# 3 The Social and Economic Drivers of the Southeastern Forest Landscape

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## INTRODUCTION

The last quarter century has witnessed an unprecedented resurgence of interest in the management of longleaf pine (*Pinus palustris*) forests, a phenomenon that has been coupled with increased understanding of the ecology, management, and restoration of these ecosystems. As interest in longleaf pine becomes more mainstream among landowners and the general public, future opportunities for restoration will be strongly influenced by the context, both economic and social, in which they occur.

In this chapter, we examine the economic and social factors that affected the development of professional forest management in the southeastern United States in the decades following the harvest of the primary longleaf pine forests. We trace the development of new markets and new approaches to managing pine forests for fiber in the second half of the 20th century, which were transformational for the forested landscape of the Southeast, resulting in huge impacts on patterns of ownership, forest conditions, and expectations of land owners for their forests. We next review the literature on longleaf pine microeconomics that emerged in response to a heightened interest in restoration and management that began in the late 1980s. Finally, we address the three important changes that are affecting the forested landscape of the Southeast and its management in the

21st century: (1) a wholesale divestiture of forest industry lands, (2) the acceleration of land use change (especially urban development), and (3) the changing demographics of family forest owners. These dynamics present both challenges and opportunities for restoration and management of longleaf pine across the region.

## HISTORICAL CONTEXT

The decline of longleaf pine ecosystems—from about 92 million acres prior to European settlement (Frost 2006) to about 3 million acres by the end of the 20th century (Outcalt and Sheffield 1996)—has been well documented. The rapid and ubiquitous harvesting of southeastern virgin pine forests during the early 20th century was the continuation of the boom and bust of regional "lumbering" rather than an application of forestry (Earley 2004; Boyd 2015). Most logging enterprises treated the land as an expendable commodity; when one area was depleted, the company and mill (and often the entire town) simply moved on to a new area of virgin forest. The rapid exploitation of longleaf pine forests, with little to no planning for the regeneration of cutover lands, led to a denuded landscape in many areas that could not support the continuation of the lumber industry as it was practiced at the time (Williams 1989; Boyd 2015). Estimates of cutover land in the "yellow pine belt" were as high as 100 million acres (Vance 1932).

Although there were some early successes with efforts to naturally regenerate longleaf pine or plant longleaf pine, these ultimately proved to be the exception rather than the rule. More commonly, cutover longleaf pine sites were captured by loblolly (*Pinus taeda*) or slash pine (*Pinus elliottii*), both of which are much more prolific and dependable seeders. Fire protection efforts that became widespread in the 1920s (Boyd 2015) thwarted longleaf pine reproduction and instead favored growth of newly established loblolly and slash pine, both of which require a fire-free interval for several years after germination. Although foresters were beginning to understand the complexities of longleaf pine and how to manage for the species (Wahlenberg 1946; Croker 1968), societal objectives for forests were evolving, opening a new chapter in the history of southeastern forestry.

Perhaps the most fundamental challenge to establishing widespread sustainable forest management in the region was the lack of confidence that managing second-growth forest stands could be profitable. Absent a well-defined production technology for regenerating and rapidly regrowing forests, and—given the availability of relatively inexpensive old-growth softwood timber in other regions—landowners simply viewed the economics of forest management as inferior to other capital investments. Indeed, the relatively low—though rising—timber prices and the hurdles of the high-opportunity costs of choosing forestry over alternative investments delayed any kind of long-term forest management practices on U.S. private lands for many decades (Hough 1878; Graves 1919).

Although the inability to reliably regenerate longleaf pine continued to frustrate those who took an interest in rehabilitating the forestlands of the Southeast, the ease with which loblolly and slash pine adapted to former longleaf pine sites and the rapid growth of these species did not escape notice. This phenomenon coincided with the growth of the nascent U.S. forestry profession, a discipline firmly rooted in the European tradition that viewed forests as a commodity that could be profitably regenerated, managed, and harvested at maturity (Chapman 1942). The rise of forestry as a profession, coupled with technologies developed in the late 1800s for producing pulp and making paper from wood fiber, gave birth to a new market that would profoundly change the way forests were managed in the Southeast (Boyd 2015). Further development of the paper-making technology improved the process of delignifying wood fiber from pine and other resinous tree species to produce kraft paper, ultimately enabling the production of newsprint and higher quality paper from southeastern pines. As the viability of paper production became recognized as a profitable business, the number of pulp mills in the Southeast began to grow, reaching 36 by 1935.

In 1932, production of southern yellow pine lumber was only three billion board feet, the lowest annual figure for the entire 20th century (Carter et al. 2015). After World War II, a growing supply of wood from second-growth forests and higher demand for lumber from the housing market led to new investments in modern sawmills (Wheeler 1969). Timber volume of southeastern forests grew dramatically, increasing by almost 70% from 1953 to 1977 (Oswalt et al. 2014). Although a fiber production model dominated in many areas, solid wood products remained an important component of southeastern forest outputs, with production tied closely to economic cycles and housing starts (Wear et al. 2013).

Growth of the pulp and paper industry resumed after World War II; by 1955, 73 southeastern mills were using local pine as feedstock. The opportunities presented by the GI Bill also contributed to unprecedented growth in the forestry profession, with university forestry program enrollment increasing nationally from about 1100 in 1944 to 7000 in 1946 (Gray 1988). From 1950 to 1961, five new university forestry programs were added to the eight operating in the Southeast. As the forestry profession grew, these newly trained professionals populated the ranks of private companies and public agencies, especially state forestry agencies. With state forestry agencies fully staffed, the new models of plantation forestry were more broadly disseminated and wildfire control efforts were much more successful, neither of which benefitted longleaf pine.

Early recognition that U.S. forest resources were not inexhaustible and that poor forestry practices had undesirable impacts on water resources resulted in legislation such as the Organic Act of 1897, the Weeks Act of 1911, and the Clark-McNary Act of 1924. In the Southeast, the cutover longleaf pine forests served as case studies for identifying and resolving these problems. Both private industry and the U.S. Forest Service successfully experimented with broad-scale plantings of pine in the 1920s; and the Civilian Conservation Corps planted >1.5 million acres across the region in the 1930s (Fox et al. 2007).

After World War II, the growth of the forest products industry and the economic importance of a dependable supply of fiber and sawtimber prompted further concerns about sustainable management of southeastern forests. Despite the natural regeneration of loblolly and slash pines on large acreages of cutover longleaf pine sites, estimates of degraded agricultural land and cutover longleaf pine in need of reforestation ranged from 13 to 29 million acres (Wakely 1954; Wahlenberg 1960). The planting of seedlings expanded rapidly, driven by both the interests of the burgeoning pulp and paper industry and the desire to rehabilitate degraded farm land through federal incentives such as the Soil Bank Program. Significant investment in nursery propagation of pines was underway, with the federal government, all the southeastern states, and many private forestry companies operating nurseries to supply seedlings for pine plantations.

The 1950s marked the beginning of a highly productive period for forestry research and development, largely the product of an unprecedented level of cooperative projects involving the U.S. Forest Service, land grant universities, and private industry. Some of the most important undertakings were tree improvement programs for both volume and form of loblolly and slash pine, most notably through the Texas Forest Service, the University of Florida, and North Carolina State University. Progeny from first-generation seed orchards were 20% more productive than progeny from wild-collected seed (Todd et al. 1995), with second-generation orchards projected to increase volume growth by 14%–23% over first-generation orchards (Li et al. 1997). Formal research programs also began to build upon the early efforts of practicing foresters to improve the performance of pine plantations through refined mechanical site preparation techniques, chemical control of competition, and fertilization to accelerate growth (Fox et al. 2007). Concurrent with these operational advances, more sophisticated growth and yield models for slash and loblolly pine were developed and refined, allowing the forest industry to predict the financial performance of their pine plantations with a higher degree of accuracy.

The advances in forest management resulting from these alliances among government, academia, and private industry ushered in what has been called the "Golden Age of Industrial Forestry," with the annual rate of plantation establishment reaching >2 million acres in the 1980s and early 1990s (Carter et al. 2015). As loblolly and slash pine plantation acreages increased under these new models of forest management, declines continued for the longleaf pine forests that remained after the initial cut of the late 1800s and early 1900s. By the 1980s, only 3.8 million acres remained of the 12 million acres that were reported in 1955 (Kelly and Bechtold 1990), and decreases continued until longleaf pine forests (defined as Forest Inventory and Analysis longleaf pine forest type) reached a low of about 3 million acres in the 1990s (Outcalt and Sheffield 1996). Additionally, there were as many as 600,000 acres of longleaf pine/oak forest type remaining at this time (Frost 2006).

## FOREST OWNERSHIP IN THE SOUTHEAST

Before European settlement, total forest area in the Southeast was estimated at 354 million acres (Williams 1989). By the 1920s, forested acreage reached a low of about 220 million acres, but recovered to 231 million acres (Oswalt et al. 2014) by the end of the century. Contributing to this recovery were incentives and other efforts to encourage reforestation, combined with a comparative advantage of forestry over crop production on a portion of the landscape. The area of land used for urban or other developed uses has steadily grown, partially offset by a simultaneous transition of marginal cropland and pastureland to forest cover (Wear 2013). By 2012, forestland in the Southeast stood at about 245 million acres. Timberland, defined as acres capable of producing >20 cubic feet of industrial timber annually, accounted for roughly 210 million of that acreage (Oswalt et al. 2014).

The abbreviated history of the development of forestry and the forest landscape in the 20th century described above paints a rather simplistic picture. In reality, complex and dynamic public and private ownership patterns and approaches to forest management characterize the forest landscape of the Southeast.

### PUBLIC OWNERSHIP

Publicly held forests are estimated at approximately 32.7 million acres (slightly >13% of all forestland), with 27.4 million acres classified as timberland (Oswalt et al. 2014). Federal timberland ownership is approximately 18 million acres; approximately 12.7 million of those acres are managed by the U.S. Forest Service, with most of the remainder managed by the Department of Defense, U.S. Fish and Wildlife Service, and National Park Service. Another 9.4 million acres are controlled by other government organizations such as states or counties (Oswalt et al. 2014). In 2010, longleaf pine occupied approximately 1.63 million acres of public land, or 38% of the total remaining longleaf pine acreage (Oswalt et al. 2012).

In addition to being the largest single steward of public timberland in the region, the U.S. Forest Service also manages the majority of public lands that have existing and potential longleaf pine acreage. Much of the area that is now national forest was once cutover timberland and highly eroded cropland (Shands and Healy 1977). Legislative efforts to reclaim these areas began in 1907 with the establishment of the first national forest, and reclamation efforts ultimately established national forests in every state in the region. Historically, management of national forests was broadly defined in the Organic Act of 1897, which outlined a mission of providing favorable conditions for water flow and furnishing a continuous supply of timber (Glasser 2005).

Because of the degraded conditions that characterized many southeastern national forests, early management focused on restoration and replanting (Williams 2003). As second-growth stands matured and U.S. demands for timber grew, harvesting timber from these forests became more common in the 1960s (Carter et al. 2015). The overall approach to forest management tended to follow what was considered to be the state of the art for modern forestry at the time; on harvested longleaf pine sites this often meant replanting using a plantation model for loblolly or slash pine (Earley 2004).

Public response to the increasingly visible and aggressive management of national forests throughout the United States resulted in controversies and legal rulings in the early 1970s and enactment of the National Forest Management Act of 1976. What followed was a significant policy shift in which a broader range of multiple uses—including ecological values, water quality and quantity, wildlife, and recreation—were put on equal footing with timber production as objectives for national forests (Carter et al. 2015). The new legislation also provided for extensive public input into decisions about national forest management as well as specifically encouraging forestry on private lands. Public controversy over old-growth logging on national forests in the Pacific Northwest and the federal listing of the northern spotted owl (*Strix occidentalis caurina*) under the Endangered Species Act led to a reduction in timber harvesting on all national forests and shifted harvesting pressure to the Southeast, particularly on private lands (Wear 2014). Similar to the situation in the Pacific Northwest, status of the red-cockaded woodpecker (*Picoides borealis*) drove many federal land management policies in the Southeast, particularly with respect to management of longleaf pines—a trend that continues today. U.S. Forest Service data from 2015 Forest Inventory and Analysis (FIA) surveys indicate approximately 690,000 acres of longleaf pine on national forestlands (Miles 2016). As of 2008, land and resource management plans for national forests in the region projected a long-term restoration goal of about 1.5 million acres for the forest type (ALRI 2009).

