Draft Study Plan

March 20, 2009

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Southern Forest Futures Project

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April 1, 2009

Introduction

The US Forest Service, Southern Research Station and Southern Region, in partnership with the Southern Group of State Foresters, have launched the Southern Forest Futures Project (Futures Project). This effort builds directly on the Southern Forest Resource Assessment (2002) which identified several forces of change reshaping forests and the potential implications of these changes for economic conditions and ecological services. The Futures Project now examines how these and other emerging factors could reshape forests over the next half century and beyond. While SFRA forecasted some conditions, it focused primarily on understanding trends and conditions. The SFFP focuses now on forecasting future change and its potential implications to address the following goal:

…to ***inform forest management choices, policy discussions, and science programs with the best possible understanding of the long term implications of changes in southern forests***

This document details the technical plan for conducting the Futures Project utilizing a three tier analysis approach. The plan is designed to address the simultaneous needs for a coherent regional outlook on forest futures and a more detailed analysis of ecological, economic, and social effects. The three tiers, forecasting analysis, meta-issue analysis, and subregional analysis are described in turn below.

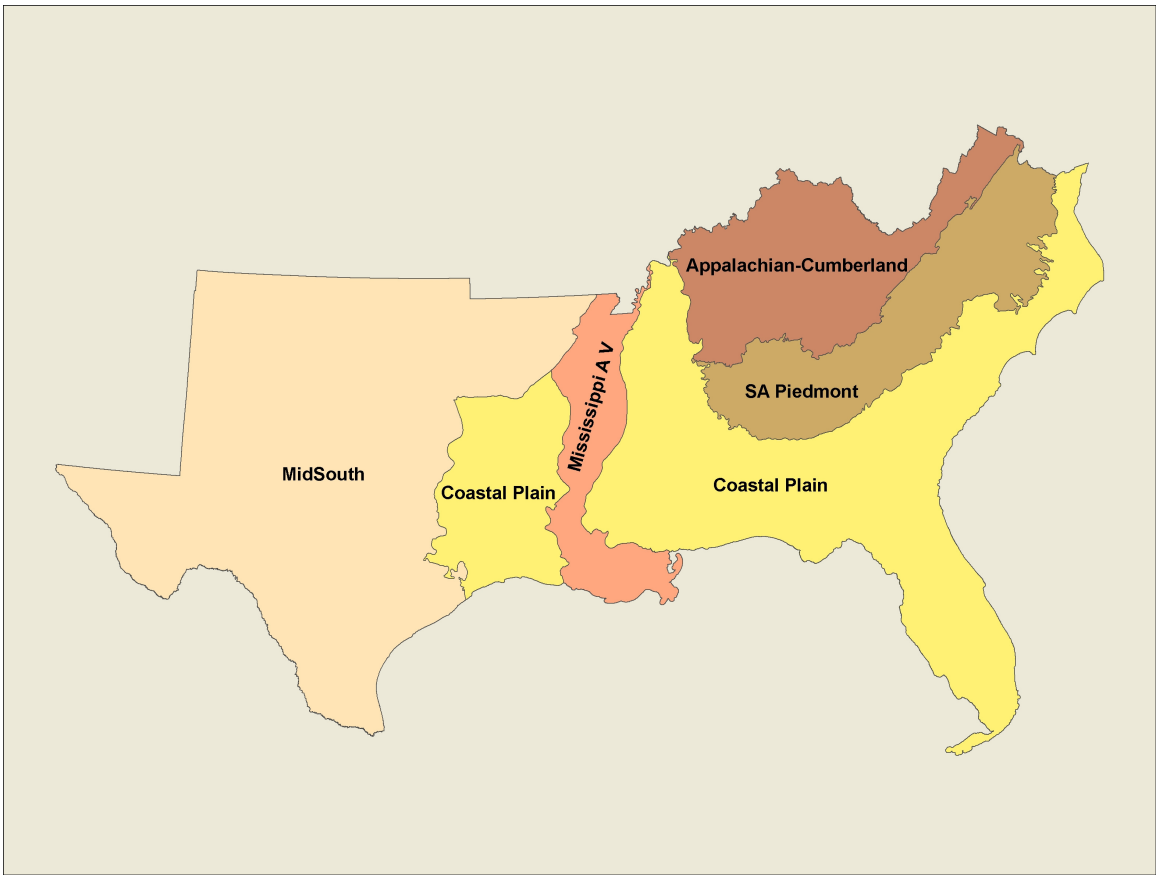
Forecast Analysis: The first tier of analysis will address a number of alternative scenarios describing potential futures. These scenarios will be drafted by a team of experts using the input from public meetings as a starting point. Each scenario will describe a distinct set of possible, and internally consistent, social, economic, and biophysical forces and how they may play out over the next 50 years. Quantitative models will then be used to forecast the implications of these discrete scenarios. [1]

Meta-Issue Analysis. This second tier of analysis will be used to address broad issues at the regional level using a knowledge-synthesis approach similar to that used in the Southern Forest Resource Assessment. That is, for each regional meta-issue developed through the public input process (see Wear, Greis, and Walters 2009), scientists/analysts

[1] Quantitative analysis of forest futures will be organized around a technical forecasting system, the US Forest Assessment System or USF^{A}S (Wear 2005). This forecasting system simulates future forest conditions and structure in response to land and resource markets as well as climate and other disturbances for all states in the South (see Figure 1).

will be enlisted to compile the best available information to address the various aspects of the issues. They will use forecast results and a deductive approach to describe the possible effects of scenarios on the evolution of these issues and gauge the uncertainty associated with effects.

Subregional Analysis: Every subregion of the South has unique ecological and social attributes and specific issues of concern regarding forest ecosystem and economic changes. What's more, most ecological and forest resource research is specific to particular ecosystem types. In this third tier of analysis, a team for each sub-region will interpret findings from the other two tiers. These teams will evaluate the "downscaled" results of the scenario-based forecasts (tier 1) and the findings of the regional meta-issue analyses (tier 2) to further describe specific implications for each sub-region. In a few limited cases, additional expertise will be secured at the sub-regional level to address very specific sub-regional issues not addressed by the other tiers.



For the Futures Project, the South has been divided into five large sub-regions (Figure 1). These divisions are roughly based on aggregations of similar ecological units and each has separate social/cultural/economic identities as well. However, individual sub-regions are not homogenous, so the sub-regional teams will strive to address the diversity of conditions and concerns within their sub-region. The five sub-regions are:

- Coastal Plain—the southeastern coastal plain from Virginia, down the Atlantic Coast and across the Gulf Coast to the Mississippi Valley.

- Piedmont—the Southern Appalachian Piedmont from northern Virginia through Alabama to the Mississippi Valley.
- Appalachian-Cumberland—including the Southern Appalachian Mountains and the Cumberland Plateau and ecological sections to the north of these mountains. This includes the entire states of Kentucky and Tennessee as well as portions of Alabama, North Carolina, and Virginia.
- Mississippi Alluvial Valley—from Tennessee to the Gulf of Mexico.
- Mid South—all land to the west of the Mississippi Valley and extending to the western boundaries of Texas and Oklahoma.[2]

Structure of the Plan

The forecasting tier is organized around three modeling components:

A. Land use forecasts
B. Wood products forecasts
C. Forest condition forecasts

The meta-issue analysis tier addresses nine broad meta-issues regarding the future of southern forests:

1. Social and Economic Factors
2. Wildlife and Forest Communities
3. Water
4. Taxes
5. Climate Change
6. Fire
7. Forest Ownership Changes
8. Invasive Species
9. Bioenergy

For each of these twelve areas (three forecasting and nine meta-issues) we provide an organizing question and then several specific issues that will be addressed. Related subregional issues are listed, along with the subregion(s) where each was identified during public meetings and where subregional team leaders propose to address them. Some of the subregional issues apply to multiple subregions, and may also be addressed in them.

