A Review –

Techniques and Progress in Regenerating Southern Pines

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The past few decades can be considered an era of regeneration in the southern pine region. During this time significant progress has been made in developing techniques for natural and artificial regeneration and applying them on a large scale. This paper briefly traces the rapid transition from almost complete indifference towards perpetuation of the forest resource to the most intensive regeneration program in the country. It also predicts some further changes.

THE SOUTHERN PINE REGION embraces about 100 million acres, most of which are highly productive for pines. Coniferous species include loblolly (*Pinus taeda* L.), slash (*Pinus elliottii* var. *elliottii* and *Pinus elliottii* var. *densa* Little & Dorman), shortleaf (*Pinus echinata* Mill.), longleaf (*Pinus palustris* Mill.), Virginia (*Pinus virginiana* Mill.), pitch (*Pinus rigida* Mill.), pond (*Pinus serotina* Michx.), spruce (*Pinus glabra* Walt.), table-mountain (*Pinus pungens* Lamb.), and sand pine (*Pinus clausa* (Chapm.) Vasey). The first five are the most important; singly or in mixtures they are probably dominant on 95 percent or more of the South's pinelands. The others are found in relatively small areas where they are favored by unique site conditions such as rocky mountain ridges, deep sands, extreme wetness, or fertile hummocks along streams (22).

The discussion will refer primarily to the major species, which have received greatest emphasis in research and practice. Comparatively little is known about regeneration of table-mountain, spruce, pond, and pitch pines. Sand pine received scant attention until a few years ago, when landowners began to plant it on a large scale in the sandhills of northwest Florida. Although detailed information may be lacking for some of the species, it is known that all southern pines have a history of depletion and restocking that is quite similar.

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Aftermath of Original Cutting

Cutting of the virgin pine timber in the South was largely completed by 1930. Moreover, many second-growth stands had been high-graded for sawtimber or harvested for pulpwood. Left behind were vast expanses of denuded lands, especially in the Coastal Plains where longleaf once occupied 45 to 60 million acres. W. R. Mattoon (69), a knowledgeable and respected forester, reported that, "About 6,000,000 acres of longleaf timber land, it is estimated, are cut in this country yearly, and about 4,000,000 acres are left fire-swept and practically idle."

A great opportunity to regenerate millions of acres was lost by failure to protect the small residuals left in the harvest of the original forests (22, 24). Since cutting of virgin stands was to a diameter limit, many undersized trees were passed by. Unfortunately, most of them were destroyed in skidding operations or killed by fire and storm (22). Surviving residuals responded to release and developed into seed bearers that restocked uncounted acres (14), but foresight and the means to preserve more of these trees might have changed southern forestry drastically in the years that followed.

The best source of seed was usually on wet areas such as the stream bottoms that are prevalent throughout the uplands. Probably loggers left more residuals on boggy soils. And, of course, these sites were naturally protected from the devastating wildfires that swept over drier areas. Once fire protection was improved, the trees often restocked surrounding land as much as 10 chains away.

Wildfires probably caused greater losses than all other factors combined (88). They burned over tremendous acreages each year, destroying seed trees and young stands that had reproduced naturally. In addition to direct effects, the incidence of fires discouraged most landowners from investing in a future crop (20).

Two other major factors retarded the rebuilding of the South's pine forests. First, intensive turpentining reduced vigor of trees in the longleaf-slash pine belt and caused heavy mortality (69, 88). Moreover, the pitch-soaked faces left trees highly vulnerable to destruction by fire. Second, longleaf seedling stands on thousands of acres were killed by free-roaming hogs that uprooted trees to feed on the succulent roots (37).

Though they caused great destruction, the wildfires were sometimes beneficial. Well-stocked pine stands became established occasionally when burning exposed mineral soil coincidentally with a bumper seed crop. Such examples of natural restocking helped influence the few observant foresters who early advocated the use of fire in management (11, 32). Probably wildfires were most beneficial by retarding the invasion of worthless hardwoods, which complicate pine regeneration.

