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Outlook for Coastal Plain Forests:

A SUBREGIONAL REPORT from the Southern Forest Futures Project

Kier Klepzig, Richard Shelfer, and Zanethia Choice

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Cover photos

MAIN IMAGE: Longleaf pine forest understory (W. Robert Maple, USDA Forest Service, Bugwood.org). TOP ROW LET TO RIGHT: Prescribed fire, upper Tampa Bay, FL (Dale Wade, Rx Fire Doctor, Bugwood.org); egg galleries produced by female southern pine beetle (Southern Forest Insect Work Conference Archive, Bugwood.org); gopher snake (James Henderson, Golden Delight Honey, Bugwood.org); flail residues from a clean chipping operation are a source of available biomass (Dana Mitchell, USDA Forest Service); mature bottomland hardwood forest (USDA Forest Service).

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PROLOGUE

The Southern Forest Futures Project Co-Leaders

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This report describes a set of likely forest futures and the management implications associated with each for the Coastal Plain, one of five subregions of the U.S. South. Its findings are based on the findings of the Southern Forest Futures Project, a multi-agency effort to anticipate the future and to analyze what the interaction of future changes might mean for forests and the benefits they provide in the 13 Southern States. The Futures Project investigators examined a labyrinth of driving factors, forest outcomes, and human implications to describe how the landscape of the South might change. Their findings, which are detailed in a 17 chapter technical report (Wear and Greis 2013) and synthesized in a compact summary report (Wear and Greis 2012), consist of analyses of specific forecasts and natural resource issues. Because of the great variations across southern forest ecosystems, the Futures Project also draws out findings and management implications for each of five subregions (fig. P1) including the one addressed in this report.

Why spend several years sorting through the various facets of this complicated puzzle? The reasons are varied but they all revolve around one notion: knowing more about how the future might unfold can improve near term decisions that have long-term consequences. For example, knowing more about future land use changes and timber markets can guide 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

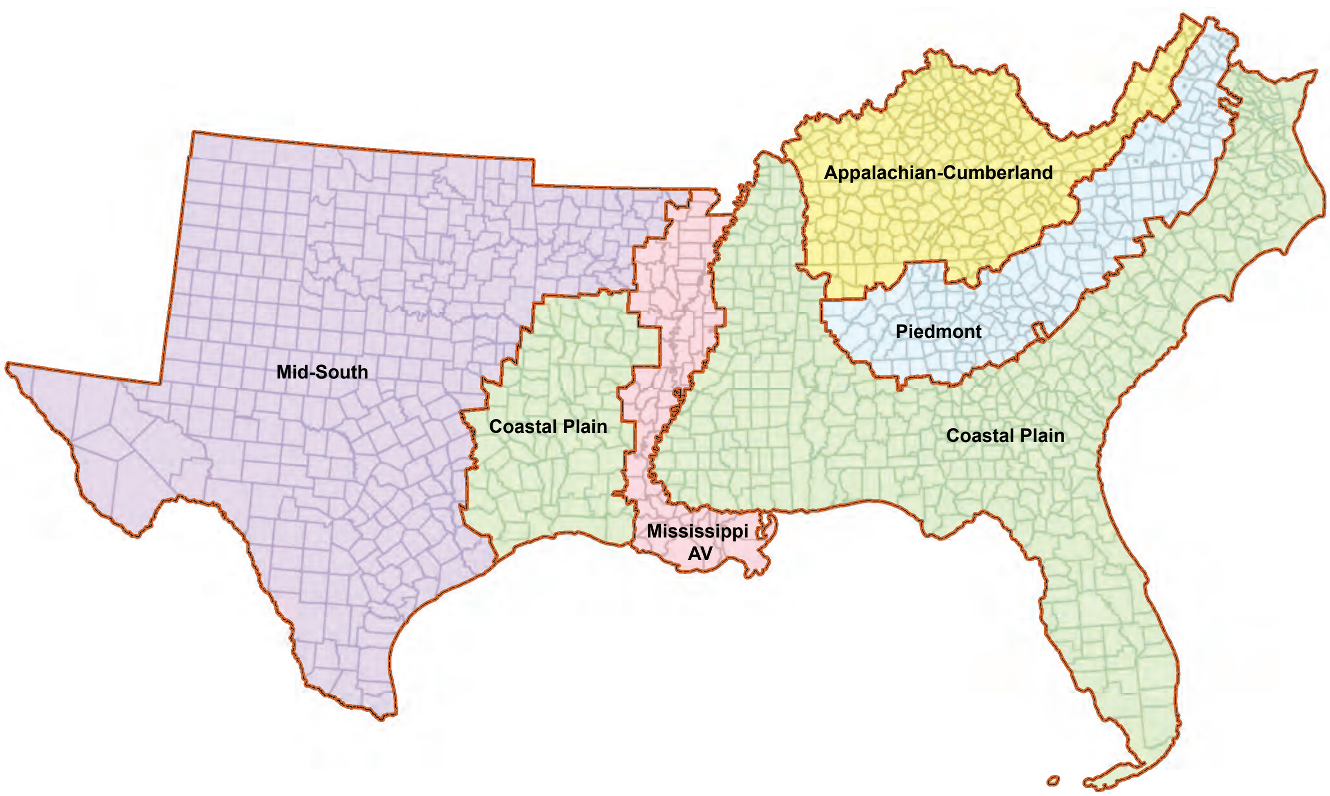

Figure P1—The five subregions of the U.S. South.

fiber markets can inform and improve bioenergy policies. Consequently, the intended users of the Futures Project findings are natural resource decisionmakers, professionals, and policy analysts as well as those members of society who care about natural resource sustainability.

From the dozens of detailed topic-specific findings in the technical report, 10 were identified and discussed in the Futures Project summary report. They are:

- The interactions among four primary factors will define the future forests of the South: population growth, climate change, timber markets, and invasive species.
- Urbanization is forecasted to cause losses in forest acreage, increased carbon emissions, and stress to forest resources.
- Southern forests could sustain higher timber production levels; however, demand is the limiting factor, and demand growth is uncertain.
- Increased use of wood-based bioenergy could generate demands that are large enough to trigger changes in forest conditions, management, and markets.
- A combination of factors, including population growth and climate change, has the potential to decrease water availability and degrade quality; forest conservation and management can help to mitigate these effects.
- Nonnative invasive species (insects, pathogens, and plants) present a large but uncertain potential for ecological changes and economic losses.
- Fire-related hazards in wildlands would be exacerbated by an extended fire season combined with obstacles to prescribed burning that would accompany increased urbanization (particularly in response to air quality and highway smoke issues).
- 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 highland.
- Increasing populations would increase demand for forest-based recreation while the availability of land to meet these needs is forecasted to decline.

The impetus for the Southern Forest Futures Project comes from a desire to understand how a wide variety of dynamics including economic, demographic, and environmental changes might affect forest resources. An assessment of some aspects of forest sustainability (Wear and Greis 2002a, 2002b) was completed a decade ago, but the rapid pace of change and the sudden emergence of new and complex natural resource issues prompted a new study that could take advantage of recent science findings and forecasting methods. In December 2007 the Futures Project got underway under the joint sponsorship of the U.S. Department of Agriculture Forest Service and the Southern Group of State Foresters.

Designing the Futures Project

The Futures Project investigators started by identifying a set of relevant questions and then defining a targeted and robust process for answering them. Their process consisted of 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. A series of public information gathering sessions addressed the first two stages of the process: 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 Southern States—contributed input on what they saw as the important issues and future uncertainties affecting forests (Wear and others 2009). These meetings shaped the thinking about alternative futures and led to the selection and definition of meta-issues, each of which describes an interrelated complex of questions (for example, 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).

The South defines a discernible biological and socioeconomic region of the United States, but also contains a vast diversity of biota and socioeconomic settings within its boundaries. The meta-issues and the 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, the broad-scale approach was not considered adequate to address specific implications that these forecasts and issue analyses hold for forest management and restoration activities in more localized conditions; doing so required a scale that more closely matched the different forest ecosystem types in the South (fig. P2).

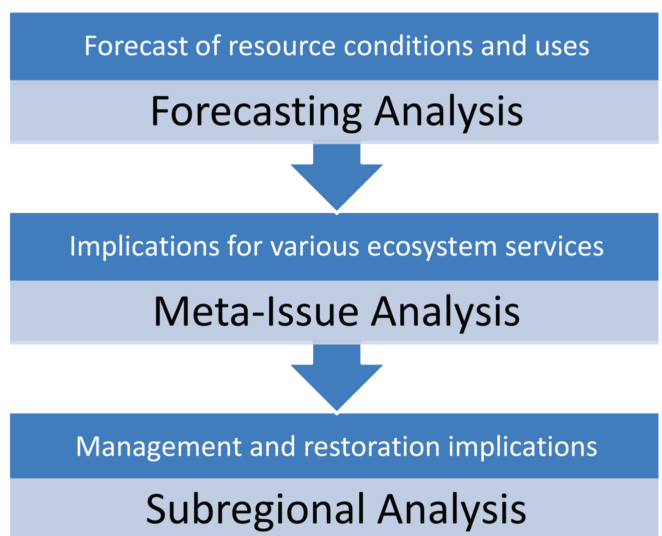

Figure P2—The three phases of the Southern Forest Futures Project.

Thus the second phase of the Futures Project, in which separate efforts examined the management/restoration implications for the five subregions of the South: Coastal Plain, Piedmont, Appalachian-Cumberland highlands, Mississippi Alluvial Valley, and Mid-South (which includes all of Texas and Oklahoma). Still further spatial resolution was provided by breaking the subregions into a number of ecological sections; some issues are discussed at that scale as well.

The analytical centerpiece of the Futures Project is a set of forecasting models contained in the U.S. Forest Assessment System, which was developed for the U.S. Forest Service 2010 Resources Planning Act (RPA) Assessment as a means of conducting national forecasts. The system uses global projections of climate, technological, population, and economic variables to drive the simulation of changes in land uses, forest uses, and forest conditions at a fine spatial scale—thus facilitating subregional and other fine scale analyses. Specific RPA scenarios were chosen that define the set of variables that "drive" the forecasts, linking national economic and climate changes to the worldviews contained in international climate assessments (Intergovernmental Panel on Climate Change 2007).

Although the Futures Project tiered directly to the 2010 RPA Assessment (USDA Forest Service 2012), its investigators developed more specific implications for the South within the bounds of the scientific literature.

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 the best—that is, the most accurate—forecast is not likely to be known ahead of time. As a result, forecasters hedge their expectations of future conditions by including a range of plausible futures and thus addressing the risk of generating precise forecasts of the wrong future.

The Futures Project investigators considered a large number of scenarios based on the 2010 RPA Assessment and public input, and then narrowed them to a half dozen that captured the broad range of potential conditions. These "Cornerstone Futures" define six combinations of climate, economic, population, and forest-products sector projections (fig. P3). The assumption was that unfolding events would 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.

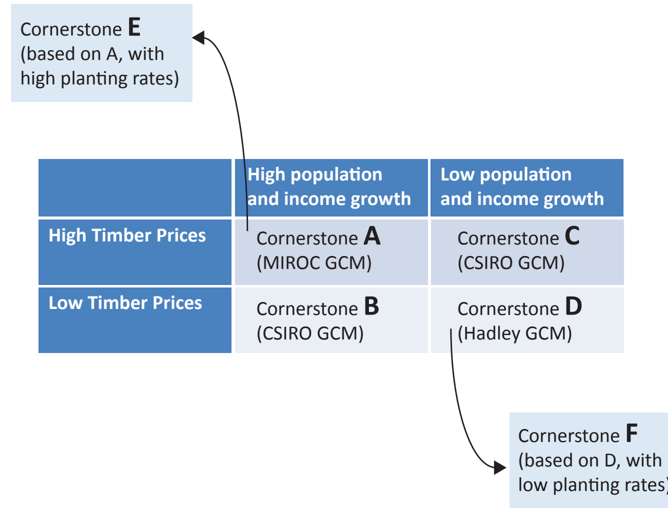

Figure P3—Six Cornerstone Futures, each of which represents a general circulation model (MIROC3.2, CSIROMK3.5, CSIROMK2, or HadCM3) paired with one of two emission scenarios (A1B representing high-population/high-economic growth, high energy use, and B2 representing low growth and use) and two timber price futures; and then extended by evaluating forest planting rates above and below current levels. Sources: Intergovernmental Panel on Climate Change (2007); USDA Forest Service (2012).

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, such as water or fire, additional models helped translate forest forecasts into specific implications. For other meta-issues, such as taxes or ownership, 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, a description of the current situation, and a summary of the relevant scientific literature.

This report draws together the findings from the 17 chapters of the Southern Forest Futures Project technical report (Wear and Greis 2013) to isolate the findings of most critical consequences for management and policy decisionmaking within the Coastal Plain. The findings described here also offer an interpretation of the most important findings from the technical report and their implications for forest management and restoration activities within the Coastal Plain.

The Cornerstone Futures

Southern Forest Futures Project investigators developed six Cornerstone Futures (A to F) to describe the factors that are likely to drive changes in southern forests. The Cornerstone Futures were selected to represent the range of findings from a much broader set of possibilities that were developed by combining county-level population/income and climate projections, assumptions about future timber scarcity, and assumptions about tree planting rates (Wear and Greis 2012, 2013).

County-level forecasts of population and income, variables critical to the Cornerstone Futures, were projected within the context of two global perspectives on socioeconomic change—downscaled descriptions of demographic change and economic growth (Intergovernmental Panel on Climate Change 2007)—to construct global forecasts of climate changes and their implications. The first yielded about a 40 percent growth in overall population from 2010 to 2060, and the second yielded a higher rate of 60 percent. The projections vary by county, with the populations of some counties growing substantially and others shrinking.

Timber price futures either describe increasing or decreasing scarcity with an orderly progression of real prices: assumed to be 1 percent per year from a base in 2005 through 2060. Real returns to agricultural land uses were also held constant throughout the forecasts for all Cornerstone Futures.

Each of the population/income projections embedded in the Cornerstone Futures is linked to a worldwide emissions storyline that drives alternative climate forecasts. The result was three climate projections driven by the population/economic projections and downscaled to the county level. Forecasted variables included changes in temperature, precipitation, and derived potential evapotranspiration. One climate forecast was selected for each of the Cornerstone Futures in a way that incorporated the full range of climate projections. These are taken from four downscaled climate models—MIROC3.2, CSIROMK2, CSIROMK3.5, and HadCM3.

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 assume rates of post-harvesting tree planting that are based on future planting forecasts derived from planting frequencies between the latest two forest survey periods for all States and all major forest types (data from Forest Inventory and Analysis, Southern Research Station, U.S. Forest Service). Because this was a period of rapid expansion in planted pine, perhaps associated with displacement of harvesting from the Western United States, baseline rates were set at 50 percent of the observed frequencies.

Cornerstones E and F depart from the first four, with Cornerstone E increasing planting rates by 50 percent for Cornerstone A (strong economic growth and expanding timber markets); and Cornerstone F decreasing planting rates by 50 percent for Cornerstone D (reduced economic growth and decreasing timber markets).

Forecasts for the Cornerstone Futures provide the foundation for understanding the potential implications of the meta-issues identified by the Futures Project.

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CONTENTS

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ABSTRACT

The U.S. Coastal Plain consists of seven sections: the Northern Atlantic, Eastern Atlantic, Peninsular Florida, Southern Gulf, Middle Gulf-East, Middle Gulf-West, and Western Gulf. It covers a large area, consists of a diverse array of habitats, and supports a diverse array of uses. This report presents forecasts from the Southern Forest Futures Project that are specific to the Coastal Plain, along with associated challenges to forest management in this subregion: warmer temperatures; increases in urban land use; population increases; more planted pine; increased harvesting for bioenergy; impacts to hydrology and water quality; increased impacts from invasive organisms; and longer, more intense wildfire seasons. Understanding these impacts and the tools available to address them will be key to effective management of the Coastal Plain forests.

Keywords: Climate change, Coastal Plain, fire, forest management, invasives, Southern Forest Futures Project, water, wildlife.

KEY FINDINGS

The Coastal Plain consists of seven sections—the Northern Atlantic, Eastern Atlantic, Peninsular Florida, Southern Gulf, Middle Gulf-East, Middle Gulf-West, and Western Gulf; detailed synthesis of the information from the Southern Forest Futures Project (Wear and Greis 2013) revealed several forecasts that were of particular interest to the Coastal Plain:

- All models from the Southern Forest Futures Project Cornerstone Futures anticipate warmer temperatures for the Coastal Plain; most call for little change in precipitation.

- The Coastal Plain is projected to see significant increases in the amount of land converted to urban use, especially in coastal areas—Peninsular Florida alone could experience a 30-percent loss of forest area by 2060.

- The Coastal Plain (especially southern Atlantic States) is expected to experience a 68-percent increase in population; this increase, especially near public lands and water, would put added pressure on limited recreational resources.

- Coastal Plain forests are projected to continue experiencing increased liquidity of corporate-owned land; activity by timber investment management organizations and real estate investment trusts has been especially prevalent, representing the largest ownership transition in the last century.

- Planted pine is projected to increase in acreage in the Coastal Plain; coupled with increased productivity (because of improved genetics and silviculture), this would position landowners to produce more timber than at the market peak of 1998.

- Because of forest investments, Coastal Plain forests could support strong growth in timber production without reducing forest inventories or greatly increasing prices.

- The future of timber markets will be shaped by strong and relatively certain timber supply and less certain changes in timber demands.

- Harvesting for bioenergy could define a strong new demand for timber from the Coastal Plain but depends on policies that are uncertain.

- Abiotic and anthropogenic factors are likely to affect Coastal Plain hydrology: increased urbanization upstream could alter hydrology and water quality substantially on Coastal Plain watersheds; numerous lower order streams in the Coastal Plain will likely be directly impacted by reductions in forest cover and increased impervious surfaces at local scales; and climate change could cause sea-level rise on about 5,000 miles of coastline, impacting forests and wildlife.

- Under all Southern Forest Futures Project forecasts, water stress would increase in the Coastal Plain (and most especially on the Florida Panhandle), resulting from increased temperatures and climate driven water use by trees, population growth, and land use changes.

- Rising sea levels and urbanization would exacerbate loss of biodiversity and the imperilment of flora and fauna in the species-rich forests of the Coastal Plain.

- Expected increases in the occurrence, abundance, and impacts of invasive plants—particularly cogongrass—would degrade the benefits provided by Coastal Plain forests.

- Introductions of new insect pests and pathogens are very likely, although the nature and extent of their impacts is unknown; climate change is predicted to shift their potential range.

- The Coastal Plain will likely experience an increase in the range and severity of impacts from economically important invasive species.

- Wildfire seasons are forecasted to increase in duration at the same time that prescribed burning becomes more restricted and its use as a fuel reduction tool more difficult.

CHAPTER 1.
The Forests and People of the Coastal Plain

One of five subregions of the U.S. South (along with the Appalachian-Cumberland highland, Piedmont, Mid-South, and Mississippi Alluvial Valley), the Coastal Plain emerges from the Gulf of Mexico and Atlantic Ocean and extends from Texas to Virginia. It touches the southern and eastern borders of the Piedmont, the western border of Appalachian-Cumberland highland, and both the eastern and western borders of the Mississippi Alluvial Valley—as such, it is the only subregion without continuous boundaries. Its 188 million acres are divided into seven physiographic sections (figs. 1 and 2): the Northern Atlantic in Virginia and North Carolina; the Eastern Atlantic in North Carolina, South Carolina, Georgia, and Florida; Peninsular Florida; the Southern Gulf in Florida, Georgia, Alabama, Mississippi, and Louisiana; the Middle Gulf-East in Alabama, Tennessee, Kentucky, Mississippi, and Louisiana; the Middle Gulf-West in Louisiana, Arkansas, and Texas; and the Western Gulf in Louisiana and Texas.

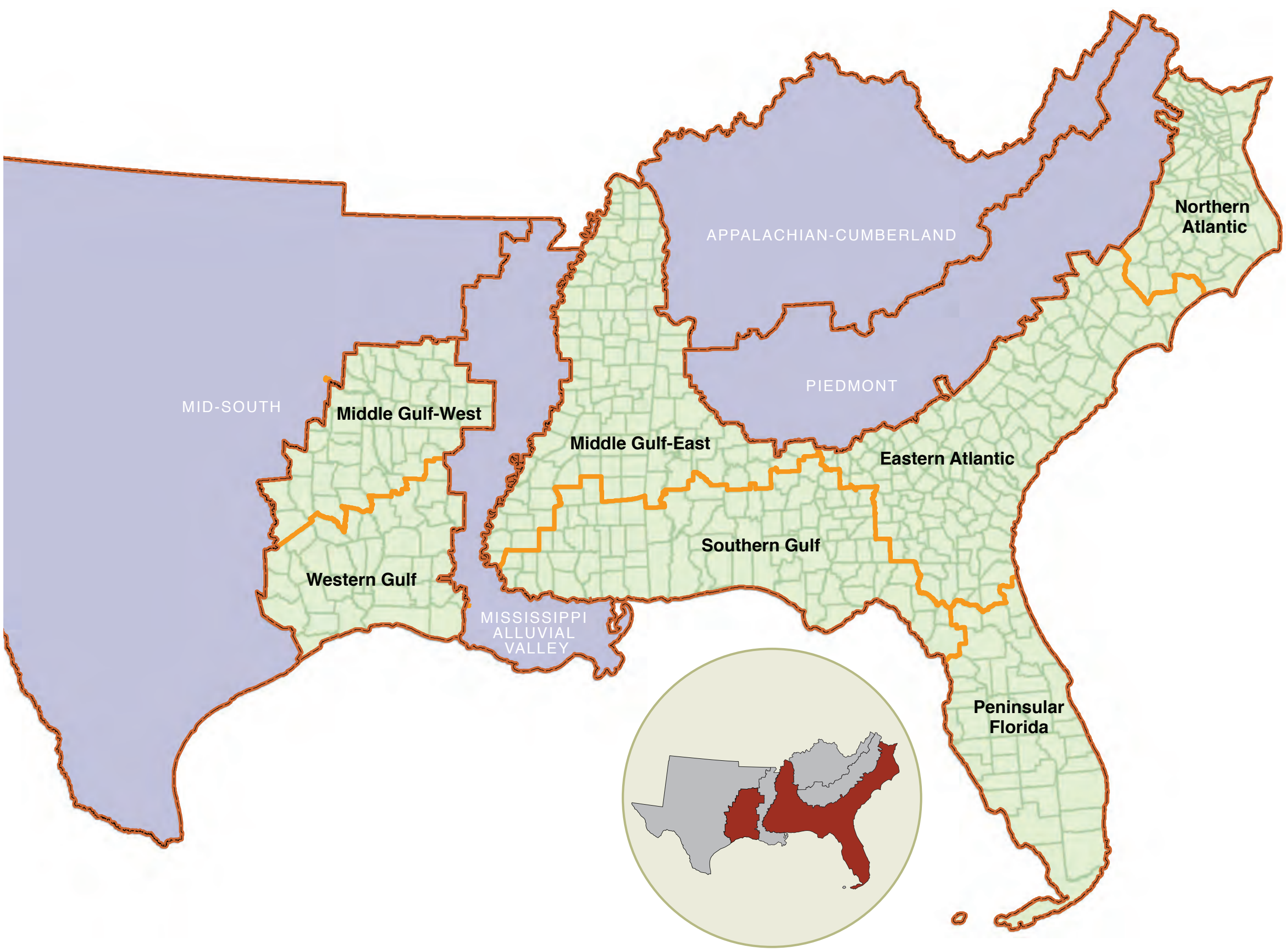


Figure 1—Sections of the U.S. Coastal Plain.

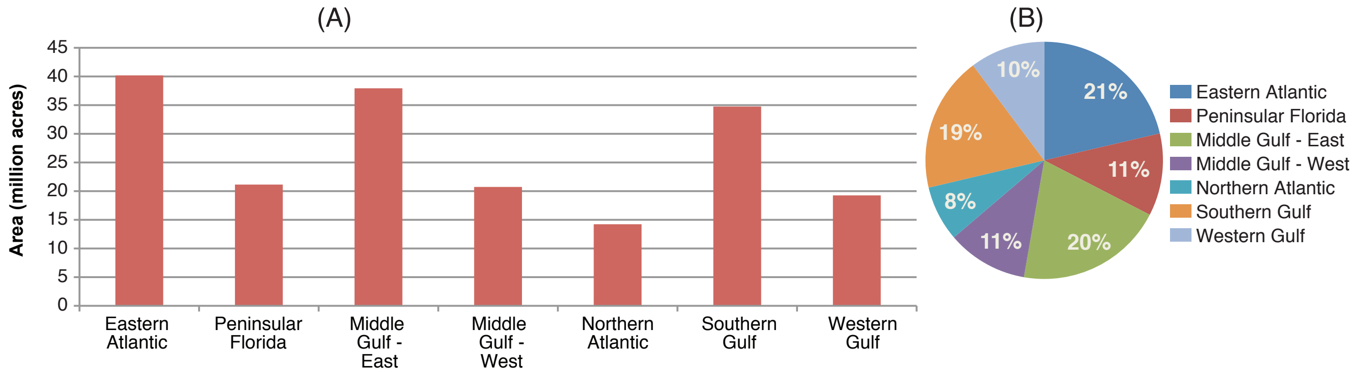


Figure 2—Sections of the U.S. Coastal Plain, 2010, depicted (A) in area occupied, and (B) as a percent of total area in the subregion.

COASTAL PLAIN SECTIONS

Covering about 14 million acres, the **Northern Atlantic** section consists of eastern portions of the Virginia and North Carolina—with 30 counties in North Carolina and 23 counties and 1 independent city in Virginia.

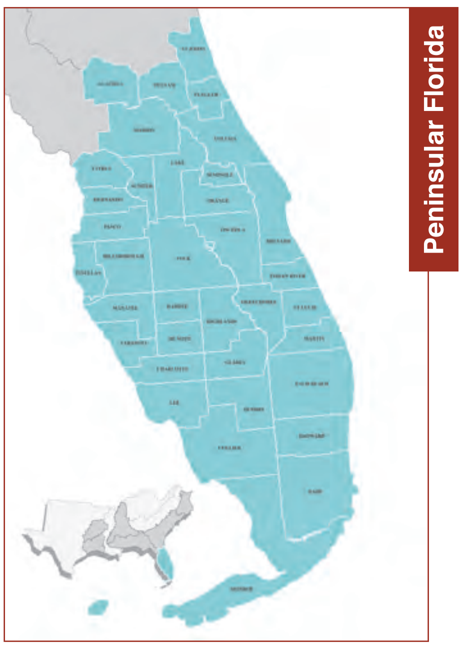
A level plain (USDA NRCS 2006) with two distinct topographic areas—the eastern, coastal edge and the western inland portion—the North Atlantic coastal area consists of sea-level to slightly higher elevations (<25 feet), and is dotted by swamps, estuaries, dune fields, beaches, lagoons, embayments, and barrier islands; soils are primarily Histosols. Areas farther inland are relatively flat and weakly-to-moderately dissected by stream channels; elevation ranges from 25 to 165 feet and soils are primarily Spodosols and Ultisols.

Both areas of the North Atlantic section consist of unconsolidated sediments of mud, silt, sand, and gravel, containing largely coarse textured and poorly drained soils with a dominant thermic temperature and aquic and udic soil moisture. These sediments are primarily Tertiary to Quaternary and have formed localized areas of organic, peat soils (USDA NRCS 2006). The primary geomorphic processes that have formed this landscape are erosion, transport, and deposition from coasts and rivers (McNab and Avers 1994).

The 40-million acre **Eastern Atlantic** section covers portions of the North Carolina coast (13 counties), all coastal areas in South Carolina (28 counties) and Georgia (72 counties), and a portion of the northeastern Florida coast (9 counties).

The Eastern Atlantic section is a nearly level plain consisting of shallow valleys with stream channels. Along the coast are weakly dissected flat alluvial plains of well-drained deep sands with local areas of highly organic soils. Farther inland, the terrain becomes weakly dissected irregular or smooth plains underlain about equally by sands and clays of marine and continental origin. Sediments are primarily Tertiary to Quaternary.

The section consists of sea islands that extend along the Atlantic Coast from South Carolina to Jacksonville, FL, with Alfisols and Entisols as the dominant soil order. Also present is a mixture of river-laid sediments in old riverbeds and on terraces, flood plains, and deltas that is composed of clay, silt, sand, and gravel combinations (USDA NRCS 2006). Cretaceous marine, near-shore shale, sandstone, and limestone deposits occur beneath the surface. Elevation ranges from sea level to 165 feet, with typical local relief <35 feet.



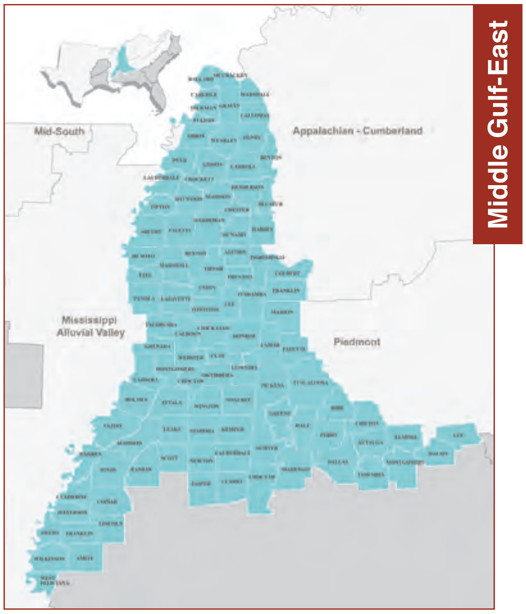
Consisting of the southern peninsula portion of Florida, and containing 36 counties, **Peninsular Florida** covers about 21 million acres.

Peninsular Florida is a low, flat, young marine plain, more than half of which consists of swamp and marsh. Soils are predominantly Entisols with a significant amount of Alfisols and Histosols; the soil temperature regime is predominantly hyperthermic, the soil moisture regime is aquic or udic, and the mineralogy is siliceous or carbonatic (USDA NRCS 2006). The terrain is a weakly dissected landscape of irregular or smooth plains formed on marine deposits of sands, limestone, and clays. The highlands are hilly with excessively drained coarse deep sands and loamy sands. Sinkholes occur in areas of recently deposited calcareous formations.

In most years the southern portion of Peninsular Florida is shallowly inundated with slow flowing, nonsaline water from the north. Along the coast, beaches, swamps, and mudflats are created and maintained by sediment from rivers and shore zone processes (McNab and Avers 1994). Elevation is ≤80 feet and local relief is ≤25 feet. A sandy marine deposit of Pleistocene age at the surface covers Tertiary age rocks including very fine-grained shale, mudstone, limestone, and dolomite beds.

The 35-million acre **Southern Gulf** consists of the southwestern portion of Georgia (15 counties), the northwestern portion of Florida (22 counties), the southern portions of Alabama (20 counties) and Mississippi (20 counties), and the western portion of Louisiana (7 parishes).

The Southern Gulf section consists of a flat, weakly dissected landscape with marine (limestones) and terrestrial (sands) deposits along the coast, and marine deposits of sands and clays farther inland. Beaches, swamps, and mudflats are creat and maintained by deposition from rivers and shore zone processes. Elevation is ≤655 feet and local relief is ≤50 feet. Rock units that formed during the Cenozoic Era consist of Tertiary and Quarternary marine deposits of sand, silt, and clay (McNab and Avers 1994). Dominant soil orders are Ultisols, Entisols, and Inceptisols; the soil temperature regime is predominantly thermic, the soil moisture regime is udic or aquic, and mineralogy is siliceous or kaolinitic (USDA NRCS 2006).



The 38-million acre **Middle Gulf-East** section contains the northernmost areas of the Coastal Plain and consists of the western portions of Kentucky (8 counties), Tennessee (20 counties), and Alabama (22 counties), and the eastern portions of Mississippi (51 counties) and Louisiana (1 parish).

The topography in the Middle Gulf-East varies from a strongly rolling to hilly or nearly mountainous landscape of marine-deposited sediments ranging from sands and silt to chalk and clays and varying from acid to alkali. Irregular plains and gently rolling hills, with steep bluffs and wind-deposited, deep, fine-texture soils of varying thickness occur on the loess mantle near the Mississippi River.

The area is underlain by unconsolidated sand, silt, and clay, mainly of marine origin. Some sediments were deposited by rivers draining the surrounding uplands, and others are Cretaceous and Tertiary marine sediments formed during the Mesozoic and Cenozoic Eras. Dominant soil orders are Alfisols, Entisols, Inceptisols, and Ultisols; consisting of deep, medium textured soils, they have a thermic soil temperature regime, an udic soil moisture regime, and mixed mineralogy (USDA NRCS 2006). Current active geomorphic processes include gentle-gradient valley stream erosion, transport, and deposition. Elevation ranges from 80 to 600 feet and local relief is seldom >100 feet.

The 21-million acre **Middle Gulf-West** section is located west of the Mississippi Alluvial Valley and consists of the western portion of Arkansas (21 counties), the northwestern portion of Louisiana (9 parishes), and the eastern portion of Texas (16 counties).

The Middle Gulf-West consists of level to steep uplands that are intricately dissected by streams with broad flood plains and terraces along some streams (USDA NRCS 2006). It has moderately dissected irregular plains of marine sands and clays with isolated influence of limestone. The plains were formed by deposition of continental sediments onto submerged, shallow continental shelf, which was later exposed by sea-level subsidence (McNab and Avers 1994). Rock units were formed during the Cenozoic Era. Underlying most of the section are Tertiary and Cretaceous marine sediments with interbedded and unconsolidated sand, silt, and clay and calcareous clays and marls. Underlying the flood plains and terraces along the major drainages are sand, silt, and clay alluvium. Dominant soil orders are Alfisols and Ultisols; they have a dominantly udic or aquic soil moisture regime and a very deep loamy or clayey texture (USDA NRCS 2006). Elevation ranges from 80 to 650 feet, increasing gradually from southeast to northwest. Local relief is ≤300 feet.

The 19-million acre **Western Gulf** section is also located west of the Mississippi Alluvial Valley and consists of the southwestern portion of Louisiana (17 parishes) and the southeastern portion of Texas (18 counties).

The Western Gulf section is nearly level to gently sloping and has low local relief. Elevation is ≤330 feet. Underlying the entire area is unconsolidated clay, silt, sand, and gravel deposited by ancient rivers in the late Tertiary and Quaternary. Recent silt, sand, and gravel deposits fill the valleys along most of the rivers (USDA NRCS 2006).

Inland areas have level, undissected plains of alluvial sands recently deposited on unconsolidated limestone formations. Coastal areas are flat, weakly dissected alluvial plains with some low, narrow, sandy ridges. Beaches, swamps, and mudflats are created and maintained by deposition from rivers and shore zone processes. The marine-deposited continental sediments range from sands to clays, with some organics, with salt domes, natural gas, and petroleum deposits occurring below the surface.

Dominant soil orders in the Western Gulf are Entisols, Histosols, Alfisols and Ultisols; they have a hyperthermic or thermic soil temperature regime, aquic or udic soil moisture regime, and siliceous or smectitic mineralogy. Soils are poorly drained with a loamy or clayey texture. Continuously saturated shallow depressions are common.

MAJOR FOREST TYPES AND VEGETATIVE COMMUNITIES

Forest covers about half (118 million acres) of the land area in the Coastal Plain (fig. 3A): 23 percent in the Eastern Atlantic, 22 percent in the Southern Gulf, 21 percent in the Middle Gulf-East, 12 percent in the Middle Gulf-West, 10 percent in the Western Gulf, 7 percent in the North Atlantic, and 6 percent in Peninsular Florida. The area supports both softwoods and hardwoods, with 27 percent in planted pine (fig. 3B), 22 percent upland hardwood, 20 percent lowland hardwood, 19 percent natural pine, and 12 percent of its acreage in oak-pine (*Pinus* spp. – *Quercus* spp.). Although climatic conditions are similar across these sections, edaphic conditions play a major factor in the vegetation, with entirely different plant species occurring on well-drained soils than on poorly drained soils (Pessin 1933).