We then specify the analysis methods that will be used to address the questions/issues, along with sources of information, potential cooperators, and linkages to other sections of

[2] In addition, Puerto Rico and the U.S. Virgin Islands are initiating a forest resource assessment as a first step toward forecasts of future Islands forests. An Islands Team will eventually be formed and a parallel approach to evaluating the Islands forest future will be linked to the Futures Project.

the Futures Project. Finally, the Plan concludes with a description of the general approach for conducting the subregional analyses.

Forecasting Analysis

Forecasting analysis will be conducted using the US Forest Assessment System (USFAS) developed for the national RPA assessments. This system interprets forest uses (land use and timber production) in the context of forest growth dynamics (including natural succession, disturbance, and climate) to forecast forest conditions. We divide the analysis of forecasts into three major areas: (1) land use change, driven by various social and economic factors, (2) forest products markets, driven by markets for various goods and services, and (3) forest condition forecasts driven by human uses and various biophysical factors, including climate.

Forecasts using the USFAS and ancillary models will be driven by a set of scenarios developed for the Futures Project. These scenarios will be designed to evaluate a broad suite of potential futures that could alter forests in the region.[3]

A. Land Use Changes

Question: How will land use change in response to alternative futures regarding social and environmental conditions in the South?

Issues:

- Forecast land area in agricultural, developed, forest, and other land uses.
- Evaluate alternative patterns of urbanization.
- Define changes in the extent of the wildland urban interface.
- Forecast changes in these variables in response to alternative multiple attribute scenarios (anticipated futures)

Subregional Issues:

- Changes in land use, and in particular urbanization *(Piedmont)*
- Effects of agricultural commodity prices on land use *(MAV)*

Manager: David N. Wear, Southern Research Station, USDA Forest Service

Methods of Analysis: We will use two econometric models of land use at the county level to evaluate future land uses in the region. These models, one developed by Plantinga and Alig (2000x) and the other by Hardie and others (200x , see also Wear 2002) provide projections of future land use based on several driving variables such as population growth, personal income, farm income, farm costs, biophysical productivity measures, and timber prices. Patterns of urbanization are largely shaped by population forecasts. Land use projections are made for aggregate use classes: developed, crops,

[3] Scenarios will be described in a separate document.

pasture, forest and all other. Forecasts are generated by altering the path of these various input variables, for example, the change in population density over time.

Data and Information Sources: Comprehensive land use observations are based on detailed NRI inventories for the years 1982, 1987, 1992, and 1997. Additional state-level data are available for calibrating models for the year 2002. Agricultural data (including crop revenues and costs) are taken from the Census of Agriculture and population and other demographic data are taken from Census of Population. Forecasts of demographic variables are based on Woods and Poole (2008) as modified for the 2010 RPA Assessment.

Products: For each scenario, the model will be run to produce forecasts of all land classes for every county in the South on a decadal time step. These data will be summarized using tables and maps of land use change.

Potential cooperators: Analysis will be coordinated with RPA 2010 Assessment projections and models through Ralph Alig, USFS Pacific Northwest Station..

B. Forest Product markets

Question: How will forest products markets change in response to changing social and environmental conditions?

Issues:

- Forecast harvest of timber of various qualities
- Forecast change in response to various multiple attribute scenarios (anticipated futures)

Subregional Issues:

- Lack of wood processing industry and harvesting infrastructure in sub-region *(MAV)*
- Establishment of infrastructure to support transportation and processing of raw materials for new markets *(MAV)*
- Interaction of bioenergy markets and high quality hardwood markets and management *(App-Cumb)*
- Mulch industry (hurricane protection versus short term economics) *(Coastal Plain)*
- Impacts of pine straw management and harvesting *(Coastal Plain)*
- Effect of changing markets, including losses of traditional markets and gains in new markets. *(Piedmont)*
- Effect of changing markets and mill capacity on social conditions in rural counties *(Mid South)*
- Agroforestry opportunities that might supplement income on forested properties *(Mid South)*

Manager: David N. Wear, Southern Research Station, USDA Forest Service

Methods of Analysis: Forest products markets will be simulated using a set of nested models within the US Forest Assessment System. The South is one region in the US Forest Products Model (USFPM) which is nested within the Global Forest Products Market Model (GFPM). Analysis for the 2010 RPA Assessment will provide market forecasts for final products and timber products based on three scenarios (based on downscaled IPCC international scenarios). We will also evaluate fine scale changes in markets within the South, using demand functions for southern timber products and supplies derived from our forest dynamics model.

The GFPM simulates market clearing activities in multiple, linked forest product and timber markets using an optimization approach. As currently defined GFPM simulates markets for all countries in the world for fourteen classes of products. In addition, the GFPM simulates forest area and forest stock.

To address markets in the United States for RPA analysis requires more detail than provided for in the GFPM. In particular, it is important to examine separately the markets for hardwood and softwood sawnwood as well as the derived demands for hardwood and softwood pulpwood. The important interplay between public and private forests in the West and mainly private forests in the east suggests the need for regional market definitions. Separate regional US wood products markets in the GFPM framework allow simulations of policy and exogenous change that are relevant for RPA and SFFP needs.

Scenarios will evaluate the effects of changes in product markets, including biomass feedstocks for bioenergy production. In addition, we will use literature reviews to examine specific issues regarding production infrastructure and mulch and pine straw markets.

Data and Information Sources: FIA/TPO reporting defines the basis for modeling domestic timber market activities. FAO data are the basis for global products modeling. Timber price data will be derived from Timber Mart South reports.

Products: For each scenario we will provide projections of timber production quantities and timber prices for four product categories: Softwood and hardwood sawtimber and non-sawtimber (pulpwood and other small diameter products) across the region. Our forest dynamics model will provide estimates of where in the South harvests would be concentrated under each scenario. Harvest intensity maps will be provided.

Potential cooperators: Peter Ince (USFS Forest Products Laboratory), and Joseph Buongiorno (University of Wisconsin), and Jeff Prestemon (USFS Southern Research Station).

C. Forest Conditions

Question: How will forest inventories change in response to changes in land use, forest products markets, and environmental conditions?

Issues:

- How will the distribution of forest tree species be influenced by changes described in the anticipated futures?
- How will anticipated futures affect the area of forests within the region? Define where forest area will be most stable and where change will be focused.
- How will anticipated futures alter forest inventory within the region, including measures of biomass, size classes, and forest types.
- How would anticipated futures affect the carbon flux and sequestration capacity of forests within the region?

Subregional Issues:

- Conservation of coastal cypress-tupelo swamps in the Mississippi Valley *(MAV)*
- Increase in White Pine on ridges with fire exclusion *(App-Cumb)*
- Increase in Poplar post harvest *(App-Cumb)*
- Saltwater tolerant species/selections in coastal restoration *(Coastal Plain)*
- Saltwater incursion and regeneration and reestablishment of cypress forests *(Coastal Plain)*
- Declining forest types, specifically longleaf and shortleaf pine. *(Piedmont)*

Manager: Robert Huggett, North Carolina State University

Methods of Analysis: The Forest Dynamics Domain of the US Forest Assessment System will be used to simulate change in forest inventories over time. This model projects conditions at each plot within the existing forest inventory of each state using a set of transition probabilities attached to key plot attributes. Using stochastic modeling approaches, the condition of the new plot is generated to reflect timber harvesting, climate, forest aging, and natural succession. Once the condition of a plot is forecast then a historical plot with comparable conditions is selected to populate the future inventory. This imputation approach to generating future inventories allows for the full details of the inventory to be retained into the future.

Alternative inventories are generated in response to each scenario. Future inventories are sensitive to changes in land use (taken from forecast component A), timber harvesting driven by timber prices (taken from forecast component B), and climate futures (taken from Global Circulation Models and IPCC scenarios).

Data and Information Sources: The model is built from the most recent FIA inventory in each state. Transition models are built from observations of change in matched plots across multiple inventories linked to climate (e.g., temperature, precipitation, and potential evapotranspiration) and economic data (e.g., timber prices). Historical climate data are taken from PRISM datasets and forecasts of climate are taken from several IPCC scenarios and Global Circulation Models, downscaled for the 2010 RPA Assessment.

