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1954: Recent Developments in Planting and Direct Seeding in the Southern Pine Region

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RECENT DEVELOPMENTS IN PLANTING
AND DIRECT SEEDING IN THE
SOUTHERN PINE REGION

Proceedings
Third Annual Forestry Symposium
School of Forestry
Louisiana State University
Baton Rouge, Louisiana

April 8-9, 1954
Agricultural Auditorium
Recent Developments in Planting and Direct Seeding in the Southern Pine Region

Proceedings of the Third Annual Forestry Symposium
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General Chairman

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* Prepared Comment
The possibility of reforestation through direct seeding has intrigued and challenged foresters since the very beginning of the practice of forestry. Although this means of artificial regeneration appears simple, it is fraught with obstacles. The reward for a successful venture however, is great.

So discouraging have been results with direct seeding of longleaf pine that W. G. Wahlenberg, in his book "Longleaf Pine", commented: "Seeding costs on several thousand acres were exorbitant, being often several times that of planting stock. Only six percent of this work could be termed successful. Thus heavy applications of seed and thorough preparation of the site sometimes produced the stands desired, but only at a sacrifice of the original objective, low cost."

By C. H. Lewis, Jr., Chief Forester
Crosby Chemicals, Inc.
DeRidder, Louisiana
These statements could apply to practically all tree species in the Gulf Coast area. This article, however, deals specifically with the longleaf pine.

**WHY REFOREST WITH LONGLEAF?**

The superiority of the longleaf tree to the other southern pines, on former longleaf sites, is seldom seriously questioned. The shortcomings of slash and loblolly pine, when grown on these drier sites, are many.

The contorted remains of several large slash pine plantations on the Kisatchie National Forest in central Louisiana are mute testimony of the susceptibility of this species to ice or glaze damage. This section of the state has experienced three such freaks of weather within the past ten years. Complete tip moth infestation and a disappointing rate of growth on the drier sites have curbed enthusiasm for the use of loblolly pine to reforest the longleaf cut over lands of central and southwest Louisiana.

The susceptibility of each of the two species mentioned above to cronartium infestation and the ominous danger of complete loss from wild fires make the choice of either species a compromise selection. To make matters worse, it is now known that neither of these species is immune to hog damage.

Longleaf pine, on the other hand, is highly resistant to insect attack. Cronartium infestation is not a problem. Ice damage is comparatively light. The growth rate, after the seedling has reached the size of 1" in diameter at root collar, is quite good. The longleaf pine seedlings, saplings and young poles are highly resistant to fire damage. The inherent quality of bole straightness adds greatly to the ultimate dollar value of a longleaf plantation.

For these reasons, the search for an economical means of reproducing this species continues. The direct seeding effort discussed in this report represents a continuation of this search for a more satisfactory procedure.

**WHY DIRECT SEED LONGLEAF?**

Much of the early effort of reforestation in the original longleaf area of Louisiana was devoted to the transplanting of 1-0 nursery stock. The results of this work were so poor that the popularity of longleaf nursery stock for reforestation has steadily declined. The use of other southern pines in this area for artificial regeneration has become increasingly popular.

A simple roadside tour of the longleaf pine plantations in Louisiana and Mississippi originating from 1-0 nursery stock reveals the serious imperfections in this procedure. True, there have been some improvements in technique within recent years. Clipping and wax coating of the needles offer some promise of reduction of losses in the first year due to excessive transpiration; but, even with these improvements, instances
of 50% or greater survival in commercial field plantings are rare. The resulting cost per live seedling at the end of the first summer is high.

This unfortunate situation exists today despite years of research by some of the best qualified forest technicians in the United States Forest Service.

A study of the adventures in longleaf direct seeding reveals that the results here also present a disappointing picture. In this instance, however, comparatively little work has been done. A preponderance of the tests has been conducted on a small plot basis.

From these efforts, however, it has been possible to isolate many of the agencies which contributed to the heavy seed losses. At the same time, it has been possible to observe certain strong characteristics of longleaf seed and seedlings. A tabulation and analysis of these points indicate that the full exploitation of these favorable characteristics offers, at least, a good "gambler's chance" of success in regeneration through direct seeding. The principal points of consideration are listed below.

FACTORS WHICH CONTRIBUTE TO PAST FAILURES OF DIRECT SEEDING WITH LONGLEAF PINE

1. Birds and rodents have a strong affinity for the sweet white meat of the seed. This has probably been the greatest single source of failure in direct seeding with this species. The migratory bird population (meadowlarks, blackbirds, and we can now add vesper sparrows) build up rapidly after the beginning of cold weather, generally becoming serious about the latter part of November. By December 15, the concentration becomes so heavy that the destruction of any seed which has not completed the germination process and shed its coat is virtually assured.

2. High temperatures and low relative humidity are responsible for many abortions in freshly germinated seed. This precludes the possibility of early fall sowing or late spring sowing in southwest Louisiana.

3. Depth of planting. Seed planted deeper than one-fourth (1/4) inch beneath the surface of the ground seldom have sufficient energy to break through the upper crust.

4. Age of seed. Longleaf pine seed is difficult to store from one season to the other without a considerable loss in viability and vitality.

5. Competition from grass during the early life of a seedling seriously impairs the development of the seedling. Until the plant reaches an approximate size of one inch in diameter at the root collar, height growth will not commence.

6. Range hogs devour pine seed and also eat the roots of pine seedlings and saplings. Reforestation in any manner with longleaf, without first taking effective control measures against
range hogs when present in large numbers, is folly.

CHARACTERISTICS OF LONGLEAF WHICH FAVOR SUCCESS IN DIRECT SEEDING

1. Seed germinate quickly. The time interval for complete germination under favorable conditions is approximately thirty days. After this time it is no longer subject to serious depredation by birds and rodents.

2. Weather conditions which generally prevail during the month of November and early December are ideal for the rapid germination of longleaf seed. Young longleaf seedlings do not appear to be seriously damaged by freezing temperatures of short duration.

3. Heavy concentrations of seed eating birds occur some thirty days later than the earliest practical sowing date, thus allowing time for complete germination before the birds become uncontrol­lable.

4. Acceleration of germination is possible through ground prepara­tion. Seed pressed firmly in a moist cultivated seed bed absorb moisture rapidly, thus hastening the germination process.

5. Fresh longleaf seed possess unusually strong germinative characteristics. It is not uncommon for a radicle to extend one-fourth of an inch before contact with the soil is made.

6. Elimination of grass competition in the early life of the seedling accelerates development, thus offering the possibility of commencement of height growth at an early age through control of grass competition.

7. Seedlings grown on disked ground develop strong and deep root systems rapidly, thus minimizing the danger of losses due to early summer drouths.

The basic decision to reforest the large blocks of company owned land in southwest Louisiana with longleaf pine had been previously made by the President of Crosby Chemicals, Inc.

An evaluation of the factors listed above indicated that our best possible chance of success lay in the direct seeding approach. In 1952 we began our project on nine-hundred (900) acres of land in the southeastern corner of Vernon Parish, Louisiana.

PROCEDURE FOLLOWED IN GROUND PREPARATION, SOWING OF THE SEED, AND BIRD CONTROL

The advantages to be gained by sowing on disked ground (possibility of early height growth -- rapid germination and assurance against loss from drouth) seemed to outweigh the cost involved (less than $3.00 per acre). It was therefore a basic decision to sow the seed on a prepared
seedbed, in much the same manner as seed is sown in the nurseries.

The disking operation was begun during the early summer of 1952 on barren cut over land which had been burned during the preceding month of March. An eighteen-hundred (1800) pound Rome, scalloped disk harrow, towed by a D-2 Caterpillar, effectively turned over the sod and exposed the roots to the wind and sun. The disking was done in strips. The average width of the disked strip being eight feet. The interval between strips was eight feet.

After two or three weeks exposure to the sun, the strips were then redisked with a tandem disk harrow towed by a John Deere Crawler Type Tractor. This operation leveled the strip and pulverized the sod. The roots of the native grasses were more completely exposed to the sun and wind as a result of this second operation. This treatment for the control of grass competition during the first year of the plantation was effective.

A two row mechanical seeder, in the meantime, had been developed by the ingenious machine shop superintendent at Crosby Chemicals, Inc. Plant in DeRidder, Louisiana. This planter dispensed seed at a controlled rate, much in the same fashion as a conventional corn planter. The machine was towed behind a John Deere Crawler Type Tractor. The seed hoppers were spaced four feet apart and each had a capacity of twenty pounds of longleaf pine seed. Two rows of seed were sown on each disked strip, four-feet apart.

A light roller smoothed out the heavy clods of dirt immediately ahead of the seed chute. Another roller followed the chute. It was hoped that this roller would press the seed firmly into the prepared seed bed. Approximately thirty percent of the seed were actually pressed into the ground or slightly covered with loose soil. There was much room for improvement in this particular feature of the planter.

By sowing on a well prepared bed and pressing the seed into the soil, it was thought that we might reasonably expect a higher percentage of germination than if we had broadcast the seed in a light rough. One and seven tenths (1.7) pounds of fresh (1952) seed were sown in the operation. The cost of this seed was $2.00 per pound. The cost of sowing was forty cents (40¢) per acre.

On November 10, a two-inch rain fell in the project area. The temperature fell to the optimum 50-70 degree range. On November 11, the seeding operation began. Two seeding machines operated ten hours per day. They were towed at a speed of three miles per hour. Each machine planted an average of four acres per hour. On November 27, the seeding of the nine-hundred (900) acres was complete.

During the first two weeks of the operation it appeared that the ever plentiful meadowlarks preferred a diet of insects over seed. While grasshoppers and other small insects were plentiful, seed losses from birds were not severe. Cold weather, however, soon drove these insects into hibernation. During the last week of November, the bird problem became a serious one.
A shot gun patrol, consisting of one to six men, was kept on the area during the daylight hours. During the early days of the patrol activities the meadowlarks were fairly easy to kill. After being flushed and frightened several times, these birds became quite wild. By December 10, it was difficult to move within shot gun range of these, now wary, birds. As the days passed, the resident meadowlarks were joined by their migratory cousins. The meadowlark population by December 15 was many times that of two weeks previous, despite the fact that over three hundred had been taken from the area.

On December 17, the meadowlarks were joined by a very large drove of blackbirds, numbering perhaps five-thousand. A shot gun patrol was even less effective against blackbirds.

At approximately this same time, countless flocks of vesper sparrows (50 to 200 per flock) began feeding on the area. The damage from the blackbirds and vesper sparrows was intense on one eighty-acre block. This block had been burned late in the summer, immediately before the disking began. The earth was completely bare. In this particular area these birds destroyed practically every seed. The rows were littered with seed hulls and fragments. Their damage to the remainder of the plantation, while serious, was not comparable to that on the freshly burned-disked area.

By January 1, 1953, germination was complete. Our losses from birds were severe. We also lost a great many seed and young seedlings following the heavy late November rains, as a result of silting and improper drainage in the disked strips.

In March 1953, the Alexandria Branch of The Southern Forest Experiment Station assisted us in making a survey to determine the percentage of the seed which escaped damage. We were surprised to find that we had come through the ravages of birds, silt and water with a stocking of approximately nine-hundred seedlings per acre.

**CATTLE DAMAGE**

Four-hundred head of cattle had been permitted to range within the ten-thousand acre fenced area, of which this nine-hundred acres is a part. During late spring the cattle began moving into the seeding area. The tender grass which was beginning to spring up in the disked strips was a welcome repast to the cattle. By the middle of the summer, there were at least two hundred head of cattle feeding entirely on the disked strips. So gradual was the build up of the cattle concentration that the damage which they were doing to the seedlings in the strips went unnoticed until late summer.

During the month of September a recount of the seedlings was made. Cattle had destroyed fifty-two percent (52%) of the seedlings. It was not through their grazing, but rather through the trampling which accompanied the grazing, that the damage was done. This was a factor which we completely overlooked in our planning.
EVALUATION

It is now possible to assay properly the results of this project and extract from it further information from our failures and our partial success, which might be of service to others who contemplate such a program in the future.