Atlantic Coast

Patchy open pine canopies and dense herbaceous layers extend from southern Virginia to southern South Carolina (the entire Northern Atlantic section and a portion of the Eastern Atlantic section). Prevalent grasses (Schafale 2005) include pineland threeawn (*Aristida stricta*), toothache grass (*Ctenium aromaticum)*, Carolina dropseed (*Sporobolus pinetorum*), little bluestem (*Schizachyrium scoparium*), broom sedge (*Carex scoparia*), wireleaf dropseed (*Sporobolus teretifolius)*, and cutover Muhly (*Muhlenbergia expansa*). Most savanna associations have a large suite of other characteristic herbs, resulting in a high level of species richness. In both the Northern Atlantic and Eastern Atlantic sections, forests include mixtures of longleaf pine (*Pinus palustris*), loblolly pine (*P. taeda*), pond pine (*P. serotina*),

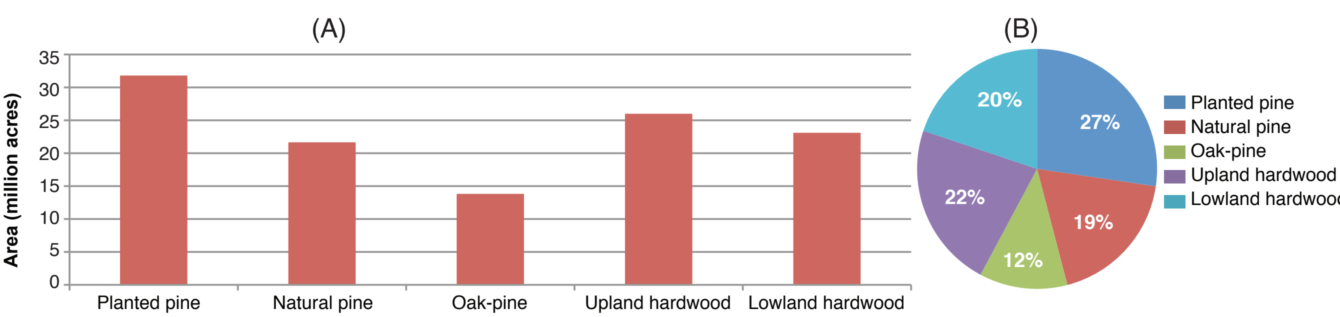


Figure 3—Forest management types, 2010, in the U.S. Coastal Plain depicted (A) as area occupied, and (B) as a percent of the total forested area in the subregion (Source: U.S. Department of Agriculture Forest Service, Forest Inventory and Analysis).

slash pine (*P. elliottii*), oak-gum-cypress (*Q.* spp.–*Nyssa* spp.–*Cupressus* spp.), oak-pine, and oak-hickory (*Carya* spp.). The 35 million acres of forested land consist of 10.5 million acres (30 percent) of planted pine, 8 million (23 percent) lowland hardwood, 6.5 million (19 percent) natural pine, 6 million (17 percent) upland hardwood, and 4 million (11 percent) oak-pine (fig. 4). Loblolly pine, sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), blackgum (*N. sylvatica*), and oaks dominate inland; water tupelo (*N. aquatica*), blackgum, baldcypress (*Taxodium distichum*), sweetgum, and red maple dominate on the coasts (USDA NRCS 2006). Most of the forests are <40 years old—an age class dominated by the pine management types (fig. 5). Nearly all planted pine forests are in this age class, but natural pine and oak-pine forests are more evenly spread across age groups through age 60. A strong majority of the oldest age group (≥81 years) is in lowland hardwood.

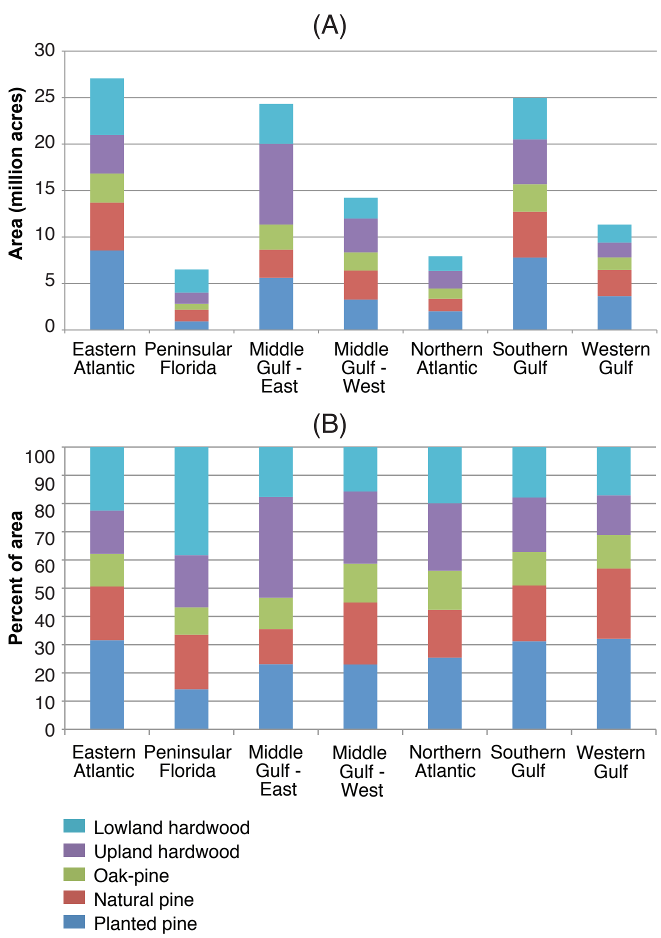


Figure 4—Forest management types, 2010, for the seven sections of the U.S. Coastal Plain depicted (A) as area occupied, and (B) as a percent of the total forested area in the subregion (Source: U.S. Department of Agriculture Forest Service, Forest Inventory and Analysis).

Peninsular Florida

Peninsular Florida consists of about 7 million acres of forested land: about 2.5 million acres (36 percent) of lowland hardwoods, 1.3 million acres of natural pine (19 percent), 1.2 million acres (17 percent) of upland hardwoods, 1 million acres (14 percent) of planted pine, and 1 million acres (14 percent) of oak-pine (fig. 4). The northern portion supports "sand hill" vegetation: turkey oak (*Q. cerris*), bluejack oak (*Q. marilandica*), and longleaf pine are the major tree species; running oak (*Q. pumila*), gopher apple (*Licania michauxii*), bluestems (*Andropogon* spp.), and panicum (*Panicum* spp.) are in the understory. The central highlands consists of a mainly "flatwood" vegetation: forests consist of longleaf pine, sand pine (*Pinus clausa*), slash pine, cabbage palmetto (*Sabal palmetto*), and upland hardwood; saw palmetto (*Serenoa repens*), large gallberry (*Ilex coriacea*), bluestem, and wiregrass (*Aristida beyrichiana*) are in the understory.

Along the coast, forests consist mainly of wet grasslands and oak-gum-cypress. The main marsh vegetation found in this area includes sawgrass (*Cladium* spp.), pickerelweed (*Pontederia cordata*), willow (*Salix* spp.), buttonbush (*Cephalanthus occidentalis*), and maidencane (*Amphicarpum* spp.). Baldcypress and mangrove (*Avicennia* spp.) trees are the dominant swamp species.

Farther inland, forests are mostly slash pine and oak-gum-cypress cover types (USDA NRCS 2006). More than 3.5 million acres of forests are <40 years old, primarily consisting of planted pine, natural pine, and oak-pine (fig. 5). Nearly all planted pine forest forests are <40 years old.

Southern and Western Gulf

The Southern Gulf and Western Gulf sections consist of about 37 million acres of forested land: 12 million acres (32 percent) of planted pine, 8 million acres (22 percent) of natural pine, 7 million acres (19 percent) of upland hardwood, 6 million acres of lowland hardwood (16 percent), and 4 million acres (11 percent) of oak-pine (fig. 4). Scrub oaks commonly make up the sandy portions of these sections. Turkey oak, post oak (*Q, stellata*), bluejack oak (*Q. incana*), and live oak (*Q. virginiana*) are the main scrub species. Longleaf pine also occurs as does sand pine (although confined mainly to sand dunes). Haw (*Crataegus* spp.), and the gopher apple are the most common understory species.

Historically, longleaf pine is the dominant species found in the moist soils. Nonetheless, on inland sites longleaf pines have been replaced with loblolly pine on moist soils and shortleaf pines on drier soils where the supply of longleaf seeds is too small for regeneration. Slash pine, sweetbay (*Magnolia virginiana*), and blackgum occur on moist soils

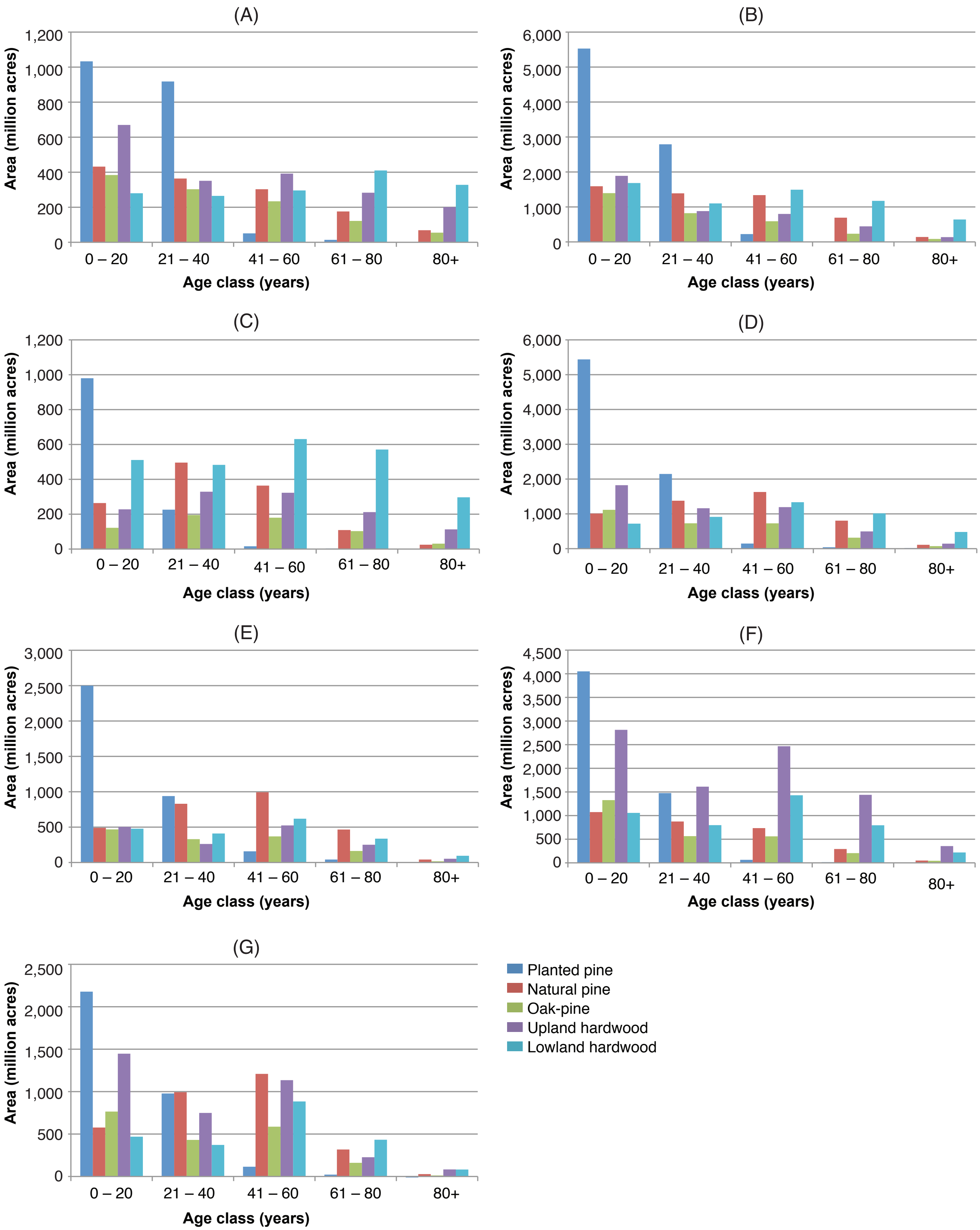


Figure 5—Forest age class distributions by forest type for the seven sections of the U.S. Coastal Plain: (A) Northern Atlantic, (B) Eastern Atlantic, (C) Peninsular Florida, (D) Southern Gulf, (E) Western Gulf, (F) Middle Gulf-East, and (G) Middle Gulf-West (Source: U.S. Department of Agriculture Forest Service, Forest Inventory and Analysis).

bordering bay heads, springs, creeks, and ponds. In areas that are commonly inundated with water, red maple, bald and pond cypress (*Taxodium ascendens*) along with blackgum and water tupelo are the main species (Pessin 1933). Most of the forests are <40 years old, primarily consisting of planted pine, natural pine, and oak-pine (fig. 5).

Middle Gulf

The Middle Gulf (eastern and western) sections consist of 39 million acres of forested land: 13 million acres (33.3 percent) of upland hardwood, 9 million acres (23.1 percent) of planted pine, 6 million acres (15.4 percent) of natural pine, 6 million acres (15.4 percent) lowland hardwood, and 5 million acres (12.8 percent) of oak-pine (fig. 4). They are dominated by pine forests on the uplands, shortleaf (*Pinus echinata*) to the north, and longleaf and loblolly to the south—both of which are mainly found on the eroded soils of uplands and ridges. The understory consists of Japanese honeysuckle (*Lonicera japonica*), greenbrier (*Smilax* spp.), little bluestem, native lespedezas (*Lespedeza* spp.), plumegrass (*Dichelachne* spp.), low panicum, rush (*Juncus* spp.), and sedge (USDA NRCS 2006). It is dissected by numerous river systems dominated by forested wetlands of largely lowland hardwood forests of black gum, sweetgum, elm (*Ulmus* spp.), ash (*Fraxinus* spp.), and various oak species (Neal 2002). Upland hardwood and shortleaf pine are intermixed in drier and sandier areas. Beech-magnolia-holly (*Fagus* spp.–*Magnolia* spp.–*Ilex* spp.) forests dominate on narrow ridges and in steep ravines (USDA NRCS 2006). The loess hills support oak-pine, loblolly-shortleaf pine, oak-hickory, and oak-gum-cypress cover types. Most of the forests are <40 years old, primarily consisting of planted pine, upland hardwood, natural pine, and oak-pine. (fig. 5).

HISTORICAL DEVELOPMENT

Longleaf pine woodlands of the South began to appear toward the end of the Wisconsin glacial period—coincident with the arrival of the first human populations (Mitchell and Duncan 2009), whose use of fire greatly altered the landscape. Longleaf pine was the primary forest type found in the Coastal Plain at the time of European settlement. Native Americans used wood for housing, firewood, and other purposes and deployed fire as their primary tool of landscape management (Loehle and others 2009). Burning reduced fuels and wildfire risks, enhanced wildlife habitat and hunting success, fostered plants that produced berries and nuts, protected encampments from enemies and predators, and improved health and quality of life by reducing populations of biting insects. Burning helped maintain a shifting mosaic of prairies, savannas, and upland woodlands—promoting rich, fire-dependent, and floristic communities while allowing more fire-sensitive species such as hardwoods to develop in bottoms and in fire shadows.

As the native populations declined, so did the use of burning, resulting in prairies and open savannas gradually succeeding to denser oak-pine forests (Mitchell and Duncan 2009). European settlers had a great influence on the landscape, clearing the forest to make way for agriculture. In some areas, >90 percent of forests were plowed under, mostly for cotton production (Mitchell and Duncan 2009). Attacks by pests—most notably the boll weevil (*Anthonomous grandis*)—and the exhaustion of soils from poor agricultural practices prompted large-scale abandonment and old-field succession, mostly into loblolly pine. These forests lacked much of the diversity of the longleaf system they replaced (Mitchell and Duncan 2009).

Dating back to first the clearing of major waterways, forests were exploited for timber and chemicals. Then, with the advent of the steam engine, clearing continued farther inland in the mid to late 19th century. The longleaf pine ecosystem, where logging peaked in the early 1900s, was largely extirpated by the mid-1920s. Forests were also cleared for the development of railway lines. Only a small amount of the original forests developed into the second-growth of longleaf pine because longleaf usually failed to regenerate (Mitchell and Duncan 2009). Numerous swamps were also drained during this time for use as agricultural land (Loehle and others 2009).

Modern forest management also played a prominent role in the loss of longleaf pine from much of the landscape. After World War II, new technologies allowed loblolly and slash pine to be used widely for pulp—changing the distribution of southern pines from older, multi-aged native longleaf stands to young, even-aged plantations of loblolly and slash pines. Improved silvicultural practices accelerated the rapid production of fiber from pine lands. From 1930 to 1945, >2 billion slash and loblolly pines were planted (Mitchell and Duncan 2009). By the mid-1960s, forest acreage had increased by >7 million acres in the Coastal Plain, but longleaf forests had decreased by >5 million acres (Mitchell and Duncan 2009). Starting with passage of the Endangered Species Act in the 1970s, biodiversity improvement practices (such as stand thinning, promotion of understory species, and prescribed burning), primarily in support of the red-cockaded woodpecker (*Picoides borealis*), became a common feature of forest plans on Federal lands and the area of longleaf pine increased (Mitchell and Duncan 2009).

Forests have been—and remain—a critical renewable natural resource in the Coastal Plain, where they are valued for timber production; biological diversity; sequestration of carbon; and protection of water, soil, and air quality. Favorable habitats for game species provide opportunities for hunting along with other forms of recreation. And forests provide raw materials for the wood products industry, a significant contributor to the economies of most States in the Coastal Plain (Loehle and others 2009).

ISSUES OF CONCERN FROM PUBLIC INPUT SESSIONS

Process for Soliciting Input

The Southern Forest Futures Project was conducted through an open process that was designed to engage and be responsive to all sectors of southern society, ranging from passionate stakeholder groups to somewhat interested individuals. In a process conducted as transparently as possible, participants were engaged through several means. A Web site (http://www.srs.fs.usda.gov/futures/) featured an online comment form for direct submission of input and accumulated planning documents, input from participants, methods, datasets, and draft and final reports. Several webinars were conducted to gather input online.

In addition, a series of public meetings were held during the initial problem formulation phase and several times during the analysis phase. The 14 meetings—at least one in each Southern State and engaging >600 participants—each covered both general issues and those specific to the local area. Locations in which the Coastal Plain was the sole focus were Gainesville, FL, and Charleston, SC. The Mississippi Alluvial Valley was an additional focus in Baton Rouge, LA, and Stoneville, MS. The Piedmont was an additional focus in Raleigh, NC, Athens, GA, and Auburn, AL.

This first phase of the Southern Forest Futures Project gathered input on concerns about the forces of change and resources at risk over the next 50 years (Wear and others 2009). The issues listed below were identified as being of particular (if not unique) importance to the Coastal Plain. Many of these issues are addressed within the context of the analyses that follow. Others are specifically addressed at the end of this report. For a few, further research or analysis (or both) will be needed.

Concerns Specific to the Coastal Plain

Participants expressed concern about the effects of forest management (particularly of bedding, ripping, and fertilization) on soil and the productivity of forest ecosystems, climate-induced impacts (such as increased flooding, and sea-level rise), and the ability of managers to adapt through the use of ditching and draining. Likewise, the potential effects of climate warming on species shifts (invasives as well as natives and species migration) were seen as being especially worrisome in the Coastal Plain.

Cogongrass (*Imperata cylindrical*) was identified as the top concern for the South by some participants at the Coastal Plain sessions. Other forest pests —southern pine beetle (*Dendroctonus frontalis*), Japanese climbing fern (*Lygodium japonicum*), kudzu (*Pueraria montana*), annosus root rot (*Heterobasidion annosum*), popcorn tree (*Triadica sebifera*), laurel wilt fungus (*Raffaelea lauricola*)—were also of high concern (especially the potential for the long-distance spread of some of these through the use of industry equipment). Nutria (*Myocastor coypus*) was also mentioned as a threat to forest regeneration and reestablishment (especially of cypress).

Although participants viewed the wastewater (sewage and runoff) assimilation benefits provided by forested wetlands as a positive, some voiced concerns about projected negative impacts to forest cover. As an example of pressures from competing uses, some cited the profitable cypress mulching business (which could compromise coastal protection from hurricane impacts) and stressed the importance of accurately quantifying the economic and social value of coastal restoration.

Other comments focused on:

- The complementary and competitive nature of timber harvesting and hunting
- Loss of fire as a silvicultural tool in the face of increased urbanization
- Potential loss of ecotones resulting from ditching and burning
- The impacts of pine-straw harvesting (and management of forests for that purpose)
- Divestiture of forests by the forest products industry (and the emerging prevalence and influence of forest investment groups)
- Shifting global markets (especially cheaper imports)
- Susceptibility to policy shifts and market fragility

CHAPTER 2.
Changes in the Physical Environment

CLIMATE

Current Conditions

Peninsular Florida—This section is characterized by a rainy, hot, humid subtropical maritime climate; winter freezing temperatures are rare (fig. 6). The average annual temperature is 19 to 24 °C. Average temperatures during the coldest month (January) range from 4 to 20 °C, and 27 to 28 °C in the hottest months (July and August). During the warmest time of the day, relative humidity throughout this section averages 50 to 60 percent, in cooler hours ranging from 70 to 80 percent. These levels can make temperatures feel about 6 °C higher than actual. The growing season ranges from 325 to 365 days (USDA NRCS 2006). The average annual precipitation, all in the form of rainfall, is 1380 mm with about 60 percent occurring from June to September (fig. 7). Most precipitation occurs

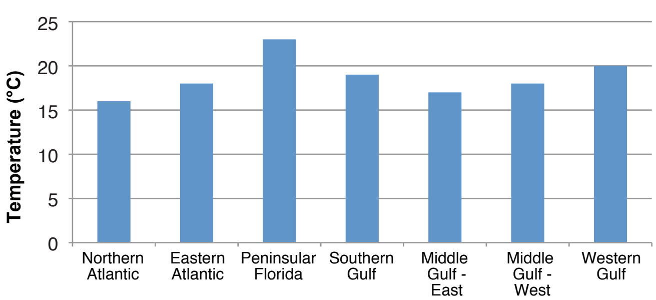


Figure 6—Average annual air temperature, 1997 to 2006, for the seven sections of the U.S. Coastal Plain.

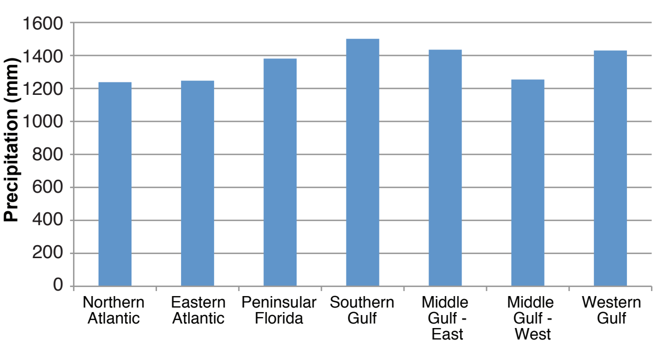


Figure 7—Average annual precipitation, 1997 to 2006, for the seven sections of the U.S. Coastal Plain.

as moderate-intensity tropical storms or during periods of torrential rain (defined as ≥8 cm in a 24-hour period). Southern Florida is classified as tropical savanna, a climate that is shared with most of the Caribbean islands. This climate is sometimes called the wet and dry tropics because precipitation is highly concentrated in the warmer months (National Climate Data Center 2010).

The Azores-Bermuda or North Atlantic Subtropical High Pressure system exerts a powerful influence on Peninsular Florida during the winter. Within this high-pressure system, air is subsidizing, and as a consequence precipitation cannot take place. Prolonged presence of this system can delay the summer rainy season, which normally first begins in southeastern Florida in late April and then moves northward. The position of the North Atlantic Subtropical High strongly influences variation in summer precipitation, with variability increasing as the center moves westward and increases in intensity (Li and others 2011). The El Niño-Southern Oscillation also has an effect on the climate in Peninsular Florida, bringing in about 30 to 40 percent more rainfall and cooler temperatures in the winter, while its opposite La Niña brings a warmer and much drier than normal winter and spring (National Climate Data Center 2010).

Middle Gulf—The Middle Gulf (eastern and western) climate is characterized by mild winters and hot, humid summers. As shown in figure 6, temperatures average from 16 to 20 °C, decreasing from south to north (McNab and Avers 1994). The growing season lasts about 200 to 300 days, increasing in length to the south. Precipitation averages 1250 to 1430 mm as shown in figure 7. Annual precipitation is evenly distributed, but a brief period of mid to late summer drought occurs in most years. Most rainfall occurs as frontal storms in early winter, spring, and early summer. Some high-intensity convective thunderstorms occur in summer, and some heavy rains occur during tropical storms in winter. Storm fronts can also create brief periods of powerful straight-line winds. Snowfall occurs infrequently and is limited to northern areas. Average annual water deficit (precipitation minus potential evapotranspiration) ranges from zero in the southern portion of the section to seven in the northwest.

Other Coastal Plain sections—The Northern Atlantic, Eastern Atlantic, Southern Gulf, and Western Gulf sections have a maritime climate, characterized by mild winters and hot and humid summers. Temperatures average 14 to 23 °C, with lower temperatures to the north and seasonal variation in temperature increasing away from the coast (fig. 6). The growing season lasts about 200 to 330 days, longer in areas closer to the Gulf of Mexico (USDA NRCS 2006). Precipitation is abundant with rare periods of summer drought. Average annual precipitation is around 1200 to over 1400 mm overall (fig. 7). The maximum precipitation occurs in the summer throughout the sections, with northern Atlantic sections generally driest, southern sections wettest. Rainfall also tends to decrease away from the coast. Precipitation falls almost entirely as rainfall: occurring as moderate-intensity, tropical storms that can produce large amounts of rain in autumn and winter; as frontal storms in late autumn, winter, and early spring; and as convection storms in summer.

Frequent disturbance also results from subtropical hurricanes, and snowfall can occur in the Northern Atlantic and Eastern Atlantic. The position of the North Atlantic Subtropical High strongly influences variation in summer precipitation, with variability increasing as the center moves westward and increases in intensity (Li and others 2011). El Niño also has an effect on the climate of these sections, producing average winter temperatures that are 1 to 2 °C cooler and increased springtime precipitation along the entire eastern coast. El Niño events also create upper atmospheric conditions that tend to inhibit the development of Atlantic tropical storms. Conversely, La Niña is associated with fewer hurricanes (Karl and others 2009).

Other Processes at Work

Potential evapotranspiration describes the amount of water that would be evaporated and transpired if there were sufficient water available. Potential evapotranspiration is usually higher in the summer, on sunnier days, and on windy days; at those times, the evaporated moisture can be quickly moved from the ground or plant surfaces, allowing more evaporation to take place. Potential evapotranspiration in the Coastal Plains varies from 2100 to 2600 mm in along a north-south gradient (fig. 8). Annual precipitation usually exceeds potential evapotranspiration by 50 to 400 mm; however, for much of the summer actual evapotranspiration is often less than potential evapotranspiration because there is not enough water supply to support more evapotranspiration.

Water deficits increase to the south and west (Barbour and Billings 2000). The aridity index, a numerical indicator of the degree of dryness of the climate, is used to classify areas based on their water availability. The Coastal Plain has an average aridity index of 1.3 to 1.4, which is well above the threshold for a classification of "humid" (>0.65).

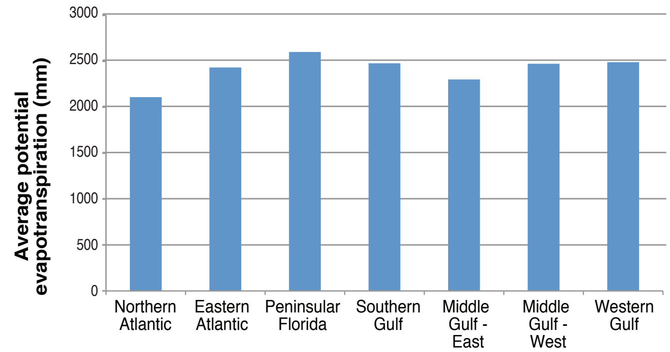


Figure 8—Average potential evapotranspiration, 1997 to 2006, for the seven sections of the U.S. Coastal Plain.

Climate Projection Models

The Southern Forest Futures Project used climate forecasts downscaled to the county level from the National Resources Planning Act (RPA) Assessment (USDA Forest Service 2012). Forecasts were based on two emission storylines developed by the Intergovernmental Panel on Climate Change (2007), labeled A1B and B2. Of the two, B2 provides the lower rate of population growth (a 40-percent increase from 2010 to 2060), and A1B provides a higher rate of growth (60 percent). Income growth is also higher with A1B. Both of these storylines are connected to detailed global economic/demographic projections (USDA Forest Service 2012).

Another element of the projections embedded in the Cornerstone Futures is the climate forecasting derived from the application of specific general circulation models—MIROC3.2, CSIROMK3.5, CSIROMK2, and HadCM3—to the assumptions of the storylines (McNulty and others 2013):

- **Cornerstone A** is characterized by moderately high population growth and high economic growth, and is forecasted to be dry and hot (MIROC3.2+A1B).
- **Cornerstone B** is also characterized by moderately high population growth and high economic growth, but is forecasted to be wet and warm (CSIROMK3.5+A1B).
- **Cornerstone C** is characterized by lower population and income growth, and is forecasted to be moderate and warm (CSIROMK2+B2).
- **Cornerstone D** is also characterized by lower population and income growth, and is also forecasted to be moderate and warm (HadCM3+B2).

Climate Projections

Following on southwide county-level projections of changes in climate variables reported by McNulty and others (2013) for the Southern Forest Futures Project, this report presents several forecasted trends that are specific to the Coastal Plain.

Although the magnitude, timeframe, and geographic distribution of climate change impacts are uncertain, all indications are that change is certain. Even the most conservative estimates of climate change impacts include dramatic changes in the Coastal Plain in ecosystem water use (Lockaby and others 2013), carbon sequestration (Huggett and others 2013), species composition (Huggett and others 2013), and human societies (Abt 2013). Forecasts indicate that the Coastal Plain will experience warmer temperatures than have been seen in the past and according to McNulty and others (2013), "none of the models used in this analysis, nor any others published by other climate scientists, suggest that air temperatures will remain stable or will cool."

All Cornerstone Futures predict >2 ºC increases in air temperature by 2090, but most predict relatively little change in precipitation. Precipitation forecasts range between current/historical levels and somewhat lower than what the Coastal Plain is currently experiencing. However, variation could be significant among and within Coastal Plain sections, with a higher degree of uncertainty for some areas (especially in Peninsular Florida). Cornerstone A, in particular, predicts much drier and warmer conditions (figs. 9 and 10).

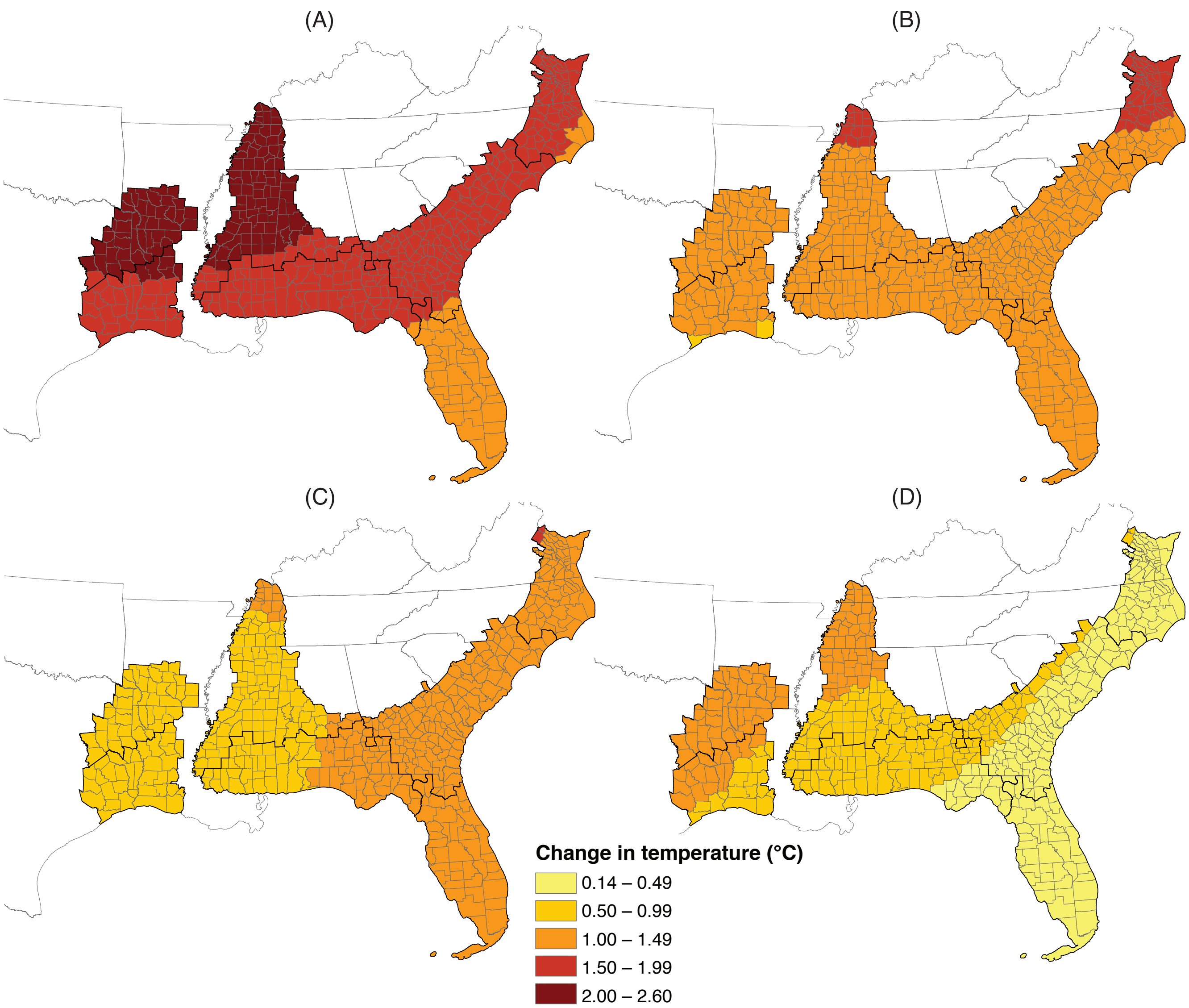


Figure 9—Predicted change in air temperature, 2010 to 2050, for the U.S. Coastal Plain as forecasted by four Cornerstone Futures, each of which represents a general circulation model paired with one of two emission storylines—A1B representing low-population/high-economic growth, high energy use, and B2 representing moderate growth and use—paired with four general circulation models: (A) MIROC3.2+A1B, (B) CSIROMK3.5+A1B, (C) CSIROMK2+B2, and (D) is HadCM3+B2 (Sources: Intergovernmental Panel on Climate Change 2007, McNulty and others 2013).

