



United States
Department of
Agriculture

Forest Service
Southern Research Station

General Technical
Report SRS–168

The Southern Forest Futures Project: Summary Report

David N. Wear and John G. Greis






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October 2012

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The Southern Forest Futures Project: Summary Report

David N. Wear and John G. Greis

Abstract

The Southern Forest Futures Project provides a science-based "futuring" analysis of the forests of the 13 States of the Southeastern United States. With findings organized in a set of scenarios and using a combination of computer models and science synthesis, the authors of the Southern Forest Futures Project examine a variety of possible futures that could shape forests and the many ecosystem services and values that forests provide. The science findings and modeling results could inform management and policy analysis of the South's forests. In this summary report, the authors distill detailed results from the Southern Forest Futures Project technical report and provide a set of key findings and implications.

Keywords: Forest conservation, futuring, integrated assessment, Southern Forest Futures Project, sustainability.

INTRODUCTION

This report summarizes the findings of the Southern Forest Futures Project, also referred to in these pages as the Futures Project. The Southern Forest Futures Project is an effort to anticipate the future and analyze what the interaction of future changes might mean for the forests of the South and the services the forests provide in the region's 13 States (fig. 1). We explore a labyrinth of driving factors, forest outcomes, and human implications to sketch how the landscape of the South might change. In this summary report, we consolidate the findings of 17 detailed analyses on specific forecasts and natural resource issues, and we synthesize them into a set of key findings; throughout this summary report, references to specific chapters guide the reader to more detailed information in the technical report (Wear and Greis, in press).[1] A subsequent phase of this effort will be to develop management and restoration implications for the various forest types and subregions in the South.

Why might we want to spend several years sorting through the various facets of this complicated puzzle? The reasons are varied but they all revolve around one notion, that knowing more about how the future might unfold can improve decisions that have long-term consequences. Knowing more about future land use changes and timber markets can guide timber investment decisions. Knowing more about the intersection of anticipated urbanization, intensive forestry, and imperiled species can guide forest conservation policy and investments. And knowing more about the potential development of fiber markets can improve bioenergy policies. Consequently, our intended audiences are natural resource decision makers and professionals (managers and policy analysts) as well as members of the broader public who care about natural resource sustainability and policy.

This summary report starts with a description of southern forests and the forces acting upon them. A description of research methods and the assessment process is followed by descriptions of the following 10 key findings.

- The interaction of four primary factors will define the South's future forests: population growth, climate change, timber markets, and invasive species.
- Urbanization is forecasted to result in forest losses, increased carbon emissions, and stress to other forest resources.
- Southern forests could sustain higher timber production levels, but demand is the limiting factor and demand growth is uncertain.
- Bioenergy futures could bring demands that are large enough to trigger changes in forest conditions, management, and markets.
- A combination of factors has the potential to decrease water availability and degrade quality; forest conservation and management can help to mitigate these effects.
- Invasive species create a great but uncertain potential for ecological changes and economic losses.

Figure 1—The 13 State regions evaluated by the Southern Forest Futures Project.

[1] All chapters may be accessed on the Futures Project Web site: http://www.srs.fs.fed.usda.gov/futures/

- An extended fire season combined with obstacles to prescribed burning would increase wildland fire-related hazards.
- Private owners continue to control forest futures, but ownership patterns are becoming less stable.
- Threats to species of conservation concern are widespread but are especially concentrated in the Coastal Plain and the Appalachian-Cumberland subregions.
- Increasing populations would increase demand for forest based recreation while the availability of land to meet these needs is forecasted to decline.

These key findings summarize a number of potential futures for southern forests. To be clear, this is not an attempt to prescribe decisions or advice on how best to form policy in response to anticipated changes. Rather, the findings provide a foundation of information for others to evaluate management and policy alternatives in light of possible futures. Our ultimate measure of success will be the extent to which the findings are used for such analysis.

BACKGROUND

On a day-to-day basis, forests change less rapidly than most other aspects of the modern world. Trees live long lives, and harvesting or natural disturbances are relatively infrequent. Nevertheless, forests are diverse and dynamic. Today's southern forests stand in sharp contrast to the landscape observed centuries ago by European settlers. The forests also differ substantially from the cutover forests that dominated the South at the start of the Great Depression. The forests even are structurally dissimilar to the forests of just 30 years ago. As these differences demonstrate, slow change does not necessarily equate to small change.

Southern forests are unique, exceptionally diverse, and nationally significant. They develop much more rapidly than forests in other regions, partly because of humid temperate and subtropical climates and partly because of the relatively fast growth rates of native tree species. Another factor is the southern forest products sector, which harvests a majority of the Nation's fiber and has invested in forest growth, largely through relatively short-rotation pine plantations. Private corporations and families own and manage the vast majority of southern forests for a variety of products and services, with the result that landscape conditions can and do change, sometimes suddenly, in response to a variety of economic forces.

Several important socioeconomic changes continue to influence forest conditions and uses in the South (fig. 2). Recent population and economic growth has outstripped national growth rates, with the resulting urbanization steadily consuming forests and other rural lands. Changes in Federal public lands policies in the 1990s reduced timber harvesting from the western forests and increased demand for southern timber. Economic events at the turn of the century suddenly and irreversibly altered the commercial ownerships that controlled a large portion of the South's forests and that had long been seen as semi-permanent but that now appear much less stable. Policy decisions at multiple scales could play an important role in determining the trajectory of forest changes by influencing markets and land management practices.

Other changes, some unprecedented, may also hold important implications for forests in the coming decades. Shifts in climate patterns and associated changes in precipitation and air temperature could change species ranges and productivity. Insects, diseases, and newly introduced nonnative plants could similarly restructure forest species composition with unclear implications for wildlife. Interactions between climate change and invasive species could amplify their individual impacts. Recent declines in forest product demand combine with potential new demand for bioenergy to make markets and forest values uncertain.

The impetus for the Southern Forest Futures Project comes from a desire to understand the implications of potential changes. An assessment of forest sustainability (Wear and Greis 2002a, 2002b) had been completed in 2002, but the rapid pace of these various forces of change and the sudden emergence of new and complex natural resource issues called for a new study that could take advantage of recent science findings and forecasting methods to address the questions of the day. In December 2007, the authors of this report were assigned leadership of the Southern Forest Futures Project, a collaborative venture between the Forest Service (U.S. Department of Agriculture) and the Southern Group of State Foresters.

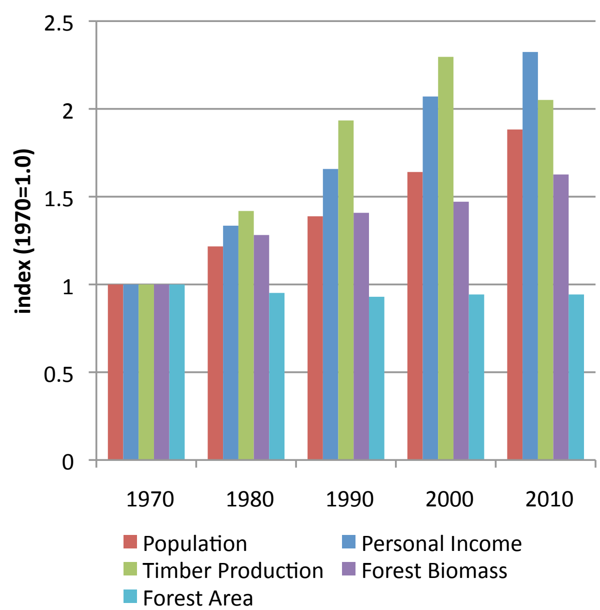

Figure 2—Proportional changes in some key variables affecting the forests of the Southern United States, from a base year of 1970. Notes: From 1970 to 2010, population grew by 88 percent and disposable personal income more than doubled. From 1970 to 2000, the volume of timber products more than doubled while the amount of forest biomass grew steadily and forest area declined slightly.

The Future of Southern Forests: An Ongoing Conversation

At least since the 1960s, trends in southern forest conditions and uses and the potential for change have been the focus of study and deliberation by natural resource professionals. The Southern Forest Futures Project represents the fourth broad scale assessment of southern forests in 5 decades. Each new assessment has addressed a broader complement of issues, and the time step between assessments has decreased, perhaps indicating an accelerated rate of change.

1969—The South's Third Forest. Supported by the wood products industry and owners of large private forests, the Third Forest Report uses literature reviews and an evaluation of trends to examine the future of the South's timber supply (Wheeler 1970). Its focus is on timber supply issues in light of increased demand for wood products and perceived underinvestment by private landowners. Concerned that timber scarcity could limit expansion of the forest products sector, the authors recommend policies to increase planting and management of private forests; protect forests from insects, diseases, and fires; and build stronger institutions to support forestry training, technology transfer, and forest research. They foresee the population-driven urbanization and the expansion in timber growing and timber production that was realized in the South between 1970 and 2000.

1988—The South's Fourth Forest: Alternatives for the Future. Nearly 20 years after the Third Forest Report, the Forest Service authors ask some of the same questions about the future of timber-producing in the South (USDA Forest Service 1988). In the Fourth Forest Report, forecasts of increasing timber scarcity derive from a timber market model, and technical analysis focuses on potential investments by nonindustrial private forest owners. Findings anticipate the growth in timber production realized through the 1990s and highlight again the potential for programs and policies to encourage reforestation, management, and forest protection. Although a few pages are dedicated to the impacts of timber projections on wildlife and water, the emphasis is squarely on the future of timber management and production.

2002—The Southern Forest Resource Assessment. The growth in forest management and timber production in the South (largely anticipated by the Third and Fourth Forest Reports) coupled with the emergence of satellite chip mills in the late 1990s raised several questions about the sustainability of forests in the South (Wear and Greis 2002a and 2002b). An interagency effort led by the Forest Service and driven by a set of questions developed from public meetings conducted around the region, the Southern Forest Resource Assessment draws knowledge from the extensive literature and databases to address concerns ranging from imperiled terrestrial and aquatic species to wetlands; from outdoor recreation to the influence of policies, regulations, and laws on forest management; from air pollution to the future course of timber markets and land use changes. It identifies urbanization as a key threat to forest sustainability and raises additional concerns about the effects of multiple forces on wildlife habitats, water resources, and forest health. It also identifies several rare forest communities and highlights an increasing scarcity of recreational opportunities in parts of the South.

Today—The Southern Forest Futures Project. Five years after completion of the Southern Forest Resource Assessment, new issues and questions about the future of forests in the South emerged from the natural resource community. Forest industry has largely divested its land holdings, science has provided new insights into potential future climates, and questions about water sustainability have intensified. To address these and other questions—again deriving from extensive public involvement—the Forest Service and the Southern Group of State Foresters commissioned the Southern Forest Futures Project. Where its predecessor relied mostly on literature reviews and stand-alone analyses of future impacts, the Futures Project focuses on forecasting the future under a variety of assumptions that integrate findings across multiple questions. The Futures Project builds from the knowledge foundation of former assessments, updates some topical areas, and lays out a range of futures for consideration by policy makers and forest managers.

Designing the Futures Project

Design of the Southern Forest Futures Project started with defining a set of relevant questions and then defining a targeted and robust process for answering them. This process required enumerating the critical socioeconomic and biophysical changes affecting forests, defining the most important management and policy information needs, and addressing forecasts and questions at the most useful scale of analysis (chapter 1) (throughout the summary report, we refer to the findings from the companion technical report by chapter number). A series of public information gathering sessions addressed the first two issues: more than 600 participants with a wide array of backgrounds and perspectives at 14 meetings, with at least one meeting in each of the 13 states, contributed their input on what they saw as the important issues affecting forests and the key future uncertainties (Wear and others 2009). These meetings shaped the thinking about alternative futures and led to the selection and definition of 10 meta-issues (table 1), each of which describes an interrelated complex of questions about the future of forests in the South (e.g., the bioenergy meta-issue is constructed from a set of questions that address conversion technologies, impacts on sustainability, Federal and State policies, and economic impacts). Additional issues, undoubtedly important to many people in the region, nevertheless did not surface during the public meetings, e.g., aquatic ecosystems and their relationship to forest conditions. Furthermore, in this case and others, technical analysis in the 2002 assessment was considered up to date (Wear and Greis 2002a).

The South, a discernible biological and socioeconomic region of the United States, contains a vast diversity of biota and socioeconomic settings within its boundaries. The meta-issues and forecasts of future conditions were analyzed at the broad regional level, with results broken down to finer grains of analysis, where feasible and appropriate. However, our broad-scale approach was not appropriate for addressing the specific implications that these forecasts and issue analyses hold for forest management and restoration activities. These implications are best evaluated at a scale that more closely matches the different forest ecosystem types in the South (fig. 3). In the second phase of the Futures Project, separate efforts examine the management/restoration implications for five subregions of the South (fig. 4): the Coastal Plain, the Piedmont, the Appalachian-Cumberland Highlands, the Mississippi Alluvial Valley, and the Mid-South (which includes all of Texas and Oklahoma). Further spatial resolution is provided by breaking the subregions into a number of sections, and some issues are discussed at that scale as well.

The analytical centerpiece of the Futures Project is a set of forecasting models from the U.S. Forest Assessment System. Developed for the Forest Service 2010 Resources Planning Act (RPA) Assessment, the U.S. Forest Assessment System uses global projections of climate, technology, population, and economic variables to drive the simulation of changes in land uses, forest uses, and forest conditions at a very fine spatial scale, producing subregional and other fine scale analyses. Specific RPA scenarios define the variables that drive the forecasts, linking national economic and climate changes to the worldviews of international climate assessments. The Futures Project tiers directly to the 2010 RPA Assessment (USDA Forest Service, in press), developing more specific implications for the South within the context of the scientific literature for a subset of the RPA scenarios.

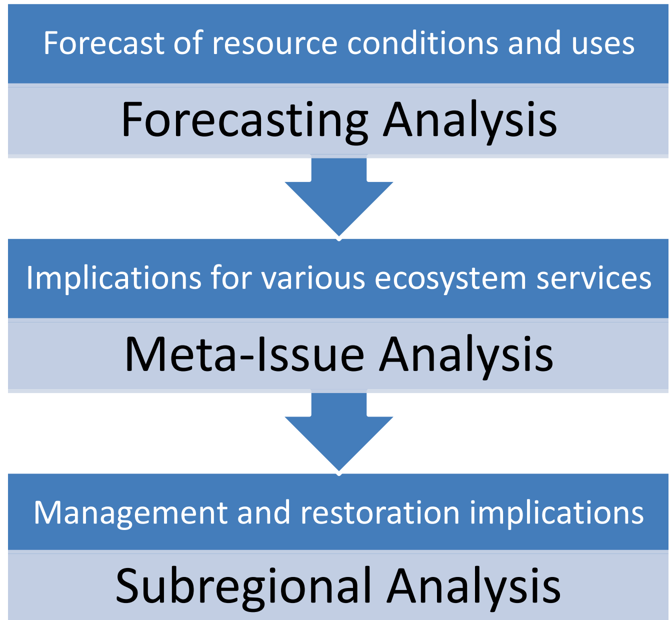

Figure 3—The three phases of the Southern Forest Futures Project.

Perhaps the only absolute truth about any forecast is that it will be an inaccurate description of future reality to one degree or another and that it is improbable that the best, i.e., the most accurate, forecast can be identified ahead of time. As a result, forecasters generally hedge their expectations of future conditions by including a range of plausible futures. That approach addresses an inherent shortcoming of thorough technical analysis: the risk of generating precise forecasts of the wrong future.

We considered a large number of scenarios based on the 2010 RPA Assessment analysis (USDA Forest Service 2012; USDA Forest Service, in press) and public input, and then narrowed the scenarios to a half dozen that capture the broad range of future conditions and address key meta-issues (chapter 2). We call these scenarios Cornerstone Futures, which describe six combinations of climate, economic, population, and forest products sector projections. Our assumption was that unfolding events will be captured by a future that is close to one of the Cornerstone Futures. The validity of this assumption, however, will only be revealed by the course of future events. Another benefit of evaluating a range of futures is determining which resource implications vary by scenario and which are invariant.

Table 1. Outline of the Southern Forest Futures technical report (Wear and Greis, in press)

Chapter Number	Title	Author(s)
1	**Design of the Southern Forest Futures Project**	David N. Wear and John G. Greis
2	**Constructing alternative futures**	David N. Wear, Robert Huggett, and John G. Greis
3	**Climate change**	Steven McNulty, Jennifer Moore Meyers, Peter Caldwell, and Ge Sun
4	**Forecasts of land uses**	David N. Wear
5	**Forecasts of forest conditions**	Robert Huggett, David N. Wear, Ruhong Li, John Coulston, and Shan Liu
6	**Forest ownership dynamics of southern forests**	Brett J. Butler and David N. Wear
7	**Outdoor recreation in a shifting societal landscape**	H. Ken Cordell, Carter J. Betz, and Shela H. Mou
8	**Outdoor recreation in the South: Projections 2010 to 2060**	J.M. Bowker, Ashley Askew, H. Ken Cordell, and John C. Bergstrom
9	**Timber products markets**	David N. Wear, Jeffrey Prestemon, Robert Huggett, and Douglas Carter
10	**Forest biomass-based energy**	Janaki R.R. Alavalapati, Pankaj Lal, Andres Susaeta, Robert C. Abt, and David N. Wear
11	**Effect of taxes and financial incentives on family-owned forest land**	John L. Greene, Thomas J. Straka, and Tamara L. Cushing
12	**Employment and income trends and projections for forest-based sectors in the U.S. South**	Karen L. Abt
13	**Forests and water**	Graeme Lockaby, Chelsea Nagy, James M. Vose, Chelcy R. Ford, Ge Sun, Steve McNulty, Pete Caldwell, Erika Cohen, and Jennifer Moore Meyers
14	**Wildlife and forest communities**	Margaret Trani Griep and Beverly Collins
15	**The invasion of southern forests by nonnative plants: current and future occupation with impacts, management strategies, and mitigation approaches**	James H. Miller, Dawn Lemke, and John Coulston
16	**Insect and disease pests of southern forests**	Donald A. Duerr and Paul A. Mistretta
17	**Fire**	John A. Stanturf and Scott L. Goodrick

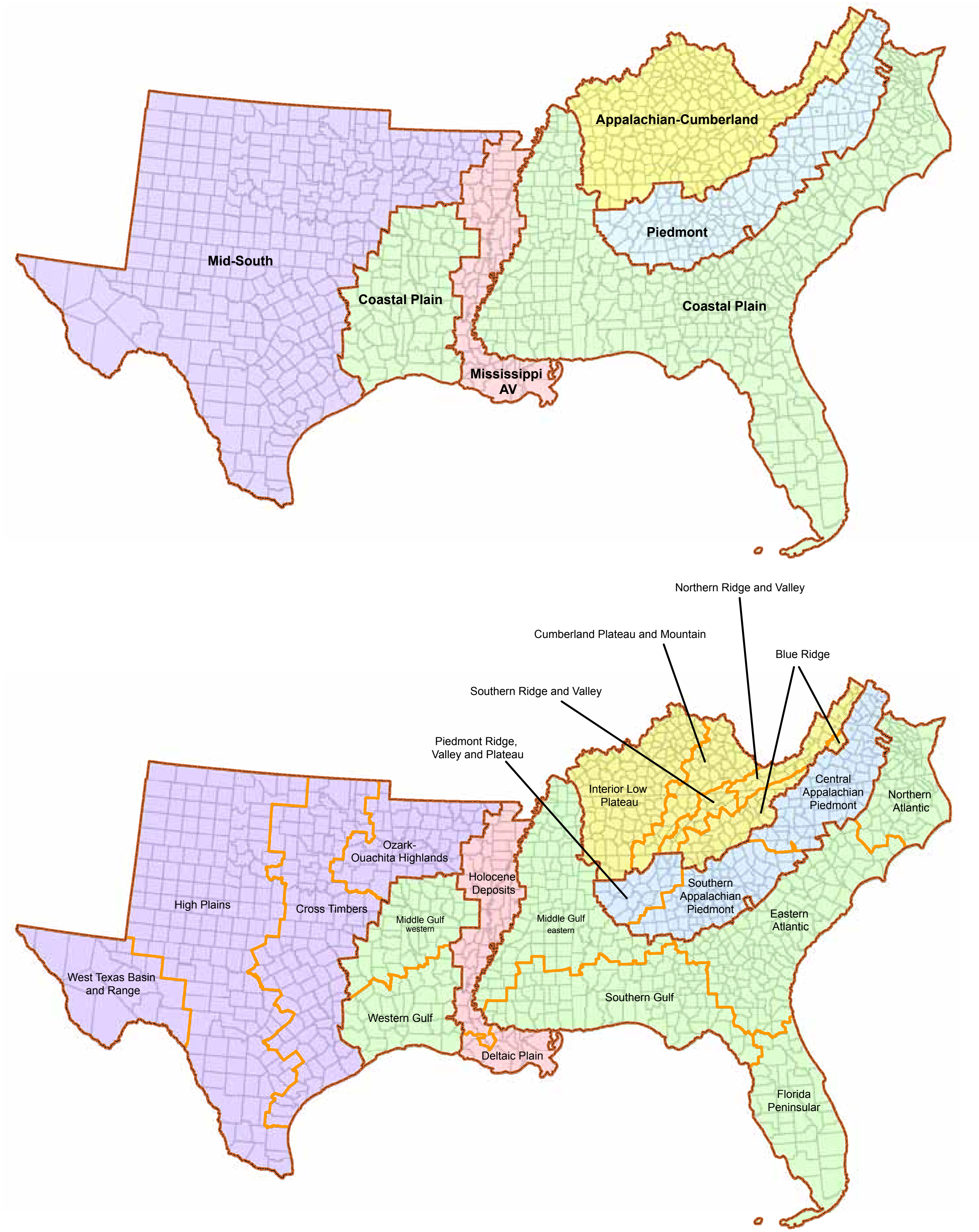

Figure 4—Subregions and sections for analysis in the Southern Forest Futures Project.

The U.S. Forest Assessment System

The U.S. Forest Assessment System is a set of computer models designed to forecast alternative futures for the Nation's forests. As a forward-looking adjunct to the Forest Inventory and Analysis (FIA) Program of the Forest Service, it was implemented by Forest Service research and development staff to take full advantage of the FIA's newly established continuous inventory process; as additional inventory panels are completed, the panels can augment and improve the information content of these models. The FIA program provides nationwide monitoring through repeated inventories that provide consistency over time and a high level of detail. The U.S. Forest Assessment System accounts for changes driven by multiple vectors, including biological, physical, and human factors. Its models address the influence of changing climate, market-driven timber harvesting, and land use changes, along with changes resulting from the natural succession of forest conditions.

Figure 5 shows a general schematic of this modeling system. The first column describes the input of data beginning with internally consistent combinations of social, economic, and technology forecasts defined as scenarios. The scenarios are linked to various general circulation models (climate models) to provide climate forecasts consistent with each scenario. FIA data define the starting conditions for all forested plots. The second column provides a general picture of the modeling framework. Future forest conditions are driven by biological dynamics—such as growth and mortality—that are affected by climate factors. Models of forest dynamics were developed from matched FIA forest inventories in each State. The third column represents the interplay of human choices about allocations among land uses, disposal of forest land, timber harvesting, and forest management also affect changes in forests; these projections are consistent with the flow of forest products and land use changes. Effects on several other ecosystem services, including water and biodiversity, can also be derived from the forecasted changes in forest conditions and land uses (column 4). These and other modeling results are used to evaluate the various meta-issues of the Futures Project.

The U.S. Forest Assessment System uses an empirical approach wherever possible, thereby anchoring forecasts of future behavior on patterns observed in the past. For example, land use models describe urbanization relationships observed in the 1990s; forecasts are consistent with the institutional arrangements of that specific historical period and would not reflect changes in policy affecting land use since the 1990s. Likewise, harvest choice models reflect historical behavior, although these models derive from more recent data.

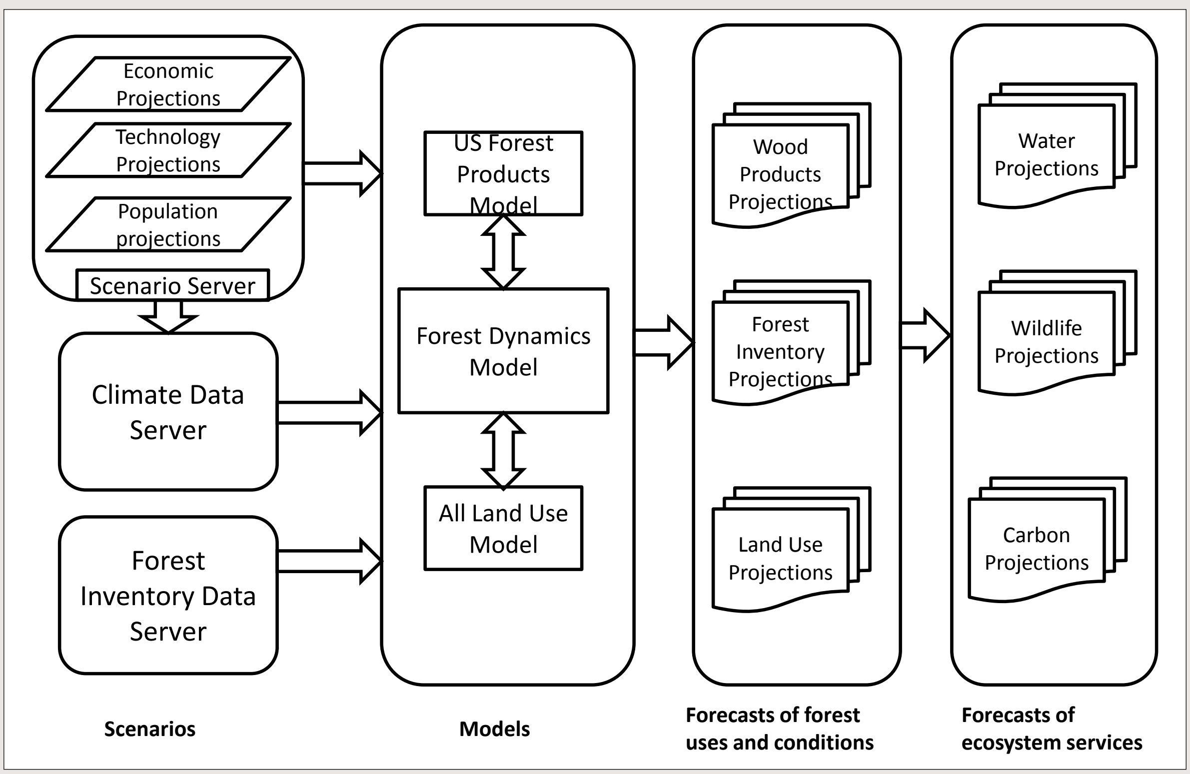

Figure 5—Schematic of the U.S. Forest Assessment System (Wear and others, in press).

The Cornerstone Futures

The Southern Forest Futures Project developed six Cornerstone Futures (labeled A to F) to describe the factors likely to drive changes in southern forests. As the label indicates, we selected the Cornerstone Futures to represent the range of findings from a much broader set of possibilities based on a combination of county-level population/income and climate projections from the 2010 RPA Assessment, assumptions about future timber scarcity, and assumptions about tree planting rates (chapter 2).

County-level forecasts of population and income, variables critical to the Cornerstone Futures, were projected in the 2010 RPA Assessment within the context of two global perspectives on socioeconomic change (downscaled descriptions of demographic change and economic growth used by the Intergovernmental Panel on Climate Change to construct global forecasts of climate changes and their implications), the first yielding about a 40 percent growth in overall population from 2010 to 2060, and the second yielding a higher rate of 60 percent (USDA Forest Service 2012). The projections vary by county, with the populations of some counties growing substantially and others shrinking.

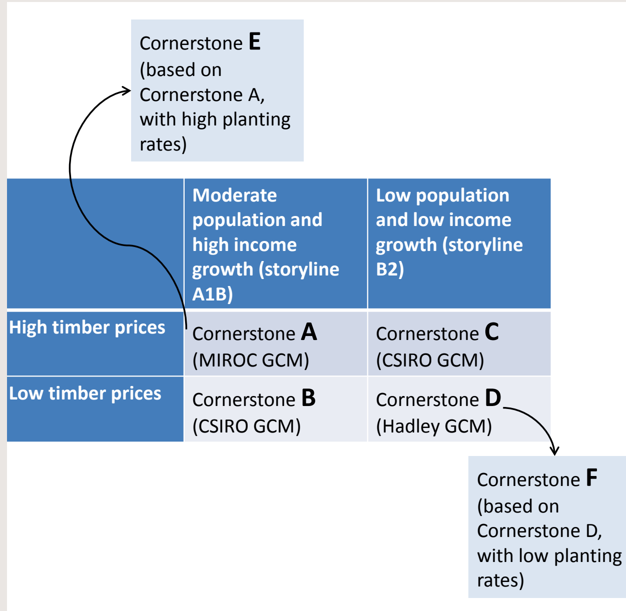

Figure 6—The six Cornerstone Futures defined by permutations of two 2010 Resources Planning Act (RPA) Assessment/Intergovernmental Panel on Climate Change storylines (USDA Forest Service 2012) and two timber price futures (see chapter 2 of the technical report of the Southern Forest Futures Project); and then extended by evaluating increased and decreased forest planting rates.

Timber price futures either describe increasing or decreasing scarcity with an orderly progression of real prices: either increasing or decreasing in real terms at 1 percent per year from a base in 2005 through 2060. We also hold the real returns to agricultural land uses constant throughout the forecasts for all Cornerstone Futures (chapters 2 and 4).

Each of the population/income projections embedded in these Cornerstone Futures is linked to a worldwide emissions storyline that drives alternative climate forecasts using various models. The 2010 RPA Assessment provides three climate projections driven by the population/economic projections and downscaled to the county level. Forecast variables include changes in temperature, precipitation, and derived potential evapotranspiration. We selected one climate forecast for each of the Cornerstone Futures in a way that incorporated a full range of climate projections. These are taken from three different downscaled climate models—MIROC, CSIRO, and Hadley—used by the 2010 RPA Assessment (chapters 2 and 3).

In figure 6, the six Cornerstone Futures are displayed in a diagram that emphasizes their key variables. Cornerstones A through D are defined by the matrix formed by intersecting low and high population and income forecasts with increasing and decreasing timber price futures as described above:

Cornerstone A: High population/income growth with increasing timber prices and baseline tree planting rates
Cornerstone B: High population/income growth with decreasing timber prices and baseline tree planting rates
Cornerstone C: Low population/income growth with increasing timber prices and baseline tree planting rates
Cornerstone D: Low population/income growth with decreasing timber prices and baseline tree planting rates

These four Cornerstones use what we label baseline rates of tree planting following a harvest based on future planting forecasts derived from FIA-observed planting frequencies for harvested plots between the latest two surveys for each State and major forest type. Because this was a period of rapid expansion in planted pine, perhaps associated with displacement of harvesting from the Western United States, we set baseline rates at 50 percent of the observed frequencies. Cornerstones E and F depart from these four, with Cornerstone E augmenting planting rates by 50 percent for Cornerstone A, where economic growth is strong and timber markets are expanding; and Cornerstone F decreasing planting rates by 50 percent for Cornerstone D, where economic growth is reduced and timber markets are declining. Forecasts for the Cornerstone Futures provide the foundation for exploring the potential implications for the meta-issues explored by the Futures Project.

Forecasts provide practical insights only when they are examined in the light of specific issues and historical changes. The meta-issues provided specific questions to be addressed using the forecasts along with other available information. For some meta-issues, e.g., water (chapter 13) or fire (chapter 17), additional models helped translate forest forecasts into specific implications for ecosystem services. For other meta-issues, e.g., taxes (chapter 11) or ownership (chapter 6), a more qualitative approach linked the analysis of meta-issues to forecasts. But for each meta-issue, the analysis started with a thorough synthesis of historical trends, the current situation, and the scientific literature on the topic.