The statements made below cover points of special interest encountered in this project.

1. Sowing on a flat bed was a mistake. Many seed and seedling were "drowned" following heavy rains. This was a result of our failure to elevate the bed and provide drainage in the strips.

2. The seed were sown too late. By the time germination had begun on the major portion of the area, the bird concentration had become so great that we were unable to cope effectively with the problem.

3. Cattle were permitted to graze unrestricted on the area. This was a serious mistake. Their concentration on the disked strips was responsible for a loss of fifty-two percent (52%) of the established seedling crop. This occurred during the late spring and early summer.

4. It appears that the added expense of diskimg was justified. The seedlings developed rapidly in the relative absence of competing vegetation. Losses due to drought were light. The seed germinated readily on the soft mineral seed bed. At the end of one growing season many of the seedlings have attained a root collar diameter of three-eighths inch to one half inch (3/8" to 1/2"). These seedlings might possibly begin height growth early in 1955, (the third growing season).

5. The mechanical seeder designed for this project was adequate. The rollers, however, were too light. As a consequence, only thirty percent of the seed were actually pressed into the soil. This fault has since been corrected by placing a four-hundred (400) pound crowned type roller ahead of the seed chute. The rolling of the seed into the ground is highly desirable since it reduces the seed loss due to abortions, promotes rapid germination and provides some protection from bird damage.

6. The cost of the operation, including cost of diskimg, seeding and sowing, was $7.22 cents per acre (direct costs only). With effective bird control and more attention to seed bed preparation, this cost can be reduced by perhaps a dollar per acre.

7. Birds are a tremendous problem. Bird control through shot gun patrols on large areas is costly and relatively ineffective. Some more effective bird control measure must be found before direct seeding of longleaf can be done with any degree of assurance of success.

It is evident that the only two real problems now involved, in this
type of operation are:

1. Effective control of seed eating birds during the month of November.
2. The securing of large quantities of high quality, fresh, longleaf pine seed for sowing in early November.

Neither of these obstacles is insurmountable. Interest in these two points and intelligent research aimed at them can solve these problems.

After we have the answers to these problems, direct seeding of longleaf pine will become the fastest and cheapest means of restocking the longleaf "cutover" of central and southwest Louisiana.
DIRECT SEEDING RESEARCH
WITH LONGLEAF, LOBLOLLY, AND SLASH PINES

By
William F. Mann, Jr.

Why have so many foresters experimented with direct seeding over the past 50 years? They were simply seeking a quick and cheap substitute for planting tree seedlings, following nature's way of doing the job.

Most attempts at direct seeding have ended in failure. Successes have been too infrequent to prescribe a reliable technique. Too often the real causes of failure were not determined so methods to insure success were not developed. Therefore, most projects were dropped after several setbacks. It is our belief that artificial direct seeding will work, even though we can afford to sow only a fraction of the seed used in nature. Causes of failure must be learned through detailed observations on experimental seedings in order to develop reliable methods for overcoming them. Only by careful, and sustained research can the correct combination of all factors be worked out so as to give us the methods we need.

Due to the importance of direct seeding, the Southern Forest Experiment Station has studies underway with each of the three major southern pine species. Since methods of direct seeding are different for each species, I will discuss them separately, reporting the progress we have made so far.

LONGLEAF PINE

Direct seeding of longleaf pine has received the highest priority in our research program because it is the most difficult and expensive species to plant. At the same time it is the species best suited for much of our severely cut-over lands. Studies were started in the fall of 1947; all work 1/

Information for this paper is based on loblolly pine studies carried on at the Crossett and Alexandria Research Centers of the Southern Forest Experiment Station. All longleaf and slash pine studies have been conducted at the Alexandria Research Center. Many of these studies have been made possible through the cooperation of the Crosby Chemicals, Inc., DeRidder, Louisiana, Crossett Lumber Co., Crossett, Arkansas, Hillyer-Deutsch-Edwards Lumber Co., Oakdale, Louisiana, International Paper Co., R. O. Martin Lumber Co., Alexandria, Louisiana, Nebo Oil Co., Good Pine, Louisiana, Louisiana Forestry Commission, and the Kisatchie National Forest.

Research Forester, Southern Forest Experiment Station, U. S. Forest Service.
has been concentrated on open, cut-over land. The first studies were made on 1/4-acre test plots. The most successful methods observed here were selected for pilot-plant tests on areas of 100 to 1,000 acres. Seed was sown from early November to February on a variety of prepared seedbeds and at rates ranging from 1.7 to 5.0 pounds per acre. Airplanes, hand-operated grass seeders, and tractor-mounted seeders have been used to distribute the seed. Various methods of reducing seed losses to birds have also been tried.

All told, about 3,400 acres have been direct seeded to longleaf pine in Louisiana, on which we have detailed records. A successful seedling stand was established on about half of this acreage; the balance either failed or produced a partial stand. But the effectiveness and reliability of direct seeding cannot be judged by these figures because some of the procedures used in the early work are now known to be wrong. Furthermore, some good stands were sharply reduced by inadequate protection against hogs and heavy grazing.

Since time will not permit a detailed account of each test, I will simply give our best recommendations and point out the factors that are most apt to cause failures.

Time of sowing. --The key to successful direct seeding of longleaf pine is to sow in the fall when soil moisture is adequate for prompt germination. This must be done after the drought season is past, but before migratory birds become too numerous. Two inches of rainfall will provide the desired soil moisture. This amount of rain may be expected in Central and Southern Louisiana anytime from late October to late November. Any delay in sowing after ample rain has fallen can lead to failure because large flocks of migratory birds begin to arrive in December. Many of our failures can be attributed to late sowing followed by heavy seed losses to birds. Late sowing is so hazardous that we now recommend delaying seeding a year if fall rains do not start until December.

No benefits can be obtained from premature sowing—by that I mean early October or sooner—because it means undue exposure of seed to predators. Moreover, hot weather which is apt to continue until the fall rains come, may spoil the seed.

Seedbed preparation. --A "light rough" of 1-year-old grass is the recommended seedbed condition for direct seeding of longleaf on most sites. It is not only an effective seedbed which will not attract birds, but it is cheap and easy to develop. Burning should be done in the spring, preceding fall sowing, to destroy the accumulation of dead grass so the seed can reach mineral soil. Spring burning will also reduce the rodent population through the following fall season. Because fresh burns are highly attractive to birds, burning in the summer or early fall should be avoided. For the same reason, fresh burns should not be made near or adjacent to a seeded area.

Discing on a light rough is advised for dry, sandy sites to provide insurance against heavy drought losses during the first year. Discing will stimulate seedling growth during the first growing season through the reduction of grass competition. For the best kill of grass roots, such discing
should be done in the summer, several months before sowing. If strips 8 feet wide and 6 to 8 feet apart are disc ed, costs can be held to about $2.50 per acre. In the summer of 1948, it was clearly demonstrated that reduction of grass competition cuts seedling losses from drought. One-year old seedlings on both disc ed and furrowed plots survived the severe summer drought, while those on comparable plots having a grass rough, were lost. This drought was so prolonged that extensive longleaf plantations on a nearby area, failed completely. On better sites, however, it is doubtful if discing is a justified expense for drought insurance, because seedling stands have been lost only once in the last 6 years.

Discing also has several disadvantages which must be weighed when deciding on the type of seedbed to use. First, disc ed strips are more attractive to birds than a light rough. Second, some seed is buried by silting and some seedlings are lost by flooding. Third, the preferred forage found on disc ed ground may require special protection from livestock which tend to congregate there to graze. Finally, there is a strong possibility that early pulpwood yields will be less on disc ed strips because the undisced areas between strips have no seedlings.

Seed. -- Sow at least 10,000 viable seed per acre. This means that with good seed, testing about 70 percent germination, at least 3 pounds of dewinged seed are required per acre. Under favorable conditions, it can be expected that 10 to 30 percent of the seed will produce established seedlings. Therefore, it would be risky to reduce the prescribed rate of sowing until better control measures for predators are found.

Either fresh or stored seed can be used. It will often be necessary to use stored seed because it is difficult to obtain fresh seed in time for early sowing. Longleaf seed is the most difficult of the southern pines to store and requires careful handling from the time cones are collected until it is sown. Tests have shown it can be stored for several years with no loss of viability, if handled properly, while fresh seed lots have been spoiled quickly by improper handling. To maintain the viability of stored longleaf seed, it is necessary to reduce the moisture content to 10 percent or less immediately after extraction to keep it at that moisture level and at a constant temperature of about 36°F.

The germination percent of all seed lots, regardless of species, should be accurately determined before they are sown. In 1948, direct seeding on 550 acres failed, simply because an insufficient quantity of poor seed was used, the germination test being delayed until after the seed was sown.

Methods of sowing. -- On 1-year grass roughs seed can be sown by airplane or by hand-operated grass seeders. Airplane seeding is fast and large areas can be sown in one day's time. It is difficult, however, to obtain uniform seed distribution. Moreover, planes are often grounded at the very time when weather conditions are ideal for germination. Cost including those of flagging, to guide the flight strips, have averaged about $1.20 per acre in our most recent work.
Hand-operated grass seeders are reliable and cheap. An unskilled crew can be quickly trained to distribute the seed uniformly over the area. The machine can be stopped to by-pass any local area not requiring reproduction, thereby saving considerable seed. One man can sow about 30 acres in an 8-hour day.

Disced strips can be seeded with a tractor-mounted seeder at the rate of 40 gross acres per 8-hour shift. They can also be broadcast seeded by hand, which can be done at the rate of about 20 acres per man-day.

Birds.--Birds constitute the greatest single obstacle to direct seeding Longleaf pine. In all large-scale tests some loss to birds has been recorded, and in several tests, birds were primarily responsible for failures. Species and numbers of birds have varied not only from year to year, but even in the same year on study areas less than 20 miles apart. Meadowlarks, juncos, blackbirds, and vesper and savannah sparrows have been the chief species to take seed in the fall. Meadowlarks are probably the most destructive, especially when seeding is done early. Some birds are yearlong residents but in the fall their numbers are increased by migratory flocks. The other species are primarily migratory birds that begin to arrive in Louisiana in late October or November. As a rule these birds feed in large flocks and can cause considerable damage in a short period of time. However, blackbirds prefer to feed on fresh burns and are rarely troublesome on a light rough. Juncos and sparrows will feed on all types of seedbeds, but fortunately have seldom been numerous enough to be a serious threat before December. The best protection against bird predations that we now have is early seeding and, of course, avoidance of fresh burns.

A shotgun patrol has been tried in several trials, and is believed to reduce bird losses considerably. It is difficult to assay the value of patrolling, because several seedlings have been destroyed even when patrolled, while other seeded areas have been highly successful with no protection. The effectiveness of a bird patrol cannot be measured by the number of birds killed, as some benefits accrue by keeping them moving. Until better bird control measures are developed, it seems advisable to keep a one man shotgun patrol on each 200 acres of the area. This should be maintained for a period of 5 weeks, which is the average length of time it takes for longleaf to complete germination. Since the most critical periods are early morning and late afternoon, by splitting the 8-hour work day into these periods protection can be had at a cost of about $1.00 per acre. Federal and State permits must be obtained to kill birds.

To make direct seeding a fully reliable method of artificial regeneration we need an effective bird repellent to apply to the seed. Almost 2 years ago the U. S. Fish and Wildlife Service agreed to cooperate with the Alexandria Research Center on this project. The first task was to find a sticker or adhesive that would be sufficiently durable to resist weathering, but yet would not impede water absorption by the seed. After many trials, it was found that asphalt emulsion met these stringent requirements.
At the present time we are testing various chemicals and seedcoat colorations with caged meadowlarks. It is a well-established fact that unnatural colors are highly repellent to many grain-eating birds, but our tests indicate that they are only slightly repellent to meadowlarks. The best leads so far obtained are two chemical preparations, Anthraquinone and Morkit, which caged meadowlarks have repeatedly refused to eat. Last fall both chemicals were tested in the field and the results were highly encouraging. Seed treated with Morkit and sown at the rate of 3 pounds per acre yielded 4,500 seedlings per acre as against only 195 per acre with untreated seed. In a similar test, initial seedling stands averaged 3,778 per acre for seed treated with Anthraquinone and 1,778 for untreated seed.