State ownership of timberland more than tripled from approximately 2 million acres in 1953 to 7 million acres in 2012, with >2 million acres of the increase occurring in Florida (Oswalt et al. 2014). Because Florida historically had an aggressive conservation land acquisition program and the largest concentration of longleaf pine, some portion of the total forest acreage increase presumably includes longleaf pine. Most state-managed lands are administered through state forestry or wildlife agencies; relatively little consistent information is available about the composition of these forests or how they are managed. FIA estimates from 2015 for eight of the states within the longleaf pine range suggest that approximately 456,000 acres of state land were occupied by longleaf pine (Miles 2016).

Total public timberland in the Southeast grew from 17.4 million acres in 1953 to 27.4 million acres in 2012, an increase of approximately 10 million acres, which included 3.3 million acres on federal land and 5 million acres on state land. During that same time period, total private timberlands decreased by about 4.5 million acres (Oswalt et al. 2014).

## Private Land Ownership

The vast majority of the timberland in the Southeast has historically been controlled by the private sector. Private ownership held >91% of the acreage in 1953, and 87% remained in private ownership through 2012 (Oswalt et al. 2014). Private timberlands were historically divided into two broad categories: those owned by vertically integrated forest product companies (with the same company owning both the supply source and the processing facility), and those held by all other forest owners (historically referred to as "nonindustrial private owners"). Of the 182 million acres held in private timberland ownership in 2012, about a third was classified as corporate or industrial, and two-thirds was held by noncorporate or "family forest" owners (Oswalt et al. 2014). In 2010 about 2.7 million acres, or 62%, of longleaf pine acreage was on privately owned land (Oswalt et al. 2012).

In the last half of the 20th century, forest industry acreage steadily increased and peaked at 38 million acres in 1989. The late 1990s marked the beginning of sweeping changes, with most industrial timberlands divested into a diverse group of corporate ownership structures, primarily timber investment management organizations (TIMOs) and real estate investment trusts (REITs). By 2010, <7 million acres remained in traditional industrial ownership (Zhang et al. 2012), prompting a redefinition of ownership categories. Forest industry acres are now included in the "corporate" category, and the former nonindustrial private forest owners are now known as "family forests." Overall, the corporate category grew from 1953 to 2012, now standing at >61 million acres. During the same period, acreage of family forests (the former nonindustrial private category) decreased by 34 million acres to about 121 million acres (Oswalt et al. 2014).

## Family Forest Owners

As the most significant group of forest owners in the region in both numbers and acreage, family forest owners have played a major role in shaping the southeastern landscape. Historically, forest management by this group, as measured by productivity, has been considered lacking when compared to industrial, public, and other ownerships, all of which typically employ forestry professionals. For example, a 1952 study found that productivity of family forests was 65% as high as productivity on forest industry land and 75% as high as productivity on national forests (Paley 1952). Efforts to address this gap included federal incentives, university forestry extension programs, and state forestry agency landowner assistance. In addition to these government efforts, many forestry industry companies began to collaborate on landowner assistance programs. For example, the Southern Pulpwood Conservation Association was founded by leaders in the pulp and paper industry to develop forest management guidance tools, establish "pilot forests" to demonstrate these concepts, improve access to technical assistance, and promote forestry to the general public (Fickle 2001). In the late 1950s, individual forest products companies further developed this effort by providing various levels of assistance within the wood-procurement areas of their mills, primarily to ensure a sustained supply of feedstock (Carter et al. 2015). The late decades of the 20th century also saw the rise of consulting foresters that offered their services to owners who had sufficient acreage to require occasional professional services but not enough to hire a full-time forester. Other efforts to encourage better stewardship and more active management included establishment of organizations such as the American Tree Farm System and the Forest Landowners Association.

Despite these efforts, family forest productivity as measured simply by the amount of timber harvested still lagged behind other ownerships. However, an alternate perspective from social science research concluded that the management styles of family and industry forest owners were both consistent with value optimization even though their management outcomes differed (Newman and Wear 1993). The most significant difference was that family forest owners placed a higher value on standing forests—consistent with recreation and other nontimber values—and required higher returns to motivate them to harvest their timber. These findings, which are encouraging for the design of policies to reestablish longleaf pine on family forestlands, suggest that many private land owners are likely to respond to well-designed incentives that help achieve their values and objectives for their land.

## Forest Industry and Other Corporate Owners

The early 1990s saw a rapid expansion of international import/export markets, supported by evolving technologies and policies developed to support the North American Free Trade Agreement and other instruments that had been established to promote more connected global economies. Larger U.S. forest products companies were likely to have a well-integrated national presence, and some companies, such as International Paper and Westvaco, had begun to establish an international presence; but for the most part, forest industry in the Southeast was American owned and focused on regional operations (Carter et al. 2015). Changes occurred rapidly in the 1990s, when mergers and acquisitions created fewer but larger companies. At about the same time, a strong American dollar began driving exports down and increasing imports, including pulp and paper products. This forced the forest products industry to become much more competitive and much more globally focused, and ultimately contributed to a downturn in the U.S. domestic forest products business (Ince et al. 2007). Southeastern pulpwood prices peaked in 1997, decreased by 50% by 2002, and increased slightly after 2002. Since 1998, pulp and paper demands in developed countries have steadily declined, especially in response to expanding electronic media, causing U.S. paper production capacity to shrink (Wear et al. 2016).

Concurrent with these developments, institutional investors began to appreciate the potential of timberland as a component of their portfolios. The 1974 Employee Retirement Income Security Act encouraged diversification of pension plans beyond fixed income securities, but institutional investors also began to recognize that timberland assets are counter-cyclical to other investment vehicles and therefore could serve as a hedge against market volatility (Zinkhan 1988, 1992; Binkley et al. 1996). As investment analysts began to more fully understand the forest products industry as a whole, various pressures prompted these companies to contemplate a change in structure. These included the significant debt that many companies had taken on in the wave of consolidation that had occurred in the 1990s; the poor fit of standing timber values in standard accounting protocols, which negatively impacted overall balance sheets; and the more favorable tax treatment that alternate corporate structures offered compared to traditional C-corporations, in which income is taxed at both corporate and owner levels (Clutter et al. 2005; Binkley 2007). Furthermore, imports of raw materials were increasing and many family forest owners had begun providing fiber to mills, primarily because of silvicultural advances that had increased the productivity of their forests.

All this meant that maintaining timber supply for mills was no longer the concern that it had been historically, and many companies felt comfortable moving away from the vertically integrated model that had driven their land ownership. Perhaps most fundamentally, because coordinating the economic operations of timberlands with wood products production involves substantial transaction costs, these companies anticipated economic gains from separating the two functions (disintegration of many nonforest vertically integrated industries that occurred at the same time were based on these same economic fundamentals).

From 1998 to 2008, forest product companies divested about 75% of their lands. Most of this land was purchased by institutional investors such as pension funds and university endowments through TIMOs or by shareholders in REITs. Some forest products companies, such as Weyerhaeuser, restructured themselves as timberland REITs. TIMOs do not actually own forestlands, but rather acquire, manage, and sell them for their investors, often under term-limited investment periods. REITs differ in that they allow investors to pool capital for participation in real estate ownership, with shares in real estate that are either publicly traded or privately held.

This divestiture of forest industry land has been termed the largest U.S. land ownership transfer of the last century (Butler and Wear 2013). Institutional investment in timberland grew from approximately $2 billion in 1990 to over $40 billion by 2006. Today, TIMOs and REITs represent a fluid, but significant, ownership of large blocks of timberland within the range of longleaf pine.

## RENEWAL OF INTEREST IN LONGLEAF PINE

The 1960s saw the beginning of heightened awareness of environmental issues in the United States. Landmark environmental legislation passed in the early 1970s included the Clean Air Act, the Clean Water Act, the National Environmental Policy Act, and of particular importance to the longleaf pine ecosystem, the Endangered Species Act. This legislation granted the U.S. Fish and Wildlife Service regulatory authority over habitat for listed species and prohibited federal agencies from engaging in activities or funding activities that might degrade habitat for listed species. The listing of the red-cockaded woodpecker as an endangered species effectively put longleaf pine ecosystems in the spotlight to a degree that had not been seen for decades.

Meanwhile, in the years after World War II, researchers and forest managers had begun to understand the basic ecology of longleaf pine and how to manage it successfully (Croker 1968). Knowledge of the fundamental aspects of the ecosystem, such as the role of fire, episodic masting and regeneration, competitive interactions, and wildlife-habitat relations, contributed to better-informed management and restoration programs. Research on seedling production, notably the development of containerized seedlings (Barnett and Brissette 1986), made longleaf pine a viable choice for afforestation or reforestation from the standpoint of seedling survival and growth. Federal policies dramatically slowed the conversion of second-growth longleaf pine to plantations on national forestlands, and many resource professionals in the U.S. Forest Service embraced the value, as well as the challenges, of managing for longleaf pine, prescribed fire, and the red-cockaded woodpecker.

The decline of longleaf pine ecosystems and their associated wildlife also became a subject of interest for academics, nongovernmental organizations (NGOs), and private landowners. Longleaf pine became an area of increased focus for research organizations such as the U.S. Forest Service—Southern Research Station, Tall Timbers Research Station, the Joseph W. Jones Ecological Research Center, as well as individual researchers in university natural resource programs across the Southeast, with important publications highlighting the conservation value and conservation status of the species (Frost 1993; Landers et al. 1995; Means 1996). Longleaf pine ecosystems and their associated rare species became conservation targets for The Nature Conservancy and other NGOs, and for state agency natural heritage and nongame wildlife programs. In the mid-1990s, a group of longleaf pine proponents came together to establish The Longleaf Alliance, an education and outreach organization originally housed at Auburn University. The Safe Harbor program for red-cockaded woodpeckers, an innovative U.S. Fish and Wildlife Service program that removes many disincentives for managing for high-quality longleaf pine on private lands, was established in 1995.

As momentum and interest in longleaf pine continued to grow, a collaborative group of 22 federal agencies, state agencies, and conservation NGOs formed in 2007 to develop a range-wide conservation plan for longleaf pine ecosystems (see Chapter 1). The plan was released as America's Longleaf Restoration Initiative (2009). The broad goal of this plan is to increase longleaf pine acreage to 8 million acres while improving the condition of existing longleaf pine forests and creating higher-quality habitat for longleaf pine-associated wildlife species. Since the plan's release, a diverse group has coalesced to form the Longleaf Partnership Council, whose primary mission is to facilitate implementation of the plan through enhanced communication and collaboration. Longleaf pine is an increasing focus of foresters, game managers, nongame wildlife biologists, botanists, academics, public natural resource agencies, NGOs, private landowners, and those concerned with and affected by threatened and endangered species. The membership of the Longleaf Partnership Council is representative of the diversity of this group and reflects the broad range of motivations, goals, and objectives of its members.

Although distinguishing—in a value-neutral way—between the reestablishment of longleaf pine as a tree species on a given site and the holistic restoration of the longleaf pine ecosystem is important, the two goals are not mutually exclusive; rather, reestablishment can be viewed as a prerequisite for restoration. However, one cannot simply equate reestablishment of longleaf pine trees with restoration of the ecosystem. Ecosystem restoration encompasses the full suite of structural, functional, and compositional elements found in reference sites. Reestablishment can buy opportunities for ecosystem restoration, but expecting that all acres of reestablished longleaf pine will be managed solely for ecosystem values is neither reasonable nor realistic. The rangewide conservation plan acknowledges this by targeting a 3-million acre subset of the 8-million acre goal for ecosystem management, or what is termed "maintenance class" condition (Ware 2014), with the remainder either managed for more utilitarian purposes or classified as developmental. However, framing this as a binary choice would be a mistake; for many ownerships, some mix of economic, ecological, and aesthetic goals will drive decisions.

