SLASH PINE: CHARACTERISTICS, HISTORY, STATUS, AND TRENDS

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Abstract—Slash pine is the premier tree species on many sites throughout the South. Its ease of establishment and early growth, however, has extended its range to many sites where its performance has been less than ideal. For that reason, the acreage and volume of slash pine are declining. Nonetheless, it will continue to be the favored species on many sites where it is the most appropriate and productive species. This paper reviews slash pine's important silvical characteristics, its history of use and management, and the status and trends of this important resource.

INTRODUCTION

Typical slash pine (*Pinus elliottii* Engelm. var. *elliottii*) is an excellent timber tree and one of the most important pine species in the Southern United States. Many prefer it for its fast growth and excellent utility for fiber, lumber, poles, and gum naval stores. The habitat and preferred sites within its natural range include poorly drained flatwoods and stream edges, as well as seasonally flooded areas such as bays and swamps.

The ease and success of planting slash pine have significantly increased in its range. Extensive planting and natural regeneration of open agricultural and forest land brought a sharp rise in slash pine acreage between 1952 and 1970 (Sheffield and others 1983). Much of the planting was on sites that did not favor slash pine, and where performance was less than optimal. As a result, land managers have planted either loblolly (*P. taeda* L.) or longleaf (*P. palustris* Mill.) after harvesting the slash pine. However, slash pine is an excellent species and should be favored on appropriate sites.

This paper reviews the important silvical characteristics of slash pine; provides a history of its development, use, and management; reviews its status in southern forest ecosystems; and explores trends in managed slash pine forests.

SILVICAL CHARACTERISTICS

Identifying Characteristics

The typical slash pine tree has a long, clear bole and a relatively short crown, which results from self-pruning. South Florida slash pine (*P. elliottii* var. *densa*) (Little and Dorman 1954) differs from the more northern variety in a number of ways, primarily because its seedlings go through a dwarf "grass stage" similar to longleaf pine. Its stem divides into large, spreading branches that form a flat-topped or rounded crown. Its uniqueness and limited range have encouraged neither research nor management of south Florida slash pine.

The needles and cones of the typical slash pine represent its primary identifying characteristics. Needles are 7 to 10 inches long in fascicles of two and three on the same tree. They are dark, glossy green, and tufted at the ends of tapering branches. They extend back some distance along the branch and persist until the end of the second season. Cones are 4 to 6 inches long, ovoid conic, and sessile (fig. 1). They usually remain on the tree until the second summer. Cones are reddish brown, lustrous, and armed with a sharp spine. The seeds are about one-fourth inch long, dark brown-black mottled, with thin, translucent wings about 1 inch long.

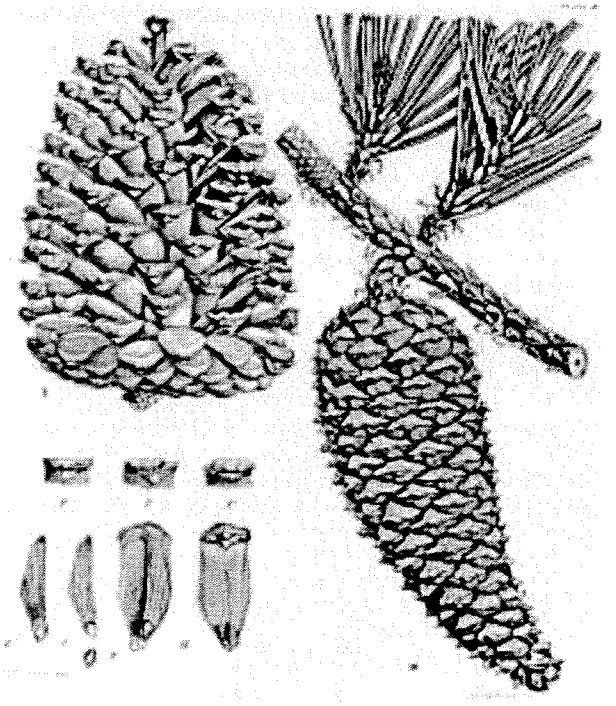

Figure 1—(A) mature, 2-year, closed cone (3 to 6 inches long); (B) mature cone open after shedding seed; (C) tips of cone scale showing variation in form of apophysis and stout prickle; (D) ventral side of cone scale with seed in place (left), and dorsal side (right); (E) and (F) seed and wing detached; (G) seed and wing intact (Mohr 1896).