These tests are being repeated this spring on a light rough and on a fresh burn. Under these conditions, we hope to obtain a more severe test than with fall sowing.

The Fish and Wildlife Service has tentatively agreed to assign an ornithologist to this problem in the near future. He will be stationed at Alexandria and will participate in all tests. With this assistance, it will be possible to test all promising repellents on a much larger scale with the hope that a satisfactory solution to the bird problem will be found.

Other predators. — Almost every living creature found on open areas will eat longleaf pine seed or newly germinated seedlings. But only a few of these ordinarily do enough damage to cause failure.

Town ants and hogs will destroy seed and seedlings. They must be eliminated from the area before sowing, just as would be done in advance of planting.

Several species of smaller ants and millipedes have been observed eating both seed and seedlings. However, total losses have never exceeded 5 percent of the seed sown, and control measures do not seem necessary.

Raccoons, opossums, and rabbits are known to take seed, although they are seldom present in sufficient numbers to cause heavy losses. Last fall, for the first time, rabbits alone were responsible for severe losses on a 275-acre seeded area. They took seed throughout the germination period and then destroyed new seedlings. Although 120 rabbits were legally killed on this area in an effort to control them, damage was not completely checked. This type of damage can be prevented by making a careful presowing inspection of the area to determine if animals are numerous enough to require control and then applying available control measures. It is only fair to point out that a similar concentration of rabbits would probably cause widespread damage even in loblolly or slash pine plantations.

Although other rodents feed heavily on pine seed, they have not been a serious factor on a light rough or on strips disced on a light rough. Apparently, burning 5 to 6 months in advance of seeding is helpful in checking them. Results from tralines have shown that other rodents are scarce during the fall seeding, while on the same area they are very numerous by the next spring.
Costs. -- The cost of direct seeding longleaf pine depends on the price of seed, method of seedbed preparation, and individual labor and equipment-use rates. Seed can be purchased in bumper years for $1.00 per pound, while in 1953 it cost $2.00 a pound. Assuming an average seed price of $1.50 per pound, seeding on a light rough will cost about $6.00 per acre including a bird patrol. Using disced strips and a seeding rate of 3 pounds per acre, costs will average about $8.50 per acre. Both costs compare favorably with planting costs which average between $12 and $15 per acre at the recommended spacing.

Summary of Recommendations

Although considerable progress has been made with direct seeding of longleaf pine, it must still be considered as being in the experimental stage. Recognizing this fact, I would like to sum up my previous remarks in a brief set of tentative recommendations.

1. Seeding should be done as early as soil moisture conditions permit, but not before late October. Seeding after December 1 should be avoided, even if it means deferring the job a year.

2. A 1-year-old grass rough is the best seedbed condition, except on dry, sandy sites where discing in strips on a light rough is necessary to prevent heavy drought losses during the first year. Avoid fresh burns on or near the seeded area.

3. Sow 10,000 viable seed per acre. Test all seed before it is used.

4. Preliminary work should include hog exclusion and town-ant control.

5. Assign a competent man to each 200 acres to patrol for birds during the germination period. He should also make detailed observations of germinating seed to determine if seed losses are heavy and if special control measures are needed.

6. Make a systematic seedling count about 12 months after seeding. Often a seeded area appears to be a failure until an inventory is made. Don’t write-off the seeding as a failure for at least 2 years; the first year seedlings are hard to see.

7. Exclude grazing animals from the seeded area until height growth starts. Burning, discing, and other cultural practices attract livestock that may trample or browse the reproduction.
LOBLOLLY PINE

Many of the basic principles of direct seeding which have already been discussed in detail for longleaf pine are equally important for the other southern pines. Consequently, such factors as the need for careful seed handling and testing before sowing, timeliness and methods of discing, and avoidance of fresh burns will not be reemphasized.

Since loblolly pine direct seeding studies have been underway for only a few years, we don't have the experience that has been compiled for longleaf and we are not ready to recommend direct seeding of loblolly pine in Louisiana. However, many of the requirements for successful seeding have been determined and pilot-plant tests of the most promising treatments are underway.

Loblolly investigations have been divided into two separate categories. The first is upland pine sites dominated by low-grade hardwoods. Characteristically, these areas have little or no grass to compete with small seedlings. The second is open, cut-over land with a heavy grass sod.

Pine Sites Dominated by Inferior Hardwoods

The first loblolly investigations were undertaken in the fall of 1950, on upland sites dominated by inferior hardwoods. These areas must be planted by hand which is far more expensive than machine planting. Typically, the areas we have used for study have had dense hardwood stands averaging about 5 inches in diameter with almost all grass and brush shaded out by the hardwood competition.

Initial tests evaluated discing and burning for seedbed preparation, different seasons of sowing, and the use of untreated and cold stratified seed. Because loblolly is usually a very slow germinator, laboratory tests were also started to find a pre-sowing seed treatment to speed germination. The most effective treatment found was cold stratification for 90-days, which reduced the time it took seed to start germination and shortened the germination period.

In most of our studies one pound of seed or about 13,000 viable seed per acre has been sown. Loblolly seed is easily stored for 5 years or more, so the primary consideration is to use 1 pound of seed per acre, testing 60 to 70 percent germination, or to increase the amount of seed sown in proportion to the germination percent actually found. Seed has been broadcast using hand-operated grass seeders, which are well-adapted for the job.

The best treatment found for hardwood areas has been to sow untreated seed in November on a fresh burn. Burning permits the seed to reach mineral soil immediately, yet much of the seed is quickly covered and concealed from birds by falling leaves. The new leaf cast also masks out the fresh burned appearance of the area which is attractive to birds. The seed begins to germinate in February or March when daytime temperatures reach 70°F. Since overwinter exposure stratifies the seed thoroughly, no pre-sowing treatment of the seed is needed. The light covering of leaves forms no barrier to the new seedlings, as they quickly push up into the light.
The big disadvantage of fall sowing is that seed is vulnerable to predators for about 3 months even though it is covered with leaves. In several recent trials rodents have caused heavy seed losses during this time. These losses suggest that spring sowing of 90-day stratified seed on areas burned the previous November, before all the leaves have fallen, may have merit. In early tests, where rodents were not a problem, similar treatments were found to be the second best method of seeding. It is noteworthy that both of these treatments are almost the same. In one the seed is stratified naturally, while in the other method it is artificially stratified. Consequently, studies are now installed comparing these two outstanding treatments.

Fall germination, which can be forced by sowing stratified seed in October or November, has not been successful because newly germinated seedlings were killed by freezing temperatures. Discing in hardwood stands is not necessary because there isn’t enough grass to seriously compete with seedlings.

Rodents have been the greatest cause of loblolly seed losses. Up until this year no control measures of any kind have been taken, but in our current work some baiting for rodent control is being tried.

Bird damage is usually light wherever there is a protective layer of leaves. A few seedlings are lost to birds in the last stages of germination when they grab the seed coat which protrudes through the leaves. Ants have also taken seed and destroyed young seedlings, but these losses alone have not been a serious factor.

The best time to girdle the overtopping hardwoods is in May or June after seedling counts indicate there is enough reproduction to justify the work. Girdling or any chemical treatment resulting in quick crown kill is satisfactory. Precautions must be taken to prevent overgrazing as released areas are highly attractive to livestock.

Hand planting hardwood areas will cost from $10 to $12 per acre. Either fall or spring sowing will cost less than $4.00 per acre, assuming a seed price of $3.00 per pound. Of course, girdling of hardwoods will add to both the planting and direct seeding costs. Seed can be purchased in bumper years for about $2.00 per pound. If it is stored for use in lean seed years an extra saving can be made. In the event of a drought or other failure the area can be seeded a second time for a total cost below that of planting.

Seedling Loblolly Pine on Open Cut-over Land

Loblolly direct seeding trials on open cut-over land were started in the spring of 1952. Fall sowing was automatically rejected because fall germinated seedlings would be killed during cold weather and fall sown-spring germinating seed would be consumed by predators during the long period of exposure.

One pound of seed per acre, testing at least 60 percent germination, has been the standard sowing rate in all tests. Sowing has been done about
March 1, when temperatures were first favorable for prompt germination. Sowing beyond this time has not been tried because seedlings would probably be too small to withstand a June dry spell. Untreated and 90-day stratified seed have been tried and the stratified seed has consistently given superior results.

High initial seedling catches have been obtained on most of the different seedbeds tried. First year survival has been satisfactory, however, only on disced strips where the grass competition was reduced enough to let the seedlings come through. On fresh burns and grass roughs most seedlings were quickly overtopped and smothered by the rank growth of grass.

Putting all these factors together, the best treatment found is to sow 1-pound of 90-day cold stratified seed per gross acre on disced strips in late February or early March. Only the disced portions are sown and the seed is scattered by hand.

No protective measures have been included in our tests, other than discing on a light rough and avoiding fresh burns near the area. Sparrows, meadowlarks, and doves have taken seed, but after the first few rains many of the seeds are covered with a thin layer of washed soil which affords a fair measure of protection against birds. Rodents have been troublesome and we are considering limited control measures to reduce these losses. Silt ing has destroyed some seedlings, particularly in two heavy rainstorms in the spring of 1953 when seedlings were completely covered with soil. The best safeguard against flooding and silting damage is to disc strips in such a manner as to provide some surface drainage. When seeded on disced strips, loblolly must be protected from grazing animals for several years.

Seeding costs have averaged about $6.00 per acre, using a seed price of $3.00 per pound. This included $2.50 per acre for strip discing, $0.40 per acre for hand sowing and $0.10 per pound for the seed treatment. Planting similar areas by machine at 6 x 8-foot spacing averages from $8 to $10 per acre, so the economic advantage of direct seeding on open areas is less than on hardwood areas.

**SLASH PINE**

Slash pine seeding studies have been limited so that work could be concentrated on longleaf and loblolly. However, some good leads on slash pine were obtained in small-plot tests established in 1947 and 1948.

Two key points were fairly well established from these early studies. First, unlike loblolly pine, it appears that newly germinated seedlings can withstand freezing temperatures. This may mean that fall sowing and fall germination will not be barred solely by climate factors. Fall sowing is far more preferable than spring seeding because bird and rodent depredations are less severe, providing the seed germinates promptly. The second important point gleaned from small plots is that slash pine can outgrow competing grass on a light rough or fresh burn. Therefore, discing may not be needed to obtain a seedling stand on open
areas. This means that seeding costs can be held to about $3.00 per acre.

With this background to guide us, a comprehensive study of slash pine direct seeding was started on open land in 1953 to compare three types of seedbeds, two seasons of sowing and several seed treatments.
The title of my paper may give you the impression there is a fight pending with a young challenger - direct seeding - matched against an old champion - planting. Such, I assure you, is not the case. I prefer to think of the two methods of regeneration as complementary and supplementing each other - not as one better to the exclusion of the other. In the short time allotted me I would like to discuss a few of the factors which should be given consideration in selecting the method to be used to regenerate a given piece of forest land.

At the very outset, I want to make it crystal clear there are exceptions to any general observations I may make. Despite the wealth of published experimental data on both planting and direct seeding, there still are large gaps in our knowledge, particularly for the Southern Region. We are, however, making progress. In the past ten years we have learned something of the factors affecting seeding in Louisiana and, to some extent, in other parts of the South. We still lack specific information for much of the 12 to 16 million acres yet to be regenerated.

Direct seeding, according to the literature, was the initial method of regeneration in every forest region throughout the world. This was natural - it is nature's way. An effort was made to duplicate her methods within the economic limits imposed by man. After varying lengths of time and repeated failures, direct seeding gave way to the planting of seedlings. Some years later the foresters again tried direct seeding in a modest way. They began to find out why direct seeding failed, what carried seed away, why seed failed to germinate, or why the germinated seed failed to develop afterwards. This knowledge came when large scale trials failed and smaller, more precise experiments were initiated. Data from these explained why some of the old large scale sowings simply did not have a chance.