Products: We will generate forest inventories for each scenario evaluated on a decadal basis. Inventories are generated at the plot level and will be summarized in a variety of ways: states, survey units, sub regions, and portions of subregions. Data will be delivered as maps and as standard FIA tables for these subdivisions.

Potential cooperators: David Wear, Robert Abt (North Carolina State University), Ruhong Li (North Carolina State University), Linda Joyce (USFS Rocky Mountain Research Station) and John Coulston (USFS Southern Research Station).

Meta-Issue Analysis

The Futures Project began with a thorough scoping of the issues of concern to the interested public (Wear, Greis and Walters 2008). The public participation process yielded a large complement of issues to be considered in the conduct of the Futures Project. Among these were nine overarching issues that warrant thorough study. We've labeled these "Meta-Issues."

The Meta-Issues are described below. In addition to an overarching question, the Meta-Issue is defined by a set of specific issues that need to be addressed in terms of their broad regional implications. We also define a set of issues that are especially important within specific subregion of the South. Each Meta-Issue will be addressed by an analyst or a team of analysts. Implications for each Subregion will be drawn out by the Subregional analysis teams working with the meta-issue teams.

1. Social/Economic

Question: How will alternative futures be affected by changing demographics and values and how will these futures alter certain social and economic benefits in the South?

Issues:

- How are population, demographics, and values changing and what might these changes mean for forests futures?
- How and where will population growth, changing demographics ownership and land use affect supply and demand for different types of forest-based recreation?
- How and where might forest-based employment and income be affected by anticipated futures?

Subregional Issues:

- Increased use of federal and state lands resulting from growth in adjacent metropolitan areas*(MAV)*
- Increased use of federal and state lands resulting from exclusive recreational development by new owners of private lands *(MAV)*
- Increased afforestation for non-timber objectives *(MAV)*
- Shift in jobs from timber to recreation *(App-Cumb)*
- Wood energy markets impacts on employment *(App-Cumb)*

- Changes in outdoor recreation and impacts on forests (especially public forests) *(App-Cumb)*
- Conflicts in recreation *(App-Cumb)*
- Decreasing timber production and increasing recreation from piedmont forests *(Piedmont)*
- Changes in demographics of timber harvesting workforce and implications on supply of labor for traditional forest industry *(Mid South)*
- Changing cultural attitudes toward forests and forest management associated with changing ethnic populations, especially Hispanics *(Mid South)*

Meta-Issue Managers: Karen Abt, Ken Cordell, and Mike Bowker, Southern Research Station, USDA Forest Service

Methods of Analysis:

A. How are population, demographics and values changing and what might these changes mean for forests and their uses? The South is one of the fastest growing regions in the United States in terms of population, economic activity and land development. The South is also one of the most rapidly changing regions in terms of the demographic makeup of its population. The purpose of this analysis will be to describe and interpret population, housing, associated development, demographic, economic, and other societal trends and futures across the scenarios defined for the 2010 Renewable Resources Planning Act Assessment. This work will provide 50-year projections of population totals and 30-year projections of population by demographic strata across the 3 IPCC scenarios adopted for the 2010 RPA Assessment. Both spatial and temporal scales will be analyzed and displayed. (These projections are also incorporated in land use and product demand forecasts.

B. How and where will population growth, changing demographics ownership and land use affect supply and demand for different types of forest-based recreation? Forecasts of recreation demand developed for the three IPCC scenarios adapted to the 2010 RPA Assessment will be used to evaluate a range of likely futures for recreation in the South. These forecasts will be used to evaluate questions regarding the evolving scarcity of recreational opportunities, potential for congestion and conflict among recreation groups, and increasing pressure on public lands in the South

C. How and where might employment and income be affected by anticipated futures? This question can be broken into four separate components: (1)What will the 'new' logging industry look like? (2) How will employment in traditional industries change as a result of forecast changes in final demands from these industries as well as competition for the timber resource from biofuels/energy industries? The current economic recession, combined with renewed federal subsidies and interest in biofuels/energy development could lead to long term structural changes within the traditional industries, permanently altering industry employment and income. (3) What will be the employment profiles of the new biofuels/energy industries? Will the shift from traditional to biofuels/energy

industries move jobs and change total employment? (4) What is the future of employment/income which relies on forest-based recreation?

Forecasts will reveal shifts in timber harvests (geographically and over time). These shifts will correspond to changes in wood-using industry employment. In addition, continued changes in labor and capital productivity will alter employment even if the industry otherwise stays exactly the same. Response coefficients and multipliers developed previously for state-level analysis will be used, in addition to information from other sources, to provide qualitative estimates of changes in employment and income from the forecasts. In addition, recreation analysis from above will provide input on how recreation demand will vary by forecast.

Data and Information Sources:

Principal data sources for A will include:

-The Forest Service RPA population, demographics, housing, economic and land use trend and forecast data which is based on Census 2000, Census projections, IPCC scenario projections, and data products from Woods & Poole Economics, Inc. and their CEDDS data set, and other sources as needed.
-Social tracking systems, such as the Pew Center's social trends.
-National surveys such as the American Housing Survey, American Time Use Survey, National Personal Transportation Survey, and others.
-Department of Homeland Security, U.S. Citizenship and Immigration Services (formerly the Immigration and Naturalization Service) data bases covering legal immigration from abroad, estimates of net undocumented immigration, intra-country migration, net movement between Puerto Rico and the U.S. mainland, and other regional population change forces.
-Current estimates and spatial projections of population migration trends relative to land use changes, including FIA and NRI data, and land cover changes, e.g., NLCD.
-Current Business Patterns and other economic census data.

Products: We will produce a discussion of historical and forecasted changes in population, demographics and values in the South as well as historical and forecasted change in recreational uses and employment and income. Maps as well as tabular displays of forecasted changes will also be generated.

Potential cooperators: Robert Rummer and Janaki Alavalapati

2. Wildlife and Forest Communities

Question: How might changes in forest environmental and social conditions affect terrestrial wildlife (birds, mammals, reptiles, and amphibians), their habitats, and forest vegetation communities in the South?

Issues:

- How would anticipated fragmentation and population growth, urbanization,and related infrastructure affect wildlife habitats within the region?
- How might anticipated futures affect wildlife diversity in the region and where would changes likely be concentrated?
- What are the implications of anticipated futures for imperiled, rare, threatened and endangered wildlife and plant species?
- How will rare forest communities be affected by anticipated futures?

Subregional Issues:

- Effects of anticipated futures on Ivory-billed woodpecker, Louisiana black bear, and other rare species. (MAV)
- Effects of anticipated futures on wildlife and plants from potential degradation/loss in high elevation forests. (*App-Cumb*). Section content is dependent on modeled predictions received from Forecast Team.
- Effects of potential changes in early successional communities; includes effects on neotropical migrants and other species relying on these habitats. (*App-Cumb*). Section content dependent on modeled predictions received from Forecast Team.
- Effects of anticipated futures on interior forest species of upland hardwood forests. (*App-Cumb*). Section content is dependent on modeled predictions received from Forecast Team.
- Effects of anticipated futures on the capability to manage TES. Discussion will include urban/wildland interface, and other factors affecting habitat management approaches. (*Piedmont*)
- Effects of anticipated futures on bird migration corridors (e.g., neotropical migrants, waterfowl, and others). (*MAV*)
- Effects of nutria on regeneration and reestablishment of cypress forests. (*Coastal Plain*)
- Effects of anticipated futures on forest-grassland ecosystems (*Mid South, Coastal Plain, App-Cumb*).

Meta-Issue Managers: Margaret Trani Griep, Southern Region, USDA Forest Service
Beverly Collins, Western Carolina University

Methods of Analysis:

1. How would anticipated fragmentation and population growth, urbanization and related infrastructure affect wildlife habitats within the region?

- Synthesize the published literature relevant to wildlife and fragmentation, land use change (including wildland/urban interface), urbanization, and infrastructure.
- Describe consequences of fragmentation including loss of interior forest, increases in edge, habitat isolation, and reduced patch size of natural-occurring wildlife habitat.
- Identify potential causes of fragmentation (development, road networks, other), and how wildlife is influenced both positively and negatively by the resulting landscape pattern.