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Phenology

Seeds mature in a 3-year period from when the strobili are initiated. The primordia of new strobili are detectable in late spring. These cone initials overwinter as buds the first year. When pollen is shed in late January or February of the second year, the male strobili are purple and 2 inches long. The female strobili appear on stalks in the upper crown and are about 1 inch long and red to purple at the time of pollination. Soon after pollination, the pollen tube stops growing and appears to remain in a quiescent state for the summer and winter. During the third growing season fertilization occurs—some 12 to 14 months after pollination. Cones enlarge and seeds mature during the third summer. Needles develop on new growth in spring and persist until the end of the second growing season.

Distribution

The natural range of slash pine is the most restricted of all major southern pines, extending from southern South Carolina to central Florida and westward to southeastern Louisiana (fig. 2). Although its natural range is relatively small, slash pine has been planted widely and its range extended into eastern Texas, southern North Carolina, and the sandhills between the Coastal Plain and the Piedmont through much of the Southeast (Fisher 1983).

Slash pine has been introduced into many countries for timber production. Large-scale introductions have occurred in Brazil, Chile, Argentina, Venezuela, China, South Africa, New Zealand, and Australia. In most of these countries, it is an adequate seed producer, and natural or artificial regeneration continues.

SOILS AND PHYSIOGRAPHY

Soils within the range of slash pine are mostly Spodosols, Ultisols, and Entisols. It is generally believed that prior to extensive fire suppression and planting programs, slash pine was restricted to ponds, pond margins, and Coastal Plain flatwoods where ample moisture provided some degree of protection for young trees that are often killed by fire (Gruschow 1952). Topography varies little throughout the southeastern Coastal Plain, but small changes in elevation often coincide with abrupt changes in soil and site conditions.

Although slash pine adapts to a wide variety of conditions, it grows best on deep, well-aerated soils that supply ample moisture during the growing season. Generally, growth and site index increase with depth to a restrictive layer or seasonally high water table, if these features occur within 20 to 30 inches of the soil surface. Where depth to a restrictive layer exceeds about 30 inches, site index declines with increasing depth to a reliable source of moisture, such as a stable water table or a soil horizon with large moisture-holding storage capacity. Soil properties useful in estimating site index of slash pine include depth to gray mottles, depth to a spodic horizon, depth to the least-permeable layer or to a fine-textured horizon, thickness of the A1 horizon, and texture of the least-permeable or finest textured horizon (Lohrey and Kossuth 1990, Shoulders and Parham 1983).

SILVICULTURAL CHARACTERISTICS

Slash pine is a subclimax species that without human intervention and in the absence of fire or other catastrophic event will proceed to a mixed hardwood forest. Some authors consider it intermediate in tolerance to shade, others consider it intolerant. It will reproduce naturally in small openings and invade poorly stocked longleaf pine stands, although competition from overstory and understory vegetation reduces growth and causes much mortality. The two varieties of slash pine differ in their patterns of growth. Typical slash pine makes excellent early height growth, but south Florida slash pine has a grasslike, almost stemless stage that lasts from 2 to 6 years. Moreover, south Florida slash pine lacks the straight axis or stem characteristic of the typical variety and often develops forked boles with large branches and an open, spreading, irregularly shaped crown (Little and Dorman 1954).