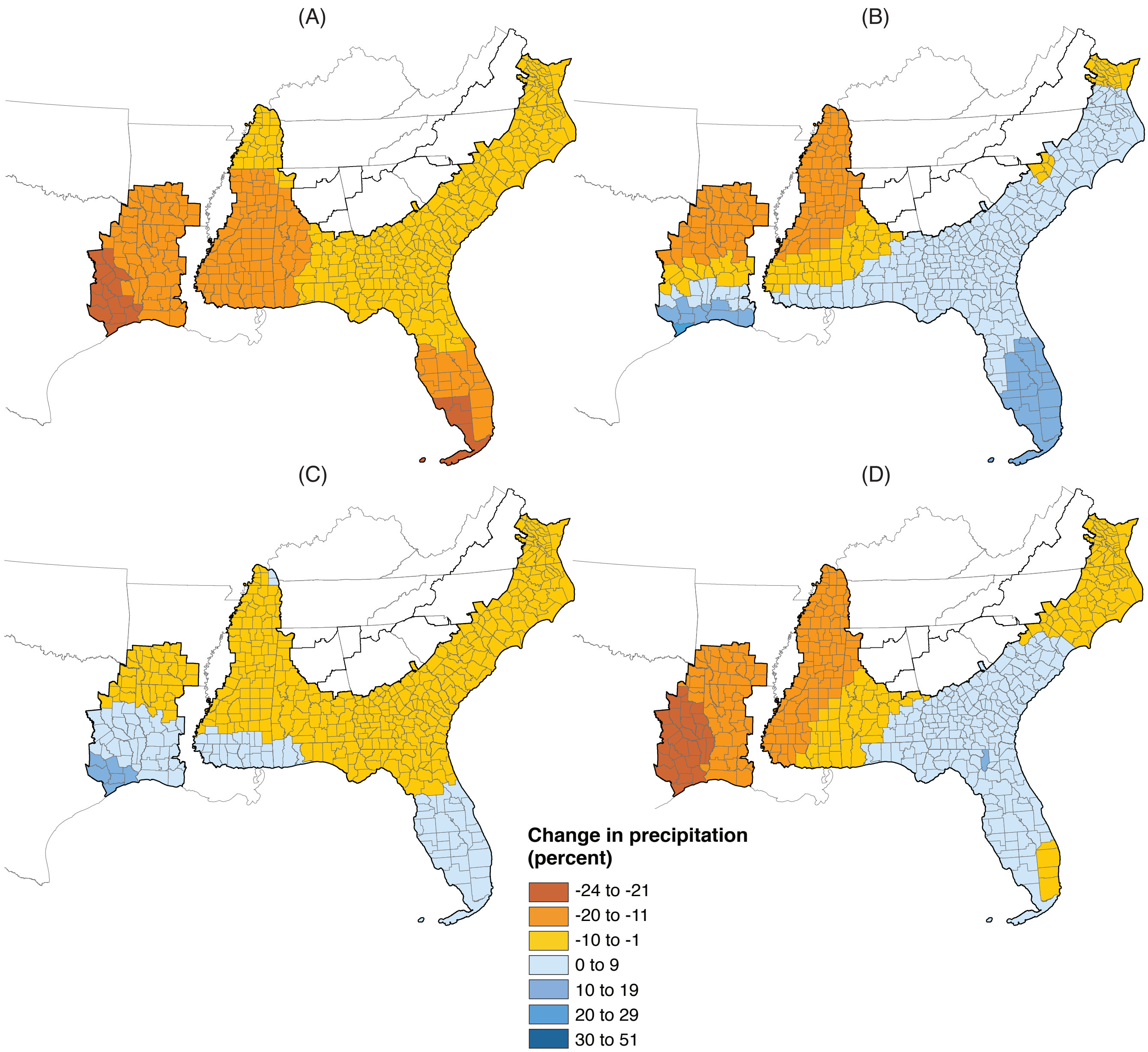


Figure 10—Predicted change in precipitation, 2010 to 2050, for the U.S. Coastal Plain as forecasted by four Cornerstone Futures, each of which represents a general circulation model paired with one of two emission storylines—A1B representing low-population/high-economic growth, high energy use, and B2 representing moderate growth and use—paired with four general circulation models: (A) MIROC3.2+A1B, (B) CSIROMK3.5+A1B, (C) CSIROMK2+B2, and (D) is HadCM3+B2 (Sources: Intergovernmental Panel on Climate Change 2007, McNulty and others 2013).

Even with stable precipitation, however, increased temperatures would lead to increased evapotranspiration and decreased water availability for plant growth. These and other interactions between temperature and water, many of which are detailed below and by Lockaby and others (2013), invariably result in increased water use. Even under predictions of small increases in precipitation, we can anticipate that water shortages, and streamflow reductions will become more common. The resulting increased demand for irrigation, coupled with sea-level rise/salt-water intrusion, is likely to cause additional impacts to availability of groundwater supplies. Water shortage issues are expected to increase in frequency and impact, even if precipitation remains at historical levels—most forecasts call for lower than historical levels.

FIRE

Fire is important in shaping the forests of the South. Most of the projections reported by Stanturf and others (2013) for the Southern Forest Futures Project are applicable throughout the region, but a few key findings apply specifically to the Coastal Plain.

Spring and autumn wildfire seasons are forecasted to increase in duration. Major wildfire events are also predicted to occur more often and have larger impacts. Compounding these issues, the seasonal window for prescribed burning (used extensively in the pine forests of the Coastal Plain) is expected to narrow with climate change, and increased urbanization could lead to reduced acceptance of fire as a management tool. These and other concerns about the management and control of wildland fire have prompted the formulation of a National Cohesive Wildland Fire Management Strategy—a multiagency, cross-jurisdictional planning and implementation effort—in 2011, followed in 2013 by a regional action plan (USDA Forest Service and U.S. Department of the Interior 2013).

CHAPTER 3. The Human Footprint

POPULATION, DEMOGRAPHY, AND ECONOMIC ACTIVITY

With about 44 million people as of the 2010 census, and largely located along the Gulf of Mexico and Atlantic coasts, the Coastal Plain subregion has the largest population (44 percent) in the South. As shown in figure 11, Peninsular Florida supports the largest share of this population—36 percent (>16 million)—followed by the Eastern Atlantic with 17 percent (nearly 8 million), Western Gulf with 15 percent (about 6 million), Southern Gulf with 11 percent (about 5 million), Middle Gulf-East with 11 percent (about 5 million), Northern Atlantic with 7 percent (about 3 million), and Middle Gulf-West with 4 percent (about 2 million).

Though analyses of human demographics (Cordell and others 2013) were not specifically centered on the Coastal Plain with regards to all trends, the region as a whole has seen substantial change. The lowest percentage increase in the South was for non-Hispanic Whites (14 percent between 1990 and 2008). The population of African Americans in the South (18.9 million) was more than half of the national total (37.2 million), and the growth rate was 35.4 percent. The South has seen strong increases in the relatively small populations of American Indians (704,000 people and 36.4 percent, respectively). The region has also seen a relatively large increase in the small population of Asian or Pacific Islanders (2.5 million people and 170.6 percent, respectively). The level and growth rate for Hispanic populations have been high throughout much of the South (16 million people and 143 percent, respectively); but they have been especially high in North Carolina and Georgia. North Carolina stands out, with growth of >376 percent for the State and growth occurring in all but a handful of its 100 counties. Similarly, Hispanic populations have more than tripled in large portions of Georgia, South Carolina, Alabama, Arkansas, and Mississippi. Population growth of non-Hispanic Caucasians has mostly been confined to metropolitan areas such as Atlanta.

The population density of the Coastal Plain is 148 persons per square mile. Peninsular Florida has the highest density with 500 persons per square mile, while the Middle Gulf-West has the lowest with 55 persons per square mile. Between those extremes are the Western Gulf at 211 persons per square mile, Northern Atlantic at 131 persons per square mile, Eastern Atlantic at 120 persons per square mile, Southern Gulf at 87 persons per square mile, and Middle Gulf-East at 78 persons per square mile (fig. 12).

Areas of Growth and Decline

The coasts of Florida and the major cities of Texas have experienced much of the population growth in the Coastal Plain. Some of this growth was substantial, exceeding the U.S. Census Bureau definition of an urban area (500 persons per square mile) in many coastal counties—both on the Gulf of Mexico and the Atlantic Ocean—as well as near the metropolitan areas in Louisiana (New Orleans), Arkansas (Little Rock), Mississippi (Jackson), Oklahoma (Oklahoma City), Alabama (Birmingham, Montgomery, and Huntsville),

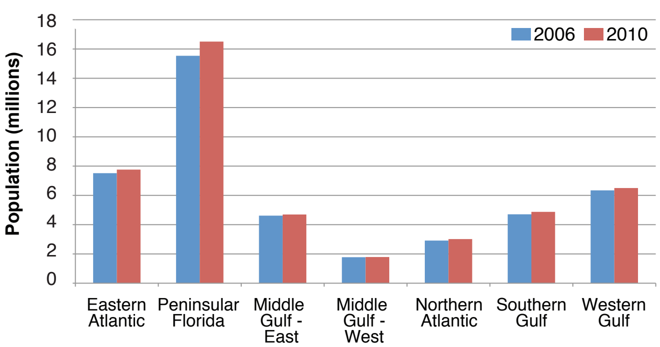


Figure 11—Total population for the seven sections of the U.S. Coastal Plain, 2006 and 2010.

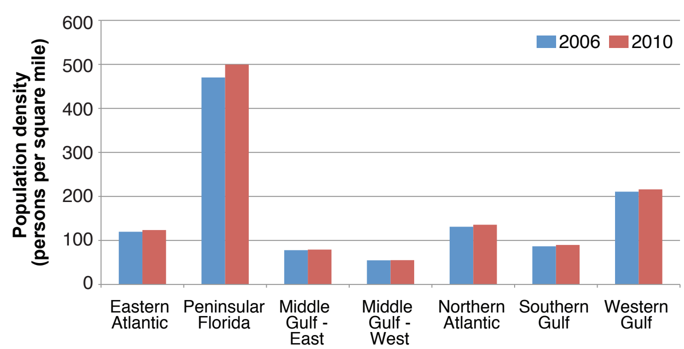


Figure 12—Population density for the seven sections of the U.S. Coastal Plain, 2006 and 2010.

South Carolina (Columbia), and Tennessee (Nashville, Knoxville, and Memphis).

With the exception of a handful of counties scattered throughout the eastern portions of the South, most of the lowest-density counties are in the plains area of western Texas (fig. 13). Much of the overall growth in population density has occurred along the northern Atlantic coast, down the Piedmont and Southern Appalachian Mountains from North Carolina to Alabama, along both Florida coasts, and around the major cities of Texas (fig. 14).

In 2003, the Pew Ocean Commission reported that more than half of the U.S. population resides in coastal counties comprising only 17 percent of the Nation's land area, resulting in a coastal population density almost five times the national average (Henry 2009). This is reflected in portions of the southern Coastal Plain, especially in Florida.

The Coastal Plain of Virginia is the second most populous area in the State, supporting 36 percent of Virginia's population (2.57 million people) on just >20 percent of the land area. It has the highest population density of the State

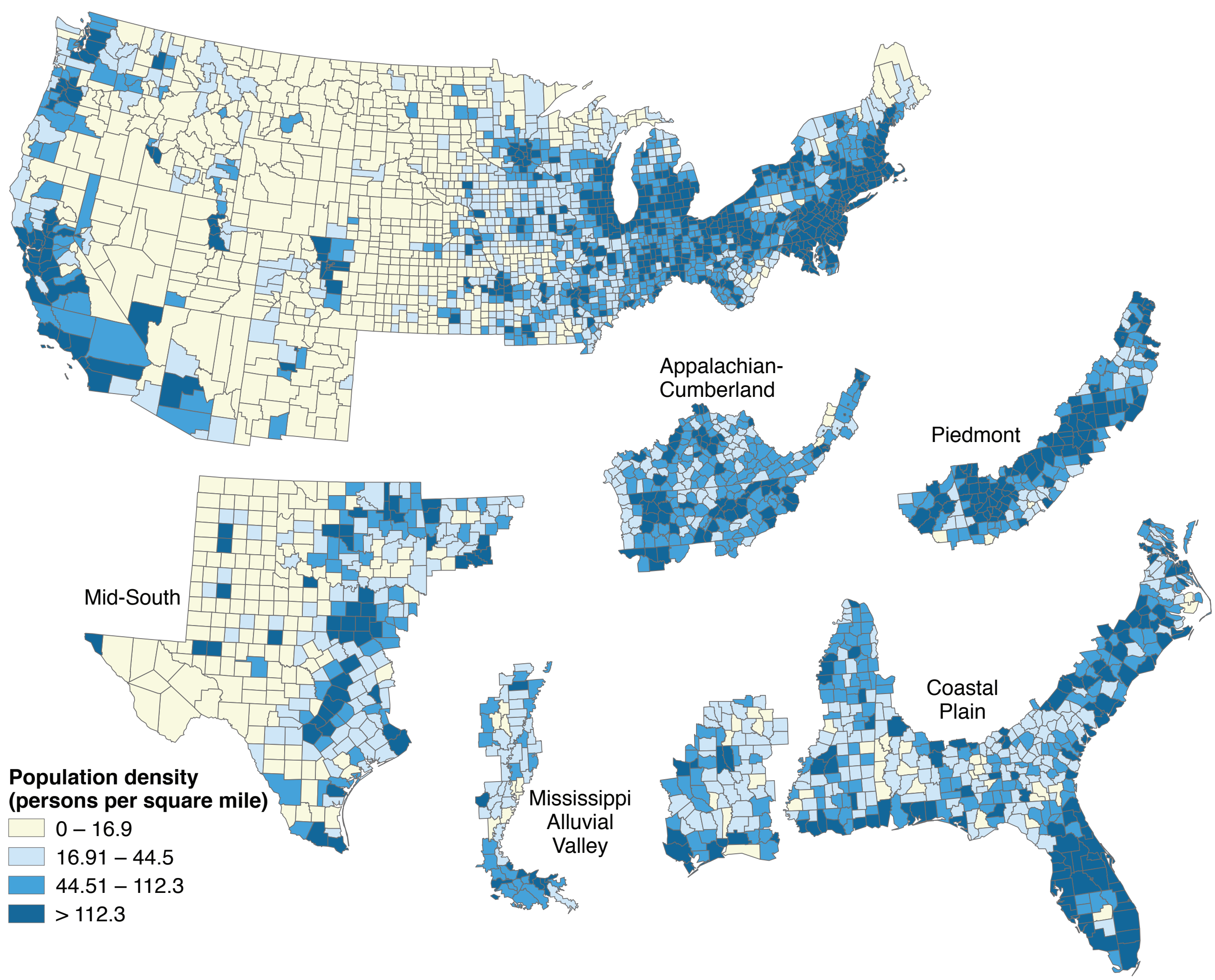


Figure 13—County-level population density, 2008, of southern subregions within the context of the United States as a whole.

at 317.5 persons per square mile and the four most populous areas—Richmond, Norfolk, Virginia Beach, and Hampton (Virginia Department of Game and Inland Fisheries 2005). Both North and South Carolina have increased rapidly (21.4 percent from 1990 to 2000). In 2000, the combined populations of Coastal Plain counties in North Carolina and South Carolina was nearly 6 million people—according to Campbell and Coes (2008), about 40 percent of the total in North Carolina (3.2 million) and 63 percent of the total in South Carolina (2.5 million). Similarly, the population of the Georgia Coastal Plain counties grew an average of 16 percent per decade from 1970 to 2000 (Henry 2009), and the population of Peninsular Florida, the most developed section of the Coastal Plain, increased >140 percent (from 4.2 million to 10.3 million) from 1970 to 2000. Large urban areas—including Orlando, St. Petersburg, and Tampa (Drummond 2011)—are prevalent in Peninsular Florida.

Still, the majority of the Coastal Plain is considered rural. In 2000, the Coastal Plain area of Alabama supported about 1.9 million people and population density was very low (about 63 persons per square mile). Almost 500,000 people reside in

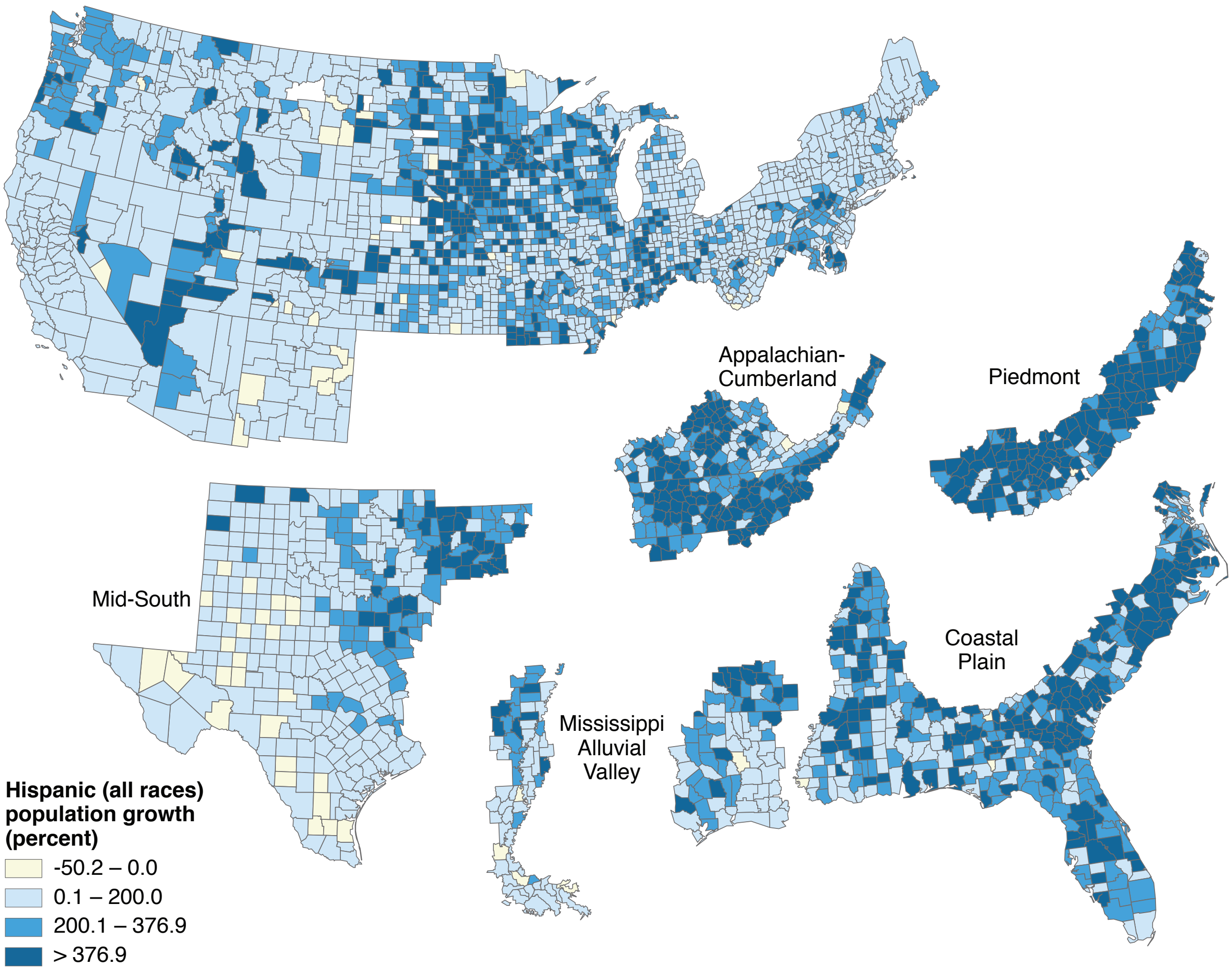


Figure 14—County-level change in Hispanic population, 1990 to 2008, of southern subregions within the context of the United States as a whole; note that Hispanics may be of any race (Source: Cordell and others 2013).

three cities (Montgomery, Mobile, and Tuscaloosa) while the three least populated counties support <12,000 people (Nielson 2007). Low population is also the norm in the Coastal Plain area of Arkansas, where some of the least populated counties in the State are located and where many county seats have <2,000 people. Even in one of the largest cities, El Dorado, the population is only 18,884 (Stroud 2011).

Income Levels

The rural areas of the Coastal Plain remain distinctive for their low-income areas, where unemployment rates are higher, per-capita income is significantly lower, poverty rates are higher, and educational achievement is lower than other subregions (Fleer 1994). Compared to other U.S. regions, rural South suffers both the highest percentage (38 percent in 1990) of adults without high school diplomas, and the lowest percentage (14 percent) of college graduates (Gibbs 2001). A rural profile conducted by the University of Arkansas (Farmer and others 2011) showed that Arkansas has the second highest poverty rate in the Nation (19 percent), with >20 percent in the Coastal Plain areas. Nonetheless, the Coastal Plain counties in Arkansas also had the highest average wage in the State ($32,317) in 2008. A fifth of all the jobs in these counties are provided by the manufacturing industry (Farmer and others 2011). In contrast, rural areas in the coastal counties of North Carolina had a per-capita income of $13,661 in 1990—$5,182 less than Piedmont counties (Fleer 1994).

Although the majority of Coastal Plain residents are in the "high poverty" category, this is not true for all areas. For instance, Peninsular Florida has a thriving economy with numerous major metropolitan areas. In 2011, Florida had a per-capita income of $39,563, a 3.5-percent increase from 2010; its gross domestic product (GDP) was $754.3 billion, fourth highest in the United States (Bureau of Economic Analysis 2012). Harris County in Texas and Lafayette Parish in Louisiana, both located in the Western Gulf section and both with metropolitan centers, are also anomalies. In 2010 Lafayette Parish had a per-capita income of $43,733, the second highest in Louisiana; in 2011, Harris County had a per-capita income of $44,757 the 15th highest in Texas. And the Virginia Beach metropolitan area of the Northern Atlantic section had a per-capital income of $40,234 in 2010, a 2.3-percent increase from 2009 (Bureau of Economic Analysis 2012).

Population Forecasts

Population projections for the Cornerstone Futures reflect the potential for substantial growth in the South with all subregions exhibiting strong growth. In 2006, the Coastal Plain subregion contained 44 percent of the South's population (about 43 million out of 99 million people). For Cornerstones A, B, and E the Coastal Plain's population is projected to rise by 64 percent (to >71 million people) by 2060 with the strongest growth in Peninsular Florida (89 percent). Cornerstones C, D, and F show about a 46-percent increase in the Coastal Plain's population over the same period (to 63 million people).

LAND USES

Current Land Use

Urban—From 1945 to the mid-1990s, the amount of land dedicated to urban uses has tripled (Mitchell and Duncan 2009). Nonetheless, with the exception of counties in Peninsular Florida, most Coastal Plain counties still contain <5 percent urban land use (fig. 15). Outside Peninsular Florida, the Coastal Plain counties with the most developed area are located along the Gulf and Atlantic Coasts (fig. 15).

Although Peninsular Florida has the highest increase in urbanization, large swathes of public land—Indian reservations, national parks, and game refuges—occupy much of its southern portion, which is characterized by open marshes used for hunting, fishing, and other recreational activities (USDA NRCS 2006).

Forest—A majority of the counties in the Coastal Plain are ≥25 percent forested, and many are >50 percent forested (fig. 15). Timber production is a major industry in the Northern Atlantic, Eastern Atlantic, Southern Gulf, and Middle Gulf-East sections. Lumber and pulp production are prominent in the Middle Gulf-West and Peninsular Florida section, portions of the Middle Gulf-East section, and the coastal portions of the Southern Gulf and Northern Atlantic sections (USDA NRCS 2006). The Middle Gulf, Western Gulf, Southern Gulf, and Eastern Atlantic sections (fig. 15) contain the highest concentration of forested land in the Coastal Plain and Peninsular Florida contains the least (fig. 15). Recent losses of forested land use have occurred along the eastern coasts of Florida, North Carolina, and Virginia (Wear 2013). Some increase in forests has occurred in counties in middle Georgia, Alabama, Mississippi, and eastern Texas (Wear 2013).

Cropland—Counties with the largest portion of cropland are concentrated in the upper Coastal Plain from southwestern Georgia through the lower Carolinas, and in coastal Texas and southern Florida (fig. 15). Cash-grain crops and forage production are important. Soybeans, vegetables, cotton, tobacco, peanuts, corn, rice, sorghum, and wheat are the major crops grown throughout the area. Although only about 10 percent of the Peninsular Florida is cropland, this section is a major citrus-producing area and also produces winter vegetables, sugarcane, avocado, and papaya (USDA NRCS 2006).

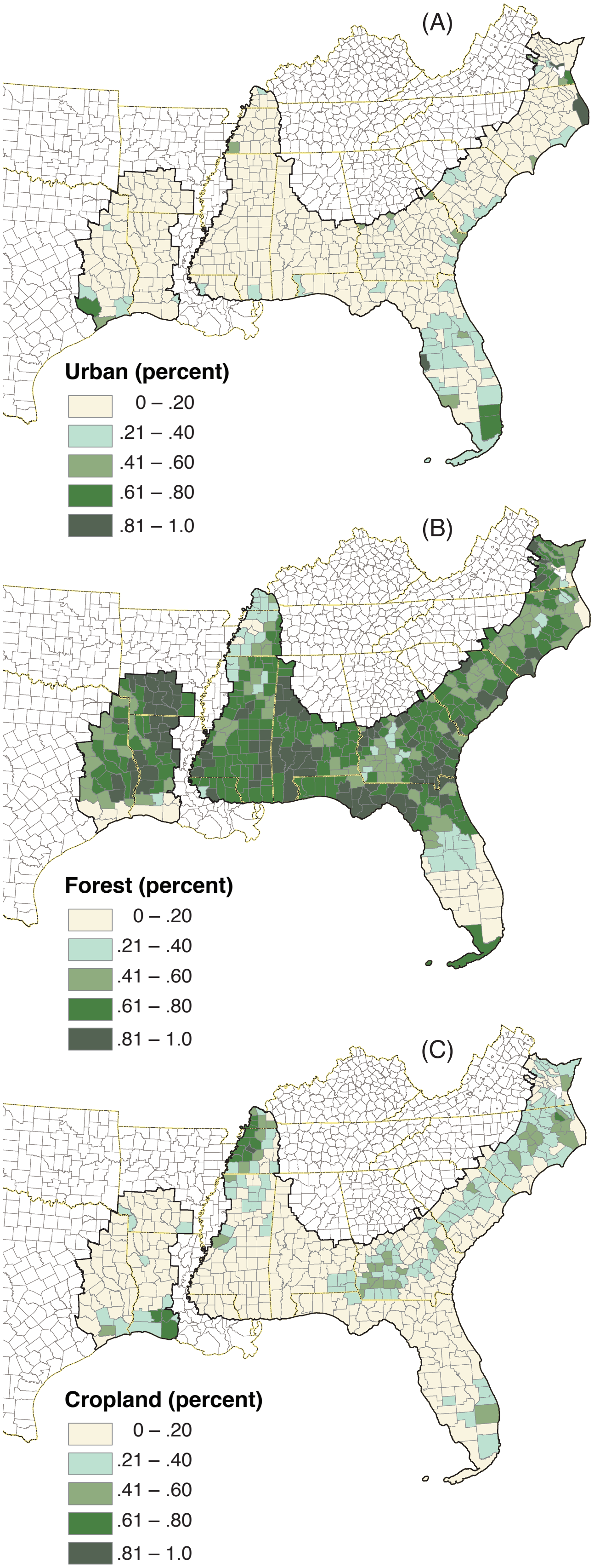


Figure 15—Land uses, 1997, for the U.S. Coastal Plain: (A) urban, (B) forest, and (C) cropland (Source: Wear 2013).

Pastures are grazed mainly by beef cattle (*Bos primigenius*), but some dairy cattle and hogs (*Sus scrofa domesticus*) are also raised in the Coastal Plain. The major pasture grasses are bahiagrass (*Paspalum notatum*) and bermudagrass (*Cynodon dactylon*). Poultry farming is an important enterprise in the Northern Atlantic section. Swine operations are of major importance in North Carolina and Virginia.

Forecasts

Forecasted southwide county-level trends in land use are reported by Wear (2013) for the Southern Forest Futures Project and summarized for subregions including the Coastal Plain. In the following section, we summarize impacts to the Coastal Plain.

The concern, identified in the public input sessions, about competing uses for coastal forests would appear to be well grounded. By 2060, the South is forecasted to lose 11 (7 to 13 percent) to 23 million acres (13 percent) of forested lands, nearly all of which would be diverted to urban use. As much as 43 million acres of land in the South are forecasted to be developed for urban uses by 2060 from a base of 30 million acres in 1997; almost 18 million of these acres occur in the Coastal Plain. The heaviest forest losses are projected to occur in Peninsular Florida, which is forecasted to be the biggest loser at 34 percent (figs. 16 and 17).

All sections of the Coastal Plain are projected to experience increases in the amount of land in urban usage; however the effects may be especially focused in coastal areas. Especially high increases of urban lands (209 percent) are forecasted for the Middle Gulf-East, followed by the Middle Gulf-West at 190 percent, the Northern Atlantic at 172 percent, and the Southern Gulf at 166 percent (table 1, fig. 18). Even losses of forested land in other subregions (such as the Appalachian-Cumberland highland and Piedmont) could have far-reaching effects, with water quantity and quality impacts accumulating and exacerbating similar effects in downstream Coastal Plain watersheds (fig. 16).

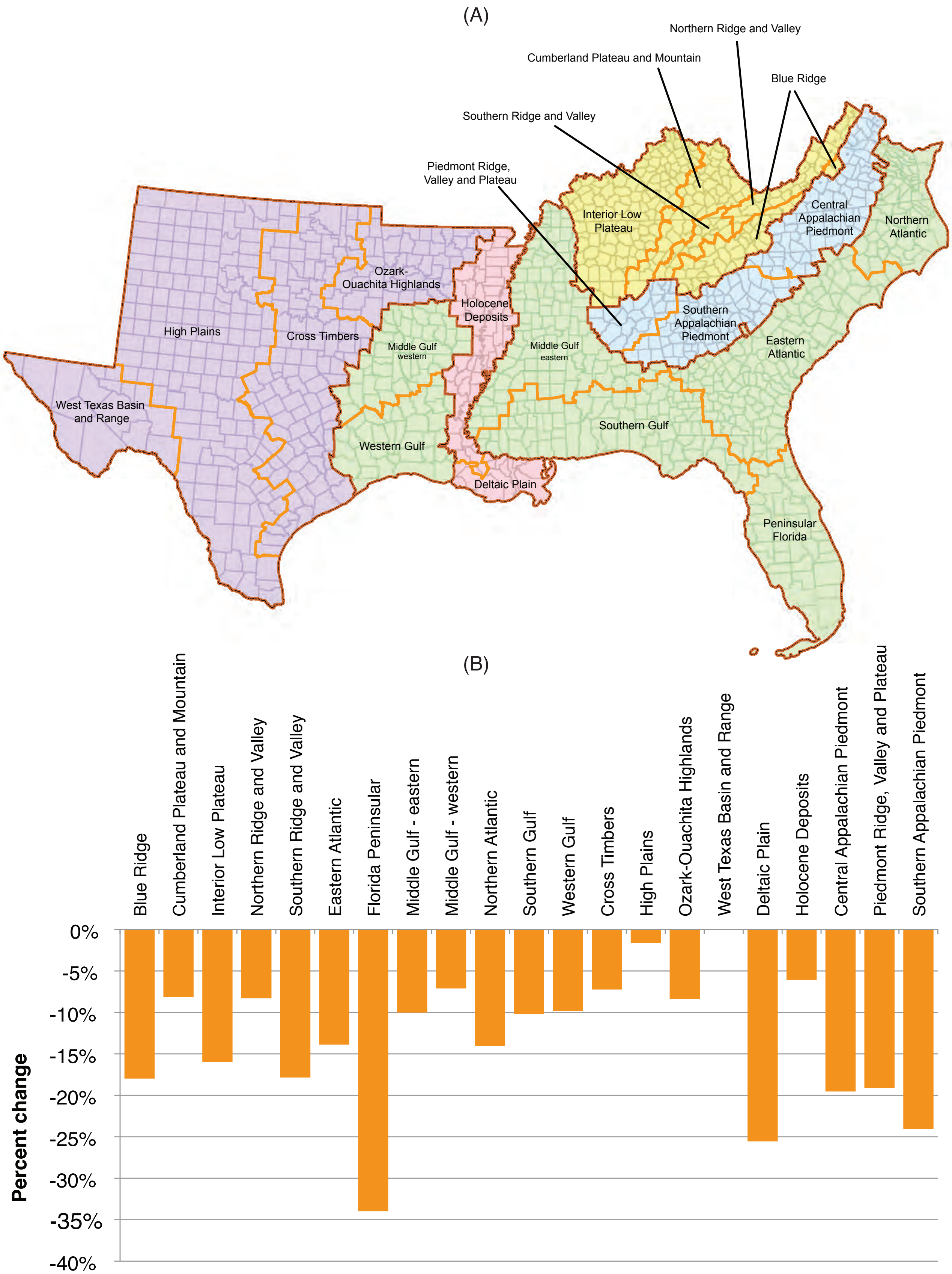


Figure 16—(A) Subregions and sections of the Southern United States, and (B) change in forest land uses by subregion and section of the Southern United States, 1997 to 2060, based on an expectation of large urbanization gains with decreasing timber prices—Cornerstone B (Source: Wear 2013).

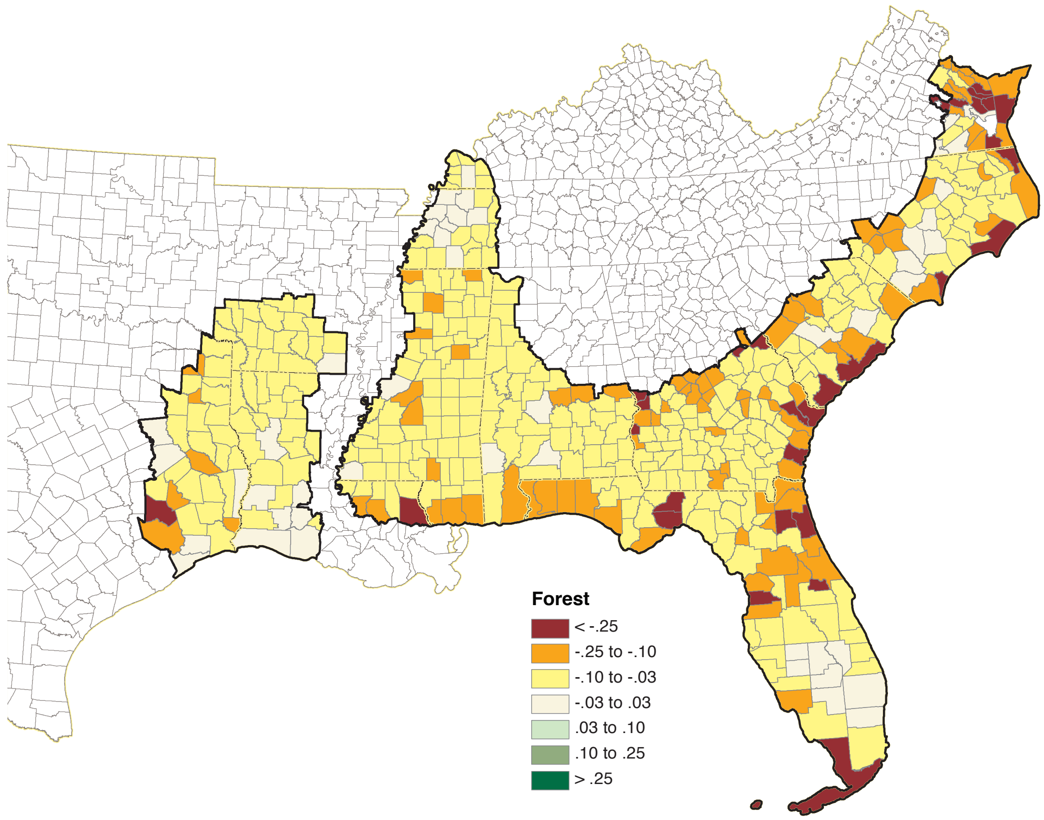


Figure 17—Change in forest land use, 1997 to 2060, in the U.S. Coastal Plain based on an expectation of large urbanization gains and decreasing timber prices—Cornerstone B (Source: Wear 2013).