Mann and Lewis, in preceding papers, have given you a resume of the work in progress in the South. I would like to cover a few of what I consider the more important points, which may be considered in the selection of the method of regeneration, "to direct seed or plant".

I want to compare the impact of the numerous factors which influence seedling establishment and growth. Some are limited to direct seeding; others only to planting. In most cases, however, both methods of regeneration are affected and vary in degree only.

Rainfall during the establishment period is very important, particularly for direct seeding. Sufficient moisture must be available in the
top two to four inches until the seedling roots can get hold of a good volume of soil from which sufficient moisture can be extracted. This means that rains must be frequent, decreasing with the age of the seedlings. The first six months are the most critical, especially on sandy soils on those areas carrying a heavy stand of competing vegetation.

Field plantings of nursery stock, on the other hand, do not require the same distribution of rainfall. Soil moisture at six to ten inches must be greater at the time of planting than for young seedlings in order to sustain the larger transplanted seedlings, permit them to recover from the shock of transplanting and re-establish root contact with the soil. Frequent light showers may not benefit planted seedlings at all but would be highly important to the small naturally reproduced seedlings with only a limited root system. Conversely, the same amount of moisture in a good soaking rain would be highly beneficial to planted seedlings.

Looking at the South as a whole, fall and winter moisture decreases from west to east. Winter droughts can and do occur periodically throughout the region but the records clearly indicate these longitudinal differences. East Florida this year, for example, did not have a single measurable rain for over thirty days - from late January to the end of February. This, coupled with the sandy, excessively drained soil and higher evaporation rate during the winter, created lethal conditions for even the limited number of seedlings coming from last fall's seed crop. Likewise, plantations suffered from the drought, but yet have a chance to survive. This, I want to assure you, is not an uncommon sequence of events. About eight years ago in Florida we obtained an excellent stand of slash and longleaf pine seedlings on the Osceola, Apalachicola, and portions of the Ocala Forests. Everyone was elated at the prospects of securing adequate regeneration on areas that had not gained a single seedling for the past 10 or 15 years. The winter drought, however, completely wiped out the stand in a three-month period and we were right where we had started.

Now let us consider another factor - that of soil surface temperatures. It is an established fact that lethal temperatures frequently occur at the surface of the soil during the germination period. Longleaf pine is particularly susceptible to temperatures above 75° (air temperature). Soil surface temperatures range from 10° to 20° above this, depending on the amount of moisture present. Slash, loblolly, and shortleaf pine seed are affected by high temperatures but to a somewhat lesser degree. Past experience in direct seeding indicates this may be a factor in October and November. Low temperatures likewise inhibit germination and, in some cases, heavy mortality occurs after germination.

Temperatures lethal to germinating pine seed, either high or low, do not affect planted seedlings. They passed through this stage in the nursery. Frost heaving, however, does exert a material influence during the first year in direct seeding and in plantations. Frost action occurs generally in the Piedmont and mountain sections, especially on the heavier soils. It has occurred, however, in central Louisiana and south Mississippi. Nursery losses in fall sown longleaf pine have been appreciable in
some years. Planted seedlings suffer severely in some years when re­peated freezing and thawing lift the seedlings completely out of the ground. All regeneration in the Piedmont and mountain sections must take into account the damage resulting from frost action.

We now come to the question of predators - that host of animals, rodents, insects, diseases, and birds, which use seed or the resulting seedling as food or host. Damping off is a field as well as a nursery disease. Under certain conditions it is a material factor in seedling establishment. It occurs more frequently on moist sites during periods of warm weather. Although there is little we can do about it, recogni­tion of its presence may explain some of the vagaries obtained in direct seeding or natural regeneration. Insects, such as ants and centipedes, are known to consume pine seed and, unless controlled, they may prove quite damaging in limited areas. Population varies widely; likewise the species. Texas town ants, well known to you, are found west of the Mississippi. To the east, harvester ants take some seed during the germination period. Damage, however, is limited to areas near the nests and, in most in­stances, is not serious. In Florida, however, heavy losses to ants have been observed in sand pine stands. Seed of this species is actually carried into the nests. That may be more work, but it's a more certain meal than the usual practice with longleaf pine, slash pine, and loblolly seed where the ant waits for the germination period to feed on the endosperm.

Birds probably constitute the greatest hazard to direct seeding. Meadowlarks, blackbirds, doves and sparrows seem to be the greatest predators in the limited studies conducted to date. Others doubtless will be added in due time. I think it is safe to say that the losses of seed to birds generally increase as other bird foods decrease. This is especially true after the first hard freeze when the insect population takes a sudden plunge. All of the data obtained to date agrees on this point. It is believed to be the major cause of failure of the late sowings made in recent years.

With the exception of Texas town ants, planted seedlings are not affected by birds and other predators so lethal to seed and germinating seedlings. Salamanders affect all seedlings alike - by eating the roots as they develop. The damage continues for a period of several years. Hogs, and to a lesser extent sheep, are most important animals to consider in pine regeneration. It is virtually useless to attempt to grow longleaf, slash, or even loblolly pine where the piney woods rooter is allowed free range. Longleaf pine, of course, is the most susceptible but the damage in plant­ations of other species is all too frequently an inhibiting condition. Let us hope that the day is not too far distant when this animal will be eliminated from woodland grazing. Sheep damage is confined to bud nipping of long­leaf pine and, to a lesser extent, slash and loblolly pine. Repeated nipping throughout the growing season has proved to be a serious problem in certain areas until the seedlings become too large to be ridden down by the sheep. In passing, it is of interest to know that the roots and buds of longleaf pine have a carbohydrate content greater than that of corn. Thus it is easy to understand why hogs and sheep make them a part of their diet.
From the above discussion it becomes plain that the problems of direct seeding are many. Favorable conditions must extend throughout the entire establishment period. A weak link or a miss in the chain of favorable events will cause failure, either complete or partial. The use of planting stock is simply a means whereby many but not all of the loss factors are either minimized or eliminated. Areas very favorable to seed germination and seedling growth are but a limited part of the land on which seeding or planting is attempted, simply because nature already has stocked most of these, despite a limited seed supply in numerous instances. Here cover has not inhibited seed from reaching a satisfactory germinating medium. Soil moisture is ample. Conditions during initial growth of the seedlings do not quite reach the lethal stage.

In producing planting stock the severity of site condition is given consideration. The quality of the planting stock is, or I should say should be, tailored to meet anticipated site conditions. The more critical these become, the more attention seedling quality should be given. For example, there is a direct correlation between root extent and survival under relatively severe conditions. Sometimes all seedlings - poor, good, or excellent - survive. At other times all fail, depending on the severity of the conditions. If you consistently get poor results with the best possible stock, then I certainly would not attempt to direct seed. Conversely, if you obtained good results from only fair quality planting stock, then moisture may be sufficient to consider direct seeding as an alternative method of regeneration.

Longleaf pine planting on many of the more sandy soils in Florida and elsewhere has resulted in a series of failures interspersed with only a few outstanding successes. Success came from using stock of fair to good quality during years when rainfall was plentiful and well distributed throughout the initial establishment period. Less spectacular results were secured using what was considered high quality stock, when rainfall was less plentiful and on sites with heavy cover of competing vegetation. On the same area, stock graded fair to good failed completely. The chances for successful direct seeding on such areas are too dim to be attractive.

We now come to the economics of planting versus direct seeding on sites where the latter may be considered an alternative method. If we could afford to duplicate nature in the quantity of seed sown, the frequency with which she does it, over 10, 20, or perhaps 30 years, I am confident that we could direct seed practically all of the land in the south. Nature, during years of bumper seed crops, literally feeds all of the birds and rodents on the area, gives the ants a feast during the germination period, and still has enough left over to provide a good stand of seedlings; if, of course, other conditions are favorable. If not, a fresh start is made with a bumper crop 3, 5, or 10 years later. Eventually nature does strike the right combination of weather, soil and other site conditions and a stand of seedlings is started, but at a cost of time we simply cannot afford.

The ease with which direct seeding can be done and its initial cost when compared to planting certainly recommend it. If, however, reseeding
50% to 75% of the area is required, the difference in cost between seeding and planting narrows sharply. It is true planting fails miserably in certain years. Direct seeding on identical sites in the same year likewise fails. It then becomes a matter of which method gives the most for the money expended.

In summary, I would like to list a few of the points I consider pertinent:

1. Direct seeding should not be attempted on areas where good quality, well planted seedlings failed.
2. Sites heavily stocked with scrub oak or grass are considered unsuitable for direct seeding. Here the competition is too great to expect more than a few seedlings to survive.
3. Planting should be the preferred method of regeneration until the major causes of losses from drought, birds, insects, disease, rodents, and other predators in direct seeding are known and evaluated over a period of years sufficient to prove that measures can be taken economically to permit establishment of an acceptable stand.
4. I want to make a plea here for pilot plant trials of direct seeding, including a planting check, before large scale sowings are attempted. All too frequently one sowing trial in a favorable year on a favorable site can be so misleading that thousands of dollars are wasted in an effort to duplicate it. We succeeded but we don't know why. We fail on large scale sowings and, all too frequently, we still don't know why. Carefully controlled pilot plant sowings and plantings yield more useful information than any other method of experimentation we have at our command.

Let's continue these experiments and start others in new locations, but on a reasonable scale to avoid costly failures. In other words, proceed with caution!
DISCUSSION AFTER FIRST SESSION

Additional comments by Charlie Lewis:

"We have just completed direct seeding of 1600 acres on disked ground. We made seedlings out of 37% of the seeds we sowed. Sowing in a one year rough, 10, possibly 12% is as well as anybody has been able to do so far. Seed are lost through flooding and through silting. We recognize that. We have attempted to elevate our rows to minimize this loss. The fact that we have made seedlings out of 37% of our seeds indicates that we can accept some of that loss and still justify the disking since seed costs $2.00 a pound, we used 1.2 pounds to seed our area at a cost of $2.40. The standard treatment for sowing in a one year rough is to sow three pounds per acre at a cost of $6.00 for seed. That gives us $3.60 to spend as we choose for disking and still have the cost lower than that of direct seeding in one year roughs. We figure that our disking costs us from $1.75, possibly to as high as $3.00 per acre. Another point is the fact that it is very discouraging from the financiers' standpoint to see their money spent on direct seeding put in seed in a one year rough and after a six year period of time the seedlings have not begun height growth. This we hope to eliminate or minimize through our disking. These are the principal reasons why we have chosen to disk, and I guarantee it is no picnic."

"One other point. In our disked strips after 4 months our seedlings have developed root systems 16 inches deep. On comparable light rough sowing, those roots only extend 4-1/2, possibly 5 inches deep. Therefore we already have the drouth insurance that insures our crop of success, where with others, with a late spring drouth or a summer drouth it is questionable."

Q. "You mentioned rodent damage earlier; I wondered how serious this damage was?"

A. (Lewis) "In my opinion the rodent problem where we disk as we do is comparable to the ant problem. It is there, but the amount of damage is nothing comparable to the birds."

Comment (Donald D. Stevenson) - "I would like to comment on time of year for direct seeding. I come from north Florida and the rainfall pattern there is such that the best rains are during the summer, starting in June. Last year a neighbor, a practical man in charge of a township of land, conceived the idea, contrary to forestry ideas (but it worked very well) of direct seeding in June, and he has done that for two years with slash pine with great success. He disks similar to Mr. Lewis and has designed a hopper from which seed are thrown behind the disk. He has had excellent success starting his seeding in June."
I. F. "Cap" Eldredge, Moderator

SOIL SITE CLASSIFICATION
AS A GUIDE TO PLANTATION SURVIVAL

By
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Forest Service, U. S. Department of Agriculture

You have all made the observation that, within the same general planting area, survival and early growth of planted seedlings is excellent on some sites and a complete failure on others. This may be true even when the seedlings are of the same stock, are grown, handled, and planted identically, and when weather conditions are the same over all areas. Our recent drought years have accentuated these events in that plantation failures have been more common, so that we are more aware than ever before of the risk involved in regeneration by planting. The explanation for the failures can often be found in site differences due to soil and topography.