This summary report draws from the 17 chapters of the Southern Forest Futures Project technical report (Wear and Greis, in press) to isolate findings of most critical consequence for management and policy decision making. Each chapter provides its own assessment of key findings with respect to specific forecasts and the meta-issues, and each chapter has undergone a rigorous peer review. The findings described here offer a high-level synthesis of findings from multiple chapters of the technical report and attempt to draw out the potential causative links and the chains of impacts that the future might hold for the forests of the South.

THE FOREST LANDSCAPE OF THE SOUTHERN UNITED STATES

The South, defined in this report as the 13 States from Texas to Virginia, is a heavily forested region with forest densities reaching more than 80 percent in several areas (fig. 7). The area of forest uses generally exceeds 40 percent of the landscape area with exceptions generally occurring outside the forest-grassland biome boundary in western Texas and Oklahoma and in areas where agricultural uses dominate—in particular, the Mississippi Valley, the lower half of Peninsular Florida, and parts of Kentucky and Tennessee. Otherwise, as shown in figure 7, urban uses substantially replace forest uses at the multi-county scale in only a few areas, including Atlanta and Charlotte, NC. Total forest area has been relatively stable since the 1970s, but this stability reflects offsetting trends: forests have been converted to urban uses at about the same rate that agricultural lands have been converted to forest uses.

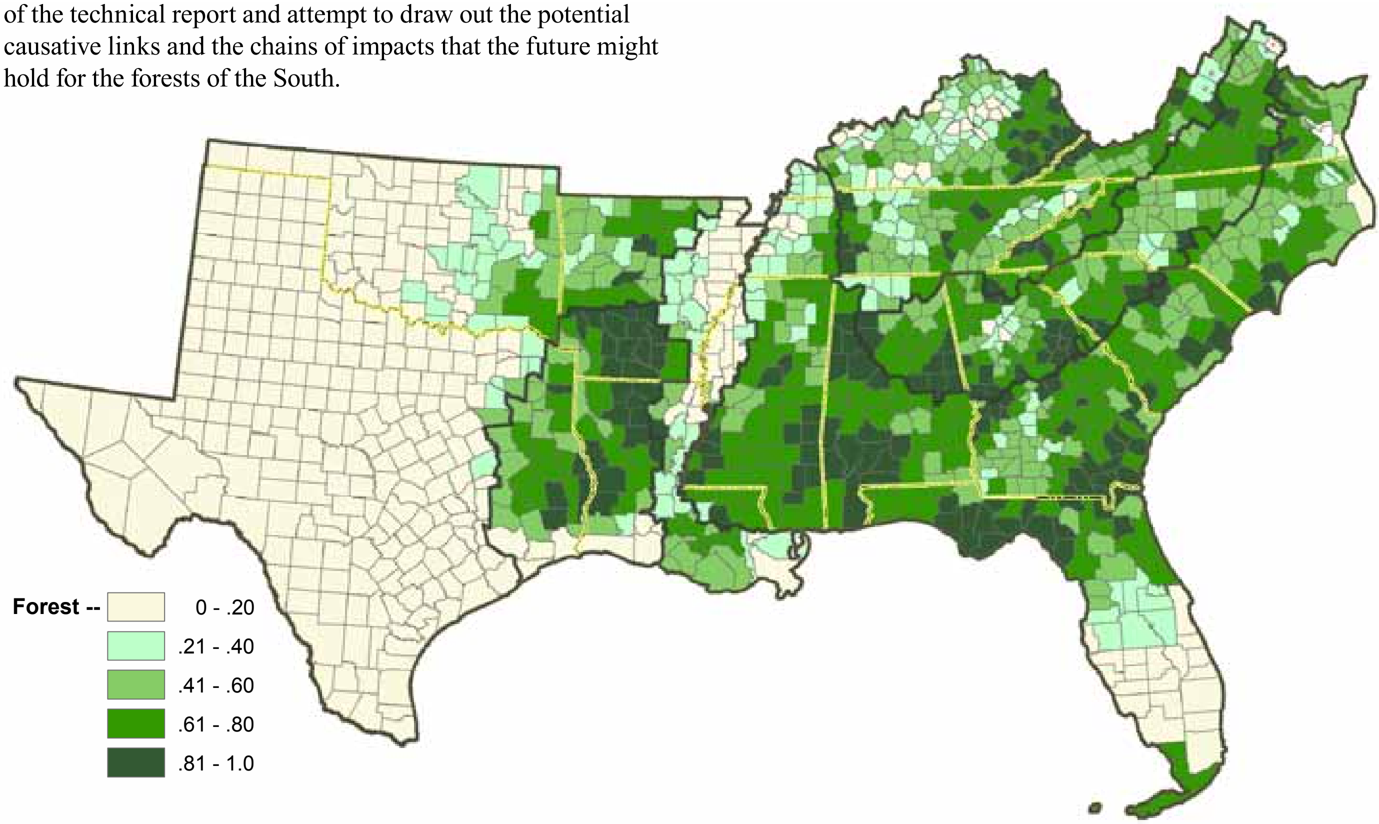

Figure 7—Proportion of counties in forestland use, based on land use data from the 1997 National Resource Inventory (USDA 2009; see also chapter 4 of the technical report of the Southern Forest Futures Project).

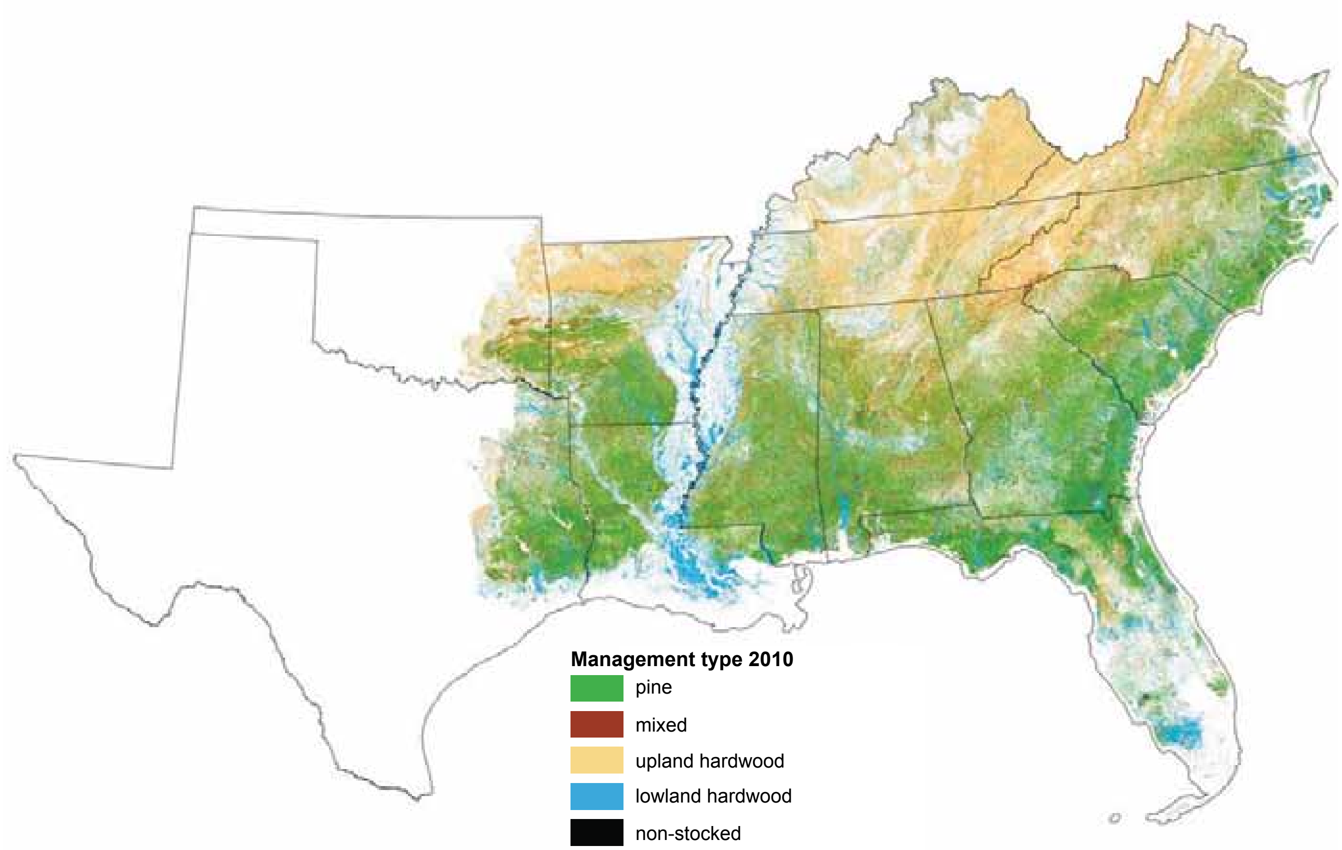

Figure 8—Forest area by broad forest management type in the Southern United States, 2010. "Mixed" refers to the oak-pine forest management type.

Forest Types and Distribution

Southern forests are highly diverse, ranging from upland oak-hickory forests to lowland gum-cypress swamps, from naturally regenerated old growth pines to intensively managed pine plantations, and from high elevation spruce-fir to coastal mangrove and live oak forests. Figure 8 displays the distribution of four highly aggregated forest types across the region. Upland hardwoods dominate in areas north of the Piedmont and Coastal Plains from northern Alabama to Kentucky, in northern Arkansas, and throughout the western halves of Virginia and North Carolina. Pines dominate throughout the Coastal Plain from Virginia to Florida along the Atlantic Coast, and from Florida to Texas along the Gulf of Mexico. Lowland hardwoods are concentrated in the lower Mississippi Alluvial Valley and in the Okeefenokee and Great Dismal swamps but are widely distributed in ribbon-like configurations along the rivers of the Coastal Plain and Piedmont.

Figure 8 also demonstrates the comingling of forest types, with upland hardwoods and pine types intermixed in a broad zone between the pine-dominated Coastal Plain and the hardwood-dominated mountains. Microclimate and other site conditions create a wide variety of growing conditions which in turn determine which of a wide variety of species assemblages will occupy any site.

Hardwood types occupy 55 percent of southern forest land, and pines occupy 34 percent (fig. 9). The remaining 11 percent contains an oak-pine mixture that represents a blending of species often at early stages of stand development.

Forest Production and Products

Landowners have harvested timber from southern forests for more than 300 years since European settlement, and most forests have been harvested multiple times. When examining changes prior to the mid-19th century, it is difficult to separate the impact of land clearing by settlers from other commercial harvesting in the region (Williams 1989). Although export markets were active throughout the United States (and in the South, especially for naval stores), land clearing and local consumption of cleared material likely dominated. Commercial harvesting to support settlements in less forested areas—such as the prairie areas of the Midwest and the urban centers throughout the Nation—and export markets grew rapidly beginning in the second half of the 19th century. Large-scale commercial harvesting in the South commenced in the 1880s as the timber inventories of the Lake States declined, and peaked in the 1920s (Williams 1989).

The South's timber harvesting expanded faster than the Nation's from the 1950s to 1990s (fig. 10), more than doubling as new technologies developed, national policies changed, and private

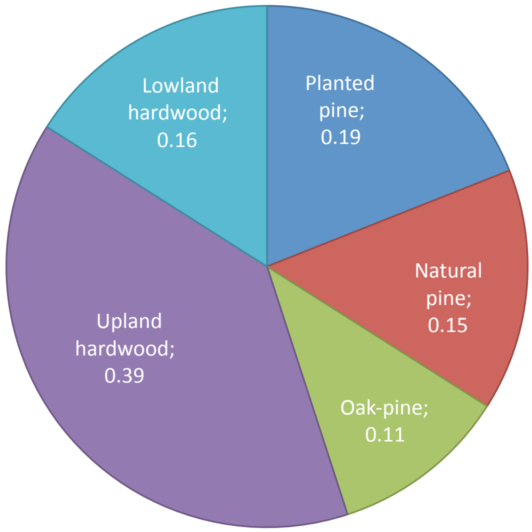

Figure 9—Distribution of forests in the Southern United States by broad forest management types, 2010.

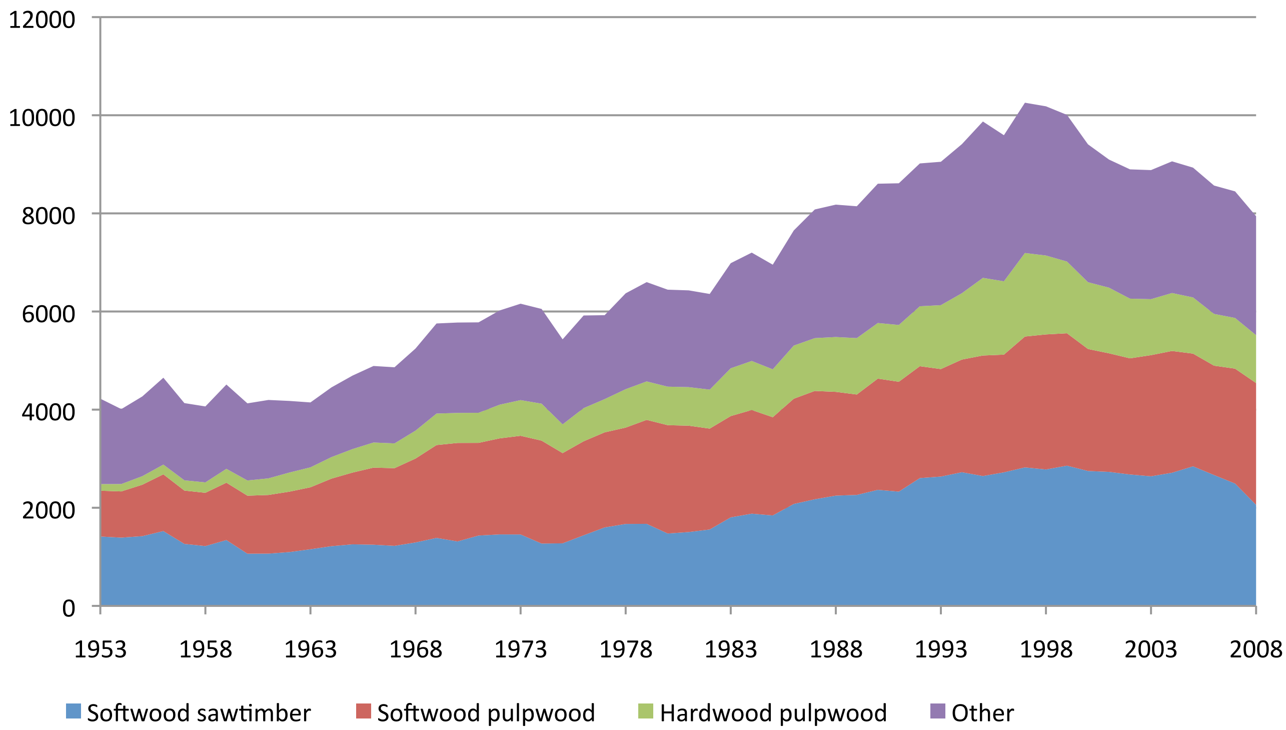

Figure 10—Roundwood production in the Southern United States, all products, 1953–2008.Sources: USDA Forest Service timber product output reports as defined in Wear and others (2007).

landowners invested in timber production (chapter 9). This expansion was fueled by a technology-driven shift toward outdoor use of treated southern pine lumber along with growth in paper manufacturing during the 1970s and 1980s, and sustained through the 1990s by harvest reductions from public lands in the West (chapter 9). New production technologies also shifted demand from larger to smaller diameter trees, with the shift from plywood to oriented strand board perhaps being the best example (chapter 9). The increased comparative advantage for southern forests, combined with declining western forest timber production shifted the region's share of national timber production from 40 percent in 1952 to nearly 60 percent in 1996 (figs. 10 and 11). U.S. timber production peaked in the late 1990s, after which a combination of factors leveled and then decreased total output through 2007—harvesting in 2007 was about 91 percent of 1996 levels. Historic declines in the construction sector since 2008 have depressed timber production levels even further. Even so, since 1986, if the South were compared with any other country, none would produce more timber than this region of the United States. The wood-related sectors of the South's economy contributed more than 1 million jobs and more than $51 billion of employee compensation in 2009 (chapter 12).

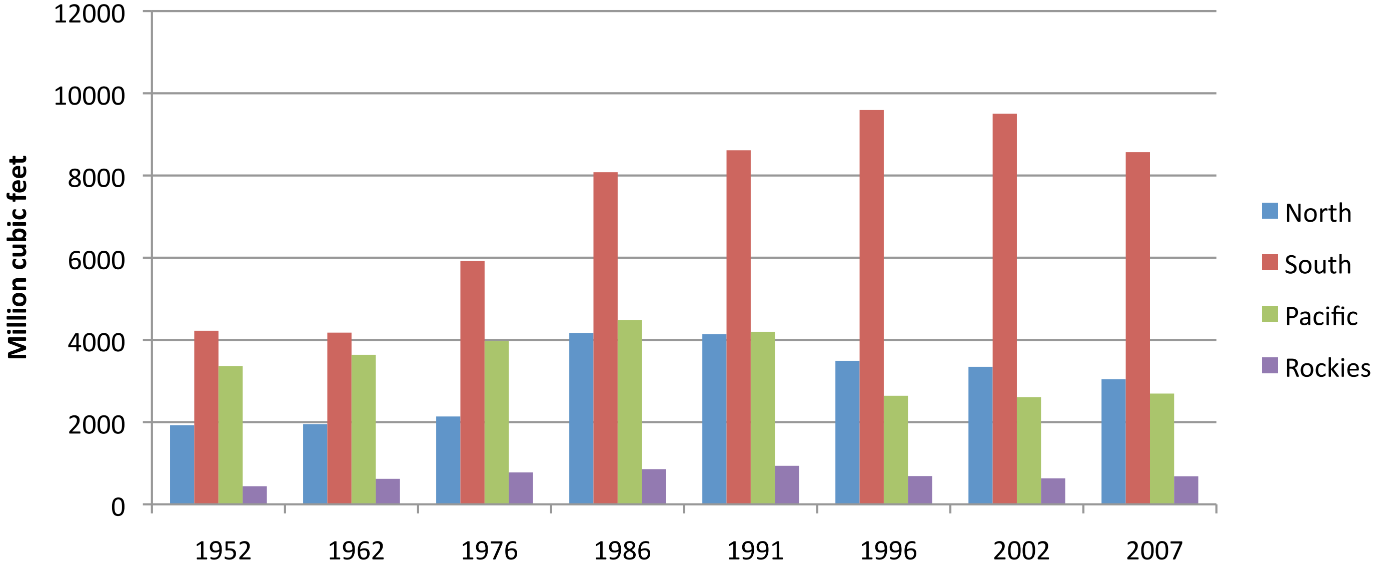

Figure 11—Timber harvest in the United States by region. Source: USDA Forest Service timber product output reports as defined in Wear and others (2007).

Expanding demand for timber in the South encouraged forest landowners to increase their investments in timber production thereby expanding timber supply (chapter 5). The area of planted pine has grown strongly over the past 50 years, from nearly none in 1952 to about 39 million acres (or 19 percent of forests) by 2010, with a near doubling of planted pine acres from 1990 to 2010 alone (fig. 12). In the Coastal Plain, 27 percent of forests are now classified as planted pine type. The area of planted pine continued to expand even after the market peaked in 1998 and harvesting began to decline. This expansion, combined with increased productivity from genetic and silvicultural improvements, means the forests of the South are positioned to produce even more timber than they did at the market peak. Although the planting of pines occurs to some extent throughout the region, the vast majority of pine plantations are located in the Coastal Plain.

The formation of public policies also has played a role in the development of the private timber investments in the South. Federal Government assistance to private landowners dates to the Clarke-McNary Act of 1924, which fostered State-Federal cooperation in several areas of forest protection and management (Steen 1976). Since then, a variety of Federal and State programs have supported wildland fire protection programs as well as technical advice for landowners in conjunction with cost sharing for forest establishment, regeneration, and silvicultural treatments. Cost-share programs for planting, such as the Soil Bank and Conservation Reserve Programs, have motivated substantial afforestation on nonindustrial forest ownerships (Lee and others 1992). Fire protection represents perhaps the most visible and significant form of assistance, reducing the risk of catastrophic forest losses and thereby improving the odds of realizing a profitable return on investments. This type of risk mitigation undoubtedly encouraged tree planting and active forest management, and has played an important role in the expansion of forest production since the 1940s.

Not all policies encourage forest ownership and investment. Federal and State taxes reduce pre-tax values of family-owned forest land in the South. Property taxes can produce relative disadvantages to holding forest land and contribute to conversion of some forest land in States with higher property tax rates. Likewise, estate taxes can encourage forest land sales and timber harvesting to cover the cost of such taxes under some circumstances (chapter 11).

From the 1960s to the 1990s, the period when timber harvesting more than doubled, the biomass in southern forests also grew steadily, reflecting high growth rates (fig. 13). From the 1950s to 2010, growth exceeded total removals, increasing the hardwood biomass inventory by 80 percent and the softwood biomass inventory by 60 percent (chapter 5). While growth still exceeds removals, the reservoir of southern biomass and the stores of carbon it represents have begun to level off.

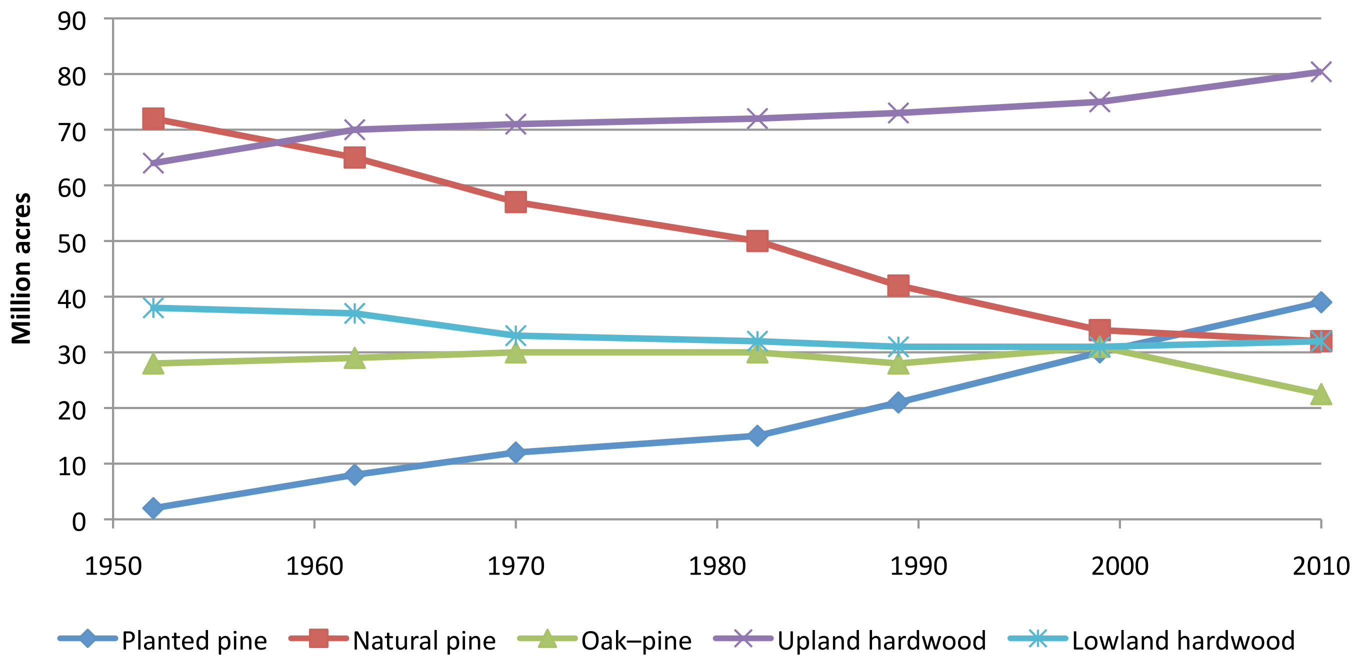

Figure 12—Historical trends in forest area by broad management type, 1952–2010.

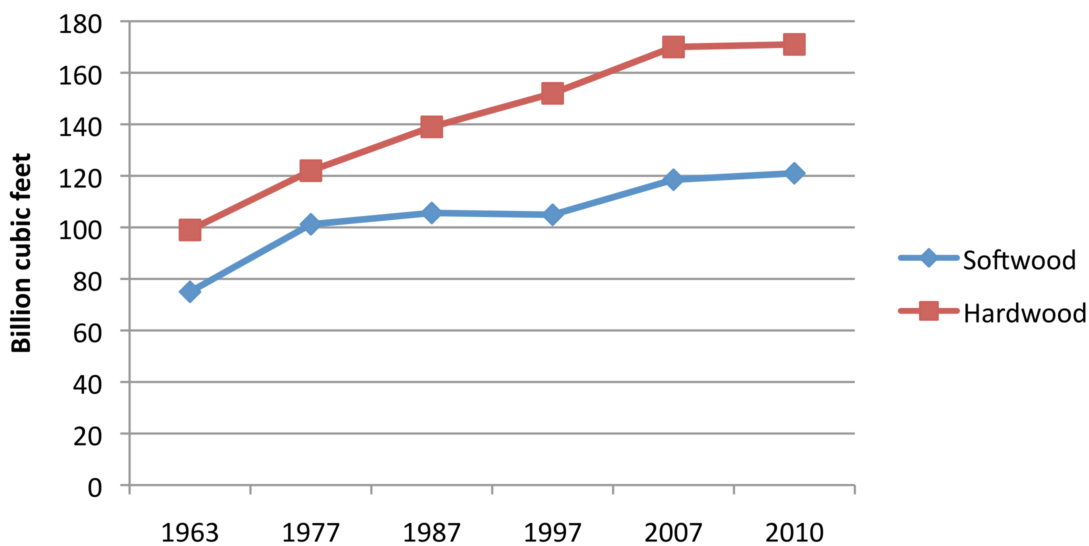

Figure 13—Trends in standing biomass measured as volume of growing stock inventory. Source: Forest Inventory and Analysis surveys as summarized by Smith and others (2001, 2004, 2009).

Forest Ecology and Services

The diversity of forest settings in the South supports a diverse biota and contains 1,027 native terrestrial vertebrates (fig. 14): 178 amphibians, 504 birds, 158 mammals, and 187 reptiles. Species richness is highest in the Mid-South (815) and Coastal Plain (691), reflecting both the large area of these subregions and the diversity of habitats within them (chapter 14). The geography of this diversity varies by taxa. Amphibians flourish in portions of the Piedmont and Appalachian-Cumberland highlands and across the Coastal Plain. Bird diversity is highest in the coastal and wetlands forests along the Atlantic Ocean and Gulf of Mexico, mammal diversity is highest in the Mid-South and Appalachian-Cumberland highlands, and reptile diversity is highest in forests farthest south.

The long history of intensive land use has changed the habitat structure of many southern forests. The near elimination of once-dominant longleaf pine ecosystems was perhaps the greatest ecosystem alteration resulting from intensive forest management and land use conversion in the South. Because of losses in this and several other upland and wetland forest ecosystems, southern species considered to be of conservation concern now include 152 terrestrial vertebrates, 81 of which are federally listed; and more than 900 plants, 141 of which are federally listed (figs. 15 and 16). Species of conservation concern include those that have a Global Conservation Status Rank of “vulnerable (G3),” “imperiled (G2),” or “critically imperiled (G1)” as described in chapter 14. The proportion of these species at risk varies among taxonomic groups (fig. 16): 45 percent of imperiled vertebrate species are amphibians, followed by reptiles (24 percent), mammals (16 percent), and birds (15 percent). The Coastal Plain (64) and Mid-South (55) lead in the numbers of imperiled vertebrate species (fig. 15), followed by the Appalachian-Cumberland highlands (31), Piedmont (29), and Mississippi Alluvial Valley (9).

The recent influx of nonnative invasive plants, insects, and diseases has been an unwelcome addition to southern forests. Of the most important invasive insects and diseases affecting southern forests, several have been established in the last 10 years (chapter 16), e.g., emerald ash borer and laurel wilt have been introduced only recently and are spreading rapidly throughout the range of their host species.

Of the 380-plus recognized nonnative plants in southern forests and grasslands, 53 are rated high-to-medium risk for natural communities (chapter 15). These plants often out-compete native species and alter species composition of forests, resulting in impacts to forest productivity, diversity, and wildlife habitat

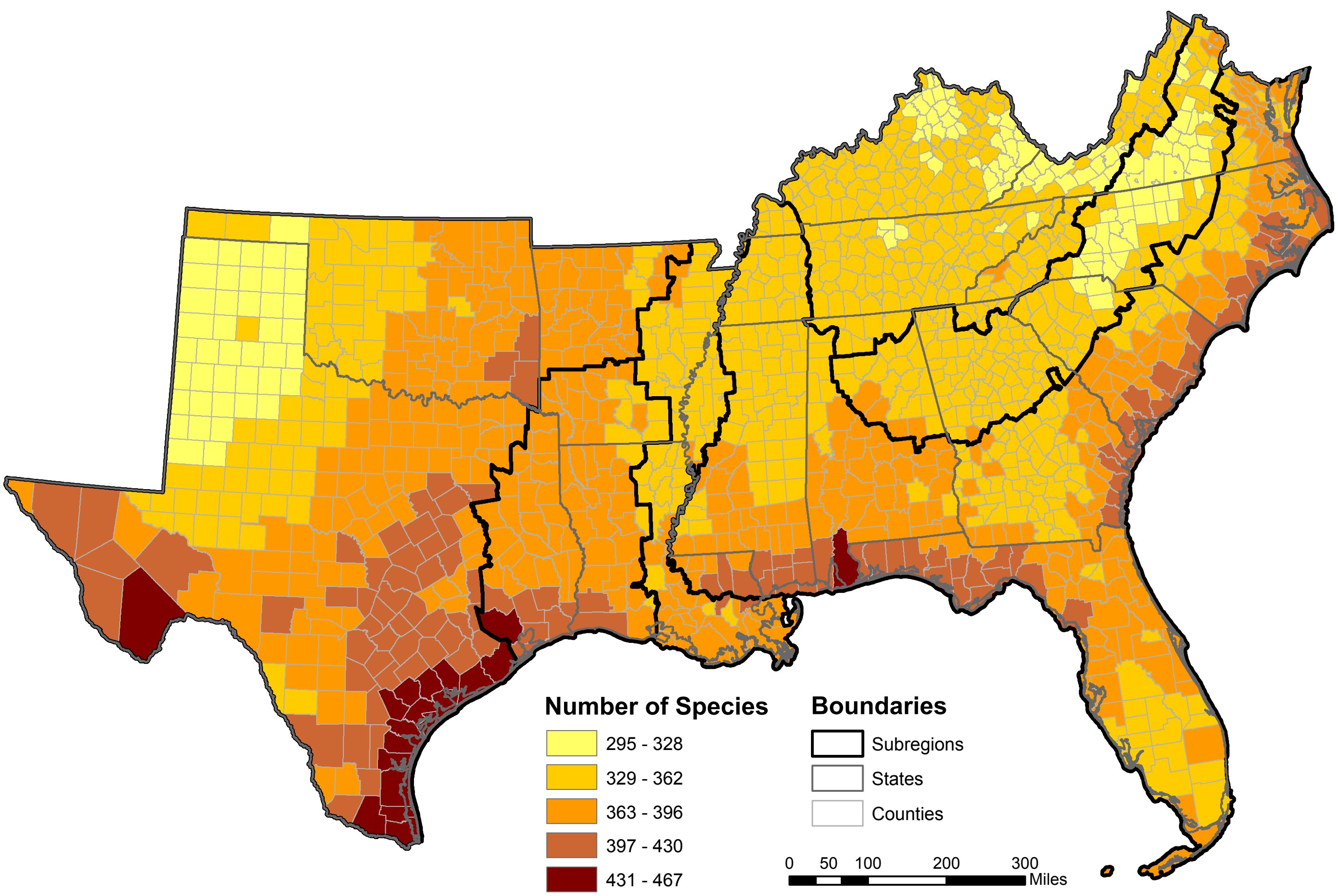

Figure 14—County-level counts of native terrestrial vertebrate species in the Southern United States. Source: NatureServe 2011.

that can be exceedingly difficult to manage, especially when multiple species are involved. As a group, their distribution is southwide, though occurrence and concentration of individual species within subregions is variable (fig. 17).