- Identify how habitat and selected species are affected by roads, highways, and selected other infrastructure (disruption of movement corridors, migration routes, bisecting critical habitat, alteration and degradation of habitat).
- Identify and describe the effects of anticipated futures on bird migration corridors.

2. How might anticipated futures affect wildlife diversity in the region and where would changes likely be concentrated?
   - Identify and describe areas of unique species richness and list representative species occurring in these areas. Discuss anticipated effects of future forecasts (both positive and negative) on these areas.
   - Identify effects on selected game, pest, and urban wildlife species.

3. What are the implications of anticipated futures for imperiled, rare, threatened and endangered forest plants and wildlife species in the region?
   - Identify and describe hotspots of occurrence for critically imperiled, imperiled, and vulnerable (G1-G3) and federally listed terrestrial vertebrates and forest plant species. Analyses will be separated for these taxa.
   - Discuss the effects of anticipated futures on the ivory-billed woodpecker, Louisiana black bear, and other species of conservation concern.
   - Create tables and graphics of regional G1-G3 bird, mammal, reptile, and amphibian species.
   - Discuss effects of anticipated futures on selected species and their habitats within these groups.
   - Describe vulnerability and threat factors for selected wildlife and forest plant species.
   - Discuss the effects of anticipated futures on the capability to manage imperiled species.
   - Describe management challenges for selected wildlife and plant species. Discussion will include factors affecting specific approaches.

4. How might rare forest and other communities respond to anticipated futures (including potential climate conditions)?
   - Identify rare forest communities and discuss factors affecting them, and the species that depend on them, in the context of anticipated futures. Include early seral communities, high elevation forests, and grassland-forest communities; consider longleaf-wiregrass, pine-bluestem, and oak woodland. Section content is dependent on modeled predictions received from Forecast Team.
   - Synthesize the published literature relevant to the potential influence of climate change on selected plant communities and related wildlife. Focus on vulnerable communities in the subregions; discuss how changing climate (e.g., extended drought, precipitation events) may influence plant associations and why these communities may be more affected than others.

Data and Information Sources:
- Regional habitat relationships literature for the four taxa.
- Forecast tables and maps from SFFF research team.

- NatureServe spatial and tabular data.
- Fish and Wildlife Service federally listed species status and related data.
- Partners in Flight, Bird Conservation Region, and Joint Ventures species priority lists and habitats of concern.
- Published literature.
- Potential RPA hotspot analysis data.

Links to other parts of the Southern Forest Futures: The analysis will use the forest condition, land use, and population forecast data supplied by the team to project changes in wildlife species composition and habitat in the South. The analysis will also coordinate with the Forest Landownership, Fire, Invasive Species, and Climate Change Meta issue teams.

Products: In addition to the narrative final report, the following products will be developed:

- Regional and state terrestrial forest plant and wildlife tables with conservation status ranks and habitat associations.
- Graphic: Proportion of southern terrestrial vertebrate species at risk.
- Graphic: No. of terrestrial vertebrate species at risk by major taxa.
- Maps and related tables of areas supporting unique species richness (separate products by taxa) potentially defined by population occurrence or frequency counts by county.
- Maps and related tables of hot spots of species rarity depicting the distribution of G1-G3 species (separate products by taxa) potentially defined by population occurrence or frequency counts.
- Maps and related table depicting the distribution of federally listed threatened and endangered species (separate products by taxa) potentially defined by population occurrence or frequency counts by county.
- Maps of selected rare or at-risk plant communities by subregion.
- Graphic: Proportion of plant species at risk in selected habitats (at-risk communities and focal habitats (upland and lowland hardwoods, natural and planted pine).

Potential cooperators:

- NatureServe
- American Bird Conservancy
- Coordinators from SE Partners in Flight, Bird Conservation Regions, and Joint Ventures.
- U. S. Fish and Wildlife Service
- State herpetologists
- So. Center for Wildland/Urban Interface Research and Information
- SE Partners in Reptile and Amphibian Conservation
- Gap Analysis

3. Water

Question: What roles do forests and forested wetlands play in producing and protecting water resources in the South and how might future land management and land use change affect these roles?

Issues:

- Describe the relationship between forests and water timing, flow and quality.
- Discuss how forest conversion and loss affects these relationships.
- Describe the implications of intensive forest management for water.
- Discuss the roles of forested wetlands and riparian areas in protecting water quality, and describe potential implications of their conversion and loss.
- Discuss the implications for increased demand and interactions with forest conversion, drought, and climate change.
- Describe the known effects of impoundment construction on forests and associated resources.

Subregional Issues:

- Effects of Hemlock loss on riparian ecosystems *(App-Cumb)*
- Effects of wetland loss on wastewater assimilation *(Coastal Plain)*
- Effects of wetland loss on storm mitigation *(Coastal Plain)*
- Effects of changes in forests on water quality and quantity, in particular resulting from and affecting urban areas. *(Piedmont)*
- Restoration of riparian buffer strips and artificial wetlands *(MAV)*
- Nutrient sequestration and the Gulf Hypoxic Zone *(MAV)*
- Loss or gain of connectivity between river and floodplain *(MAV)*
- Projections of water quantity between 90th and 105th meridian (*Mid South*)

Meta-Issue Managers: Graeme Lockaby, Auburn University and James M. Vose, Southern Research Station, USDA Forest Service

Methods of Analysis:

Describe the relationships between forests and the timing, quality, and quantity of water. These relationships have been described in detail in many publications and recent syntheses (e.g., the National Research Council Report 2008). We will draw on some of the most recent work conducted by Lockaby as part of an Eastwide synthesis of forest-water relationship in collaboration with Dr. Paul Barten at University of Massachusetts.

Discuss how forest conversion and loss affects these relationships. We will compare and contrast variation in water resources (quality, quantity, and timing) across a range of land uses (i.e., forest, urban, agriculture) in the South. We will draw on some of the most recent work conducted by Lockaby as part of an Eastwide synthesis of forest-water relationship in collaboration with Dr. Paul Barten at University of Massachusetts.

Discuss the roles of forested wetlands and riparian areas in protecting water resources, and describe potential implications of their conversion and loss. We will draw on existing literature to briefly describe the role of riparian wetlands as filters for pollutants in surface waters and in maintaining stable flows. The effect of land use changes on direct losses of wetlands as well as the impact of those changes on downstream hydrographs and, subsequently, decreased connectivity between terrestrial and aquatic systems will be postulated and summarized. We will use this information to estimate the net effect of changing land use and climate on the protective functions afforded by riparian wetlands in regard to surface water quality and quantity.

Describe the implications of intensive forest management on water resources. For implications for water quality, we will review existing literature and utilize a recent synthesis of the effectiveness of BMP's conducted by Anderson and Lockaby as part of a project assessing BMP effectiveness in the South. For water quantity, we will summarize results from experimental watersheds and other measurement methods (e.g., sapflow) to examine impacts of intensive forestry and the quantity and timing of water resources.

Discuss the implications for increased demand and interactions with forest conversion and drought. We will adapt the modeling approach develop by Ge Sun et al. (JAWRA 44(6):1441-1457) to assess how the combination of increased demand, changing forest cover, and increased drought frequency will impact water resources in the South. Areas that are projected to be most impacted will be identified and displayed graphically.

Describe the effects of impoundment construction on forests, downstream wetland and riparian ecosystems, and other associated resources. We will quantify the volume of surface water that will be required to satisfy water demand for all uses in the next 30 years, then estimate the acreage of land required to impound (and the associated watershed size required to keep it full) that volume of water on a state-by-state basis. We will then provide an estimate of the loss of forest habitat and future management options, as well as an assessment of how altered flow regimes impact downstream aquatic and riparian wetland ecosystems.

Data and Information Sources:

- Previous studies
- USGS Streamflow Gauges
- Land Cover Maps (current and projected)

Products: (1) maps of areas where the combination of projected changes in forest cover and increased demand are likely to result in water shortages (with and without drought), (2) maps of areas where projected changes in forest cover are likely to impact water quality (3) maps of wetland and riparian areas most vulnerable (and with the highest impact if lost) to forest conversion.