As knowledge and experience have grown, it is clear that longleaf pine ecosystem restoration is a long-term developmental process rather than a discreet intervention. Beyond establishment, restoration will require ongoing inputs such as prescribed fire and thinning, and intermediate treatments such as midstory control or ground cover restoration. Perhaps most challenging is the protracted time scale over which longleaf pine ecosystem development unfolds and the long-term commitment required to achieve the desired structure and function. These longer time scales also present challenges for the economic performance of longleaf pine compared to other southeastern pine species.

## LONGLEAF PINE ECONOMICS RESEARCH

For many private landowners, particularly those with large parcels, economic considerations play a role in their motivations for owning forestland. Economic considerations also factor into their decisions about forest management, including the basic question of whether to grow longleaf pine as opposed to other pine species. The modern literature on the economics of longleaf pine is limited compared to other southeastern pine species, reflecting the commercial dominance of loblolly and slash pine and the substantial support of the forest industry to meet applied information needs for these species. Beginning in the 1980s, research interest in longleaf pine management and economics began to grow; the literature subsequently reflects the heightened interest in the species and provides insight into the economics of longleaf pine compared to other southern pine species. The following section broadly summarizes trends and significant points from the emerging longleaf pine economics literature.

The use of capital budgeting techniques in the forest industry became more common in the 1970s; before then, relatively simple techniques such as payback analyses (the length of time required to recover capital investment) were often used. Increasingly, methods and concepts from the mainstream economics and business literature were used to incorporate the time value of money into forest investment analyses, including net present value (NPV), soil expectation value (SEV), internal rate of return (IRR), and other valuations (Bailes and Wendell 1979; Cubbage and Redmond 1985). Discount rates are annual rates of compound interest that are used to account for the time value of cash flows (Bullard et al. 2002). The discount rates chosen for forest investment analyses are often determined by the weighted cost of capital or the rate of return that could be earned from an alternative investment of similar length and risk.

NPV, the difference in the present (discounted) value of future cash inflows and future cash outflows, is one of the most common metrics used to analyze forest investments. For these investments, NPV is the difference between discounted costs, such as plantation establishment costs incurred early in the rotation, and discounted returns, which are typically profits from the sale of timber during and at the end of the rotation. A project is deemed acceptable if, for a chosen discount rate, NPV is a positive number; higher values are preferable to lower values. This metric does not indicate the relative scale of a project, meaning that a given figure for NPV does not distinguish between a large and a small investment, thus potentially obscuring the relative value. Also, NPV is typically calculated with a single value at the completion of the specific project, thus potentially confounding comparisons of projects with significantly different time frames. SEV, which is sometimes called land expectation value (LEV), is the net present value, per unit area, of the projected costs and revenues from an infinite series of identical even-aged forest rotations, starting initially from bare land. This allows comparisons of investments with different time horizons.

The internal rate of return (IRR) is the discount rate at which the present value of the costs is equal to the present value of the revenues, or the point at which NPV equals zero. It represents the actual rate of return on the investment, equivalent to a rate of compound interest that could be earned if the funds were invested elsewhere. This metric has the advantage of expressing results transparently in a common format, allowing comparisons of projects that are dissimilar in size or type. Although all of these metrics are employed in analyses and NPV is regarded by many as theoretically superior, IRR is often preferred as a quantitative decision criterion by the forest industry (Cubbage and Redmond 1985; Hogaboam and Shook 2004).

Historically, the prevailing perception was that economic returns from longleaf pine were categorically inferior to faster growing pine species. The range of approaches found in the literature for examining longleaf pine economics includes analyses of economic returns from longleaf pine alone, comparisons of economic returns from longleaf pine versus loblolly and/or slash pine, and comparative studies of volume growth of longleaf and other pine species without extending that analysis to capital budgeting analyses. A subcategory of this research addressed the economic aspects of managing for the red-cockaded woodpecker. For example, specific parameters of stand structure that have been defined in the red-cockaded woodpecker recovery plan require lower stocking rates and diameter distribution guidelines that inherently produce lower timber volumes and thus have negative impacts on economic returns (Lancia et al. 1989; Glenn 2012).

Most publications about the economics of longleaf pine management are found in the "gray" literature: conference proceedings, white papers, brochures, case studies, theses, and other reports that have not been subjected to rigorous peer review. The primary outlet for peer-reviewed forestry publications in the South was the *Southern Journal of Applied Forestry* (no longer published), but other outlets include a variety of forestry and economics journals. Taken as a whole, an important characteristic of these publications is the lack of consistency among the variables that drive the analyses. Differences in management regimes, discount rates, stumpage-value assumptions, and product output make direct comparisons across multiple analyses difficult. Some of these differences are attributable to subjective decisions on the part of the investigators; others involve changes in variables, such as stumpage values, during the 25 years that these analyses span.

However, these studies shared one consistent theme: the impact that the time value of money has on the economic returns for management of longleaf pine over longer rotations. A basic premise of financial analyses that use discounting, such as NPV, is that income earlier in the analysis cycle has higher value than income later in the cycle. Despite considerable gains in the development of longleaf pine establishment techniques that reduce time in the grass stage and accelerate early growth, the species still exhibits slower early growth than loblolly or slash pine in most situations (Schmidtling 1987; Cram et al. 2010). This is partly attributed to the inherent growth characteristics of the individual species, but also a reflection of decades-long tree improvement programs for slash and loblolly and the greater response of these species to fertilization and other silvicultural inputs (Bailian et al. 1999; Borders and Bailey 2001; Dickens, Moorhead, Morris, et al. 2012). Thus, the comparatively slower early growth of longleaf pine interacts with the time value of money and places it at an economic disadvantage compared to other pine species when analytical techniques that involve discounting are used, especially in short-term analyses. The essence of this disadvantage is that the other pines usually reach a valuable final harvest sooner than longleaf pine; thus, most economic analyses that involve direct comparisons of economic performance of longleaf and loblolly or slash pine invariably show longleaf pine to be inferior. However, many of these analyses also assume that products harvested from longleaf pine and other pine species are equivalent. Particularly when compared to loblolly pine, longleaf pine is preferred for pole production (Croker and Boyer 1975), produces dimensional lumber that has higher tensile strength, and has a higher weight-to-volume ratio (Meier 2016) as well as higher specific gravity (Jackson 1968).

To address the time value of money, several studies incorporated income pulses early in the analysis period (Hamilton 1998; Mills and Stiff 2008; Johnson 2011). For example, income from pine straw harvesting or incentive programs was shown to have very significant positive impacts on discounted metrics such as NPV and LEV as well as narrowing or eliminating disparities between the economic performance of longleaf pine versus other southern pine species. Incentive programs can offer early income in the form of establishment cost share or payments for given practices under a range of contractual periods (most typically within the first 10–15 years after establishment). Straw harvesting can begin at canopy closure, usually at age 6–8 depending on planting density and site productivity, and can continue for a decade or so until the first thinning. Many longleaf pine incentive programs prohibit straw raking, citing concerns about impacts on wildlife habitat and ground cover condition, illustrating that these two sources of early income are often mutually exclusive.

The discount rate (or rates) chosen for past analyses has varied widely, with many as low as 4%. Although a 4% discount rate would be appropriate for current analyses, using such a low rate in the 1980s and 1990s (and even early 2000s) does not accurately reflect the actual cost of capital during that time. Other confounding factors are variability in site indices used in different analyses and differences in management regimes. Finally, the disparity in stumpage prices and product mixes among studies was substantial. Assumptions about stumpage price are typically not explicit and are often referenced simply as being consistent with then-current market trends. Although the analyses that compare longleaf pine and loblolly pine rarely distinguish product classes and values between species, a few incorporate a reasonable percentage of poles in the longleaf pine harvest (Cubbage and Hodges 1989; Glenn 2012) and reflect the price differential in timber income. One analysis suggests that when combined with straw income, the higher rate of pole production yields equal or superior results for longleaf compared to loblolly in a range of scenarios (Mills and Stiff 2013). Another (Busby et al. 1993) modeled an unusually high rate of pole production (90% of all stems that met size/length requirements), perhaps skewing results favorably for longleaf pine. Yanquoi (1992) offered one of the better examples of a sensitivity analysis that highlights the significance of these variables and their interactions.

General timber-value trends for economic metrics are summarized in Table 3.1. For longleaf pine analyses that used both high and low discount rates, results are presented for the lower discount rates. Given the disparity in methodology among analyses, meaningful quantitative analysis or statistical exploration (such as meta-analysis) is not feasible.

The results for NPV of longleaf pine ranged from −$476 to + $766 per acre in analyses that used a 4%–5% discount rate. Within that range, NPV most commonly ran from about $150 to $500. Depending on management intensity, average results for loblolly pine (Siry 2002) ranged from $411 to $1082 at a 6% discount rate. This was considerably higher than longleaf pine, especially considering the discount rate used was 100–200 basis points higher. All other factors being equal, higher discount rates result in lower performance in discounted capital budgeting analyses because the time value of money has greater impact.

SEV for longleaf pine ranged from −$497 to + $967 per acre at a 4%–5% discount rate, with most results running from $200 to $600. At a 6% discount rate, SEV of loblolly pine ranged from $411 to $1411 per acre (Siry 2002).

IRR for longleaf pine ranged from 0%–10.1%, with most results in the 3%–7% range. IRR for loblolly (Siry 2002) in 2000 ranged from 9.6%–13%. This is consistent with later analyses (Cubbage et al. 2007) that suggest an IRR of 7.7%–12.5% for loblolly, reflecting recent overall decreases for pulpwood prices (Wear et al. 2013).

Rates of returns can be increased by >60% with annual income from pine straw in loblolly, slash, and longleaf pine forests (Dickens, Moorhead, Bargeron, et al. 2012). The inclusion of pine straw raking in several of the longleaf pine analyses demonstrates that this income source can improve

**TABLE 3.1**
**Comparison of Averages for Commercial Value Measures for Longleaf Pine and Loblolly Pine Using Low and High Discount Rates (DR)**

| | Longleaf Pine | | Loblolly Pine | |
|---|---|---|---|---|
| | Low DR | High DR | Low DR | High DR |
| **Net Present Value[a] (US$/acre)** | 150 | 500 | 411 | 1082 |
| **Soil Expectation Value[b] (US$/acre)** | 200 | 600 | 500 | 1411 |
| **Internal Rate of Return[c] (%)** | 3 | 7 | 9.6 | 13 |

Note that analyses concentrated on timber only, rather than other commercial and ecological values of the two species.

[a] The difference between the present—or discounted—value of future cash inflows and future cash outflows.

[b] The net present value of the projected costs and revenues from an infinite series of identical even-aged forest rotations, starting initially from bare land.

[c] The discount rate at which the present value of the costs is equal to the present value of the revenues, or when net present value equals zero.

economic returns (Roise et al. 1991; Mills and Stiff 2008; Johnson 2011; Glenn 2012) for two primary reasons: (1) as outlined above, the ability to derive income from straw early in the investment cycle has significant impacts on metrics that use discounting, and (2) the income from straw over the life of a stand can equal or exceed income from timber. Recent multiyear averages range from $50 to $150 per acre per raking, although revenues as high as $300–$400 per acre have been reported in high-quality longleaf pine stands (Dickens, Moorhead, Bergeron, et al. 2012). Longleaf pine comparisons of LEV for timber-only and timber-plus-straw showed increases of as much as 300% when straw was included (Glenn 2012), with a more common range of 15%–90% (Mills and Stiff 2008). NPV increases ranged from 26%–350% (Mills and Stiff 2008; Johnson 2011).