At present it is impossible to predict climatic conditions very far in advance, and therefore we take a risk every year that we plant.
This paper will outline those conditions of soil and topography which may combine to make a site a good or a poor planting risk. The term "planting risk" is used here qualitatively to indicate the relative site potential for early survival and growth of planted seedlings.

When summer showers are ample and well spaced, planted southern pines will survive and grow on nearly all combinations of soil and topography in this area— that of the central Gulf Coastal Plain. The poor risk as well as the good risk sites will support pine seedling growth. However, the drier the growing season, the more likely the possibility of poorer survival on the poorer risk sites.

Survival and growth of seedlings is dependent upon the development of an adequate root system. And root development is affected by at least four underground factors: (1) moisture, (2) aeration, (3) temperature, and (4) fertility. Root development of southern pine is apparently rarely limited by the two latter factors. Moisture and aeration conditions, however, are more important and usually account for much of the growth differences found. Therefore, those soil and topographic characteristics which affect soil moisture and aeration need to be recognized in the field by the forester because they do account for site variations. Surface conditions, such as litter and sod, and competing hardwood and herbaceous vegetation are not considered in the following discussion. Such factors often play an important part in plantation survival, but time does not permit the coverage of these related conditions.

Subsoil limitations

Soil moisture usually does not become limiting to growth on any site before early June. By that time, newly planted seedlings will have had nearly three months to grow and develop root systems. During this spring period, lack of aeration in some soils limits root growth. Shallow heavy subsoils or "pans" with poor internal drainage, having been recharged with water during the winter rains, become saturated or "water logged" by spring rains. The roots of young pines will not expand down into these poorly aerated zones, but will be confined to a sparse development in the first few inches of surface soil. By the time excess water has drained away, much of the growing season is lost to root growth. Only a moderate summer drought is then needed to dry this surface layer, and thus kill the seedlings. This explains why plantings on the fringes of natural prairies in southeastern Arkansas have notably been poor risks during dry summers. The internal drainage is poor, and excavated root systems of dead seedlings indicate that essentially no root development takes place during the spring.

On the other hand, a well-drained subsoil will have favorable aeration to deep depths almost immediately following any spring rain. Pine seedling roots will grow into this subsoil, if relatively near the surface, during the three months before summer dry periods. Prolonged droughts are less likely to kill plantings made on these sites.

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Surface soil effects

It is obvious from the foregoing that the thickness of the surface soil is important. At one extreme we have shallow surface soils overlying a restricting subsoil. Such soils are poorer risks than moderately deep surface soils overlying the same restricting subsoil, as there isn't space above the subsoil for good root development. The optimum surface soil depth is between 12 and 24 inches, but dependent on subsoil drainage: as internal drainage becomes poorer, thickness of surface soil should increase. For example, a well drained sandy clay loam subsoil can more safely be near to the surface than can a silty clay subsoil of poor internal drainage.

At the other extreme of surface soil depth, deep sandy soils are found which extend 30 or more inches down to subsoil. Although aeration may be excellent and early root penetration deep, such soils will dry out rapidly and deeply during the summer, and drought kill of seedlings may result.

Surface soil textures can often be the indirect cause of success or failure in a plantation. The finer silt loam soils have a much slower infiltration rate, and thus a greater water loss by rainfall runoff, than do the sandier soils. Even if equal amounts of precipitation move down into the soil, the loamy sands will be wet to a much greater depth than the silt loams. This combination of more water into the ground to a greater depth often results in the subsoil under a loamy sand benefiting by summer rainfall, whereas that subsoil underlying a silt loam may receive no moisture from the same rain. Even light summer showers during drier years are critically important in this area, and the amount of this rainfall that actually gets into the ground and down to the root zones can spell the difference between success and failure of a new plantation. This effect of surface soil texture, as it regulates summer infiltration, is much more important on open abandoned agricultural lands than on areas where there is protective litter and brush covering to reduce runoff.

To summarize these soil effects, poor risk areas are those with fine-textured, shallow surface soils overlying heavy subsoils or pans with poor internal drainage. Good risk areas are those having light-textured, moderately deep surface soils overlying friable subsoils of good internal drainage. There are all combinations and graduations between these two extremes, of course, and it is necessary for field observation to determine whether a particular site falls to one side or the other.

Topographic effects

Topography also plays an important role in seedling survival and growth, in that it too affects soil moisture and aeration conditions. Rolling lands sometimes constitute a water deficiency problem, while flat areas often impose a root aeration problem. Both of these topographic
situations must be considered conjointly with soil conditions of internal drainage, because of the interacting effects of soil and topography on good or poor root environments.

In general, flat areas not only retain all rain water which falls upon them, but may also receive runoff water from surrounding areas. This added water aggravates that condition of poor aeration discussed above on soils having slowly permeable subsoils or pans. The so-called "pin oak flats" within our pine areas show signs of current natural pine reproduction only during periods of light winter and spring rainfall. On the other hand, if internal drainage is good, the poor surface drainage on such flat lands may be a definite asset by maintaining higher levels of soil moisture during the summer.

There is also the danger on low areas that an extremely wet period will flood and "drown" pine seedlings. The failure of seedlings to survive on such topography on a large area in Bradley County, Arkansas, is traceable to flooding. After aerial seeding of this area, germination was deemed good, and early indications were that regeneration was established. However, excessive rainfall in May submerged the lower portions of the whole area and most seedlings were drowned.

In contrast to the flat lands, sloping areas may suffer from a lack of soil moisture, particularly during dry summers. Much water which falls during summer showers will be lost as runoff, especially on the finer textured surface soils.

Topographically, the poor risk planting sites are those flat areas of poor internal drainage, and steeply sloping areas with finer surface soils. The good risk sites are flat areas with good internal drainage, and gently sloping areas with coarser surface soils.

Field guide

I have prepared a chart which may prove helpful in estimating the risks of planting particular sites. The first breakdown lies in the topographic position—-flat or sloping. Within each of these positions two soil factors are considered: subsoil drainage, and thickness of surface soil. Each of the soil factors are broken down into simple classes, easily determined in the field. Table 1 has been prepared to aid in assigning the subsoil to its proper class--well drained or poorly drained. Then the chart indicates the risk involved by surface soil depths. For simplicity, the effect of surface soil texture is omitted from this chart, and risks are calculated for medium-textured surface soils. The chart is based on general information, and not on any specific data.

The above guide is rather generalized, but I feel that it is better than no guide at all. We must remember that it involves only the theoretical risk involved in losing planted pine seedlings during an unusually dry year. The more optimum the soil conditions of moisture and aeration, the more vigorous will be the spring development of the root system, and the better the chances are for survival during a dry period.
Figure 1. -- Planting risk chart for southern pines based on topographic position and soil profile properties.
Table 1. -- Classification of subsoil into one of two drainage classes by readily discernible soil properties

<table>
<thead>
<tr>
<th>Color</th>
<th>Textural grade</th>
<th>Consistance when moist</th>
<th>Internal drainage class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bright yellows, reds, or browns</td>
<td>Sandy clay loams to light clays</td>
<td>Firm but friable to semi-plastic</td>
<td>GOOD</td>
</tr>
<tr>
<td>Mottled grey with dull yellows and reds</td>
<td>Silty clays to heavy clays</td>
<td>Stiff and plastic to very plastic</td>
<td>POOR</td>
</tr>
</tbody>
</table>

Soil series with characteristic internal drainage

A. Well-drained subsoils

1. Uplands

Norfolk
Ruston
Orangeburg
Red Bay
Luverne
Tifton
Kirvin
Nacogdoches
Greenville
Magnolia

B. Poorly-drained subsoils

1. Uplands

Caddo
Pheba
Bladen
Lufkin
Boswell
Susquehanna
Sawyer
Hyde
Plummer
Portsmouth

2. Terraces

Kalmia
Cahaba
Amite
Chattahoochee

Myatt
Leaf
Stough
Bell
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Russell, M. G.

Winters, E., and Simonson, R. W.
Disregarding for a moment the relative ease or difficulty of getting a given species established, planters are interested in site classification primarily as a guide to which of several areas to buy or plant, and as a means of predicting the yield of whatever species may be planted on the area chosen.

The conventional method of classifying sites—as by observing the heights and ages of dominant and codominant trees—has the advantage of direct utilization of tree growth to measure productive capacity. It has the disadvantage of requiring measurements in at least moderately well-stocked stands 15 to 20 years old and preferably older. Such stands, of course, are conspicuous by their absence on areas needing planting.

The possibilities of evaluating sites by observing soil characteristics have just been discussed. On pine planting sites entirely devoid of pines, no better method suggests itself.

Where, however, there are occasional clumps or scattered individuals of pines 8 or 10 to 20 years old, as on many planting sites, a third method may be feasible. This is to average "5-year intercepts" measured on a number of the young trees. The 5-year intercept for any one tree is the length of trunk formed in 5 consecutive years, during the first of which the tree attains breast height.

The intercept method has the advantage of utilizing tree growth directly in site determination, without requiring full stocking, exact uniformity of age, or any determination of total age. It largely eliminates the disturbing influences of injuries occurring before trees reach breast height, such as brown spot and grass competition in the case of longleaf pine, and rabbit damage and the most severe phases of tip-moth damage in other species.

The effectiveness of the method depends upon the fact that, despite the multinodal growth habit of the southern pines, successive annual increases in height can readily be distinguished on trees up to 15 and sometimes even 20 years old. Regardless of the number of internodes formed in any one year, the first one formed in the spring is almost invariably much
the longest, and the last formed in the summer or early fall much the shortest. In addition, the branches which have developed from overwintering lateral buds (which of course are at the bases of the very long spring internodes) are generally longer, much stouter, and in more definite whorls than branches arising during the growing season.

In longleaf and slash pines 20 to 30 feet high or a little higher, successive annual increases in height from breast height upward are ordinarily very distinct. In loblolly and shortleaf of the same sizes they are often partly obscured and sometimes entirely obscured by tipmoth damage. Even with these species, however, the growth pattern can ordinarily be discerned in a great majority of trees.

Measurement of 5-year intercepts is easy, especially with a 2-man crew. By examination of each tree in turn, 5 successive years of growth are identified, the first of which includes (or occasionally begins at) the breast-high mark. The zero end of a steel tape attached to a suitable pole is raised to the top of the fifth year's growth, and the total growth made in 5 years is read directly from the tape opposite the beginning of the year's growth that includes the breast-high mark.

An unpublished study by José Marrero, U. S. Forest Service, Puerto Rico, made in 1946 in northern Mississippi, and incorporating some data from Georgia and Louisiana, demonstrated the ability of the method to distinguish rather fine gradations of site quality in plantations. Comprehensive tables of intercepts over a complete range of sites have not yet been compiled, but Marrero found that average intercepts based on 25-tree samples of planted longleaf, slash, and loblolly pines varied from 19 or more feet on the better sites to 16 feet or less on the poorer ones. Where exact ages of planted trees were known and soils could be evaluated reliably from physical characteristics, intercept lengths showed good correlation with total heights and with soil productivity ratings. In two instances, non-correlation between intercept lengths and total heights revealed errors in recorded ages of plantations.

Two other findings make the intercept method seem particularly promising in connection with classification of sites in need of planting. Marrero found on a number of sites that intercept lengths of trees already established naturally at time of planting coincided closely with intercept lengths of trees planted later. Subsequent work indicated the possibility of translating intercept values for young trees into terms of heights of dominants at 50 years. Both these findings suggest that the intercept method might repay systematic development as a means of classifying sites on which scattered young pines occur.
CHOICE OF SPECIES AND STAND COMPOSITION

By
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I have accepted this subject because of an early and sustained interest in the artificial planting of pine. While still a student at L. S. U. I was privileged to work with Phil Wakeley. We dug up seedlings in the nursery to study their root systems. We also dug up saplings in the field, some of which had been planted with root systems including the tap root intact, while others had been pruned. Some time later, I assisted in planting thousands of acres around Bogalusa. Because I had a part in its beginning, I have watched the development of the beautiful stands of planted pine under Paul Garrison's management with a sense of personal pride.

