plots. The impact of harvesting and pine regeneration on availability of specific organic carbon compounds: sugars, carbohydrates, amino-acids, electron-rich polyphenols, aromatics, amino-sugars, and organic acids will be assessed. A long pre-treatment data set will be used to examine effects of harvesting on these compounds.

Key Publications:


FAST-GROWING FOREST TREE MANAGEMENT SYSTEMS FOR FLORIDA AND SIMILAR AREAS

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Scope and Objectives: This project develops and evaluates management options for appropriate fast-growing tree species grown as short rotation woody crops (SRWC) for applications such as energy wood and dendroremediation including genetic improvement, intensive culture, and short rotations on agricultural, forest, and non-traditional sites such as reclaimed mined and contaminated lands. Objectives are to 1) develop various cottonwood, eucalyptus, cypress, and slash pine management systems, and 2) evaluate short rotation woody crop, mined land reclamation, and dendroremediation systems.

Timetable and Funding Sources: AGENCY: CSREES FLA
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: NEW
START: 01 OCT 2004 TERM: 30 SEPT 2009 FY: 2004

Project Description: Several existing and new field studies will assess SRWC options including genetic variation, site amendments, vegetation control, planting densities and configurations, and rotation lengths across broad geographic, climatic, and edaphic ranges. Eucalyptus and cypress seed orchards will be developed. Two genetic engineering approaches will be tested to increase SRWC energy per acre. Applications of SRWCs in Florida and similar areas may be derived from several large studies that evaluate silvicultural practices and genetic options. Growth modeling will extend existing preliminary growth and yield models. Superior production and harvesting systems will be identified through performance of individual components (soil type, land preparation method, fertilization practices, planting method, planting configuration, planting density, SRWC species and genotype, cultural practices, harvest method, harvest frequency, plantation yield performance at first harvest and succeeding harvests, etc.) and combining them within a mathematical model. Tree-based systems will be evaluated in established studies on a wide range of contaminated sites. SRWC systems will be compared against various economic alternatives for lands with SRWC potential.

Key Publications:

CARBON STORAGE IN CO₂-ENRICHED PLANT SYSTEMS: BELOWGROUND PROCESSES

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Scope and Objectives: The principal focus of this effort will be to assess the role of root growth in terrestrial carbon processes as affected by atmospheric CO₂ concentration. Specifically, the objective is to measure root growth and development in 1) agronomic systems (conventional and sustainable), 2) a model regenerating longleaf pine community (competition study), and 3) a maturing loblolly pine forest system (17 years old) exposed to elevated atmospheric carbon dioxide levels.

Timetable and Funding Sources: USDA INHOUSE PROJ STATUS: NEW

Project Description: New measurement technologies for use in long-term studies of belowground processes are being sought. Minirhizotron technology, perhaps the best field technique available, will be used to measure root growth dynamics in all three studies. In collaboration with Duke University, minirhizotrons, which may represent the best available technology for quantitative measurement of temporal and spatial root growth in situ, were used to examine root production and turnover in an intact, 13-year-old loblolly pine stand exposed to ambient or Free-Air CO₂ Enrichment (FACE) of atmospheric carbon dioxide within the Duke Forest, Durham, NC. Root length, number, production, mortality, and turnover were not significantly affected by atmospheric carbon dioxide level (although values were numerically greater in elevated plots); however, average diameter of live roots at the shallowest soil depth were significantly enhanced in carbon dioxide-enriched plots. These results suggest modest, if any, increases in ecosystem-level root productivity under carbon dioxide enrichment; however, overall productivity of this stand, and its response to elevated carbon dioxide, could be enhanced through forest management practices (e.g., fertilization, thinning).
TERRESTRIAL SEQUESTRATION OF CARBON DIOXIDE

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Scope and Objectives: The purpose of this agreement is to address questions about costs, capacities, and residence times of terrestrial carbon sinks. Specific objectives are to 1) evaluate and assess the full-scale life-cycle costs and efficiencies associated with integrated energy production and utilization as well as enhancement of terrestrial sinks, 2) identify ways in which coal combustion by-products can contribute to increased terrestrial sequestration effectiveness, and 3) develop innovative and advanced concepts that integrate energy production with approaches to enhance natural terrestrial sinks.

Timetable and Funding Sources:
START: 30 SEPT 1999 TERM: 30 SEPT 2004, DOE Carbon Sequestration

Project Description: The focus of this study is on soil restoration through the addition and incorporation of forest biomass and waste before replanting with loblolly pine (Pinus taeda L.). The approach for this study is to test the effects of different levels of incorporated (to a depth of 18 inches) biomass and various waste materials, including coal combustion by-products. The design is proposed to be a randomized complete block. Three replications of three treatment levels will be tested: 1) incorporating twice the normal logging slash load, 2) incorporating the normal logging slash load, and 3) using the normal load without incorporation. Measurements will include above- and belowground carbon pools, carbon fluxes (CO₂ and dissolved organic carbon), organic matter turnover, soil chemical properties, soil physical properties, and water chemistry. These measurements will enable the development of a carbon mass balance, an assessment of corresponding responses of productivity, and an assessment of the potential for coal ash incorporation into forest soils. The operational system and the economics of the treatments will also be evaluated. The study will be installed in Upper Coastal Plain soils at the Savannah River Site in Aiken, SC.
HOW DOES INTENSIVE FOREST MANAGEMENT MODIFY SOIL CARBON EFFLUX IN LOBLOLLY PINE?