Strong population growth and associated urbanization has increased demand for water and challenged water availability in several areas, especially in the Piedmont, throughout Florida, and in much of Texas (fig. 18). Conversion of forests to urban and other land uses has resulted in a loss of natural buffering, increasing water pollution loads, elevating peak flows, and reducing base flows in affected watersheds. The consequences are more frequent and more severe flooding, lower stream flows during drought conditions, and water quality that is degraded—sometimes to the point of threatening public health. Although the degree of adverse hydrologic responses to urbanization differs across subregions, the link between conversion of forest land to urban uses and degraded water quality in affected watersheds is well documented (chapter 13).

To recap, forests dominate much of the South's landscape and play a critical role in the lives and livelihoods of the region's populace. Forest types and the species they support are highly diverse, reflecting a range of biophysical conditions. The South leads the United States in timber production, and intensive management has expanded the productivity of its pine forests. Southern forests also provide a variety of ecosystem services including clean water, biodiversity, and carbon storage. Although timber inventory has increased over the past 2 decades as a result of management, there are indications that increases may have come at a cost to some ecosystem services. Diverse values and dynamic forest conditions combined with high uncertainty about the future give rise to the questions that have been the focus of the Southern Forest Futures Project.

KEY FINDINGS OF THE SOUTHERN FOREST FUTURES PROJECT

Each of the chapters that comprise the Southern Forest Futures Project technical report represents a full review of its respective topic and contains a list of key findings (Wear and Greis, in press). The 10 key findings presented here are not a compilation or ranking of those from the individual chapters. Instead they represent a synthesis, with each drawing from the Cornerstone Futures and an analysis of one or more of the meta-issue chapters to highlight the most important conclusions from the project as a whole.

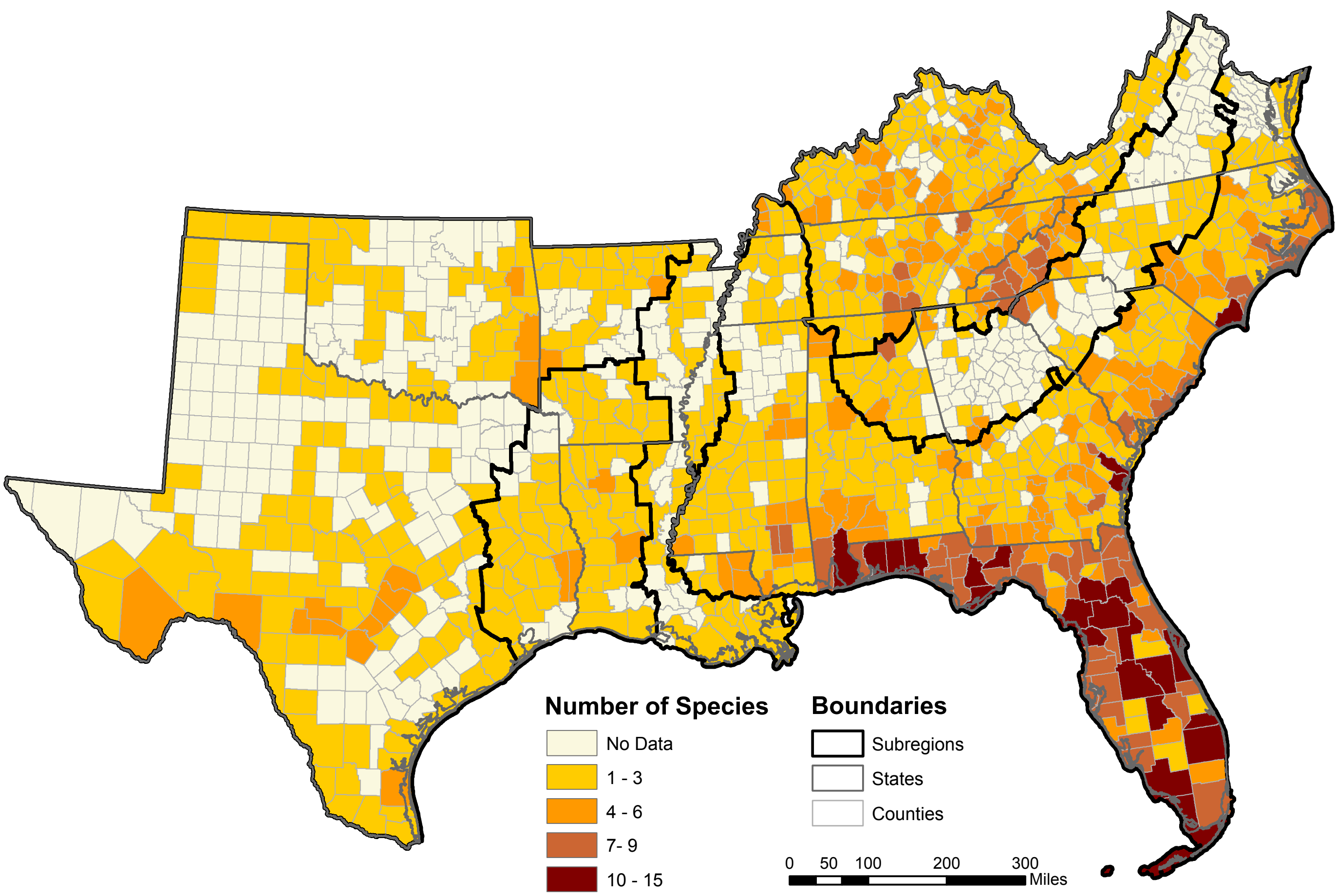

Figure 15—County-level counts for terrestrial vertebrate species of conservation concern in the Southern United States. Source: NatureServe 2011.

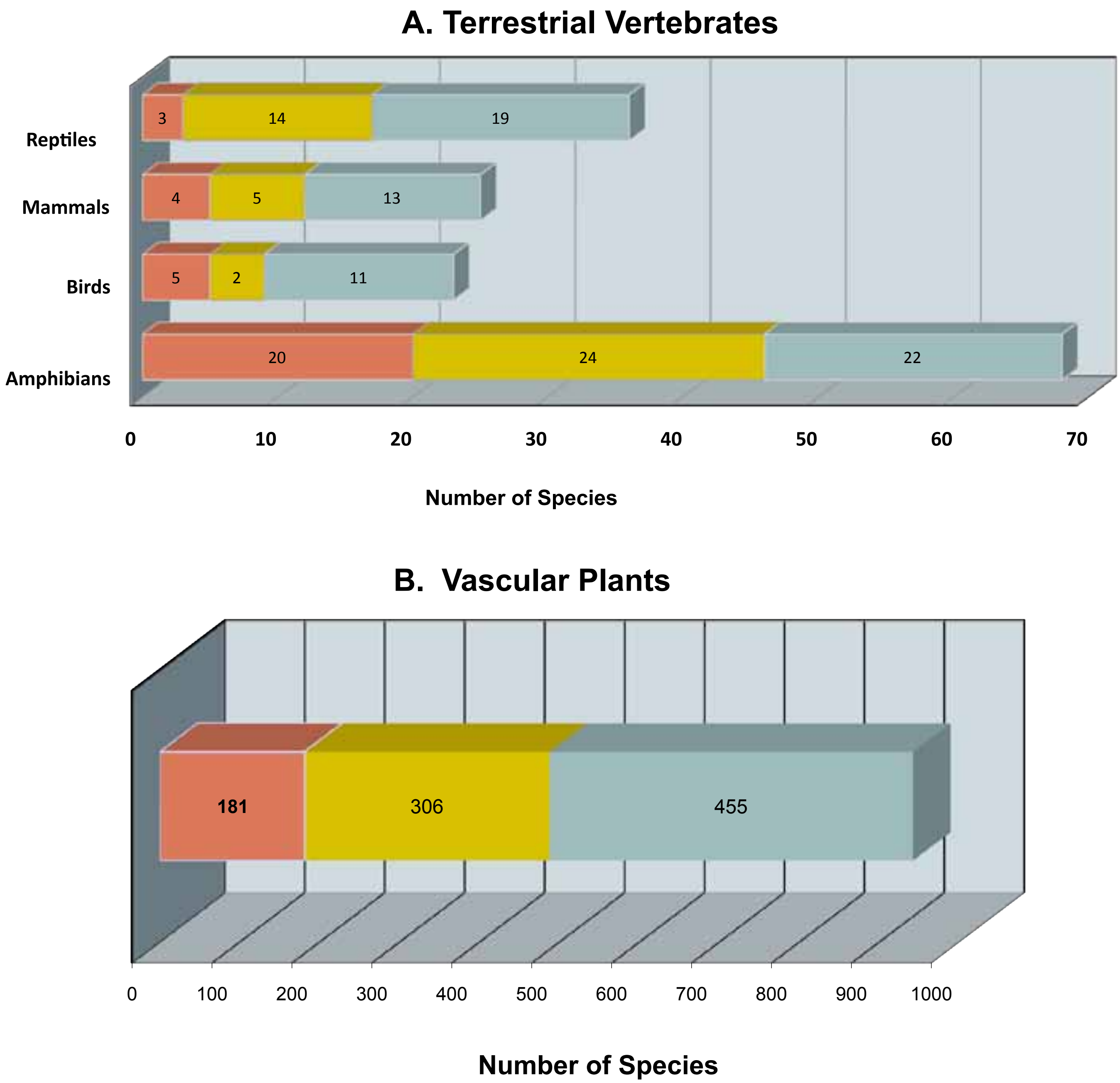

Figure 16—Number of species of conservation concern (the sum of vulnerable, imperiled, and critically imperiled species) in the Southern United States for (A) terrestrial vertebrates and (B) vascular plants. Source: NatureServe 2011.

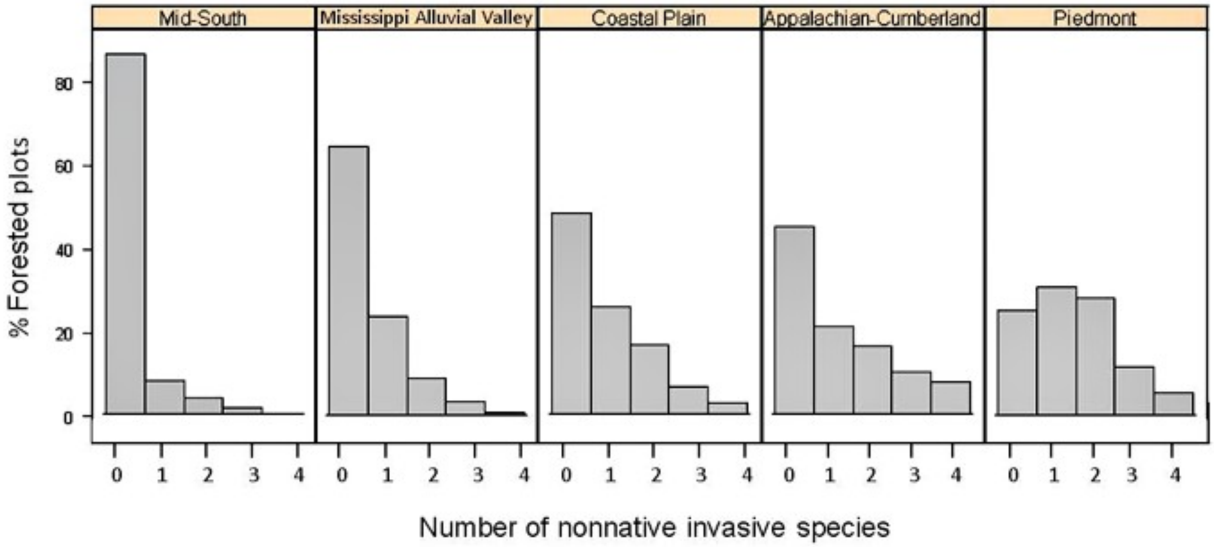

Figure 17—Percentage of forested survey plots in which one to four nonnative invasive plant species were reported in the Mid-South, Mississippi Alluvial Valley, Coastal Plain, Appalachian-Cumberland highlands, and Piedmont. Source: USDA Forest Service, Forest Inventory and Analysis databases.

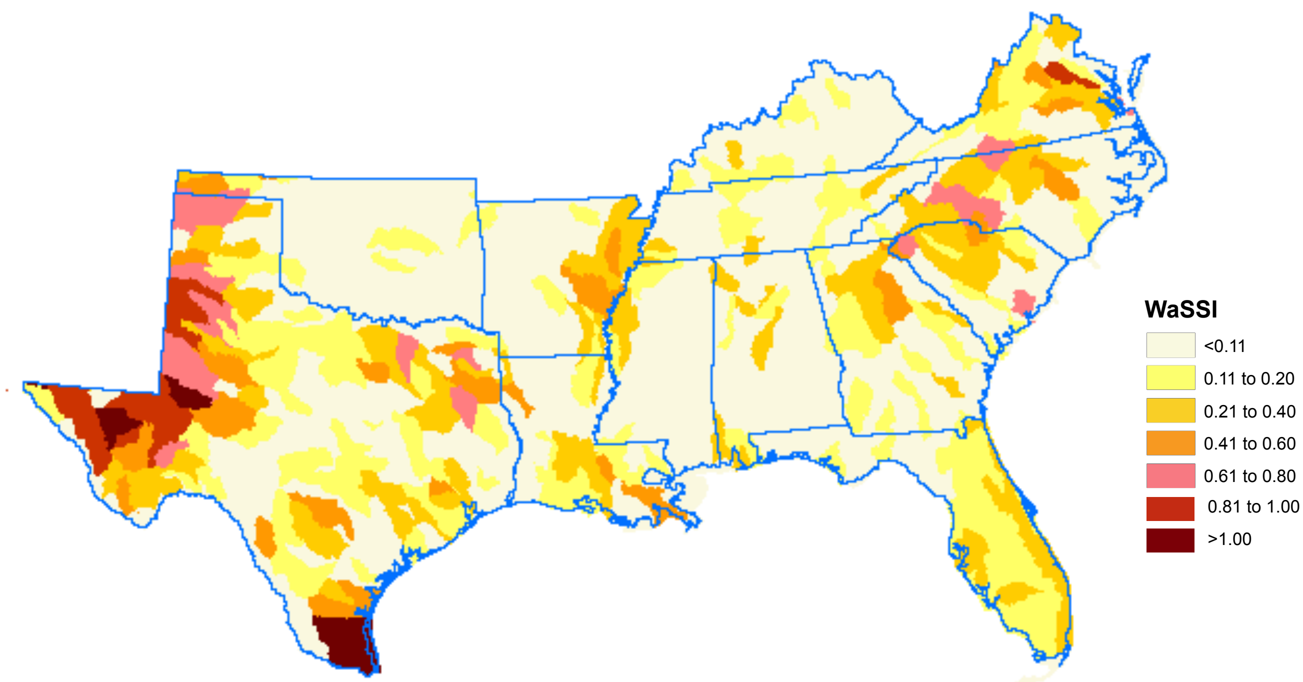

Figure 18—Water supply stress index (defined by the Water Supply Stress Index or WaSSI and calculated by dividing water supply into water demand) under baseline (1995–2005) conditions. Darker colors indicate higher levels of stress (see chapter 13 of the technical report of the Southern Forest Futures Project).

1. A combination of four primary factors will interact to reshape the South's forests.

No single dominant force of change will affect the forests of the South. Rather, a combination of socioeconomic and biophysical factors will reshape the forests of the South, and their interaction may well amplify the direct effects. Forest futures will most strongly depend on combinations and interactions of the effects of four key factors: population growth, climate change, fiber markets, and invasive insect, disease, and plant species.

Population growth—By 2060, the South's human population is forecasted to increase by 40–60 percent (fig. 19). Figure 20 shows population density forecasts for the South under Cornerstone Futures A and B (60 percent). The Piedmont, with the greatest population density in 2006, is forecasted to grow the most over the projection period. By 2060, population density in the Coastal Plain would be as high as current densities in the Piedmont. However, several areas are forecasted to experience population declines—including parts of the High Plains in Texas and Oklahoma, much of the Mississippi Alluvial Valley, and parts of southern Alabama and Mississippi—so population growth is accompanied by redistribution. This redistribution would focus growth in urban areas resulting in declines in forest cover, increases in demand for ecosystem services, and restrictions that complicate the ability to manage forests for the full spectrum of uses.

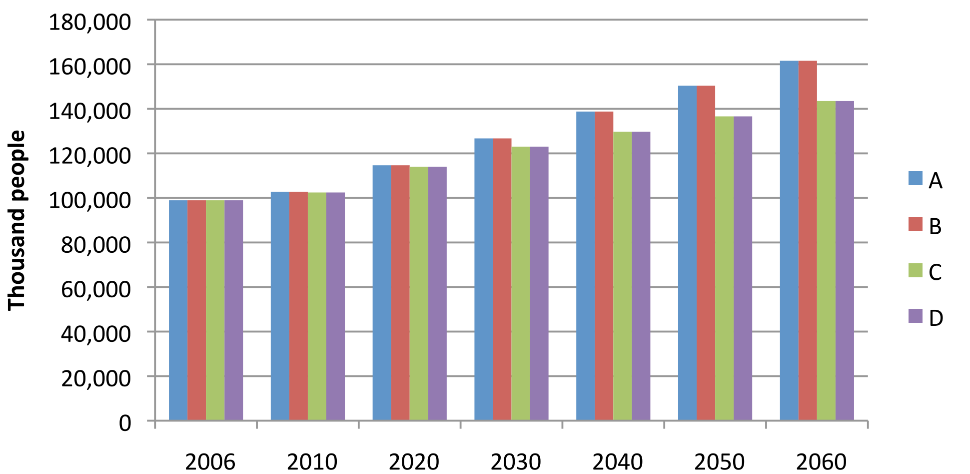

Figure 19—Projections of population in the Southern United States for Cornerstone Futures A and B and Cornerstone Futures C and D. Source: USDA Forest Service 2010.

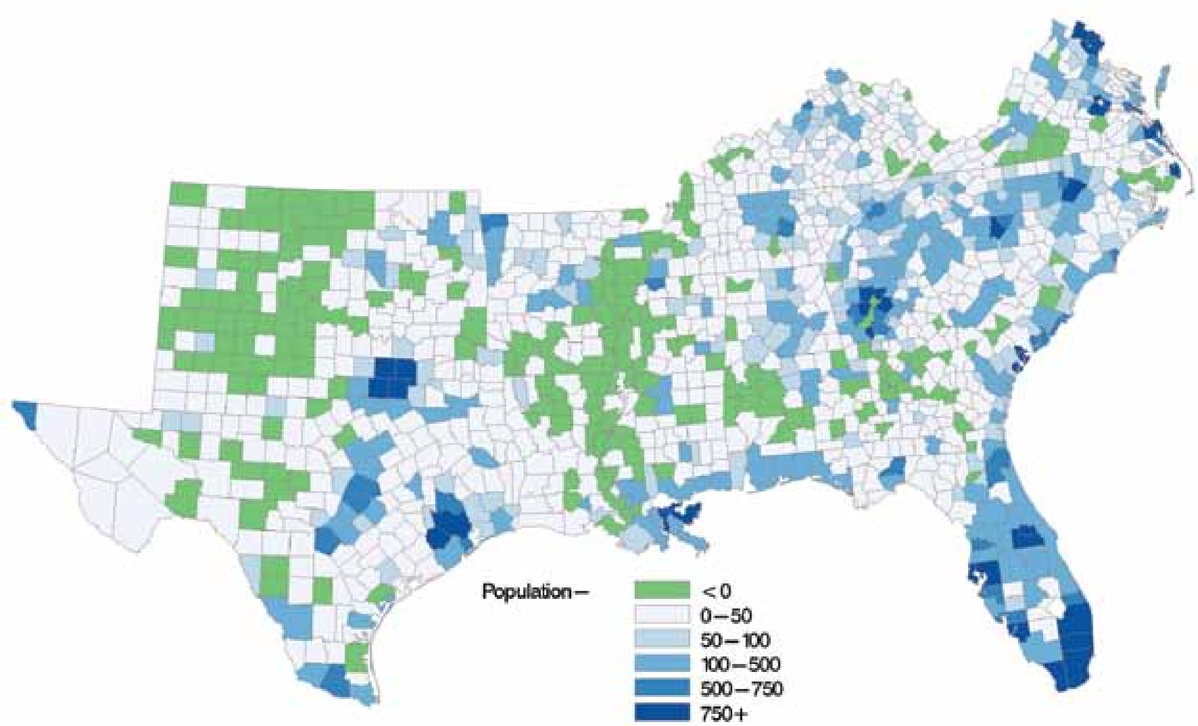

Figure 20—Projection of population change (change in people per square mile) for Cornerstone Futures A and B; counties in green have forecasted population losses.

Climate change—Forecasts from the climate models used by the Cornerstone Futures consistently indicate a warmer future, with average annual temperatures increasing 2.5 to 3.5 °C by 2060 (fig. 21). Precipitation forecasts are much more variable across the models, generally ranging between historical levels and levels that are somewhat lower with high spatial variability across the South (fig. 22). The regional averages are not as informative as forecasts for specific subregions (fig. 23); at the subregion level, there is a higher degree of uncertainty for some places like Florida and western Texas, but more consistency in others such as the drier conditions predicted for Arkansas and Oklahoma. Concerns about climate change over the next 50 years are focused on the margins of forest distributions in the South. In places where water availability is a limiting factor, fire and other forest disturbances may accelerate change in species composition and forest extent (chapters 5 and 17). More frequent and severe droughts coupled with increased demand from growing populations would stress water supply in parts of the region (chapter 13). Climate change could alter the spread of some invasives (chapters 15 and 16) and cause a rise in sea level, with associated impacts on coastal forests (chapter 13).

Timber markets—The South contains the most intensively managed forests in the United States. Over the last 50 years timber production more than doubled and the area of planted pine grew from virtually nonexistent to 39 million acres, or about 19 percent of forests (chapter 9). Forest landowners have shown a strong propensity to convert naturally regenerated forests to planted pines after harvesting, especially in the Coastal Plain, an investment response that is strongly linked to the condition of forest product markets. For example, with a forecast of timber harvesting (fig. 24) driven by a return to 2006 demand relationships, harvesting increases as a result of supply growth, which in turn is readily accommodated by the increased area of planted pine since the 1990s (the area of planted pine essentially doubled between 1990 and 2010). Future timber markets could affect the forests of the South in two important ways. First, strong timber markets encourage retaining forests rather than converting them to

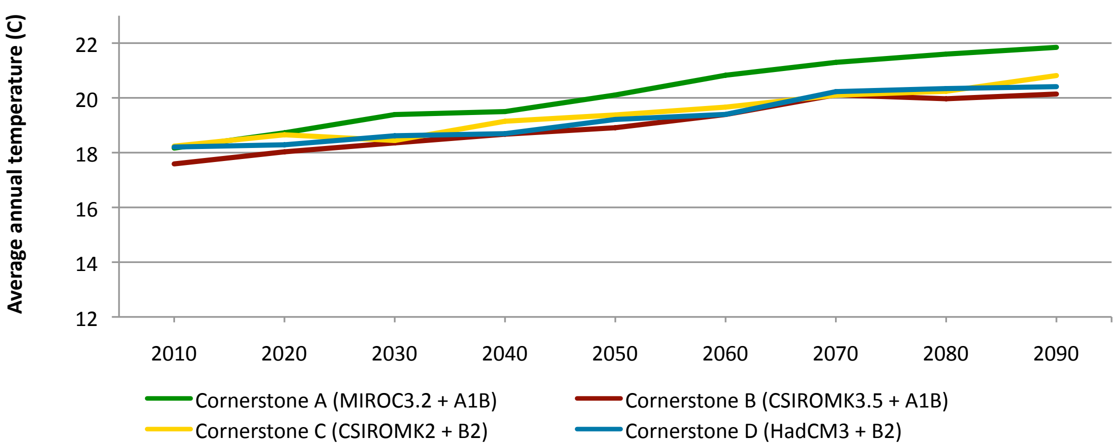

Figure 21—Predicted annual air temperature (2010, 2020, 2040, 2060, and 2090) for the Southern United States as forecasted by four Cornerstones Futures (A–D), each of which represents a general circulation model paired with one of two emission scenarios—A1B representing low-population/high-economic growth, high energy use, and B2 representing moderate growth and use. Source: IPCC 2007.

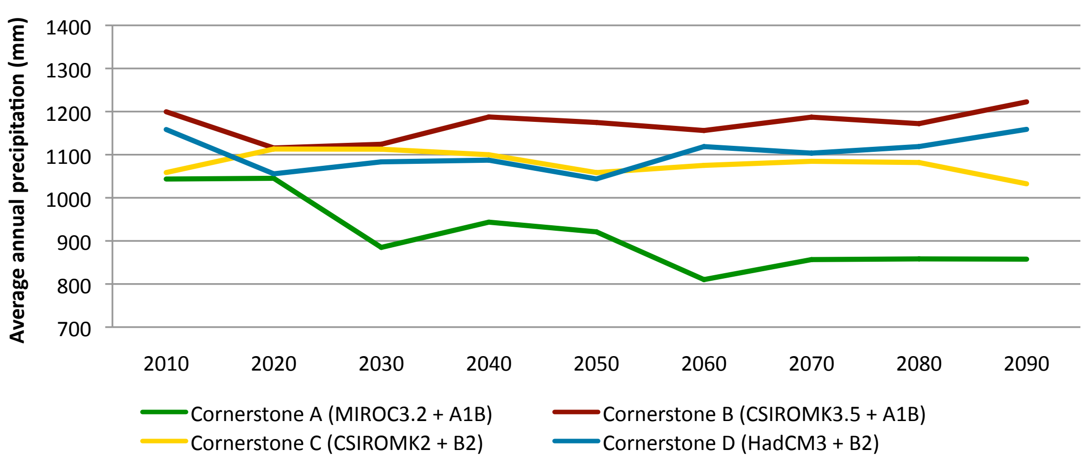

Figure 22—Predicted annual precipitation (2010, 2020, 2040, 2060, and 2090) for the Southern United States as forecasted by four Cornerstones Futures (A through D), each of which represents a general circulation model paired with one of two emission scenarios—A1B representing low-population/high-economic growth, high energy use, and B2 representing moderate growth and use. Source: IPCC 2007.

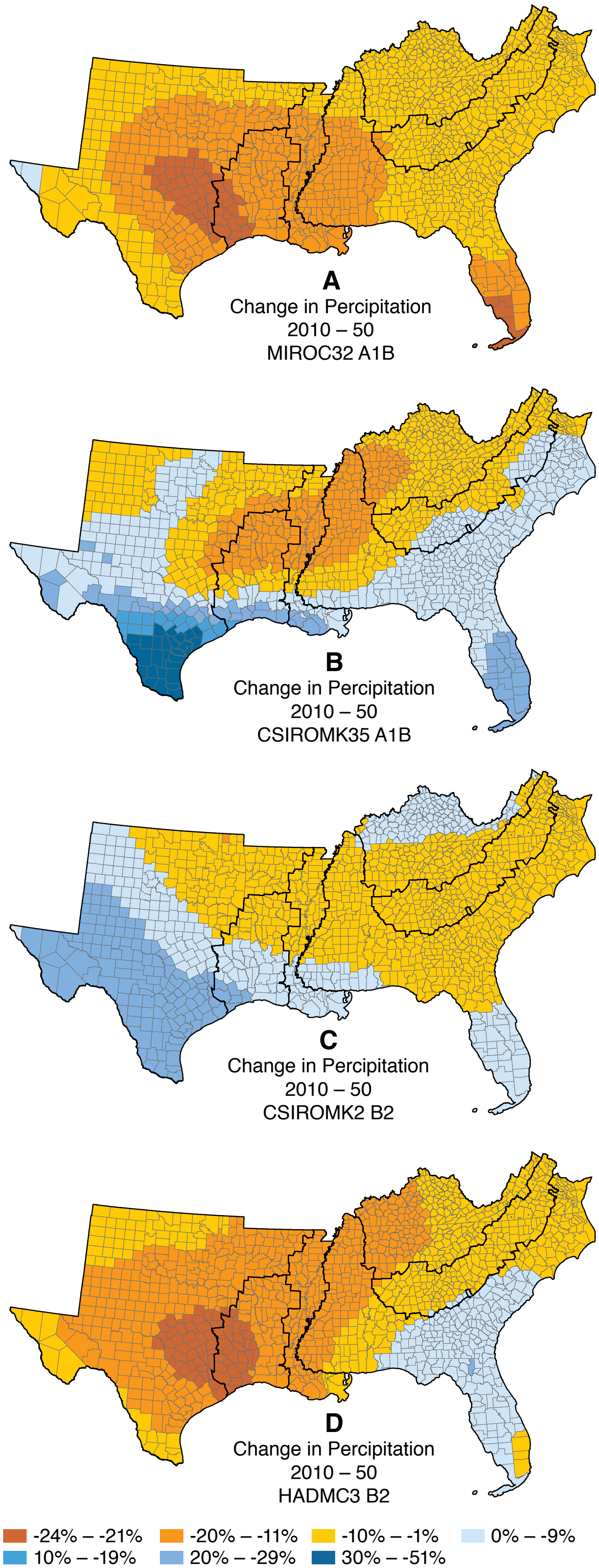

Figure 23—Change in precipitation (percent) from 2010 to 2050 by Cornerstone Future (A through D); Cornerstone Future E has the same climate as A and Cornerstone Future F has the same climate as D.

other land uses, so high timber prices can help delay or even reverse forest losses in areas where forest management is still feasible. Secondly, strong timber markets encourage continued investment in forest management, and forecasts suggest that the area of planted pine could increase from the current 19 percent to between 24 and 36 percent by 2060. Strong growth in market demand could result from the emergence of markets for bioenergy, but appears less likely to emerge from markets for traditional forest products. As a result, timber market growth would likely be centered on small diameter pines with strong market interactions between paper and bioenergy industries (chapter 10).

Invasive species—New nonnative insects, diseases, and pest complexes are emerging across the South with significant implications expected for several tree species (chapter 16), such as hemlock (*Tsuga spp.*), ash (*Fraxinus spp.*) and redbay (*Persea borbonia*). The rate of introduction and spread for several invasive plant species (chapter 15) has accelerated over the past decade (fig. 25). Some species have almost immediate and acute impacts on stand composition, diversity, and productivity; an example is the quick spreading and fire-adapted cogongrass (*Imperata cylindrical*), which effectively precludes forest regeneration in affected forests. Other species, such as tree-of-heaven (*Alianthus altissima*), act on a slower time frame and only gradually displace native species. Either type—or in some cases, both types—of invasion of forested ecosystems can imply long-term changes in plant and animal assemblages, displacement of wildlife, and changes in forest productivity for various goods and services. Although additional invasion of southern forests by nonnatives is essentially certain, their rate of spread, extent of damage, and the ultimate implications for forest conditions make them the least certain of the factors affecting forests (chapter 15).

Interactions of factors—It is the combination and interaction of these four dominant forces that will shape the southern forests of the future. For this reason, it is important to evaluate their impacts in concert, e.g., through the integrated modeling approaches adopted for the Futures Project. Indeed, to evaluate one set of drivers in isolation from all the others would lead to incomplete and perhaps erroneous conclusions.

2. Urbanization is forecasted to result in forest losses, increased carbon emissions, and stress on other forest resources.