Several days ago I was looking over a report I submitted on 64 mortality plots in 1929. Particularly interesting to me were the reports on two of those plots. One was in a planting of longleaf pine which had been needle clipped. The survival in September after planting was 84.3%. The other was one planted with selected stock of the best longleaf seedlings; survival for this plot was 98.3%.

The whole problem of planting the right species on the right site is an ecological one. If we completely understood the ecological requirements and relationships of each of our pine species, we could plant the best suited species on any given site. This, of course, would require a thorough knowledge of the relationships between any given soil condition and each of our pine species.

Let us review, briefly, some of the known ecological relationships of slash, loblolly, longleaf and shortleaf pines. First, though a word of caution concerning generalizations when discussing or working with any tree species. Site changes can and do occur in the space of a few feet. The inter-relations between a given species, the soil on which it grows and other plant life will vary greatly from area to area.

One other word of caution. The only site curves available for the species we are considering are found in USDA Miscellaneous Publication No. 50. This was used even though its producers have since questioned its accuracy. When sites are classified it is found that for a 90' site, the dominants in a 20 year old shortleaf stand would be 44', in longleaf 46', in loblolly 48' and in slash 54'. This is due to the rapid early growth rate of slash, where the difference is greatest. Of course the gaps gradually close until they reach 50 years, at which time they are equal.

Slash is being planted more extensively than any other southern pine in the deep South. This is true even though its natural range is far
smaller than that of the other principal pine species. Slash pine range has been approximately tripled by artificial establishment. It is being planted on sites far different from those on which it had grown naturally. Within its natural range it occupies a greater area than it originally did. Most of this increase on its original range has been at the expense of longleaf pine.

McCulley describes the better slash sites in the Florida-Georgia area as being incompletely drained and bearing such indicator species as good growths of gallberry and waxmrytle with an occasional pitcher plant. His site map indicates that 60 and 70 foot sites predominate on the area. Soils underlain with a hard pan are less productive than the above but more productive than the "crawfish flats" with extremely poor drainage.

In Southeast Louisiana near Abita Springs, the Great Southern Lumber Company of Bogalusa set aside in the early twenties one township as a piling reserve. The greater portion of the pine stand was slash; ages ranged up to 90 years; fourteen, sixteen and eighteen inch diameters predominated. Piling as long as 100 feet were cut from this area.

Site classes in planted stands as related to soil type have been checked using permanent plot data supplied by Garrison and a soil survey map.

Slash sites on Kalmia fine sandy loam were approximately 95 feet. This soil occurs on moderately well-drained sandy terrace sites such as are found along the Pearl River and was spoken of as "gallberry flats" because of the vigor and prevalence of that species.

Site class dropped to about 85 feet on Myatt fine sandy loam. This is the "crawfish" soils of that section. Associates were gallberry, black gum and sweet bay. Site class on rolling well drained upland soils was also approximately 85 feet. Natural mixtures of slash and loblolly on our pine straw plots at the Fruit and Truck station near Hammond give a site class of 110' based on loblolly site class charts. Hal Townsend made a detailed study of mixed planting of slash and loblolly in North Louisiana during 1948 and 1949. He concluded that up to 20 years of age, there was little difference between the growth of the two species.

Loblolly On moist areas with good internal drainage, loblolly normally will out produce other southern pine species. Coile found that in North Carolina, pine sites varied according to the depth of the A horizon and soil structure. On friable soils, site class is 57' with a 2" A horizon and rises to 89' with a 12" A horizon. On the poorest, most plastic type soils, site classes varied from 30 to 61.

At Bogalusa, plots of planted loblolly show sites of 95 on rolling land near streams, 85 on Kalmia fine sandy loam and 80 on the drier, hilly sites. Where small areas of loblolly were planted on Myatt fine sandy loam, height growth is noticeably poor. Mann, whom you heard this morning, reports a 100 ft. plus site on a well drained Ruston fine sandy loam for planted loblolly on the Alexander State Forest in Central Louisiana. In Livingston Parish loblolly site reaches 120'. There is no reason to
believe that planted stands would not do as well.

**Longleaf** Nature seems to have accidentally grown longleaf pine much better than we foresters have been able to, a rather strong indication that foresters have a great deal to learn about this species. This is regrettable in the face of the fine qualities of longleaf once we get an adequate stand out of the grass.

Original longleaf stands grew on a wide variety of soil types; it was found on the deep sands of Florida along with scrub oaks; it grew on the wet "crawfish soils" associated with black gum and pitcher plants. However, its best development occurred on the drier - better drained hill sites. Wahlenberg sums up the soil conditions of the original longleaf sites thus: "Although longleaf soils are characteristically poor in organic matter, acid in reaction, and low in fertility, the response of the species at any age to soil enrichment is strong evidence that poor soil is not preferred. Research evidence indicates that arid and infertile habitats are endured from necessity, not choice."

In the flat woods of Louisiana, longleaf pine reproduction is nearly non-existent. Even though seed trees were left, little reproduction has resulted. In many places slash or occasionally loblolly has taken over. Only slight elevational changes from the normal flat woods is required to support good stands of loblolly.

Plots in natural stands of young longleaf on Ruston fine sandy loam west of Bogalusa indicate a 90' site class.

**Shortleaf** Shortleaf is usually associated with loblolly in the southern portion of its range. Some writers have asserted that shortleaf has a growth advantage over loblolly on the drier sites. In North Carolina Coile found the loblolly outgrew shortleaf on all sites; the site index for loblolly equals shortleaf index times 1.13.

In East Feliciana Parish site was determined for a mixture of loblolly, longleaf and shortleaf growing together on a former longleaf site. With an average age of about 30 years, the site classes were: Loblolly 85', longleaf 80 to 85' and shortleaf 80'.

On a typical loblolly shortleaf site one mile west of the above plots, the site class was 95 for loblolly and 90 for shortleaf. Dense stands of yaupon are mixed with the pine; this is a normal association on most of the better loblolly-shortleaf sites of this area.

**Seedling Production in the Gulf States** Before the choice of seedlings for planting is discussed let us look at the number of seedlings by species being planted in the South. The men who select the planting stock are responsible for the production of a profitable forest crop so their choice must be given special consideration. During 1953, Florida produced over 53 million slash and about 200,000 loblolly and longleaf each; Alabama produced approximately 13-3/4 million slash, 13 million loblolly and 2-1/4 million longleaf; Mississippi produced approximately 15-1/2 million slash,
3-3/4 million longleaf, 2-1/2 million loblolly and 1/2 million shortleaf; Louisiana produced approximately 23-1/2 million slash, 21 million loblolly and 1/5 of a million longleaf; Texas produced approximately 12-1/4 million slash, 7-1/2 million loblolly, 1/2 million shortleaf and 1/5 of a million longleaf. As compared to 1951, no species showed a general trend upward or downward; Alabama, Texas and Louisiana had a big percentage increase in loblolly while Mississippi had a large increase in longleaf and a decrease in loblolly.

In addition to supplying the above information the state forestry organizations made certain other estimates of interest. Abandoned farm land planted in Alabama was 75% of the total, in Texas it was almost 40% and about 30% in Mississippi. Cut over longleaf land made up about 60% of the total in Mississippi, 40% in Texas, 35% in Louisiana and 5% in Alabama. Farmers and other small owners are planting approximately 1/2 of the seedlings grown in Alabama, Florida, Louisiana and Texas and some 30% in Mississippi.

Species Selection for Planting  As already pointed out slash is the most popular species for planting in the deep South. Its use on the more poorly drained areas of its natural range can hardly be questioned. Careful consideration is in order when slash is planted on better drained sites outside its natural range.

Mann has placed the cut over lands of Southwest Louisiana in three classes: first, soils with poor internal drainage where slash has a very definite advantage; second, soils having fair internal drainage where slash and loblolly grow on about equal terms; and third, soils that are well drained such as Ruston where loblolly has a definite advantage.

The rolling, well drained soils near Bogalusa are growing slash at a rate equal to or exceeding loblolly.

Slash is relatively free of tip-moth damage. Applequist's plantings on rolling longleaf soil at the Agricultural Experiment Station, Washington parish, show that slash has gained a 3' advantage in 4-1/2 years, apparently due to heavy tip-moth infection on loblolly. Ice storms have damaged slash to a greater extent than other species. Damage has been greatest in open stands, especially where rather heavy thinnings have recently been made in dense stands. Mann made available records for a slash planting on the Palustris Experimental Forest. In 1934-39, 1150 trees were planted; thinnings have been made at 3 year intervals, beginning in 1948; most ice damaged trees have been removed; at present there are 234 trees left per acre and total annual production has averaged 1-1/2 cords per acre. Mann also reports that most of the severely damaged areas in that section have at least 100 good trees per acre. On plots of mixed slash and loblolly checked by Townsend, moderate damage went as high as 45% and heavily damaged as high as 16.6% for slash. Comparable figures for loblolly were 40.0 and 12.3%.

Slash ranks second to longleaf in fire resistance. Concrete proof of this is the fact that Palmer of Nebo Oil Company has successfully burned
4 year old slash plantations. In localities where fire control is uncertain, slash offers greater success than loblolly.

Slash pine usually has a clearer stem than loblolly or shortleaf. In our unthinned check plots at Hammond, made up of a mixture of slash and loblolly, the bole length clear of live limbs is from 5 to 7 feet greater on slash than on loblolly. Bole length clear of all limbs favors slash by about the same margin.

Fusiform rust is a serious disease of southern pine in some areas. In Southeast Louisiana, highest to lowest incidence occurs as follows; slash, loblolly, longleaf and shortleaf. Infection may be so severe in local areas that a final crop of healthy trees cannot be obtained, however this is not often the case. Our unthinned check plots at Hammond have 6% of the slash and 5% of the loblolly with stem or limb infection within 2 feet of the trunk. Mann informs me that young stands on the experimental area were approximately 25% infected.

Townsend found only light fusiform infections on either slash or loblolly in North Louisiana and concluded that it was not an important factor there.

The advantages of longleaf were well portrayed by Charlie Lewis this morning. There are doubtless many sites that would be planted to this species if the land owner had some assurance that height growth on 3 to 5 hundred seedlings per acre would be secured within 3 to 5 years. It is to be hoped that work now being done will make possible this early emergence from the grass stage. Until then, land owners are apt to continue using other species.

These data on species have been presented to review for you some of the factors that might be useful in selecting species for planting. Foresters are seeking, rather feverishly, methods of increasing forest yields. The planting of one species over wide areas without regard to the suitability of the species to changing sites may mean a loss of 25% or more of the productive capacity of the soil. Mann states that loblolly is producing 27% more wood than slash on the Alexander State Forest. Even shortleaf which has been by-passed in the planting program might be a good choice on some sites, especially if fusiform rust is a threat to loblolly.

By a study of soil conditions and by close observation of minor vegetation the forester should be able to judge the suitability of the site for the various species.

Mixtures Some sites seemingly will grow two or more species about equally well. It is possible that before the stand is mature one or the other of these species may show marked superiority. It seems that a one or two row mixture of suitable species might be planted. Through selection during intermediate cuts, the mixture could be maintained or one species could be removed completely while the other was retained for the final crop.

Mixtures may be advisable on areas of dry sandy soil. McCulley reports that early growth on the sandy soils of Florida indicate a much higher site class than older stands on the same area do. It is possible that
a species with slower initial growth may maintain moderate growth longer and eventually prove a more desirable species. And then the best species for a given soil could eventually be developed for the final crop.