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Scope and Objectives: A better understanding of processes controlling \( S_{\text{CO}_2} \) in forest plantations is essential for evaluating the long-term effects of intensive forest management on soil carbon sequestration. Our objectives are to 1) examine the influence of irrigation and fertilization on annual soil carbon efflux in 6-year-old and 12-year-old loblolly pine, and 2) examine the influence of irrigation and fertilization on microbial respiration versus fine root respiration.

Site Location(s): Forest Service: Savannah River Site, New Ellenton, SC;
International Paper: Bainbridge, GA

Timetable and Funding Sources: Funding pending, January 2006.

Research Gaps and Opportunities: Fine root production, root exudates

Project Description: Management of southern pine forests continues to intensify to maximize fiber production, but there is uncertainty concerning the influence of more intensive forest management practices on soil \( \text{CO}_2 \) efflux (\( S_{\text{CO}_2} \)) and soil carbon cycling. \( S_{\text{CO}_2} \) is the largest component of total ecosystem respiration and more than half of the carbon fixed in gross primary productivity is released back to the atmosphere from the soil. Many factors influence \( S_{\text{CO}_2} \) including the activity of microbes and fine roots. Root respiration is up to 70% of \( S_{\text{CO}_2} \) in some pine stands, but microbial respiration can be 50% of the carbon evolved from the soil and microbial activity is sensitive to fertilization and soil moisture. It has been suggested that forest management practices may alter the heterotrophic versus autotrophic components of soil respiration, but few studies have examined autotrophic and heterotrophic soil respiration simultaneously. A better understanding of processes controlling \( S_{\text{CO}_2} \) in forest plantations is essential for evaluating the long-term effects of intensive forest management on soil productivity and soil carbon sequestration. In a study of a 6-year-old loblolly pine plantation under intensive management since establishment, annual soil carbon efflux but not fine root mass was 20% lower in stands treated with irrigation plus fertilization than in control stands. We hypothesized that lower soil carbon efflux in stands receiving more intensive management was a result of decreases in microbial biomass or activity and reduced heterotrophic respiration. We propose to test this hypothesis on a 6-year-old and 12-year-old loblolly pine plantation under intensive management since planting. \( S_{\text{CO}_2} \), fine root mass and respiration, and microbial biomass and respiration will be examined simultaneously and bi-monthly over one year at two research installations, one managed by International Paper, Inc. and the other by the Forest Service. Both studies are replicated and the treatments are 1) weed control only, 2) irrigation, 3) fertilization, and 4) irrigation plus fertilization. Instantaneous \( S_{\text{CO}_2} \) will be measured using a soil chamber connected to a portable infrared gas analyzer and in situ fine root respiration at the same location will be measured using a separate portable gas exchange system.
**PHYSIOLOGICAL AND MORPHOLOGICAL CONTROLS OF PRODUCTIVITY IN SOUTHERN FORESTS**

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**Scope and Objectives:** This project examines leaf and canopy level physiological processes, biomass allocation, productivity, and carbon sequestration by pine and hardwood stands in response to varying resource availability and management intensity. Objectives are to 1) determine the influence of resource availability on tree physiological processes, canopy morphology and productivity of southern forests; and 2) estimate carbon sequestration in intensively managed southern forests.

**Timetable and Funding Sources:** PROJ TYPE: MCINTIRE-STENNIS  PROJ STATUS: START: 01 OCT 2001 TERM: 30 SEPT 2006 FY: 2005

**Project Description:** Tree physiological processes, canopy morphology, and net primary productivity will be examined in important pine species, such as Pinus taeda, and hardwood species under varying levels of resource availability provided through irrigation and fertilization at multiple research installations in the southeast. In addition, clonal variation in growth efficiency in response to resource availability will be examined in Populus deltoides. Tree physiological processes to be examined include net photosynthesis, stomatal conductance, leaf $^{13}$C, canopy and stand water use, and leaf water relations. Canopy morphology and net primary productivity will be determined from measurements of leaf area index and harvesting above- and belowground biomass. Stand- and landscape-level carbon sequestration in response to management intensity and stand characteristics will be estimated from biomass, measurements of soil CO$_2$ flux, and process level modeling.