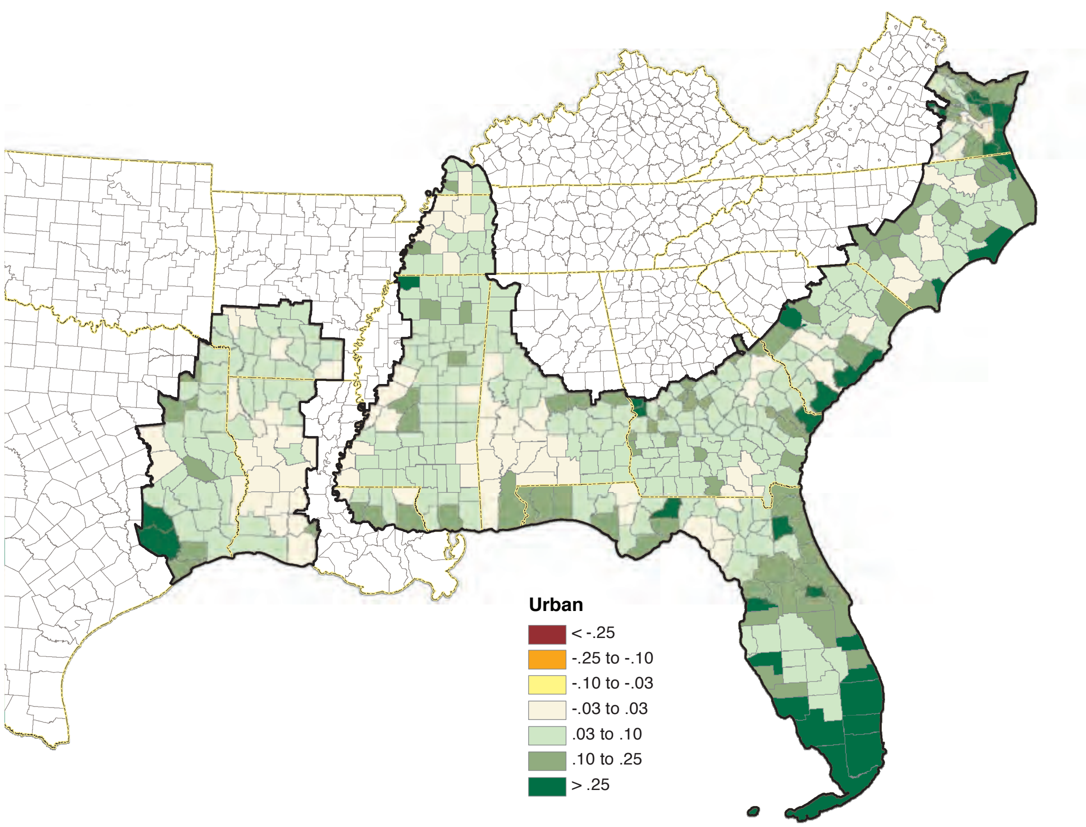


Figure 18—Change in urban land use, 1997 to 2060, in the U.S. Coastal Plain based on an expectation of small urbanization gains with increasing timber prices—Cornerstone C (Wear 2013).

Table 1—Forecasted area of non-Federal urban land in the South, 1997–2060, based on an expectation of large urbanization gains, either with increasing timber prices (Cornerstone A) or with decreasing timber prices (Cornerstone B)

Subregion	Section	Area in urban use					Change from 1997 to 2060	
		1997	2010	2030	2040	2060	Area	Percent
		- thousand acres- - - - - - - - - - - - - - - - - - -						
Coastal Plain	Eastern Atlantic	2,713.76	3,395.82	4,615.85	5,261.60	6,807.01	4,093.25	150.8
	Florida Peninsular	3,348.83	4,471.36	5,571.94	5,945.23	6,652.38	3,303.55	98.6
	Middle Gulf-eastern	1,496.16	1,957.23	2,861.68	3,359.27	4,627.79	3,131.63	209.3
	Middle Gulf-western	726.64	928.79	1,321.43	1,539.08	2,110.12	1,383.48	190.4
	Northern Atlantic	904.00	1,174.00	1,653.72	1,899.70	2,459.74	1,555.74	172.1
	Southern Gulf	1,663.88	2,085.55	2,907.67	3,349.93	4,426.32	2,762.44	166.0
	Western Gulf	1,624.49	2,000.27	2,471.46	2,672.09	3,135.43	1,510.94	93.0
Total		**12,477.77**	**16,013.02**	**21,403.75**	**24,026.90**	**30,218.79**	**17,741.02**	**142.2**

Associated with this widespread land-use change, population density in the Coastal Plain is expected to increase, even rising to as high as current densities in the Piedmont (fig. 19). However, timber markets, and the ownership patterns and trends associated with them, could mediate these changes. Although stronger timber markets might ameliorate losses of southern forests somewhat, this would likely come at the expense of cropland uses (fig. 20). In addition, the increased liquidity of corporate owned forested land (and increased trading and decreased size of holdings) could accelerate impacts in the Coastal Plain, where activity by forest investment groups has been especially prevalent (as voiced during public input sessions).

What is non-Federal land?

For the purposes of this publication, non-Federal land includes land held by private organizations, individuals, families, local governments, Indian reservations, and U.S. States. It does not include U.S. military bases or lands managed by the U.S. Department of Agriculture and the U.S. Department of the Interior.

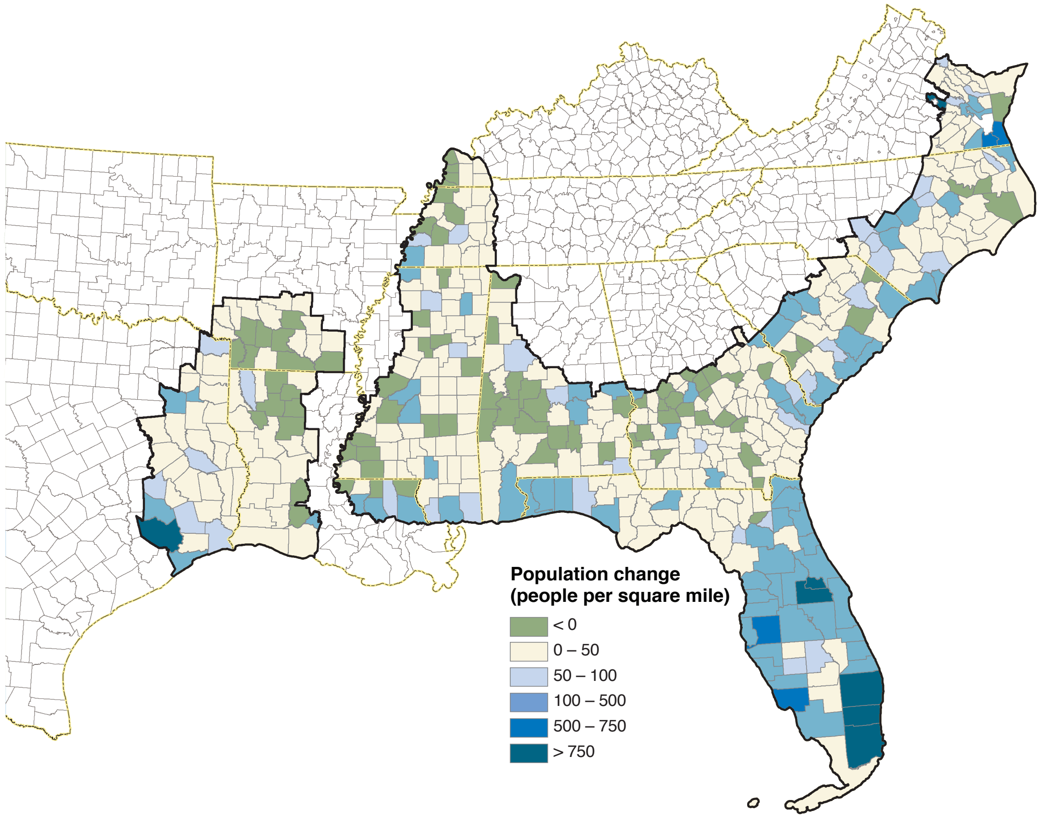


Figure 19—Projected population change in the U.S. Coastal Plain based on an expectation of large urbanization gains, regardless of increasing or decreasing timber prices (Source: Wear and others 2013a).

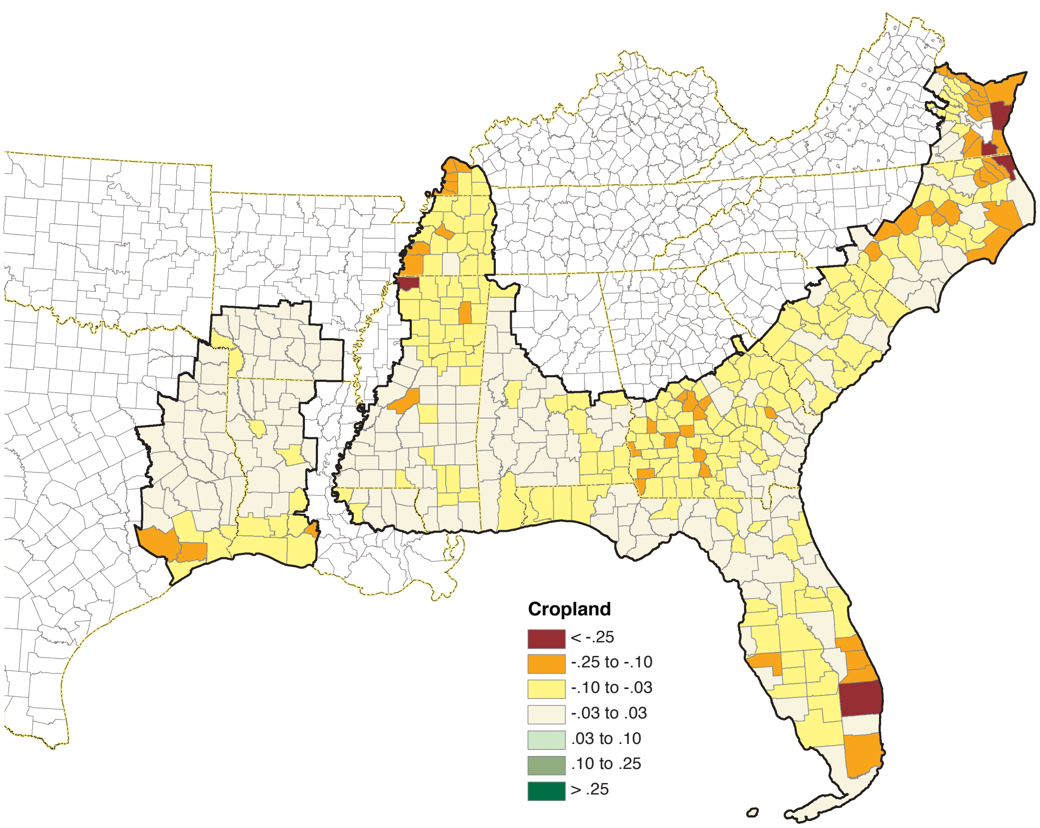


Figure 20—Change in cropland use, 1997 to 2060, based on an expectation of small urbanization gains with increasing timber prices—Cornerstone C (Source: Wear 2013).

FOREST OWNERSHIP

Forest Ownership and Recent Trends

Eighty-eight percent of the forests in the Coastal Plain are privately owned, with more than half characterized as family forests (fig. 21) and three-quarters owned by people 55 years and older in age (Butler and Wear 2013). As shown in figure 22, most private owners hold <10 acres of land and occupy <5 percent of the total forested acreage (Butler and Wear 2013). The remaining private forest land is owned by corporate or organizational entities, mostly focused on timber management as a business enterprise. Two such forest investment groups—timber investment management organizations and real estate investment trusts—have generally replaced traditional forest industry ownership throughout much of the Coastal Plain. Of the 118 million acres of forested land in the Coastal Plain, only 4.7 million acres (4 percent) is Federally managed (fig. 21); most of this acreage is in 19 national forests (USDA Forest Service 2011).

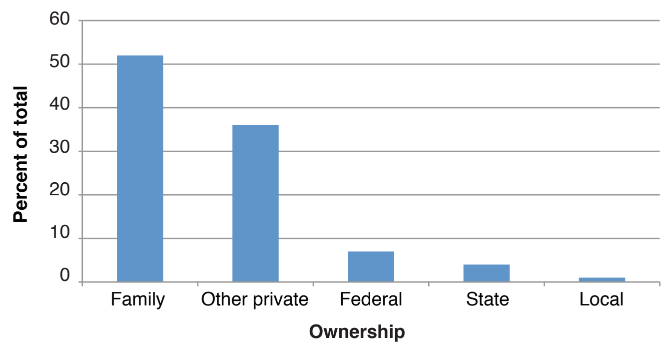


Figure 21—Area of forest land by ownership category in the U.S. Coastal Plain.

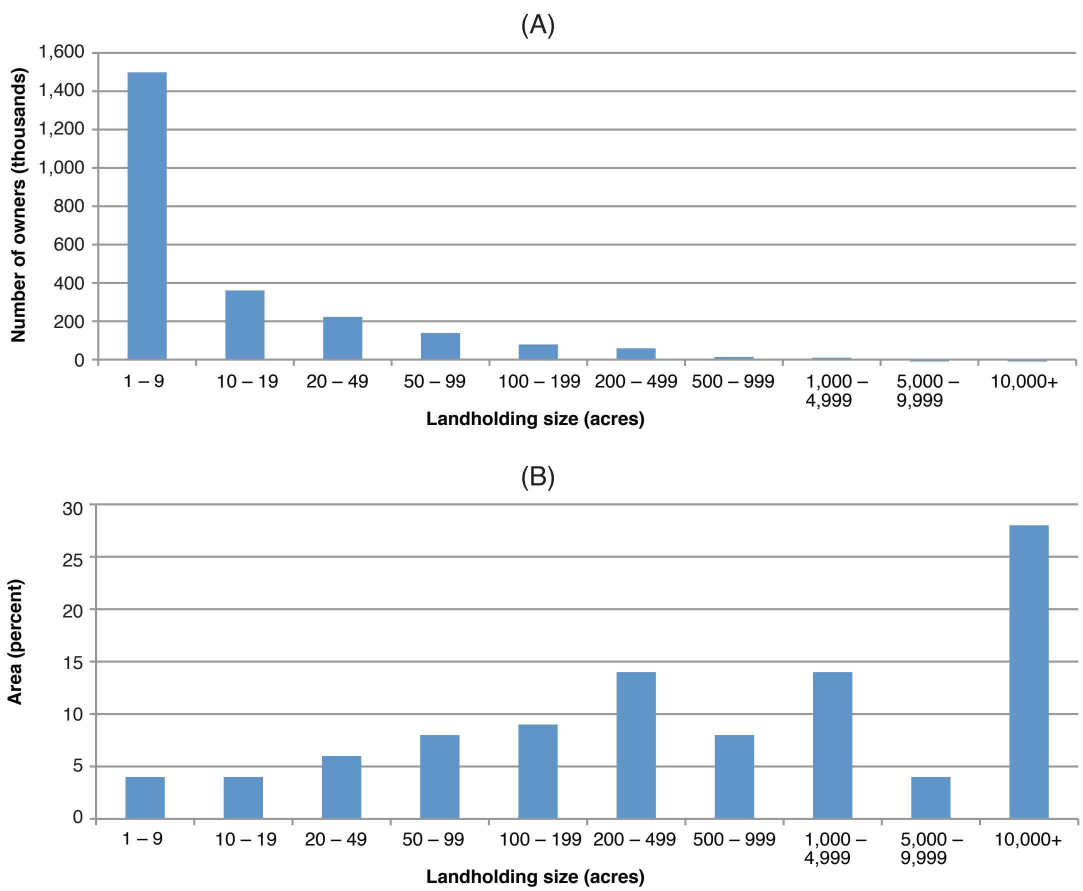


Figure 22—For each size category of private forest ownership, 2006, in the U.S. Coastal Plain (A) number of owners, and (B) percent of total area.

The reasons given by families for owning forested land vary appreciably, but a common theme is that most owners have multiple objectives, such as aesthetics, inheritance property for heirs, privacy, nature protection, and the association of the land with their primary home (Butler and Wear 2013). Lumber and timber production were also seen as financially important to many owners.

Atlantic coastal sections—Forest ownership is fairly consistent along the Atlantic coasts (Northern Atlantic, Eastern Atlantic, and portions of Peninsular Florida). About 8 percent of forest acreage is on public land and the remaining 92 percent is on private land—44 percent held by farmers and 48 percent held by other private owners. Private ownership is dynamic and varies across this area. For example, in the Coastal Plain of South Carolina from 1987 to 1993, a small change in private forest land ownership (4-percent increase) masked larger changes within the category: a 26-percent decrease for farmers, a 19-percent increase for other individuals, a 29-percent increase for corporations, and a 2-percent increase for forest industry (Koontz and Sheffield 1993). Conversely, in the coastal areas of North Carolina from 1990 to 2001, individual ownership decreased 6 percent, forest industry decreased 32 percent, and corporate owned forest nearly doubled from 508,000 acres to 797,000 (Conner and Brown 2001).

Gulf coastal sections—Similarly, most of the forested land in the sections along the Gulf Coast—Middle Gulf-East, Western Gulf, Middle Gulf-West, Southern Gulf, and a portion of Peninsular Florida—is privately owned; and ownership in the corporate sector is growing. Much of the remaining longleaf forests in Louisiana and Texas are publicly owned; largely attributed to large holdings by the Kisatchie National Forest, two military training facilities, and a National Guard Camp in the Western Gulf section (The Nature Conservancy 2012). Sixteen percent of the land in Mississippi is public, and a small portion is held by Native American tribes; forest industry owns about 7 percent of the privately owned land while individuals own 77 percent (Mississippi Institute for Forest Inventory 2006).

Outlook for Forest Ownership

As reported by the Southern Forest Futures Project, forest ownership is undergoing significant changes throughout the South (Butler and Wear 2013). By all measures, private ownership dominates, both for the South as a whole and for its Coastal Plain. More than 5 million private forest owners (from multinational corporations to families to individuals with only a few acres) across the South hold 200 million acres of forested land, or about 86 percent of the total forested land area. On average, families and individuals own 2 out of every 3 acres of private forest land. Corporations (as well as or including timber investment management organizations and real estate investment trusts) own most of the remaining third, with a smaller amount held by conservation organizations, partnerships, and tribes.

Although the forest products industry land base had long been perceived to be stable and predictable, significant changes have occurred recently and more could be on the horizon. The large gain in ownership by forest investment groups (in which the forest products industry divested about three-fourths of its timberland holdings) occurred from 1998 to 2008 and represents the largest ownership transition in the last century. These land transfers, which have been especially active in the Coastal Plain, were identified as a particular concern in public input sessions. Texas experienced the largest decrease in industry ownership (about 3 million acres) while Alabama, Georgia and Louisiana each lost about 2 million acres (fig. 23A). Increases in ownership by timber investment management organizations in the Coastal Plain were similar to regional trends with gains of 3 million acres in Texas, 1.5 million in Louisiana, and 1.3 million in Alabama (fig. 23B). Ownership by real estate investment trusts is mostly concentrated in Arkansas, Louisiana, Mississippi, and Alabama (fig. 24B); ownership by timber investment management organizations is more diffuse throughout the Coastal Plain, with some concentrations in eastern Texas and western central Louisiana (fig. 24A). These changes were likely the result of mergers, fewer concerns about timber scarcity, new fiber acquisition technologies, redeployment of capital, and efforts to reduce tax burdens.

This increased liquidity of forest assets has implications for a variety of issues (Butler and Wear 2013) and illustrates the need for more and improved monitoring of ownership changes and forest-land transaction values.

TAXES AND FINANCIAL INCENTIVES

Taxes have significant and substantial impacts on forest use, ownership, and management. Most of the projected impacts reported by Greene and others (2013) for the Southern Forest Futures Project apply southwide.

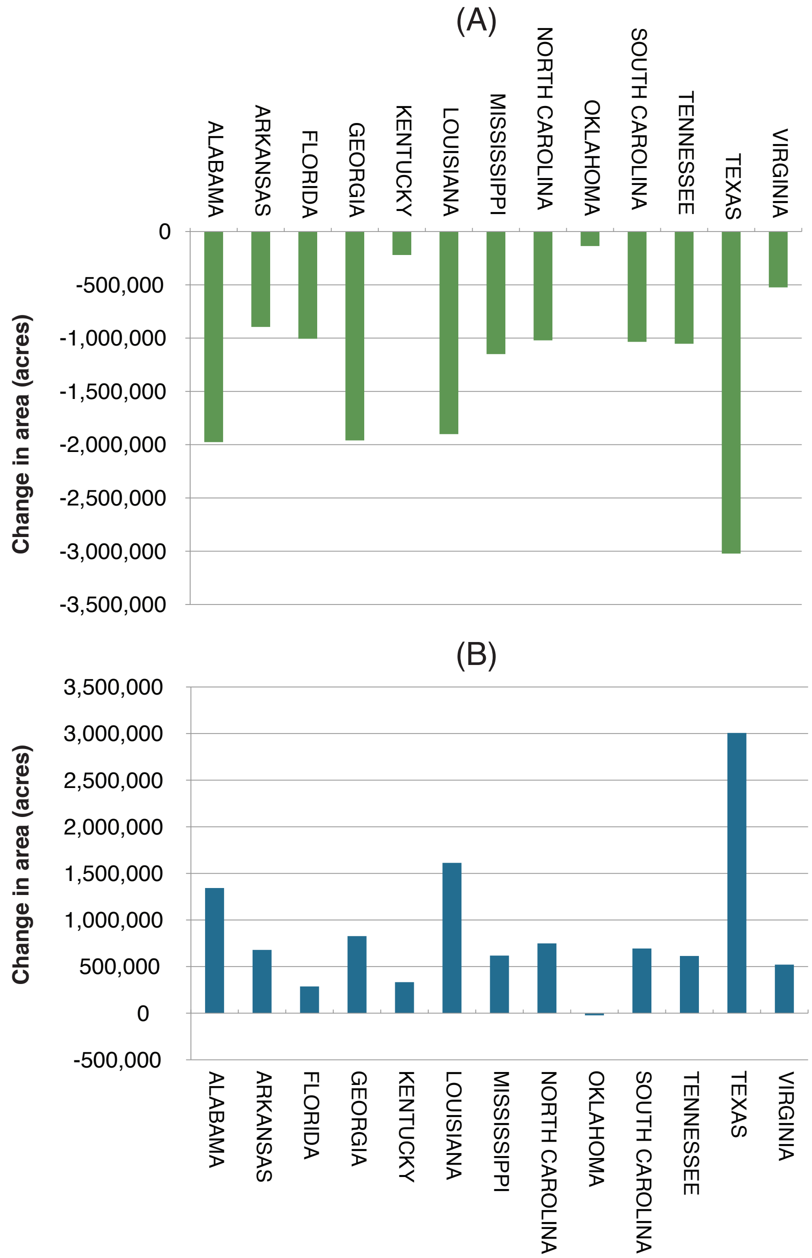


Figure 23—Change in forest products industry land ownership, 1998 to 2008, in the Southern United States for (A) the forest products industry, and (B) timber investment management organizations (Source: Butler and Wear 2013).

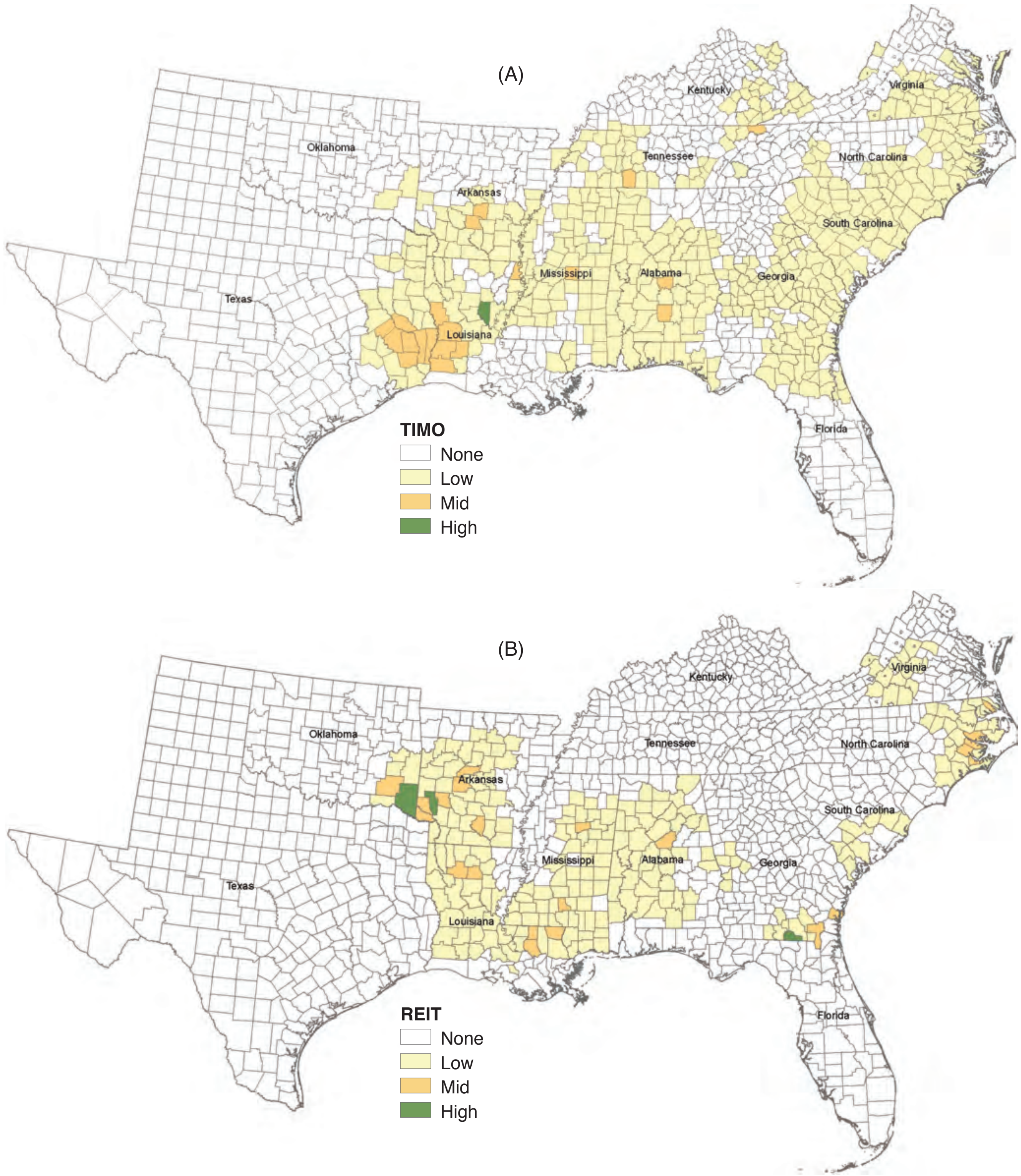


Figure 24—Concentration of forest land, 2008, in the Southern United States owned by (A) timber investment management organizations, and (B) real estate investment trusts (Source: Butler and Wear 2013).

CHAPTER 4. Biological Threats

INVASIVE PLANTS

The analyses of invasive plants reported by Miller and others (2013) for the Southern Forest Futures Project are a rich source of information on their influence and future in the South, but some specific projections are particularly applicable for the Coastal Plain.

Future projections (table 2) call for increases in the occurrence, abundance, and impacts of invasive plants. These increased occupations (forecasted for the next 50 years) would likely impact a variety of goods and services provided by the forests of the Coastal Plain. Although some could find uses in biomass and composite products, their impacts are projected to be mostly negative. In particular, a number of invasive plants—cogongrass, Japanese climbing fern, kudzu, and tallowtree—were identified as species of concern at the Coastal Plain public input sessions.

Cogongrass

Cogongrass was identified as the number one invasive plant concern in the Coastal Plain. This highly invasive and recalcitrant grass remains most concentrated near the points of initial introduction in coastal Alabama, coastal Mississippi, and central Florida (fig. 25). Despite eradication efforts in Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina, northward spread is underway, with the potential range encompassing most of the United States. Occupation would mainly be on nonforested land like pastures, rights-of-way, and special habitats like bogs, water edges, and glades.

Tallowtree

Tallowtree was initially planted in coastal South Carolina and Georgia in the late 1700s, followed by more extensive planting in Louisiana and Texas in the 1900s. As a result, it currently occurs mostly along the Gulf of Mexico and Atlantic Ocean, with the highest concentration around Houston, TX (fig. 26). This plant occupies a larger area (>0.5 million acres) than any other nonnative invasive tree. Its coverage is projected to increase by 45 percent under current climate conditions and to extend farther north with warming temperatures until its range encompasses the entire South.

Other Invasive Trees

Tree-of-heaven (*Ailanthus altissima*) is expected to expand southward, spreading from prior plantings in rural and urban settings for an eventual 24-percent increase in cover. Chinaberrytree (*Melia azedarach*), the third most abundant invasive tree in the South, is most prevalent in the Coastal Plain (fig. 27); even absent climate change, it is expected to spread northward because it is not limited by temperature (table 2). Brazilian peppertree (*Schinus terebinthifolius*), the fifth most abundant invasive tree in the Coastal Plain, is found only in Florida and the southern tip of Texas; having recently expanded to the Florida Panhandle, it is expected to increase its coverage by 30 percent—including expansion northward even with no change in climate (table 2). Finally, melaleuca (*Melaleuca* spp.) primarily occurs in central Florida, where it covered >0.5 million acres by 1993, but it also occurs as an escape along the southern shores of Lake Pontchartrain near New Orleans, LA. In a warming climate, it could spread northward for a 65-percent increase in the next 50 years—the highest percentage increase for any invasive tree (table 2). Insects native to the range of this invasive tree are being released—with success—to achieve biological control.

Invasive Shrubs

Invasive shrubs are also projected to continue to influence Coastal Plain forests. Several invasive privets (*Ligustrum* spp.) are widespread throughout the South, with an epicenter around Birmingham, AL (fig. 28) and with the least amount of forest coverage in Kentucky and Florida; they are expected to increase by 37 percent, or about 1.2 million more acres. Cherokee rose (*Rosa laevigata*), the second most common invasive shrub in the South, is found across the Coastal Plain especially in the southern Alabama portion of the Black Belt (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia). Invasive roses as a group occupy almost 700,000 acres of forests. Because

Table 2—High-priority invasive plants of southern forests: their origin, date of introduction or extensive planting, current cover, annual rate of spread, and projected cover in 2060 (absent control programs)

Species	Origin	Date of introduction or extensive planting	Current cover	Average annual rate of spread	Projected cover 2060
			- - - - - - - - - - -	*acres*	- - - - - - - - - - -
Invasive Trees					
Tallowtree	Asia	About 1900	596,239	5,420	867,257
Tree-of-heaven	China	1784	243,111	1,076	296,897
Chinaberrytree	China/India	1830	101,426	563	129,600
Silktree, mimosa	Asia	1785	90,055	400	110,067
Brazilian peppertree	South America	1898	83,434	745	120,681
Melaleuca	Australia	1934	61,631	811	102,178
Princesstree	China	1844	27,009	163	35,144
Total			**1,202,905**	**9,178**	**1,661,824**
Invasive Shrubs					
Invasive privets	China/Europe/Japan/Korea	Ave 1875	3,180,488	23,559	4,358,447
Invasive roses	Japan/Korea/China	Ave 1877	693,618	5,215	954,377
Invasive lespedezas	Japan	Ave 1863	532,235	3,621	713,267
Bush honeysuckles	Asia	About 1950	345,622	5,760	633,640
Invasive elaeagnus	China/Japan/Europe/Asia	Ave 1930	96,421	1,205	156,684
Sacred bamboo	Asia/India	1960	24,595	492	49,190
Tropical soda apple	Brazil/Argentina	1988	9,570	435	31,320
Winged burning bush	Asia	1980	8,710	290	23,227
Total			**4,891,259**	**40,578**	**6,920,152**
Invasive Vines					
Japanese honeysuckle	Eastern Asia/Japan	About 1850	10,342,030	64,638	13,573,914
Japanese climbing fern	Asia/Australia	About 1918	314,758	3,421	485,822
Kudzu	Japan/China	About 1920	226,889	2,521	352,938
Invasive wisterias	Japan/China	Ave 1873	57,129	417	77,979
Invasive ivies	England/Europe/Asia	Ave 1762	29,328	118	35,241
Vincas, periwinkles	Europe	Ave 1780	25,255	110	30,745
Invasive climbing yams	Asia/Africa	Ave 1900	20,691	188	30,096
Wintercreeper	Asia	1907	11,860	115	17,617
Old World climbing fern	Africa/Asia/Australia	1960	9,369	187	18,738
Oriental bittersweet	Asia	1860	8,654	58	11,539
Total			**11,045,963**	**71,773**	**14,634,630**
Invasive Grasses and Canes					
Nepalese browntop	Tropical Asia	1919	935,529	10,281	1,449,556
Tall fescue	Europe	1940	767,208	10,960	1,315,214
Cogongrass	Japan/Phillipines	About 1935	60,107	801	100,178
Invasive bamboos	China	1882	56,581	442	78,683
Chinese silvergrass	Asia	1957	10,130	191	19,687
Total			**1,829,555**	**22,675**	**2,963,318**
Invasive Forbs					
Garlic mustard	Europe	About 1900	5,991	54	8,714
GRAND TOTAL			**18,975,673**	**146,947**	**26,658,728**

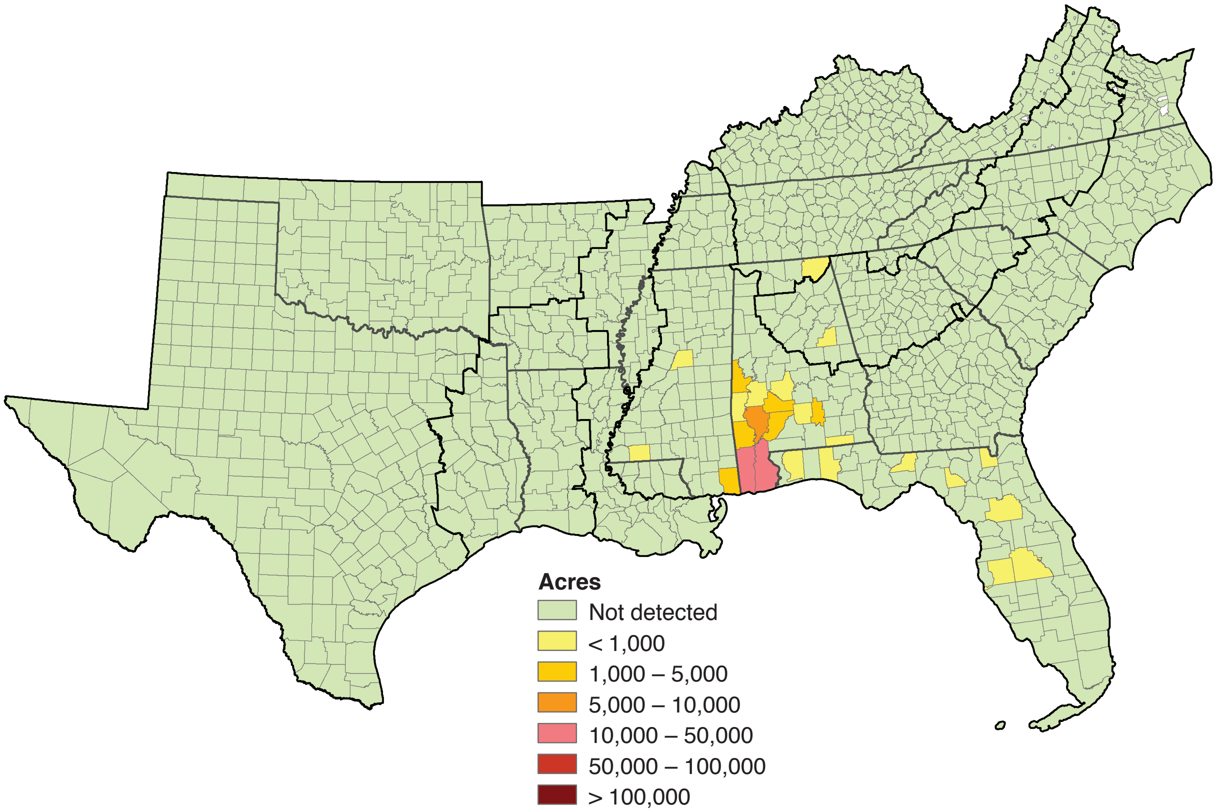


Figure 25—Infestations of cogongrass, 2010, in the Southern United States (Miller and others 2013) [Source: Southern Region, Forest Inventory and Analysis, U.S. Forest Service. Plants: http://srsfia2.fs.fed.us/SNIPET/. (Date accessed: June 11, 2013)].