Some analyses of straw-harvesting economic impacts in longleaf pine forests suggest either implicitly or explicitly that timber harvesting plus straw raking can be fairly competitive with timber harvesting alone in loblolly pine forests (Table 3.2). Interestingly, very few publications that compare longleaf pine and other pine species also incorporated a scenario in which loblolly or slash pine straw is harvested for income. One line of research examined straw management and revenues (Dickens et al. 2011, 2014; Dickens, Moorhead, Bergeron, et al. 2012), comparing straw raking and timber harvesting combinations for loblolly, slash, and longleaf pine. The studies suggested that although longleaf pine straw is clearly viewed as the superior product and commands wholesale prices that are nearly 100% higher than loblolly pine straw, loblolly pine forests produce 30% more bales per acre. Slash pine forests fall in between the two, both in price and in productivity. An informal survey (McIntyre, unpublished data) of wholesale straw suppliers suggests that slash pine is the largest seller by volume because of abundant supply and higher quality compared to loblolly, and that longleaf pine sales are constrained by supply. Analyses that include straw in economic comparisons would benefit from examining the potential for straw harvesting from all species of southeastern pines. A comparison of various loblolly, slash, and longleaf pine straw/timber scenarios found longleaf pine to have slightly higher SEV (+2.6%) than slash pine and much higher SEV (+12.3%) than loblolly pine at 33-year rotations, but it still greatly underperformed both species at 24-year rotations (Dickens et al. 2014).

One of the drivers for the range-wide efforts to restore longleaf pine is the availability of habitat for the suite of wildlife species that are associated with longleaf pine, from federally listed nongame species such as the red-cockaded woodpecker to more common game species such as the northern bobwhite (*Colinus virginianus*). Although longleaf pine-associated species may differ in the details of their individual requirements for optimal habitat, as a group they share many general characteristics of preferred habitat including a relatively open canopy, lower stocking rate, and grass-dominated ground cover that is maintained by frequent fire. All of these characteristics represent opportunity costs compared to longleaf pine forests managed for maximum timber production.

Two studies addressed this issue by examining opportunity costs within the context of red-cockaded woodpecker management. Lancia et al. (1989) found opportunity costs of $125–$250 per acre in SEV in areas that were managed for red-cockaded woodpecker foraging habitat as outlined in the 1985 recovery plan for the species. Comparing SEV of longleaf pine managed for maximum timber value with longleaf pine managed for red-cockaded woodpecker habitat, Glenn (2012) found opportunity costs ranging from $322 to $439 per acre (depending on site index and level of straw harvesting).

The management strategies in both of these studies essentially drove SEV into negative territory, the exception being two of the more aggressive straw harvesting regimes that resulted in positive SEV (Glenn 2012). Red-cockaded woodpeckers arguably represent the high end of the range of opportunity costs for wildlife habitat because of their preference for older trees and lower stocking, as defined in the habitat recovery plan for the species. Although the guidelines for red-cockaded woodpeckers differ significantly from the regimes in forests that are managed for fiber production, landowners who manage for sawtimber products would likely not view them as such a significant departure from their regimes. Managing for the broader community of longleaf pine-associated wildlife certainly involves some opportunity costs, but these costs are likely to be less than those incurred when managing

**TABLE 3.2**
**Significant Economic Studies for Longleaf Pine and Other Southeastern U.S. Pines, Comparing Net Present Value (NPV)[a], Internal Rate of Return (IRR)[b], and Soil Expectation Value/Land Expectation Value (SEV/LEV)[c]**

| Investigator(s) | Scenario | Age (yr) | DR (%) | IRR (%) | NPV (Low DR) | NPV (High DR) | SEV/LEV (Low DR) | SEV/LEV (High DR) |
|---|---|---|---|---|---|---|---|---|
| | | | | | (US$/acre: Numbers in Parentheses Indicate Negative Values) | | | |
| **Cubbage and Hodges (1989)** | Longleaf natural regeneration | 45 | 4.0 | 6.0 | 146 | – | 170 | – |
| | Longleaf natural regeneration | 80 | 4.0 | 6.8 | 443 | – | 460 | – |
| | Longleaf artificial regeneration, 1 thinning | 40 | 4.0 | 5.2 | 165 | – | 208 | – |
| | Longleaf artificial regeneration, no thinning | 40 | 4.0 | 6.2 | 408 | – | 516 | – |
| | Longleaf artificial regeneration, 2 thinnings | 50 | 4.0 | 6.3 | 538 | – | 626 | – |
| **Kessler and Straka (1991)** | Longleaf natural regeneration and supplemental artificial regeneration, no thinning, with straw raking | 37 | 4.0 | – | 709 | – | 627 | – |
| **Roise et al. (1991)** | Longleaf natural regeneration, shelterwood, with straw raking | 60 | 4.0 | – | – | – | 1198 | – |
| | Longleaf natural regeneration, shelterwood, with straw raking | 80 | 4.0 | – | – | – | 1227 | – |
| | Longleaf natural regeneration, shelterwood, with straw raking | 100 | 4.0 | – | – | – | 1268 | – |
| | Longleaf natural regeneration, shelterwood, with straw raking | 120 | 4.0 | – | – | – | 1298 | – |
| **Yanquoi (1992)** | Longleaf natural regeneration, site index of 70 | 40–80 | 4.0 | – | – | – | 261–424 | – |
| **Alavalapati et al. (2002)** | Longleaf, 42-year rotation | 42 | 5.0 | – | – | – | 515 | – |
| | Slash, 30-year rotation | 30 | 5.0 | – | – | – | 1146 | – |

*(Continued)*

**TABLE 3.2 (*Continued*)**
**Significant Economic Studies for Longleaf Pine and Other Southeastern U.S. Pines, Comparing Net Present Value (NPV)[a], Internal Rate of Return (IRR)[b], and Soil Expectation Value/Land Expectation Value (SEV/LEV)[c]**

| Investigator(s) | Scenario | Age (yr) | DR (%) | IRR (%) | NPV (Low DR) | NPV (High DR) | SEV/LEV (Low DR) | SEV/LEV (High DR) |
|---|---|---|---|---|---|---|---|---|
| | | | | | (US$/acre: Numbers in Parentheses Indicate Negative Values) | | | |
| **Teeter and Somers (2005)** | Longleaf artificial regeneration, site index of 70 | 50 | 5.0, 7.0 | – | (20)–100 | (60)–(160) | – | – |
| | Longleaf artificial regeneration, site index of 80, | 50 | 5.0, 7.0 | – | 150–250 | (60)–25 | – | – |
| | Longleaf artificial regeneration, site index of 90, | 50 | 5.0, 7.0 | – | 375–475 | 60–175 | – | – |
| **Cubbage et al. (2007)** | Longleaf natural regeneration, southeastern United States | 80 | 8.0 | 4.3 | – | (165) | – | – |
| | Loblolly artificial regeneration, southeastern United States | 30 | 8.0 | 9.5 | – | 133 | – | – |
| | Pine spp. artificial regeneration, South America | 18–22 | 8.0 | 10.5–16.9 | – | 460–748 | – | – |
| | Eucalyptus artificial regeneration, South America | 7–16 | 8.0 | 12.8–22.9 | – | 1486 | – | – |
| **Mills and Stiff (2008)** | Loblolly artificial regeneration, low site index | Variable | 5.0, 7.0 | – | 502 | 183 | 611 | 213 |
| | Longleaf artificial regeneration, low site index | Variable | 5.0, 7.0 | – | 245 | 49 | 308 | 53 |
| | Longleaf artificial regeneration, with straw raking, low site index | Variable | 5.0, 7.0 | – | 548 | 175 | 593 | 178 |
| | Loblolly artificial regeneration, high site index | Variable | 5.0, 7.0 | – | 895 | 470 | 1180 | 583 |
| | Longleaf artificial regeneration, high site index | Variable | 5.0, 7.0 | – | 766 | 385 | 967 | 457 |
| | Longleaf artificial regeneration, with straw raking, high site index | Variable | 5.0, 7.0 | – | 968 | 503 | 1109 | 597 |

*(Continued)*

**TABLE 3.2 (*Continued*)**
**Significant Economic Studies for Longleaf Pine and Other Southeastern U.S. Pines, Comparing Net Present Value (NPV)[a], Internal Rate of Return (IRR)[b], and Soil Expectation Value/Land Expectation Value (SEV/LEV)[c]**

| Investigator(s) | Scenario | Age (yr) | DR (%) | IRR (%) | NPV (Low DR) | NPV (High DR) | SEV/LEV (Low DR) | SEV/LEV (High DR) |
|---|---|---|---|---|---|---|---|---|
| | | | | | (US$/acre: Numbers in Parentheses Indicate Negative Values) | | | |
| McIntyre et al. (2010) | Longleaf low intensity selection harvest, land value included in analysis | Ongoing | 6.0 | 3.21 | – | – | – | – |
| | Longleaf medium intensity selection harvest, land value included in analysis | Ongoing | 6.0 | 3.29 | – | – | – | – |
| | Longleaf high intensity selection harvest, land value included in analysis | Ongoing | 6.0 | 3.48 | – | – | – | – |
| Johnson (2011) | Longleaf artificial regeneration, timber harvesting, no straw raking | 45 | 4.5, 6.0 | 6.0 | 197 | (3) | – | – |
| | Longleaf artificial regeneration, timber harvesting with straw raking | 45 | 4.5, 6.0 | 11.0 | 894 | 482 | – | – |
| | Longleaf artificial regeneration, 50% cost share, timber harvesting, no straw raking | 45 | 4.5, 6.0 | 7.0 | 282 | 81 | – | – |
| | Longleaf artificial regeneration, Conservation Reserve Program incentives, timber harvesting, no straw raking | 45 | 4.5, 6.0 | 29.0 | 787 | 545 | – | – |
| | Longleaf artificial regeneration, Conservation Reserve Program incentives, timber harvesting, straw raking at year 15 | 45 | 4.5, 6.0 | 30.0 | 1317 | 883 | – | – |
| Glenn (2012) | Longleaf, no straw raking | Variable | 4.0 | 0.0–4.6 | (476)–113 | – | (497)–142 | – |
| | Longleaf with conservative straw raking | Variable | 4.0 | 2.3–5.4 | (209)–192 | – | (218)–386 | – |

(*Continued*)

**TABLE 3.2 (*Continued*)**
**Significant Economic Studies for Longleaf Pine and Other Southeastern U.S. Pines, Comparing Net Present Value (NPV)[a], Internal Rate of Return (IRR)[b], and Soil Expectation Value/Land Expectation Value (SEV/LEV)[c]**

| Investigator(s) | Scenario | Age (yr) | DR (%) | IRR (%) | NPV (Low DR) | NPV (High DR) | SEV/LEV (Low DR) | SEV/LEV (High DR) |
|---|---|---|---|---|---|---|---|---|
| | | | | | (US$/acre: Numbers in Parentheses Indicate Negative Values) | | | |
| | Longleaf with moderate straw raking | Variable | 4.0 | 3.6–6.1 | (52)–463 | – | (54)–584 | – |
| **The following studies are shown to provide comparisons of financial returns for loblolly pine.** | | | | | | | | |
| **Sedjo (2001)** | Loblolly, southwide average | * | * | 12.5 | – | – | – | – |
| **Siry (2002)** | Loblolly with five levels management intensity | 25–30 | 6.0 | 9.6–13.0 | – | 416–1082 | – | 504–1411 |
| Dickens et al. (2006) | Loblolly | 24 | 8.0 | 6.2–11.9 | – | – | – | – |

DR: Discount rates;
–: Value not calculated; *: Information not available;
[a] The difference between the present—or discounted—value of future cash inflows and future cash outflows.
[b] The discount rate at which the present value of the costs is equal to the present value of the revenues, or when net present value equals zero.
[c] The net present value of the projected costs and revenues from an infinite series of identical even-aged forest rotations, starting initially from bare land.

primarily for red-cockaded woodpecker. A study that focused on management of mature longleaf pine for a broader suite of wildlife found IRR ranging from 3.21%–3.48% (McIntyre et al. 2010). This study incorporated income from a hunting lease and included land costs as an initial investment expense. IRR analyses for forestry do not often include land costs; sensitivity analyses (Cubbage et al. 2007) found that IRR for pine management increases by about 50%–60% on average when land costs are not included. Using this as a correction factor suggests that IRR results from McIntyre et al. (2010) would range from 5%–5.4% without land costs, comparable to other IRR analyses for longleaf pine.