Land use forecasts for all Cornerstone Futures indicate a decrease in forest area, a qualitative change from the trends of the previous 30 years. Net forest losses reflect a shift in the complex of dynamics that have historically offset each other to yield little change in total forest area in the South. Looking to the future, strong urbanization rates continue in response

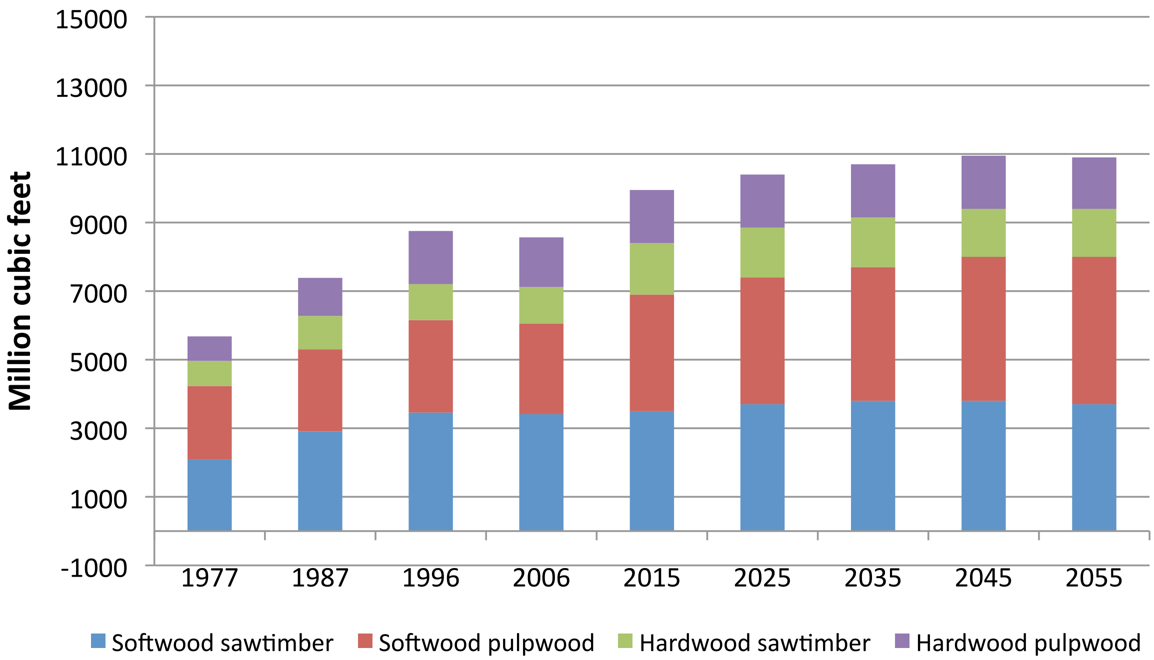

Figure 24—Forecasts of timber harvest quantities assuming constant demand for timber and land uses/economic growth associated with Cornerstone Futures A (high population/income growth with increasing timber prices) and B (high population/income growth with decreasing timber prices).

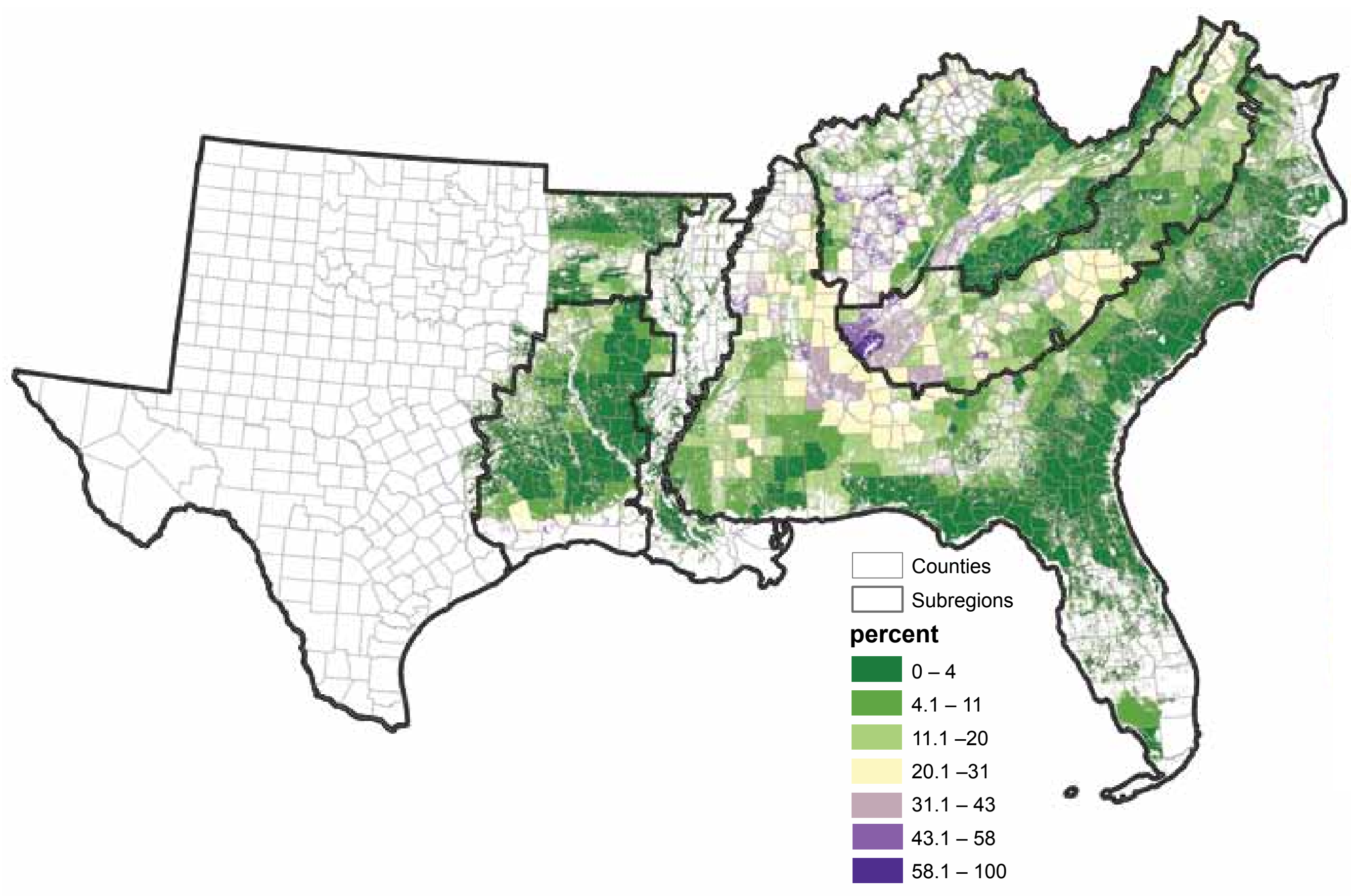

Figure 25—Percent of survey plots within a county occupied by one to four invasive plants. Source: USDA Forest Service, Forest Inventory and Analysis databases.

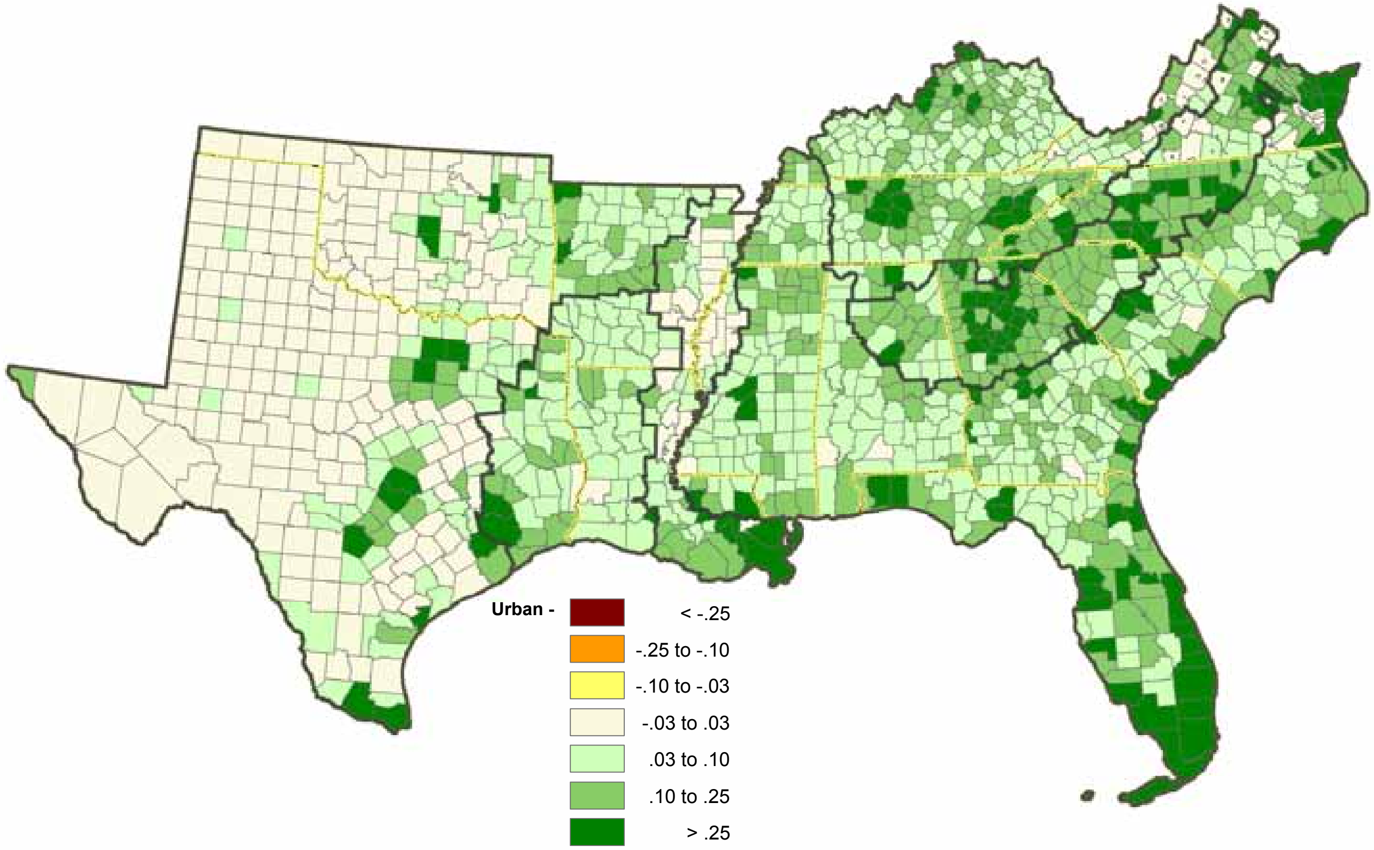

Figure 26—Forecasted change in the proportion of counties in urban land use for Cornerstone Futures A and B (high population/income growth).

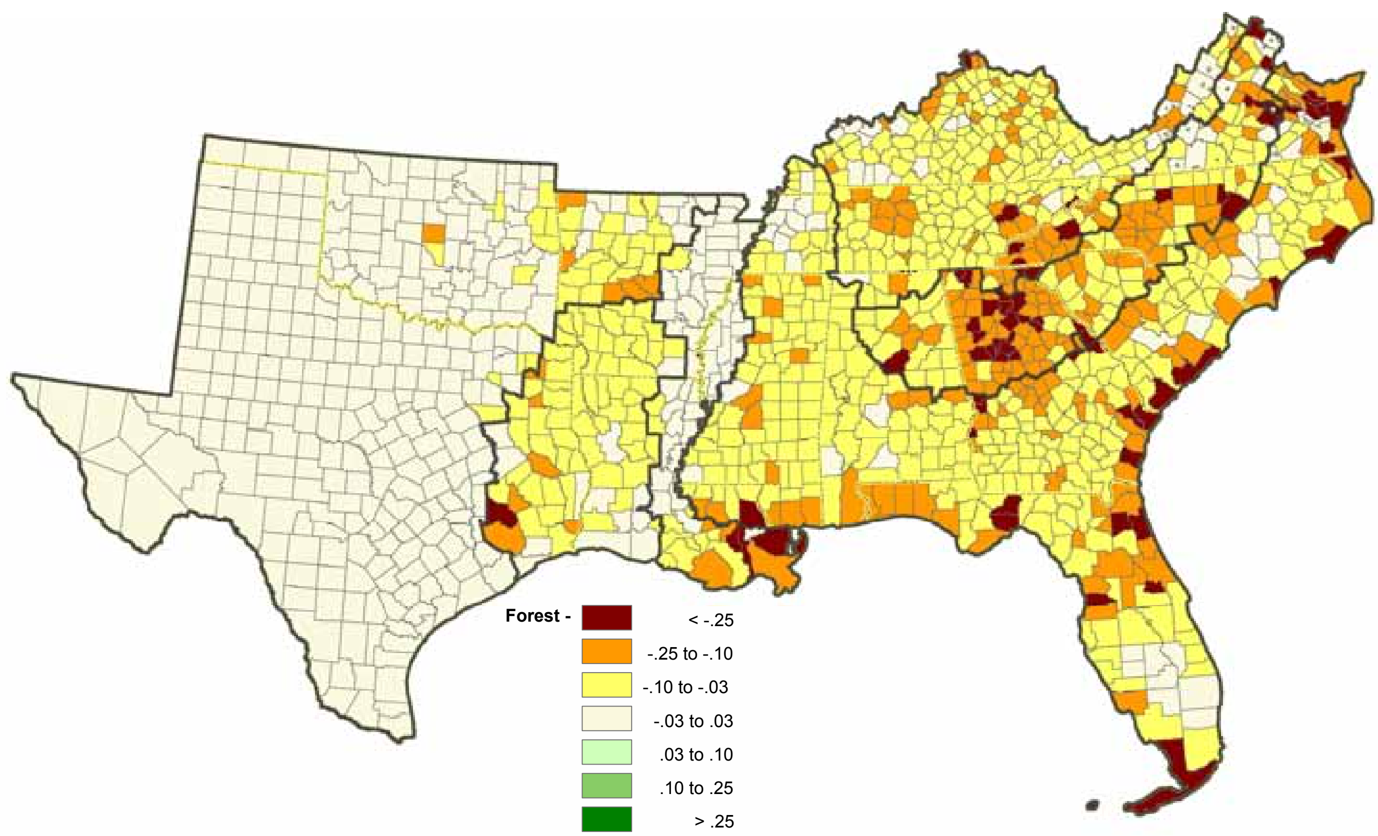

Figure 27—Forecasted change in the proportion of counties in forest land use for Cornerstone Future B (high population/income growth with decreasing timber prices).

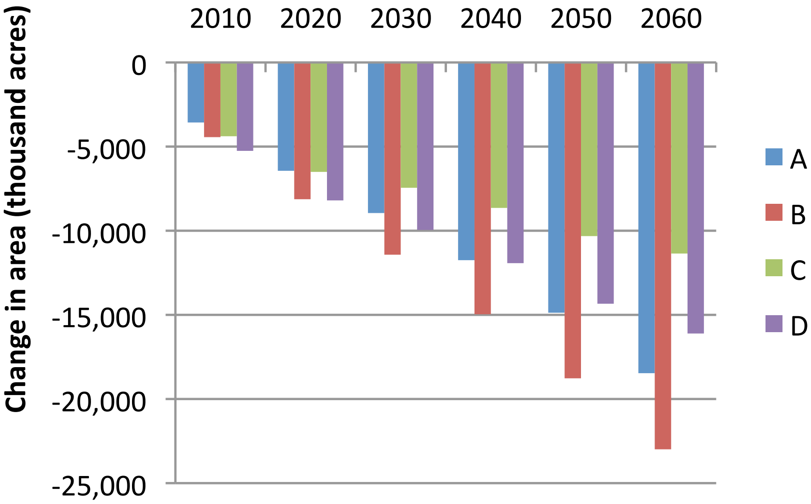

Figure 28—Change in area of forest land uses for the South from 1997 to 2060 under four Cornerstone Futures: (A) large urbanization gains with increasing timber prices, (B) large urbanization gains with decreasing timber prices, (C) moderate urbanization gains with increasing timber prices, and (D) moderate urbanization gains with decreasing timber prices.

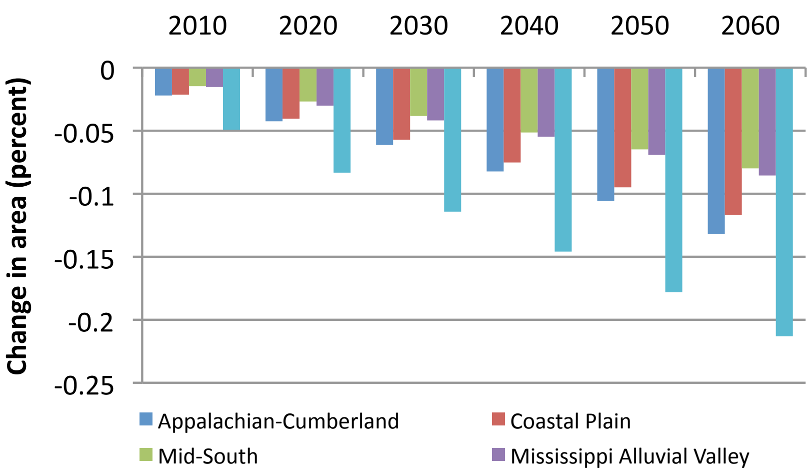

Figure 29—Change in forest area by southern subregion from1997 to 2060, expressed in percent, based on an expectation of large urbanization gains with decreasing timber prices (Cornerstone B).

to growth in population numbers as well as in household income. However, transitions from agriculture to forest uses, which had offset losses from urbanization in the past, are not forecasted to continue. This dynamic depends on agricultural markets, however, and unanticipated declines in the returns to crop production could ameliorate forest losses by shifting urbanization more toward agricultural lands.

From the base year of 1997 to 2060, an additional 30 to 43 million acres of southern rural lands are forecasted to be converted into urban uses (fig. 26). Total forest losses are forecasted to range from 11 million to 23 million acres, depending on the rate of population growth and the future of timber markets—low population growth with strong timber markets would yield the smallest losses (fig. 27). At 7–13 percent of current forest area, these losses would still equal nearly all the forests in Kentucky or South Carolina at the low end of the range, and nearly all the forests in Georgia or Alabama at the high end.

Because losses coincide with expanding urban centers, the heaviest forest losses would be in the Piedmont (as much as 22 percent) and Peninsular Florida (more than 30 percent). Low rates of forest losses are also forecasted for many other areas of the South where forecasted population change is moderate but where urbanization responds to expected general gains in personal income. Empirical land use models indicate that land development rates are positively influenced by income—even without population growth, a region can experience some land development if income increases.

The impact of urbanization on forests goes beyond loss of forest area. The functional value of forests in providing wildlife habitat, for example, would decline through fragmentation and an increased presence of humans in forest settings (chapter 14). This comingling of urban and forest uses in the wildland-urban interface affects a number of other functional aspects—such as water quality protection (chapter 13)

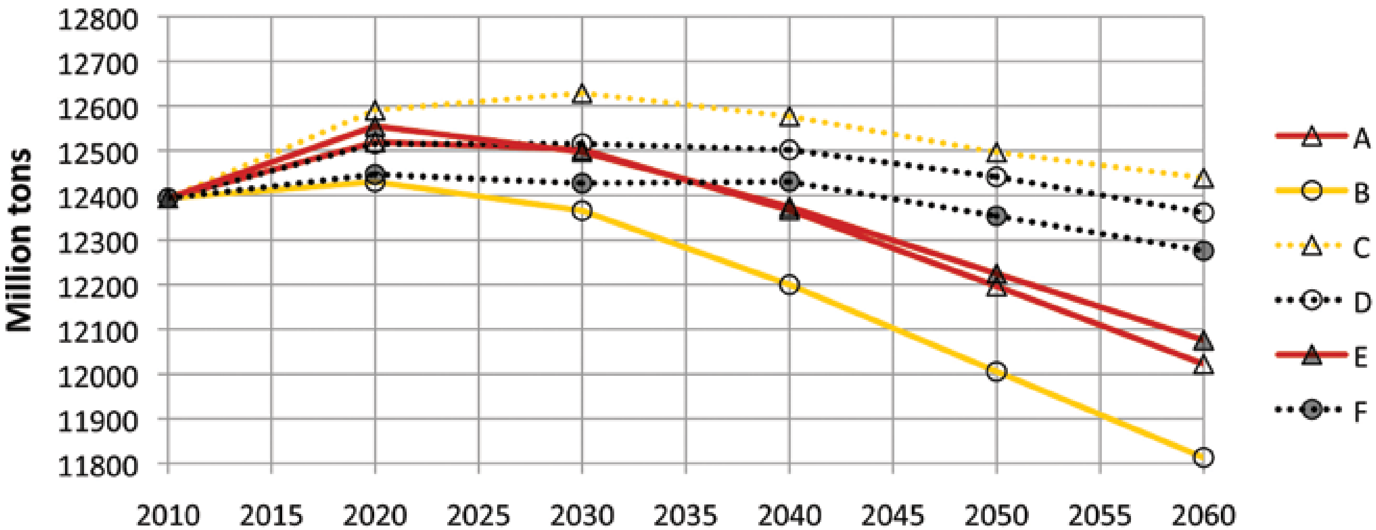

Figure 30—Total forest carbon stock (million tons of carbon), 2010–60, by Cornerstone Future.

and carbon storage (chapter 5)—as well as the ability to use fire to manage forests for a range of goals (chapter 17).

These forecasts of forest losses (figs. 28 and 29) differ from the no-net-loss forecast reported in the 2002 assessment (Wear and Greis 2002b). Although the pattern of urbanization remains consistent—largely due to the importance of population forecasts in determining future urban development—the range of forecasts is somewhat narrower here, and our updated forecast for the longer time period anticipates a minimum 7 percent net loss over the next 50 years.

The loss of forest area provides only a small impact on timber markets, since urbanizing areas are not usually near areas that are intensively managed for timber. Loss of forest area does however, reduce the amount of carbon stored in forests. Under most futures considered, the carbon fixed in the South's forests and their soils reaches a maximum between 2020 and 2030 and then declines through 2060 (fig. 30). Futures with stronger timber markets yield somewhat more forest carbon but fail to completely offset the carbon losses dominated by land use changes. A decrease in forest carbon stocks represents a reversal of a long-term trend of carbon accumulation—according to Heath and others (2011), the stock of forest carbon in the United States increased by about 7 percent from 1990 to 2008. While not all losses of forest carbon are emitted to the atmosphere, the potential decline in forest carbon storage would be a challenge for carbon mitigation policies, presenting a dynamic baseline where a first-order policy objective might be to stabilize rather than expand forest carbon stocks.

Land Use Changes in the South, Findings from Chapter 4

- Between 30 million and 43 million acres of land in the South are forecasted to be developed into urban uses by 2060, from a base of 30 million acres in 1997.
- The South is forecasted to lose between 11 million and 23 million acres (7 and 13 percent, respectively) of forests from 1997 to 2060. All subregions are expected to lose at least some acreage; nearly all of this area would be converted to urban uses.
- Strong timber markets can ameliorate forest losses somewhat, by shifting urbanization to agricultural lands.
- Among the five subregions of the South, the Piedmont is forecasted to lose the greatest proportion of its forest area, possibly as much as 21 percent by 2060. The Mid-South and Mississippi Alluvial Valley are forecasted to lose the least (between 8 and 9 percent).
- Among the 21 sections that make up the subregions of the South, Peninsular Florida is forecasted to lose the most forest land (34 percent). All sections within the Piedmont region are forecasted to lose at least 19 percent.

3. Southern forests could sustain higher timber production levels, but demand is the limiting factor and demand growth is uncertain.

Market forecasts for wood products—coupled with land use, climate, and demographic changes—suggest that southern forests could satisfy growth in wood products demand, even the high rates of growth observed in the early 1990s. Moderate demand growth would apply little upward pressure on the prices for most southern timber products because of ongoing supply growth.

As softwood timber supply rose from 2000 to 2010, demand for timber products fell, leading to reduced production levels and prices (figs. 31 and 32). These supply gains had derived from investments in planted pine that continued long after demand for timber products peaked in 1998. Demand declined first in pulp and paper manufacturing as per capita U.S. consumption of paper products trended downward; demand for solid wood products remained strong through 2007 but then fell dramatically in 2008 with the unprecedented decline in the construction industry. In 2009, housing starts totaled only 554,000, compared to lows that had not fallen below a million units since 1959.

Forecast models show the sector able to meet substantial new demands with little upward pressure on prices (fig. 33). A return to the peak harvest levels of the late 1990s would not cause a return to the 1990s peak prices because of expanded forest inventories and supply (fig. 33). Productive capacity has expanded especially strongly in the southeastern Coastal Plain where most pine plantations are located. A substantial structural shift in demand, for example, caused by demands for forest bioenergy feedstocks, would be necessary to increase softwood prices to the historical highs of the late 1990s (figs. 34 and 35). In contrast, hardwood prices could rebound more quickly because direct investment in their production has not occurred and their inventories are forecasted to be reduced by land use changes.

The 2002 assessment (Wear and Greis 2002a) emphasized the orderly progression of timber markets in the region. Timber scarcity concerns dominated earlier assessments, and, indeed, scarcity was a consistent mantra of forest policy throughout most of the 20th century. But strong forest investment indicates that private forest investors have anticipated and responded to perceived scarcity in spite of the long maturation of such investments. To the extent that expectations about the future are correct, timber supply should continue to respond in ways that anticipate future demand. The recent history of strong expansionary investment coupled with sustained declines in demand indicates that private investors may have "overshot" in the past decade, raising questions about a potential for eventual disinvestment if additional demand growth does not materialize.

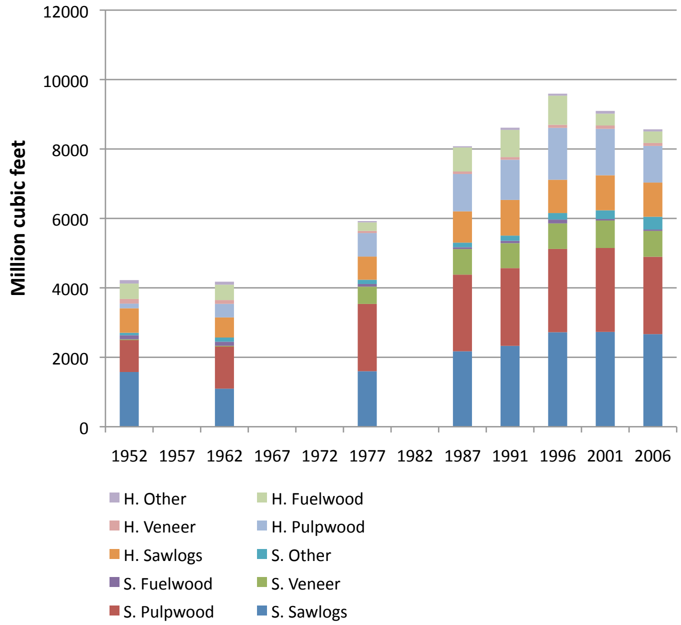

Figure 31—Roundwood harvests in the Southern United States by product, 1952–2006, various years. Source: based on various USDA Forest Service timber product output reports as defined in Wear and others (2007). (H refers to hardwoods, and S refers to softwoods.)

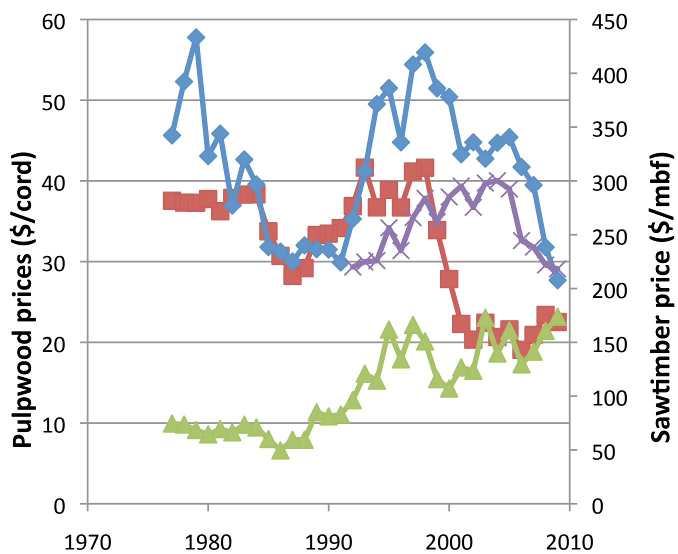

Figure32—Real stumpage prices in the Southern United States by product, 1977–2008. Source: Database of prices constructed from Timber Mart-South quarterly price reports (e.g., Timber Mart-South 2008) and deflated by the Consumer Price Index deflator.

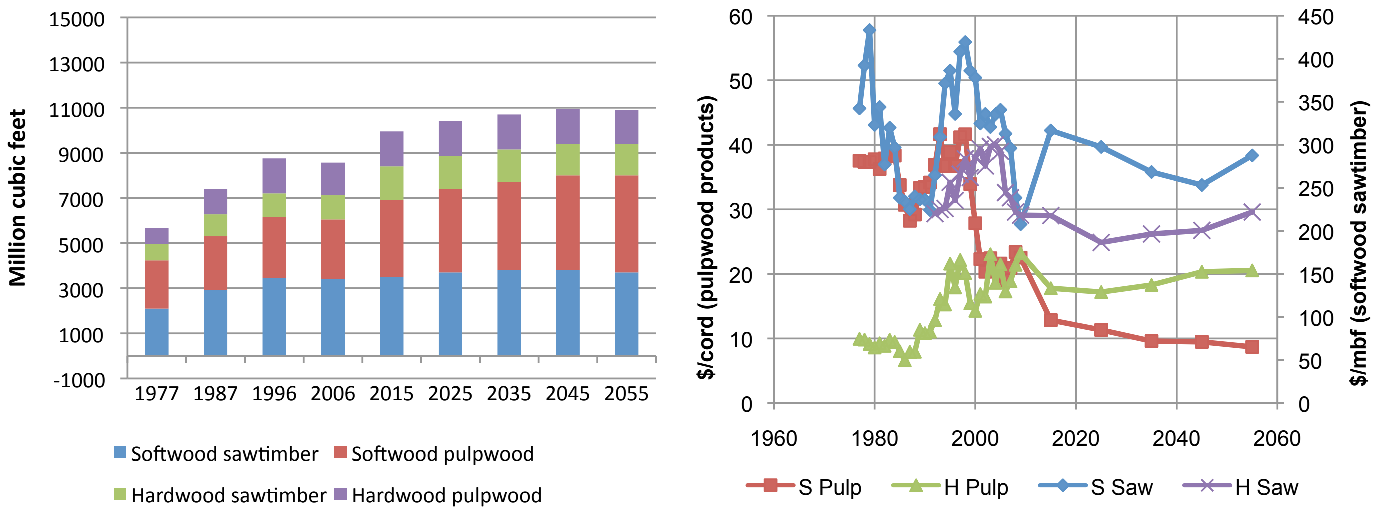

Figure 33—Forecasts of standing timber harvest quantities and real timber prices (2009=100) assuming a constant timber demand and Cornerstone A economic scenario.

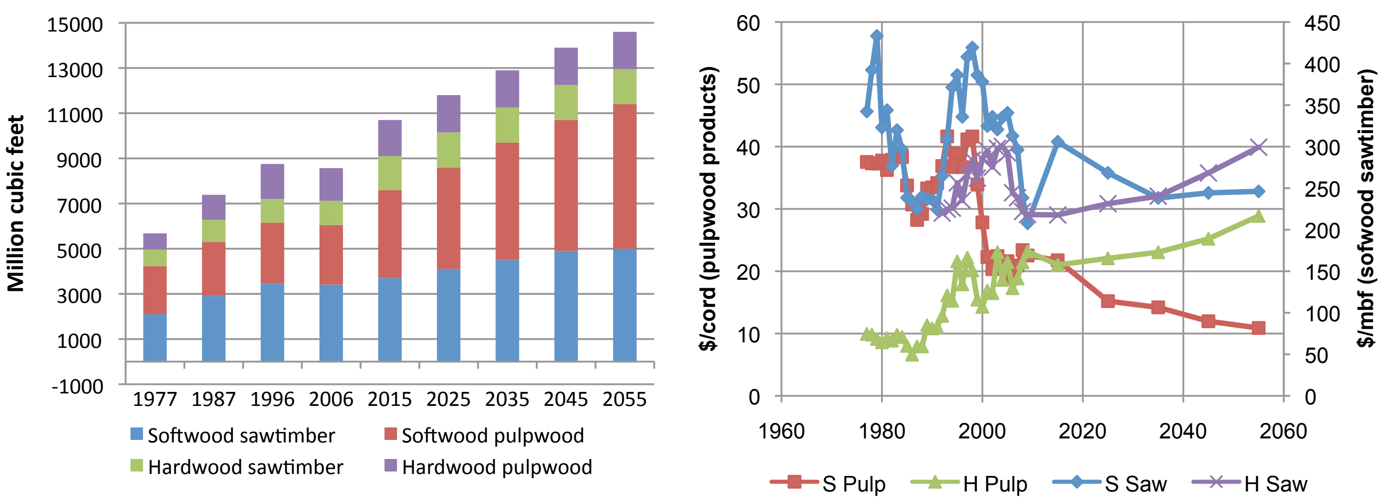

Figure34—Forecasts of timber production and real timber prices (2009=100) assuming an expanding timber demand and Cornerstone A economic scenario.