**Key Publications:**

COLLABORATIVE RESEARCH: CLIMATE CONTROLS OVER ECOSYSTEM RESPIRATION: USING ISOTOPE TO DETERMINE THE SOURCES AND AGE OF RESPIRED CARBON

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Scope and Objectives: The work proposed here will combine new measurement and modeling approaches for separating autotrophic and heterotrophic respiration, and determining the age of C respired from soils at field sites that span a range of North American biomes and climates. The data generated will be used to partition soil-respired C into autotrophic and heterotrophic components, to determine the age of heterotrophically respired C and identify the components of soil organic matter contributing to its production, and to determine how these relationships change with controlling variables (photosynthesis rate, soil conditions, etc). The results will be used to parameterize a new autotrophic respiration component of the CASA ecosystem model, and to test how well the model predicts the balance of sources of heterotrophic respiration on seasonal to interannual timescales.

Timetable and Funding Sources:
START: 01 OCT 2002 TERM: 30 SEPT 2006 (Estimated)
NSF GEOLOGY AND PALEONTOLOGY

Project Description:
Carbon enters ecosystems through a single process, photosynthesis, and nearly all is returned to the atmosphere through respiration, some 50-80% of which occurs below ground. Soil respiration integrates root metabolism and the activity of decomposer organisms. While the major processes affecting plant metabolic (autotrophic) respiration and decomposition rates (heterotrophic respiration) are known, the ability to predict variations in soil respiration in space and time is limited—a major uncertainty in the current and future carbon cycle. The work proposed here will combine new measurement and modeling approaches for separating autotrophic and heterotrophic respiration, and determining the age of C respired from soils. At field sites in the Ameriflux network that span a range of North American biomes and climates, these methods will include 1) frequent automated measurements of soil respiration and related factors; 2) isotope mass balance methods based on measurements of stable isotopes and radiocarbon in respired CO2; 3) incubations to determine responses of heterotrophic respiration components to changing soil conditions; and 4) at some sites, manipulation of soil moisture content through rainfall exclusion. The data generated will be used to partition soil-respired C into autotrophic and heterotrophic components, to determine the age of heterotrophically respired C and identify the components of soil organic matter contributing to its production, and to determine how these relationships change with controlling variables (photosynthesis rate, soil conditions, etc). The results will be used to parameterize a new autotrophic respiration component of the CASA ecosystem model, and to test how well the model predicts the balance of sources of heterotrophic respiration on seasonal to interannual time scales. This work will advance fundamental understanding of how terrestrial ecosystems influence the global carbon cycle, and will improve projections of future atmospheric concentrations of carbon dioxide by showing how heterotrophic respiration will respond to changes in temperature and moisture.
A RANGE WIDE ASSESSMENT OF SOIL CO$_2$ EFFLUX, HETERTROPHIC RESPIRATION AND SOIL CARBON IN MANAGED LOBLOLLY PINE STANDS

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Scope and Objectives: 1. Determine stand and environmental variables related to soil carbon pools and fluxes in managed loblolly pine; 2. Develop models to accurately predict soil CO$_2$ efflux from managed loblolly pine stands with a particular emphasis on understanding thinning and fertilization effects.

Site Location(s): Throughout the southeastern U.S. on state, federal and industry lands. The Forest tree Nutrition Coops RW18 study sites will be emphasized.

Timetable and Funding Sources: January 2006 – December 2008, NASA

Remaining Gaps/Opportunities: Accurate predictions of management effects on soil carbon pools and fluxes are critical to understanding net ecosystem productivity.

Project Description: We will be visiting a wide range of stands (age, site quality, soils, management practices) throughout the southeastern U.S. several times a year. The Forest Tree Nutrition Coop study sites and other industry lands will be utilized so that stand history will be documented. Specifically, fertilized and thinned stands will be targeted. Age since thinning and fertilization will vary. At each site the following data will be collected: (a) GPS located, (b) above ground volume estimated, (c) basal area (pine and hardwood), (d) trees per acre, (e) leaf area index, (f) understory vegetation, (g) leaf litter, (h) soil sample (core), (i) total soil CO$_2$ efflux (3 subsamples, IRGA with closed system chamber), (j) soil heterotrophic efflux (3 subsamples, IRGA closed system chamber), (k) soil and air temperature (Thermocouple), and (l) soil moisture (TDR).

Utilizing this data, relationships will be developed using regression analysis. In this analysis, we will be examining the relationship between efflux rates and soil and stand variables. This analysis will also be used to examine the influence of thinning and fertilization. Additionally we will compare our new models with past models which were developed for specific sites in South Carolina and Virginia (Gough et al. 2005).

Key Publications:
CARBON SEQUESTRATION IN URBAN FORESTS: APPROACHES AND VALUES

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Scope and Objectives: The purpose of this project is to evaluate carbon sequestration opportunities provided by urban forests in the U.S. and to develop approaches to carbon credit trading. The project has the following measurable objectives: (1) Examine worldwide status and trends of carbon sequestration in urban forestry; (2) Assess motivations and objectives for urban carbon sequestration with stakeholders, including potential sellers (e.g., cities, counties, and non-profit organizations) and potential buyers (e.g., major energy utilities, manufacturers, and retailers); (3) Develop protocols for measuring, monitoring, and auditing carbon sequestered in urban forests; and (4) Develop tradable carbon credits to effectively meet market objectives.