Taken as a whole, these studies clearly suggest that, on many sites, longleaf pine lags in growth and thus economic returns (for timber only) compared to other southeastern pine species when using shorter time scales and discounted cash flow analyses. However, many of these analyses used older growth and yield models that did not incorporate the faster growth of containerized seedlings or the effects of modern longleaf pine establishment techniques. Also, few studies attempted to incorporate the economic advantages of long-term management, such as the minimal stand reestablishment costs afforded by natural regeneration under multiple age-class management strategies. Although yet-to-be-developed analytical approaches, such as updated growth and yield models, would likely cast longleaf pine in a better light, there are existing considerations that support longleaf pine as a viable economic choice for some land ownerships.

Several studies did not actually employ discounted capital budgeting analyses but rather focused on growth rates of longleaf pine and other southeastern pine species. These studies showed that volume growth of longleaf pine can compete with volume growth of loblolly pine on xeric sandy soils and other low productivity sites, suggesting that differences in economic returns may not be significant under these circumstances (Outcalt 1993; Cram et al. 2010). This has significant economic implications for large-acreage landowners who are evaluating fine-scale variations in site quality across their timberland portfolios. Further, several studies suggest that longleaf pine "catches up" to other southeastern pine species on many sites between the ages of 20 and 25 years (Schmidtling 1987; Boyer 1996; Harris et al. 2000).

Another aspect of longleaf pine that bears on this discussion is its reputation for high-quality wood products. Compared to other southeastern pine species, longleaf pine is known to produce higher percentages of poles (Williston et al. 1989) and wood that has higher tensile strength, specific gravity (Markwardt and Wilson 1935), and weight-to-volume ratio. These attributes should, in theory, result in higher economic returns for longleaf pine. Pole values are reflected in some of the analyses, and pole product classes have held their value in recent years. However, with few exceptions, longleaf pine sawtimber is generally lumped with other southeastern pine species with respect to stumpage prices. Although its heavier weight-to-volume ratio arguably captures some of this value, the broader attributes of longleaf pine are typically not valued in the marketplace. The degree to which this is captured in longleaf pine economics studies is unclear.

Research has also evaluated characteristics of longleaf pine that could provide greater diversification of a forest management portfolio to improve resilience for impacts from hurricanes, wildfires, and pine beetle outbreaks (Croker and Boyer 1975; Hodges et al. 1979; Strom et al. 2002; Johnsen et al. 2009). However, quantitative analyses of management risks have yet to be fully incorporated into economic comparisons of longleaf pine and other southeastern pine species. At the stand level, lower overall financial risks (a general finding from the studies listed earlier in this paragraph) should increase the relative return of longleaf pine management compared to other forest management choices. At a broader landscape level, considerations of risk management might suggest the increased use of longleaf pine in a portfolio of forest management strategies as a hedge against biophysical and financial risk, similar to risk spreading in a portfolio of financial assets (Dixit and Pindyck 1994). Beyond a consideration of risk, the different pattern of revenue streams across time and product classes (sawtimber versus pulpwood) for longleaf and loblolly pine suggests a countercyclical potential for a portfolio of forest investments that include both species (Wear et al. 2013).

Consistent with a basic principle of discounting in which cash flow earlier in an analytical cycle has higher value, the literature clearly suggests that supplemental income early in a forest management cycle, such as straw raking, establishment cost share, or incentive payments, can often make longleaf pine economically competitive. Finally, it should be recognized that the inclusion of broader management objectives in addition to economic returns, such as wildlife habitat and legacy values, implies some degree of opportunity cost. Some landowners may be willing to assume these opportunity costs, but for others, compensatory mechanisms such as incentives may be required to offset opportunity costs.

## THE CHANGING LANDSCAPE—FUTURE PROJECTIONS FOR SOUTHEASTERN FORESTS

Wear and Greis (2013) developed forecasts of land use for southeastern forests using a set of scenarios or "cornerstone futures" as a framework for predicting change from 1997 to 2060. Their primary driving variables were growth (economic and population) and timber and crop prices (high or low to define increasing or decreasing demand) within an econometric model of land use change. Their historical land use categories (pasture, crops, forest, range, or urban) and area data were based on the Natural Resources Inventory (USDA NRCS 2001).

Urbanization is projected to continue driving regional land use patterns as rapid population growth continues, with forecasts ranging from 30 to 43 million additional acres of land developed for urban use by 2060. As a component of the overall acreage lost to urbanization, forestland is expected to decrease by 11–23 million acres. The highest collective losses are expected in the Piedmont; but forest loss in the Coastal Plain would also be significant, with most development expected to occur near the Atlantic Ocean and Gulf of Mexico, and with Florida projected to lose 34% of its existing forest cover (Klepzig et al. 2014).

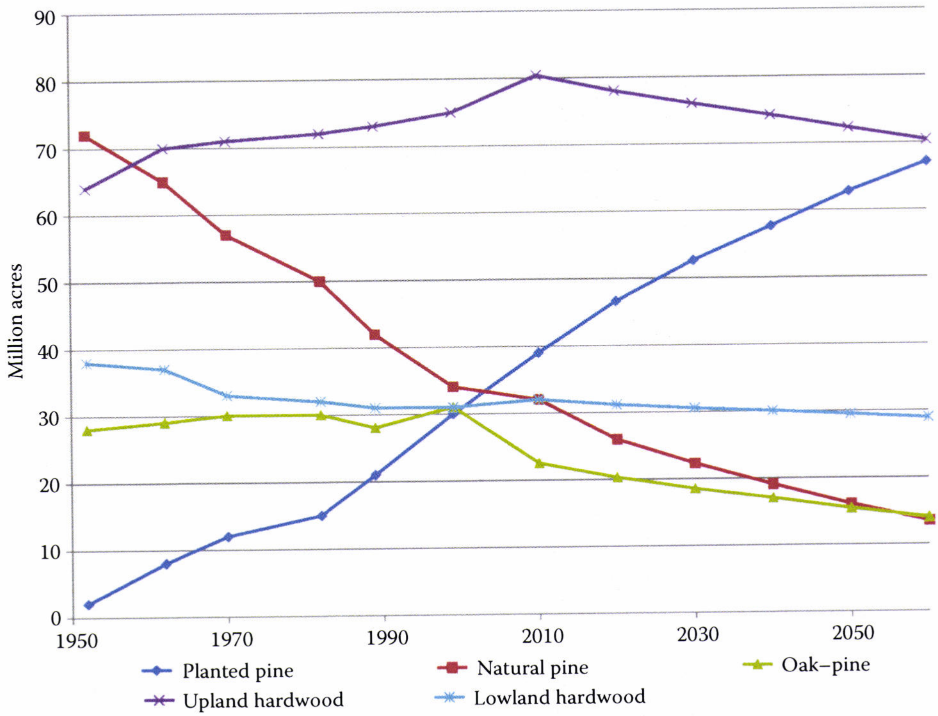


**FIGURE 3.1** Forecasted forest area by forest management type, 1952–2060, for southeastern U.S. forests under the assumption of high urbanization, high timber prices, and more tree planting. (Redrawn from Huggett, R. et al., *Forecasts of Forest Conditions*, USDA Forest Service, Southern Research Station, Asheville, North Carolina, 73–101, 2013.)

Forest condition is also predicted to change over this time frame. Huggett et al. (2013) considered five broad categories of southeastern forests (Figure 3.1): planted pine (all species), natural pine, mixed pine and oak (*Quercus* spp.), upland hardwood, and lowland hardwood. They predicted that only planted pine will increase in area, from its current levels of 39 million acres (19% of southeastern forests) to somewhere between 47–67 million acres (24%–36% of southeastern forests), depending on the scenario. Declines in area of natural pine are expected to continue their historical trajectory and are inversely related to gains in planted pine, with losses projected to range from 7.6 to 18.0 million acres. Models also predicted overall forest carbon to increase slightly until 2020/2030 and then begin to decrease. Market projections also indicated a continued concentration of timber production in the Southeast, specifically in the Coastal Plain, which is consistent with the prediction of expanding areas of planted pine.

## THE PLACE OF LONGLEAF PINE IN THE LANDSCAPE IN THE 21ST CENTURY

### Current Status of Longleaf Pine

The current estimate of longleaf pine acreage stands at 4.28 million acres and is based on FIA data (Miles 2016). These data include two forest types: longleaf pine and longleaf pine/oak. The longleaf pine forest type is defined as those stands with greater than 50% stocking of pine in which longleaf pine is the dominant pine. The longleaf pine/oak forest type is defined as stands in which pine accounts for 25%–50% of the stocking and longleaf pine is the dominant pine species (Oswalt et al. 2012). Longleaf pine forests that remain today are not evenly distributed across the historical range of the species. About 89%, or 3.8 million acres, is located in an area of the Coastal Plain that stretches from the Mississippi River eastward to the Atlantic Ocean, with large concentrations in the Florida Panhandle, southern Alabama, Georgia, and Mississippi (Oswalt et al. 2012). Regionwide, 62% of the existing longleaf pine is controlled by private landowners, with the remaining acreage managed by public agencies. This concentration of longleaf pine forest type (38%) on public lands (Oswalt et al. 2012) is disproportionate to the total forested acreage in the Southeast (13%) that is occupied by public lands (Oswalt et al. 2014), thus demonstrating the importance of public lands to longleaf pine conservation.

Given the aggressive goals for restoration of longleaf pine forests and the rapid changes occurring on the southeastern landscape, significant questions emerge about how, where, and within what context these goals will be accomplished. The complex set of variables that interact to drive these considerations include land use changes, smoke management in the wildland-urban interface, the opportunity costs associated with longleaf pine, and the stability of land ownership.

## Opportunities for Restoration on Public Lands

The fact that public lands contain 38% of the remaining longleaf pine on just 13% of the Southeast's forested land base highlights the critical role that public lands have played, and will continue to play, in the conservation and management of longleaf pine ecosystems. Going forward, they will also play an important role in the effort to increase longleaf pine acreage. Longleaf pine restoration on public lands represents perhaps the most valuable investment of available funding because of the low risk of conversion to other land uses or forest types, institutional capacity and resources to implement management activities, less concern about the economic opportunity costs of longleaf pine, and a commitment to long-term management, thus the potential for full realization of ecological restoration goals.

The ecological values of longleaf pine align well with the primary objectives of many public lands, including wildlife values, biodiversity conservation, carbon storage, and other ecosystem services. The advantages of prioritizing restoration on public lands include a much higher likelihood of longleaf pine persistence into the future, opportunities for expansion of significant core areas where longleaf pine dominates across functional landscapes, and consistent management planning over long time scales.

Perhaps the most important opportunity for longleaf pine restoration on public lands will occur on national forests, which comprise about 4 million acres within the historical range of longleaf pine (USGS 2016). In a review of Southeastern national forests land management plans, the U.S. Forest Service identified approximately 808,143 acres of existing longleaf pine and a target of 1,492,374 desired acres. Data for existing acreage differed from FIA sampling estimates because they originated from actual stand-level inventories (ALRI 2009). The other significant federal land holders in the Southeast are the U.S. Fish and Wildlife Service (national wildlife refuges) and the Department of Defense (military installations). The opportunities for national wildlife refuges are limited, primarily because of their historical emphasis on wetlands and the relatively low acreage of uplands in their land portfolio, but the U.S. Fish and Wildlife Service is actively working on longleaf pine restoration where appropriate. Although military installations have some of the best remaining examples of longleaf pine ecosystems because of their history of frequent fire, land requirements for the military mission may preclude significant expansion of longleaf pine acreage on these lands.