Cooperators: Steve McNulty and Ge Sun, USDA Forest Service Southern Global Change Program; Dr. Paul Barten, University of Massachusetts; Dr. Yanli Zhang, S.F. Austin University.

4. Taxes

Question: How might taxation influence the loss, gain or retention and management of forest land in the South?

Issues:

- Consider effects of estate, income, severance and property taxes for non-industrial forest owners.
- Describe the effects of differential income taxes for "C" corporations.
- Describe how the tax structure is known or likely to affect conservation easements or other forms of forest stewardship.

Subregional Issues:

- Alteration to county tax bases resulting from afforestation *(MAV)*
- Altered tax bases resulting from afforestation of private lands and increased public ownership (*MAV*)

Meta-Issue Manager: John Greene, Southern Research Station, USDA Forest Service

Methods of Analysis:

Describe the effect of federal and state income taxes on non-industrial private forest owners: Summarize the findings of ongoing research on the effect of federal and state income taxes on forest productivity and returns to forest management; combine with the results of recently completed research on non-industrial private forest owner knowledge of federal income tax provisions to estimate the overall effect.

Describe the effect of property taxes, the federal estate tax and state estate and inheritance taxes on harvests from and sale or conversion of non-industrial privatef forest land: Summarize the findings of recently completed research on the effect local property taxes and the federal estate tax on non-industrial private forestland; combine with updated results from existing tax effects models to estimate the overall effect.

Describe the effect of differential income taxes on harvests from and sale or conversion of forestland held by "C" corporations: Summarize the findings of recent research on the economic effect of the differential federal income tax rates paid by "C" corporations and by REITs (Real Estate Investment Trusts) and TiMOs (Timber Management Organizations).

Consider how the current tax structure affects the use of easements and other conservation mechanisms, sustainable forest management, and provision of ecosystem services: Summarize federal, state, and local tax provisions that encourage or discourage sustainable forestry and the use of easements and other conservation mechanisms;

combine with the literature review and findings of recently completed research on financial incentives for practicing sustainable forestry on non-industrial private forestland.

Describe the effect on county governments in the MAV of decreased property tax revenues resulting from the afforesation of cropland and increased public ownership of forestland resulting from property tax default: Develop a preliminary case study based on interviews with tax officials in selected MAV counties.

Data and Information Sources:

- National Woodland Owner Survey database;
- Research database on the effect of the federal estate tax on forest estates;
- Research database on forest owner knowledge and use of federal income tax provisions;
- Research database on the total tax burden on private forestland in the U.S.;
- Draft annotated bibliography of the literature on the tax, cost-share, and other financial incentives available to non-industrial private forest owners;
- Research database on state agency forester assessments of public and private financial incentive programs available to non-industrial private forest owners;
- Research database on non-industrial private forest owner attitudes toward public and private financial incentive programs; and
- "Financial Incentive Programs for Non-Industrial Private Forest Owners" website.

Products: Narrative report with tables.

Potential Cooperators:

- Brett Butler, Research Forester, USDA Forest Service, Northern Research Station, Family Forest Research Station;
- Tamara Cushing, Assistant Professor, Clemson University, Department of Forestry and Natural Resources;
- Terry Haines, Research Forester, USDA Forest Service, Southern Research Station, Economics and Policy Research Unit;
- Evan Mercer, Research Forester, USDA Forest Service, Southern Research Station, Economics and Policy Research Unit;
- Steverson Moffat, Research Forester, USDA Forest Service, Southern Research Station, Economics and Policy Research Unit;
- Tom Straka, Professor, Clemson University, Department of Forestry and Natural Resources; and
- Linda Wang, National Forest Taxation Specialist, USDA Forest Service, Region 8 Cooperative Forestry.

5. Climate Change

Question: How might the environmental conditions associated with climate change affect forest ecosystem health and productivity?

Issues:

- Describe forecasts for pertinent climate change variables and how southern forests are likely to be affected.
- Where in the South might forecasted changes in environmental conditions due to climate change be most/least significant?
- Evaluate the nature and extent of interactions of potential climate change outcomes e.g. severe weather events, drought, with forest pests.
- Describe the range of economic consequences of extreme weather events for landowners, forest industry and local government.

Subregional Issues:

- Effect of warming on high elevation forests *(App-Cumb)*
- Effects of sea level rise on coastal forests *(MAV)*
- Projected shifts in hydrographs of major rivers and tributaries *(MAV)*
- Inclusion of transitional forests and grasslands in these assessments *(Mid South)*

Meta-Issue Manager: Steve McNulty, Southern Research Station, USDA Forest Service

Methods of Analysis:

A. Describe forecasts for pertinent climate change variables and how southern forests are likely to be affected. Where in the South might forecasted changes in environmental conditions due to climate change be most/least significant? The PnET model is an in-house tool that has been used to predict forest productivity under several climate change scenarios for previous assessments. Climate change forecasts will be processed for use in the PnET model to provide estimates of NPP and water availability.

B. What are the possible effects of sea level rise on coastal forests (MAV)? Global mean sea-level rise was estimated by the IPCC for the 21st century for the six special report on emissions scenarios (SRES). The sea-level rise estimates ranged between 0.28 to 0.43 meters. In a regional or local context sea-level rise can be higher than the global mean, especially in areas like the Mississippi Delta that experience subsidence (Nicholls et al., 2007). Costal forests are adversely affected by sea-level rise through increased flood frequency, soil salinity, or coastal erosion (Williams et al, 1999). Utilizing the United States Geological Survey (USGS) National Elevation Dataset (NED) and the United States Forest Service (USFS) Forest Inventory Analysis (FIA) / Remote Sensing Application Center (RSAC) Forest Types of the United States dataset we will determine the coastal forest area and specific forest species within the Southern Research Station that would be affected by a 1 meter or 2 meter sea-level rise.

C. What are the projected shifts in hydrographs of major rivers and tributaries (MAV)? We will use the Water Supply Stress Index model (WASSI) to predict how the ratio of water demand to supply in the MAV is influenced by the pertinent climate change

scenarios. Output from the model will be displayed as maps detailing potential changes in the hydrographs of major rivers or streams.

D. Evaluate the nature and extent of interactions of potential climate change outcomes e.g. severe weather events, drought, with forest pests. Human alterations of natural disturbances can affect tree physiology and the ability of tree species to recover from or resist forest pests (O'Leary, 1981). The disturbances across the forested landscape differ in time, space, magnitude and return periods; therefore these variations should be considered and evaluated with regard to the physiological responses in trees or forests to climate change. Short-term exposure to drought conditions may increase tree resistance to pest by subsequently lowering tree growth rates and shifting the use of photosynthate to the production of resin. Chronic drought conditions may increase the insect influence of pest attack due to depleted carbon reserves (Christiansen et al. 1987). As ecosystem consequences of drought and other severe climate events are realized, tree species mortality rates may increase resulting in more adverse disturbances such as increases in fire intensity and severity and insect reproductive cycles. Regulatory measures on emissions and better management of our forests may help mitigate the overall impact of disturbances on the regions forested ecosystems. We review and synthesize existing literature to evaluate these potential impacts in the South.

Data and Information Sources:

For A, B, and C:

- Climate change forecasts (IPCC SRES) for the five subregions.
- FIA derived map of forest types and/or tree species of interest in the five subregions.
- Empirical data to relate PnET model estimates of NPP to NEE and NEP.
- NPP, NEP and NEE estimates across subregions from PnET

For D:

- Literature search –
    - identify the interactions of climate change and forest insects and the associated ecosystem consequences.
    - identify the most relevant pests to forest infestation, damage and species mortality in southern US.
    - identify the most relevant tree species or forest types that are most susceptible to forest pests.
- Map of current insect infestations (including taxonomic classifications and spatial extent) across subregions.
- Map of forest types in subregions.
- Climate change forecast and/or occurrence of extreme weather events for the five subregions.