Site Location(s): Urban forests of the U.S., several sites will be selected for trials.

Timetable and Funding Sources: 2006 Start, 2-yr project duration. Funding: USFS.

Remaining Gaps/Opportunities: Developing a working carbon credit market.

Project Description: The role of forests in sequestering carbon is becoming increasingly recognized, and financial incentives to consider carbon storage benefits in management decisions are also emerging with the development of tradable carbon storage credits. Rapidly growing urban and suburban areas in the United States continue to encompass more and more forestland, and that which escapes development is gradually removed from industrial timber management and becomes an urban forest. Today, for example, nearly 20 percent of forestland in Georgia is located in metropolitan areas. Urban forests owned and managed by local governments and non-profit organizations frequently become permanent reserves not subject to commercial harvest in the foreseeable future. Therefore, unlike commercial forests, urban forests can under certain conditions be considered as a permanent repository of carbon. Given the substantial potential of urban forests to store carbon in trees and soils, there is a need to develop procedures and protocols that would facilitate carbon projects and transactions. In addition to helping reduce atmospheric carbon concentrations, carbon sequestration projects could provide local governments and non-profit organizations with additional income to conserve, sustain and expand urban forests.
CARBON STORAGE IN TERRESTRIAL ECOSYSTEMS

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Scope and Objectives: For different ecosystems, determine the effects of altering or disrupting the litter decomposition cycle on soil C storage. Determine the effects of changing the kinetics of soil N mineralization and immobilization on C sequestering in different ecosystems. Objectives are to 1) elucidate the effects of changing ecosystem vegetation on the soil decomposition process, 2) determine the effect of N mineralization and immobilization on soil carbon storage, 3) produce a model of N cycling in relation to C storage in each system, and 4) develop a soil C storage index for these systems and test the index with other ecosystems.

Timetable and Funding Sources: SUBFILE: CRIS  AGENCY: ARS 5348
PROJ TYPE: USDA INHOUSE PROJ STATUS: TERMINATED
START: 01 APR 2002 TERM: 30 SEPT 2004 FY: 2002

Project Description: Soil carbon storage was evaluated in five ecosystems across the United States including loblolly pine forest, Douglas fir forest, semi-arid desert, and agricultural cropland using $^{15}$N-labeled field soil and a model of N cycling in relation to carbon storage in each system.
SCALING UP FOREST ECOSYSTEM CARBON BUDGET FROM STAND TO LANDSCAPE: IMPACTS OF FOREST STRUCTURES

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Scope and Objectives: The overall goal of this project is to improve our understanding of the impacts of the multi-dimensional forest structures on scaling up forest ecosystem carbon cycle from stand to landscape through the integrative use of remote sensing, ecological models, and ground observations. The project will take the necessary steps to transform the understanding of mass and energy exchange between forest ecosystems and the atmosphere at Duke Forest to a regional understanding.

Timetable and Funding Sources:
START: 01 MAY 2004 TERM: 30 APR 2007 (Estimated)
NSF GEOGRAPHY AND REGIONAL SCIENCE

Project Description: The project will use the AmeriFlux and Free-Air CO$_2$ Enrichment (FACE) sites in the Duke Forest as the anchor points for scaling up through the integrative use of remote sensing and ecosystem models. Currently the global FLUXNET has over 200 flux towers worldwide, and the up-scaling strategy investigated in this project will provide in-depth understanding of how to scale up from FLUXNET measurements to improve our understanding in global carbon cycle. The project proposes to use multisensor remotely sensed data to map multi-dimensional forest structures, including tree size and density, stand ages, leaf area index, and subpixel tree cover. The remotely sensed data include high-resolution (=1m) digital orthophoto quads and space-born images from IKONOS/QuickBird, medium resolution (30 m) Landsat images, and coarse-resolution (250m) MODIS/MISR images. The project will develop algorithms to use information from spatial, spectral/temporal, and directional domains of remotely sensed data. The project can substantially enhance the use of remote sensing to extract detailed spatial vegetation information. A series of well established ecological models will be used in the project, each of which will take forest structure at the appropriate scale to simulate terrestrial ecosystem carbon cycle. In addition to quantifying the errors caused by omitting forest structures in simulating carbon cycle, the project will lead to major improvements to the these models.
APPLICATION AND DEVELOPMENT OF APPROPRIATE TOOLS AND TECHNOLOGIES FOR COST-EFFECTIVE CARBON SEQUESTRATION

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Scope and Objectives: The overall objective of this project is to refine the tools and methodologies for cost-effective, verified measurements of the long-term potential of various carbon sequestration and land use emissions avoidance strategies, using real projects as proving grounds. We will be working in close collaboration with U.S.-based companies and NGO partners to undertake research that will enhance the likelihood of implementing more successful carbon sequestration projects in the future. Our goals are to 1) improve carbon offset estimates produced in both the planning and implementation phases of projects, 2) build valid and standardized approaches to estimate project carbon benefits at a reasonable cost, and 3) lay the groundwork for implementing more projects to provide new test ground for increasing knowledge on how to sequester significant amounts of carbon from the atmosphere.