National forests regularly update management plans for their lands, with revised guidance set forth in the 2012 planning rule. The U.S. Forest Service has been a leader in the public sector for longleaf restoration efforts, including the development of the range-wide conservation plan. As southeastern national forests embark on revisions of their land management plans, it is anticipated that longleaf pine will become a higher priority on national forests within its historical range. In the interim, until forest plan revisions are undertaken in coming years, amendments to existing plans could be a tool for increased longleaf pine restoration. Prioritization of longleaf pine restoration on all appropriate national forest sites could result in significant increases in desired acres of longleaf pine. For example, the recently completed plan for the Francis Marion National Forest in South Carolina approximately doubles the goal for acres of upland longleaf and wet pine savanna and flatwoods ecosystems compared to the previous plan. Additionally, annual targets for prescribed fire were increased substantially and greater emphasis will be placed on growing-season fire for ecological objectives (USDA FS 2016). As additional national forests begin plan revisions, similar increases may be forthcoming given the evolving focus of national forest management and the new national planning rule. The U.S. Forest Service has a history of leadership in longleaf pine restoration, an existing capacity for forest management, a strong prescribed fire program, and a mandate for multiuse management that includes ecological values. With the largest portfolio of public lands within the historical range of longleaf pine, the opportunity to focus restoration efforts on sites with such a high degree of ownership stability that allows for management of longleaf pine over the long term is tremendous.

State-owned properties such as wildlife management areas and state forests are also good candidates for restoration of longleaf pine, but acreage varies widely among states. For example, for all of the states (excluding Texas) where FIA data report longleaf pine, Florida has as much state-owned land and almost twice as much longleaf pine acreage as all of the other states combined (Miles 2016). Across the region, longleaf pine on state-owned public lands comprise approximately 456,000 acres. As with national forests, the overall management purposes for these lands typically align closely with the attributes of longleaf pine ecosystems.

Assuming some level of increase across the board on national forests and some level of contribution from state lands and other federal lands, a forecast of ≥1 million acres of potential longleaf pine restoration on public lands would not be unreasonable. However, public agencies face a range of challenges, including budgetary limitations and constraints mandated by legislation such as the National Environmental Protection Act. From 2013 to 2015, annual longleaf pine establishment on all public lands averaged just 26,000 acres (Longleaf Partnership Council 2014, 2015, 2016). Thus, acceleration of longleaf pine restoration on public lands will be a critical component of meeting the goals of the regional restoration initiative.

## Opportunities and Challenges for Restoration on Private Lands

Although public agencies support longleaf pine restoration and are more than willing to meet challenges and implement restoration on the lands that they manage, most of the acreage gains required to achieve the 8-million acre goal of the regional restoration initiative will need to occur on private lands—continuing a trend of acreage gains on private lands, particularly those held by family forest owners. From 2013 to 2015, approximately 450,000 acres of longleaf pine establishment were documented, with >75% occurring on private lands (Longleaf Partnership Council 2014, 2015, 2016); about 50% of these private land acres were established under incentive programs, for which corporate landowners are typically ineligible. This suggests that at least half of the increase in longleaf acreage occurred on family forests.

The multiple values of longleaf pine, which include aesthetics, wildlife habitat, moderate timber income, and legacy benefits, align well with the objectives of many family forest landowners. The increase in longleaf pine establishment from 2013 to 2015 built on the planting of >900,000 acres of longleaf pine plantations from 1985 to 2010 (Oswalt et al. 2012). However, these numbers for newly established longleaf do not tell the whole story of longleaf pine acreage dynamics. Based on preliminary examination of changes in FIA data from 2010 (Oswalt et al. 2012) to 2015 (Miles 2016), longleaf pine acreage losses appear to have negated any gains (see Chapter 1), with most of those losses presumably from older, established stands on private lands. These data illustrate some of the challenges involved in restoring longleaf pine on private lands.

### Restoration on Family Forestlands

Individuals or families own two-thirds of the private forestlands in the Southeast, or about 132 million acres (Butler and Wear 2013). Insights into the motivations and dynamics of this diverse group can be taken from social science surveys conducted by the U.S. Forest Service since the late 1970s, initially through its stewardship program (Birch 1997) and more recently through its woodland owners survey (Butler 2008, 2016). Through the years, a consistent theme of these surveys has been that family forest owners value their forests for a variety of reasons, many of which are independent of economics (Figure 3.2). This evidence that family forest owners typically rank timber income lower in their priorities than other forest amenities is particularly encouraging for longleaf pine. Although timber income may be an important component of their suite of overall values, these surveys suggest that discounted economic metrics are not the primary drivers of their decision processes.

One of the most significant opportunities for longleaf pine on family forestlands is the ability of this group of landowners to access federal incentive programs. These programs offer cost-share support for longleaf pine establishment and for specific management activities such as prescribed fire. Other programs have also offered yearly incentive payments for a defined period, usually 10–15 years, to maintain longleaf pine. Many of the longleaf pine establishment acres are a direct result of USDA incentive programs offered through Natural Resources Conservation Service and Farm Service Agency, such as the Conservation Reserve Program, the Longleaf Pine Initiative, and Working Lands for Wildlife, as well as Department of Interior programs such as Partners for Fish and Wildlife. These programs have resulted in approximately 556,000 acres of longleaf pine establishment since the late 1990s (D. Hoge, personal communication; L. Jones, personal communication). Payments through these programs provide income early in the discounting cycle and are often large enough to offset opportunity costs of choosing longleaf pine over faster growing pine species.

Although there has been past success and opportunities remain, longleaf pine restoration on family forests also faces challenges, many stemming from a rapidly changing southeastern landscape.

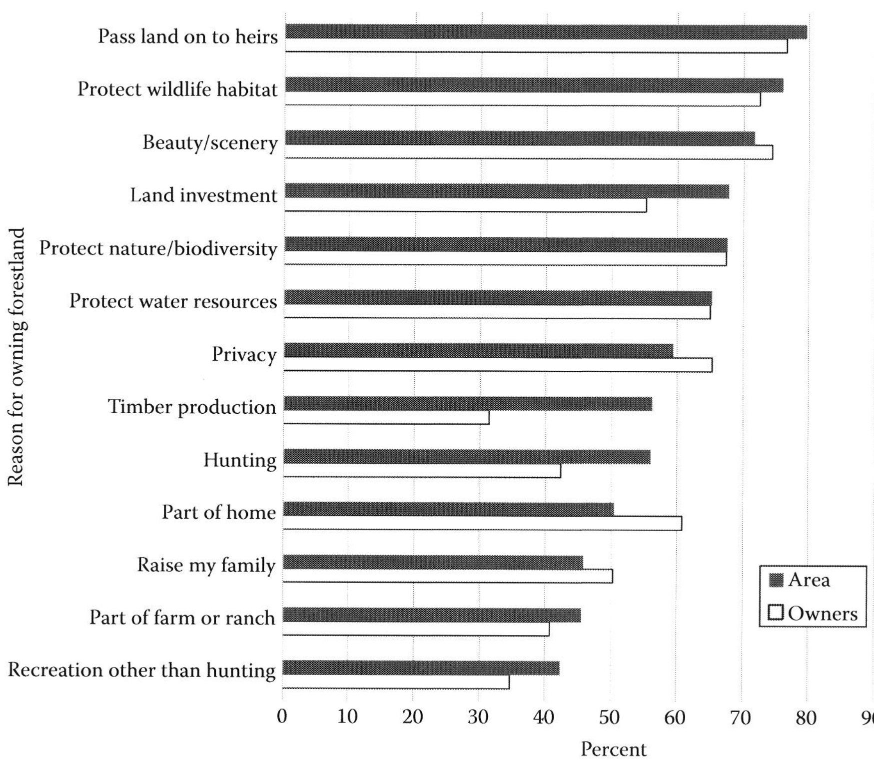


**FIGURE 3.2** Survey data on motivations of U.S. Forest Service Southern Region family forest owners, 2011–2013 (excludes West Texas and West Oklahoma). (Modified from Butler, B. J. et al., *USDA Forest Service National Woodland Owner Survey: National, Regional, and State Statistics for Family Forest and Woodland Ownerships with 10+ Acres, 2011–2013*. Resource Bulletin NRS-99, USDA Forest Service, Northern Research Station, Newton Square, Pennsylvania, 2016.)

The average size of the family forest parcel is 29 acres (Butler and Wear 2013). FIA survey data suggest that parcelization is continuing (Figure 3.3). During the period covered by these surveys, the percentage of forests in parcels of ≤100 acres almost doubled, and tracts of ≥1,000 acres were reduced by half, reflecting both divestiture of forest industry lands as well as transfer of family forestlands. Decreasing parcel size of forestland in the Southeast is well documented and recognized as an issue for viability of ongoing forest management (Hatcher et al. 2013).

Small-parcel forest holdings have long been a source of concern in the forestry community for two primary reasons: first, economies of scale make implementation of certain forest management practices, such as prescribed fire and thinning, difficult on smaller tracts; and second, smaller tracts tend to have higher rates of parcelization. Addressing some of the management issues by aggregating tracts or establishing cooperative arrangements with neighboring properties has been suggested, but neither of these options has been widely used in the United States (Cubbage 1983; Kittredge 2005). As shown in Figure 3.4, approximately 86% of individuals who own family forests own parcels of <100 acres, but almost two-thirds of the actual acreage is in parcels ≥100 (Butler et al. 2016). Although direct causal mechanisms can be difficult to verify and may be highly variable from one situation to the next, the size of a forest holding is a good proxy variable for predicting several elements of forest management. As the size of forest holdings increases, land tenure increases, the probability that the owner will actively manage timber increases, participation in cost-share programs increases, the percentage of owners with a management plan increases, and the tendency to seek professional advice increases (Hatcher et al. 2013).

A primary scale-related issue associated with smaller-acreage family forests is the practicality and economic viability of operational management. Many of the costs associated with timber harvesting—such as equipment, labor, and transportation—are fixed and essentially independent of tract size or timber volume. Studies suggested that the minimum tract size for economically viable timber management ranges from 40 to 50 acres (Row 1973, 1978; Lazarus and Schaible 2015) to 80 acres (Wikstrom and Alley 1967). Wikstrom and Alley (1967) also suggested that prescribed burning of tracts <25 acres is prohibitively expensive and that the minimum average costs cannot be realized until tract size reaches 125 acres. Unless a smaller stand can be bundled with a neighboring property to reach a size that attracts a contractor for thinning or burning, executing operations on

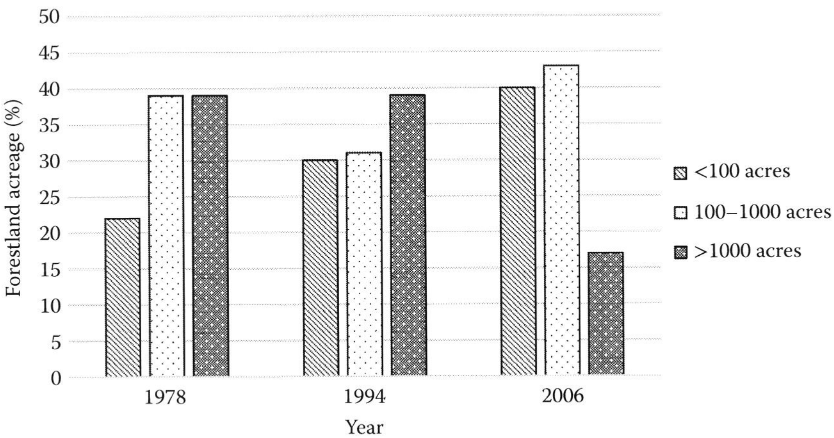


**FIGURE 3.3** Parcel-size breakdown for forests in the southeastern United States, 1978–2006. (From Birch, T. W. et al., *The Private Forest-Land Owners of the United States*. Resource Bulletin WO-1, USDA Forest Service, Washington, DC, 1982; Birch, T. W., *Private Forest-Land Owners of the Southern United States, 1994*. Resource Bulletin NE-138. USDA Forest Service, Northeastern Forest Experiment Station, Pennsylvania, 1997; Butler, B. J., *Family Forest Owners of the United States, 2006*, General Technical Report NRS-27, USDA Forest Service, Northern Research Station, Newtown Square, Pennsylvania, 2008.)