Outstanding examples of natural reproduction were also found on abandoned farmland (91). Sales of cutover land for agriculture boomed around the turn of the century. From the Atlantic coast and the Piedmont across the Gulf Coastal

MUCH OF THE REFORESTATION JOB remaining is on areas with dense stands of worthless hardwoods. Heavy disks and brush choppers do a good job of preparing such sites.

Plain to Texas, as much as 10 percent of the land was put into cultivation after the virgin stands were harvested. Many of these operations failed, and the abandoned fields were quickly invaded by pines or low-grade hardwoods. Old-field stands—some of which had the best stocking to be seen in the early days of forestry—are noteworthy because they demonstrated that pines could be regenerated and would grow rapidly. They furnished, and still do furnish, a sizable proportion of pulpwood and sawtimber in many sections.

By 1930, after 40 years of heavy cutting that removed almost 500 billion board feet of pine (38), the South was faced with a tremendous job of rebuilding its forests. The lands were not completely barren by any means, for it was estimated that 200 billion board feet of sawtimber was still standing in the late 1930's (28, pp. 12-14), but the situation was grim. About 10 percent of the acreage still had old-growth stands, the bulk of which had been high-graded. Twenty-five percent, lacking adequate reproduction and seed trees, was so depleted that the only hope of restoration was by artificial regeneration. From 5 to 10 percent of the region was well stocked with second-growth that had originated accidentally on old fields and on cutovers. The remainder was partially stocked, but the stands were mostly open and tree quality was accordingly poor.

Starting to Rebuild

The early 1920's saw the beginning of large-scale regeneration programs. This was about the time that the Forest Service and some schools and private companies started research programs, and it was not long before many southern states had taken the first steps to establish fire-protection organizations. Research coupled with commercial trials led to the accumulation of knowledge in all phases of regeneration from seed handling and nursery culture to site preparation and protection of the young stands. Prior to this time, successful planta-

Table1. — LITERATURE CURRENTLY APPLICABLE TO REGENERATION TECHNIQUES FOR THE SOUTHERN PINES.[1]

Species	Natural Regeneration		Planting	Direct Seeding	Site Preparation	Intensive Culture
	Evenaged	Unevenaged				
Loblolly Pine	(2,12,19,25, 27,43,46-50, 55,59,74,75, 91,95,96)	(13,27,80,91, 96)	(5,6,35,40, 54,56,62,70, 85,87,93)	(16,63,64,65) 67)	(1,9,17,21,31, 49,50,55,70, 73,76,78,79, 85,86,91,97, 99)	(23,39,42,91, 94)
Slash Pine	(58,72)		(36,40,60,62, 70,84,85,87, 98)	(16,63,64,65, 68)	(1,17,30,70, 71,73,79,85, 86,97,99)	(30,39,77,94)
Shortleaf Pine	(25,27,41,43, 51,52,96,100)	(27,96)	(56)	(16,33,44,56, 63,64)	(17,43,46,51, 52,73,83,86, 97,100)	(81)
Longleaf Pine	(3,8,10,11, 90)		(35,90,93)	(16,18,63,64)	(8,11,61,73, 90,93)	(93)
Virginia Pine	(51,52,53,82, 96)	(96)	(56)	(7,16,33,56, 57,63,64)	(4,17,52,73) 86,97)	(23)
Pitch Pine	(43,96)	(96)		(16,44,45,63)	(17,43,51,53, 73,86)	
Pond Pine					(26,73)	
Spruce Pine				(16)	(17,73,86)	
Sand Pine	(15,34)				(17,73,86)	

[1]Nos. in parentheses refer to "Literature Cited" at end of text.

tions were estimated to total less than 500 acres (93); planned natural stands probably were equally uncommon.