Timetable and Funding Sources:
START: 09 JULY 2001, TERM: 10 JULY 2007, DOE Carbon Sequestration

Project Description: There is great potential for cost-effective carbon sequestration projects both in the United States and abroad. However, without the development and refinement of tools and technologies that allow accurate and cost-effective assessments of the emissions reduction benefits of carbon sequestration, the international community may not recognize these approaches as a credible means for reducing greenhouse gases. The Conservancy has begun development of several new projects in the United States, Central and South America, and Asia. Through this grant, we will develop additional project ideas in the United States. All projects are designed to balance the investor’s need for cost-effective greenhouse gas mitigation with The Conservancy’s mission to protect biodiversity and the host country’s sustainable development objectives. The Conservancy builds credibility for these projects by working with experts to directly measure the carbon emissions offset by the project. Monitoring and verification activities involve the determination of a “baseline scenario” (i.e., an estimate of the amount of carbon that would be stored at the project site over time without the project), as well as the measurement of carbon storage in the project site over time. Carbon is measured in a large number of sample plots so estimates have a high degree of sampling precision. The carbon benefits are derived from the difference between the “without-project” baseline scenario and the actual carbon storage in the project area. Within the United States, the feasibility and potential carbon benefits of seven domestic projects of different types will help to build the necessary foundations for encouraging more domestic project activities. Software and tools for initial screening of the feasibility of domestic project ideas will be developed.
THE BIOLOGY OF FOREST PRODUCTIVITY

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Scope and Objectives: The purpose of this project is to determine the degree to which nitrogen acquisition, leaf area dynamics, radiation use efficiency, and carbon allocation control forest productivity. This project will utilize both direct experimentation and simulation modeling to determine how the processes of nitrogen acquisition, canopy leaf area, radiation use efficiency and carbon allocation control forest productivity.

Timetable and Funding Sources: AGENCY: CSREES GEOZ
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: NEW

Project Description: A better understanding of the physiological and genetic processes that control forest productivity is needed in order to design the most effective management regimes. The loblolly pine plantations selected for study will represent a wide range of productivity as well as a range of genotypes. Portions of each stand will be fertilized with nitrogen. In both fertilized and unfertilized plots we will measure leaf area, nitrogen content of the canopy, growth rate, water use, photosynthesis, respiration, total absorbed radiation, and canopy characteristics such as the light extinction coefficient. The results from these measurements will allow us to determine if there are consistent physiological factors explaining the variation in growth rates and productivity across sites. A process model will be developed to integrate measurements spatially and temporally.
HOW DOES TEMPERATURE ACCLIMATION AFFECT PHOTOSYNTHESIS,
RESPIRATION AND GROWTH?

Principal Investigator(s), Institution(s), Primary Contact Information
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Scope and Objectives: Elevated temperatures expected from global warming may adversely affect forest ecosystems. The objective is to determine the degree to which loblolly pine and yellow poplar seedlings can adjust to changing temperature conditions through acclimation, or optimization, of the rates of physiological processes affecting growth.

Site Location(s): Coweeta, NC; Athens, GA; Macon, GA; Newton, GA; Gainesville, FL

Timetable and Funding Sources: 2004-2006, MacIntire-Stennis

Remaining Gaps/Opportunities: How changes in temperature will affect forest productivity is poorly understood. Larger scale projects experimentally warming forest ecosystems would be very useful.

Project Description: Seedlings of a single genotype are grown in different climatic conditions, and in controlled environmental conditions (growth chambers) with optimal water and nutrient supply to remove belowground limitations to growth. Growth rate (height, diameter) and biomass accretion are measured along with temperature response curves of photosynthesis and respiration to determine how well the seedlings have adjusted to the different climatic regimes that extend across a 9°C range of growing season temperatures.
INTERNAL RECYCLING OF CO₂ IN TREES

Principal Investigator(s), Institution(s), Primary Contact Information:
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Scope and Objectives: The purpose of this project is to determine whether trees can internally recycle and reuse the CO₂ released from root and stem respiration. Two objectives will be addressed in this study: 1) determine how much internally-transported CO₂ is refixed by photosynthetic cells in stems, branches and leaves; and 2) develop a diurnal carbon balance for trees that accounts for photosynthetic use of both internal and external sources of CO₂.