Products:

In addition to the narrative final report, we will develop maps showing:

- current and projected future forest growth across the five subregions.
- current and projected future forest water availability across the five subregions.

- current and projected future NEE and NEP rates across the five subregions.
- projected shifts in hydrographs of rivers and major tributaries for the MAV.
- current and projected carbon flux rates across the five subregions.
- Map showing historical disturbance spatial interactions (e.g., overlay drought 2007, forest type, and forest pest outbreak for region).
- Map showing future disturbance spatial interactions (e.g., overlay drought 2020, forest type, and forest pest outbreak that is based on empirical data or inferential evidence).
- Assess pest damage and the spatial extent of how and why that future damage under a changing climate departs from historical spatial patterns and occurrences.
- Identify if the reproductive cycle of pest coincide with the weather event (TABLE) (i.e., if the reproductive cycle of the pest is not synchronized with the event then there is no affect).
- Table showing our level of certainty that climate change will have ecologically significant consequences on the most relevant and sensitive forests and forest pests in the region.

Potential Cooperators:

Staff of the Southern Global Change Program (Others TBD)

References:

Christiansen, E., Waring, R.H., and Berryman, A.A. 1987. Resistance of conifers to bark beetle attack: Searching for general relationships. Forest Ecology and Management 22, 89-106.

O'Leary, M. H. 1981. Carbon isotope fractionation in plants. Phytochemistry 20, 553–67.

Nicholls, R.J., P.P. Wong, V.R. Burkett, J.O. Codignotto, J.E. Hay, R.F. McLean, S. Ragoonaden and C.D. Woodroffe, 2007: Coastal systems and low-lying areas. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 315-356.

Williams, Kimberlyn; Pinzon, Z. S.; Stumpf, R. P.; Raabe, E. A., 1999. Sea-level rise and coastal forests on the Gulf of Mexico. Open file report 99-441. U.S. Geological Survey, Center for Coastal Geology St. Petersburg, Florida, p.127.

6. Fire

Question: How will fire behavior and fire risk change over time and what are the likely effects on communities and people?

Issues:

- Describe the current and potential fire behavior/fire risk in the South and discuss the factors contributing to potential changes.
- Discuss the likely future of prescribed burning in the South, factors affecting this practice, and alternatives to its use as a management tool.
- How will restricted or excluded prescribed fire affect fire-adapted and fire-dependent forest communities and other dependent species, and where will these effects be concentrated?
- Describe the economic consequences of reduced prescribed burning, including potential property and structural damage and loss, timber devaluation, liability, and emergency rehabilitation and reforestation costs.
- Compare wildfire and prescribed burning in the context of the carbon cycle, air pollution, forest productivity and forest health.

Subregional Issues:

- Species losses due to hotter fires *(App-Cumb)*
- Limitations on use of prescribed fire on fire-dependent ecosystems. *(Piedmont)*
- Wildfire risk with establishment and development of afforestation sites *(MAV)*
- Changing patterns of vegetation under fire exclusion in shrublands and grasslands *(Mid South)*

Meta-Issue Managers: John Stanturf and Scott Goodrick, Southern Research Station, USDA Forest Service

Methods of Analysis:

Describe the current and potential fire behavior/fire risk in the South and discuss the factors contributing to potential changes. We will use the Southern Fire Risk Assessment System (SFRAS) that was used to produce the Southern Wildfire Risk Assessment (SWRA) to evaluate current fire risk by sub-region and evaluate wildfire risk under future climate scenarios for areas of changing land use and population growth. Five sets of model runs of SFRAS will produce maps of the Wildland Fire Susceptibility Index for (1) baseline of current land cover, climate and fire occurrence; (2) changed land cover, current climate and fire occurrence; (3) changed climate, current land cover and fire occurrence; (4) changed land cover and fire occurrence, current climate; and (5) changed climate, land cover, and fire occurrence. Within each change scenario, we will display results at decadal intervals for 50 years.

Discuss the likely future of prescribed burning in the South, factors affecting this practice, and alternatives to its use as a management tool. We will develop an analysis of the current and potential policy and regulatory constraints on the use of prescribed burning based on current research and discussions with collaborators and examine alternatives based on reviews conducted for JFSP, available literature, and on-going research. We will discuss the implications of these constraints in terms of forest productivity, fire-dependent species, and fire-sensitive species.

How will restricted or excluded prescribed fire affect fire-adapted and fire-dependent forest communities and other dependent species, and where will these effects be concentrated? We will overlay a forest cover type map imputed from FIA with historic fire occurrences map to identify where conditions are favorable for fire adapted communities. We will correlate this with projected land use changes that could restrict or exclude prescribed fire. This spatial analysis will inform an analysis of effects based on literature.

Describe the economic consequences of reduced prescribed burning, including potential property and structural damage and loss, timber devaluation, liability, and emergency rehabilitation and reforestation costs. The analysis above of changing wildfire risk under land use/population change scenarios will be further developed using the outcome risk (values at risk) component of SWRA. The outputs from SWRA will be analyzed and compared to literature values.

Compare wildfire and prescribed burning in the context of the carbon cycle, air pollution, forest productivity and forest health. We will use outputs from the SWRA analysis (above), literature values and current research to develop scenarios for comparing severe wildfire versus frequent prescribed burning for pine forests of the Coastal Plain and how changing climate could affect fire behavior and fire occurrence.

Data and Information Sources:

- Southern Group of State Foresters Southern Wildfire Risk Assessment (SWRA)
- NatureServe database of TES species, data layer of fire-dependant communities from J. Coulston, biodiversity/wildlife data from Biodiversity/Wildlife Meta Issue manager
- FIA database of forest cover types
- Southern Fire Encyclopedia
- IPCC climate change scenarios, consistent with those used by the Climate Change Meta Issue manager
- Landuse/landcover change and forest conditions forecasts from the Forecast and Analysis Team
- Relationships between demographics and arson fires from the Values and Economics RWU
- Previous studies

Links to other parts of the Southern Forest Futures Project

- Forecasting and Analysis Team Land (use/land cover change forecasts)
- Climate Change Team (IPCC Climate Models need to be consistent)
- Invasives Team (data on cogongrass biomass and occurrence)

Products: In addition to the narrative final report, we will prepare review/synthesis/journal papers on smoke from wildland fire as an environmental hazard; evaluation of the SFRAS and recommendations for improvements; use of the Keetch-

Byram Drought Index to forecast climate change effects on potential for wildland fire under the IPCC climate scenarios; descriptions of current fire risk by sub-region with accompanying GIS layers on CD-ROM

Potential cooperators:

- Staff of the Center for Forest Disturbance Science
- Staff of the Economics and Evaluation Research Work Unit (Fire Economics Team)
- Southern Group of State Foresters
- Others TBD

7. Forest Ownership Change

Question: Describe recent and anticipated changes in forest ownership in the South and the implications of these changes for forest ecosystem conditions, management and productivity.

Issues:

- Describe how much and where forest land has changed ownership in recent years and where changes will likely be concentrated in the future.
- Describe the economic determinants for ownership change (all ownership categories) and how they might change in the future.
- Describe how forest land use and forest uses are likely to change as a result of shifts in ownership.
- Evaluate how forest management practices are influenced by ownership change and describe the ramifications of those influences.
- Describe how changing forest ownership is likely to affect the forest products industry.