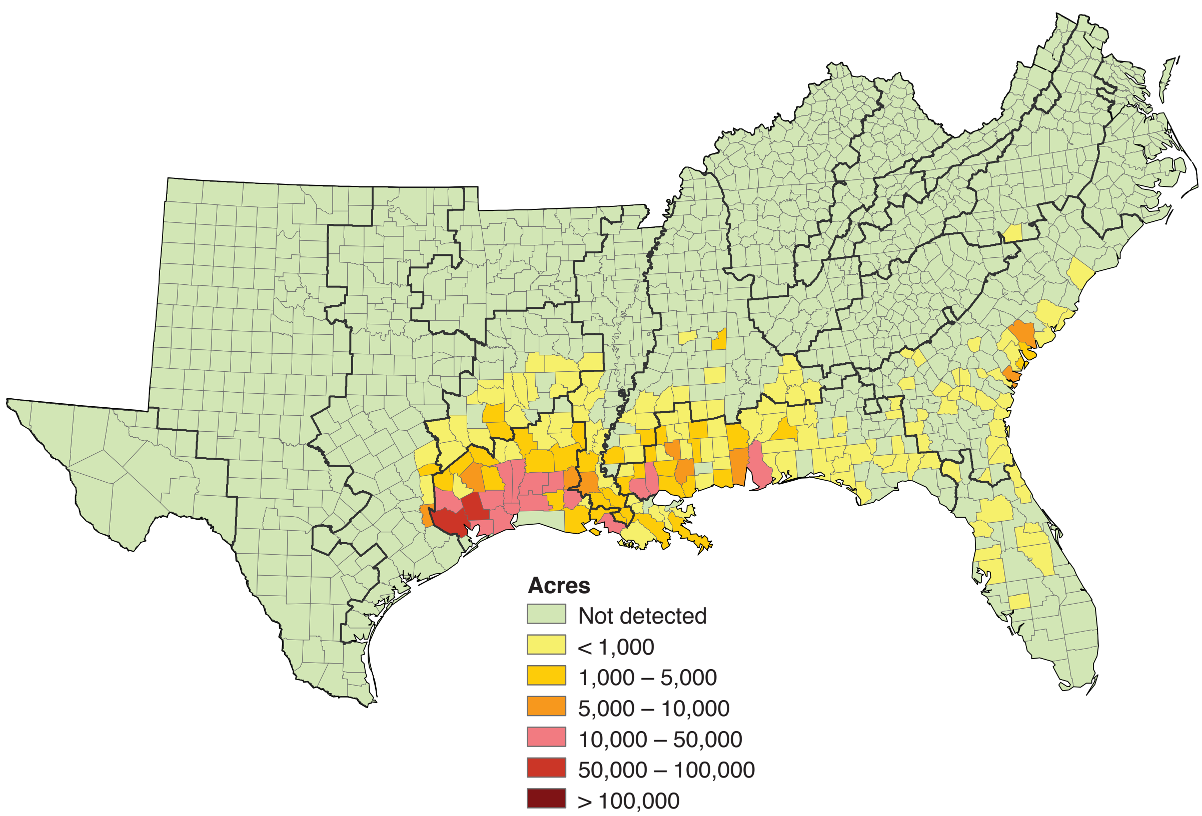


Figure 26—Infestations of tallowtree, 2010, in the Southern United States (Miller and others 2013) [Source: Southern Region, Forest Inventory and Analysis, U.S. Forest Service. Plants: http://srsfia2.fs.fed.us/SNIPET/. (Date accessed: June 11, 2013)].

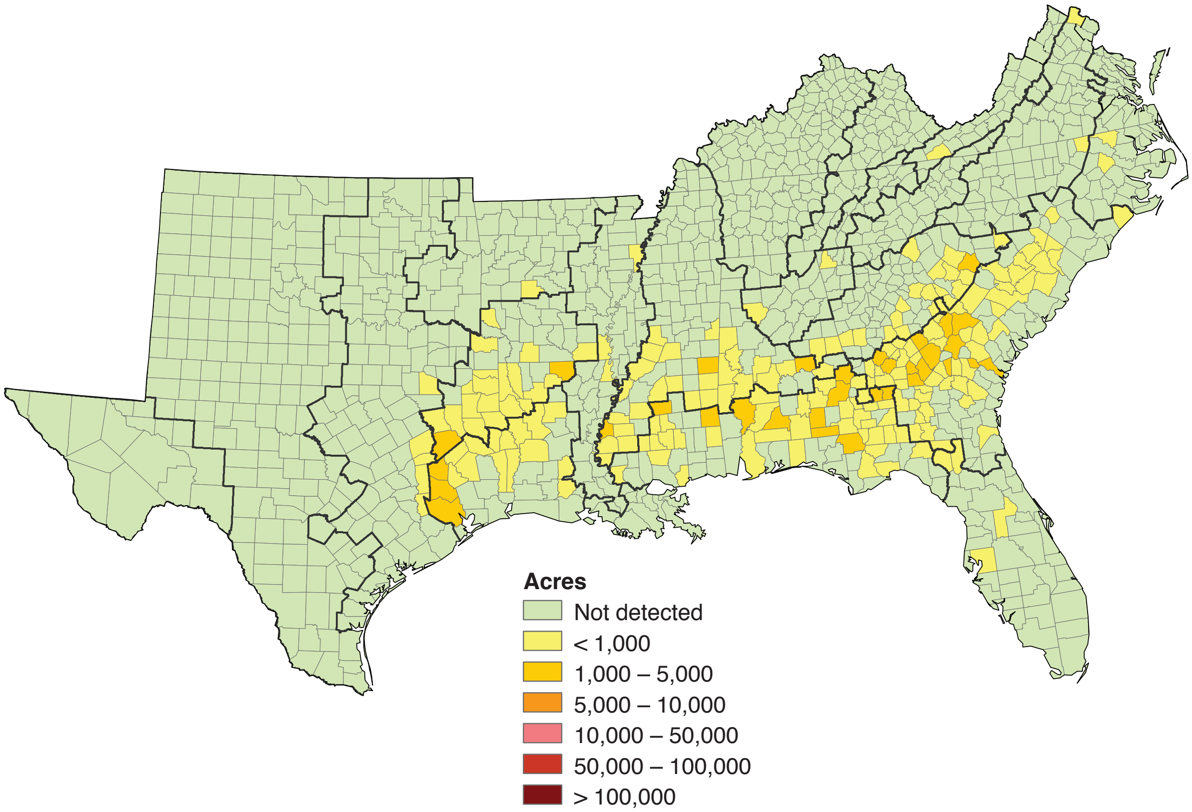


Figure 27—Infestations of chinaberrytree, 2010, in the Southern United States (Miller and others 2013) [Source: Southern Region, Forest Inventory and Analysis, U.S. Forest Service. Plants: http://srsfia2.fs.fed.us/SNIPET/. (Date accessed: June 11, 2013)].

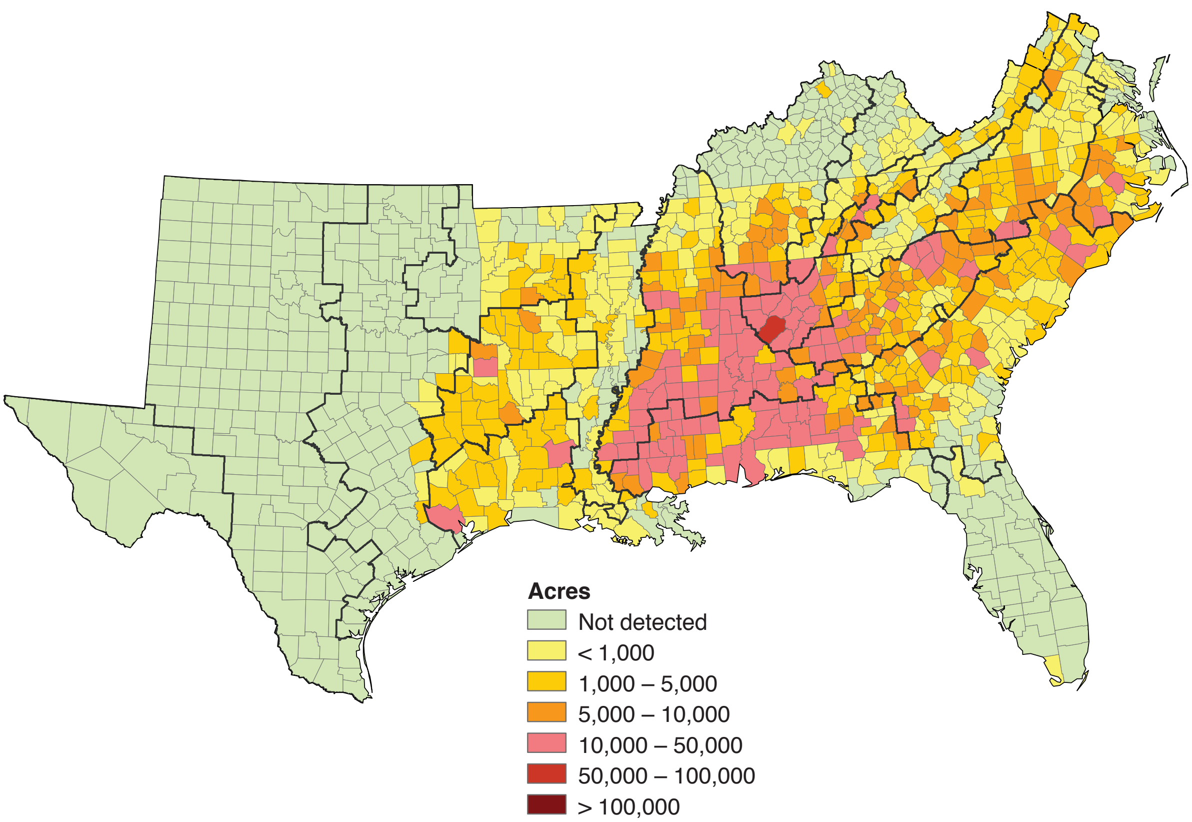


Figure 28—Infestations of invasive privets, 2010, in the Southern United States (Miller and others 2013) [Source: Southern Region, Forest Inventory and Analysis, U.S. Forest Service. Plants: http://srsfia2.fs.fed.us/SNIPET/. (Date accessed: June 11, 2013)].

of their continued spread along highway margins and into forests edges, the coverage by these plants is expected to increase by 37 percent. Tropical soda apple (*Solanum viarum* Dunal) is mostly found in the Coastal Plain, but it will grow and reproduce as far north as Illinois. Further spread is forecasted in the South, mostly in pastures and forest edges; active control programs are underway in every State where it occurs.

Other Invasive Plants

Other, more scattered occupations of invasive plants also impact Coastal Plain forests. Japanese climbing fern, a relatively recent introduction, is projected to increase in coverage by almost 54 percent over the next 50 years, principally in the Coastal Plain (fig. 29). This fern is spreading at a rapid rate via wind-blown spores, more so than other invasive plants. Kudzu is widespread in the Coastal Plain, mostly on nonforested open lands, although forest infestations are numerous in Mississippi and Alabama, where planting was promoted from 1930 to 1950. Wisteria (*Wisteria* spp.) occurs in scattered dense infestations around old homestead plantings throughout the South but most frequently in the Coastal Plain and Piedmont (fig. 30); it is expected to increase by about 27 percent. Invasive ivies (*Hedera* spp.) cover <30,000 acres southwide, but can be extremely dense, blocking introduction of native species. Chinese yam (*Dioscorea oppositifolia*), air yam (*Dioscorea bulbifera*), and water yam (*Dioscorea alata*) threaten forested parks and preserves by covering native plants (table 3). Old World climbing fern (*Lygodium microphyllum*) is found only in Florida but has blanketed entire tree islands in the Everglades; it is projected to steadily spread northward, doubling its current coverage initially in adjoining States. Tall fescue (*Schedonorus arundinaceus*) infestations in the South are most severe in the forests of western Kentucky and Tennessee, although some are also found in the Coastal Plain, especially in Mississippi and a portion of North Carolina (fig. 31). This is one of the most widely planted cool season grasses for pastures and soil stabilization, with a multitude of varieties bred for different southern landscapes making all southern forests increasingly vulnerable to invasion from adjacent lands and roadways. A warming climate could confine its spread somewhat.

Concerns about invasive animals were also raised during the Coastal Plain public input sessions. In particular, nutria (*Myocastor coypus*) (an invasive rodent) has significant impacts on the regeneration and reestablishment of cypress, a keystone coastal species.

INSECTS AND DISEASES

By their nature, invasive pests and pathogens are not confined to geopolitical or jurisdictional boundaries. In addition, their biology and ecology (including movement both on their own and when assisted by humans) makes fine scale analyses problematic (Duerr and Mistretta 2013). However, a future that does not bring new invasions by insect pests and pathogens is difficult to imagine. Predicting with certainty their rates of spread, extent of damage, and impacts on forests is difficult. Climate change will most certainly complicate predictions even further.

For instance, the climate of the Coastal Plain is currently highly suitable for the establishment of sudden oak death (*Phytophthora ramorum*). This could be exacerbated (warmer temperatures) or ameliorated (drier conditions) by predicted changes in climate. Laurel wilt (*Persea borbonia*), which could result in the extirpation of its hosts, has spread rapidly through its host range in the southern Coastal Plain. Likewise, thousand cankers disease (*Geosmithia morbida*) is spreading to new States, causing mortality of black walnut (*Juglans nigra*) and English walnut (*Juglans regia*).

Insects, too, are projected to cause increasing damage. A relative newcomer, the Sirex woodwasp (*Sirex noctilio*), is causing only limited mortality in the Northern United States. However, if it becomes established in the South, it could become a primary tree-killing insect. And although effective prevention and suppression techniques (including biological control) are available, how effective these would be in the South is unknown. Southern pine beetle (*Dendroctonus frontalis*), the most destructive insect pest of pine forests in the South, is forecasted to continue to have significant impacts. This would be especially likely with increases in pine acreage and the planting of high-susceptibility species in dense plantations. A warmer, drier climate would increase southern pine beetle activity and impacts. Even under current conditions, the northern edges of its known range are experiencing unprecedented outbreaks, raising concerns of mortality in stands even farther north.

Saltwater intrusion into coastal forests, an issue of particular concern raised in Coastal Plain public input sessions, could interact with insect and disease impacts. An example is the baldcypress leafroller (*Archips goyerana*), which periodically defoliates baldcypress in Louisiana and Mississippi. In areas experiencing chronic saltwater intrusion, projected to increase with sea-level rise, trees die after as few as two consecutive years of defoliation.

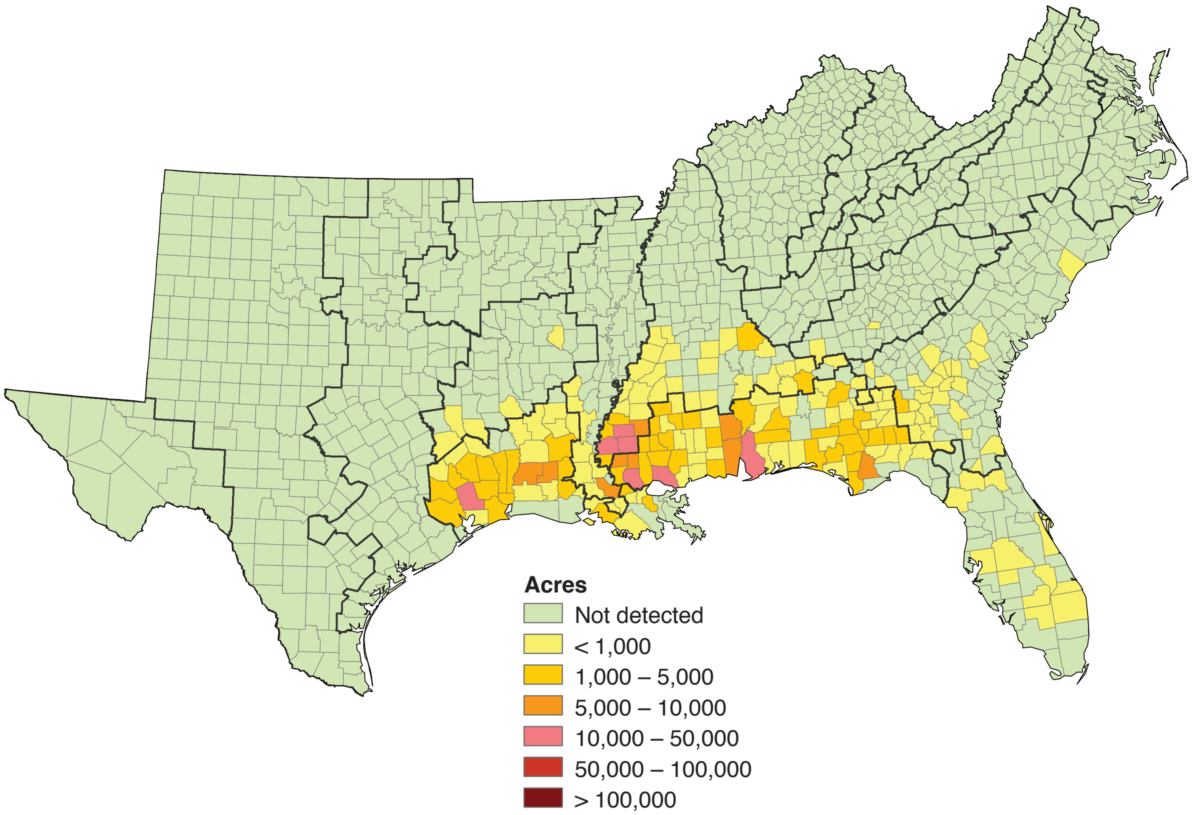


Figure 29—Infestations of Japanese climbing fern, 2010, in the Southern United States (Miller and others 2013) [Source: Southern Region, Forest Inventory and Analysis, U.S. Forest Service. Plants: http://srsfia2.fs.fed.us/SNIPET/. (Date accessed: June 11, 2013)].

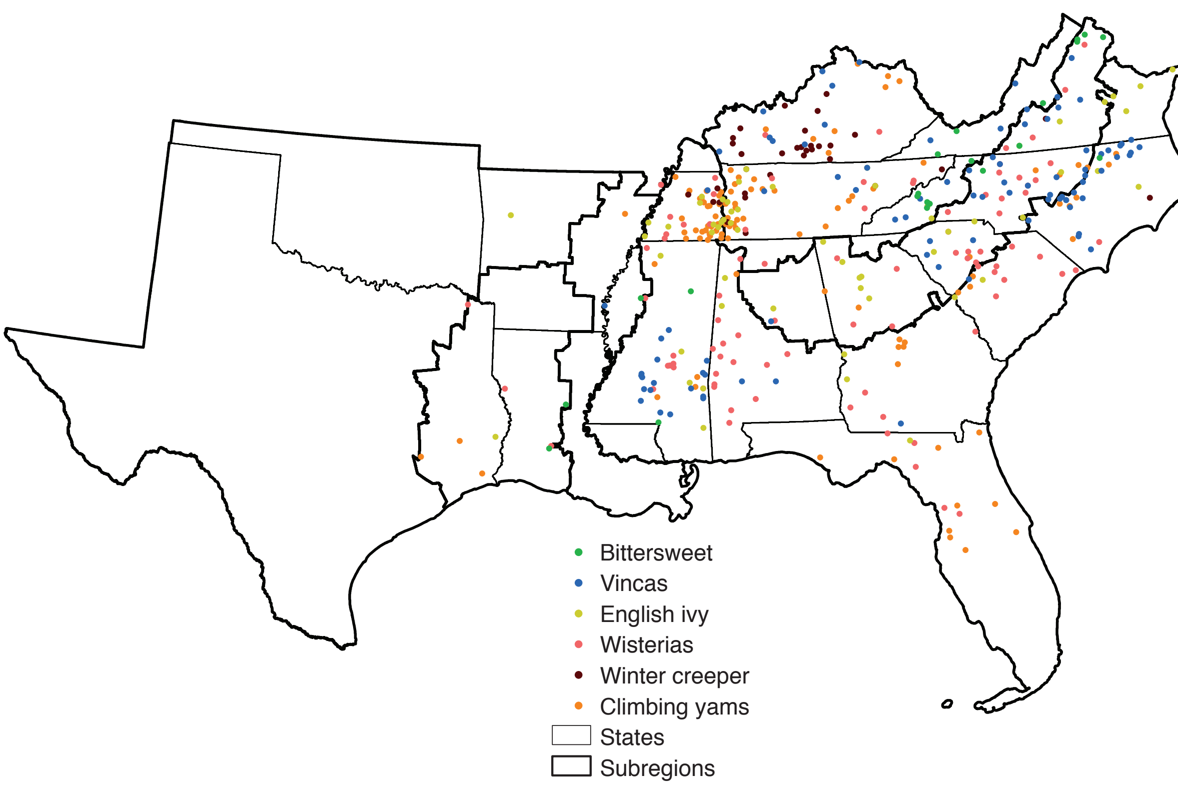


Figure 30—Infestations of invasive vines (oriental bittersweet, wisterias, vincas, winter creeper, ivies, and climbing yam), 2010, in the Southern United States (Miller and others 2013) [Source: Southern Region, Forest Inventory and Analysis, U.S. Forest Service. Plants: http://srsfia2.fs.fed.us/SNIPET/. (Date accessed: June 11, 2013)].

Table 3—Forest community layers and edges prone to be replaced by these species of invasive plants

Overstory replacers	Midstory replacers	Understory and ground-layer replacers	Edge and gap eroders	Persistent infestations in openings (disturbed areas)
Tallowtree	Silktree	Japanese honeysuckle	Silktree	All invasive plants readily establish in openings and disturbed areas
Princesstree	Privets	Bush lespedeza	Chinaberrytree	
Tree-of-heaven	Bush honeysuckles	Sacred bamboo	Privets	
Melaleuca	Invasive elaeagnus	Winged burning bush	Invasive roses	
Brazilian peppertree	Oriental bittersweet	Japanese climbing fern	Tropical soda apple	
Chinaberrytree	Japanese climbing fern	Winter creeper	Invasive lespedezas	
Kudzu	Wisterias	Vincas, Periwinkles	Kudzu	
Wisterias		Invasive ivies	Japanese climbing fern	
Cogongrass		Nepalese browntop	Wisterias	
Bamboos		Cogongrass	Invasive climbing yams	
Old World climbing fern		Garlic mustard	Oriental bittersweet	
			Nonnative ivies	
			Invasive bamboos	
			Cogongrass	
			Nepalese browntop	
			Chinese silvergrass	

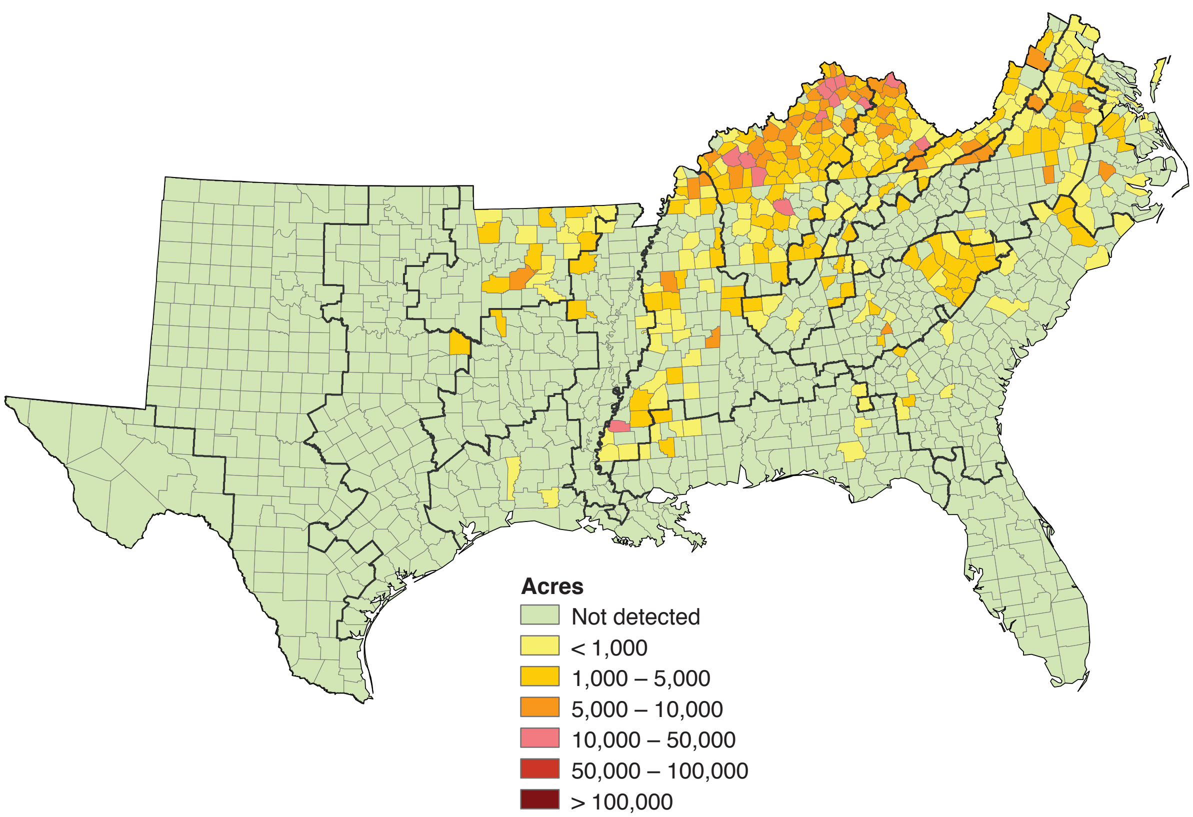


Figure 31—Infestations of tall fescue, 2010, in the Southern United States (Miller and others 2013) [Source: Southern Region, Forest Inventory and Analysis, Southern Research Station, U.S. Forest Service. Plants: http://srsfia2.fs.fed.us/SNIPET/. (Date accessed: June 11, 2013)].

CHAPTER 5.
Effects on Forests and their Values

FOREST CONDITIONS

The Coastal Plain is often described as the "wood basket of the Nation," because of its productive forests, especially pine. With more than triple the growing stock volume of any other subregion in the South, it is not expected to lose the designation anytime soon.

The Eastern Atlantic and Southern Gulf sections support most of the softwood growing stock in the Coastal Plain, and Peninsular Florida supports the least amount (fig. 32). The only subregion in which softwood inventories dominate hardwoods (fig. 32), the Coastal Plain supports 71 percent of the softwood growing stock and 51 percent of the hardwood growing stock in the South. A full 77 percent of southern softwood removals come from the Coastal Plain, demonstrating its importance as a commercial timber producer.

Forecasts of Forest Conditions

As well as describing the effects of urbanization (population and income) and climate (chapter 2), the six Cornerstone Futures (A through F) have underlying assumptions about timber prices that affect forecasts of forest conditions. Two additional Cornerstone Futures (E and F) alter the underlying assumptions about landowner investments in tree planting (Huggett and others 2013, Wear and others 2013a).

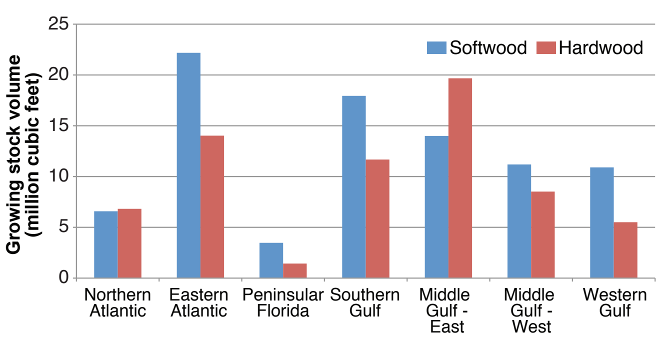


Figure 32—Volume of hardwood and softwood growing stock, 2010, for the seven sections of the U.S. Coastal Plain (Source: U.S. Department of Agriculture Forest Service, Forest Inventory and Analysis).

- **Cornerstone A** is characterized by moderately high population/income growth and increasing timber prices.
- **Cornerstone B** is characterized by moderately high population/income growth and decreasing timber prices.
- **Cornerstone C** is characterized by lower population/income growth and increasing timber prices.
- **Cornerstone D** is characterized by lower population/income growth and decreasing timber prices.
- **Cornerstone E** has the same assumptions as Cornerstone A, but with 50-percent higher tree planting rates than current levels.
- **Cornerstone F** has the same assumptions as Cornerstone D, but with 50-percent lower tree planting rates than current levels.

Timber price futures, which address increasing or decreasing scarcity, assume that real prices will progress upward or downward at an orderly rate of 1 percent per year from the 2005 base through 2060 (the real returns to agricultural crops were held constant throughout the forecasts). Although some new forests could be established through afforestation, more substantial forest-type changes are likely to accrue in response to management choices (reforestation). Cornerstones A through D use historical tree planting rates following harvests (by State and forest type) to forecast future planting. The two additional Cornerstones (E and F) depart from these four by increasing or decreasing planting rates from the baseline.

Under the Cornerstone D prediction of moderate forest loss (Huggett and others 2013), the South would lose as much as 12.2 million acres of private forests, with decreases experienced in all Southern States. Florida, Georgia, and North Carolina—the States with the largest projected increases in population and urbanization—are expected to experience the largest decreases, both in percentages and in absolute terms. At 4 to 6 percent, losses for Alabama, Arkansas, Louisiana, Mississippi, and Texas would be lower than the regional average. Losses under the other Cornerstones would follow the same pattern, albeit to a lesser degree (Wear 2013).

Total growing stock volume in the Coastal Plain is predicted to increase in the next decade under all projections, then level off for the Cornerstones B, C, and F or decrease for the Cornerstones A, C, and E that assume increasing timber prices (fig. 33). Growing stock levels do not drop below 2010 levels for any of the projections. Planted pine area is expected to increase for all Cornerstone Futures, especially E; forest area is expected to decrease for all other forest types (natural pine, oak-pine, upland hardwood, and bottomland hardwood). Under the high planting rates predicted by Cornerstone E, volume in younger age classes is projected to increase for planted pine and decrease for all other forest types, which are forecasted to have increasing volumes in older age classes (fig. 35). However, under a future of lower prices and low planting rates (F), volume in mid-age classes would increase slightly for planted pine and decrease for natural pine. Young oak-pine is projected to decrease.

The Coastal Plain is forecasted to continue functioning as a major sink for forest carbon. Total forest carbon stock is projected to increase over the next two decades, and then either stabilize or decrease for all Cornerstone Futures (fig. 36). The three Cornerstones with decreasing forest carbon stocks are associated with futures with higher rates of urbanization and forest losses. Total removals from growing stock are projected to increase slightly under Cornerstones B, D, and F, and increase substantially under Cornerstones A, C, and E (fig. 37). This same general trend would apply for softwood sawtimber, hardwood sawtimber, and softwood pulpwood.

Beyond concerns about coverage by pine and the attending economic issues, participants in the Coastal Plain public input sessions expressed concern about coastal restoration (and the need to quantify the social and economic benefits of doing so), and the effects of various intensive management activities (such as bedding, ripping, fertilizing, ditching, and burning). Although not addressed specifically here, these are issues warranting further investigation, or at least knowledge syntheses, especially in light of anticipated climate changes and sea-level rise.

Huggett and others (2013) reported on additional projected changes in forest conditions at the county level for the Southern Forest Futures Project.

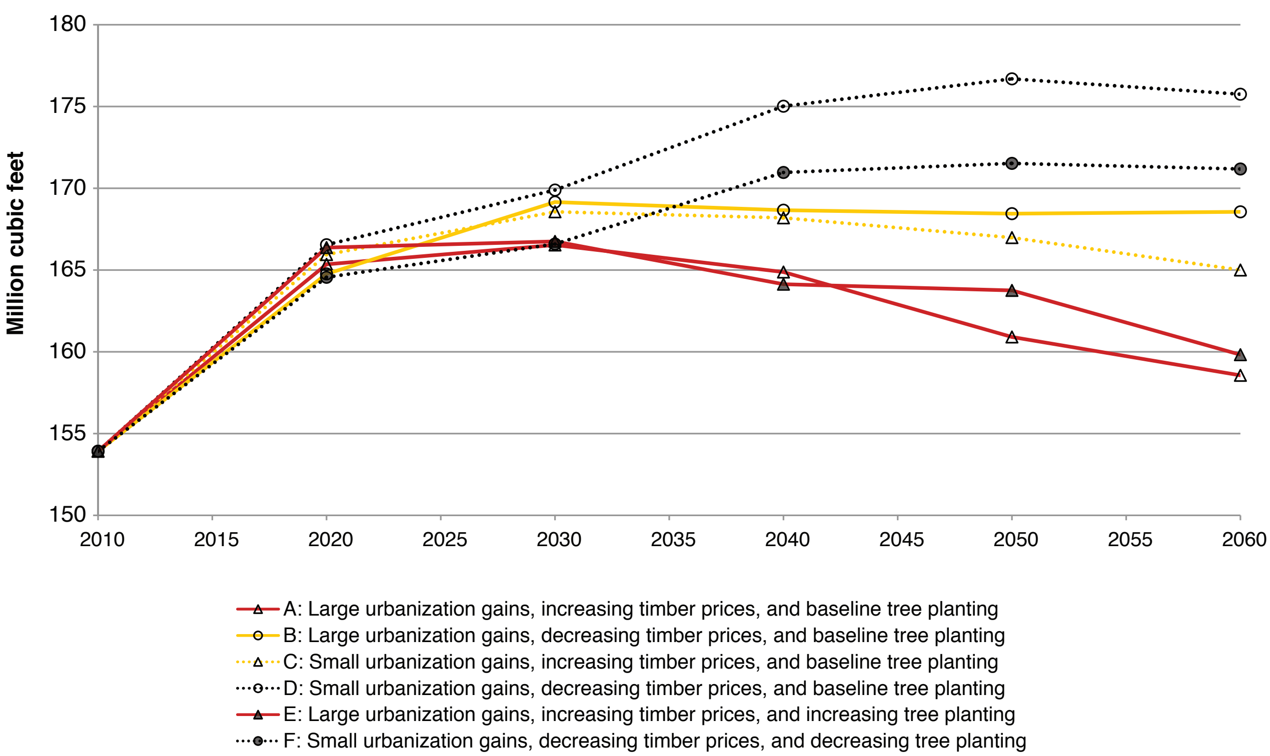


Figure 33—Forecasted growing stock volume, 2010 to 2060, in the U.S. Coastal Plain based on six projections—labeled Cornerstones A through F by the Southern Forest Futures Project—each with a different combination of increasing or decreasing urbanization, timber prices, and tree planting rates (Huggett and others 2013).