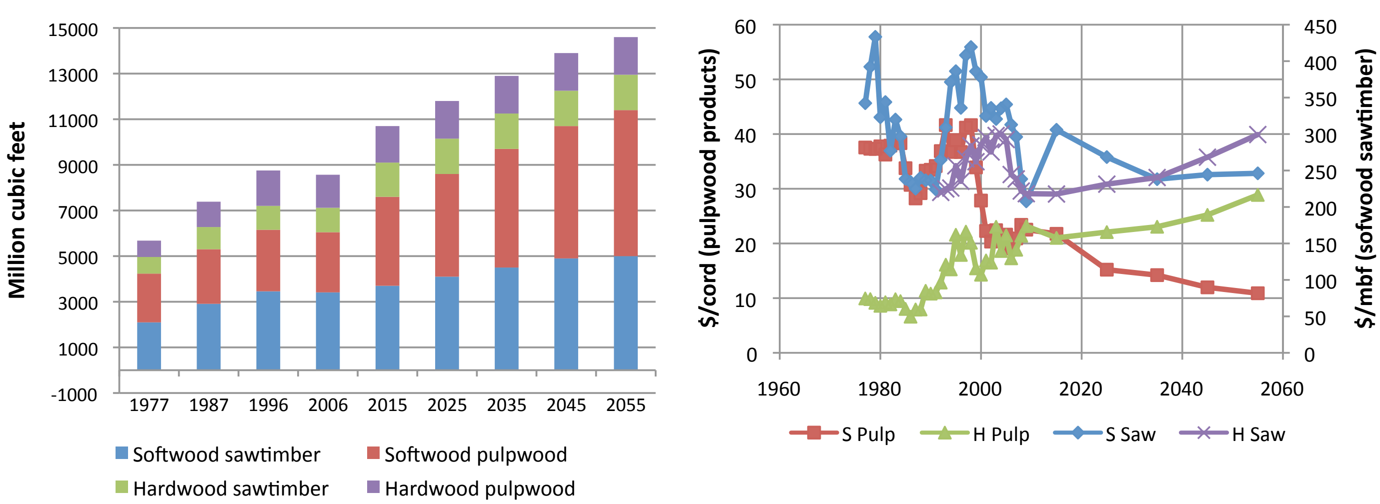

Figure 35—Forecasts of timber production and real timber prices (2009=100) assuming an expanding timber demand and productivity growth supply scenario.

The question of great relevance to an assessment that addresses multiple resource values is not solely how much harvesting will increase or decrease but where those changes are most likely to be concentrated. Forecasts of the Cornerstone Futures indicate that, consistent with history, increased harvesting is likely to be concentrated at the "intensive margin" rather than at the "extensive margin", i.e., more intensive management and expansion would take place in the pine plantations of the southeastern Coastal Plain where production and production growth has been focused for decades.

Even at high levels, timber harvesting is not forecast to substantially reduce total standing biomass in the region's forests. High prices encourage more harvesting but simultaneously encourage retention of forest land uses on private lands and investment in reforestation and other management treatments (chapter 5). The historical accumulation of biomass in southern forests would, however, reach a zenith over the forecast period and begin to decline after about 2030 for several Cornerstone Futures (fig. 36). Under none of the forecasts would biomass decline below current levels.

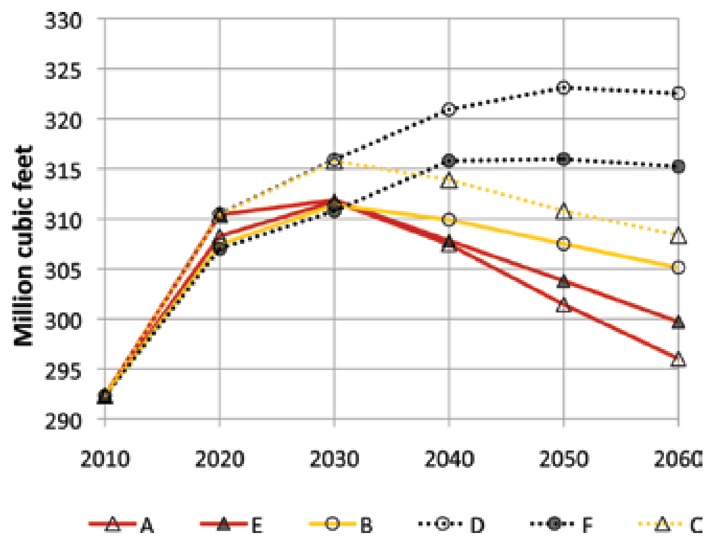

Figure 36—Total forest biomass measured as growing stock volume (million cubic feet) for the Southern United States, 2010–60, by Cornerstone Futures.

Markets for Southern Timber Products, Findings from Chapter 9

- Although timber production in the South more than doubled from the 1960s to the late 1990s, output levels have declined over the last 10 years, signaling structural changes in timber markets.
- As demand receded, investment in softwood production continued to expand, leading to increased supply for softwoods, especially softwood pulpwood. The net result was a substantial reduction in softwood pulpwood prices.
- Forecasts of timber markets show an increasing supply of softwood timber, especially softwood pulpwood, as new plantations mature and additional plantations accumulate across the South; softwood pulpwood supply increases throughout the next 40 years, and softwood sawtimber supply increases over the next decade and then stabilizes.
- Forecasts of hardwood supply indicate a gradual contraction as urbanization shrinks inventories.
- If timber product demand remains at 2006 levels, total timber production is forecasted to increase by about 25 percent over the next 50 years, with a 50-percent price decrease for softwood pulpwood and little change in price for softwood sawtimber and hardwood pulpwood.
- If timber product demand returns to the growth levels of the 1980s and 1990s, total timber production is forecasted to increase by about 40 percent over the next 50 years, with the greatest gains in softwood pulpwood output; softwood pulpwood prices would stabilize at 2006 levels, and softwood-sawtimber and hardwood-pulpwood prices would increase by slightly less than 1 percent per year.
- If timber product demand increases and planted pine forests become more productive, total timber production is forecasted to increase by about 70 percent, with production of softwood pulpwood more than tripling; price stabilizes for softwood sawtimber, decreases less than 1 percent per year for softwood pulpwood, and increases less than 1 percent per year for hardwood pulpwood.
- Forecasts indicate that the region's timber supply could expand if moderate rates of future forest investments are added to investments in forests made over the past 20 years. Forecasts for 2055 show that annual production of softwood pulpwood could increase beyond 2006 levels by an additional 2.4 billion to 3.7 billion cubic feet (36.6 million to 57.9 million green tons) without substantial price effects.
- Without an expansion in timber demand, the private forest landowners would be expected to eventually experience a strong shift away from forest management as investment returns diminish to the point where continued investments could not be justified.

4. Bioenergy futures could bring demands that are large enough to trigger changes in forest conditions, management, and markets.

The most likely source of new demand growth for timber is bioenergy, depending on policy actions which are highly uncertain. Demand for paper products trended downward since the late 1990s and a precipitous decline in solid wood product demand followed the 2007 housing-related recession. Although our forecasts are long run and, therefore do not predict the timing of the wood products industry's recovery from the 2007 recession, a gradual return to solid wood product demand at levels comparable to long run averages is likely.

Energy forecasts under various policy scenarios (chapter 10) show wood use for bioenergy starting with and then quickly exhausting harvest residuals and other available wood waste (fig. 37). As a result, bioenergy demand would lead to additional harvesting of raw material, especially softwood pulpwood. This new demand could offset and even exceed the declining demand for softwood pulpwood for pulp and paper manufacturing. The question of critical importance here is how the total demand for forest products would compare to historical levels.

Forest product market forecasts (chapter 9) indicate that markets could accommodate about a 40-percent expansion in harvesting by 2060 at current levels of forest productivity and a 70-percent expansion with moderate forest productivity growth assumptions. However, forecasts of wood use for bioenergy linked to U.S. Department of Energy projections suggests a 54- to 113-percent expansion of harvesting levels over current levels by 2050 (chapter 10). Especially at the higher levels, this would likely result in some structural changes for timber growing and wood utilization.

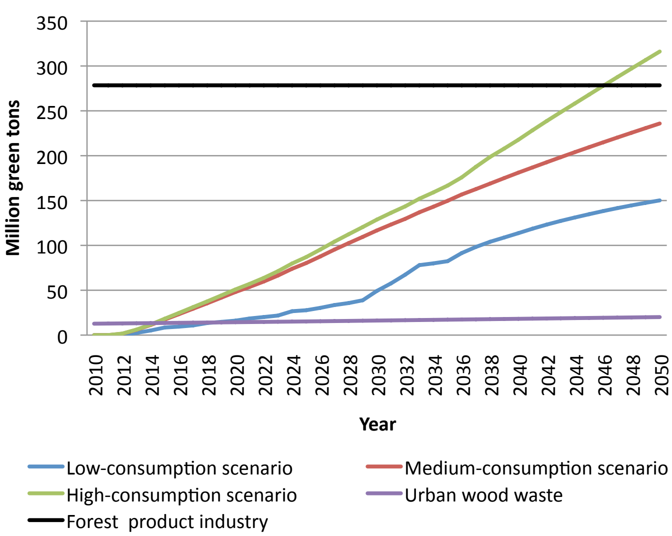

Figure 37—Woody biomass demand for energy in the South under low-, medium-, and high-consumption scenarios; with demand from traditional forest industry and availability from urban wood waste, 2010–50.

By their nature, structural changes in a market are difficult to predict, mostly because they depend on myriad factors that influence choices by landowners and producers. Our forecasts indicate that bioenergy uses would strongly favor softwood pulpwood, and this would provide strong incentive for expanding the area of planted pine in the South (fig. 38). Under strong demand forecasts, planted pine could expand by as much as 28 million acres, from 39 million acres in 2010 to about 67 million acres in 2060, or from 19 to 34 percent of the region's forests (chapter 5), an expansion that mostly would come from conversions of natural pine forests after harvesting. Additionally, price incentives would likely lead to higher rates of productivity growth as landowners invest in more intensive management. Conservative estimates of growth potential indicate a capacity to substantially increase the total output of softwood products (chapters 9 and 10)—enough to accommodate the bioenergy forecasts.

Other less certain structural changes also need to be considered. One is how energy producers would respond if timber scarcity increased, perhaps by turning away from wood and substituting switchgrass or other cellulosic feedstocks. Additionally, agricultural land could be converted to short-rotation woody crops using such species as cottonwood (*Populus* deltoides), non-native poplars (*Populus spp.*), eucalypts (*Eucalyptus spp.*), or other fast-growing species.

A 54- to 113-percent increase in harvesting would lead to important changes in southern forests. Our analysis of bioenergy futures (chapter 10) indicates that satisfying the highest level of predicted potential demand for woody biomass would require a combination of plantation growth, productivity enhancement, and short rotation woody crops on agricultural lands. Harvesting and management at this level could accelerate wildlife-habitat losses (chapter 14) and exacerbate water stress (chapter 13). The focus on softwood pulpwood for bioenergy uses means that most of these harvests and their impacts would be concentrated in the Coastal Plain. The potential for structural changes and for changes in a variety of ecosystem services indicates needs for monitoring and careful management planning as this sector develops in the South (chapter 10).

The future of demand is not the only bioenergy uncertainty. Energy forecasts are based on uncertain price futures for fossil fuels, and they anticipate developments of new technologies even though the use of cellulose in transportation fuels is not yet commercially viable. In addition, many forecasts assume the extension of current policy and the implementation of future policy, clearly an unknown trajectory.

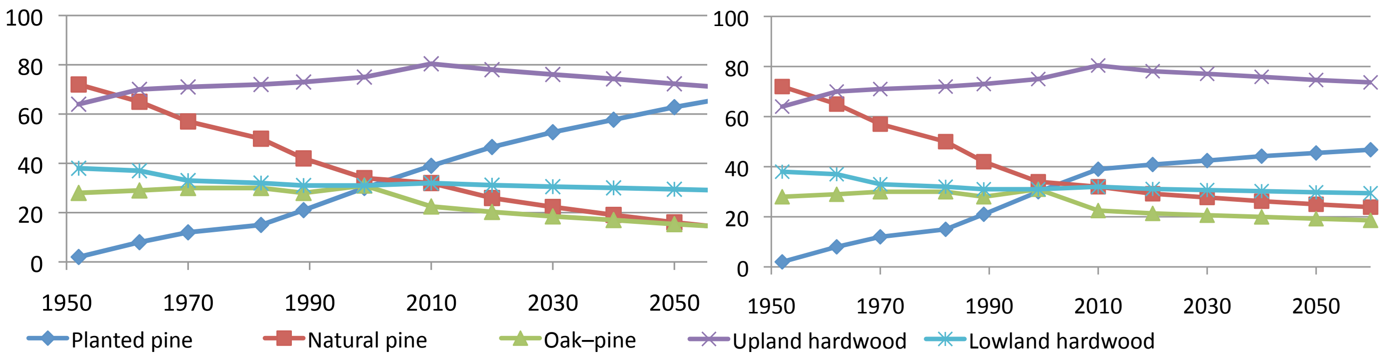

Figure 38—Forecasted forest area by forest management type, 2010–60, for (A) Cornerstone E, which is characterized by high urbanization, high timber prices, and higher planting rates; and (B) Cornerstone F, which is characterized by low urbanization, low timber prices, and lower planting rates.

Bioenergy Markets, Findings from Chapter 10

- Harvesting woody biomass for use as bioenergy is forecasted to range from 170 million to 336 million green tons by 2050, an increase of 54 to 113 percent over current levels.
- Consumption forecasts for forest biomass-based energy, which are based on Energy Information Administration projections, have a high level of uncertainty given the interplay between public policies and the supply and investment decisions of forest landowners.
- It is unlikely that the biomass requirement for energy would be met through harvest residues and urban wood waste alone. As consumption increases, harvested timber (especially pine pulpwood) would quickly become the preferred feedstock.
- The emergence of a new woody biomass based energy market would potentially lead to price increases for merchantable timber, resulting in increased returns for forest landowners.
- While woody biomass harvest is expected to increase with higher prices, forest inventories would not necessarily decline because of increased plantations of fast growing species, afforestation of agricultural or pasturelands, and intensive management of forest land.
- Because it would allow more output per acre of forest land and dampen potential price increases, forest productivity is a key variable in market futures.
- The impacts that increased use of woody biomass for energy would have on the forest products industry could be mitigated by improved productivity through forest management and/or by increased output from currently unmanaged forests.
- Price volatility associated with increased use of woody biomass for energy is expected to be higher for pulpwood than for sawtimber.
- The impacts of wood based energy markets tend to be lower for sawtimber industries, although markets for all products would be affected at the highest levels of projected demand.
- Different types of wood based energy conversion technologies occupy different places on the cost feasibility spectrum. Combined heat and power, co-firing for electricity, and pellet technologies are commercially viable and have good prospects in the future. Biochemical and thermochemical technologies used to produce liquid fuels from woody biomass are not yet commercially viable.
- Current research does not suggest which woody species and what traits would likely be most successful for energy production. The future of conversion technologies is uncertain.
- In the absence of government support, research, pilot projects, and incentives for production and commercialization of woody bioenergy markets are unlikely to develop.
- Forecasted levels of woody biomass harvests could lead to a reduction of stand productivity, deterioration of biodiversity, depletion of soil fertility, and a decline in water quality.
- Although research provides some guidelines for the design of management to protect various forest ecosystem services, forest sustainability benchmarks for bioenergy are not well defined and existing certification systems have few relevant standards.

5. A combination of factors has the potential to decrease water availability and degrade quality. Forest conservation and management can help to mitigate these effects.

The interacting effects of climate change, population growth, intensive forest management practices, and land use change are expected to increase water stress in several areas of the South. Increases in water demand from expanding populations and decreased supply coupled with changes in land use and climate could result in more frequent water shortages and degraded water quality in affected watersheds. Certain elements of our forecasts are uncertain, especially future precipitation, but the full range of forecasts raises concerns about water in the South and strengthens the link between forests and the future availability and quality of water.

The conversion of forests to urban uses has particularly significant impacts on water flow and availability. It increases impervious surface and decreases infiltration of rainfall, which in turn increases the amount and changes the timing of runoff. As a result, storms generate larger peak flows and reach them more quickly. The slow release of water common in forested watersheds is short-circuited, exacerbating low flows between storms and interfering with groundwater recharge. Though timber harvesting can contribute to these conditions, if the scale of harvesting is large relative to watershed size, these effects are much more limited in magnitude and duration.

Urbanization is forecasted to be focused in certain parts of the South, especially the Piedmont, coastal areas, and parts of the Appalachians. Increased urban land use forecasted for the Appalachians and Piedmont could have far-reaching effects, with hydrologic and water quality impacts accumulating and exacerbating similar effects in downstream Coastal Plain watersheds (fig. 39).

The impacts of reduced shallow ground water recharge may be especially important in small Coastal Plain watersheds. It is in these areas where intensive forest management is most commonly practiced—and where planted pine is most concentrated. Forecasted intensification of forest management would increase evapotranspiration and reduce the amount of water available for streamflow. The intensity of these effects depends on a number of variables, including tree species, level of planting and silvicultural treatments, and percentage of watershed affected.

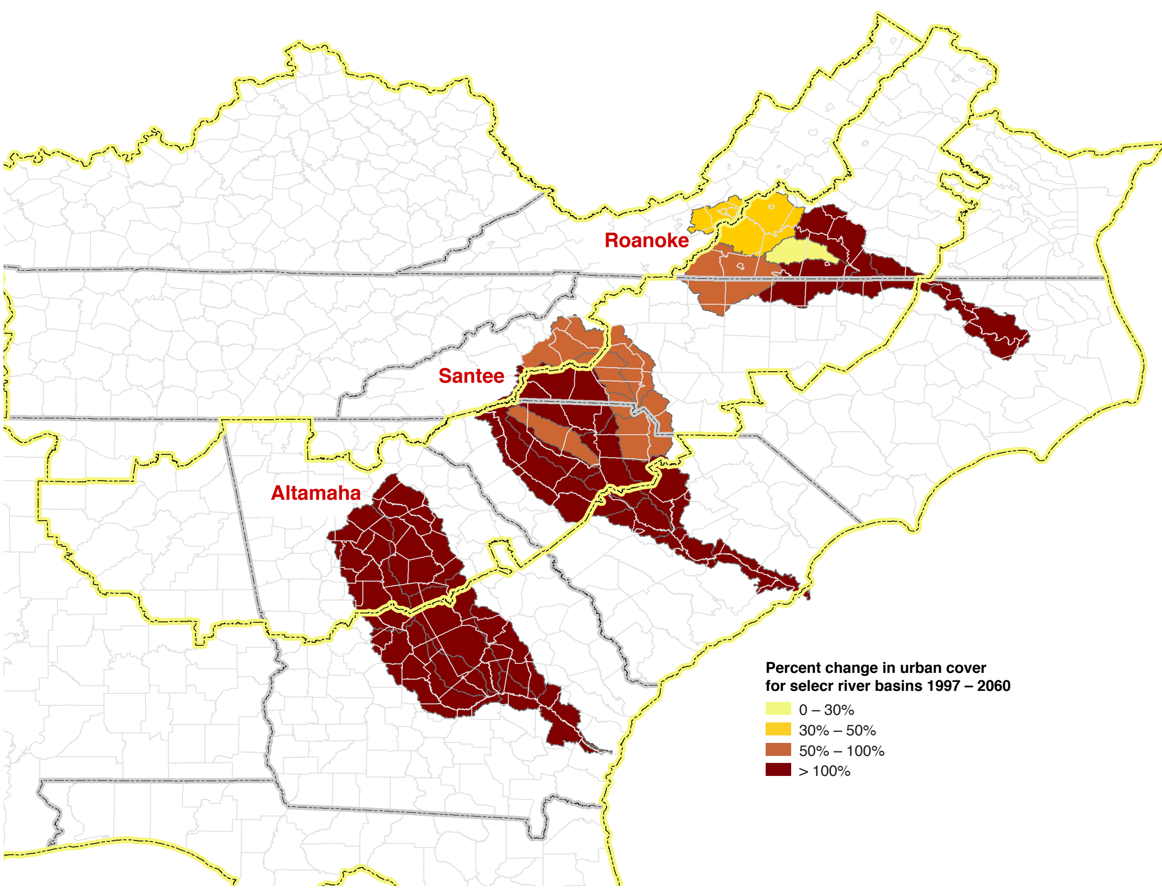

Figure 39—Projected increases (shown as percentage of change) in urban cover in three major river basins of the Southern United States from 1997 to 2060 under Cornerstone Future A (high population/income growth with increasing timber prices).

In addition, coastal watersheds could be further affected by forecasted sea-level rise on about 5,000 miles of highly vulnerable southern coastline. Saltwater intrusion of groundwater and increased salinity of near-coast waters are the likely direct results of sea-level rise, with cascading effects on associated forests and wildlife habitat.

On average, water supply model projections for the South indicate that by 2050 the combination of population growth and land-use change will increase water stress by 10 percent, but that effects will vary across the region (figs. 40 and 41). Forecasts of future water stress also vary across climate forecasts, for example, with Cornerstone A yielding strongly elevated levels of water supply stress across much of the South (fig. 42). Hot spots for future water stress include much of Oklahoma, central to eastern Texas, southern Florida, and many watersheds along the Gulf of Mexico.

Although somewhat influenced by natural geographic processes and past land use, water quality in urbanizing watersheds will also be affected by what happens to forests within them. High rates of forest losses from conversion to developed uses can be expected to degrade water quality, with water-borne pollution from the new land uses potentially affecting human health. The loss of buffering or filtering provided by riparian and floodplain forests is especially important. Impacts on water quality begin at relatively low levels of imperviousness in a watershed and increase rapidly as imperviousness increases. Skillful management and retention of forest cover in the development process can mitigate some of these negative effects.

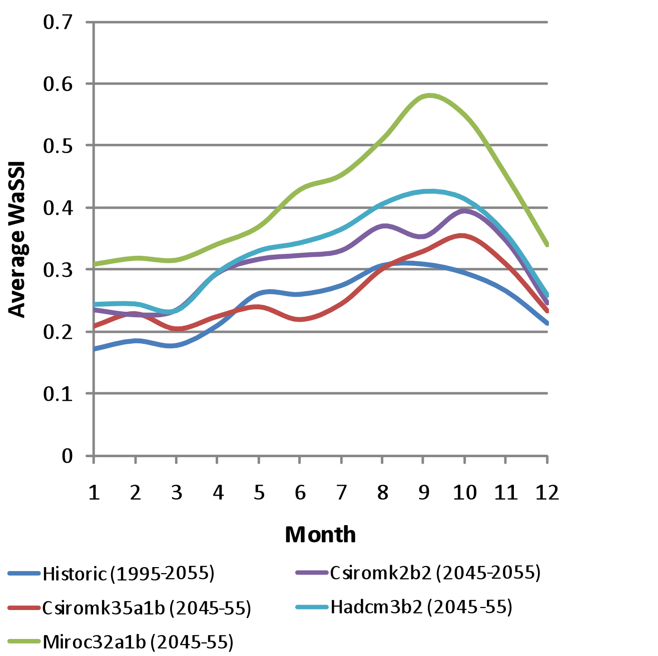

Figure 40—Average monthly water supply stress (defined by the Water Supply Stress Index or WaSSI and calculated by dividing water supply into water demand) among all Natural Resource Conservation Service Watershed Boundary Dataset Hydrologic Unit Code watersheds (HUCs) in the South under historic and four future climate scenarios.

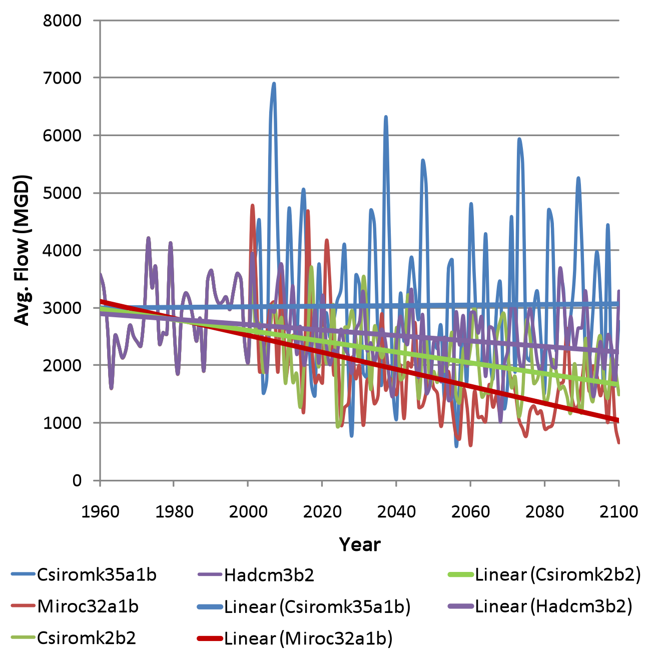

Figure 41—Projected average river flows among the 674 Natural Resources Conservation Service Watershed Boundary Dataset 8-digit Hydrologic Unit Code watersheds (HUCs) in the Southern United States South under four future climate scenarios.

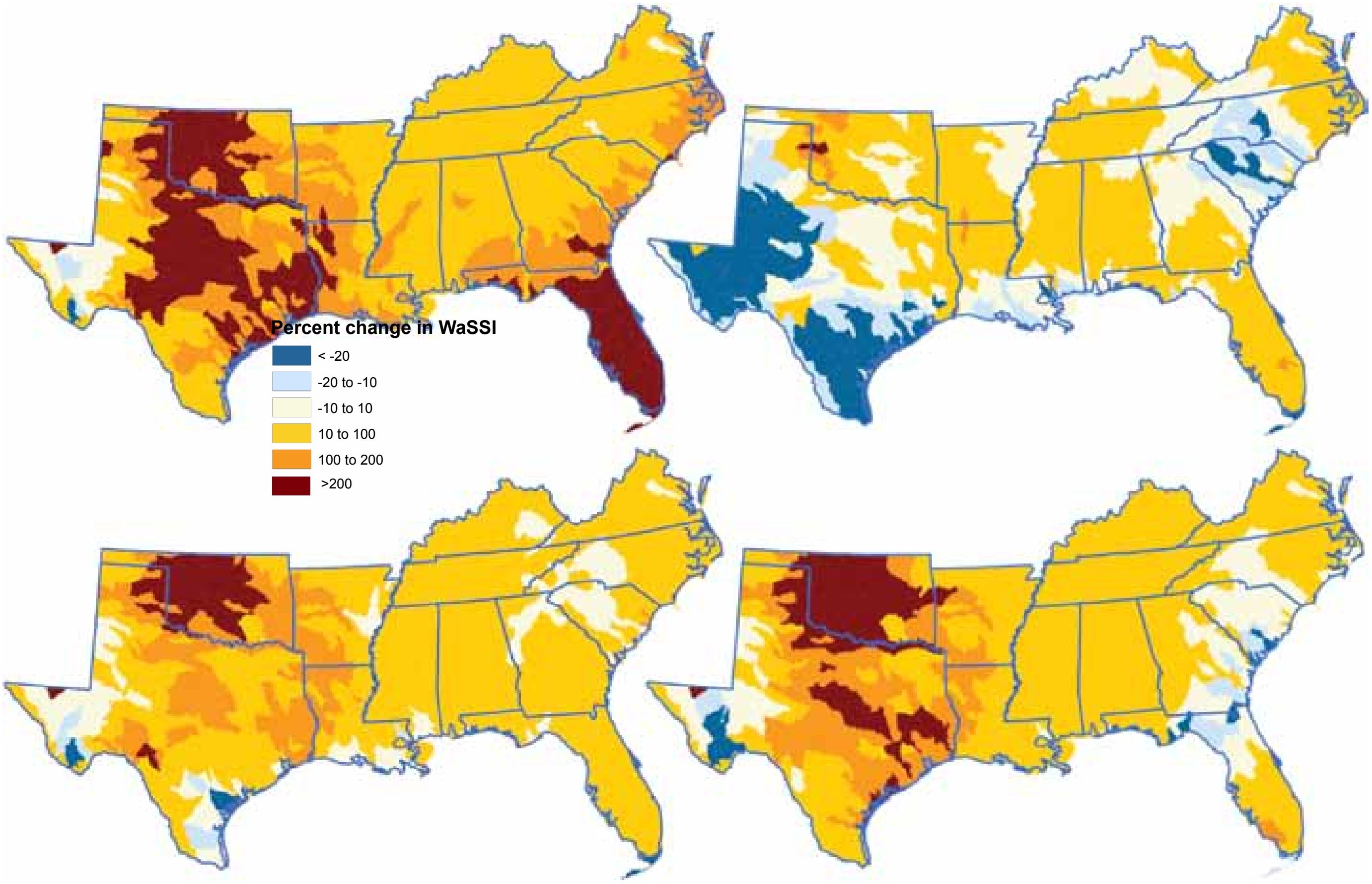

Figure 42—Percent change in water supply stress due to climate change (defined by the Water Supply Stress Index (WaSSI) and calculated by dividing water supply into water demand) by 2050 under four Cornerstone Futures.

Forests and Water, Findings from Chapter 13

- Forest conversion to agriculture or urban use consistently increases discharge, peak flow, and velocity of streams. Subregional differences in hydrologic responses to urbanization are substantial.
- Sediment, harmful chemicals, pathogens, and other substances often become more concentrated after forest conversion. If the conversion is to an urban use, the resulting additional increases in discharge and concentrations will produce even higher loads.
- Although physiographic characteristics such as slope and soil texture play key roles in hydrologic and sediment responses to land use conversion, land use (rather than natural geographic processes) is the primary driver of water chemistry responses.
- Conversion of forest land to urban uses may decrease the supply of water available for human consumption and increase potential threats to human health.
- Increases in urbanization by 2060 in the Appalachians, Piedmont, and Coastal Plain would increase imperviousness and would further reduce hydrologic stability and water quality in the headwaters of several major river basins and in small watersheds along the Atlantic Ocean and Gulf of Mexico.
- On average, water-supply model projections for the South indicate that by 2050 the combination of population growth and land-use change will increase water stress by 10 percent.
- Water stress will likely increase significantly by 2050 under all climate change projections, largely because higher temperatures would result in more water loss by evapotranspiration but also because precipitation would decrease in some areas.
- Approximately 5,000 miles of southern coastline are highly vulnerable to sea-level rise.

6. Invasive species create a great but uncertain potential for ecological changes and economic loss.

Threats from a number of key invasive insects and diseases have grown substantially over the past 10 years, portending extensive losses for several tree species in the South. Nonnative invasive plants are a less dramatic but perhaps more insidious and pervasive force of change, with one or more nonnative invasive plants infesting about 19 million acres or 9 percent of the region's forests (chapter 15). Climate change could encourage spread and spread dynamics for known invaders, increasing the area of infestation to about 27 million acres over the next 50 years. Japanese honeysuckle (*Lonicera japonica*) alone is projected to occupy 13.5 million acres. However, projections of spread dynamics are highly variable across the climate projections (chapter 15). Suitable but as yet unoccupied habitats are much more extensive than occupied ones for most nonnative plants.