Subregional Issues:

- Increase in public/ federal lands *(MAV)*
- Increase in absentee ownership *(MAV)*
- Public access to private lands change *(App-Cumb)*
- Focus of REIT/TIMO changes on coastal plain management *(Coastal Plain/Mid South)*
- Changes in land ownership, particularly increasingly smaller parcels *(Piedmont)*
- Impacts of transgenerational transfer and changes in permanence of residency on forest management by the NIPF sector *(Mid South)*
- Changes in timberland use resulting from the transfer of industry ownership to REITs/TIMOs, and effects on social conditions *(Mid South)*

Meta-Issue Managers: David N. Wear, Southern Research Station, USDA Forest Service
and Brett J. Butler, Northern Research Station, USDA Forest Service

Methods of Analysis:

Describe how much and where forest land has changed ownership in recent years and where changes will likely be concentrated in the future. Through a contract with Lansworth Industries, we will use their land ownership data base and GIS to generate estimates of total acres of private ownership classified into the following categories: Forest Industry, TIMO, REIT and Other. We will evaluate totals and changes by subregion and state cross boundaries for the years 1998, 2003, and 2008. These estimates will be compared with other sources from the University of Georgia and FIA and with detailed analysis being conducted by Butler and Zhang (Auburn). Use results from National Woodland Owner Survey to characterize changes within the NIPF ownership class. Where feasible, assign ownership variables, such as TIMO/REIT classifications and parcel size, to the FIA database. This will allow for basic assessment of the current conditions, including mapping, and incorporation of these data into the forecasting model.

Describe the economic determinants for ownership change (all ownership categories) and how they might change in the future. We will base our discussion of the determinants of landownership change on a paper currently in revision by Wear and Clutter (in process) and will update a literature review to examine these causative factors. It will be especially important to examine the potential implications of future economic scenarios on these causative factors. This will cover the full range of ownership transitions. Based on the "new" FIA data, we will be able to create ownership transition matrices and conduct analyses on these data. Ideally, we would be able to take a land-use modeling approach to ownership change, but time constraints may not allow this.

Describe how forest land use and forest uses are likely to change as a result of shifts in ownership. We will use simulations from land use models to examine how changing economic conditions may affect the transition of land from forest to other uses and how different structures of landownership may affect the rates of transitions. In addition, we will synthesize existing literature on this topic.

Evaluate how forest management practices are influenced by ownership change and describe the ramifications of those influences. We will complete a meta-analysis of recent and ongoing research on structural dissimilarities of management by different types of forest ownership. This would be informed by forest owners surveys as well as empirical comparisons using FIA data.

Describe how changing forest ownership is likely to affect the forest products industry. We will use the US Forest Assessment System to simulate the effects of potential changes in timber supply on the region's timber markets—i.e., on production and prices of various products (fed in from previous elements of the study). Time permitting; we can conduct a "social availability" analysis that is analogous to the one being conducted by Butler and Ma in the north. Need to also consider the impact of these shifts on research and fire fighting resources.

Address the changing characteristics of family forest owners. Following a synthesis of existing literature, data from the National Woodland Owner Survey will be used to assess trends in the characteristics of family forest owners. Characteristics examined will include, but not be limited to, parcellation and its impact on resource availability, absentee ownership, public access to private lands, and intergenerational transfer of lands. The impact of these changes on future resource conditions will be difficult to test in a rigorous manner. Where feasible, we will tie ownership characteristics to plot characteristics and project them through time using the US Forest Assessment System. Otherwise, we rely on existing literature and expert interpretation to describe the potential consequences.

Data and Information Sources:

- Landsworth landownership data base
- University of Georgia Forest Business Center (forest land transition data base)
- FIA—ownership data (longer run)
- National Woodland Owner Surveys
- Previous studies

Links to other parts of the Southern Forest Futures Project: The project will use economic forecasts from the Forecasting and Analysis team to examine possible future changes in forest landownership. We will also coordinate our analysis with the Taxes meta issue, given the role of taxation on ownership.

Products: In addition to a narrative final report, we will produce: 1) maps of forest ownership across the region for 1998, 2003, and 2008, 2) maps identifying areas where ownership change has been focused between 1998 and 2008, and 3) tables of changes by state and sub-region within each state.

Potential cooperators:

- Mike Clutter, University of Georgia.
- Daowei Zhang, Auburn University
- Zhao Ma, Family Forest Research Center

8. Invasive Species

Question: How will invasive plants, insects and diseases likely affect southern forests and related ecosystems in the future?

Issues:

- Describe historical spread and forecast future spread of significant invasives.
- Discuss the expected consequences of the spread of important invasives for forest composition, riparian health, and dependent communities.
- What is the likelihood of effective invasives control in the future, given anticipated fragmentation, parcelization and urbanization interactions?
- What forest species are likely to be completely lost as a result of the spread of invasive pests?

Subregional Issues:

- Spread of Chinese tallow tree (*MAV*)
- Expansion of Chinese tallow in west Gulf region (Mid South)
- Hemlock Wooly Adelgid and the loss of Eastern Hemlock *(App-Cumb)*
- Catastrophic losses due to sudden oak death *(App-Cumb)*
- Effects of oriental bittersweet and other exotics on submesic and mesic areas *(App-Cumb)*
- SPB epidemics spreading to new areas and species *(App-Cumb)*
- Invasive pathways through ports *(Coastal Plain)*
- Effect of invasives on forest management and on native species *(Piedmont)*
- Issues associated with native invasive red cedar *(Mid South)*

Meta Issue Managers:
Paul Mistretta (USDA Forest Service, Southern Region), Forest Pathogens
Don Duerr (USDA Forest Service,Southern Region), Forest Insects
Jim Miller (Southern Research Station, USDA Forest Service) with John Coulston (USDA Forest Service, Southern Research Station) and Stephen F. Enloe (Auburn University).

Methods of Analysis:

Invasive pests will be discussed divided into two categories: Native and non-native
Pests discussed will include: Diseases, insects, plants, and animals

Describe the historical spread of high threat invasive pests and forecast future spread. If accurate and adequate historical summaries exist for pests of concern in readily accessible form, we will cite the appropriate material, and update it only as necessary. (Note: For those species previously described in the SFRA document and the data remain accurate and adequate to the present analysis, these will be referenced and only minimally repeated in the current assessment.)

For pests which do not have adequate, readily available summaries we will compile summaries using existing literature the basic species biology, host range for diseases and insects, home range for nonnative plants, and current U.S. geographic occupation. Range maps will be prepared for each pest where sufficient data are available. Existing risk maps developed by FHP and the Forest Health Technology Enterprise Team will be presented as one form of projecting future spread.

For invasive insect and diseases generalized probable scenarios will be described based on past experience with invasive pests and the individual pests will be tabulated with a rating of probable/possible outcomes of continued activity into the future.

Existing FIA occupation maps for invasive plants will be used and spread projections will be attempted using outputs from the US Forest Assessment System and/or modeling using SRS FIA forest plot and invasive plant data. Where insufficient data are available,

forecasts will be based on analogous information from the pest's behavior in its home range.

Evaluate the expected consequences of the spread of existing and potential invasive species with respect to forest productivity, composition, and biodiversity; imperilment of threatened and endangered species; watershed and soil health; carbon storage; and fire dynamics. Where known, specific information will be given for damage caused by insects and diseases to the host(s) and to its (their) ecosystem(s), both direct and indirect effects in the short and long-term. Projections of the future will be done for each described damage scenario with identification of pests likely to be (inter)active in each scenario.

For invasive plants, descriptions will be provided on potential changes in forest succession by forest type assisted by FIA modeling and impacts to attributes will be summarized from existing literature. Accurate projections of costs of possible control/management strategies will be very difficult to make, but in cases where projections can be reliably made, they will be provided.

Discuss how effective invasive pest management programs might work in the future, given that most high threat pests are in our region to stay, while others could be prevented from entering. For each invasive species, a projection for the probability of control will be provided, based both on current and potential future methodologies, including possible biocontrol and establishment of a future dynamic equilibrium in the context of a modified ecosystem. For invasive plants, developing elements of Adaptive Collaborative Restoration programs and defensive strategies will be outlined and discussed. Potential forest management strategies for successful control of invasive pests will be documented. Where possible legislation or regulation can be imposed to aid in controlling a pest, it will be suggested as part of the analysis.

Evaluate what forest species and forest types are likely to be lost or severely damages as a result of the spread of invasive pests. Current occupation and spread projections will be used to discuss extirpation of a host species or ecosystem or the permanent alteration of its function or structure. Further discussion will explore any potential radical alteration in the affected ecosystem's ability to support recreation, hunting, ecosystem services, or any other value-producing function will be reflected in each analysis.