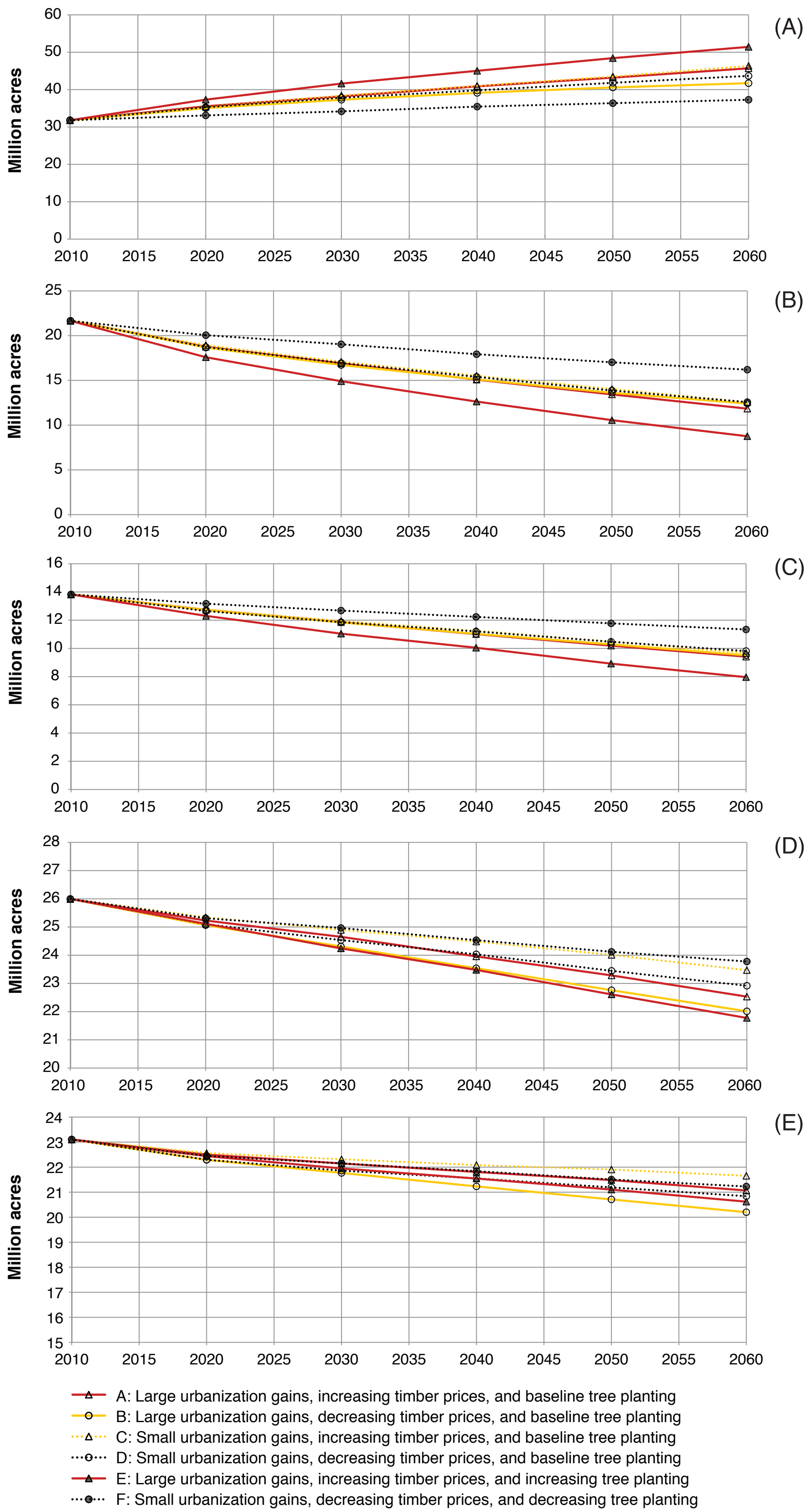


Figure 34—Forecasted forest area, 2010 to 2060, in the U.S. Coastal Plain based on six projections—labeled Cornerstones A through F by the Southern Forest Futures Project—each with a different combination of increasing or decreasing urbanization, timber prices, and tree planting rates for (A) planted pine, (B) natural pine, (C) oak-pine, (D) upland hardwood, and (E) lowland hardwood (Huggett and others 2013).

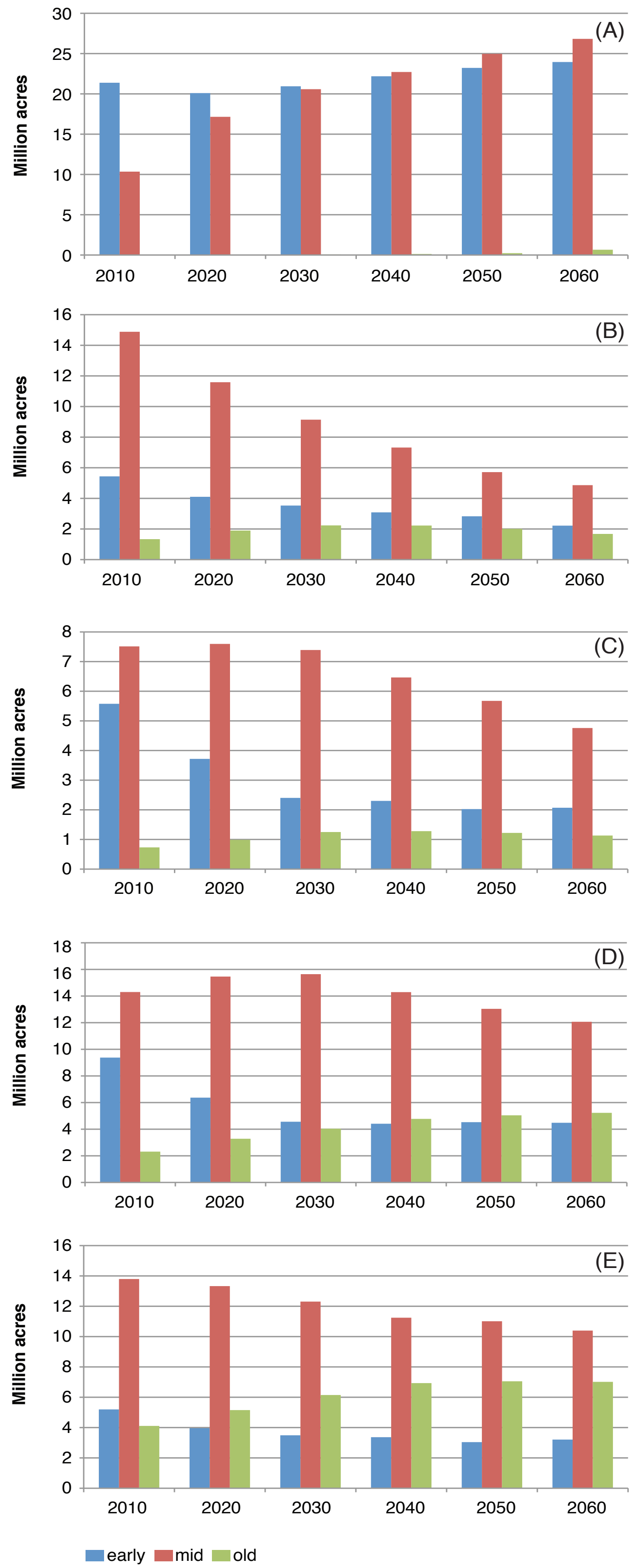


Figure 35—Forecasts of forest age classes, 2010 to 2060, in the U.S. Coastal Plain—assuming large urbanization gains, increasing timber prices, and increased tree planting—for (A) planted pine, (B) natural pine, (C) oak-pine, (D) upland hardwood, and (E) lowland hardwood (Huggett and others 2013).

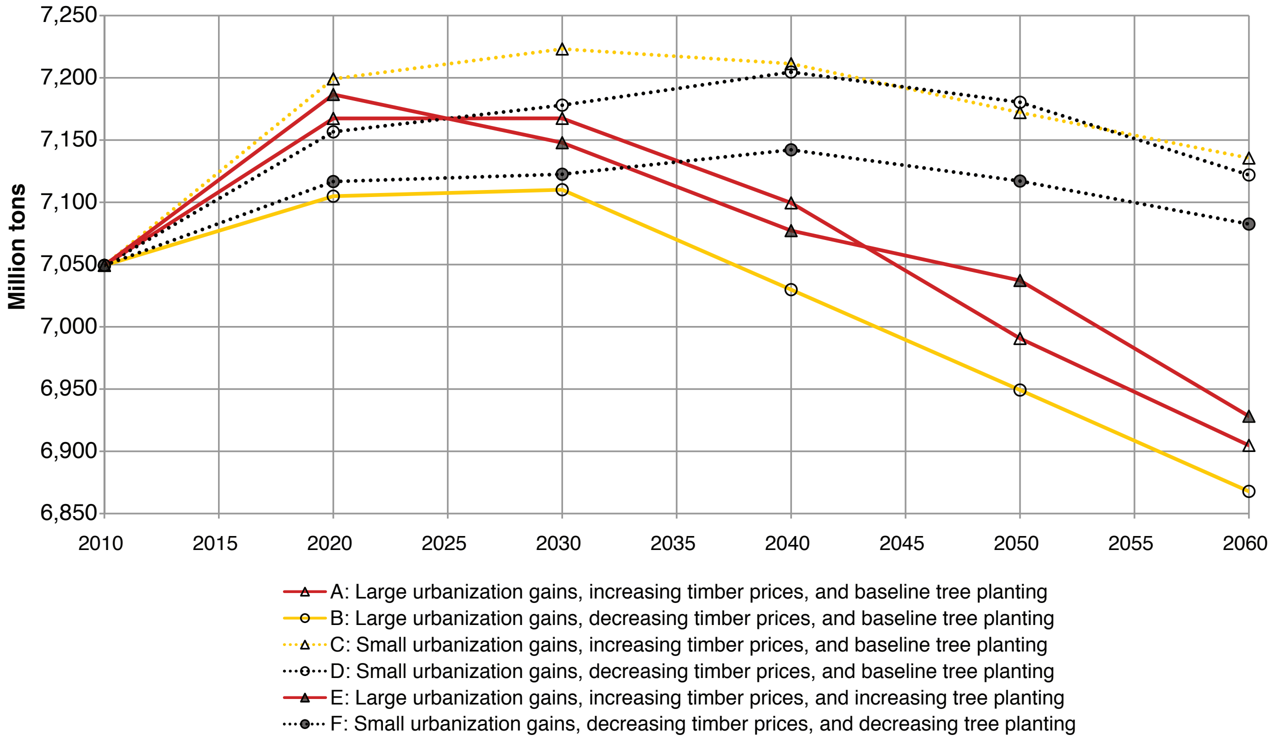


Figure 36—Total forest carbon stock, 2010 to 2060, in the U.S. Coastal Plain based on six projections, each with a different combination of increasing or decreasing urbanization, timber prices, and tree planting rates (Huggett and others 2013).

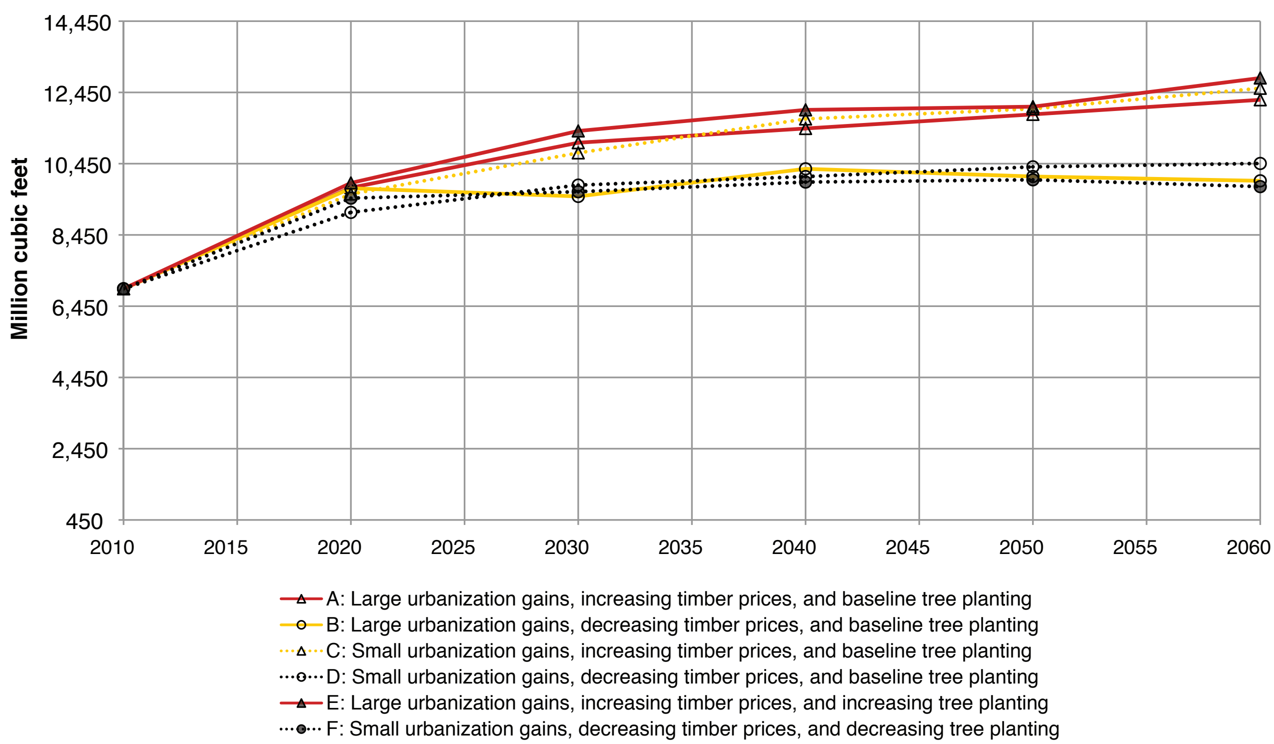


Figure 37—Forecasted total removals from growing stock, 2010 to 2060, in the U.S. Coastal Plain based on six projections—labeled Cornerstones A through F by the Southern Forest Futures Project—each with a different combination of increasing or decreasing urbanization, timber prices, and tree planting rates (Huggett and others 2013).

WILDLIFE

Most of the projections reported by Trani Griep and Collins (2013) for the Southern Forest Futures Project are applicable throughout the region, but some important findings apply specifically to the Coastal Plain. Its high level of wildlife species richness can be attributed to its large geographic area as well as variety of its habitats. Amphibians, in particular, flourish across the Coastal Plain. With 105 species, the Coastal Plain leads the South in overall amphibian richness as well as frog and toad richness. Bird diversity and richness in the South is highest in coastal and wetland forests. Second only to the Mid-South, the Coastal Plain supports more waterfowl, shorebirds, and wading birds than any other subregion. The Coastal Plain ranks second in the number of species in the "other mammal" (all except bats and rodents) and reptile (including the most turtle species) categories.

Diversity and Species Richness

In ecology, diversity is usually thought of as being composed of richness (the number of kinds of things) and evenness (the relative abundance of things). Most commonly these terms are used with reference to species diversity, a concept that includes species richness (the number of species) and species evenness (the relative abundances of the different species). An area with 100 plant species (richness = 100) is considered to be more diverse than an area with only 10 species (richness = 10). But an area with 100 species where each species is reasonably well represented would also be considered more diverse than an area where 99 percent of the plants are a single species and the other species are all very rare.

National Center for Ecological Analysis and Synthesis, https://groups.nceas.ucsb.edu/sun/meetings/calculating-evenness-of-habitat-distributions.

Species richness, however, is threatened, especially in the Coastal Plain and Mid-South, which lead the South in numbers of imperiled vertebrate species. Coastal Plain forests are especially vulnerable to loss of biodiversity and imperiled species because of rising sea levels, changing fire regimes, and expanding urbanization. Of particular concern for the conservation of vertebrate species are Peninsular Florida, the Southern Gulf section, and the coastlines of the Atlantic and Western Gulf sections.

The Coastal Plain also leads the South in Federally listed vertebrates, mostly concentrated in the Peninsular Florida, Southern Gulf, and Eastern Atlantic sections, but also occurring in the Cape Fear area of North Carolina, the tip of Florida, and the coastline from the Florida Panhandle westward to Louisiana. Of the nine threatened or endangered amphibian species, more than half are salamanders in the Coastal Plain and Mid-South (table 4). The Coastal Plain is home to 18 of the 22 threatened or endangered bird species, 20 of the 28 species of endangered or threatened mammal species, and 14 of the 16 threatened or endangered reptile species. Among the threats to wildlife of the Coastal Plain, inundation of mangrove and coastal live oak forests resulting from rising sea levels would reduce habitat for several taxa.

Likewise, the Coastal Plain leads the South in Federally listed vascular plants (table 5). Areas of particular concern include the Apalachicola area of the Southern Gulf section, Lake Wales Ridge and the area south of Lake Okeechobee in Peninsular Florida, and coastal counties of North Carolina in the North Atlantic section (fig. 38). This pattern of endangerment could be attributed to several factors. The first is urban development, which also impacts stopover habitat in the Atlantic Flyway and nesting habitat for imperiled sea turtles along both coastlines and in central Florida. The second is the loss of inland flora; the mixture of vegetation types in the Coastal Plain—from fire-maintained savannas to marshes, swamps, and bottomlands—are home to diversity of species that are at risk from changing fire regimes and other indirect effects of climate change (McNulty and others 2013).

The longleaf pine forest, a fire-maintained ecosystem that once dominated Coastal Plain sites from southern Virginia to eastern Texas, is only at a fraction of its original coverage (<5 percent). An extensive restoration effort is underway, with many forests now managed first for biodiversity and only secondarily for timber yield.

Ongoing efforts to restore longleaf pine are potentially threatened by urbanization. Under Cornerstone A, areas of the Coastal Plain (Virginia southward to Georgia) are projected to lose the majority of their longleaf community by 2060 (fig. 39). Cornerstone B also predicts urbanization as a threat to the range of longleaf pine communities, especially in in the Southern Gulf, Eastern Atlantic, and northern portion of Peninsular Florida. If, as projected, other areas—especially northwestern Alabama and inland areas of southern Florida—experience an expansion of longleaf, associated species could also spread or form new associations.

Projected changes in temperature and precipitation could also affect the distribution, movement, and mortality of many Coastal Plain species. These effects would be multiplied by consequent emergence of novel habitat assemblages and changes in life-cycle events. Some areas are projected to experience multiple forces of change. One example is Peninsular Florida, especially around Palm Beach and Miami, where a 10- to 25-percent increase in urbanization and rising sea levels are projected (Lockaby and others 2013). This diverse and unique area, which includes part of the Everglades, is a

Table 4—Terrestrial vertebrate species that are Federally listed as threatened or endangered in the South (U.S. Department of the Interior 2011)

Scientific name[a]	Common name	ESA[b]	Subregion name	Section[c,d]
AMPHIBIANS				
Frogs and Toads				
Bufo houstonensis	Houston toad	E	Coastal Plain, Mid-South	1_7, 5_2
Rana sevosa	Dusky gopher frog	E	Coastal Plain	1_4
Salamanders				
Eurycea nana	San Marcos salamander	T	Mid-South	5_3
Eurycea rathbuni	Texas blind salamander	E	Mid-South	5_3
Eurycea sosorum	Barton Springs salamander	E	Mid-South	5_3
Plethodon shenandoah	Shenandoah salamander	E	Piedmont, Appalachian-Cumberland	2_1, 3_2
Ambystoma bishopi	Reticulated flatwoods salamander	E	Coastal Plain	1_4
Ambystoma cingulatum	Frosted flatwoods salamander	T	Coastal Plain	1_2, 1_3, 1_4
Phaeognathus hubrichti	Red Hills salamander	T	Coastal Plain	1_4
BIRDS				
Wading Birds				
Grus americana	Whooping crane	E	Coastal Plain, Mid-South	*1_3, 5_2, 5_3*
Grus canadensis pulla	Mississippi sandhill crane	E	Coastal Plain	*1_4*
Raptors				
Falco femoralis septentrionalis	Northern Aplomado falcon	E	Mid-South	5_3
Polyborus plancus audubonii	Audubon's crested caracara	T	Coastal Plain	1_3
Rostrhamus sociabilis plumbeus	Snail kite	E	Coastal Plain	1_3
Shorebirds				
Charadrius melodus	Piping plover	T	Coastal Plain, Mississippi Alluvial Valley, Mid-South	1_1, 1_2, 1_3, 1_4, 1_7, 4_2, 5_2, 5_3
Mycteria americana	Wood stork	E	Coastal Plain, Piedmont	1_2, 1_3, 1_4, 1_5, 2_2
Numenius borealis	Eskimo curlew	E	Coastal Plain, Mid-South	1_2, 5_4
Perching Birds				
Ammodramus maritimus mirabilis	Cape Sable sparrow	E	Coastal Plain	1_3
Ammodramus savannarum floridanus	Florida grasshopper sparrow	E	Coastal Plain	1_3
Aphelocoma coerulescens	Florida scrub-jay	T	Coastal Plain	1_2, 1_3, 1_4
Dendroica chrysoparia	Golden-cheeked warbler	E	Mid-South	5_2, 5_3
Dendroica kirtlandii	Kirtland's warbler	E	Coastal Plain	1_2, 1_3, 1_4
Vermivora bachmanii	Bachman's warbler	E	Coastal Plain, Mid-South, Mississippi Alluvial Valley, Appalachian-Cumberland	1_1, 1_2, 1_4, 1_6, 1_7, 3_5, 4_1, 4_2, 5_2
Vireo atricapilla	Black-capped vireo	E	Mid-South	5_2, 5_3, 5_4
Other Birds				
Campephilus principalis	Ivory-billed woodpecker	E	Coastal Plain, Mississippi Alluvial Valley	1_3, 1_4, 1_6, 4_1

(Continued)

Table 4—(continued) Terrestrial vertebrate species that are Federally listed as threatened or endangered in the South (U.S. Department of the Interior 2011)

Scientific name[a]	Common name	ESA[b]	Subregion name	Section[c,d]
Picoides borealis	Red-cockaded woodpecker	E	Coastal Plain, Piedmont, Appalachian-Cumberland, Mississippi Alluvial Valley, Mid-South	1_1, 1_2, 1_3, 1_4, 1_5, 1_6, 1_7, 2_1, 2_2, 2_3, 3_3, 3_4, 3_5, 4_1, 5_1, 5_2
Sternula antillarum	Least tern	E	Coastal Plain, Mid-South	1_6, 5_1, 5_2, 5_3
Sternula antillarum athalassos	Interior least tern	E	Coastal Plain, Appalachian-Cumberland, Mississippi Alluvial Valley. Mid-South	1_5, 1_6, 1_7, 3_5, 4_1, 4_2, 5_1, 5_2, 5_3
Sterna dougallii dougallii	Roseate tern	E	Coastal Plain	1_2, 1_3
Strix occidentalis lucida	Mexican spotted owl	T	Mid-South	5_4
Tympanuchus cupido attwateri	Attwater's greater prairie chicken	E	Coastal Plain, Mid-South, Mississippi Alluvial Valley	1_7, 5_2, 4_2, 5_2, 5_3
MAMMALS				
Bats				
Corynorhinus townsendii ingens	Ozark big-eared bat	E	Mid-South	5_1
Corynorhinus townsendii virginianus	Virginia big-eared bat	E	Appalachian-Cumberland	3_1, 3_2, 3_4, 3_5
Leptonycteris nivalis	Mexican long-nosed bat	E	Mid-South	5_4
Myotis sodalis	Indiana myotis	E	Coastal Plain, Piedmont, Appalachian-Cumberland, Mid-South	1_5, 2_1, 2_2, 2_3, 3_1, 3_2, 3_3, 3_4, 3_5, 5_1
Myotis grisescens	Gray myotis	E	Coastal Plain, Piedmont, Appalachian-Cumberland, Mississippi Alluvial Valley, Mid-South	1_2, 1_4, 1_5, 2_1, 2_3, 3_1, 3_2, 3_3, 3_4, 3_5, 4_1, 5_1
Rodents				
Glaucomys sabrinus coloratus	Carolina northern flying squirrel	E	Appalachian-Cumberland	3_1
Glaucomys sabrinus fuscus	Virginia northern flying squirrel	E	Appalachian-Cumberland	3_2
Microtus pennsylvanicus dukecampbelli	Duke's salt marsh vole	E	Coastal Plain	1_4
Neotoma floridana smalli	Key Largo woodrat	E	Coastal Plain	1_3
Oryzomys palustris natator	Key Oryzomys	E	Coastal Plain	1_3
Peromyscus gossypinus population 1	Key Largo cotton deermouse	E	Coastal Plain	1_3
Peromyscus polionotus allophrys	Choctawhatchee beach deermouse	E	Coastal Plain	1_4
Peromyscus polionotus ammobates	Alabama beach deermouse	E	Coastal Plain	1_4
Peromyscus polionotus niveiventris	Southeast beach deermouse	T	Coastal Plain	1_3
Peromyscus polionotus peninsularis	St. Andrews beach deermouse	E	Coastal Plain	1_4
Peromyscus polionotus phasma	Anastasia beach deermouse	E	Coastal Plain	1_3
Peromyscus polionotus trissyllepsis	Perdido Key beach deermouse	E	Coastal Plain	1_4
Sciurus niger cinereus	Delmarva fox squirrel	E	Coastal Plain	1_1
Carnivores				
Canis rufus	Red wolf	E	Coastal Plain	1_2, 1_4
Leopardus pardalis	Ocelot	E	Mid-South	5_3
Puma concolor coryi	Florida panther	E	Coastal Plain	1_3
Puma concolor (all except *coryi*)	Mountain lion	SAT	Mid-South	5_2, 5_3, 5_4

(Continued)

Table 4—(continued) Terrestrial vertebrate species that are Federally listed as threatened or endangered in the South (U.S. Department of the Interior 2011)

Scientific name[a]	Common name	ESA[b]	Subregion name	Section[c,d]
Puma yagouaroundi cacomitli	Gulf Coast jaguarundi	E	Mid-South	5_2, 5_3
Ursus americanus	American black bear	SAT	Coastal Plain, Mid-South	1_5, 5_4
Ursus americanus luteolus	Louisiana black bear	T	Coastal Plain, Mississippi Alluvial Valley	1_4, 1_5, 1_7, 4_1, 4_2
Other Mammals				
Odocoileus virginianus clavium	Key deer	E	Coastal Plain	1_3
Sylvilagus palustris hefneri	Lower Keys rabbit	E	Coastal Plain	1_3
Trichechus manatus	West Indian manatee	E	Coastal Plain, Mississippi Alluvial Valley	1_1, 1_2, 1_3, 1_4, 4_2
REPTILES				
Crocodilians				
Alligator mississippiensis	American alligator	SAT	Coastal Plain, Mississippi Alluvial Valley, Mid-South	1_1, 1_2, 1_3, 1_4, 1_5, 1_6, 4_1, 5_1
Crocodylus acutus	American crocodile	T	Coastal Plain	1_3
Snakes				
Drymarchon couperi	Eastern indigo snake	T	Coastal Plain	1_2, 1_3, 1_4
Nerodia clarkii taeniata	Atlantic saltmarsh snake	T	Coastal Plain	1_3
Nerodia paucimaculata	Concho watersnake	T	Mid-South	5_2, 5_3
Turtles				
Caretta caretta	Loggerhead	T	Coastal Plain, Mississippi Alluvial Valley, Mid-South	1_1, 1_2, 1_3, 1_4, 4_2, 5_2, 5_3
Chelonia mydas	Green turtle	E[e]	Coastal Plain	1_1, 1_2, 1_3, 1_4
Dermochelys coriacea	Leatherback	E	Coastal Plain	1_1, 1_2, 1_3
Eretmochelys imbricata	Hawksbill	E	Coastal Plain	1_1, 1_3
Glyptemys muhlenbergii	Bog turtle	T	Piedmont, Appalachian-Cumberland	2_1, 2_2, 3_1
Gopherus polyphemus	Gopher tortoise	T	Coastal Plain, Piedmont	1_2, 1_3, 1_4, 1_5, 2_2
Graptemys flavimaculata	Yellow-blotched map turtle	T	Coastal Plain	1_4, 1_5
Graptemys oculifera	Ringed map turtle	T	Coastal Plain	1_4, 1_5
Lepidochelys kempii	Kemp's Ridley sea turtle	E	Coastal Plain, Mid-South, Mississippi Alluvial Valley	1_1, 1_2, 1_3, 1_4, 4_2, 5_3
Pseudemys alabamensis	Alabama redbelly turtle	E	Coastal Plain	1_4
Sternotherus depressus	Flattened musk turtle	T	Coastal Plain, Piedmont	1_5, 2_3

[a]Names follow NatureServe (2011).
[b]T = Threatened; E = Endangered; SAT = Similarity of Appearance to a Threatened taxon.
[c]Location data from NatureServe (2010).
[d]1_1 (Northern Atlantic); 1_2 (Eastern Atlantic); 1_3 (Peninsular Florida); 1_4 (Southern Gulf); 1_5 (Middle Gulf-Eastern); 1_6 (Middle Gulf-Western); 1_7 (Western Gulf); 2_1 (Central Appalachian Piedmont); 2_2 (Southern Appalachian Piedmont); 2_3 (Piedmont Ridge, Valley and Plateau); 3_1 (Blue Ridge); 3_2 (Northern Ridge and Valley); 3_3 (Southern Ridge and Valley); 3_4 (Cumberland Plateau and Mountain); 3_5 (Interior Low Plateau); 4_1 (Holocene Deposits); 4_2 (Deltaic Plain); 5_1 (Ozark-Ouachita Highlands); 5_2 (Cross Timbers); 5_3 (High Plains); 5_4 (West Texas Basin and Range).
[e]Listed endangered in the breeding colony population in Florida; threatened elsewhere.

Table 5—Vascular plant species that are Federally listed as threatened or endangered in the South (U.S. Department of the Interior 2011)

Scientific name[a]	Common name	ESA[b]	Subregion name	Section[c,d]
Ferns and Relatives				
Asplenium scolopendrium var. *americanum*	Hart's-tongue Fern	T	Appalachian-Cumberland	3_4, 3_5
Isoetes louisianensis	Louisiana Quillwort	E	Coastal Plain	1_4
Isoetes melanospora	Black-spored Quillwort	E	Piedmont	2_2
Isoetes tegetiformans	Merlin's-grass	E	Piedmont	2_2
Conifers and Relatives				
Torreya taxifolia	Florida Torreya	E	Coastal Plain, Piedmont	1_4, 2_2
Flowering Plants				
Graminoids				
Carex lutea	Sulphur Sedge	E	Coastal Plain	1_2
Scirpus ancistrochaetus	Northeastern Bulrush	E	Appalachian-Cumberland	3_2
Zizania texana	Texas Wild Rice	E	Mid-South	5_3
Cacti				
Astrophytum asterias	Star Cactus	E	Mid-South	5_3
Coryphantha scheeri var. *robustispina*	Pima Pineapple Cactus	E	Mid-South	5_4
Echinocereus chisoensis var. *chisoensis*	Chisos Hedgehog Cactus	T	Mid-South	5_2, 5_3, 5_4
Echinocereus viridiflorus var. *davisii*	Davis' Green Pitaya	E	Mid-South	5_4
Escobaria minima	Nellie Cory Cactus	E	Mid-South	5_4
Escobaria sneedii var. *sneedii*	Sneed Pincushion Cactus	E	Mid-South	5_4
Harrisia fragrans	Fragrant Prickly-apple	E	Coastal Plain	1_3
Pilosocereus robinii	Key Tree Cactus	E	Coastal Plain	1_3
Sclerocactus brevihamatus ssp. *tobuschii*	Shorthook Fishhook Cactus	E	Mid-South	5_3, 5_4
Sclerocactus mariposensis	Lloyd's Mariposa Cactus	T	Mid-South	5_4
Vines				
Apios priceana	Price's Potato-bean	T	Coastal Plain, Piedmont, Appalachian-Cumberland	1_5, 2_3, 3_4, 3_5
Bonamia grandiflora	Florida Lady's-nightcap	T	Coastal Plain	1_3
Clematis morefieldii	Morefield's Leatherflower	E	Appalachian-Cumberland	3_4, 3_5
Clematis socialis	Alabama Leather-flower	E	Piedmont	2_3
Cucurbita okeechobeensis	Okeechobee Gourd	E	Coastal Plain	1_3
Galactia smallii	Small's Milkpea	E	Coastal Plain	1_3
Jacquemontia reclinata	Reclined Clustervine	E	Coastal Plain	1_3
Herbs				
Abronia macrocarpa	Large-fruit Sand-verbena	E	Mid-South	5_2
Aeschynomene virginica	Sensitive Joint-vetch	T	Coastal Plain, Piedmont	1_1, 2_1
Amaranthus pumilus	Seabeach Amaranth	T	Coastal Plain	1_1, 1_2
Ambrosia cheiranthifolia	South Texas Ragweed	E	Mid-South	5_2
Amorpha herbacea var. *crenulata*	Crenulate Leadplant	E	Coastal Plain	1_3
Amphianthus pusillus	Little Amphianthus	T	Piedmont	2_1, 2_2
Arabis perstellata	Braun's Rockcress	E	Appalachian-Cumberland	3_5
Arabis serotina	Shalebarren Rockcress	E	Appalachian-Cumberland	3_2
Astragalus bibullatus	Pyne's Ground-plum	E	Appalachian-Cumberland	3_5
Baptisia arachnifera	Hairy Rattleweed	E	Coastal Plain	1_2
Callirhoe scabriuscula	Texas Poppy-mallow	E	Mid-South	5_3

(Continued)

Table 5—(continued) Vascular plant species that are Federally listed as threatened or endangered in the South (U.S. Department of the Interior 2011)