Timetable and Funding Sources:
START: 15 FEB 2005 TERM: 31 JULY 2006 (Estimated)
NSF ENVIRON AND STRUCTURAL SYS CL

Project Description: The purpose of this project is to determine whether trees can internally recycle and reuse the CO₂ released from root and stem respiration. The CO₂ concentration in the xylem of tree stems is very high relative to atmospheric CO₂ concentration, often in the range of 5 to 10%, and sometimes exceeding 20% (200,000 umol mol⁻¹). This CO₂ appears to be derived largely from woody tissue respiration, although a portion may also come from the soil. Using a mass balance approach to account for both internal and external fluxes of CO₂ released by stem respiration, it has been reported that as much as 50% of the carbon respired by woody tissues over a 24-hour period can remain within trees. This CO₂ dissolves in xylem water and can be transported upward in the transpiration stream. However, the ultimate fate of the transported CO₂ is unknown. This project addresses the idea that much of the respired CO₂ remaining in the stem may be transported upward and refixed by photosynthetic cells in the stem, branches and leaves, providing a previously unrecognized mechanism to recover and recycle carbon. Recovery of a portion of the carbon released by respiration of woody tissues would improve the carbon economy and growth of trees and would help compensate for the carbon costs of constructing and maintaining a large stem and branch support system for the leaves. Two experiments will address the objectives using a variety of methodology including stable isotopes, CO₂ microelectrodes, and CO₂ gas exchange techniques. There are a number of benefits to society from this project. First, results will improve our understanding of how carbon is used by trees. If this project successfully demonstrates for the first time that there is an internal pathway for recycling carbon in trees, it will revise our understanding of the carbon cycle in trees and forest ecosystems. Since forests are a key component of the global carbon cycle, this has particular relevance now. Second, this project will promote teaching, training, and learning in a number of ways. Targeted recruitment of a graduate student will help improve participation in science education by underrepresented groups. New K-12 educational experiences will be created by integrating this project with the educational programs of the Global Forest Foundation and the American Forest Foundation. Third, infrastructure for research and education will be enhanced by stimulating the use of new instrumentation in plant biology, in particular, the use of microelectrodes for measuring CO₂ concentrations and innovative use of stable isotope techniques.
IMPACT OF LAND USE CHANGE ON C SEQUESTRATION IN ALABAMA: INTERDISCIPLINARY RESEARCH LINKING ECOSYSTEM PROCESSES WITH ECONOMIC DEVELOPMENT

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Timetable and Funding Sources: SUBFILE: CRIS  AGENCY: SAES ALA
PROJ TYPE: STATE PROJ STATUS: NEW
START: 01 OCT 2005 TERM: 30 SEPT 2008

Scope and Objectives: The purpose of this project is to examine how economic development-driven land use changes and projected future land use changes influence carbon sequestration of terrestrial ecosystems in Alabama.

Project Description: Economic development is the primary driver of land use change in the southern United States. Human population expansion, urbanization, and economic development have converted large amounts of the world’s forest land into agricultural and settlement uses. However, it remains unclear how economic development-driven land use changes influence carbon sequestration in ecosystems in Alabama. We will 1) reconstruct annual land cover data sets with 1-km spatial resolution from 1970 to 2004 in Alabama including tree plantations using remotely sensed data, the U.S. Census and Agricultural Census data, and other statistical data of land use change; 2) project future land cover change from 2005 to 2030 in Alabama using an econometric model (multinomial logic) and spatial explicitly land use change models such as GEOMOD model; 3) simulate the effects of the past and future land use change on carbon storage in terrestrial ecosystems during 1970-2030 in Alabama using the TEM model; and 4) analyze the interactions between economic development and carbon sequestration in Alabama.
MODELING AND MONITORING TERRESTRIAL ECOSYSTEM DYNAMICS AND THE CARBON CYCLE IN SOUTHEASTERN UNITED STATES

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Scope and Objectives: Objectives are to 1) quantify spatial and temporal patterns of carbon sources and sinks in the terrestrial ecosystems of the southeast United States since 1980; 2) determine the relative importance of mechanisms that affect the sources and sinks of CO2 in the terrestrial ecosystems of the southeast United States such as CO2 fertilization, climate variability and change, ozone pollution, N deposition, land cover change and disturbances; 3) build consistent, accurate databases of land cover change and disturbance trends for the southeast U.S. at a resolution of 10km for model simulations; 4) improve our ability to simulate effect of multiple environmental stresses on terrestrial carbon dynamics, especially land cover change, disturbance trajectories and successional recovery; and 5) evaluate the performance of the improved models with an array of ongoing field measurements, including AmeriFlux, forest inventory, LTER and others.