Among the important invasive insects, diseases, and pest complexes, several are likely to have severe impacts on tree species (chapter 16). Laurel wilt (*Raffaelea lauricola*) is decimating the redbay (*Persea bourbonis*) population of the southern Coastal Plan and spreading rapidly through its host range (fig. 43). Hemlock woolly adelgid (*Adelges tsugae*) will likely kill most southern hemlocks over the next 50 years (fig. 44). Emerald ash borer (*Agrilus planipennis*) will likely kill much of the green ash with especially high levels of mortality in the Mississippi Alluvial Valley. Butternut canker (*Sirococcus clavigignenti-juglandacearam*) is eliminating the butternut (*Juglans cinerea* L.) population—largely found in the Appalachian-Cumberland highlands. Sudden oak death (*Phytophthora ramorum*), currently striking the forests of California and Oregon, is expected to gain a foothold in eastern oak forests (fig. 45).

The effects of climate change on these pests are largely unclear, except to the extent that their host ranges may shift. In the process, changes in species mixes would have uncertain consequences for invasives. Climate change could further stress remnant populations such as red spruce (*Picea rubens*) at high elevations and exacerbate pest dynamics in these ecosystems, increasing infestations of balsam woolly adelgid (*Adelges piceae*) and butternut canker.

Of the 380-plus recognized nonnative plants in southern forests and grasslands, 53 are rated high-to-medium risk for natural communities, and 31 are identified as threats to the conservation of native ecosystems (chapter 15). Especially troublesome are tallowtree (*Triadica sebifera)* (fig. 46), tree-of-heaven, and Chinaberrytree (*Melia azedarach*) among the trees; privet (*Ligustrum spp.*), rose (*Rosa spp.*), and lespedeza (*Lespedeza spp.*), among the shrubs; Japanese honeysuckle (*Lonicera*

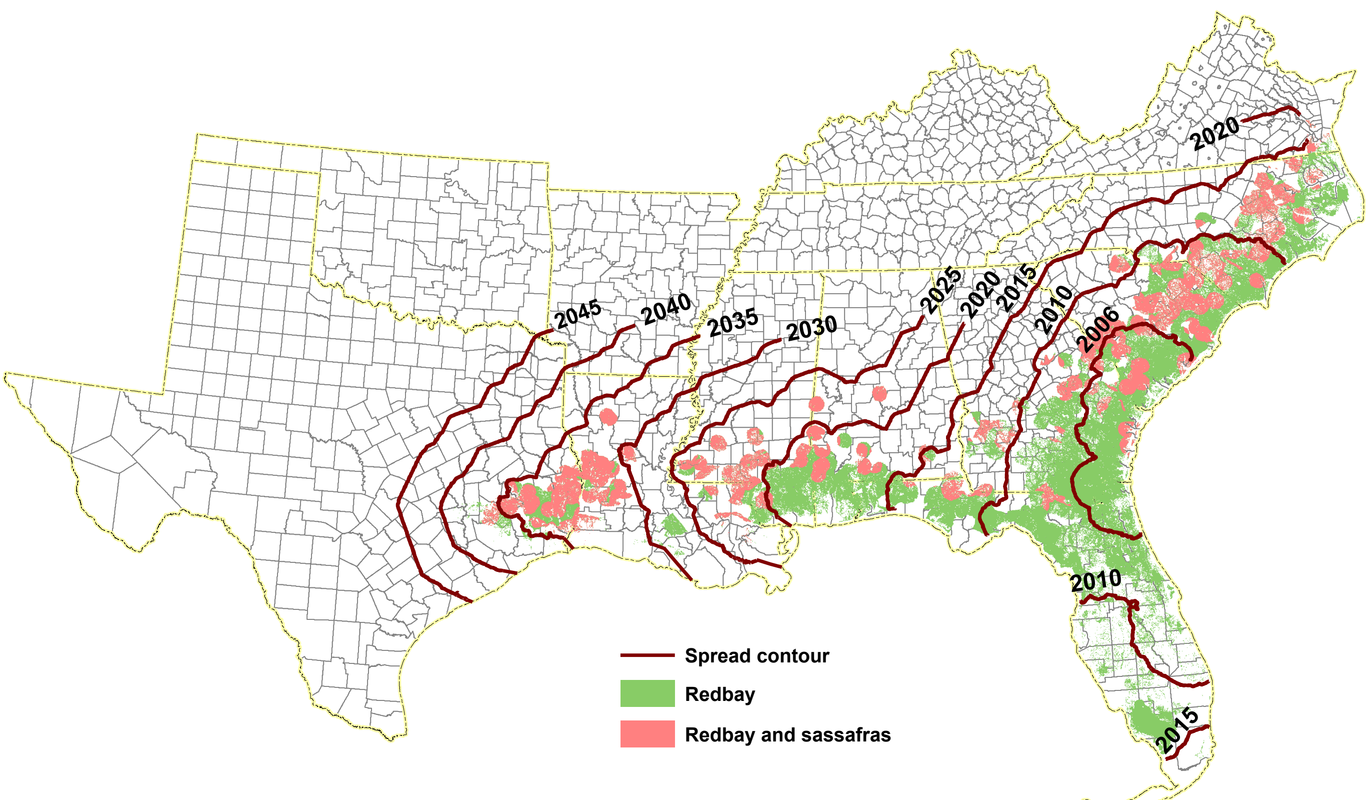

Figure 43—Probable spread of laurel wilt disease (*Raffaelea lauricola*) from 2006 to 2040, based on the current rate of spread and known distribution of the redbay (*Persea bourbonis*) host (Koch and Smith 2008).

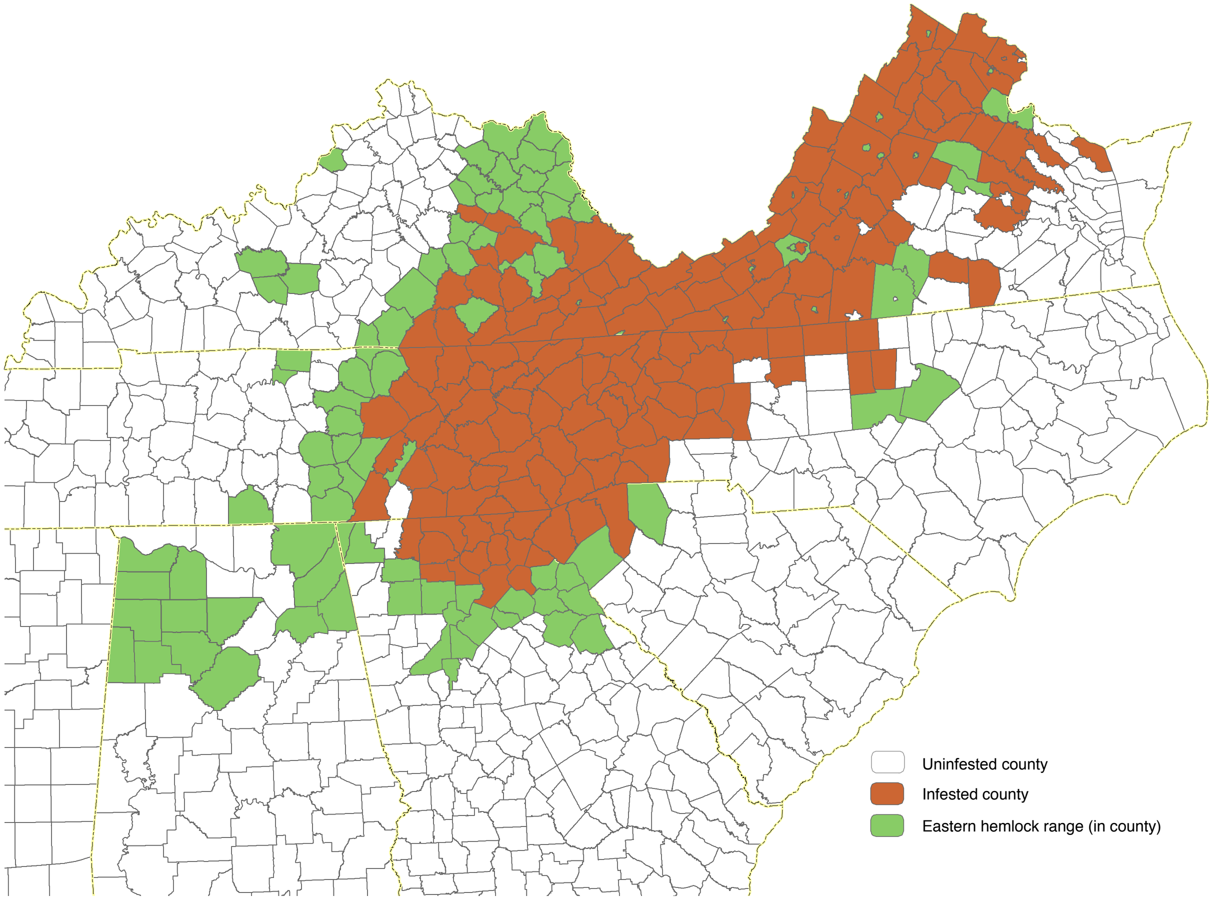

Figure 44—County-level distribution of established hemlock woolly adelgid (HWA) (Adelges tsugae) populations, as reported by State forest health officials in 2009; populations are not distributed evenly in infested counties. Source: USDA Forest Service 2010.

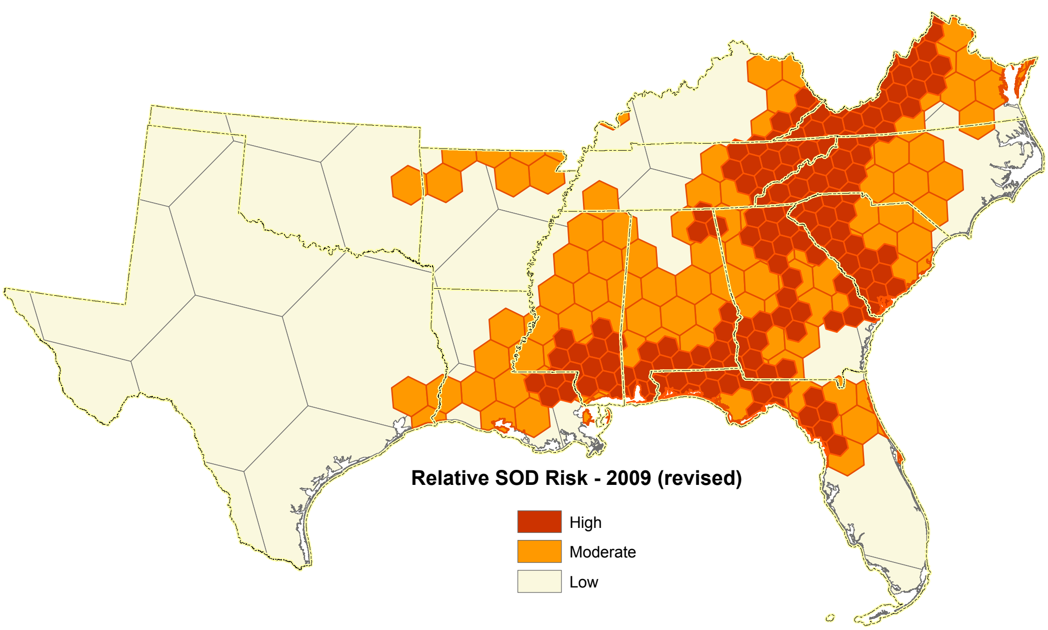

Figure 45—Predicted climatic suitability for establishing sudden oak death (Phytophthora ramorum) in the conterminous United States based on an ecoclimatic index excluding environmental stresses (Venette and Cohen 2006).

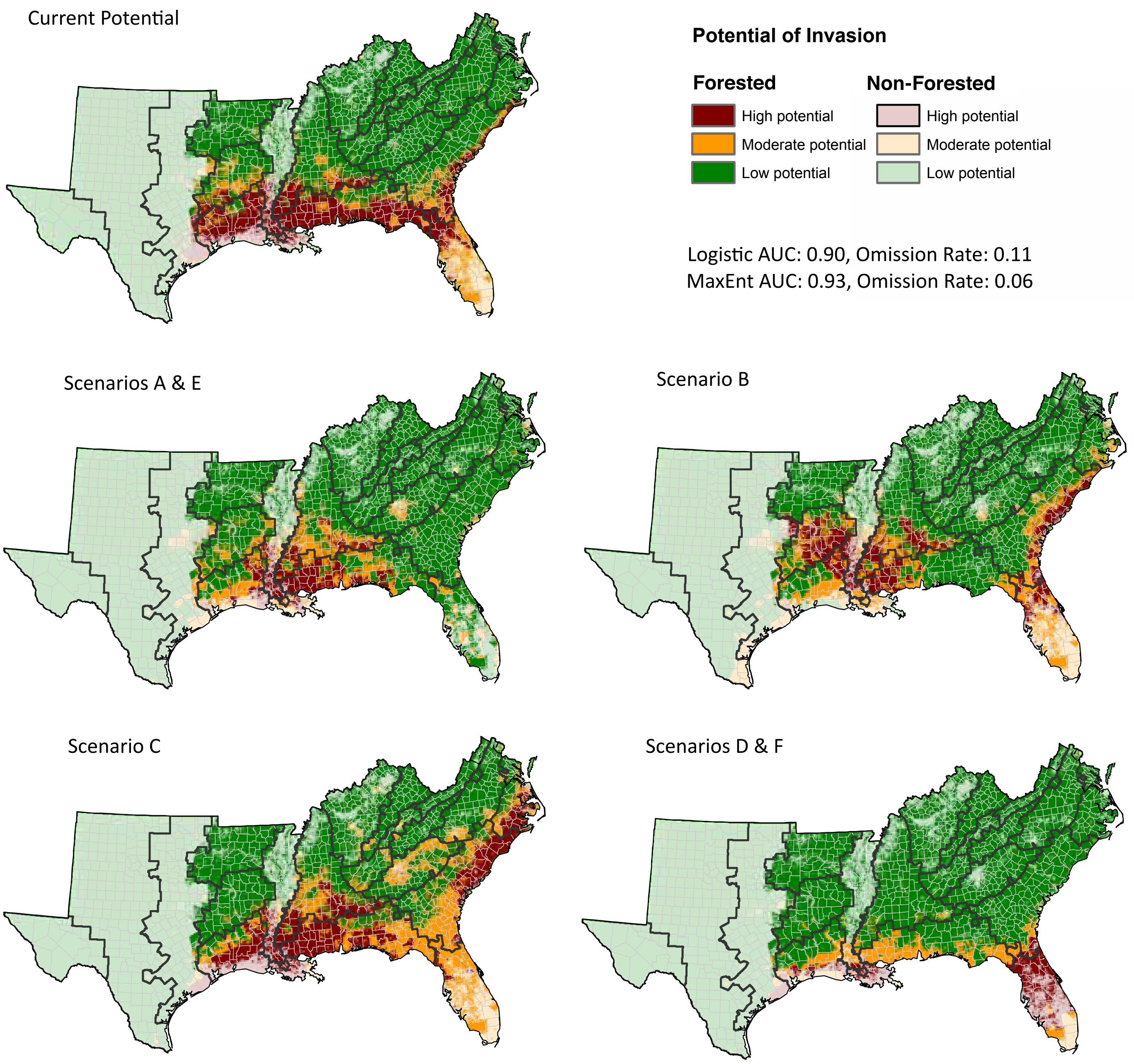

Figure 46—Tallowtree (Triadica sebifera): potential for occupation into 2060 under (1) status quo assumption that current trends will continue; (2) maximal warming and drying conditions, Cornerstones A and E; (3) moderate warming and minimal drying conditions, Cornerstone C; (4) minimal warming with increased rainfall, Cornerstone B; and (5) cooling and drying conditions, Cornerstones D and F.

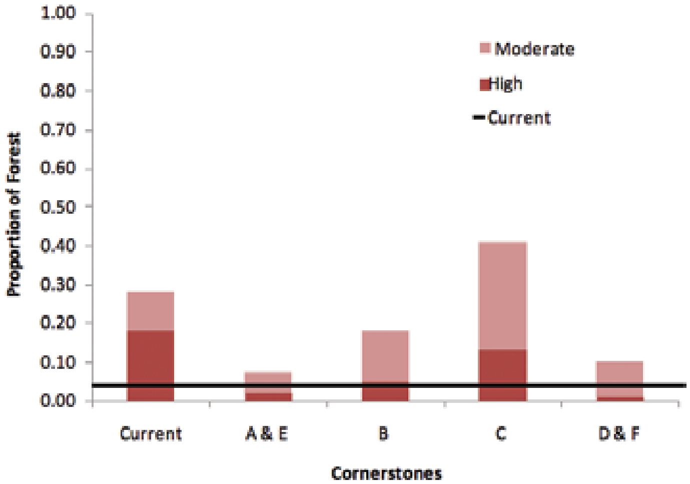

Figure 47—Nepalese browntop (Microstegium vimineum): the actual current proportion of survey plots (line), (1) status quo assumption that current trends will continue; (2) maximal warming and drying conditions, Cornerstones A and E; (3) moderate warming and minimal drying conditions, Cornerstone C; (4) minimal warming with increased rainfall, Cornerstone B; and (5) cooling and drying conditions, Cornerstones D and F at high (agreement of both models) and moderate (predicted by one model) probability.

japonica), Japanese climbing fern (*Lygodium japonicum*), and kudzu (*Pueraria thunbergiana*), among the vines; and Nepalese browntop (*Microstegium vimineum,* fig. 47), tall fescue (*Schedonorus phoenix*), and cogongrass, among the grasses. Among growth forms, vines have the greatest coverage at 11 million acres, followed by shrubs at 4.9 million acres, grasses at 1.8 million acres, and trees at 1.2 million acres.

Most plants escaping into southern forests have been imported, hybridized, sold, and planted for yard and garden beautification, soil stabilization, wildlife habitat enhancement, and livestock production. New escapes are now most often associated with nonnative plants marketed by garden centers as ornamentals.

Plant invasions hold several consequences for forest conditions, management, and benefits to society. Where infestations are dense, nonnative plants can limit or stop productive land management. At a minimum, they increase the costs of various management activities, especially for forest regeneration. Perhaps the best example is cogongrass, which can form dense mats that exclude forest regeneration and is expensive to treat. Other impacts may be less immediate. As native species are displaced, nonnatives alter (generally reduce) the diversity and quality of wildlife habitats and can change soil chemistry. Nonnative plants present a threat to biodiversity that is second only to complete habitat destruction (chapter 14), but the specific effects on native flora are yet to be fully understood.

Except where invasive plants impact commercial operations, for example, in intensive forestry and agriculture, it is questionable whether private landowners will have the resources or motivation to effectively curb establishment and spread through individual actions.

Invasive Species Impacts, Findings from Chapters 15 and 16

- “New” nonnative invasive insects and diseases will have serious impacts on southern forests over the next 50 years. Some species such as emerald ash borer and laurel wilt are expanding rapidly; they threaten the ecological viability of their hosts throughout large areas of the South.
- Given the trend in introductions of nonnative insects and plant pathogens over the last 100 years, we can expect additional introductions of previously undocumented pests that will have serious consequences for some native forest plant species.
- Very few indisputable projections can be made about the effects of climate change on native or naturalized pests. Although climate-change-induced host abundance is expected to increase the activity of some pests, others may become less active with warmer temperatures despite relatively similar levels of host availability.
- The scientific literature and the body of expert opinion are inconclusive in predicting the effects of climate change on many pests’ activity levels, often even lacking historic trend data. However, based on anecdotal reports from professionals and in the absence of other data, it is likely that pest activity levels over the next 50 years will be similar to the past 50 years with respect to impact on preferred hosts.
- A significant source of uncertainty in projecting pest impacts is the adequacy of prevention and suppression methods: how effective are existing methods, compared with those that might be available in the future; how willing and able are land managers or landowners to adopt management/control methods; how much funding is available compared to the amount needed for implementation.
- Under the influence of climate warming host plants, pests, and pest complexes are expected to migrate northward and to higher elevations. Because migration rates differ among the affected species, migrating plants are expected to form new associations, which would have additional effects on the pests, their host populations, and the interactions among them. Unexpected pests very likely would become important, while some that are currently active would be less severe in their new habitats. As host plants “migrate” to the north, an increase in the incidence of decline syndrome of plants in their previous range is expected.

- Although not expected to be a significant problem in the next 50 years, the migration of lower elevation plants to higher elevations could ultimately eliminate or at least severely restrict the host ranges of current high elevation plant associations. Pests that act on a restricted host base, such as the balsam woolly adelgid and butternut canker, could become far more significant ecologically in areas of relict host populations.
- The invasion process is accelerated by greater forest disturbance, fragmentation, parcelization, urbanization needed to accommodate and support an increasing human population, and climate warming. Approximately 9 percent of southern forests or about 19 million acres are currently occupied by one or more of the 300 nonnative plants in the region.
- The annual spread of nonnative plants in southern forests is conservatively estimated at 145 thousand forested acres, accelerated by a warming climate and by increasing numbers of forest disturbances that accommodate and support growing human populations.
- Given the current occupation and spread of nonnative plants and the increasingly common infestations by multiple species, eradication appears only probable on specific lands unless awareness and strategic programs are greatly enhanced.
- Model projections show that high-threat nonnative plants have not yet reached their potential range or density limits within the region under current conditions. A predicted warming climate would permit northward range extensions for some, while range extensions can be restricted by a simultaneous drier climate. Losses in forest production, recreation, and wildlife habitat would have quality-of-life implications for future generations that would continue to be exacerbated if not mitigated.
- Limiting the degree of occupation and impact depends on the development of adaptive management programs and actions that are coordinated across political boundaries and engage all ownerships. Piecemeal and splintered actions by agencies and ownerships, if continued, cannot stop the destructive impacts of infestations by nonnative species.
- Public awareness campaigns, cooperative spread abatement networks, collaborative programs of detection and eradication, dedicated research and extension programs, and employment of new land restoration options have been found to slow the spread of nonnative plants and prevent them from destroying critical habitats.

7. An extended fire season combined with obstacles to prescribed burning would increase wildfire-related hazards.

Wildfire potential is likely to increase over the next 50 years in response to forecasted reductions in precipitation and climate driven changes in growing seasons. Both spring and autumn wildfire seasons, when the weather is dry and conditions are conducive for fires to ignite and spread (figs. 48 and 49), are forecasted to increase in duration, especially in the Coastal Plain (chapter 17). Major wildfire events, such as the 2007 Okefenokee wildfires that burned more than 600,000 acres, are also likely to occur more often. The extreme fire season in west and central Texas during 2011 which occurred after the analysis for the Futures Project was completed, provides another recent example. Forecasts of fire potential vary across the Cornerstone Futures, indicating uncertainty about the magnitude of these changes. However, any increase in fire potential combined with urban development and expansion in the wildland-urban interface would magnify the importance of wildfire prevention and control to southern residents.

Extended fire seasons increase the importance of effective fire management in the South, but several obstacles may increasingly impede the practice of prescribed burning, the most widely used management tool in the region. Prescribed burning serves multiple functions in southern forests. It is used extensively in the pine forests of the Coastal Plain and Piedmont (more than 8 million acres per year) where numerous plant and wildlife species depend on periodic fire for competition control, reproduction, and sustained health. It is likewise being reintroduced in certain parts of the Appalachian and Ozark Mountains to improve habitat for fire-dependent species in those ecosystems. Throughout the region, it reduces fuel loads and decreases the risk of catastrophic wildfires.

Climate forecasts indicate that the "window" for safe prescribed burning may be reduced, shortening the length of time during the year when conditions are acceptable for the practice. Prescribed burning is more complicated and risky in the wildland-urban interface, and this area is forecasted to expand throughout much of the region, especially in coastal areas, the Piedmont, and Appalachian Mountains—areas where prescribed fire is particularly beneficial. Institutional issues may also reduce the capacity to conduct prescribed burning. Stricter air-quality regulations anticipated in coming years could further limit opportunities for prescribed burning. Ongoing loss of fire management capacity among many States in the South may further limit opportunities to implement effective prescribed burning. The number of State forestry agency fire personnel declined 24 percent between 2004 and 2010. In summary, hazards of reduced prescribed burning are numerous and significant for human life and property as well as for the sustainability of numerous vegetation and wildlife species.

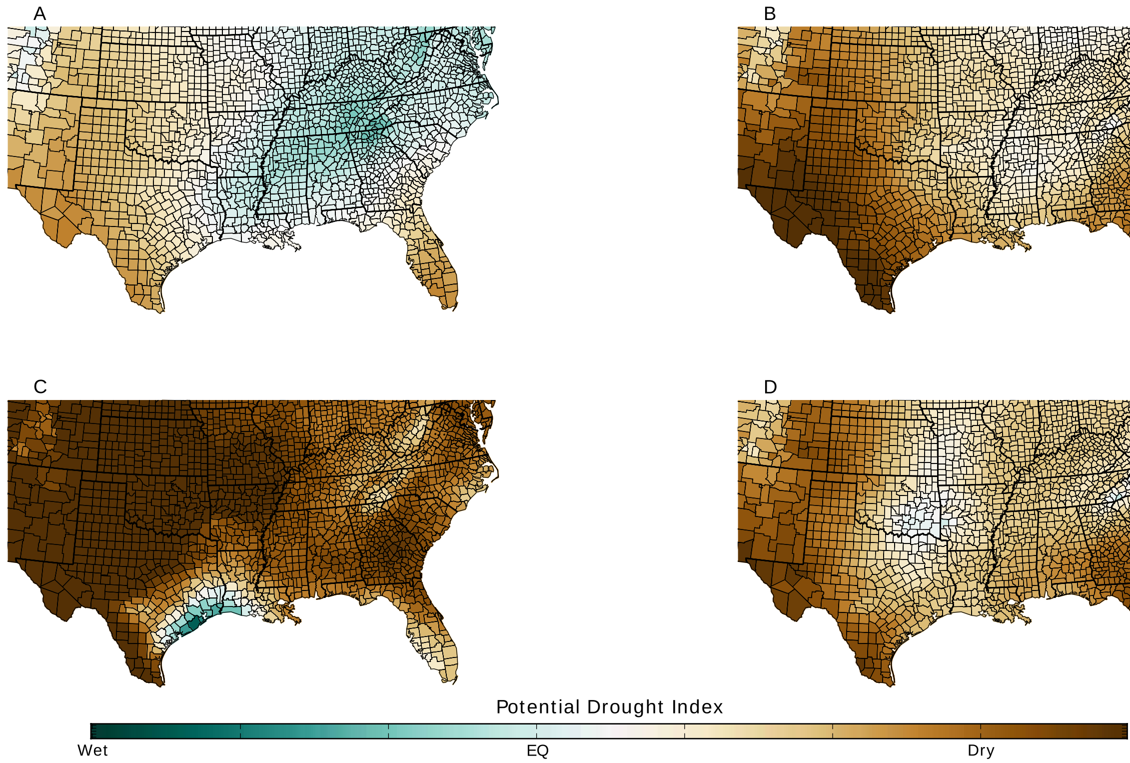

Figure 48—Seasonal view of fire potential for current conditions for (A) January, (B) April, (C) July, and (D) October for Cornerstone B. Brown (blue) areas depict areas with positive (negative) PDI. White areas reflect a PDI near zero indicating a balance between evapotranspiration and precipitation. Color intensity relates to the magnitude of departure from this balanced state.

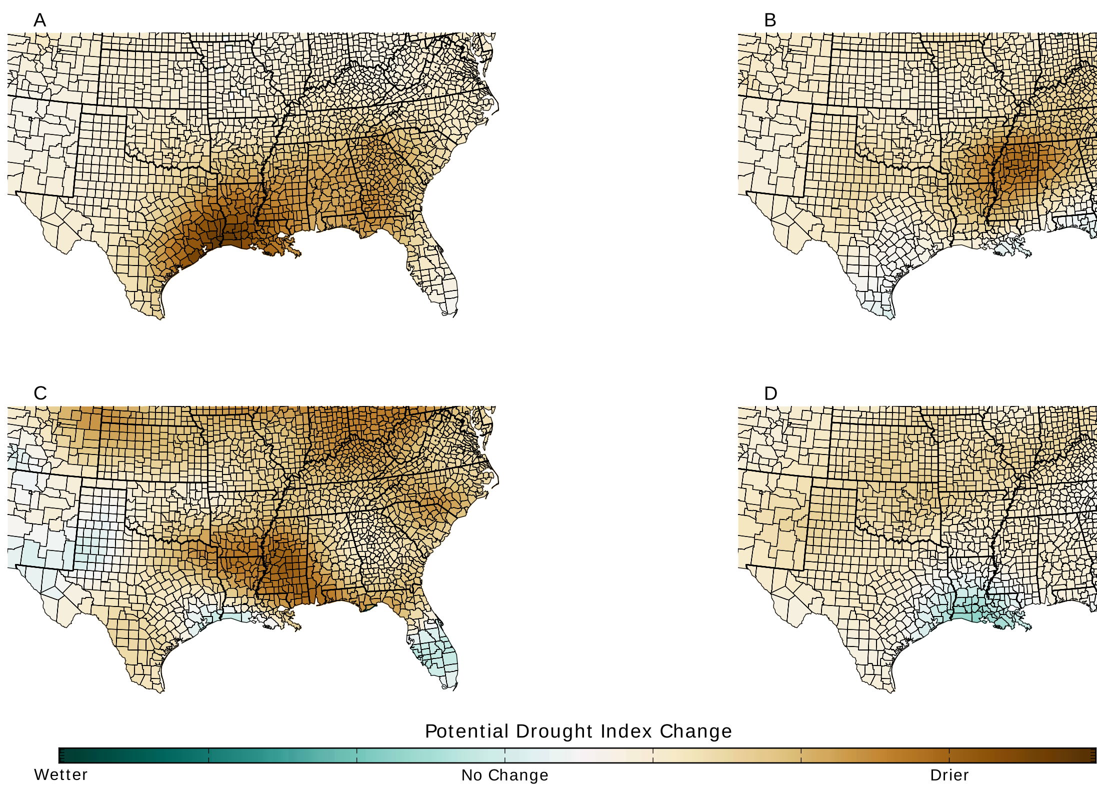

Figure 49—Change in seasonal fire potential in 50 years for (A) January, (B) April, (C) July, and (D) October for Cornerstone B. Brown areas depict areas with positive PDI. Blue areas depict areas with negative PDI. White areas reflect a PDI near zero indicating a balance between evapotranspiration and precipitation. Color intensity relates to the magnitude of departure from this balanced state.

> ### Fire in the Southern Landscape, Findings from Chapter 17
>
> - Climate forecasts indicate that the South's spring and fall wildfire seasons will be extended.
> - Major wildfire events, such as the 2007 Okefenokee wildfires, 2008 Evans Road Fire in eastern North Carolina, and recent west Texas fire seasons, are also likely to occur more often. Such events currently occur once every 50 years; however, they could be more frequent in a warmer/drier climate.
> - Land use change will have the most immediate effects on fuels and wildland fire management by constraining prescribed burning and increasing suppression complexity and cost.
> - Air quality issues will likely increase restrictions on prescribed burning over large areas, not just in the wildland-urban interface.
> - Potential health and safety concerns, in addition to air quality restrictions, will add to the regulatory constraints on use of prescribed burning.
> - Fuels buildups combined with more intense wildfires under a warmer, drier climate could severely degrade fire-dependent communities that often support one or more threatened, endangered, or sensitive species.
> - In addition to increasing the severity of wildfire events, the drier conditions and increased variability in precipitation that are associated with climate change could hamper successful forest regeneration and cause shifts in vegetation types over time.

8. Private owners continue to control forest futures, but ownership patterns are becoming less stable.

Private owners hold more than 86 percent of forests in the South and produce nearly all of the forest investment and timber harvesting in the region (fig. 50). Private ownership is diverse with roughly a third in corporate ownership and the remainder held by more than 3 million families or individuals. Forest ownership has changed and is forecasted to change more in the future. Over the past decade, the forest products industry sold or transferred much of its land holdings to timber and land investment interests (chapter 6). Commercial forests, once anchoring the largest contiguous blocks of forest cover in the South, now have a more fractured ownership and are less stable than in the past. Family forest owners are also subject to new dynamic forces that encourage parcelization and fragmentation (fig. 51).