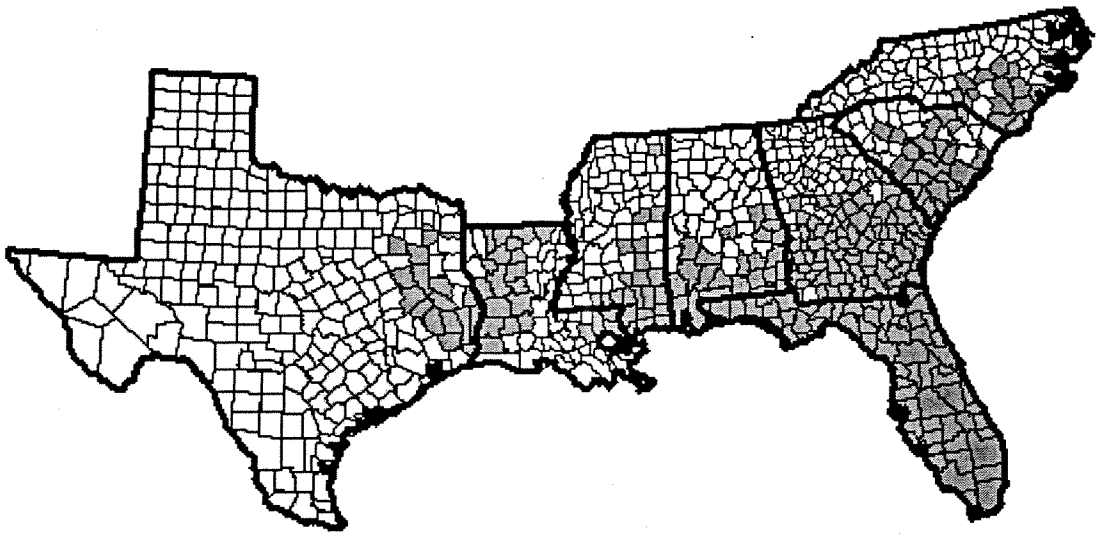

Figure 2—The current distribution of slash pine.

Typical slash pine is slow to express dominance in dense, even-aged stands. As a result, height growth is slower in very dense stands than in moderately or lightly stocked stands. Young stands respond promptly to thinning or release.

HISTORY

The development of steam-powered sawmills along the tidewater during the 1830s changed the entire complexion of timber use. Because the new mills required considerable timber to maintain continuous operations, they were built at river estuaries or along the banks of bayous. Slash pine stands were the most accessible and the first to be cut (Schultz 1983). However, it was not until post-Civil War times that more effective timber harvesting, transporting, and milling technologies were developed. It was about 1880 before more pines were cut for lumber than were being destroyed for the sake of clearing land (Vance 1935).

Naval Stores

In colonial times, the great wooden ships of domestic and international commerce needed large quantities of pitch and tar to seal cracks—and to protect operating lines from the deteriorating effects of moisture (Schultz 1983). By 1610, England was importing tree resin from the Colonies, and by 1700 South Carolina had made so-called naval stores its chief export (Schorger and Betts 1915). Production of this commodity from the South's piney woods became the State's first full-scale industry.

The primary method for producing naval stores was to tap standing slash and longleaf pine. For many years the "box" method was used (Fernow 1899), whereby deep holes were cut with a boxing ax in the tree's base and a container, or box, was attached to catch resin, "chipping" was wounding the tree surface or face with a hack tool—through the bark into the phloem. The tree's surface was chipped weekly to maintain resin flow, and boxes were emptied every 2 or 3 weeks to prevent resin loss. Because it produced more yield than longleaf, slash pine was preferred (Forbes 1930, Mattoon 1922).

Cutting deep cavities into trees for collecting gum caused significant damage to the trees. Cutting two or more boxes in larger trees nearly girdled them, causing mortality in a year or so. Through the untiring efforts of Dr. Charles Herty, the "boxing" method was largely replaced by the cup-and-gutter method around 1910. The new method yielded more and higher quality resin, killed fewer trees, and left the butt log in better condition for lumber (Croker 1979).

When U.S. Department of Agriculture Forest Service research stations were established in the South in 1921, the Southern Forest Experiment Station assigned Len Wyman to Stark, FL, to improve chipping technology for the naval stores industry. His work to reduce the size of the chipping face resulted in substantial labor savings, reduced tree mortality, and increased the length of time a tree could be worked. During World War II, research on naval stores production was emphasized, and it was determined that gum production could be stimulated by spraying the chipped area with sulfuric acid (McReynolds 1983).

Naval stores research continued into the 1980s with the development of paraquat-induced lightwood (Stubbs 1983). However, production of naval stores products dropped significantly as tree availability decreased, costs of labor-intensive work increased, and byproducts of the kraft pulping process met most of the need for turpentine and other products (McReynolds 1983).