In conclusion, these points should be considered:

1. The productive power of soils differ greatly.
2. Pine species differ markedly in their ability to produce on the various soil types.
3. The yield of forest products may be greatly increased by the selection of the best producing species as compared to lower producing ones.
4. Soil productivity may be gaged by (a) site classification on standing pine, (b) use of soil maps or other available soil data, (c) study of minor vegetation that might act as site indicators, (d) inquiries into original productivity.
5. Use mixtures if available information indicates that two or more species have approximately equal potential productivity.
SURVEY OF HARDWOOD PLANTING POSSIBILITIES IN THE SOUTH

By
Louis C. Maisenhelder

Introduction

As many of you know, the Delta Research Center of the Southern Forest Experiment Station is charged with the responsibility of carrying on all phases of research work in the bottomland hardwoods and in the hardwoods found in the brown loam bluffs along the eastern edge of the Mississippi River Delta. In fact, it is the only Research Center working exclusively with Southern hardwoods. So it is a privilege and a pleasure to share with you some of the results of our work and other information we have collected on the subject of hardwood planting.

I am deeply grateful to the various industrial companies, the State forest service organizations of Tennessee and Mississippi, the Mississippi National Forests, TVA, the School of Forestry at Louisiana State University, and the Tallahatchie Research Center of the Southern Forest Experiment Station for the information they furnished for use in this paper.

Hardwood planting in the South, as I shall define this region a little later, is still in its infancy and information concerning what has been done is both meager and scattered. With so little experience to guide us it is no wonder that our hardwood plantations are not famous for their success. With a relatively few exceptions, I know of no outstanding commercial hardwood plantations of any species in the South. The field is wide open; there is much to work on.

For purposes of clarity in this discussion, it will be necessary to define the territory under consideration. It includes the bottomlands of the Mississippi River Delta in five states; the alluvial bottoms of the larger streams along the Atlantic and Gulf Coasts from the Carolinas to Texas; the brown loam bluff area bordering the Delta on the east; and the upland hardwood areas within this general Lower Mississippi Valley and coastal plains territory which are truly hardwood producing sites. In the aggregate this area approaches forty million acres.

1/ Stationed at the Delta Branch of the Southern Forest Experiment Station, USDA, Forest Service, maintained in cooperation with the Mississippi Agricultural Experiment Station and partially financed by the Southern Hardwood Forest Research Group.
Size of the Planting Job

Let us consider briefly the need for planting and the size of the job that may ultimately have to be accomplished. Planting is usually needed only to restock areas lacking an adequate seed source. A lack of seed source is most frequently associated with abandoned farmlands and extensive areas that have been repeatedly burned. Improperly cut-over land also may be deficient in seed trees of desirable species and require reinforcement planting to assure a full stocking of the better species.

The conversion of stands to a better species composition than nature provides, especially when interferred with by unwise cutting, will probably often require the planting of the desired species. For example, to assure the replacing of a mature cottonwood stand with cottonwood will require planting, for this species does not succeed itself and is often followed by an undesirable tree such as boxelder.

An estimate of the acreage in need of planting is difficult to arrive at and I doubt if anyone is qualified or would care to make a guess as to the size of the entire potential planting job. However, perhaps we can arrive at some figures that will help us visualize what we may expect. The need for three kinds of planting is recognized. They are full planting, reinforcement planting and conversion planting.

Full planting will be needed for areas with less than about 15 percent stocking with natural tree reproduction of usable species for which there are no reasonable indications that conditions will improve naturally within a reasonable period of time. It has been estimated that only five to ten percent of all the bottomland that should be in forest in the Mississippi River Delta and the bottoms of the larger streams along the Gulf and Atlantic Coasts falls in this category. It seems reasonable to assume that this percentage will not vary materially in the hardwood areas of the territory that lie outside the bottomlands. Thus, this small percentage, however, represents an area of two to four million acres and does not include any allowance for reinforcement planting and stand conversion work.

Reinforcement planting will be necessary to supplement natural reproduction to bring to adequate stocking with desirable species areas which have more than about 15 percent natural stocking with such species. Judging by general observation and a few specialized studies in the territory under consideration, it appears that perhaps ten percent of the potential forest land, or nearly four million acres, will require reinforcement planting.

Conversion planting will be used on areas having generally adequate stands of tree species but where it is desired to change the species composition and this aim cannot be accomplished by natural seeding or some silvicultural practice. It is estimated that about ten percent of the forest area could be benefitted by such conversion planting. This amounts to another four million acres.

Thus, some twenty-five percent or about ten million acres of the hardwood forests in the territory we are considering appear to be in
need of some kind of planting to develop optimum production at an early stage.

Species and Planting Methods Used

So much for the job ahead of us, now let's see what has already been accomplished. Just as for the acreage in need of planting, the acreage which has been planted is also difficult to arrive at. Although total acreage figures do not seem to be available, reports from various sources show that many trials have been made involving a considerable number of species. For the most part the plantings have been small, ten acres or less, and there has been little organized follow-up after planting to study the results obtained. Survival and height growth have too often been unsatisfactory and as stated previously really successful commercial plantations, comparable to what has been accomplished with pine, are almost non-existent in this region. Certainly the overall net effect has been negligible except for the value of the knowledge and experience gained.

The species that have been planted divide according to their frequency of use into two groups. The first group contains cottonwood, yellow-poplar, ash (both green and white), the red oaks, black locust, and cypress. These are the ones most commonly used. Black walnut, sycamore, white oaks, sweetgum, red mulberry, hybrid poplars, hybrid willows, and catalpa have been used chiefly in small experimental plots.

The planting techniques employed have included direct seeding, the planting of one-year-old seedlings, and the setting of both rooted and unrooted cuttings. The use of seedlings is probably the most common practice. Direct seeding has been used chiefly in planting heavy seeded species such as oak and walnut since it is usually cheaper than other methods.

Seedlings of all the species mentioned have been planted. One-year-old trees obtained from a nursery are the usual planting stock. Hand planting is the general rule; however, machine planting might work on some sites.

The planting of cuttings is a newer and a less used method of establishing plantations. It is an easy and cheap method for handling the species which root readily, such as cottonwood, willow, and possibly sycamore. The techniques for planting and growing cottonwood with success have been well established and essentially the same methods will undoubtedly apply to any other species that may prove adaptable. Propagation by cuttings is a most advantageous method since there is assurance of reproducing in the new trees the desirable characteristics of the selected parent stock. This is particularly important because of the vast range in quality of individual seedlings in woods run of hardwood stock.

If all hardwood species could be reproduced by cuttings from trees of superior growth and quality characteristics, we would be well on the way to making hardwood planting successful and profitable. This is not entirely out of the question, at least for some species. Horticulturists have been able to root cuttings of many species of plants by the proper treatment with
various plant hormones. Tests are now in progress at the Delta Research Center to see what can be accomplished by treating some of these bottomland species. Some encouraging results have been obtained. For example, 47 percent of some green ash cuttings treated with hormone solutions developed roots, while only 20 percent of the untreated cuttings rooted. On the other hand, none of the treatments tried have been successful in causing sweetgum to root. Additional work is now underway on sweetgum, cherrybark oak, Nuttall oak, sycamore, and green ash. The Tallahatchie Research Center is working with yellow-poplar cuttings.

In all three of the planting methods considered, some means of destroying the ground cover before planting has been shown to be advantageous and has been practiced to some extent. Subsequent control of weeds and vines, by cultivation or other methods, to prevent overtopping of the planted trees, can also be expected to pay off. Likewise, girdling or poisoning the over-story to release underplantings has been shown to be beneficial. Such release work, however, has not been common practice in ordinary planting trials.

**Planting Costs**

No discussion of planting methods would be complete without some consideration of the costs involved. So little has been done and so much of what has been done was experimental in nature and on so small a scale that cost figures are often not realistic. There is some information, however, which will give us an idea of what may be expected. For direct seeding of acorns in underplanting a three-acre area in a river bottom of central Arkansas the cost varied from approximately $1.60 to $3.25 per acre depending on whether the spacing was 12 x 12 feet (302 trees per acre) or 8 x 8 feet (681 trees per acre).

Seedling planting costs have been reported at $10 to $12 per thousand seedlings or $7 to $8.50 per acre for 8 x 8 foot spacing.

Cuttings can be planted on a 9 x 9 foot spacing (538 trees) for $1.75 per acre or 6 x 10 foot spacing (726 trees) for $2.20 per acre. All these costs are post-war figures.

These costs do not include any allowance for pre-planting site preparation or subsequent weed control or release work both of which appear to be essential in most hardwood planting. Such practices very materially increase the cost of establishing plantations. For example, we have found that to prepare the site, plant cottonwood cuttings, and control the weed competition during the first year costs from $15 to $23 per acre. This appears to be a high cost and you may be inclined to say that planting is impractical under such conditions. Recent analyses of the returns such a plantation would provide in 30 to 35 years, assuming the best growing stock available was used, show that even higher costs could be justified.

**Need For Good Nursery Techniques**

As hardwood planting increases, hardwood nurseries will be needed
to provide planting stock. At the present time a very small supply of a few species, mostly yellow-poplar, black locust, cypress and white ash is raised at the pine nurseries to satisfy the limited demand, mostly from farmers wanting fence post material or interested in just trying something other than pine. Working out the nursery techniques necessary to grow good hardwood stock from seed will take considerable work. We must learn what constitutes a good seed source for the various species and how best to collect, store, and plant the seed. Some of this information is already available. Such establishments as the TVA nurseries and the U. S. Forest Service nursery at Vallonia, Indiana, have gained a lot of experience along these lines. In fact, there has also been a fair amount of experience with hardwood planting in the Central States. Getting closer to home, reports from the nursery maintained here at L. S. U. by the school of Forestry indicate good germination of bald cypress, sweetgum, green ash, and Nuttall oak following fall sowing as an alternative for artificial stratification. Yellow-poplar seed, they found, has poor viability, 0 to 5 percent for seed from most sources. The best ever attained was 20 percent for the seed from one exceptional tree. This is the kind of information we need for all species before mass production of hardwood seedlings can be profitably undertaken.

**Hardwood Planting Case Studies**

As a guide for future work, I am sure we are all interested in the results of plantings already done with various species. Here are a few typical illustrations. In Arkansas on a pilot plant scale test of about 17 acres, direct seeding of cherrybark oak as an underplanting on a river bottom site using acorns collected in early November and planted at once produced 17.7 percent survival after two years, with the first germination appearing eight months after planting. 1-0 seedlings of cherrybark oak and white oak planted in the same bottoms showed 20 percent survival at the end of the first growing season. The overstory of ironwood, hornbeam, holly and other weed species was girdled either before planting or during the summer following germination. Although there was little difference in survival between the direct seeding and the use of seedlings, it is reported that the seed spot area appears to be much more successful.

From Tennessee, reports for red and white oak plantings, now eight years old, estimate 25 percent survival while the Tallahatchie Research Center reports for small experimental plots 50 to 88 percent survival for white oak after five years depending on the site and whether or not release from competition was provided. On the other hand, the Delta Purchase Unit of the Mississippi National Forests experienced complete failure with cow oak and Nuttall oak on heavy clay soils. The cow oak was definitely off site and competition from ground cover was severe.

For yellow-poplar, six-year-old plantings in the bluff country of Tennessee around Fort Pillow show 75 to 80 percent survival with heights averaging ten to twelve feet. On lower slopes and branch bottoms in the
vicinity of Jackson, Tennessee, some three-year-old plantings have only two percent survival. On small experimental plots, the Tallahatchie Research Center has had five year survival ranging from 0 to 88 percent with average heights of 1/2 to 10 feet. The best results were from released trees on lower slopes; the poorest, from unreleased trees in minor bottoms.

Green ash on a heavy clay site on the Delta Purchase Unit, after one year, showed 75 percent survival and a height of about three feet. White ash on the Tallahatchie experimental plots produced 90 to 100 percent survival with average heights from 8/10 to 4.2 feet. Best development was on lower slopes.

Sweetgum planting on the Delta Experimental Forest had a survival of 61 percent and an average height of 15 feet ten years after planting. During this entire period, competition from vines and volunteer growth of tree species was most severe.