The Great Southern Lumber Company of Bogalusa, Louisiana, was the first to plant on a commercial basis (92). It began in 1920 and planted almost 13,000 acres in the next 6 years. By 1931 it had established longleaf, loblolly, and slash pine on about 26,000 acres. Southwide, only 20,000 acres were planted prior to 1927, and 73,000 acres by 1931. The pioneering of this Louisiana company was carefully followed by other landowners.

The Clarke-McNary Act of 1924, which provided for increased Federal cooperation with States in the production of planting stock, was a stimulant to nursery programs. The earliest planters had utilized wildlings, and a few companies had developed their own nurseries. State nurseries, however, were needed to supply stock for small as well as larger landowners.

The depression of the 1930's stifled many of the programs of private owners, but it led to a new and different stage in regeneration of the southern pines. The Civilian Conservation Corps was established and in a 7-year period planted in excess of 1/2 million acres. On thousands of additional acres CCC workers deadened hardwoods that were overtopping and suppressing pines.

While the planting movement was gaining momentum, a few landowners throughout the region began leaving seed trees purposely for regeneration (29). The trees thus reserved were not suppressed runts but well-spaced stems with sufficient crowns to produce seed immediately. When coupled with fire protection, many of these operations were successful, especially along the Atlantic coast where seed crops are consistently good. Further west, where seed crops tend to be intermittent, many failures occurred. Inadequate preparation of seedbed and site often resulted in low stocking even when ample seed was cast.

The selection system of management also gained in popularity during this time, especially in the loblolly-shortleaf pine type. The basic purpose of the system was to provide a steady flow of larger trees to the sawmill, and at the same time to preserve small, potentially valuable stems and to establish reproduction in small openings (29, 80). It was used extensively, even after the war, as it aided landowners and industry to make the transition from repeated high-grading to reliance on managed stands. Now, most landowners have switched to even-aged systems of management.

The prewar period was significant for demonstrating that pines could be regenerated and that the new crop would grow fast, rather than for any great progress in restoring depleted lands. It was a time of trail blazing. The successes achieved then encouraged and guided land managers after the war.

The Regeneration Boom

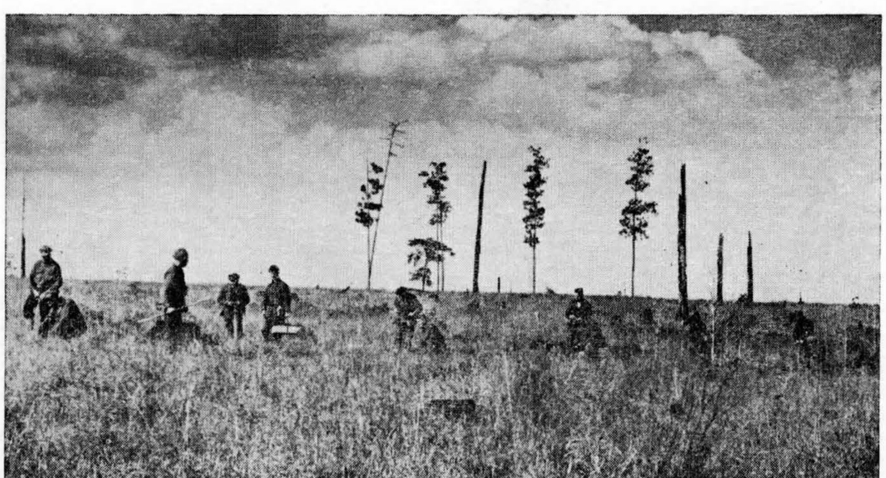
Conditions at the end of World War II were favorable for the largest reforestation program ever attempted. There was a broad awareness that southern forests could be restored to their former productivity, forest industry seemed ready to expand plant facilities, and large landowners had accumulated capital to invest in development of lands. In addition, planting machines had been invented to cut costs and speed up the work fivefold over hand planting.