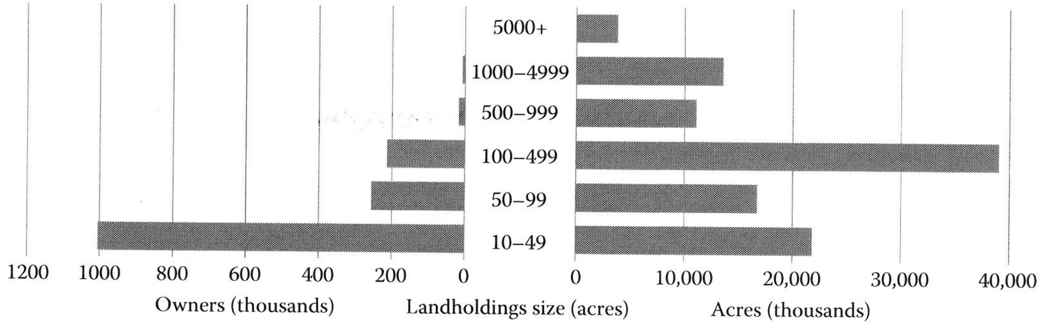


**FIGURE 3.4** U.S. Forest Service Southern Region family forest ownership survey data, 2011–2013, comparing parcel size and number of land owners (excludes West Texas and West Oklahoma). (Modified from Butler, B. J. et al., *USDA Forest Service National Woodland Owner Survey: National, Regional, and State Statistics for Family Forest and Woodland Ownerships with 10+ acres, 2011–2013,* Resource Bulletin NRS-99, USDA Forest Service, Northern Research Station, Newton Square, Pennsylvania, 2016.)

smaller stands can be difficult. These studies illustrate the urgency of current parcelization trends caused by continuing ownership turnover and parcel fragmentation (Sampson and DeCoster 2000), but they also show the difficulty of deciding which landowners to target for limited technical assistance capacity and resources.

Family forest owners are also an aging demographic, with approximately 46% of their acres held by individuals ≥65 years of age and another 30% held by individuals aged 55–64 (Butler 2016). Although these demographics imply a somewhat uncertain future for these lands, especially in terms of intergeneration transfer, continuity of management, and overall interest in forest ownership, there is little data or research to document positive or negative outcomes.

## Restoration on Corporate Forests

Estimates of corporate ownership in the Southeast, which now includes the forest industry sector, range from 54 million acres (Zhang et al. 2012) to 66 million acres (Butler and Wear 2013). Analyses of 2010 FIA data indicate that just <7 million acres of industry land remain, a reduction of about 80% from the peak of 38 million acres (Zhang et al. 2012). Acreage of TIMOs and REITs range from 16.5 million acres (Zhang et al. 2012) to 19.9 million acres (Butler and Wear 2013), respectively. Note that Zhang et al. (2012) does not include data from Mississippi and Louisiana in its estimates.

Opportunities for longleaf pine restoration by corporate ownerships have traditionally been viewed as problematic and many challenges remain for these ownerships. However, some new opportunities are unfolding. The overriding objective for many corporations is to generate returns for their investors. This is particularly true for TIMOs and REITs, which are legally required to maximize returns for investors (Ravenel et al. 2002). If opportunity costs for longleaf pine are negated or mediated in some way and investors are "made whole," longleaf pine could be a viable option.

Many of the industrial-land sales that involved TIMOs were quite large, with diverse portfolios of lands offering a variety of locations, site-quality levels, and other attributes. Given that their objectives are much broader than simply supplying timely and low-cost fiber to a mill, TIMOs often take a more nuanced approach to assessing the suite of opportunities for utilization of their lands. For example, it is not unusual for some portion of a TIMO portfolio to be targeted for residential development in areas where development returns would outperform continued forest management. These decisions are often based on spatial attributes that make such tracts appealing for development, such as proximity to existing development, transportation corridors, or natural amenities such as coastal zones, water bodies, or scenic areas. Acreage that is less suited for development is typically retained in forest management, particularly higher quality sites. On lower quality sites dedicated to forest management, such as xeric sites or low-productivity soils, more detailed analysis could reveal opportunities where longleaf pine is economically competitive. For example, the research discussed earlier relating to comparable growth/yield/productivity of longleaf pine and other southern pine species on xeric dry sites suggests that longleaf pine may be an economically viable management option on those sites. However, even if the site characteristics make longleaf pine competitive, some opportunity costs associated with reforestation must be addressed for corporate ownerships, such as the cost of longleaf pine seedlings, which is approximately 35%–75% greater than comparable quality loblolly or slash pine (IFCO 2016; Meeks 2016). Additional longleaf pine acreage could be established if eligibility for incentive programs that target the species were broadened to include corporate landowners. Corporate ownerships have traditionally been ineligible for incentives because current incentive programs have limits on adjusted gross income and acreage enrolled. Cash flow early in an investment period, which is typical for most incentive programs, can result in economic returns from longleaf pine that are competitive—even on higher-quality sites—with pine species that are not eligible for incentives (Mills and Stiff 2008; Johnson 2011).

Corporate owners with large forest holdings are likely better positioned to factor the risk mitigation values of a mixed portfolio of silvicultural approaches into their investment choices. In addition to risk mitigation from natural disturbances, different approaches to longleaf pine management can help diversify the mix of forest products, timing of product flow, and liquidity of forest products. These owners also are well suited to play a role in the development of longleaf pine markets, such as premium pine straw and high-quality solid wood. Many areas with aggregations of existing longleaf pine share a nexus with concentrations of corporate forestland, offering important opportunities to enhance landscape-level conservation of longleaf pine ecosystems (Figure 3.5).

Partnerships of corporate ownerships with NGOs and natural resource agencies offer potential for increasing longleaf pine acreage. Differences in longleaf pine productivity, wildlife-oriented stocking rates and management regimes, prescribed fire, and other opportunity costs could be compensated at a negotiated rate through incentive programs to incorporate these conservation values while allowing continued use of the lands as working forests. Some TIMOs have begun exploring opportunities to bridge the opportunity-cost gap that divides longleaf pine and other pine species; one such project is the Coastal Headwaters project in the Florida Panhandle (The Conservation Fund 2016). This project would offer permanent protection from development and convert the existing loblolly pine to longleaf pine under a long-rotation management system that balances wildlife habitat structure with timber income. Agencies and NGOs are increasingly using less-than-fee-simple strategies such as this on private lands as a means to achieve conservation goals in more cost-effective ways.

A portion of the corporate ownership category is made up of large family ownerships, a group that includes trusts and partnerships with legally defined fiduciary responsibilities. These owners often grapple with multiple objectives including the economic, recreational, and conservation uses of their land. For some, economic objectives are not only the optimization of return but also other considerations such as taxes and multigenerational preservation of wealth. This combination of objectives often translates into longer management rotations with a diversity of species and forest conditions; longleaf pine management would likely have a role in such a land portfolio. Tax benefits of working-forest conservation easements can be an additional motivating factor for this ownership.

Corporate owners that hold large acreages also bring the advantages of existing capacity for professional forest management and the economies of scale inherent with large aggregates of land. Stated simply, working with a few larger-acreage landowners is much more efficient than working with many small-acreage landowners. Additionally, parcelization and family-forest ownership trends suggest that land use and management on larger tracts are more stable than with smaller

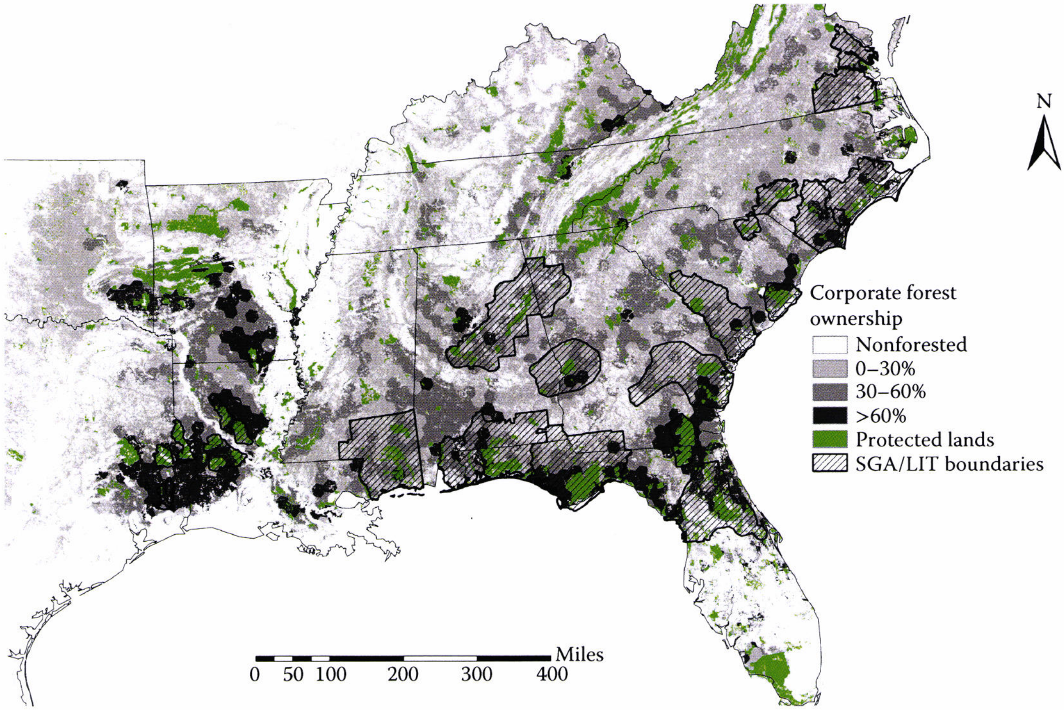


**FIGURE 3.5** Corporate forest ownership, 2008, in Southeastern United States and 2016 Significant Geographic Areas (SGAs) and Local Implementation Team (LIT) boundaries. (From Nelson, M. D. et al, *Forest ownership in the conterminous United States: ForestOwn_v1 geospatial dataset*, USDA Forest Service, Northern Research Station, Newtown Square, Pennsylvania, 2010, https://doi.org/10.2737/RDS-2010-0002. SGA/LIT boundaries data courtesy of The Nature Conservancy.)

parcels (Hatcher et al. 2013), which is consistent with the longer time scales required for longleaf pine forest development.

In contrast to family forest owners, the challenges for longleaf pine restoration on corporate land are typically driven more by economic considerations. Corporate ownership structures, predominantly TIMOs and REITs but also including family trusts and other structures, have fiduciary and legal responsibilities to investors and shareholders and must be able to demonstrate that any decision has economic parity with other options. For this reason, strategies that mitigate opportunity costs of longleaf pine, such as establishment cost share, incentive programs, or purchase of conservation easements for working forests, would likely be a prerequisite for engaging this group of landowners.

Other economic challenges that discourage corporate owners from managing longleaf pine include the lack of well-developed longleaf pine growth and yield models and the relatively nascent state of tree-improvement programs for the species, both of which have been developed for loblolly and slash by substantial and well-endowed cooperative research programs between industry, universities, and government agencies. As a result, sophisticated investors have come to expect more accurate predictability for product yield and financial performance than is currently available for longleaf pine. Similarly, although tree-improvement programs have begun for longleaf pine, they lag far behind programs for loblolly and slash pine, thus further handicapping longleaf pine in the eyes of many corporate owners. Finally, many institutional investments through TIMOs consist of closed comingled funds with limited investment periods of 5–20 years (Zhang et al. 2012). These shorter time horizons may not be well suited for the longer time scales required for longleaf pine stand development.