Timetable and Funding Sources: SUBFILE: CRIS AGENCY: CSREES ALAZ PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: NEW START: 01 OCT 2005 TERM: 30 SEPT 2010

Project Description: Carbon sequestration in the southeast United States remains uncertain. The large uncertainty in carbon sequestration highlights the need for attributing mechanisms responsible for past and current carbon fluxes. An integrated approach that combines ecosystem modeling with field measurement and remote sensing will be used for this proposed study. Our research work spans different spatial and temporary scales. For the spatial scale, we primarily focus on west Georgia including Muscogee, Harris, and Meriwether counties and the southeastern U.S. which includes 13 states. For west Georgia, we used Landsat imagery data including MSS for 1974, TM for 1983 and 1991, and ETM for 2002. For the entire Southeast, we reconstructed the annual land cover data set from 1860 to 2003. We have used TEM mode to simulate the effects of land cover change on carbon storage and flux in this region. In the next stage, we will further develop a dynamic ecosystem model to better incorporate disturbance (e.g., hurricanes) and forest management practices in the model, so we can model and monitor terrestrial ecosystem carbon dynamic better. We also plan to simulate how climate change will influence terrestrial carbon dynamics in this region.

Key Publications:

FOREST RESPONSE TO ENVIRONMENTAL CHANGE: PHYSIOLOGICAL 
AND GENETIC DETERMINANTS

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Scope and Objectives: This study explores how trees respond to environmental changes, including carbon dioxide, air pollutants, and climate. Objectives are to 1) identify the physiological and morphological traits underpinning survival and growth differences among forest tree species and genotypes; 2) explore the consequences of genetic variation on forest stand structure and function; 3) examine the relationships between genetic and biogeographic variation in traits and tree and forest response to global change factors.

Timetable and Funding Sources: CRIS AGENCY: CSREES TEX
PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: NEW
START: 02 NOV 2001 TERM: 01 NOV 2006 FY: 2004

Project Description: Elucidating the physiological and genetic factors governing carbon and water exchange from seedling to ecosystem scales is critical to understanding forest response to global change. This project will test physiological models of carbon and water exchange and how these processes underlie tree growth and scale from leaf to ecosystem. The project will explore underlying trade-offs in physiological and morphological traits in the context of genetic variation both among and within (e.g., regional, family, clonal) species. The research approach will be experimental and comparative and involve both controlled-environment (growth chamber) and field-based studies. Linked gas exchange, stable isotope, and growth analysis techniques are planned. Relevant databases from the literature, herbaria, and genetics trials will be assembled. The project seeks to link genetics, physiology, biogeography, and ecology, a necessary synthesis to address forest ecosystem and management responses to global change. Results from this research will increase understanding of woody plant encroachment into grasslands and provide a framework for determining the combined effects of global change drivers and plant functional groups on ecosystem structure and carbon exchange. It will also be used to identify the genetic and physiological basis of growth differences among pine taxa in response to environmental factors. Research in 2004 was aimed at determining tree response to growth environment among southern pines, including field and greenhouse trials of elite families and clones of loblolly pine. We identified key growth trait correlations among clones of loblolly pine and the relationships between leaf and whole-plant growth traits. New information regarding genotypic variation and physiological responses will be useful to tree improvement programs and in defining the genetic limitations to tree response to changing environments. The work will also link leaf and root traits among diverse tree species in defining the feedbacks of trees on soil and stand properties.

Key Publications:
CARBON SEQUESTRATION AND NUTRIENT CONSERVATION OF 16-YEAR-OLD NATURALLY REGENERATED LOBLOLLY PINE

Principal Investigator(s), Institution(s), Primary Contact Information:
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Scope and Objectives: Some methods of forest management may deplete site productivity. This project examines the effectiveness of naturally regenerating pine stands to conserve site nutrients and act as sink for carbon dioxide. The objectives of this study are to describe aboveground and belowground biomass, carbon content, and nutrient content of 16-yr-old naturally regenerated loblolly pine. The study will help researchers and managers appreciate the capacity of loblolly pine stands growing on poor sites to accumulate and sequester carbon from the atmosphere. We hypothesize that the biomass, carbon content, and nutrient content of these dense natural 16-yr-old pine stands is equal to or exceeds that of the previous 41-yr-old loblolly pine plantation.

Timetable and Funding Sources: SUBFILE: CRIS AGENCY: CSREES SC.Z PROJ TYPE: MCINTIRE-STENNIS PROJ STATUS: TERMINATED
START: 01 JUL 2001 TERM: 30 JUN 2006 FY: 2005

Project Description: Naturally regenerated 16-yr-old loblolly pine in the upper Piedmont of South Carolina will be examined. Diameter at breast height (DBH), height, biomass, nutrient content and other quantitative data for the 41-yr-old harvested stands that previously occupied these sites are available for comparison with the 16-yr-old naturally regenerated stands that currently occupy these sites. Root systems of 15 to 20 trees representing the DBH range of live trees will be excavated and biomass estimated. Dry weight of root systems will be regressed on DBH to develop equations to estimate root biomass. Nutrient content of roots, forest floor, and soil samples (to a 100-cm depth) will be determined. Soil carbon will also be determined.