From 1947 to 1967, about 15 million acres were planted (89). More than 99 percent of this acreage was reforested to slash, shortleaf, loblolly, and longleaf pines. Sand pine plantations totaled about 50,000 acres, and Virginia pine about 10,000 acres. The remaining four species accounted for less than 2,000 acres.

During this time planting techniques remained essentially unchanged, but there were several other shifts that merit mention. First, a gradual trend towards wider spacings developed (6, 36). Early plantings were primarily at spacings of 6 by 6 feet, whereas spacings now are 8 by 8 feet or wider. The purpose is to reduce planting costs, to hasten the time of the first thinning, and to speed the growth of large products. Another consideration is to provide access between rows, which some managers believe will be important for efficient operation of future harvesting equipment.

Reduction in plantation stocking will decrease cubic yields per acre even though diameter growth is accelerated. Many economic factors will ultimately influence how plantations are spaced. With shrinking acreage for timber production, higher land costs, and increasing expenses for owning and managing land, there may be a shift to maximum fiber production per acre, particularly for pulpwood growth. Wide spacings may be most profitable only when large trees for saw logs or veneer bolts are the major goals of management.

Another important trend has been towards intensive site preparation before regeneration. Invasion of brush following improved fire pro-



VAST TRACTS WERE LEFT virtually barren when the virgin longleaf was cut. Residuals, too small for harvest, restocked stands in some areas, but in many places—most notably in the West Gulf States—they were killed or weakened by wildfire. Hence large acreages required planting or seeding.

tection has precipitated much of the work. Heavy machines are used to destroy the small hardwoods; they prepare a good seedbed at the same time. But many landowners are disking, bedding, or chopping sites for the specific purpose of increasing growth.

Most of the easier planting chances are completed. The job now is to reestablish pines on the more difficult areas, which are usually dominated by dense stands of small brush. Many of these areas are on steep terrain and have thin soils that are apt to be droughty. Foresters have tackled them with ingenuity, using large machines for site preparation where topography will permit safe operation and herbicides on very rough ground. Other difficult sites now being regenerated are those where waterlogged soils retard pine growth. Here elaborate drainage systems have been dug to remove excess water, and elevated beds have been disked to further promote rapid growth.

In the mid-1950's direct seeding was perfected, and in the past 10 years more than 1 million acres have been sown (63, 64). The key to the development was the finding of a chemical coating to protect seed from birds, rodents, and insects (66).

This method has proven to be fast, economical, and reliable. One helicopter can sow 2,000 to 3,000 acres daily—the equivalent of two planting machines working all winter. One company in Louisiana sowed 60,000 acres in 2 years, and thus put its land into production 4 to 5 years earlier than would have been practical by planting. Savings of seeding over planting in the South are estimated to exceed 10 million dollars. They are greatest on sites that are most difficult and expensive to plant, often averaging $15 to $20 per acre. Direct seeding has been successful on many tracts that would have been nearly impossible to plant.

Regeneration by natural means also progressed at an accelerated pace after the war. On areas with a seed source, improved fire protection alone resulted in successful restocking of many thousands of acres. Foresters reproduced large acreages naturally by applying selection management in understocked loblolly-shortleaf pine stands and by harvesting mature second-growth stands on the seed-tree system. More advanced techniques have been incorporated into natural systems of reproducing stands (91). Prescribed burning, for example, has become an accepted method for seedbed preparation and the control of small hardwoods, except in mountain regions. Heavy machines are also employed for site preparation.

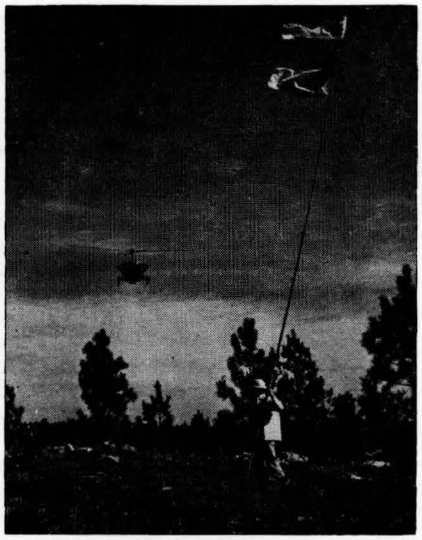
(Photo by Georgia Forestry Commission).
SEED ORCHARDS IN THE SOUTH now total 5,000 acres. In 10 years all nursery stock will be grown from genetically improved seed.