Forecasts indicate a loss of 11–23 million acres of private forest land in the South by 2060. With expanded urbanization growing outward from city centers, we expect an increased fragmentation of remaining forest holdings. Ongoing parcelization, which often takes place when estates are transferred (chapter 11) from one generation to the next (especially in urbanizing areas where property values and taxes are increasing), will likely continue to alter forest management in the South. In particular, areas of concentrated urbanization could begin to see reductions in timber harvesting and planting in small inoperable holdings, and reductions in prescribed burning because of health and

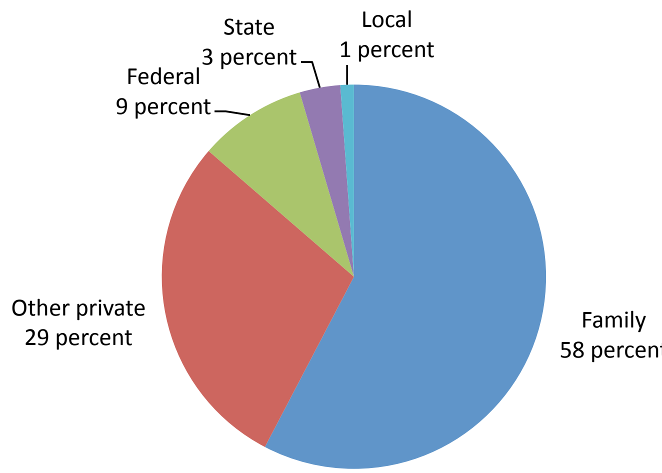

Figure 50—Distribution of forest ownership in the Southern United States, 2006.

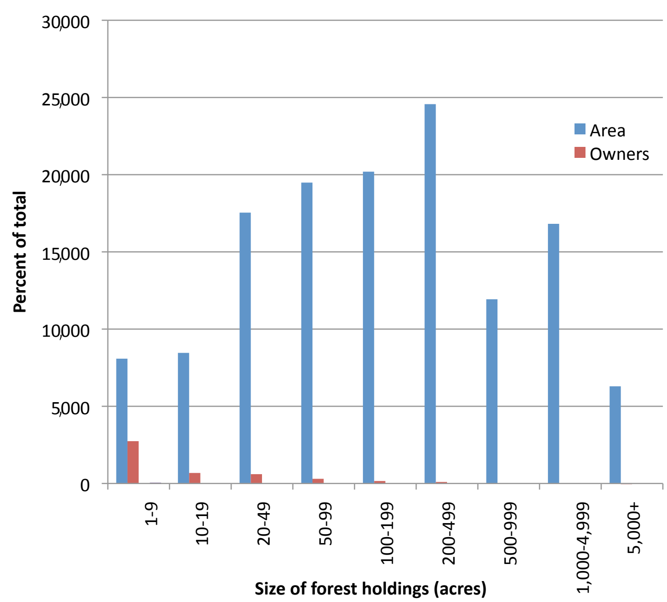

Figure 51—Percent of family forests by total area and number of owners in each of nine size classifications for the Southern United States, 2006.

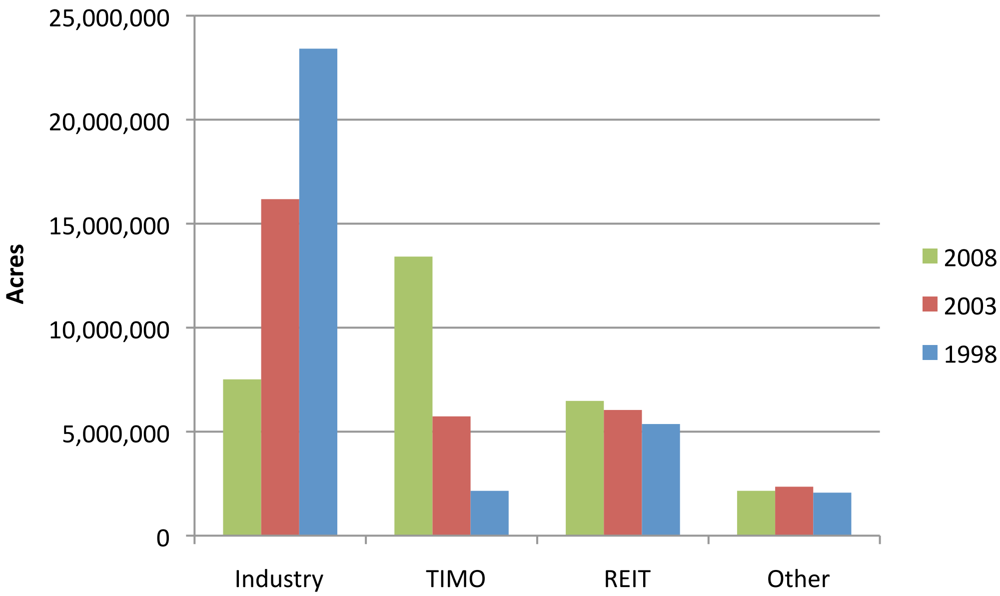

Figure 52—Corporate forest ownership for forest products industry (also known as vertically integrated timber products companies), timber investment management organizations (TIMO), real estate investment trusts (REIT), and other corporate in 1998, 2003, and 2008.

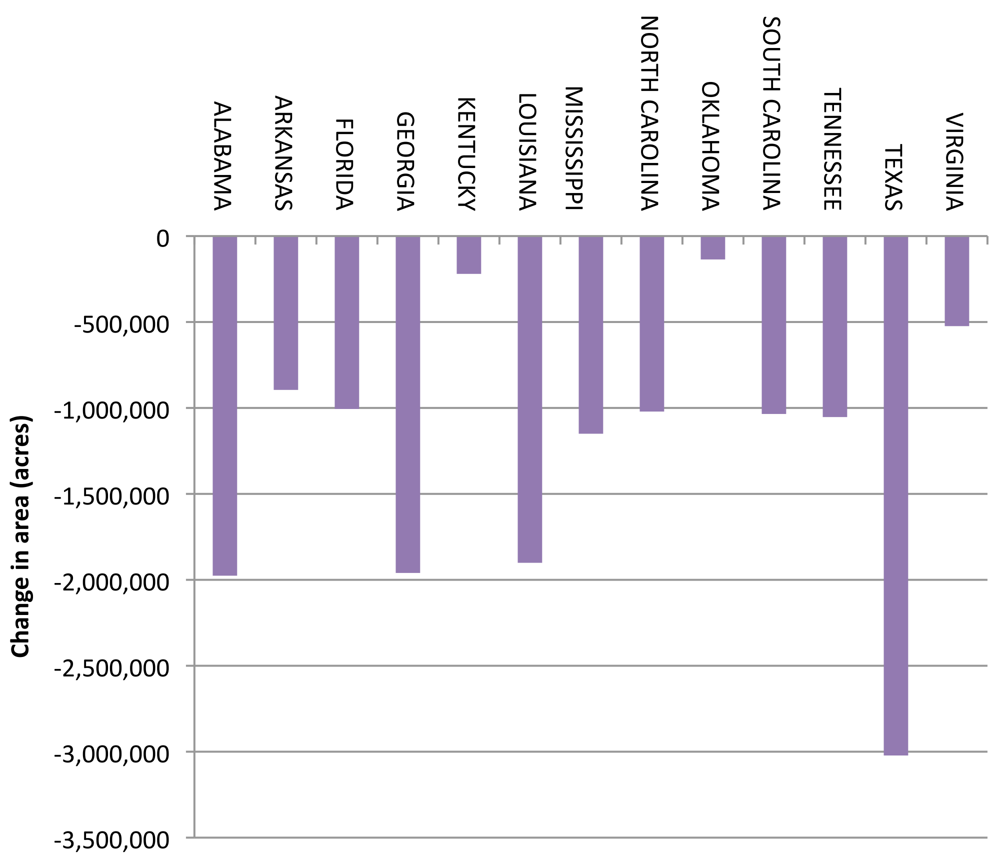

Figure 53—Decline in forest products industry ownership by State, 1998 to 2008.

safety concerns and regulatory restrictions. Habitat for forest interior-dependent species and wildlife travel corridors could be fractured and surface water quality impaired as forests are replaced by developed uses.

The divestiture of forest lands by the forest products industry from 1998 to 2010 is the most substantial transition in forest ownership of the last century (fig. 52). This divestiture substantially altered the ownership and objective structure of the corporate ownership group as much of the land shifted to timber investment management organizations and real estate investment trusts. A number of economic factors likely influenced the decisions of forest products companies to sell their land (figs. 52 and 53). An analysis of these factors suggests that the transition from large block industry ownership to a more spatially varied and fragmented ownership is irreversible in the foreseeable future.

As a result of large land transfers from the forest products industry to timber investment management organizations, corporate owned forest land is now a more liquid asset that is expected to trade more frequently in the future, and the size of individual holdings will likely continue to decline. While the industry land base had been a stable and predictable component of the southern landscape, the "new" class of corporate forest lands may be less stable and more changeable with possible implications for water quality, sensitive plant and animal communities, recreation availability, and other nontimber values. The economic forces that led to forest ownership by a new group of investors could cause rapid shifts in ownership in the future. For example, if commodity prices continue to decline beyond the 50 percent reduction in softwood pulpwood prices since 1998 (chapter 4), the resulting reduction in the profitability of timberland management would likely drive away investors. Conversely, policy driven increases in biomass demand for energy production could reverse recent downward trends (chapter 10).

Over the past 2 decades, ownership dynamics have largely occurred within the corporate or family ownerships but not between them. Our analyses of anticipated changes are consistent with this history. Structural changes in ownership—transferring land among major groups—might be possible, but these changes would have far reaching effects. For example, increasing scarcity of recreation opportunities and concern for other quality-of-life aspects of forests could lead to public acquisition of private forest land, especially at State and local levels. A substantial decline in timberland profitability could lead to a shift in ownership from corporate to family forest owners. These are both within the realm of plausibility but have not yet been observed to any great degree.

Ownership Dynamics of Southern Forests, Findings from Chapter 6

- Private landowners hold 86 percent of the forest area in the South; two-thirds of private forest land is held by families or individuals.
- Fifty-nine percent of private owners hold fewer than 9 acres of forest land, but 60 percent of privately owned forests are in holdings of 100 acres or more.
- Two-thirds of family forest land is owned by people who have harvested and sold trees from their land. Assuming that commercial owners have harvested timber, then in all, about 8 of every 10 acres of private forest land in the South is owned by individuals or organizations that have commercially harvested their timber.
- The average size of family forest holdings is 29 acres. Ongoing parcelization and fragmentation through estate disposal and urbanization will likely continue to alter forest management in the South.
- The forest products industry divested about three quarters of its timberland holdings from 1998 to 2008, the largest ownership transition in the last century. The largest gain in ownership was realized by timber investment management organizations and real estate investment trusts.
- Forest products industry divestitures were likely driven by a combination of factors including mergers, alleviation of timber-scarcity concerns, new technologies for reducing the cost of fiber acquisition, and desire to reduce tax burdens.
- As a result of the transfer of holdings from the forest products industry to timber investment management organizations and real estate investment trusts, forest land held by corporations is now a more liquid asset class and would likely trade more frequently in the future. Corporate forest holdings will likely continue to decline in size.
- Although the forest products industry land base was long perceived to be a stable and predictable component of the forest landscape in the South, corporate lands may become less stable and more changeable with implications for both timber and nontimber values (such as water quality, sensitive plant and animal communities, and recreation availability).
- Increased liquidity of forest assets argues for increased monitoring of ownership changes and of forest land transaction values to better understand the conservation implications of economic trends.

9. Threats to species of conservation concern are widespread but are especially concentrated in the Coastal Plain and Appalachian-Cumberland subregions.

Urbanization, forest management, climate change, and invasive species combine to further impact several species of conservation concern in the South, many of which are found in the Coastal Plain and Appalachian-Cumberland subregions. Coastal Plain forests are especially vulnerable to loss of biodiversity and imperiled species as a result of rising sea levels, intensifying management, spreading invasive species, and urbanization (figs. 54 and 55). This region is one of the focal areas for urbanization and would be the primary locale for any expansion in pine plantations. The Appalachian-Cumberland subregion also supports a large number of threatened plants and imperiled vertebrates (especially amphibians).

The current distribution of plant and animal diversity in the South reflects a broad range of habitats and a long history of land uses. The geography of species richness varies by taxa. Amphibians flourish in portions of the Piedmont and Appalachian-Cumberland subregions and across the Coastal Plain. Bird richness is highest along the coast and wetlands of the Atlantic Ocean and Gulf of Mexico, mammal richness is highest in the Mid-South and Appalachian-Cumberland subregion, and reptile diversity richness is highest in areas across the southern portion of the region (fig. 56).

Habitat isolation sometimes gives rise to pockets of high endemism. The legacy of the South's land use history is an unusually large number of endangered and otherwise imperiled plant and animal species. Ongoing land use change and forest fragmentation coupled with climate change continue to threaten the habitats for many imperiled species.

Although all subregions of the South contain species at risk, vertebrate and plant diversity and endangerment are especially high in the Coastal Plain. Hot spots of vertebrate species of conservation concern include the Atlantic and Gulf coasts, Peninsular Florida, and Southern Gulf. Hot spot areas for plants of concern include the Apalachicola area of the Southern Gulf Coast, Lake Wales Ridge and the area south of Lake Okeechobee in Peninsular Florida, and coastal counties of North Carolina in the Atlantic Coastal Plain (fig. 54).

Several forces of change acting on habitat quality are forecasted to also be concentrated in coastal areas, in many cases where high levels of urbanization are expected. The vast majority of intensively managed forests are located in this region, as is nearly all forecasted growth in pine plantations.

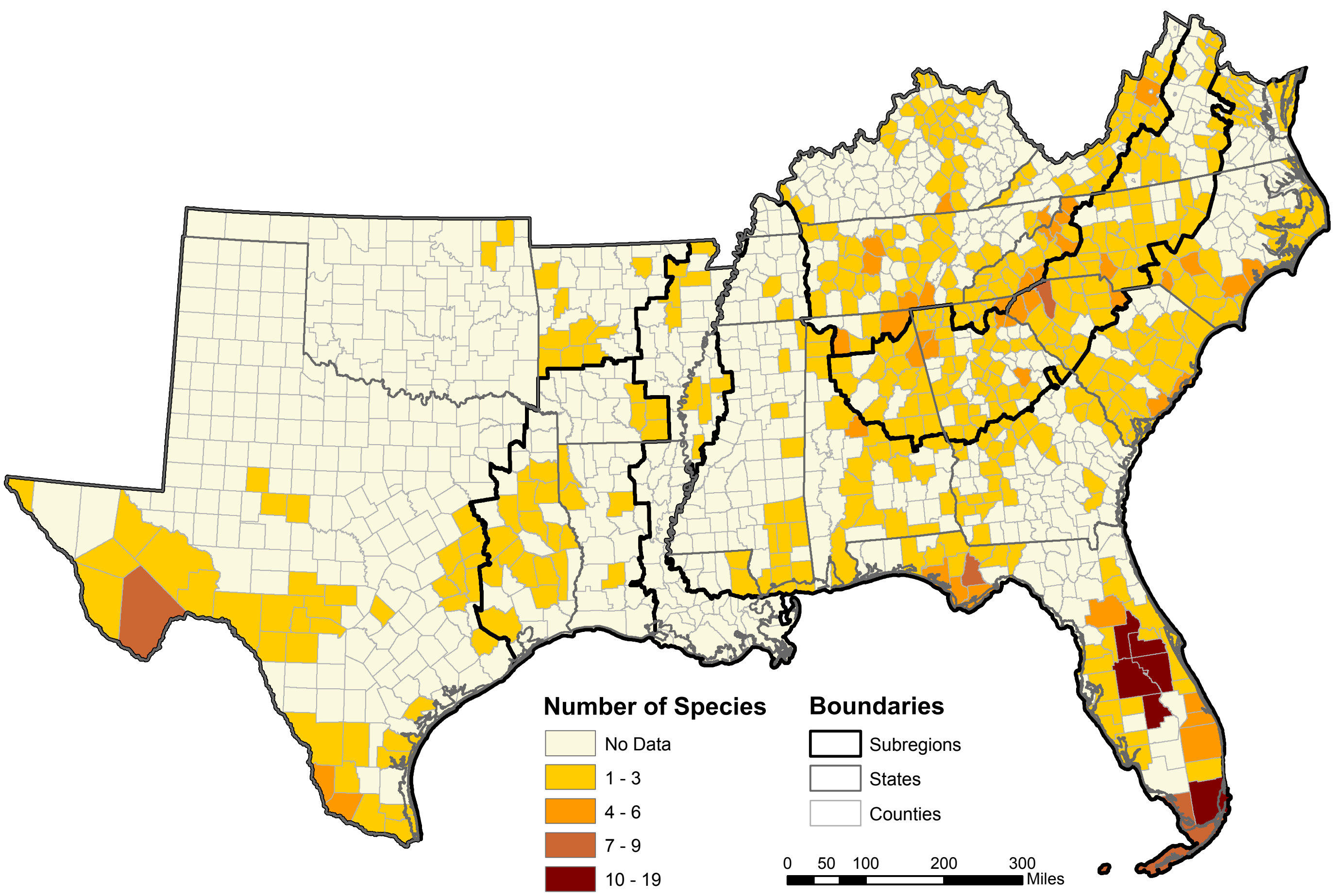

Figure 54—County-level counts for Federal status vascular plant species in the Southern United States (NatureServe 2011).

Climate changes are forecasted to cause sea level rise, extend fire seasons, and increase the frequency of large fire events throughout the Coastal Plain.

The combination of imperiled species and forces of change defines the Coastal Plain as a critical hot spot and Florida as a special concern (fig. 56). Urban development could threaten coastal species along the Atlantic Ocean and Gulf of Mexico and within the Florida Peninsula, which serves as stopover habitat in the Atlantic Flyway and nesting habitat for imperiled sea turtles. The flora of inland ecosystems is threatened by changing fire regimes. Projected inundation of mangrove and coastal live oak forests from sea-level rise would reduce habitat for several taxa. In addition, the Coastal Plain contains most of the South's highly valued longleaf pine (*Pinus palustris*); its area could be reduced by both urbanization and management-driven transition of forest types, challenging ongoing restoration efforts.

The Appalachian-Cumberland highlands contain a high percentage of bats, salamanders, and concentrations of sensitive plant species that are of conservation concern. The central Tennessee basin, adjacent escarpment, and highland rim around Nashville support plants of limestone glades, prairie-like areas, and forests. The South also contains threatened high elevation spruce-fir forests in the Southern Appalachians.

In eastern Tennessee and western North Carolina, forest loss, increased recreational use, residential development near Knoxville and Asheville, and possibly climate warming threaten to reduce the rich biodiversity of the Southern Appalachian Mountains. Even though large public land holdings (Great Smoky Mountain National Park, Blue Ridge Parkway, and Nantahala, Pisgah, and Cherokee National Forests) buffer and protect these habitats, residential development and growing recreational use threaten plant species. Warmer air temperatures, changes in precipitation or fire regime, and increases in competition from offsite plants may threaten species of high elevation habitats. The Blue Ridge supports 53 species of salamanders, 15 of which are imperiled or vulnerable. Any loss of habitat connectivity would make migration difficult for these species.

Forecasted changes in the Interior Low Plateau of central Kentucky and Tennessee threaten bats and plants that are associated with limestone glades. Urban development in the Southern Appalachian Mountains could imperil the diversity of salamanders. Growing recreational use on public lands (chapter 8) may add additional pressure on rare communities, and climate change threatens species endemic to high elevation areas.

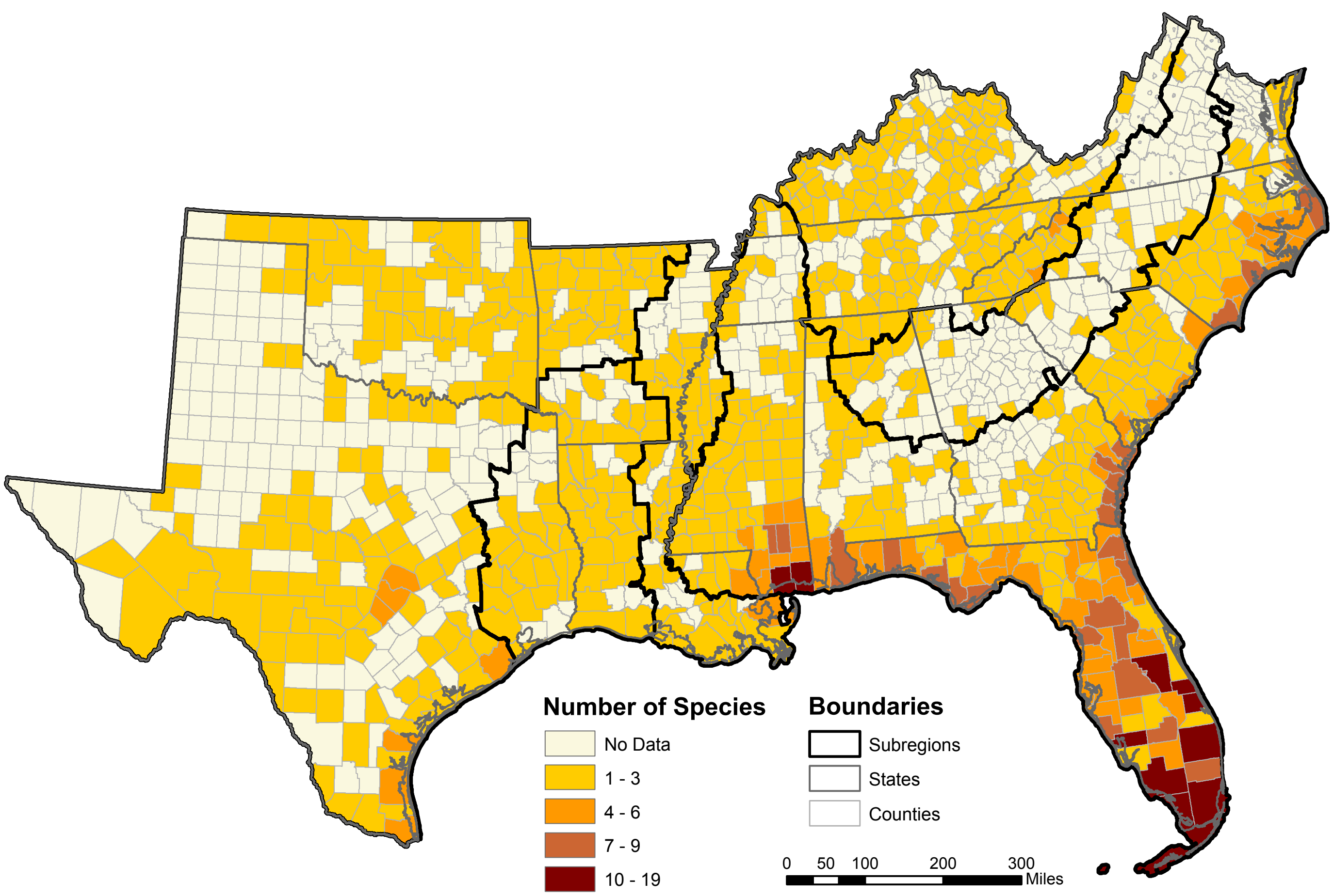

Figure 55—County-level counts for Federal status terrestrial vertebrate species in the Southern United States (NatureServe 2011).

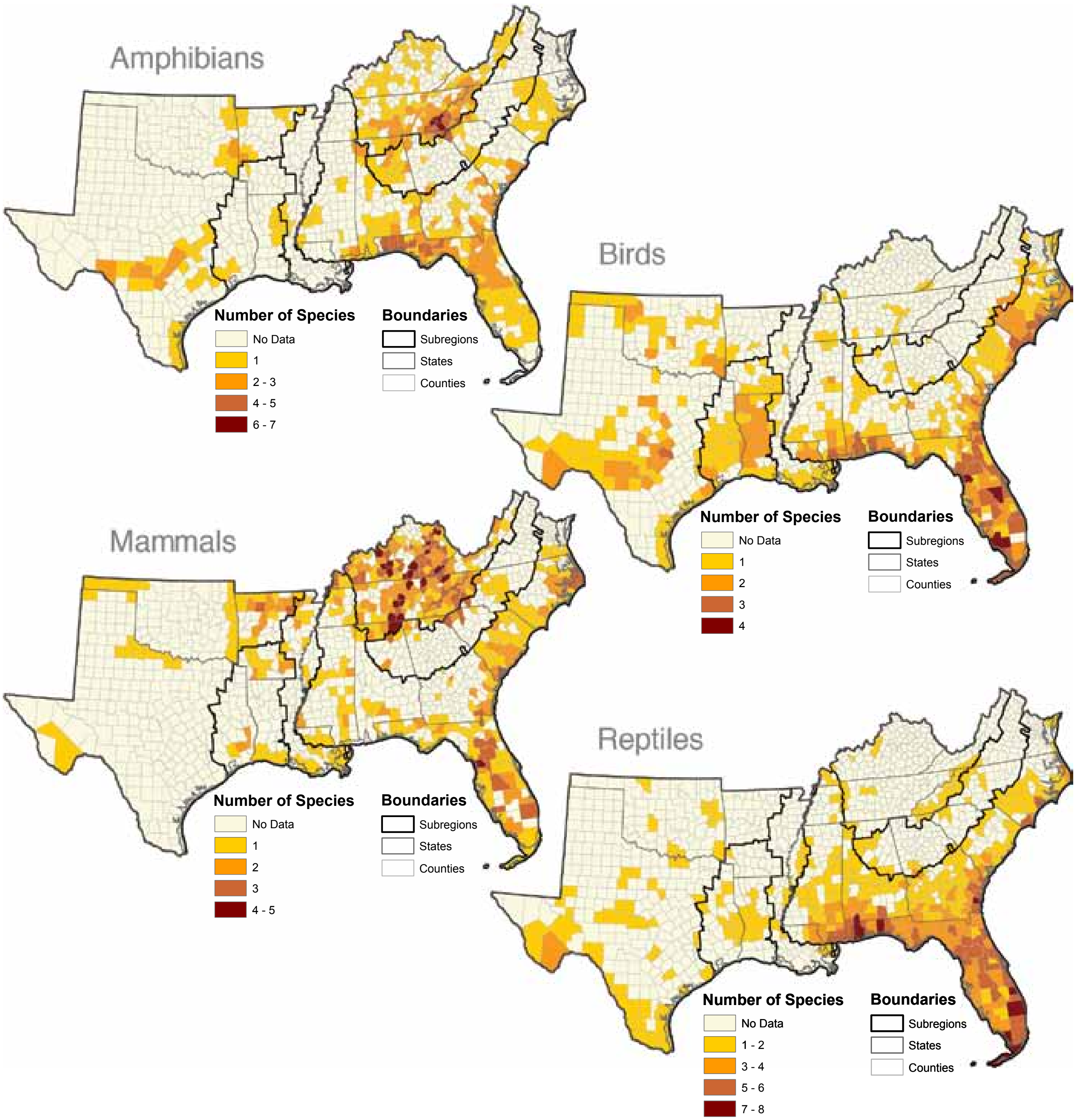

Figure 56—County-level counts for species of conservation concern by taxa in the Southern United States. (NatureServe 2011)

Wildlife and Forest Communities, Findings from Chapter 14

- The South has 1,076 native terrestrial vertebrates: 179 amphibians, 525 birds, 176 mammals, and 196 reptiles. Species richness is highest in the Mid-South (856) and Coastal Plain (733), reflecting both their large area and the diversity of habitats within them.
- The geography of species richness varies by taxa. Amphibians flourish in portions of the Piedmont and Appalachian-Cumberland subregions and across the Coastal Plain. Bird richness is highest along the coast and wetlands of the Atlantic Ocean and Gulf of Mexico, mammal richness is highest in the Mid-South and Appalachian-Cumberland subregions, and reptile diversity is highest in forests farthest south.
- The South has 142 terrestrial vertebrate species considered to be of conservation concern, 77 of which are federally listed; and more than 900 plant species, 141 of which are federally listed. Threats to biodiversity are region-wide.
- The proportion of species at risk varies among taxonomic groups: 46 percent of imperiled vertebrate species are amphibians, followed by reptiles (25 percent), mammals (16 percent), and birds (13 percent). The Coastal Plain (64) and Mid-South (55) lead in the numbers of imperiled vertebrate species, followed by the Appalachian-Cumberland (31), Piedmont (29), and Mississippi Alluvial Valley (9) subregions.
- Hot spots of vertebrate species of conservation concern include the Atlantic Ocean and Gulf of Mexico coasts, Peninsular Florida, and Southern Gulf. Emerging areas of concern include sections within the Appalachian-Cumberland subregion (Blue Ridge, Southern Ridge and Valley, Cumberland Plateau and Mountain, Interior Low Plateau) and Mid-South subregion (Ozark-Ouachita Highlands, West Texas Basin and Ridge, and Cross Timbers).
- Hot spot areas for plants of concern are Big Bend National Park, the Apalachicola area on the Gulf of Mexico, Lake Wales Ridge and the area south of Lake Okeechobee in Peninsular Florida, and coastal counties of North Carolina in the Atlantic Coastal Plain. The Appalachian-Cumberland subregion also contain plants identified by States as species of concern.
- Species of conservation concern are imperiled by habitat alteration, isolation, invasive species, environmental pollutants, commercial development, and human disturbance and exploitation. Conditions predicted by the forecasts would magnify these stressors. Each species varies in its vulnerability to forecasted threats, and these threats vary by subregion. Key areas of concern arise where hot spots of vulnerable species coincide with forecasted stressors.
- There are 614 species that are presumed extirpated from selected States in the South; 64 are terrestrial vertebrates and 550 are vascular plants. Over half of the terrestrial vertebrates were added to this list in the last decade. Factors contributing to their demise include urban growth, industrial development, incompatible agricultural practices, degradation of wetlands, alteration of natural hydrological conditions, pesticide contamination, natural and human-caused disturbance, and destruction of locally unique habitats such as prairie-like areas.
- Mid-South: Forest loss and urban growth in the Ozark-Ouachita Highlands threaten concentrations of plant and animal species. Urban development along southern borders of Texas and Louisiana in the Cross Timbers and Western Gulf sections could impact a large number of reptiles and birds.
- Appalachian-Cumberland: Forecasted changes in the Interior Low Plateau of central Kentucky and Tennessee threaten bats and plants associated with limestone glades. Urban development in the Southern Appalachian Mountains could imperil the diversity of salamanders. Recreational use may add additional pressure on rare communities, and climate change threatens species endemic to high elevation areas.
- Piedmont: Substantial urban growth and forest loss could degrade the diversity of amphibians, mammals, and plants, although species in inaccessible sites (such as rock outcrops) may be less at risk. Management on public land may become difficult due to the population pressure in surrounding counties. Species in areas transitional to other subregions may also be threatened by climate change.