Evaluate the potential for using invasive plant species for the production of bioenergy or biofuels. We will summarize the rapidly increasing global literature on the use of invasive plants currently within the southern region and planned projects for their use.

Data and Information Sources:

- EPPSI data
- FIA data
- Historical records (literature) for pest ranges and damages
- SFRA summaries
- FHTET risk mapping efforts and products

- www.invasives.org (South)
- FHM data
- Invasive species assessment "systems" such as NatureServe and ExFor
- USDA Forest Regional Task Force for the Assessment of Non-native Invasive Species of Southern Forests

Links to other parts of the Southern Forest Futures Project

- All pest analyses will use landownership forecasts from the Forecasting and Analysis Team.
- Projections from the Bioenergy Team will be used to forecast the use of invasive plants and fuels created by damaging invasive insects and diseases for bioenergy production.
- The invasive plant projections will rely on modeling assistance from the Forecasting and Analysis Team as well as SRS FIA.
- Forecasts from the Climate Change Team will be used to forecast range expansions incorporating these models and the scenarios developed for I&D damage
- Cogongrass shape files and biomass estimates will be provided to the Fire Team to explore subregional fire dynamic alterations of this highly flammable species.
- Alterations to subregional water yields by the Water Team will be explored as invasive pest infestations change structure and composition, e.g., hemlock woolly adelgid.

Products: Reports will be provided for invasive diseases, insects, plants, and animals. Written summary of pest activity currently affecting the forest ecosystems of the South including those affecting woodlands, urban forests, and the wildland-urban interface; Maps of current ranges of these pests; Projections of future impact of the current pests and potential future pests

Potential Cooperators:

- Ron Billings, Texas Forest Service, Steve Clarke, USDA Forest Service, FHP, Lufkin, TX, Jim Meeker, USDA Forest Service, FHP, Alexandria, LA and John Nowak, USDA Forest Service, FHP, Asheville, NC (southern pine beetle)
- Rusty Rhea, USDA Forest Service, FHP, Asheville, NC (HWA and BWA)
- Steve Oak, USDA Forest Service, FHP, Asheville, NC (Sudden Oak Death)
- Dale Starkey, USDA Forest Service, FHP, Alexandria, LA (Oak wilt and Oak decline)
- Steve Fraedrich, USDA Forest Service, SRS, Athens, GA (Laurel Wilt)
- John Ghent, USDA Forest Service, FHP, Asheville, NC (gypsy moth)
- Bob Rabaglia, USDA Forest Service, FHP, Washington, DC (misc non-native bark and ambrosia beetles)

9. Bioenergy

Question: What would be the likely effects of the emergence of a mature bioenergy market on southern forests, forest owners, and traditional forest product markets?

Issues:

- Describe the current and potential technologies that are needed to realize large scale production of biofuels from woody biomass, including preferred feedstock (if known).
- What might be the likely forest management regimes followed to maximize the production of woody biomass.
- Evaluate how these regimes would likely affect forest ecosystem integrity e.g. habitat quality, biodiversity, soil productivity.
- Describe how the emergence of a bioenergy market will likely affect competition with traditional forest product markets and financial returns to landowners.
- Describe the effects subsidies or other incentives could have on landowner behavior and wood product markets.

Subregional Issues:

- Development of wood biomass markets*(MAV)*
- Effect of focusing bioenergy harvests on gentle topography in mtns *(App-Cumb)*
- Lack of infrastructure to support transportation and processing of raw materials (*MAV)*
- Opportunities to develop biofuel markets in areas that have only supported limited timber markets—eg, brushy grasslands of Texas and Oklahoma, and hardwood stands on poor sites in the Ozarks *(Mid South)*

Meta-Issue Manager: Janaki Alavalapati, Virginia Tech,

Methods of Analysis

We will survey and investigate the current biochemical and thermochemical technologies utilized to produce biofuels. In addition we will contact biofuel manufacturing industry to incorporate their views about their preferred feedstock and most promising conversion technologies for the future.

We will simulate different scenarios to examine the most likely forest management regimes by performing an ecological, economic, and social analysis. For example, we will consider certain silvicultural activities such as thinnings, and prunings only for bioenergy purposes. Further, wood waste and a fraction of the final harvest might also be considered for biofuel production.

We will base our discussion in previous studies that have quantified the effect of different forest managements on the forest ecosystem integrity. In addition we will incorporate these potential impacts into our decision making analysis to select the most likely forest management.

A profit function will be developed for sawmill, pulp industry and bioenergy sectors. We then use it to assess the dynamic effects of expanding bioenergy sector on other forest product sectors. We specify the model such that all three sectors will compete for available forest biomass. In addition, we also conduct a general equilibrium analysis to assess the effect of bioenergy sector on other forest products sectors.

We will use existing survey findings to describe the effects subsidies or other incentives on landowner behavior and wood product markets.

Data and Information Sources:

- Previous studies
- IMPLAN database
- Timber-mart South prices
- Growth and yield data for major plantation species
- FIA—ownership data (longer run)

Links to other parts of the Southern Forest Futures Project: The project will use future changes in forest landownership to assess biomass supply.

Products: In addition to a narrative final report, we will produce: 1) tables of biomass supply and landowner profitability under different bioenergy market scenarios; and 2) regional economic and welfare impacts of bioenergy markets; and 3) tables/maps of wildlife habitat impacts of bioenergy markets.

Potential cooperators: Dr. Jianbang Gan, Texas A&M University; Dr .Robert Fletcher, University of Florida; and Dr. Gregory Amacher, Virginia Tech.

Subregional Analysis

For the Southern Forest Futures Project, the South has been divided and organized into five large sub-regions. Each of these sub-regions has unique ecological and social attributes and specific issues of concern regarding their forest ecosystems and economic conditions. Though they are aggregations of smaller ecological units that often do have similar ecological characteristics, differences among the subregions can be and often are distinct ecologically, socially, economically and culturally. This combination of similarities and differences will present both opportunities and challenges to subregional teams as they to strive to deal with significant conditions, issues and concerns within their sub-region.

Each of the five subregional teams will be co-led by a representative of the US Forest Service Southern Research Station and Southern Region. They will be responsible for consulting with and/or forming interdisciplinary teams comprised of experts from public

agencies and universities who are knowledgeable in subjects relevant to the forests and related issues within their respective sub-region.

Their responsibilities will be two-fold: 1) each team will interpret and summarize the "downscaled" results of the forecast and meta-issue analyses and identify specific implications for forest resource sustainability in the sub-region, 2) each team will identify sub-region specific issues based on public input or other sources (see above sets of subregional issues), develop analysis protocols in the form of a study plan, and interpret the implications of forecasts and meta-issue analyses for these issues.

Each subregional team will prepare a report containing the results of the above synthesis and analysis. Reports will be prepared by the team, and like other Futures Team reports, peer-reviewed and revised, and ultimately prepared for publication. Throughout the process, the subregional teams will coordinate their work with other Futures Team members and with the Futures Project co-leaders to ensure consistency and accuracy.

Proposed Subregional Analysis Report Outline

1. Introduction
2. Context and condition of the Subregion
    a. Ecological
    b. Geological
    c. Human
3. Analysis of issues and futures
    a. Land Use Change
    b. Forest Products Markets
    c. Forest Conditions
    d. Social/Economic Impacts
    e. Biodiversity/Wildlife
    f. Water
    g. Taxes
    h. Climate Changes
    i. Fire
    j. Forest Ownership changes
    k. Invasive species
    l. Bioenergy
4. Synthesis and conclusions
5. Key Findings

Table 1: Subregional Team Leadership for the Southern Forest Futures Project. All are US. Forest Service.

Sub-region	Southern Research	Southern Region Lead

	Station Lead	
Coastal Plain	Kier Klepzig	Richard Shelfer
Piedmont	Bob Rummer and Karen Abt	Mae Lee Haefer
Appalachians/Cumberlands	David Loftis	Joy Malone
Mississippi Alluvial Valley	Emile Gardner	Larry Moore
Mid South	Jim Guldin	Jim Crooks