The success of natural methods of regeneration varies greatly with the frequency of good seed crops and summer droughts. Probably the most favorable location is along the Atlantic coast, where seed is ample almost every year and rainfall is well distributed. At the other extreme is the West Gulf region, where seed crops occur at 3- to 10-year intervals and something like every other seedling catch is lost in dry weather during the critical first year. In areas where good seed years are infrequent, landowners are switching to artificial regeneration because they cannot tolerate the loss of production from the delay in restocking. Not only is valuable growth lost, but seedbeds deteriorate and dense brush often takes over the site when seed is not available.

But even where natural seedfall is consistently reliable, natural methods are not so inexpensive as they may appear. Lightning, wind, and insects take a steady toll of reserved trees, and the loss of only a few choice stems is costly. The presence of seed trees limits the intensity of fire that can be used for hardwood control and hampers mechanical site preparation. Moreover, stumpage returns when harvesting seed trees are usually less than those received for the main cut.

A number of landowners have begun to divert their resources to improvement of unstocked stands. Typically, these stands have 25 to 60 percent of full stocking in low-quality, open-grown trees. They are either cut back to seed trees or clearcut and then planted or direct-seeded. Often the site is prepared mechanically to destroy competing vegetation. Because 50 percent or more of the stands in the South are substantially understocked, such conversion will be a major activity for some time.

Seed orchards, which are numerous in the South, are beginning to influence regeneration practices. Production of superior seed will favor further expansion of artificial regeneration and deemphasis of natural methods. To obtain maximum benefits from limited supplies, foresters will use most of the initial production to grow nursery stock.



DIRECT SEEDING FROM AIRCRAFT, a recent development, permits landowners to sow as many as 3,000 acres daily, and at substantial savings over the cost of planting.

Within 10 to 15 years, however, there should be ample quantities of improved seed for all methods of artificial regeneration.

Table 1 lists some of the important references that are currently applicable to various methods of regenerating the southern pines. It is incomplete, because subjects are highly fragmented and a full listing would total thousands of citations. The references are mainly on silvicultural aspects of regeneration, rather than on methods of protecting against diseases, insects, animals, and other hazards. Summary bulletins and monographs are included; it is recommended that these be studied carefully before individual, specialized articles are read.

The Future

Further advances in techniques of regenerating the southern pines can be expected as land management intensifies. Their exact nature will be determined only after research, much of it already under way, is completed. But it is certain that sites will be prepared thoroughly to obtain fast growth and high productivity. Many of them may be cultivated, bedded, drained, fertilized, weeded, and perhaps irrigated.

Planting of tube-grown seedlings is currently under study by a number of landowners. In this method, seed is sown in plastic or cardboard tubes containing soil, and the seedlings—still in their individual containers—are planted when they are several months old. Potential advantages include greater production from limited supplies of genetically improved seed than by nursery sowing, extension of the planting season, and better success on adverse sites than by planting bare-rooted stock from nurseries.

Many factors suggest that close control of spacing, from seedling stands through the rotation, will become increasingly important. For this reason, studies are being made to determine how row seeding can be accomplished from aircraft. Also under development are ground-traveling row seeders that will be adaptable to a wider variety of site and cover conditions than are any present models.

In the second-growth stands of the South, the degree of success achieved in regeneration has always been the major determinant of forest productivity. Regenerative techniques will assume still greater importance as foresters seek to keep lands in continuous, full productivity and to reduce rotations by intensive cultural practices.

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