(continued)

(continued) Wildlife and Forest Communities, Findings from Chapter 14

- Mississippi Alluvial Valley: Urban growth forecasts for the Deltaic Plain could degrade the richness of shorebirds and waterfowl in the wetlands of the Mississippi Flyway as well as habitat for the Louisiana black bear. Sea level rise could inundate the coastal habitat inhabited by numerous species.
- Coastal Plain: Urban development could threaten species along both coasts and within the Florida Peninsula, which serves as stopover habitat in the Atlantic Flyway and nesting habitat for imperiled sea turtles. The flora of inland ecosystems is threatened by changing fire regimes. Projected inundation of mangrove and coastal live oak forests from sea level rise would reduce habitat for several taxa.
- High elevation forests: Spruce-fir forests in the Southern Appalachian Mountains are subject to air pollution, acid deposition, and natural disturbances. Climate warming and further housing development may result in the loss of endemic species or changes in species ranges.
- Upland hardwood forests: Declines are predicted to be 14 percent throughout the region under forecasts of high levels of urbanization and low timber prices. Predicted northward shifts in species distributions could threaten forest interior species and reassemble forest types, including the widely distributed oak-hickory forest.
- Longleaf pine forests: Portions of the Coastal Plain are expected to lose acreage under forecasts of high urbanization and high timber prices, while south-central Florida and northwestern Alabama are predicted to gain acreage of this forest type.
- Early successional forests: Under the forecast of high urbanization and high timber prices, the greatest losses are expected in the Northern Ridge and Valley section of the Appalachian-Cumberland, southern Florida and associated Keys, and scattered locations in coastal Virginia and North Carolina. Gains are expected in the Ridge and Valley of eastern Tennessee, Cumberland Plateau and Mountains, Apalachicola area of Florida, Ozark-Ouachita Highlands, and adjacent northern area of the Mississippi Alluvial Valley.
- Climate change is an additional source of stress on terrestrial species and ecosystems. Projections of temperature increase and variability in precipitation patterns may change the future distribution of many species, influencing seasonal movement, recruitment, and mortality. Species may move into the habitats of others, creating new assemblages; climate-induced changes in phenology would affect the availability of resources for nesting and feeding.
- Species at risk from climate change include those with restricted geographic ranges, patchy distributions, and those that occur at the margins of their ranges. Other characteristics include limited dispersal ability, low genetic diversity, affinity to aquatic habitats, narrow physiological tolerance, and late maturation.
- Communities at high elevations, grassland communities, and wetland ecosystems may be particularly susceptible to climate change. Species whose ranges are limited to coastal areas will be vulnerable to projected changes in sea level. Sea level rise may inundate barrier islands, coastal wetlands, and marshes of the Coastal Plain, as well as areas along the Atlantic Ocean and Gulf of Mexico.
- The forecasts pose challenges on how best to implement future conservation and management strategies. New tools and approaches to managing uncertainty (such as scenario planning, sensitivity analysis, or ecological risk analysis) may become routine.
- Integrating climate science into management planning will be important, accompanied by monitoring strategies that identify patterns in disturbance, phenology, and range shifts. As future impacts occur across large areas, the appropriate decision making level may shift to include landscape or regional scales; temporal scales may be longer than typically considered.
- An understanding of the relationship between the forecasts and the geographic pattern of species occurrence would improve planning efforts. The implications for the conservation of southern species are significant: in the midst of a growing region, the provision of biological diversity will become a critical conservation issue.

10. Increasing populations would increase demand for forest based recreation while the availability of land to meet these needs is forecasted to decline.

Recreation demand has evolved over time (chapter 7) and is forecasted to increase and change through 2060 (chapter 8). At the same time, forest area declines while the small portion of public forest area (less than 15 percent of all forest land) remains stable. The result is a decline in recreation opportunities and an increase in recreation congestion, with the potential for conflict among user groups.

By 2060, the number of southern adults participating in each of 10 popular outdoor recreation activities is projected to increase. The activity with the smallest growth in participation is hunting (8–25 percent). The activity projected to grow the most is day hiking (70–113 percent). Southern national forest recreation visits are projected to increase across all site types: federally designated wilderness areas (38–72 percent), day use developed sites (35–70 percent), overnight use developed sites (30–64 percent), and general forest areas (22–55 percent).

By 2060, acres of southern forest and rangeland per recreation participant is expected to decline by up to 50 percent across the various activities as the number of participants increases and forest area decreases. Hiking would be the most affected activity, and hunting would be the least affected.

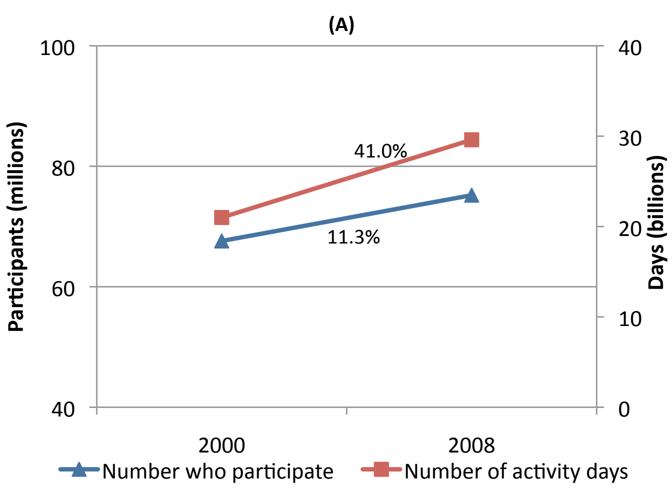

Figure 57—Growth in number of people and number of activity days in 60 outdoor recreation activities in the Southern United States, 2000–08.

Generally speaking, the number of projected participants and days of participation are expected to increase at a rate near or somewhat below regional population growth (fig. 57). For a few activities—e.g., developed site use, hiking, and birding—participant numbers as well as days of participation are projected to grow faster than regional population growth. Other activities typically associated with higher income—e.g., horseback riding on trails, motorized water use, and non-motorized water use—are forecasted to grow faster than the population if higher income levels are realized (as in Cornerstone Futures A and B). Otherwise, they will likely grow at rates slightly lower than population.

Density of use of national forest area is expected to rise by 22–55 percent as participants increasingly substitute national forests for private forest and rangelands that have been reduced by urban development. Because general forest area recreation use—including hunting, motorized off-road use, and horseback riding on trails—requires more space per user for high-quality (and safe) experiences, the projected increase in use density would be particularly challenging to national forest managers. Conflicts due to congestion may increase not only within activities (such as motorized off-road users running into each other figuratively and literally), but also across activities (with motorized off-road users disturbing game sought by hunters and degrading the hunting experience).

Across all activities and venues, private and public, there is strong evidence to suggest that the number of southern outdoor recreation participants and their annual days of use are expected to grow over the next 5 decades, putting increasing pressure on existing infrastructure (both built and natural) and thus stressing the recreation-carrying capacity of forest and rangeland resources (fig. 58). It may sometimes be possible to relieve congestion by investing in and building more infrastructure, such as hiking trails on public lands. Private land owners may also help to meet increased demand by building recreation infrastructure. Southern markets for hunting and other consumptive recreational activities on private lands have historically been fairly large and may grow further. Owners of remaining private land may also be able to serve the increased demand for non-consumptive recreational activities by investing in infrastructure traditionally provided by public lands (such as hiking trails and bird-watching facilities). Returns to recreation investments could provide another revenue stream to private forest owners, thereby increasing the retention of forest cover on private lands in the South.

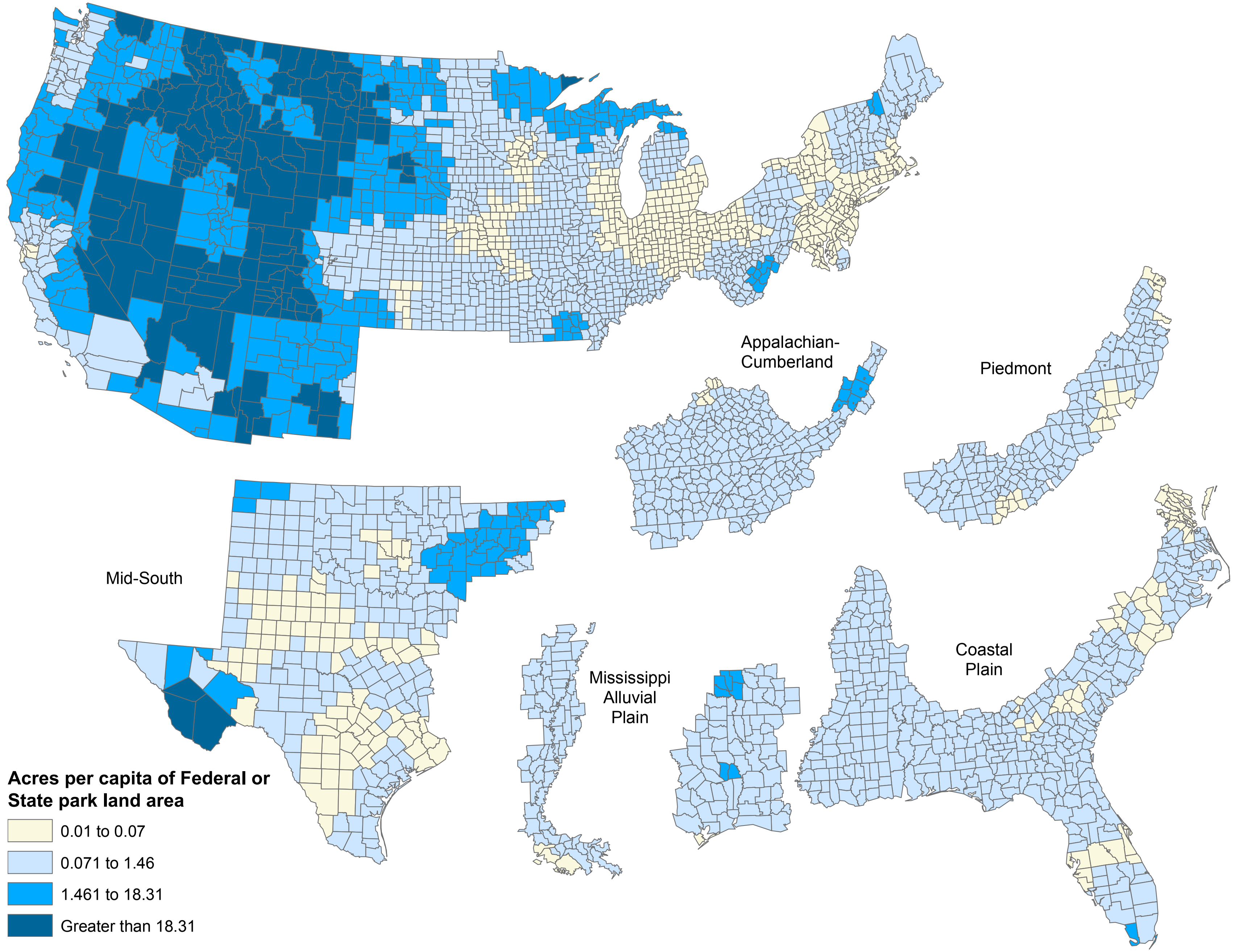

Figure 58—Acres per capita of Federal and State land area within a 75-mile recreation day trip of each U.S. county, 2008. Sources: USDA Forest Service 2008; USDI NPS 2008; USDI BLM 2008; Tennessee Valley Authority 2008; U.S. Army Corps of Engineers 2006; National Association of State Park Directors 2009.

Recreation in a Shifting Societal Landscape, Findings from Chapters 7 and 8

- The South grew considerably faster (32.5 percent) in population in the 18 years from 1990 to 2008 than the Nation as a whole (22.2 percent). The region has just over half of the Nation's non-Hispanic African American population (18.9 million) and is a close second to the Rocky Mountains in the size and growth rate of the American Indian population. Since 1990, the South (heavily influenced by Texas and Florida) passed the Pacific Coast (strongly influenced by California) in Hispanic population to lead the Nation, with growth also especially high in North Carolina and Georgia.
- The highest growth in density of population (persons per square mile) occurred down the Piedmont and Southern Appalachian Mountains from North Carolina to Alabama, along the coasts of Florida, and around the major cities of Texas. Some of this growth was substantial and exceeded the U.S. Census Bureau definition of an urban area, 500 persons per square mile. In areas like eastern Texas, higher concentrations of people in places near public lands and bodies of water are likely to put increasing pressures on these limited resources.
- With moderate growth, total population in the United States is projected to exceed 447 million people by 2060, an increase of more than 47 percent. Projected growth for the South is expected to be nearly 60 percent. The Atlantic States area of the South ranks second among its nine U.S. counterparts, with a 68-percent forecasted increase in population, followed by the Pacific Northwest with 63 percent. Of the 13 Southern States, Florida, Virginia, and Texas are projected to grow faster than the southwide rate of 59 percent.
- One overriding recreation trend seems clear—what people now choose to do for outdoor recreation is different from choices made by and available to previous generations. Fishing and hunting, often considered widely popular and among the more "traditional" of outdoor activities, are still somewhat popular but are being replaced by other activities such as wildlife or bird watching and photography.
- Of the most popular activities in the South (having over 30 million participants), the top six slots were occupied by walking for pleasure, family gatherings outdoors, gardening or landscaping, viewing/photographing natural scenery, sightseeing, and visiting outdoor nature centers. Other popular growth activities include driving for pleasure, viewing/photographing flowers and trees, viewing/photographing wildlife (besides birds and fish), swimming in an outdoor pool, and picnicking. Activities oriented toward viewing and photographing nature (scenery, flowers/trees, and wildlife) have been among the fastest growing in popularity.
- Less than 5 percent of Federal land, about 30.5 million acres, is in the South, 44 percent of which is managed by the Forest Service. More than 92 percent of Federal land is located in the Western United States.
- Federal acreage changes very little over time, but population changes greatly. In the South, Federal acres per 1,000 persons declined slightly faster than the national rate, with a 15.4-percent decrease in acres per 1,000 people since 1995.
- Federal and State-park land area in the South is expected to remain relatively constant over time. Currently, 5 percent of the total area is Federal or State park land, less than 0.3 acres per person, by 2060 expected to decrease to 0.17 acres, about 63 percent of the 2008 level. Because of population growth, the projected decline is greater for the South than the Nation.
- Total non-Federal forest land area is expected to change with continuing conversions from forests and farmlands to cities and suburbs. Currently, more than 30 percent of total land area in the South is non-Federal forest, or 1.66 acres per person. By 2060, non-Federal forest is predicted to decline to 0.95 acres per person, or 57 percent of the 2010 level. The projected decline is greater for the South than the Nation because of population growth and increased development.

CONCLUSIONS

This report summarizes the findings of the Southern Forest Futures Project, an effort to anticipate the future and to analyze what the interaction of future changes might mean for the South's forests and the valuable services they provide. In so doing, we explore a labyrinth of driving factors, forest outcomes, and human implications to sketch out how the landscape of the South might change in the future. This report distills the 17 chapters of the Southern Forest Futures Project technical report (Wear and Greis, in press) into 10 key findings.

First and foremost is the complexity of southern forest futures. Multiple factors will interact to define changes in forest conditions and benefit flows so that any assessment focused on only one of these factors could be misleading. The Cornerstone Futures provide one way to jointly examine these multiple forces in a coherent fashion. Jointly determined projections of population, economic, and climate are derived from internally consistent worldviews or storylines linked to the 2010 RPA Assessment and the Intergovernmental Panel on Climate Change analyses (USDA Forest Service 2012). A large number of potential futures were reduced to the six Cornerstone Futures to capture a representative range of future conditions and to construct a comprehensive analytical approach for addressing the meta-issues. The range of futures also illustrates uncertainty regarding the future and highlights the key variables affecting future forest conditions.

The key findings developed for this summary report synthesize findings from individual chapters in the technical report but discuss only a portion of the detailed results so that we could highlight what we believe is the most important information for managers and policy analysts. Keyed to the individual chapters of the technical report, this discussion of key findings also provides links to our more detailed findings.

All 10 key findings provide insights into the mechanisms and relative magnitudes of changes anticipated for the region. Taken as a whole, they emphasize the role and the influence of private landownership in the South in determining future forest conditions. Influenced by markets and by values of alternative land and forest uses, the South's forests have evolved rapidly over the past half-century and could change just as rapidly over the next 50 years. In general, socioeconomic factors rather than climate factors dominate forest futures in the early stages of our forecasts. But the time frames of these forces of change vary, and it is useful to think about how impacts could play out over the short, medium, and long runs.

Short-run changes, defined here as the next 10 years, are dominated by the ongoing expansion of the South's population and economy. Urbanization and loss of forests and other rural land will likely continue to reshape landscape conditions. Populations are expected to grow and consolidate around cities, expanding the wildland-urban interface while reducing populations in some of the most rural areas. Increasing returns to forest ownership, including timber products but also returns from other ecosystem services encourages retention of forests and would mitigate forest losses. Ownership changes within the commercial and family forest classes may accelerate in the short-run and are expected to be especially sensitive to market futures. The growth of the wildland-urban interface will likely bring changes and constraints in forest management, with local ordinances and health and safety concerns further restricting the use of prescribed burning to manage fuel loads. Fuel accumulates rapidly in southern forests and wildland fire impacts may increase in the short-run, especially with a growing concentration of human infrastructure in forest settings.

Medium-run changes, defined here as 10 to 20 years, involve a continuation of the short-run changes identified above, but they are compounded by other factors. Projections of demand for bioenergy feedstocks, although driven by uncertainties such as the development of new technologies and State and Federal policies, could begin to accelerate beginning in the 2020s. Our analysis indicates that, if guided by markets, strong demand growth for fiber could lead to intensified forest management focused on the Coastal Plain. This, along with urbanization would cause alterations to habitats, especially for amphibians, with cumulative effects beginning to emerge. Impacts on water availability and quality are also forecasted to intensify beginning in the 2020s. These effects on ecosystem services could feed back to constrain management options in the region and affect the trajectory of investments.

Within the long-run timeframe, defined here as more than 30 years, climate change effects become more prominent and accumulate toward the end of our 50-year time frame. All climate projections used in the Futures Project (based on four different climate models downscaled for the 2010 RPA Assessment) predict increasing temperatures through 2060, but they differ in their predictions of precipitation—as do more specific location-based forecasts of precipitation. Impacts on water, wildlife, and nonnative plant species emerge during this timeframe but are manifest differently depending on the specific climate projection. For most climate futures, invasive plant impacts are forecasted to become a growing source of ecological change and economic impact in the long-run time frame. Water stress accumulates, especially in the Piedmont, Coastal Plain, and parts of the Mid-South, mainly in response to increased demands associated with growing populations and land use changes. Wildlife impacts in the Coastal Plain become further compounded by changes in precipitation in some situations and by sea-level rise impacts on coastal forests.

The forecasts across Cornerstone Futures illustrate the important mechanisms of change in forests. The biggest losses in forest area would be under Cornerstone B with high population/income growth projections but lower timber prices. The smallest would be under Cornerstone C with low population/income projections but high timber prices. Our results indicate that urbanization affects forest area but can be offset by market futures that place higher values on forest uses. This logic extends to any other source of forest values, including payments for nontimber forest products and crucial ecosystem services. Often cited examples are watershed protection, sequestration of atmospheric carbon, and habitat protection. While not yet reaching a large proportion of the South's forests, these types of compensation programs are beginning to emerge, and our findings suggest that they could be effective in encouraging the retention of forest cover. Land use models also indicate that urbanization rates strongly depend on income as well as population so that the intensity of development for a given level of population is variable and could be altered by policy.

Our scope does not include prescriptions for policymaking, yet policy is an important factor in the forecasts. The empirical models and future forecasts are based on existing policy across several domains, and an important assumption of the forecasts is that the future develops without change to the policy setting. Land use forecasts do not account for any change in land use policies or conservation initiatives and harvest forecasts extend decision models based on current patterns of forest ownership and harvest responses. Although Cornerstone Futures contain alternative demand forecasts for timber products, these are not explicitly linked to policy futures. The unfolding of future demand will clearly depend on myriad policies including those affecting trade, domestic taxes, and perhaps most directly, policies designed to encourage bioenergy production—these last include Federal and State incentive programs and renewable portfolio standards. Subsequent assessments could benefit from drawing more direct linkages between these policies and future demand.

All forecasts of the future are likely to be wrong to one degree or another. Those addressed by the Futures Project were intended to represent a plausible range of future conditions. They were designed to examine what could happen given a reasonable range of future conditions, and therefore involve some element of judgment. Accordingly, they need to be examined in light of uncertainty derived from various sources, one of which is our limited knowledge about the modeled systems, i.e., the limits of current scientific knowledge. Models are only as complete and accurate as the science upon which they are based, and completing this effort has uncovered many knowledge limits, which are discussed in the individual chapters of the technical report.

Another area of uncertainty derives from the structure of the Cornerstone Futures that organize the analysis and includes assumptions about population growth and other variables that were used to frame each Cornerstone. Additionally, structural changes in institutions could result in very different outcomes. For example, energy or climate policies could alter the demands placed on forests for producing bioenergy or storing carbon, in turn altering landowner choices. Further analyses of new and different possible futures will be warranted as conditions and knowledge change. This will remain an active area of research (see Wear and others 2012 for analysis of forest conditions across a broader range of scenarios).

Our findings highlight the importance of monitoring the changes that take place in the South. We now have a well-developed and ongoing forest inventory system to monitor forest conditions and uses. Southern forest assessments have long depended on these data. The U.S. Forest Assessment System used for the Futures Project and the 2010 RPA Assessment could not have been built without the inventory data; indeed, the maturation and usefulness of regional and national forecasting will depend on a steady updating of these core data. Our key findings indicate that forest inventories will remain critical tools for monitoring changes, but also that monitoring certain socioeconomic elements—including land use dynamics, investment, and land transactions—is also needed. Forecasts highlight areas where changes might be concentrated in the short-to-medium runs and therefore where intensified monitoring activities might be useful. The findings also highlight the need for new and continuously measured land use data that effectively monitor changes that are driven by urbanization.

Recognizing that knowledge is never perfect nor complete, we have highlighted critical uncertainties that defined the limits of our ability to draw conclusions about causes or impacts. In addition to public policy drivers and their critical but unknowable implications for future demand are the population and income assumptions that dominate our forecasts—these could benefit from population dynamics models that better account for alternative economic development assumptions and human responses to climate variables. The effects of climate change on the spatial patterns of forests are being studied; new insights into these mechanisms of change will need to be coupled with better fine-scale predictions to reduce uncertainty about future forests. Forecasts of future impacts on plant and animal species of conservation concern currently link species presence to patterns of urbanization and intensive forest management. Future assessments would benefit from more direct links between habitat conditions and the functional needs of individual species or species groups.

Although most of the substantial impacts of our projections will take some years to play out, the changes that lead to these impacts are already at work. Populations have grown, forest management has changed, and new invasive species have been introduced over the past decade. Today's management and policy will affect their outcomes. Throughout the Futures Project, we have not prescribed management decisions or how to best form policy in response to anticipated changes. Instead, our findings provide an information foundation for others to evaluate management and policy alternatives in light of possible futures. The ultimate measure of our success will be the extent to which these findings are used for such analysis.

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APPENDIX: OVERVIEW OF CHAPTERS FROM THE TECHNICAL REPORT OF THE SOUTHERN FOREST FUTURES PROJECT

This appendix contains summaries of most of the chapters that comprise the Southern Forest Futures Project technical report (Wear and Greis, in press). Chapters 1 and 2, which focus on design and methods, are not summarized here.

Chapter 3: Climate Change Summary

Steve McNulty, Jennifer Moore Myers, Peter Caldwell, and Ge Sun

The authors summarize the Intergovernmental Panel on Climate Change predictions for climate that were chosen for use in the Southern Forest Futures Project. They also discuss the climate models and Special Report Emissions Scenarios used in the Futures Project. All were downscaled to the southern regional level for analysis and discussion. The authors describe forecasted climates under each future, focusing on temperature and precipitation changes by decade. Differences among the futures are identified. Finally, conclusions are presented about the South's forecasted climate, including some of the implications of forecasted changes.

Chapter 4: Forecasts of Land Uses

David N. Wear

Factors driving land use change are discussed and those used in the models employed in this chapter are identified. The land use models employed were developed by the author for use in the 2010 RPA Assessment, and were customized for the South. The author uses data and information from the National Resource Inventory (USDA NRCS 2009) to describe current land uses in the South and their distribution among the five subregions addressed in the Southern Forest Futures Project. Forecasts of land use change are provided for 2020, 2040, and 2060, with 2010 serving as the base year. Analysis is provided for multiple land uses, including forest, cropland, pasture, rangeland, and urban uses. Forecasted conditions for each of the five subregions of the South are provided, as well as total forecasted changes for the South from the present to 2060.

Chapter 5: Forecasts of Forest Conditions

Robert Huggett, David N. Wear, Ruhong Li, John Coulston, and Shan Liu

U.S. Forest Assessment System models are used to forecast forest conditions to 2060. Multiple potential sets of conditions, or futures, are modeled and analyzed. These futures reflect different biological, physical, and human factors that drive forest change. Forest inventory plot data are forecasted using these interacting models, and results are generated for each plot and then aggregated to reveal expected changes at larger scales. Carbon estimates are derived from inventory data, and climate change forecasts are taken from the 2010 RPA climate database. Forecasted decadal changes in forest area, forest types, management types, age class distributions, and other aspects are provided for multiple futures and discussed both by subregion and for the region as a whole. Causal drivers of change are described.

Chapter 6: Forest Ownership Dynamics of Southern Forests

Brett J. Butler and David N. Wear

The authors use many sources of information and data to describe recent trends in forest ownership in the South, including changes in forest industry, timber investment management organizations, real estate investment trusts, other corporations, and family forests. Forces that drove recent changes are described. Using data from the U.S. Forest Service National Woodland Owners Survey and other forest inventory data, the authors discuss ownership types, management objectives, and likely management preferences. Potential futures are examined based on forecasted land use change, probable management styles of owner groups, and demographic characteristics of the South's forest owners.

Chapter 7: Outdoor Recreation in a Shifting Societal Landscape

H. Ken Cordell, Carter J. Betz, and Shela H. Mou

The authors describe trends and forecasts of population, demographic makeup, recreation participation, and recreation resources available in the South. Population and demographic trends and projections are based on census data and forecasts of climate change consistent with the 2010 RPA Assessment. Available outdoor recreation resources are described. Comparisons of the South with other regions are also provided.

Chapter 8: Outdoor Recreation

J.M. Bowker, Ashley Askew, H. Ken Cordell, and John C. Bergstrom

The authors use statistical models, estimates, and projections to forecast demand for numerous types of forest-based recreation in the South, out to 2060. Estimates are provided for multiple activities for several forecasts developed by the Southern Forest Futures Project. Information is also provided for southern national forest recreation demand, by recreation site type.

Chapter 9: Markets

David N. Wear, Jeffrey Prestemon, Robert Huggett, and Douglas Carter

The authors use historical records from multiple sources to describe how timber markets have changed historically until the present, including the factors that have affected those trends. Inventory data are used to describe trends in forest inventory and production, helping to explain how timber demand, supply, and prices have interacted and are likely to interact into the future. A variety of models are used to forecast future markets for every decade out to 2060: supply, demand, prices, and inventories for several projections of demand; economic conditions; and forest productivity. Import and export factors are addressed. The potential effects of an emerging wood bioenergy demand on prices and inventories are discussed.

Chapter 10: Forest Biomass-Based Energy

Janaki R. R. Alavalapati, Pankaj Lal, Andres Susaeta, Robert C. Abt, and David N. Wear

The authors use literature sources to describe the current status and to address technology development, bioenergy policies, and sustainability issues. The Sub-Regional Timber Supply model serves as the primary tool to assess the effects of wood-based bioenergy industry on future prices, harvests, and inventories of four wood product categories—softwood non-sawtimber, softwood sawtimber, hardwood non-sawtimber, and hardwood sawtimber, as well as effects on existing forest industry. Several scenarios are presented along with anticipated effects of each.

Chapter 11: Effect of Taxes and Incentives on Family-Owned Forest Land

John L. Greene, Thomas J. Straka, and Tamara L. Cushing

The authors use questionnaires, price reports, literature searches, and personal contacts to examine a variety of tax-related questions. Awareness by landowners and effects of Federal and State tax codes on family forest owners are evaluated. Current and potential estate and gift tax effects are discussed, as is the influence of the tax code on conservation easements and other forestry. Some details are provided on specific tax provisions (as of 2010). Survey results of landowner awareness and recent estate related transactions are discussed. A list of conservation programs available to private landowners is included, along with a brief description and tax implications for each.

Chapter 12: Employment and Income Trends and Projections for Forest-Based Sectors in the U.S. South

Karen L. Abt

The author use down-scaled data from the Bureau of Labor Statistics, Bureau of Economic Analysis, and other models to address the contributions of jobs, income, and the forest products sector to the regional economy. Historical trends are presented, as are forecasts for the logging, wood products, and manufacturing sectors, and interactions of all contributing factors are discussed. Expected changes in forest-based recreation jobs and income are also projected. All forecasts are limited to a single decade. A discussion of potential economic effects of an emerging wood bioenergy industry is provided. Specific methods and data sources are included.

Chapter 13: Forests and Water

Graeme Lockaby, Chelsea Nagy, James M. Vose, Chelcey R. Ford, Ge Sun, Steve McNulty, Pete Caldwell, Erika Cohen, and Jennifer Moore Myers

A literature review synthesis describes the relationship between forest cover and stream flow and water quality. The consequences of forest conversion to agriculture and urban uses are reported for the various subregions of the South. A water accounting model is used to forecast changes in water availability given expected demand and changes in climate. Specific methods and data sources are included.

Chapter 14: Wildlife and Forest Communities

Margaret Trani Griep and Beverly Collins

The authors present an analysis of geographic patterns of plant and wildlife diversity and species at risk. They also provide an evaluation of the potential impacts of forecasted climate change and urbanization in the region. Data and their analysis are presented for the South as a whole and by subregion. The analysis uses global data provided by the NatureServe Program and also uses State-level data provided by the State Natural Heritage Program. Maps depict patterns of species diversity and rarity. Spatial and tabular forecasts of urban growth, forest loss, and climate change are used in conjunction with the species maps to identify areas of particular concern. Specific methods and data sources are included.

Chapter 15: The Invasion of Southern Forests by Nonnative Plants: Current and Future Occupation, with Impacts, Management Strategies, and Mitigation Approaches

James H. Miller, Dawn Lemke, and John Coulston

The authors use multiple data sources to provide information on nonnative plants that have invaded forests and natural areas, as well as pastures, open spaces, and wetlands in the South. They describe principles of invasion, spread, prevention, and eradication. The invasive plants data set from the Forest Inventory and Analysis Program of the Forest Service, U.S. Department of Agriculture, is analyzed for 33 regional invasive species and 20 species particular to Florida. Current occupation by State, counties, and subregions is analyzed. Predictive modeling for five species of particular concern (Japanese climbing fern, non-native roses, silktree, tallow tree, and Nepalese browntop) is performed. Maps of occupation and expected spread are included.

Chapter 16: Invasive Pests—Insects and Diseases

Donald A. Duerr and Paul A. Mistretta

The authors consult literature and professional entomologists and pathologists to describe the threats posed by 30 of the most significant insects, diseases, and insect/disease complexes in the South. Changes in climate, land use, and forest conditions provided in the Southern Forest Futures Project forecasts serve as the basis for projecting expected spread and severity of pest damage. A description of each pest, forest species affected, and expected degree of spread and damage by each is included.

Chapter 17: Fire

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The authors briefly discuss the importance of prescribed fire in maintaining healthy forests in the South and relate forecasted changes in climate and land use to the future use of prescribed burning. The Southern Wildfire Risk Assessment serves as a source of information on current fire patterns in the South. Models that indicate wildfire potential are described, as are forecasted changes in them for 2010 to 2060. Patterns of change are summarized for each group of assumptions developed for the Southern Forest Futures Project. Forecasts are provided for the South as a whole as well as for subregions. A variety of expected constraints on prescribed burning are discussed, as are the important implications of such constraints. Urbanization, changing demographic characteristics, air quality issues, and liability concerns are cited as limiting factors for future prescribed burning.

Wear, David N.; Greis, John G., eds. 2012. The Southern Forest Futures Project: summary report. Gen. Tech. Rep. SRS-168. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 54 p.

The Southern Forest Futures Project provides a science-based "futuring" analysis of the forests of the 13 States of the Southeastern United States. With findings organized in a set of scenarios and using a combination of computer models and science synthesis, the authors of the Southern Forest Futures Project examine a variety of possible futures that could shape forests and the many ecosystem services and values that forests provide. The science findings and modeling results could inform management and policy analysis of the South's forests. In this summary report, the authors distill detailed results from the Southern Forest Futures Project technical report and provide a set of key findings and implications.

Keywords: Forest conservation, futuring, integrated assessment, Southern Forest Futures Project, sustainability.