The Influence of Railroad Logging

The first generation of logging in pine flatwoods was confined to coastal areas and the immediate vicinity of rivers and navigable streams. Therefore, much of the slash pine forest was selectively cut at least once by the late 1880s (Schutlz 1983). By the middle 1880s, high timber demands and expanding mill facilities required loggers to exploit new areas. Railroad logging was an answer to the problem of accessing forests away from rivers and streams. Wherever large pines grew, rail spurs were put in to systematically remove pine timber. Low-speed locomotives were used to pull cars loaded with timber over the temporary spurs. Steam skidders were mounted on flatcars, and wire cables could pull logs to the railcars from about 1,000 feet.

Logging and milling reached their peak in the coastal flatwoods between 1890 and 1914 (Schultz 1983). Once the logging boom arrived, it took a little more than two decades to clearcut and decimate the pure pine forests of the flatwoods. Most slash and mixed slash-longleaf pine forests were cutover in the early logging and rafting days between 1780 and 1860. Fifty to one hundred years later, these areas had again grown into pure stands of slash pine and also were logged over, as were virgin longleaf stands. The complete removal of old-growth pines provided conditions for slash pine to further dominate many sites formerly occupied by longleaf pine. Large areas of the cutover longleaf pine type in Alabama, Mississippi, Louisiana, and Texas were planted to slash pine, thus increasing the range and prominence of the species (Schultz 1983). Slash pine also was planted outside its range in Georgia, South Carolina, and North Carolina in cutover longleaf sites.

STATUS

The natural range of slash pine is more restricted than the range of other major southern pines (Critchfield and Little 1966), but extensive plantings of slash pine have greatly extended its range (fig. 2). We have not distinguished typical slash pine from the south Florida variety in these data, because the latter has very limited occurrence.

While the range of slash pine is small, the species is intensely managed. Sixty-nine percent of current slash pine stands are planted compared to 52 percent in 1980. The proportion of plantations to natural stands continues to rise with each new inventory.

Slash pine is the primary species on 10.4 million acres (table 1). The slash pine ecosystem is defined as stands where yellow pine makes up one-half or more of the stocking, and where slash is the predominant pine.

The most concentrated areas of slash pine are in Florida and Georgia. These two States contain about 79 percent of the slash pine ecosystem acreage.

Table 1—Area of timberland classed as a slash pine forest type, by State, 1980 and 2000

State	1980	2000
	thousand acres	
Alabama	716	497
Florida	5,298	5,131
Georgia	4,683	3,026
Louisiana	609	631
Mississippi	671	610
North Carolina	91	156
South Carolina	499	136
Texas	212	188
Total	12,779	10,375

Nonindustrial private landowners hold 53 percent of slash pine stands, the largest proportion of ownership (table 2). Forest industries own 36 percent, while national forests and other public agencies control the remaining 11 percent.

The volume of slash pine growing-stock sized trees across the range totals 10.9 billon cubic feet (table 3). This inventory includes all slash pine growing stock, whether in stands classified as a slash pine type or in some other type. Growing-stock volume includes the solid wood content between a 1-foot stump and 4.0-inch top on only the central stem in trees 5.0 inches diameter at breast height (d.b.h.) and larger. The stated volumes exclude rough and rotten stems, stumps, tops, limbs, and trees < 5.0 inches d.b.h.

Table 2—Area of timberland classed as a slash pine forest type, by ownership class, 1980 and 2000

Ownership class	1980	2000
	thousand acres	
National forest	522	493
Other public	569	684
Forest industry	4,649	3,719
Nonindustrial private	7,039	5,479
Total	12,779	10,375

Table 3—Volume of slash pine growing stock on timberland, by State, 1980 and 2000

State	1980	2000
	million cubic feet	
Alabama	747	868
Florida	3,772	4,305
Georgia	4,644	3,525
Louisiana	748	790
Mississippi	664	771
North Carolina	33	183
South Carolina	592	215
Texas	256	235
Total	11,457	10,891

Seventy-two percent of the South's slash pine volume (7,830 million cubic feet) is located in Florida and Georgia. Alabama, Louisiana, and Mississippi account for 22 percent (2,429 million cubic feet) (table 3).