## Spatial Considerations

Just as longleaf pine may not be the most appropriate fit for the management goals of all land ownerships, there are spatial considerations that factor into the choice of the most appropriate locations for longleaf pine restoration. The regional longleaf pine conservation initiative has identified priority landscapes based on criteria such as known concentrations of existing or potential longleaf pine sites in protected status, occurrences of at-risk species, and pressures for land use change (ALRI 2009). Rather than engaging in random or opportunistic efforts throughout the historical range, the goal was to encourage spatially focused efforts to facilitate restoration of functional landscapes and viable populations of longleaf pine-associated wildlife. Within these broadly defined focus areas, additional analyses are needed to prioritize limited conservation resources.

For any conservation effort to be successful, some threshold questions must be addressed to identify the location, amount, and condition of the conservation target. Although the FIA program provides a good understanding of longleaf pine extent and condition at a coarse scale (Oswalt et al. 2012), spatially explicit information at finer scales is relatively limited. As a foundational element for future longleaf pine restoration, analyses are needed to identify appropriate longleaf pine sites based on soils, hydrology, and other biophysical characteristics as well as sites (existing and potential) that can serve as hubs and connectivity corridors for facilitating wildlife movement and sustaining species of interest (Hoctor 2013). The design of hubs and corridors should take into consideration the broader landscape-level matrix of forestland management and the potential role that traditional production-oriented forests could play in connectivity and buffering of high-priority longleaf pine sites.

Perhaps most importantly, spatial prioritization would need to include the compatibility of longleaf pine management with existing and projected land use as a proxy for the likelihood that an investment in longleaf pine restoration will produce long-term sustainable results (Figure 3.6). Some areas of otherwise-suitable longleaf pine restoration sites will undoubtedly be subjected to

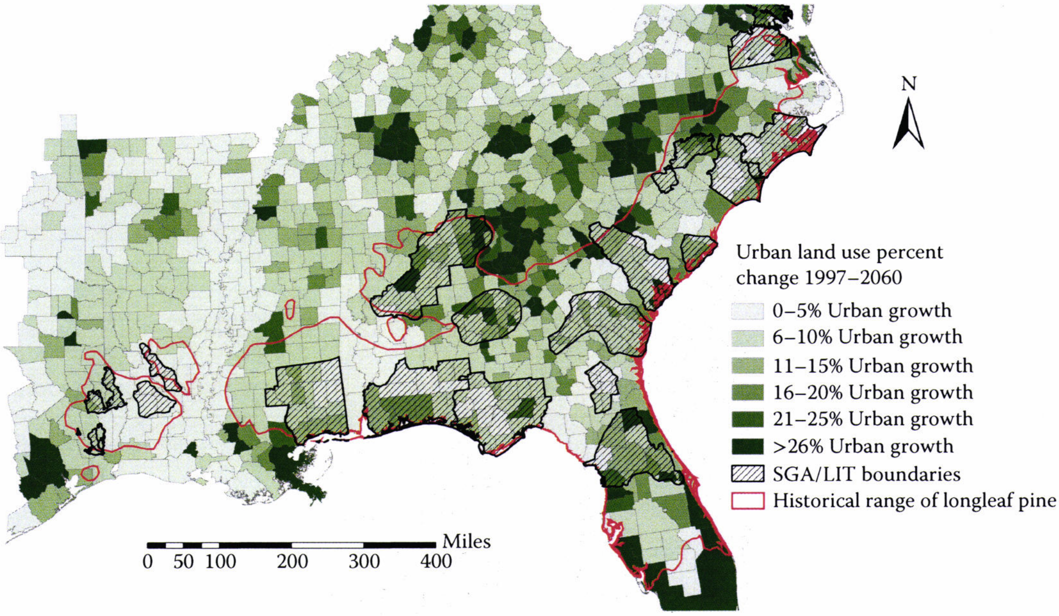


**FIGURE 3.6** Southeastern U.S. urban land use projections, 1997–2060, juxtaposed against the historical range of longleaf pine and 2016 Significant Geographic Areas (SGAs) and Local Implementation Team (LIT) boundaries. (Modified from Wear, D. N., *Forecasts of Land Uses,* USDA Forest Service, Southern Research Station, Asheville, North Carolina, 45–71, 2013. SGA/LIT boundaries data courtesy of The Nature Conservancy.)

greater intensity of urban development, thus increasing the difficulty of continued forest management, particularly for longleaf pine, on land that has the potential for more lucrative uses (Wear and Newman 2004). Urban development also brings to the forefront social considerations such as conflicts with prescribed fire and smoke management in the wildland-urban interface (Wimberly et al. 2006). Of particular concern for longleaf pine are projections of forest loss and urban growth in Peninsular Florida, the western Gulf Coast, and the southern Atlantic Coast (Klepzig et al. 2014).

The long time scales at which longleaf pine functions and the developmental period it needs to reach the desired structure also affect spatial prioritization, particularly for sites that emphasize management for ecological values. Restoration and management of this ecosystem represents a substantial investment in personnel, funding, and time—suggesting that the highest priority sites for restoration should be on lands that are likely to remain committed to a consistent management trajectory over the long term. The highest priorities would logically be land that is protected from parcelization or development by enabling legislation (public land) or legal restrictions (easements on private land). Other candidates for prioritization would be larger parcels, particularly those farther removed from projected urbanization. Larger parcels would be more likely to persist on the landscape, less likely to be subdivided, and more likely to have professional, active forest management (Hatcher et al. 2013). Parcels that are distant from urban development are less likely to experience increased valuation of bare land driven by development pressure, a primary factor in change from forested land use (Wear and Newman 2004).

Another opportunity for prioritizing longleaf pine restoration efforts is existing stands of degraded longleaf pine. These are typically former longleaf pine-dominated sites that are no longer assigned by FIA to the longleaf pine (or longleaf pine/oak) forest type because of past management practices (or lack thereof) that resulted in insufficient stocking of the dominant species. Although they may have some remaining longleaf pine overstory and elements of associated ground cover communities, they are often compromised by encroaching mesic oaks or off-site pines—typically the result of inadequate fire management. These sites, particularly those with more substantial levels of longleaf pine stocking (20%–50%) can be restored relatively quickly and far more economically than sites requiring afforestation. This approach can offer the opportunity for landowners to derive some economic returns from restoration treatments that remove merchantable hardwoods or off-site pine from the stand, thereby reducing the overall cost of restoration. Preliminary estimates suggest that 1.24–1.82 million acres of degraded longleaf pine could be considered for this type of treatment (Guldin et al. 2016). The locations of these sites and their spatial contexts are critical information needs in conservation planning for longleaf pine restoration.

## SUMMARY

The near demise of the once-vast longleaf pine forests that dominated the southeastern Coastal Plain is not unique within the historical context of U.S. development. In all regions, native ecosystems were pressed into the service of society as the land was settled and altered for economic gain. What is different, however, is that longleaf pine forests were perhaps discounted too quickly for their value to society, both economically and ecologically. As human populations grow and bring accompanying pressures for land use change, society will continue to expect more from the same acres of forestland. If forest loss continues, and perhaps accelerates into the future, it will be critical to be more thoughtful and creative in apportioning objectives and priorities among the remaining acres of forested land use. Although some forestlands will still be dedicated solely to economic purposes with others dedicated to ecological purposes, society will increasingly need to look for opportunities for concurrent gains in a broader suite of forest benefits. Longleaf pine could be uniquely suited for those multiple purpose acres.

The literature clearly suggests that longleaf pine can offer moderate, but not maximum, economic returns from timber products compared to other southeastern pines. On less productive sites, longleaf pine growth can compete with growth of other pine species, making it more economically attractive. The weaker economic performance of longleaf pine on many sites is typically not an issue for public agencies or conservation NGOs, and for many private landowners the opportunity costs inherent in longleaf pine may be adequately offset by other amenities such as aesthetics or wildlife habitat. Smaller-acreage family forest owners also have options to participate in incentive programs that can offset these opportunity costs. For corporate owners and other large-acreage landowners in the private sector, policy changes will be needed to broaden eligibility for existing incentives or new programs developed that compensate them for opportunity costs so that longleaf pine is a viable option. With about twice the acreage of private U.S. forestland owned in tracts ≥100 acres compared to tracts <100 acres, policy aimed at encouraging protection, care, and production for forestlands could more actively target the individuals and businesses that comprise this group (Larson 2004; Butler 2008).

The longleaf pine "market share" has room for further growth. Research and development for longleaf pine similar to that conducted on loblolly and slash pine over the last 40 years could improve economic returns from longleaf pine management. Tree-improvement programs have the potential to improve growth, form, and wood quality. A better understanding of longleaf pine growth and yield using data from stands established using modern silvicultural advances, such as containerized seedlings and competition control, would improve forecasting tools and would provide documentation of increases in productivity and economic returns from these silvicultural advances. If artificially regenerated, plantation-grown longleaf pine is of similar quality to logs from naturally regenerated forests over the long term, markets could be expanded for high-quality solid wood products as acreage of these size-class stands increases. Examples of these products include machine stress-rated lumber, heart pine flooring and cabinetry, and pole products. Nontimber products, primarily pine straw, can offer income pulses early in an analysis period that would mitigate opportunity costs from the slower growth that characterizes longleaf pine; preferably, these measures would be implemented in ways that reduce impacts to ecosystem function (Bailey 2015).

Longleaf pine offers great potential for adapting to a changing climate. Preliminary research indicates that longleaf pine may be significantly more water-efficient than other southeastern pines (Vose et al. 2011), suggesting that it could be a good hedge for the more frequent and severe droughts predicted for parts of the southeastern Coastal Plain (see Chapter 15). Longleaf pine is also more resilient to tropical cyclones, wildfire, and forest pests (Croker and Boyer 1975; Hodges et al. 1979; Strom et al. 2002; Johnsen et al. 2009), which are all expected to have greater impact on southeastern forests. Quantification of risk reduction could help support the economic case for longleaf pine as well as serving as a basis for targeted efforts; for example, incentives could be developed that encourage longleaf pine planting in hurricane-prone areas such as the Gulf Coast.

As discussed in this chapter, spatial prioritization of longleaf pine restoration that includes ecological, economic, and social criteria is critical. For issues such as capitalizing on soils that make longleaf pine growth competitive with other pine species, minimizing competition from other land uses, designing spatial arrangements that support healthy populations of vulnerable wildlife species and facilitate their movement across the landscape—location matters. Although longleaf pine restoration can bring benefits wherever it occurs, care must be taken to leverage scarce resources and direct restoration efforts to areas where these forests will be managed over the long term.

Forests provide many benefits to society, including clean air, clean water, carbon sequestration, wildlife habitat, and economic assets such as jobs, tax revenues, and capital investments. The logic and rationale for public support of public forests is clear. These same societal benefits are also produced on privately owned forests, but the costs of maintaining those forests are borne by the private sector. These benefits, or ecosystem services, could be monetized in future policies that address carbon storage, maintenance of water quantity and quality, and wildlife conservation as a means of maintaining private longleaf pine forests on the landscape. Defining the ecosystem service benefits of forests in the marketplace could facilitate a layering of these values with timber values, thereby ensuring more accurate valuation of forests.

Longleaf pine is not likely to ever dominate the forests of the southeastern Coastal Plain as it once did. However, the multiple values of longleaf pine forests have the potential to meet the objectives of a significantly larger land base than they currently occupy. New understandings of science and management can bolster the case for longleaf pine and justify expansion of its current footprint. Increasing longleaf pine acres on the landscape—and importantly, keeping those acres on the landscape long enough for the full suite of values to be realized—will require careful consideration of the dynamic economic and social contexts within which longleaf pine management and restoration occurs.

## ACKNOWLEDGMENTS

The authors would like to acknowledge the helpful reviews and input from Jim Guldin and James Vose. Special thanks to Chris Oswalt for assistance with updated FIA data. Jessica McCorvey provided editorial assistance with figures, tables, and proofreading. Spatial data for Significant Geographic Area boundaries in Figures 3.5 and 3.6 were produced by Analie Barnett of The Nature Conservancy.