Scientific name[a]	Common name	ESA[b]	Subregion name	Section[c,d]
Campanula robinsiae	Robins' Bellflower	E	Coastal Plain	1_3
Cardamine micranthera	Small-anther Bittercress	E	Piedmont	2_1
Chamaesyce deltoidea ssp. *adhaerens*	Wedge Spurge	E	Coastal Plain	1_3
Chamaesyce garberi	Garber's Spurge	T	Coastal Plain	1_3
Chrysopsis floridana	Florida Goldenaster	E	Coastal Plain	1_3
Clitoria fragrans	Pigeon Wings	T	Coastal Plain	1_3
Crotalaria avonensis	Avon Park Rabbit-bells	E	Coastal Plain	1_3
Cryptantha crassipes	Terlingua Creek Cat's-eye	E	Mid-South	5_4
Dalea foliosa	Leafy Prairie-clover	E	Coastal Plain, Appalachian-Cumberland	1_5, 3_5
Echinacea laevigata	Smooth Purple Coneflower	E	Coastal Plain, Piedmont, Appalachian-Cumberland	1_2, 2_1, 2_2, 3_1, 3_2
Echinacea tennesseensis	Tennessee Coneflower	E	Appalachian-Cumberland	3_5
Eriogonum longifolium var. *gnaphalifolium*	Scrub Wild Buckwheat	T	Coastal Plain	1_3
Eryngium cuneifolium	Wedgeleaf Button-snakeroot	E	Coastal Plain	1_3
Euphorbia telephioides	Telephus Spurge	T	Coastal Plain	1_4
Geocarpon minimum	Tiny Tim	T	Coastal Plain, Mid-South	1_6, 1_7, 5_1
Geum radiatum	Spreading Avens	E	Appalachian-Cumberland	3_1
Halophila johnsonii	Johnson's Sea-grass	T	Coastal Plain	1_3
Harperocallis flava	Harper's Beauty	E	Coastal Plain	1_4
Helenium virginicum	Virginia Sneezeweed	T	Appalachian-Cumberland	3_2
Helianthus paradoxus	Pecos Sunflower	T	Mid-South	5_4
Helianthus schweinitzii	Schweinitz's Sunflower	E	Piedmont	2_1, 2_2
Helonias bullata	Swamp-pink	T	Coastal Plain, Piedmont, Appalachian-Cumberland	1_1, 2_2, 3_1, 3_2
Hexastylis naniflora	Dwarf-flower Heartleaf	T	Piedmont, Appalachian-Cumberland	2_1, 2_2, 3_1
Hoffmannseggia tenella	Slender Rushpea	E	Mid-South	5_2
Houstonia purpurea var. *montana*	Mountain Bluet	E	Appalachian-Cumberland	3_1
Hymenoxys texana	Prairie Dawn	E	Coastal Plain, Mid-South	1_7, 5_2
Hypericum cumulicola	Highlands Scrub St. John's-wort	E	Coastal Plain	1_3
Iliamna corei	Peters Mountain Mallow	E	Appalachian-Cumberland	3_2
Isotria medeoloides	Small Whorled Pogonia	T	Coastal Plain, Piedmont, Appalachian-Cumberland	1_1, 2_1, 2_2, 3_1, 3_2, 3_3, 3_4
Justicia cooleyi	Cooley's Water-willow	E	Coastal Plain	1_3
Lesquerella filiformis	Missouri Bladderpod	T	Mid-South	5_1
Lesquerella lyrata	Lyrate Bladderpod	T	Coastal Plain, Appalachian-Cumberland	1_5, 3_5
Lesquerella pallida	White Bladderpod	E	Coastal Plain	1_7
Lesquerella perforata	Spring Creek Bladderpod	E	Appalachian-Cumberland	3_5
Lesquerella thamnophila	Zapata Bladderpod	E	Mid-South	5_3
Liatris helleri	Heller's Blazingstar	T	Appalachian-Cumberland	3_1
Liatris ohlingerae	Florida Gayfeather	E	Coastal Plain	1_3
Lupinus westianus var. *aridorum*	Scrub Lupine	E	Coastal Plain	1_3

(Continued)

Table 5—(continued) Vascular plant species that are Federally listed as threatened or endangered in the South (U.S. Department of the Interior 2011)

Scientific name[a]	Common name	ESA[b]	Subregion name	Section[c,d]
Lysimachia asperulifolia	Roughleaf Loosestrife	E	Coastal Plain	1_1, 1_2
Manihot walkerae	Walker's Manihot	E	Mid-South	5_3
Marshallia mohrii	Mohr's Barbara's-buttons	T	Coastal Plain, Piedmont	1_5, 2_3
Minuartia cumberlandensis	Cumberland Sandwort	E	Appalachian-Cumberland	3_4, 3_5
Nolina brittoniana	Britton's Bear-grass	E	Coastal Plain	1_3
Oxypolis canbyi	Canby's Dropwort	E	Coastal Plain	1_2, 1_4
Phlox nivalis ssp. *texensis*	Texas Trailing Phlox	E	Coastal Plain	1_7
Pinguicula ionantha	Violet-flowered Butterwort	T	Coastal Plain	1_4
Pityopsis ruthii	Ruth's Silk-grass	E	Appalachian-Cumberland	3_1
Platanthera leucophaea	Eastern Prairie White-fringed Orchid	T	Appalachian-Cumberland	3_2
Platanthera praeclara	Western Prairie White-fringed Orchid	T	Mid-South	5_2
Polygala lewtonii	Lewton's Polygala	E	Coastal Plain	1_3
Polygala smallii	Tiny Polygala	E	Coastal Plain	1_3
Polygonella basiramia	Wireweed	E	Coastal Plain	1_3
Polygonella myriophylla	Small's Jointweed	E	Coastal Plain	1_3
Potamogeton clystocarpus	Little Aguja Pondweed	E	Mid-South	5_4
Ptilimnium nodosum	Harperella	E	Coastal Plain, Piedmont, Mid-South	1_2, 2_1, 2_2, 2_3, 5_1
Sagittaria fasciculata	Bunched Arrowhead	E	Piedmont, Appalachian-Cumberland	2_2, 3_1
Sagittaria secundifolia	Little River Arrowhead	T	Piedmont	2_2, 2_3
Sarracenia oreophila	Green Pitcherplant	E	Piedmont, Appalachian-Cumberland	2_3, 3_1, 3_4
Sarracenia rubra ssp. *alabamensis*	Alabama Canebrake Pitcherplant	E	Coastal Plain	1_5
Sarracenia rubra ssp. *jonesii*	Mountain Sweet Pitcherplant	E	Piedmont, Appalachian-Cumberland	2_2, 3_1
Schwalbea americana	Chaffseed	E	Coastal Plain	1_2, 1_4, 1_7
Scutellaria floridana	Florida Skullcap	T	Coastal Plain	1_4
Scutellaria montana	Large-flower Skullcap	T	Piedmont, Appalachian-Cumberland	2_3, 3_3, 3_4
Silene polypetala	Fringed Campion	E	Coastal Plain, Piedmont	1_2, 1_4, 2_2
Sisyrinchium dichotomum	Reflexed Blue-eyed-grass	E	Piedmont, Appalachian-Cumberland	2_1, 2_2, 3_1
Solidago albopilosa	White-haired Goldenrod	T	Appalachian-Cumberland	3_4, 3_5
Solidago shortii	Short's Goldenrod	E	Appalachian-Cumberland	3_5
Solidago spithamaea	Blue Ridge Goldenrod	T	Appalachian-Cumberland	3_1
Spigelia gentianoides	Gentian Pinkroot	E	Coastal Plain	1_4
Spiranthes parksii	Navasota Ladies'-tresses	E	Coastal Plain, Mid-South	1_7, 5_2
Thalictrum cooleyi	Cooley's Meadowrue	E	Coastal Plain	1_2, 1_4
Thymophylla tephroleuca	Ashy Dogweed	E	Mid-South	5_3
Trifolium stoloniferum	Running Buffalo Clover	E	Appalachian-Cumberland	3_4, 3_5
Trillium persistens	Persistent Trillium	E	Piedmont, Appalachian-Cumberland	2_2, 3_1
Trillium reliquum	Relict Trillium	E	Coastal Plain, Piedmont	1_2, 1_4, 1_5, 2_2

(Continued)

Table 5—(continued) Vascular plant species that are Federally listed as threatened or endangered in the South (U.S. Department of the Interior 2011)

Scientific name[a]	Common name	ESA[b]	Subregion name	Section[c,d]
Warea amplexifolia	Wide-leaf Warea	E	Coastal Plain	1_3
Warea carteri	Carter's Mustard	E	Coastal Plain	1_3
Xyris tennesseensis	Tennessee Yellow-eyed-grass	E	Coastal Plain, Piedmont, Appalachian-Cumberland	1_5, 2_3, 3_5
Trees and Shrubs				
Asimina tetramera	Four-petal Pawpaw	E	Coastal Plain	1_3
Ayenia limitaris	Texas Ayenia	E	Mid-South	5_3
Betula uber	Virginia Roundleaf Birch	T	Appalachian-Cumberland	3_2
Chionanthus pygmaeus	Pygmy Fringetree	E	Coastal Plain	1_1
Conradina brevifolia	Shortleaf Rosemary	E	Coastal Plain	1_3
Conradina etonia	Etonia Rosemary	E	Coastal Plain	1_3
Conradina glabra	Apalachicola Rosemary	E	Coastal Plain	1_4
Conradina verticillata	Cumberland False Rosemary	T	Appalachian-Cumberland	3_4
Deeringothamnus pulchellus	Beautiful Pawpaw	E	Coastal Plain	1_3
Deeringothamnus rugelii	Rugel's Pawpaw	E	Coastal Plain	1_3
Dicerandra christmanii	Yellow Scrub Balm	E	Coastal Plain	1_3
Dicerandra cornutissima	Longspurred Mint	E	Coastal Plain	1_3
Dicerandra frutescens	Scrub Mint	E	Coastal Plain	1_3
Dicerandra immaculata	Lakela's Mint	E	Coastal Plain	1_3
Frankenia johnstonii	Johnston's Frankenia	E	Mid-South	5_3
Hudsonia montana	Mountain Golden-heather	T	Appalachian-Cumberland	3_1
Lindera melissifolia	Pondberry	E	Coastal Plain, Mississippi Alluvial Valley	1_1, 1_2, 1_4, 1_6, 4_1
Prunus geniculata	Scrub Plum	E	Coastal Plain	1_3
Quercus hinckleyi	Hinckley's Oak	T	Mid-South	5_4
Rhododendron chapmanii	Chapman's Rhododendron	E	Coastal Plain	1_3, 1_4
Rhus michauxii	Michaux's Sumac	E	Coastal Plain, Piedmont	1_2, 2_1, 2_2,
Ribes echinellum	Miccosukee Gooseberry	T	Coastal Plain, Piedmont	1_4, 2_2
Spiraea virginiana	Virginia Spiraea	T	Piedmont, Appalachian-Cumberland	2_3, 3_1, 3_3, 3_4, 3_5
Styrax platanifolius ssp. *texanus*	Texas Snowbell	E	Mid-South	5_3, 5_4
Ziziphus celata	Scrub Ziziphus	E	Coastal Plain	1_3

[a]Species names follow USDA NRCS Plants Database (2010).
[b]T = Threatened; E = Endangered; SAT = Similarity of Appearance to a threatened taxon.
[c]Location data from NatureServe (2010).
[d]1_1 (Northern Atlantic); 1_2 (Eastern Atlantic); 1_3 (Peninsular Florida); 1_4 (Southern Gulf); 1_5 (Middle Gulf-Eastern); 1_6 (Middle Gulf-Western); 1_7 (Western Gulf); 2_1 (Central Appalachian Piedmont); 2_2 (Southern Appalachian Piedmont); 2_3 (Piedmont Ridge, Valley and Plateau); 3_1 (Blue Ridge); 3_2 (Northern Ridge and Valley); 3_3 (Southern Ridge and Valley); 3_4 (Cumberland Plateau and Mountain); 3_5 (Interior Low Plateau); 4_1 (Holocene Deposits); 4_2 (Deltaic Plain); 5_1 (Ozark-Ouachita Highlands); 5_2 (Cross Timbers); 5_3 (High Plains); 5_4 (West Texas Basin and Range).

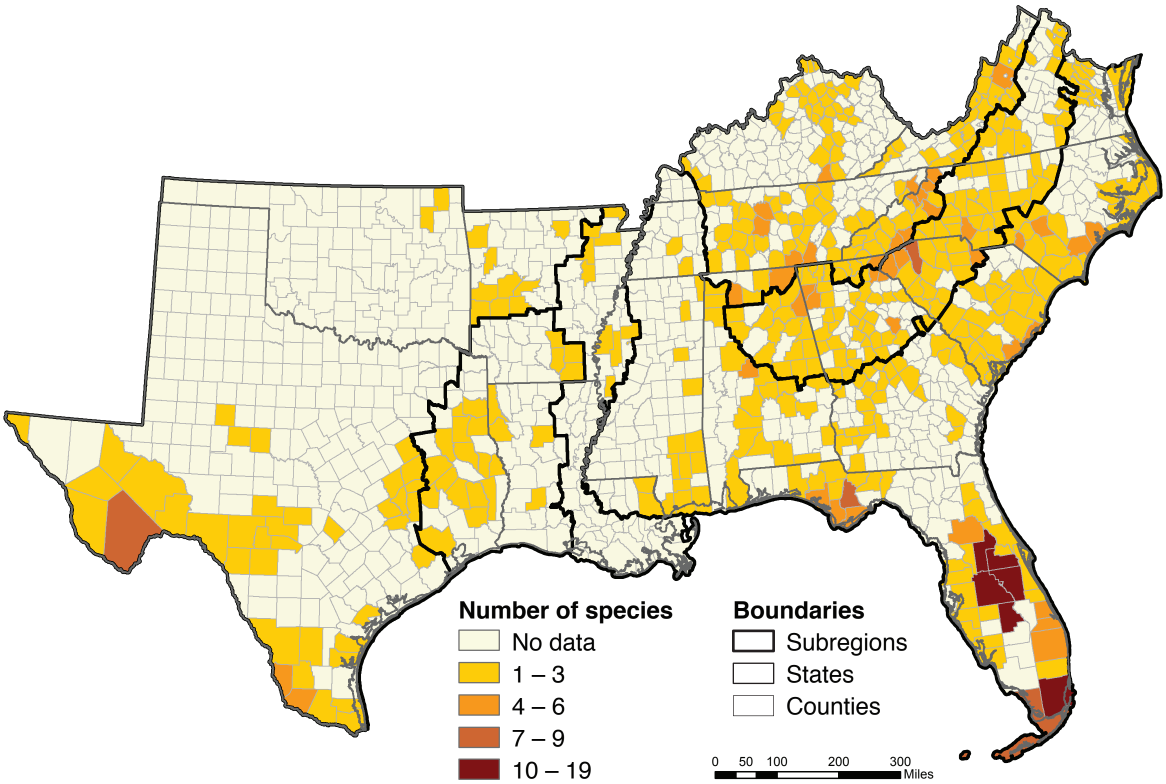


Figure 38—County-level counts for Federally listed vascular plant species in the Southern United States (Trani Griep and Collins 2013).

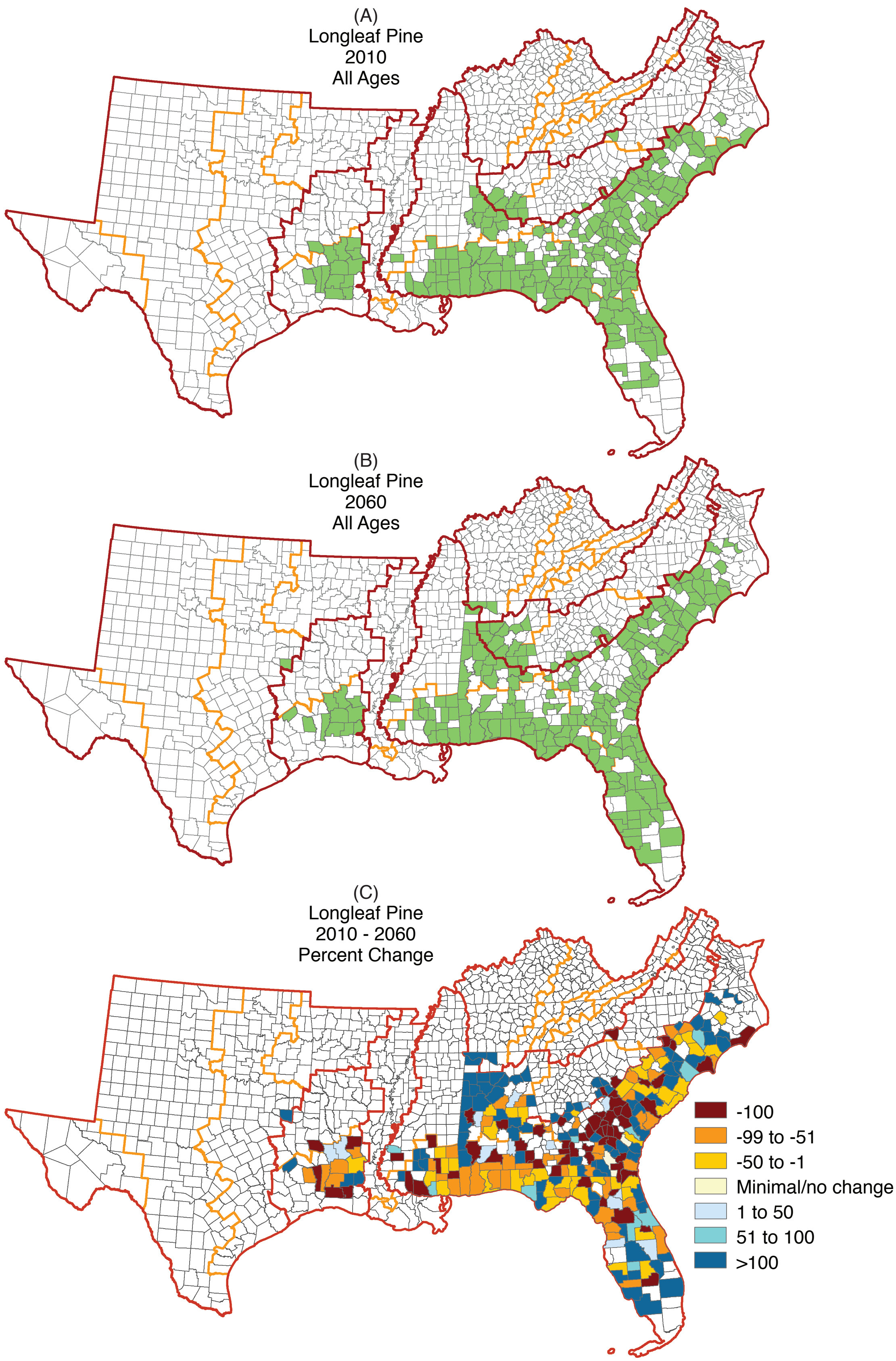


Figure 39—Assuming a future of high-urbanization and high-timber prices, (A) longleaf pine distribution in 2010 (shaded green), (B) longleaf pine distribution in 2060 (shaded green), and (C) change in longleaf pine distribution from 2010 to 2060 (Trani Griep and Collins 2013).

mixture of pine forests, hammocks, beach dune and strand, prairies, cypress swamps, mangroves, and freshwater and saltwater marshes. The combination of urban growth and sea-level rise would have drastic consequences for plants, birds, and amphibians, many of which are species of concern. Another example is the Southern Gulf, which is projected to experience a 3- to 25-percent increase in urban growth with concomitant forest loss; near-coastal areas, especially in Louisiana, are also threatened by the direct and indirect effects of sea-level rise.

WATER

Continuous abundance of fresh water is enormously important to the sustainability of productive forests and thriving communities in the South. In addition, proximity to the Atlantic Ocean and Gulf of Mexico has given rise to growing coastal cities and a well-established beach economy. The southwide analyses of water issues conducted by the Southern Forest Futures Project (Lockaby and others 2013) generally apply to all subregions, but some have particular application to key areas in the Coastal Plain. Largely because of the interactions of biological and physical controls on hydrologic processes, climate change is predicted to impact southern water resources both directly and indirectly.

Impacts on Fresh Water

Increased urbanization, forecasted to be especially focused in the Piedmont and in upper Coastal Plain areas, could have far-reaching direct effects on hydrology and water quality in downstream Coastal Plain watersheds. During public input sessions, participants voiced concern about such effects, particularly with respect to the pollutant-filtration benefits of forested lands and the potential impacts of limited water supplies, on irrigation and impacts on aquifers.

Intensive forest management may impact shallow ground water recharge in some areas of the Coastal Plain under certain scenarios. For example, projected increases in plantations of pines (Wear and others 2013b), combined with greater demand from a shrinking forest land base and emerging wood fiber markets for bioenergy (described further) would mean an increase in management intensity. This projected increased acreage of fast-growing short-rotation species for bioenergy production could reduce water yield in some watersheds, at least until the next harvest.

Under all Cornerstone Futures, water stress would increase by 2050. These projections are largely based on predicted increases in temperature, leading to increased evapotranspiration by plants, and to some extent, decreased precipitation in some areas. Water stress in the Coastal Plain is projected to increase via a variety of interactions. By 2050 the combination of population growth and land use change is expected to increase water stress by 10 percent, with particular intensity for watersheds in southern Florida and along the Gulf of Mexico. Even absent climatic effects, population growth alone could increase water stress by as much as 50 percent in much of the Coastal Plain and from 50 to 100 percent in the Florida Panhandle (fig. 40).

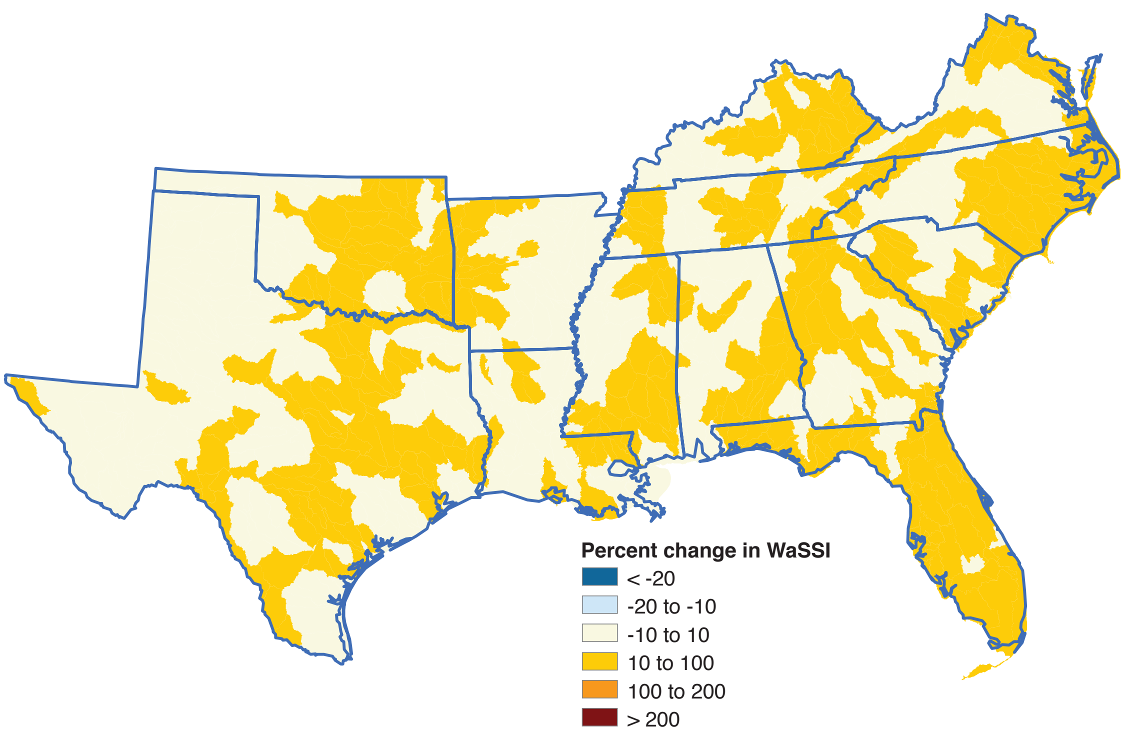


Figure 40—Change in water supply stress, 2050, caused by population change in the Southern United States (Lockaby and others 2013); water stress is defined by the Water Supply Stress Index (WaSSI) and calculated by dividing water supply into water demand.

Rising Sea Level

Direct effects of climate change are especially likely on about 5,000 miles of highly vulnerable southern coastline and were identified as a concern for the Coastal Plain during the public input sessions. Sea-level rise would have cascading effects on forests and wildlife in coastal watersheds. The availability of saltwater-tolerant species for restoration and conservation efforts was identified as a key issue by the public, and is a key concern for residents of the Coastal Plain. A projected sea-level rise of 1.5 m would impact about 1.6 million acres of forests along the Atlantic Coast and about 2.1 million acres of forests along the Gulf Coast (McNulty and others 2013 and table 6). North Carolina, Virginia, Louisiana, and Texas have the most coastal areas in the highest risk class (fig. 41). Detailed projections of sea-level changes can help managers prioritize areas of the coastline for monitoring and management (fig. 42). For example, the coastline along the Gulf of Mexico is in the high-risk category (<1.5 m) in Louisiana but only in the moderate risk category in Florida (<200 miles away).

Table 6—Estimates of rise in the sea level by the end of the 21st century

Author	Estimated rise	Model characteristics
Parry and others 2007	0.28 m to 0.43 m	Excludes dynamic ice changes
Rahsmorf 2007	0.5 m to 1.4 m	Semi-empirical (relationship: sea-level rise and surface temperature)
Soloman and others 2009	0.4 m to 1.9 m	Limited to oceanic thermal expansion
	Could increase above estimate by several meters	Includes glacier melts and ice sheet melts
McCullen and Jabbour 2009	0.8 m to 2.0 m	Includes ice changes

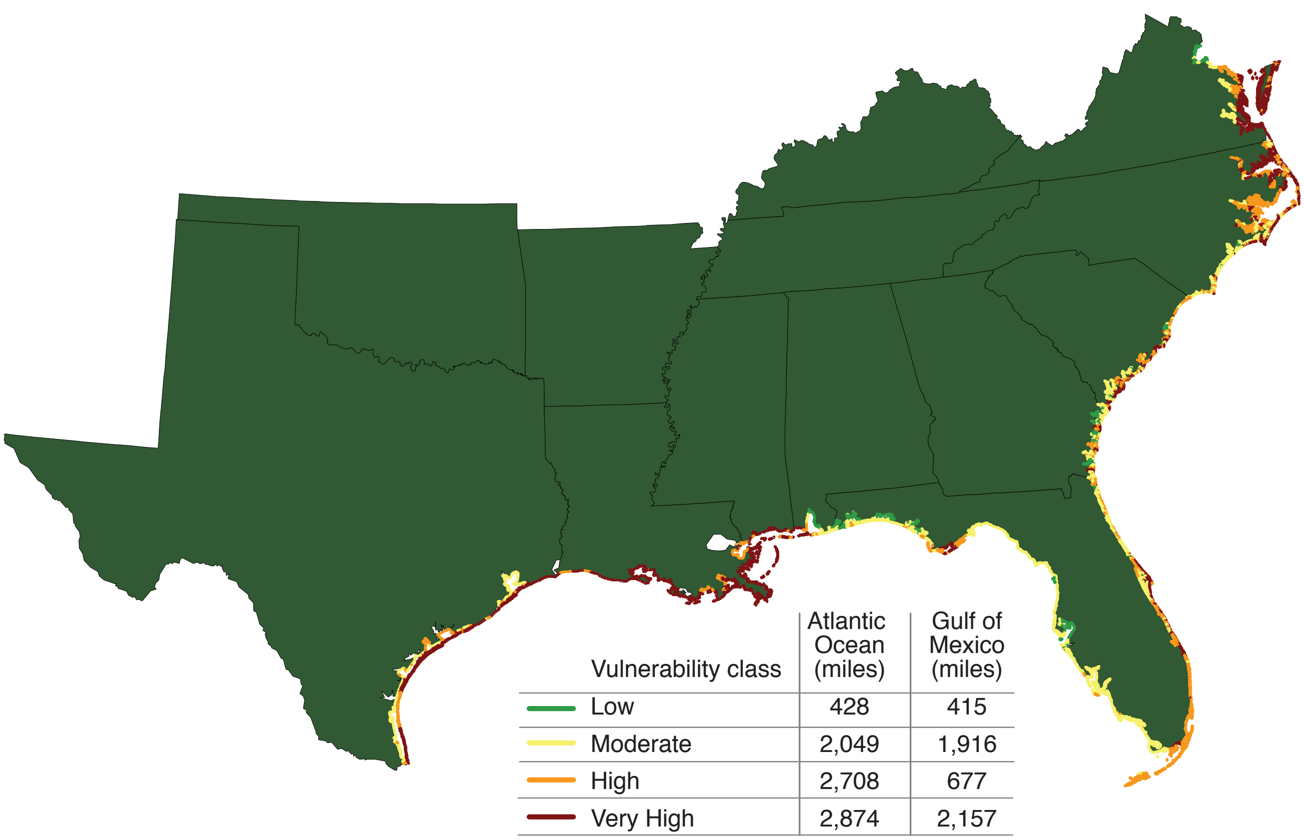


Figure 41—Vulnerability to rising sea level along the Atlantic Ocean and Gulf of Mexico coastlines (Lockaby and others 2013).

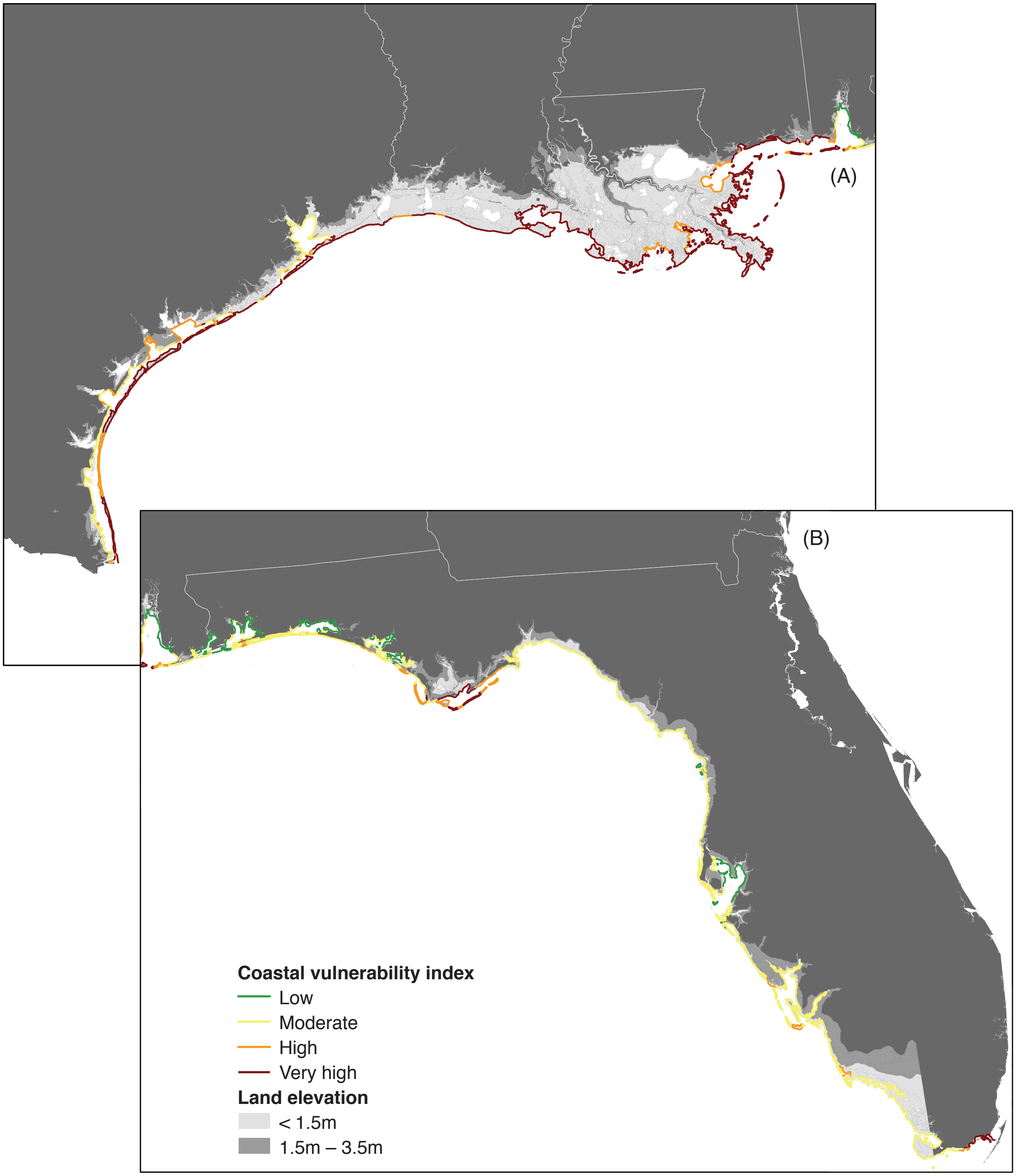


Figure 42—Vulnerability to rising sea level for U.S. coastlines along the Gulf of Mexico: (A) western coastal areas, and (B) eastern coastal areas (Lockaby and others 2013).

ECONOMIC WELLBEING AND QUALITY OF LIFE

The Coastal Plain is a productive economic area with numerous industries.

Forest products industry

Hardwood and softwood production supply the markets for everything from furniture and flooring to construction-grade solid wood to paper products. In 2009, wood-related manufacturing sectors in the South generated $230 billion in total output (Abt 2013). These sectors employed >347,000 people directly with employee compensation of $19 billion. Total employment (direct and indirect) was >1,077,000 people with employee compensation of $51 billion.

Employment in the Forest Products Industry

The Bureau of Labor Statistics estimates that the national average hourly wage for paper manufacturing (NAICS 322) is about $24 per hour while wood products manufacturing averages about $17 per hour (Bureau of Labor Statistics 2012). Average logging wages (NAICS 311) range from $13 to $18 with supervisory jobs as high as $24 per hour.

Tourism and recreation

The coastal waters are not only valued for their wildlife, but also for the white sandy beaches that attract numerous vacationers. Tourism and recreation have become a booming industry, accounting for 85 percent of all tourism revenues in the United States, according to National Oceanic and Atmospheric Administration estimates (Henry 2009). Tourism and recreation provide >620,000 jobs yielding >$9 billion each year in Coastal Plain counties along the Gulf of Mexico, with eating and drinking establishments employing >500,000 people yielding >$4.8 billion in wages, hotels and lodging establishments employing about 60,000 people yielding >$1.8 billion in wages, and amusement and recreation services employing >10,000 people yielding about $200 million in wages (National Oceanic and Atmospheric Administration 2008). On the Atlantic coast, for example, Georgia's parks brought in nearly $2 million in 2007 (National Conference of State Legislatures 2008).

Agriculture

Agriculture is also an important industry, albeit a declining one in recent years. In 2005, Alabama had 43,500 farmers on 8.6 million acres producing >$3.3 billion worth of commodities—65 percent from poultry and eggs, 11 percent from cattle and calves, 8 percent from nurseries and greenhouse, and 4 percent from cotton (Mitchell 2007). That same year, the agricultural sector in Georgia contributed $2.6 billion to its economy (National Conference of State Legislatures 2008).

Other industries

Commercial fishing has also played a major role in the Coastal Plain. This industry—which traditionally includes fish, shrimp, oysters, and crab—is worth >$662 million, mostly focused in Louisiana. Oil and gas production, which is dominant in areas along the Gulf of Mexico, provided >$12 billion in wages in 2006 (National Oceanic and Atmospheric Administration 2008). Manufacturing and infrastructure are also important to the Coastal Plain economy; for example, the manufacturing industry comprises 12 percent of Georgia's GDP (National Conference of State Legislatures 2008). Phosphate mining, although not critical to the Coastal Plain as a whole, is a big contributor to the economy in Peninsular Florida.

Timber Products and Markets

Timber products and market trends, which are covered in detail by Wear and others (2013b) for the Southern Forest Futures Project, are of particular interest for the Coastal Plain for many reasons, including the prevalence of planted pine in its forests, the importance of softwood products to its economy, recent land-use/ownership changes from the forest products industry to forest investment groups, and the susceptibility of its economy to policy shifts and market fragility.

Although the planting of pines is widespread throughout the South, the majority of pine plantations are located in the Coastal Plain. Increases in productivity from genetic and silvicultural improvements combined with expansion of acreage in planted pine even after the timber price peaks in 1998, have positioned southern forests to produce even more timber than they did at the market peak. This trend is likely to continue, with forest landowners demonstrating a strong propensity to convert naturally regenerated forests to planted pines after harvesting—timber supplies even continued to grow in spite of reduced timber demands since 2007.

Timber inventory projections—By 2060 the area of planted pine in the South is projected to increase from the current 39 million acres (19 percent of forest land) to between 47 and 67 million acres (between 28 and 34 percent of forest land; Hugget and others 2013). Planted pine in the Coastal Plain, which was about 31 million acres in 2010, is forecasted to range from 37 million acres (33 percent of forest land) to 51 million acres (46 percent) in 2060. Although high, these forecasts would actually represent a deceleration from observed rates of growth during the previous two decades

(Huggett and others 2013). The area of natural pine forests would decline by an average of 42 percent over this period (largely from harvesting and conversion to planted pines). Oak-pine (31 percent), lowland hardwood (13 percent), and upland hardwood (8 percent) are all forecasted to decrease, with steady losses in upland hardwood types most strongly affected by urbanization.