The diameter distribution of slash pine volume reflects the high proportion of slash pine in plantations and young natural stands (fig. 3). Volume peaks in the 8-inch diameter class and declines rapidly through the larger diameters. Fifty-nine percent of the slash pine volume is in the 6-, 8-, and 10-inch diameter classes.

The stand-age distribution shows that about 25 percent of slash pine stands are < 8 years old (fig. 4). This confirms the notion that the slash pine rotation age is 30 years or

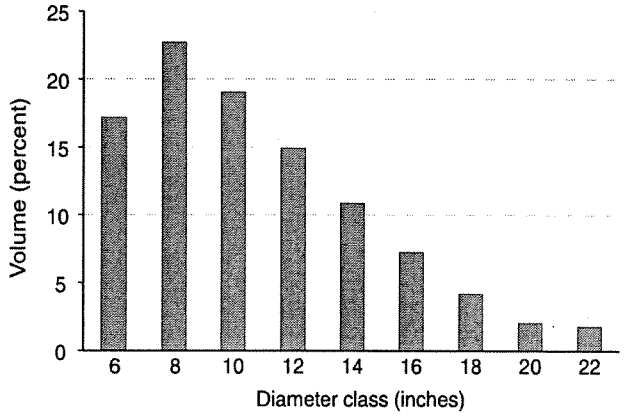

Figure 3—Slash pine growing stock by diameter class, 2000.

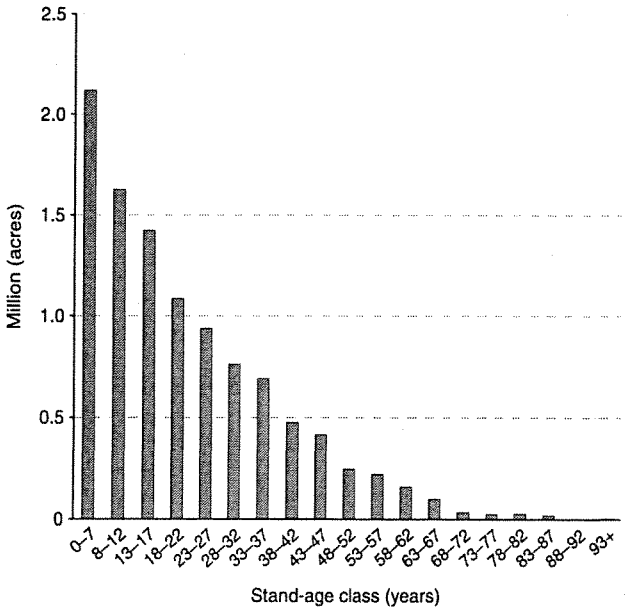

Figure 4—Stand-age distribution of slash pine, 2000.

younger, and that slash pine is intensively managed. Small-diameter trees make up a large proportion of the slash pine resource, primarily because forest industry has managed it for short rotations.

The current (2000) net annual growth of slash pine growing stock totals 871 million cubic feet (table 4). This is equivalent to a growth rate (growth as a percent of inventory) of 8.0 percent. Annual removals of slash pine growing stock total 927 million cubic feet, or 56 million cubic feet (about 6 percent) over annual growth. The most significant amount of removals over growth occurs in Florida, where it exceeded growth by 55 million cubic feet, or nearly 18 percent. Removal volumes include all slash pine trees removed from commercial forest land by human activities, regardless of whether the trees actually are used.

Table 4—Net annual growth and removals of slash pine growing stock by State, 1980 and 2000

State	Net annual growth		Annual removals	
	1980	2000	1980	2000
	million cubic feet			
Alabama	48	60	35	55
Florida	383	309	262	364
Georgia	405	338	265	316
Louisiana	83	66	41	53
Mississippi	44	45	37	54
North Carolina	9	9	0	18
South Carolina	66	20	23	45
Texas	30	25	12	23
Total	1,068	871	675	927

TRENDS

Sheffield and others (1983) published 1980 resource data in the proceedings of the 1981 managed slash pine ecosystem symposium (Stone 1983). These data, paired with year 2000 data in tables 1 through 4, provide a comparison of resource issues related to the slash pine ecosystem.