Key Publications:
DEMONSTRATION AREA: SHELTERWOOD BURN METHOD TO INCREASE OAK REGENERATION ON GOOD QUALITY UPLAND SITES

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Scope and Objectives: The research which produced evidence for the design and treatments of the demonstration area evaluated the effects of seasonal prescribed fires on hardwood regeneration. Motivation for the research was the intransigent problem of regenerating oaks on good quality upland sites due to intense competition from other hardwood species. The objectives were to find an economically viable and environmentally sensitive method using prescribed fire and harvesting to increase the oak component of the advance regeneration pool and examine the effects of seasonal prescribed fires on other species of hardwoods.

Site Location(s): The Clemson Experimental Forest, Clemson University’s multiple use research forest contiguous with the campus in Clemson, SC.

Timetable and Funding Sources: The demonstration area was established about seven years ago but is not presently active.

Remaining Gaps/Opportunities: Ecosystem carbon and nutrient sequestration could be monitored long-term along with treatment effects on vegetation. Data produced by this demonstration area, like a pilot study, could provide valuable information for future research.

Project Description: This method was developed by Dr. Van Lear and his former grad student Pat Brose. The method’s goal is to increase the oak component of the regeneration pool on good upland sites. Other species on these sites dominate the oak regeneration which, over time, reduces the numbers of oaks in the overstory.

Key Publications: (not from demonstration area)

DEVELOP KNOWLEDGE, METHODS AND GUIDELINES TO EVALUATE
THE EFFECTS OF NATURAL RESOURCE MANAGEMENT ON FORESTED
WATERSHEDS

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Scope and Objectives: Quantifies impacts of alternative forest practices on soil and water resources. Guidelines and evaluation tools will be developed with an emphasis on responses of vegetation diversity, soil nutrients, and site productivity. The Wine Spring Creek Ecosystem Management Project will continue, and the research work unit (RWU) plans new studies in three key areas: prescribed burning, land use change, and watershed restoration.


Project Description: We conducted watershed-scale studies on the effects of prescribed fire on ecosystem processes such as net primary production, nutrient and carbon cycling, and vegetation changes in multiple forest types. We examined the effects of a single dormant-season fire on carbon and nutrient cycling, water quality, and vegetation dynamics in three ecosystem types.

Key Publications:
REMOTE SENSING FOR FOREST CARBON MANAGEMENT

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Scope and Objectives: The overall aim of this component is to develop or refine the remote sensing applications and related earth system models needed for forest carbon management. Primary objectives are 1) refine our current algorithms, protocols, and models using MODIS, ASTER, ETM+, MISR and/or commercial remote sensing data to monitor and model forest area and carbon from the sub-stand to regional scales; 2) provide new methods for improving wetlands maps that utilize unique characteristics of the current suite of Earth Observing System sensors; 3) develop algorithms to remotely estimate the reforestation—and thus carbon sequestration—potential of mined lands’ and 4) decrease the run time required for the IGSCR (and other NASA-developed algorithms being used directly in support of end user applications).

Timetable and Funding Sources: NASA, 2004-2006

Project Description: Algorithms, models, and protocols being refined or developed using data from NASA and commercial sensors will support forest carbon management decision support systems used by a wide variety of partners and stakeholders, including the coal industry, NGOs, forest industry, state natural resources agencies, the USDA forest service, National Wetlands Inventory (NWI), and DOE. Building on a strong existing base, the tools and data products that we are developing in partnership with NASA improve resource management and policy decision support in the Carbon Management National Priority Application, with secondary emphases on Agricultural (Forest) Efficiency and Ecological Forecasting. Our primary focus is on making current data and methods usable for scientists and managers in the relevant federal and state agencies. This includes not only well designed web gateways, user-friendly software, understandable documentation, and tailored workshops, but also mechanisms to foster explicit integration of the information derived from remotely sensed data into institutional decision support for tactical and strategic planning.
STRENGTHENING RESEARCH ON WATERSHED HYDROLOGY IN LOUISIANA

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Scope and Objectives: This project investigates spatiotemporal associations among hydrologic conditions, inland stream chemistry, land use, and terrestrial carbon at the watershed scale for protecting and enhancing the quality of the Louisiana’s waters. Objectives are 1) space-time analyses of surface water quality at the watershed scale across the state of Louisiana; 2) evaluation of effectiveness of Louisiana’s current forest Best Management Practices in water quality protection; 3) hydrologic and hydrometeorologic impacts on water quality variability in the coastal inland streams, lakes, and wetlands; and 4) assessment of carbon conservation and sequestration potential of Louisiana’s watersheds.

Project Description: The project will be accomplished through a combination of field experiment at both plot and watershed scales, instream water quality monitoring, gathering of long-term spatial data on water quality, stream discharge, soil, land use/cover and climate, quantitative assessment, and hydrologic/biogeochemical modeling.