Any increases in harvesting are more likely to be concentrated at the “intensive margin” than at the “extensive margin,” with intensive management and expansion projected to take place where production and production growth have been focused for decades—the pine plantations of the southeastern Coastal Plain. This increase in productive capacity means that a substantial increase in production could be supported without substantially increasing softwood prices.

Projections of supply and demand for forest products—Under all Cornerstone Futures for softwoods, pulpwood supplies would increase over the next 40 years, and sawtimber supplies would increase over the next 10 years and then stabilize. Absent higher demand, this increase in supply would lead to stable prices for softwood products, especially pulpwood. And although productivity has the potential to expand substantially in the South, demands for timber could limit markets. The use of biomass for energy that is discussed below has potential to increase overall demand but its future is uncertain. A recovery of demand for wood products in construction is more certain and consistent with historical business cycles, but its timing and magnitude is not known with certainty.

Unlike solid wood, the local demand for pulpwood in the Coastal Plain has been largely driven by proximity to mills (fig. 43), which are concentrated in areas of plentiful water (southeastern Georgia, northeastern Florida, southern Alabama and southern Mississippi). Increased demands for use in oriented strand board and other engineered wood products have spread demands over a broader region in recent decades. Bioenergy markets could spread demands even further. With most of the trade in wood chips moving through Mobile, the economic impacts of increased chip imports are projected to be concentrated in Alabama and to spread outwardly from there.

With limited expansion in timber demand, and thus decreased investment returns, private forest owners would shift their investments away from forest management. Conversely, increases in demand, coupled with expected gains in productivity could expand total timber production by about 70 percent, with the production of softwood pulpwood more than tripling. Under such a scenario, softwood sawtimber prices would stabilize (falling <1 percent per year), and hardwood pulpwood prices would increase by <1 percent per year.

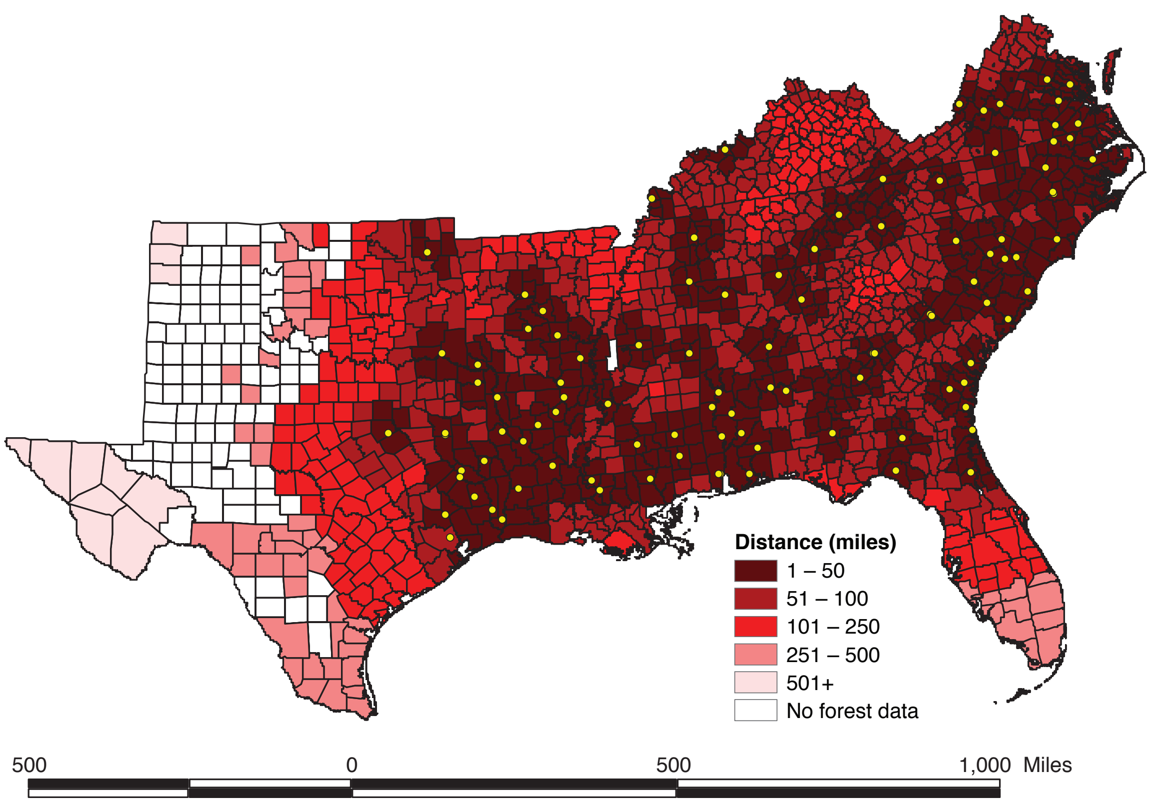


Figure 43—Distance from the forested centers of southern U.S. counties to the closest pulpmill or chipmill (Wear and others 2013b).

Demand scenarios—In addition to projections for the Cornerstone Futures, Wear and others (2013b) examined alternative demand growth scenarios for the forest products sector. The scenarios reflect the growth in timber supply consistent with the land use and economic assumptions of the Cornerstones. Harvest simulations assumed different patterns of change in demands for timber products. Findings are bracketed by a constant demand scenario (fig. 44) and an expanding demand scenario (fig. 45).

Timber harvest and price forecasts for the Constant Demand/ Cornerstone A scenario are shown in figure 44A. Over the next 50 years, harvesting would increase by about 27 percent from the 2006 level, with softwood harvests outpacing those for hardwoods and then leveling off in the 2030s. Softwood sawtimber prices would return to their 2006 levels by 2015 and then decline somewhat over the projection period.

Softwood pulpwood prices would fall as supply expands throughout the period, and hardwood pulpwood prices would remain relatively constant throughout.

For the Expanding Demand/Cornerstone A scenario (fig. 45B) harvesting would expand throughout the forecast period, with especially strong growth for both softwood products and for hardwood sawtimber. By 2055 harvesting would be about 43 percent higher than the 2006 level. Prices would rise, reflecting increased scarcity—about 120 percent for softwood sawtimber and 34 percent for hardwood pulpwood—and softwood pulpwood prices would return to about 80 percent of the 2006 level. Prices would increase for all forest products except softwood pulpwood. Another scenario which assumed increased pine productivity led to even higher softwood pulpwood harvests with somewhat lower prices (Wear and others 2013b).

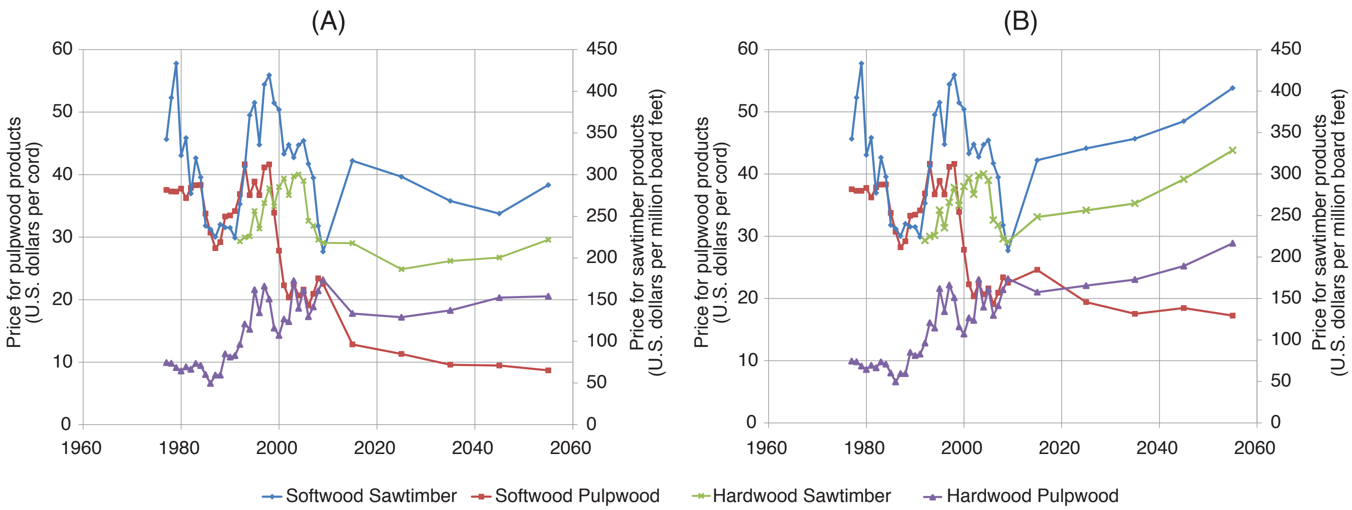


Figure 44—Forecasts through 2055 of real timber prices—assuming that 2009 is $100—based on a supply scenario that reflects increasing gross domestic product combined with (A) constant demand for timber products, and (B) expanded demand for timber products (Wear and others 2013b).

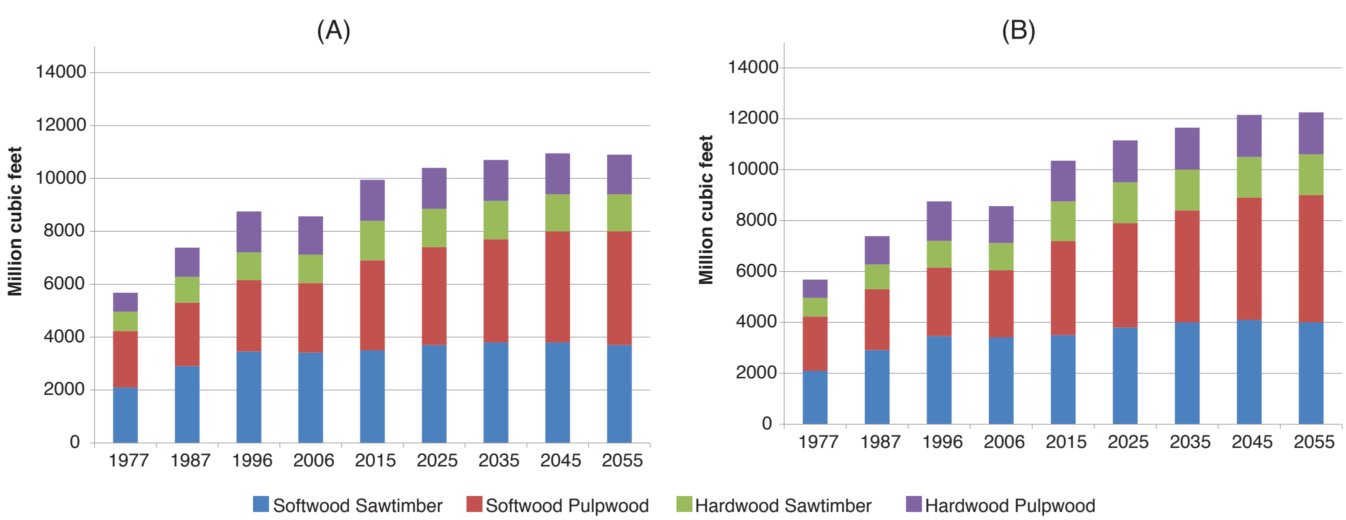


Figure 45—Forecasts through 2055 of standing timber harvesting based on a supply scenario that reflects increasing gross domestic product combined with (A) constant demand for timber products, and (B) expanded demand for timber products (Wear and others 2013b).

Across all scenarios, forecasts indicate the potential for a substantial expansion in softwood supply over the next decade as new pine plantations mature. This generally portends stable prices for softwood products, especially softwood pulpwood. Beyond 2020, supply depends on a much lower rate of expansion in forest plantations—generally the rate of planting harvested forests is assumed to be about half of what it was in the 1990s. But even at these reduced levels, the supply of timber would grow and the price of products would generally decline unless demand growth was realized over the next decades.

Growth in harvesting can be supported by the forest land of the South. A return to 1990s demand levels would result in price stabilization for softwood pulpwood and an increase of <1 percent per year for softwood sawtimber and hardwood pulpwood; as well as an increase in total output of about 40 percent from 2006 to 2055. If, in addition, productivity in pine plantations grows by 50 percent, then output could increase even more substantially—up to 70 for softwood pulpwood (Wear and others 2013b). The key to predicting the future course of timber markets is in understanding how demand will evolve. The downturn in housing-related demands for wood products will reverse with the recovery of the housing market, but it will also be influenced by changing technologies and products. Of course, the timing of the full recovery is impossible to predict with precision.

Other factors—Softwood pulpwood prices, so important to the forest sector of the Coastal Plain economy, fell by half from 1998 to 2001—in response to a 10-percent decline in production capacity by the forest products industry—and have not approached these peak levels since. The expansion of plantation forestry and its influence on a transient supply shortage in the early 1990s help to explain this dynamic, but a number of other factors are currently affecting and will continue to affect timber supply.

Urban growth will likely consume several million acres of timberland (especially, in the Coastal Plain, along the coasts). The ownership of the forests that remain is likely to be a major, albeit uncertain, influence on timber supply. Recent transfers of forest holdings from the forest products industry to timber investment management organizations and real estate investment trusts, combined with gradual transitions in family forest ownership, will likely have long-term effects that require close monitoring. No clear changes in management approaches and investment patterns have yet been detected, but these ownership changes will undoubtedly have consequences. Nontimber forest products are also of concern, particularly the impacts of harvesting pine straw and of managing forests expressly for this use; participants of the public input sessions emphasized the importance of this issue and the need for additional study.

Biomass-Based Energy

A southwide analysis on the potential influences of markets and supplies of woody material for bioenergy was reported by Alavalapati and others (2013) for the Southern Forest Futures Project. Although most of their findings generally apply to all subregions, they are especially relevant to the Coastal Plain, where a strong majority of timber production occurs.

The harvesting of woody biomass for energy could become a significant and substantial influence on the Coastal Plain, and Alavalapati and others (2013) consider scenarios that range from 20 to 336 million green tons by 2050—an increase of 0 to 113 percent above current total harvest levels. Under conditions of increased bioenergy consumption, harvesting residues and urban wood waste would not likely satisfy increased demand and pine pulpwood (found in abundance in the Coastal Plain) could quickly become the preferred feedstock. Prices for merchantable timber would increase, as would returns for forest landowners. But with increased acreage of fast growing pine plantations, forest inventories would not necessarily decrease, even in the face of such increased demand. The degree to which markets and inventories would be affected, based on levels of demand for biobased energy, are discussed further.

No change—If consumption of woody biomass for energy remains unchanged, prices would be expected to decline and removals increase for all hardwoods and for sawtimber softwoods. Other softwoods would be expected to experience decreased removals.

Low consumption—Harvesting, inventory, and removals of sawtimber would increase, much as under a no-consumption scenario (fig. 46). Acreage in private ownership would decrease from 175.39 million acres in 2010 to 170.86 million acres in 2050 (fig. 47). Increased prices would stimulate landowners to increase forest acreage, primarily in planted pine (7 percent), but also in natural pine, oak-pine, lowland hardwood, and upland hardwood.

Moderate consumption—More dramatic price increases (fig. 48) would stimulate even higher inventory increases, mostly in planted pine, than either the no-consumption or low-consumption scenarios. At this level of production, strong competition with traditional wood products sectors would emerge, especially with those using pine pulpwood.

High consumption—A more than doubling of total harvests would cause prices to increase fivefold over the 2007 level for softwoods. The pulp industry would be adversely impacted, as significant supplies would be diverted to energy production (fig. 49). Such a strong increase in demand would likely lead to structural shifts in the timber growing sector that would allow overall forest productivity

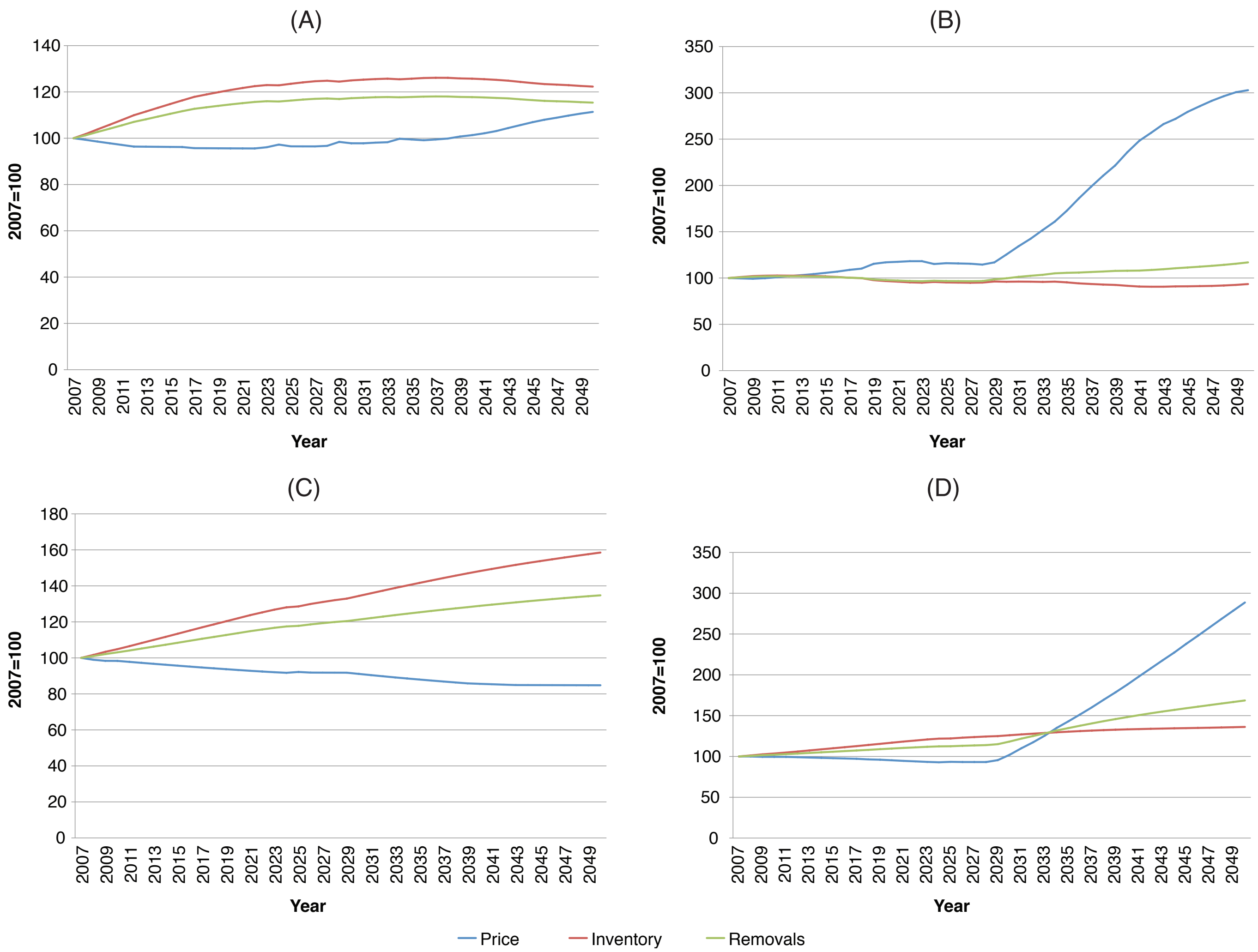


Figure 46—Assuming low consumption of woody biomass for energy through 2049, market responses—price, inventory, and removals—in the Southern United States for (A) softwood sawtimber, (B) other softwoods, (C) hardwood sawtimber, and (D) other hardwoods (Alavalapati and others 2013).

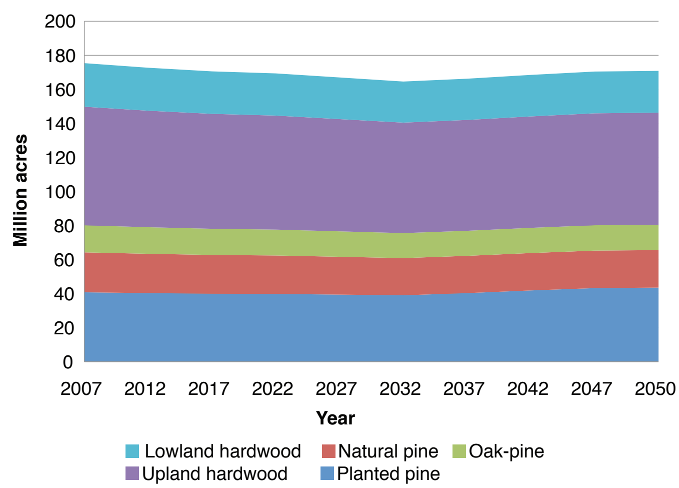


Figure 47—Forecasted changes to private forest acreage in the South, assuming low consumption of woody biomass for energy (Alavalapati and others 2013).

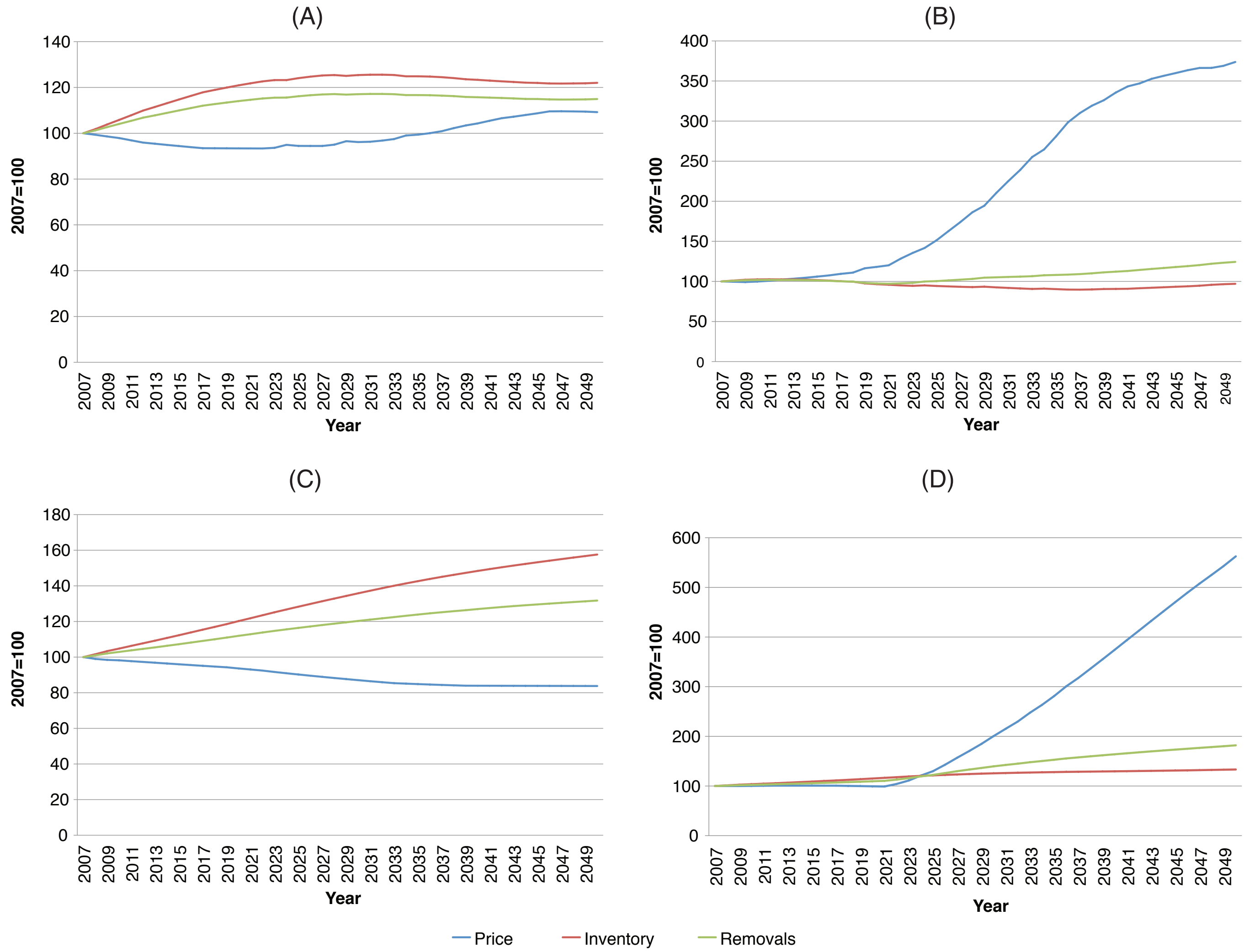


Figure 48—Assuming moderate consumption of woody biomass for energy through 2049, market responses—price, inventory, and removal—in the Southern United States for (A) softwood sawtimber, (B) other softwoods, (C) hardwood sawtimber, and (D) other hardwoods (Alavalapati and others 2013).

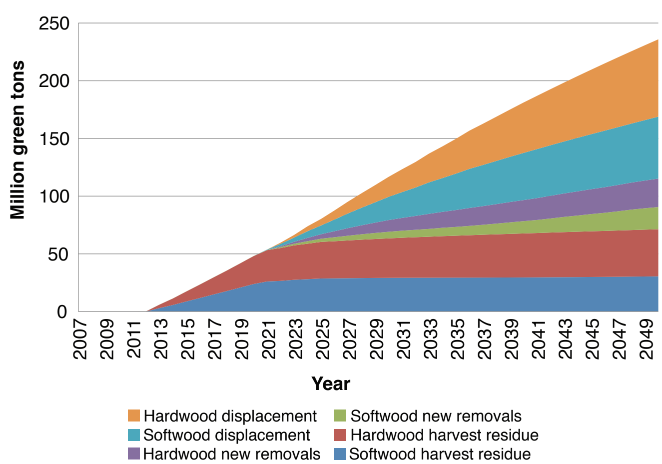


Figure 49—Feedstock composition in the Southern United States, assuming high consumption of woody biomass for energy (Alavalapati and others 2013).

to increase substantially and mitigate these projected price increases. Alavalapati and others (2013) simulate the effects of these types of productivity shifts consistent with observed productivity possibilities and find that they could mitigate price increases. At this level of demand, the structure of the wood products industry would likely change in response to strong competition among wood using technologies.

The future of forest biomass-based energy is unclear, due largely to uncertainty regarding future energy and related climate policies but also due to the complex interplay between policies and the investment decisions of private forest landowners. However, it is clear that emergence of a large wood-based bioenergy sector could lead to important changes in forests and the wood products industries.

Employment and income trends

The southwide analysis of employment and income by Abt (2013) for the Southern Forest Futures Project also applies to the Coastal Plain, where employment and income trends for the forestry sector of the Coastal Plain States continue to be tied to final product markets for paper and solid wood products such as lumber. Expected continued contractions in the southern paper manufacturing sector (17 percent between 2008 and 2018) coupled with decreases in output and continued technological advances are projected to result in a 26-percent reduction in sector employment, southwide, by 2018. Over the last decade, land ownership has changed significantly and many paper manufacturing companies have merged or been sold. Combined with declining demands for paper, these changes have resulted in declining southern pulping capacity—largely for writing papers and newsprint. Demands for bioenergy fuels, however, could increase logging sector jobs and output. If bioenergy demands compete for material with traditional wood products, the wood products and paper manufacturing sectors could experience some additional losses in jobs and output. In addition, any output and employment gains from bioenergy development and production would likely be offset by losses in conventional energy jobs. Therefore, overall impacts on output and employment of bioenergy could be minimal. And although concerns about a shortage of loggers in the South continue and increasing mechanization has reduced demand for loggers, logging jobs are projected to increase slightly between 2008 and 2018.

Recreation

Although the trends and projections in recreation presented by Bowker and others (2013) for the Southern Forest Futures Project are applicable southwide, some projections are particularly relevant for the Coastal Plain.

Population growth is resulting in the proximity of higher concentrations of people to public lands and bodies of water and is likely to put increasing pressures on these limited resources. Most southern residents have access to <1.5 acres of public land per person within 75 miles of their home county. Within this 75-mile recreation day trip zone, the largest amount of water area per-capita (aside from oceans) is in counties along the Atlantic Ocean and the Gulf of Mexico. For many States, the increased pressures of population growth on recreational resources could be coming at a time when budgetary pressures are also increasing. State park facilities are located less than an hour away, regardless of where one resides in Florida, South Carolina, or throughout much of the South. However, difficult budgetary pressures, especially in Alabama and Georgia, are occasionally forcing these facilities to close, be transferred to other government and quasi-government entities, or operate under reduced hours, services, and staffing (table 7).

A wide array of recreational activities is available in the South, with 30 to 40 million people participating annually in: driving for pleasure, viewing/photographing flowers

Table 7—State park systems affected by closure or reduction in services by State, 2009

State	Number of system areas	Number of closures	Reduction in services
Alabama	23	0	One park transferred to county government
Arizona	28	Two parks and two historic sites	Hours open were cut for two State parks and five historic parks
Georgia	63	0	One park changed to outdoor recreation area; six historic parks/sites have cut hours; and three historic sites are now operated by the counties within which they reside
Hawaii	50	0	One park transferred to a development corporation
Massachusetts	136	Two State forests	Two areas will not be staffed
Michigan	93	0	One site cut hours for the summer

Source: USDA Forest Service 2009.

and trees, viewing/photographing wildlife (besides birds and fish), swimming in outdoor pools, picnicking, visiting historic sites, swimming outdoors (besides pools), and visiting a beach. However, as southern populations increase, per-person acreage available for recreation is expected to decrease, especially for water resources (which make up a little more than 5 percent of total surface area, or 0.28 acres per person); by 2060, availability of water-based recreation is expected to be 0.18 acres per person, (a 63-percent decrease from 2008).

MANAGEMENT AND CONSERVATION CHALLENGES

The Southern Forest Futures Project identified and analyzed a list of projected changes and challenges that some might find daunting. Although an array of management practices are available that could help to control the impacts of these factors, some might need to be reconfigured and new ones will likely need to be developed.

Participants at the public input sessions voiced concerns about the management of coastal forests. The benefits these forests provide in terms of hurricane protection, hydrology, and wildlife are sometimes compromised by other uses (such as mulch harvest and ditching) or by outside forces (such as sea-level rise). Management practices that balance or offset these conflicting benefits and influences—such as introduction of saltwater tolerant trees—might need to be developed. Likewise in the Coastal Plain, intensive management, be it for pine straw harvesting or intensified planted pine cultivation, could have impacts on other benefits provided by these forests. Ecosystem water use, water filtration, carbon sequestration, wildlife habitat, and providing recreation to an ever-growing population all require specific management prescriptions.

Conducting management activities, and especially planning for the long-term management of a forest, will likely take place within the context of a changing climate. Tools like the Template for Assessing Climate Change Impacts and Management Options (http://www.forestthreats.org/research/tools/taccimo) synthesize findings from long-term and applied studies to inform management plans and achieve the desired mix of goods and services. Within such a context, the choice of species (for example, longleaf versus loblolly pine) could become especially critical to success. And the potential for the development of bioenergy markets in the South could impact pine planting and management, and even trigger the acceptance of nonnative trees such as Eucalyptus (*Eucalyptus* spp.) for intensive plantation forestry.

The increasing urbanization predicted for the Coastal Plain presents its own set of challenges. Increased water use, increased recreational pressures, and less tolerance for the use of prescribed fire are just a few of the challenges that will only escalate as the wildland-urban interface expands. The use of fire, coupled with a decreased ability to use prescribed fire, is the subject of an intensive, multiagency, cross jurisdictional effort—the National Cohesive Wildland Fire Management Strategy, which was established to provide key, impactful guidance on dealing with the threat and use of fire across the landscape (USDA and Department of the Interior 2013).

The unique diversity of wildlife and large number of imperiled species in the Coastal Plain make wildlife conservation and restoration a prime concern. The warm climate, human population growth and movement, and productive forests of the Coastal Plain attract invasive species. Prediction, early detection, and effective control are important, but neither easy nor necessarily cheap. All these interactions take place on a landscape that is a mosaic of ownerships. Although Federal and State lands are key in any forest management strategy, >5 million private forest owners across the South hold about 86 percent of the forested land base in the region. Particularly in the Coastal Plain, a number of these private owners are forest investment groups.

Addressing the needs of a small landowner with a small woodlot, as well as those of an investment consultant managing 500,000 acres, is perhaps the largest conservation challenge in the South. However, their general motives are often quite similar even though their issues differ appreciatively in scale. Of course, multiple factors (including, and maybe especially, taxes and policy) affect the decisions made on the multitude of ownerships in the Coastal Plain. Tools like the Comparative Risk Analysis Framework and Tools (http://www.forestthreats.org/research/tools/craft), which helps diverse groups come to consensus decisions on complex issues, could be part of the solution.

CONCLUSIONS

The size and diversity of the Coastal Plain make generalizations problematic. Still, this report and especially the Southern Forest Futures Project analyses from which it is drawn (Wear and Greis 2013) reveal some important trends. All of the futures described above are highly likely to play out within a context of warmer temperatures and lower available water. Coastal areas are likely to experience rising sea levels and incursions of saltwater. Likewise, Coastal Plain forests will continue to experience increased impacts and pressures from urbanization and population growth. Although these challenges will be felt more significantly in some areas than in others, their impacts (including to hydrology, recreation, and wildlife) are expected to extend throughout the Coastal Plain and beyond. The nature and extent of these impacts and the management options for addressing them, although critically important, are largely unknown.

Ownership changes are expected to continue to be an issue for the forests of the Coastal Plain. The role of the small landowner in managing for changes and the influences and management responses of forest investment groups are also to some extent unknown. The Coastal Plain has been (and will likely continue to be) influenced heavily by the extent and role of planted pine in its forests. Also important is an understanding of how markets (including bioenergy), taxes, and policies affect harvesting and management, especially on lands that are likely to be subjected to changes in climate and water availability. Even as wildfires potentially become more damaging, a variety of factors could reduce the availability of prescribed fire as a management tool.

The impacts of invasive pests and plants in isolation are difficult enough to determine, but considering these complex systems as they are mediated by other factors—especially climate change—is even more problematic. However, new studies addressing this question have begun. Kliejunas (2011) has modeled the effects of climate change on disease outbreaks on western forests. The Southern Research Station has begun a multidisciplinary, national effort to prepare an economic valuation of climate change impacts on the population dynamics of forest insects.

In addition to the issues specifically addressed in the Southern Forest Futures Project, other concerns were identified in public input sessions and merit further study, or at least a synthesis of available knowledge. Developing new, or at least additional, methods for detecting and eradicating/controlling invasive plants, pests, and diseases are needed. Another concern is restoring coastal forests and protecting the benefits they provide (a challenge that would seem even more difficult in light of the changes forecasted by the Southern Forest Futures Project). Understanding the interactions of these threats and the tools available to address them would be key to protecting the forests of the Coastal Plain. Likewise, protecting the unique biological diversity in Coastal Plain forests could become more difficult in the face of climate change, urbanization, and altered hydrology. Ready availability of sound, peer-reviewed science and science-based tools are key to addressing all of the challenges identified in this report.

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The U.S. Coastal Plain consists of seven sections: the Northern Atlantic, Eastern Atlantic, Peninsular Florida, Southern Gulf, Middle Gulf-East, Middle Gulf-West, and Western Gulf. It covers a large area, consists of a diverse array of habitats, and supports a diverse array of uses. This report presents forecasts from the Southern Forest Futures Project that are specific to the Coastal Plain, along with associated challenges to forest management in this subregion: warmer temperatures; increases in urban land use; population increases; more planted pine; increased harvesting for bioenergy; impacts to hydrology and water quality; increased impacts from invasive organisms; and longer, more intense wildfire seasons. Understanding these impacts and the tools available to address them will be key to effective management of the Coastal Plain forests.

Keywords: Climate change, Coastal Plain, fire, forest management, invasives, Southern Forest Futures Project, water, wildlife.

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