The fact that 69 percent of slash pine stands are planted indicates that the slash pine ecosystem is intensively managed. Most of the ecosystem is located in Georgia and Florida, and largely within areas adjoining the two States. However, over the last 20 years the area of timberland classified as slash pine has decreased from 12.8 to 10.4 million acres, or nearly 19 percent (table 1).

The loss of acreage in slash pine has occurred over most of its range. Data from the two States that show increases—Louisiana and North Carolina—may not represent current conditions, because forest survey data in those States have not been completely updated. Within Florida the acreage remains stable, whereas in Georgia there has been a 35-percent decrease over the last two decades.

Long-term trends indicate that slash pine acreage increased significantly during the 1950s and 1960s, with increases from about 8.4 to 10.4 million acres (Sheffield and others 1983). Those increases were related to the conversion of farmland to forests, reforestation of cutover forests, and planting out of the native range of slash pine. The trend leveled off in the 1970s and 1980s. Obviously, the trend now is one of decreasing acreage. This loss is at least partially a result of longleaf pine restoration efforts on many sites where slash pine had been planted, the loss of slash pine sites to urbanization, and the planting of loblolly pine on forest industry lands where slash was previously planted.

The greatest losses (about 20 percent) in slash pine timberland occurred on private ownership—both forest industry and nonindustrial private lands (table 2). Slash pine within the national forests decreased 5 percent, probably as a result of conversion to longleaf pine on forests outside the natural slash pine range. The only ownership showing an increase in slash pine timberland is the "other public" category.

The volume of slash pine growing stock in the entire ecosystem declined from 11.5 billion cubic feet in 1980 to 10.9 billion cubic feet in 2000 (table 3). It is particularly interesting to note the differing trends in Florida and Georgia. Although Florida's proportion of the growing stock increased 12 percent, from 3.8 to 4.3 billion cubic feet, there was a major decrease in Georgia. A 24-percent reduction in growing stock occurred in Georgia, with losses of 1.1 billion cubic feet. Texas and South Carolina were the only other States with losses of growing stock.

The year 2000 distribution of slash pine growing stock by diameter classes follows a pattern similar to that of 1980 (Sheffield and others 1983), although 59 percent of the current volume is in the 6-, 8-, and 10-inch classes compared to 64 percent in 1980 (fig. 3). In 2000, there was a smaller proportion in the 6-inch and a corresponding increase in the 14- through 22-inch diameter classes than there was in 1980. Stand-age data confirm the notion that older stands continue to be aggressively harvested, and that the average rotation age is 35 years or less (fig. 4). A relatively small proportion of stands are older than 40 years.

In contrast to the situation in 1980 when net annual growth exceeded annual removals, in year 2000 removals exceeded growth by about 6 percent (table 4). In Florida, removals far exceeded growth, although the acreage in slash pine remained relatively constant. This may be because where slash pine is intensively managed, there are large numbers of recently harvested stands that have been regenerated, but where trees have not reached a size that constitutes significant volume.

CONCLUSIONS

Slash pine is one of the most important pine species in the Southern United States, and its ecosystem produces a habitat that favors a wide range of biological diversity. It produces fast growing stands that are excellent for fiber, lumber, poles, and gum naval stores. It is adapted to short-rotation forestry, where ease of regeneration and fast early growth are important. Because of its favorable growth characteristics, the slash pine range has been widely extended.

Slash pine has performed less than ideally on many sites, particularly when rotation is longer than 35 years. However, on good sites within its natural range, it is the premier species.

Although it has been planted across the South from eastern Texas to eastern North Carolina, most slash pine volume occurs in southern Georgia and northern Florida. Even in Georgia, the volume of slash pine growing stock has declined. Many sites in the Southeast that are more adapted to longleaf pine were converted to slash pine decades ago because of the ease of regeneration and fast early growth. Recent interest in and financial support for converting such sites to longleaf pine have resulted in the reduction of slash pine acreage and volume.

Although the acreage and volume of growing stock have declined in recent years, slash pine remains the best-adapted and productive species for many sites within its range. On appropriate sites, slash pine is an excellent species that is well adapted for and should be favored in management.

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