Cottonwood is one of the most important trees in our hardwood forests both because of its exceptionally good growth on suitable sites and because of the wide range of uses for the wood. It is one species that we know can be planted successfully and the use of cuttings is the best method. The techniques for its propagation were worked out at the Delta Research Center and the recommended procedures are available from the Southern Forest Experiment Station in Bulletin 485 of the Mississippi Agricultural Experiment Station, Planting and Growing Cottonwood on Bottomlands.

A 12-year-old stand on the Delta Experimental Forest has about 75 percent survival with the leading trees averaging 70 feet tall and ten inches d. b. h. Ice damage and windstorms that blew over some of the shallow rooted trees in this swamp site account for the rather low survival.

A 15-acre plantation has been established near Greenwood, Mississippi, by sowing soybeans broadcast between the rows to control weeds. The experiment was successful and two or three crops of beans will repay the $100 an acre cost of reclaiming the site from useless run-down woods.

Several logging companies have cottonwood plantings and more plan to start such a program. The latest development is the interest of the Delta and Pine Land Company, a very large cotton plantation with considerable woodland holdings, in making their woods productive. A 3.5 acre cottonwood cutting nursery has been set out this spring to provide planting stock for 100 acres of plantations to be established next year in accordance with our recommendations.

Two-year-old black walnut plantings started with 1-0 seedlings on second bottoms at the foot of the bluffs in west Tennessee now have a survival of about 90 percent and are five feet tall. Planting in old stump holes seems to have been beneficial.

Tests of hybrid poplars and hybrid willow have been discouraging. The native species outdo them if indeed they are able to survive at all.

Reasons For Erratic Planting Results

Consideration of these results shows a great variation in the development of hardwood plantations. It seems to me, that some of the reasons for
these erratic results can be summed up as follows: (1) Hardwoods require good fertile soil for satisfactory development yet in many cases they have been put on poor sites better suited to pine. (2) Hardwoods need site preparation and release from overtopping weeds, vines, and cull trees. We have not given them this care. (3) Planting stock has been of a run-of-the-woods variety and we have not had the benefit of select stock that would make the best growth possible. (4) Finally we just do not yet know enough about the silvical requirements of the various species to be sure we are planting them under suitable conditions for satisfactory growth.

Future Work

Well, it appears as though there is a mighty big job to be done and at present we know very little about it. Where should we start in our future work? There are two major starting points both of which should be attacked simultaneously. First, we need to work out and catalog the silvical requirements of all the various species, the undesirable as well as the desirable, so we may know where to plant and what to plant to insure a full stand of the species we want and how to discourage or avoid competition from poor species. Such studies are getting underway at the Delta Research Center and the first results can be expected soon. Second, we must develop superior planting stock and learn how best to plant it. Empirical tests using direct seeding, seedlings, and cuttings as well as comparing the results of machine and hand planting together with the costs involved will readily solve many of the how-to-plant questions.

In the development of superior planting stock, we shall need to make use of both vegetative propagation to reproduce the better trees already existing and tree breeding to produce hybrids with more desirable properties. When using cuttings from natural stands, we should select for use only the best 15 or 20 percent of the one- to three-year-old trees. This selection immediately provides better stock than using run-of-the-mill material. Individual trees of any age having exceptionally good growth or quality characteristics should also be propagated to build up supplies of elite growing stock.

Tree breeding is a slower process of obtaining better trees but will be necessary when dealing with species that will not reproduce from cuttings or where the introduction of new characteristics is desired. This method requires the services of specially trained personnel and usually takes a relatively long time to produce results. We should not rule it out, however, because of these disadvantages.

Those are some of the things we should begin to work on at once, but how can we accomplish the most and who should be responsible for getting the job done? Research organizations will, of course, bear a large part of this burden but all practicing foresters who deal with hardwoods have a responsibility also. Only by working together can we make rapid progress. Research organizations will continue exploratory and empirical work combined with enough pure research to eventually provide the explanations for
the phenomena noted and solve fundamental problems which arise to block progress.

Industry and consulting foresters must keep themselves posted on the findings of research workers and others and be sure they practice the best known methods in any planting work they undertake. In addition, they should endeavor to interest their employers in permitting them to try out new practices they may originate or carry on pilot scale tests of techniques that small-plot research has shown to be promising. Small tests are rarely very expensive and often produce valuable results.

Finally, for all work undertaken, simple but complete records on what was done and the results obtained should be kept and reports made available to other workers. This will prevent duplication of effort and will help others avoid mistakes. Some organizations are already doing this and I know the Research Centers of the Southern Forest Experiment Station welcome such assistance.

If everyone cooperates, we can provide answers to our hardwood planting problems much sooner than if all the work is left for a few individuals or organizations.
THE ROLE OF GENETICS* IN IMPROVING PLANTING STOCK

By
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Recently, there has been a great deal of discussion about the role of genetics in forestry practice. The overall relationship is broad and somewhat controversial. At the close of this discussion brief mention shall be made about my ideas concerning this relationship. However, since the theme of this symposium is seeding and planting, we shall devote the major portion of allotted time to a discussion of the genetic outlook in this phase of forestry. Remember, during this discussion, the application of genetic principles is not restricted to seeding and planting, although undoubtedly its greatest value lies in this field. Any improved strains or desirable hybrid developed can hardly be utilized except through the medium of planting.

The first point to emphasize is that a tree is a plant, and such is subject to the common genetic principles that affect all plants. Each plant or tree is an individual and usually differs somewhat from other individuals of the same species. Therefore, within a species such as loblolly pine, the individuals vary with respect to form, growth rate, disease resistance, etc., just as trees of two different species vary. Actually some species have almost as much variation within themselves as is found between two closely related species. Next time you are in a plantation, take a close look at the individual trees making up the plantation. Some trees are taller than others, some have large limbs while trees nearby may have small limbs; some have long, luxuriant, possibly drooping needles and others have shorter, stiffer needles with a different color. When you study the wood of these trees you find further differences. In fact, it is difficult to find any two trees really alike.

Why do trees of the same species differ from each other? First to be recognized, of course, are environmental differences due to variation in local site and in past treatments of the individuals in the stand. Different environmental conditions cause many variations in trees, especially in certain characteristics. The second reason for differences between individuals in a species is that trees usually are genetically variable and differences in genetic makeup often produce variations of form and growth.

* It must be pointed out that the word genetics is being used loosely. Some geneticists differentiate between forest genetics, tree improvement, and tree breeding. Whatever term is used, our subject deals with the application of genetic principles to improving planting stock.
There have been numerous discussions about whether certain characteristics are environmentally or genetically controlled. Let's dispose of this argument right now by saying that a tree as we see it growing in the woods always shows the results of both kinds of control. The characteristics of the tree arise in part from its genetic makeup, in part from environmental influence. Some characteristics are more strongly controlled genetically than others, i.e., variations in environment do not affect them much. It is such "genetic" characters that produce the greatest gains from the application of genetic principles.

How can we improve the genetic quality of seed used in the South? First, we must recognize that within a species, there often is a great deal of variation from one region to another. Such geographic variation has been demonstrated for most of the major pine species. Early studies on the southern pines have shown geographic differences do exist; this has been especially well demonstrated for loblolly pine. At the present time, Phil Wakeley, representing the Committee on Southern Forest Tree Improvement, is heading a very extensive study of geographic variation within the four major southern pine species. Results of these studies should enable the delineation of seed collection areas, so that if there is a local seed crop failure a person will know where he can safely go to get seed for his needs. Already differences are becoming evident; Phil could list many of them. For example, in our portion of this test we find Maryland loblolly pine unable to exist, let alone grow, in Texas. In the seedbed the seedlings are small and look a great deal more like shortleaf than loblolly pine. After planting in the field, the seedlings died following a few hot dry days. Our overall survival of this source was less than 5% while some other sources had 75% or better survival, despite the drought. Conversely, Phil tells me that much of our Texas source died from the cold in Maryland. Choosing the proper geographic source is not only important, but is the basic framework within which all other genetic improvement must be done. Any selection or hybridization program that does not take into account geographic origin stands an excellent chance of not producing usable results.

What is the next step in obtaining genetically good seed, within the proper geographic strain? Although they have not been demonstrated as clearly as have geographic strains, so-called "local races" often are present within a species. A local race may have developed because of soil differences, or other site differences. Such local races are common in most plants that have been intensively studied and are to be expected in pines. For example, we are attempting to obtain strains of loblolly pine that are more drought hardy than average planting stock. Of course results aren't final, but after the first severe drought year we find that there are definite survival differences from seed lots collected relatively short distances apart. Seed from certain parts of the "Lost Pines" in Texas (an area of severe climatic conditions, low rainfall, low humidity and high temperature) produce seedlings that survived considerably better than those from seed of more eastern sources secured from the higher
rainfall pine region. Even of greater interest is the fact that there appears to be a difference within the "Lost Pines" themselves. Seedlings representing the very driest site in the "Lost Pines" survived better in all six of our test areas than those representing a moist creek bottom less than a mile away. Actually the difference in survival between stocks of these two seed sources only a mile apart was greater than that between stocks from Texas and from Georgia seed.

We do not know too much about local races as yet, but as we obtain more information, local races must be taken into account. Until we know more, the safest rule is to use seed from areas with climatic and soil conditions similar to those where the trees are to be grown. Certain local areas have unusual numbers of forked or crooked trees, unusual wood characters, excess limbs or extreme limb size, or other bad features. These local areas should be avoided as a source of seed until it has been shown that these undesirable stands are not genetically inferior.

The third thing that must be watched is the individual tree from which seed is to be collected. As mentioned in the introduction, studies have shown that limb form, bole characters, crown characters, vigor, disease resistance, etc., vary greatly from individual to individual and are often strongly inherited. Again, until we have more information, play it safe. Collect seed only from the best formed trees. It is often argued that since we do not know they are undesirable, why not collect seed from excessively limby, large crowned trees. The fact is, we can't know with surety and will not know until they are tested. But isn't it safer to get seed from a tree that has already demonstrated its ability to grow well? A prime example of what may happen is shown in a plantation on the Calloway Foundation lands at Hamilton, Georgia. Scattered throughout the slash plantation are a few of the scrawniest, most worthless slash pines one could imagine. They all look nearly alike, having long snaky limbs all the way to the ground; in fact, some of the limbs grow entangled with those of the neighboring trees. It certainly appears that one inferior seed tree was responsible.

It is very unfortunate, but a fact, that the best trees from the forester's standpoint are often poor seed producers. Therefore most seed collected commercially is likely to be from the poorer trees.

The importance of the individual tree as a seed source is just beginning to be recognized. Some of the more progressive companies are establishing seed production areas where the very best trees are saved for seed production and treated to increase the seed crop. This is being done by such organizations as West Virginia Pulp and Paper Company, Gaylord Container Corp. and Union Bag and Paper Company.

Assuming that better strains have been found, what can be done about getting improved seed in quantity? One answer is in the establishment of seed production areas. Another approach, still in its infancy in the South, is the establishment of seed orchards. Such orchards are set up specifically for the production of seed, from stock that has already been proven to be genetically outstanding. These, like agricultural seed
farms, will produce seed which can be certified as to geographic origin and genetic makeup, as well as to purity and viability. What will seed from seed orchards and seed production areas cost? We don't know yet, but present research underway and planned should give the answer. The Europeans report the cost to be very little more - in fact, it has been said that a seed orchard produces seed more cheaply than that collected by standard methods.

In summary, to get the best seed from a genetic point of view, you must consider (a) the geographic location of the seed source
(b) the possibility of either inferior or specially desirable local races, and
(c) the apparent quality of the tree from which the seed is collected.

Now, one quick statement of the overall relationship of genetics to forestry as I see it. Forest genetics, tree improvement or tree breeding, whatever you want to call it, can be of value to the practicing forester only insofar as it can be applied to silvicultural practices. In effect genetical know-how is just another silvicultural tool, like knowledge of soils or of pruning, thinning, and reproduction cuttings and must be used harmoniously with them. It is the only tool, however, which enables the forester to control his trees by modifying their heritable characteristics instead of altering environment. It gives him an intimate knowledge of the thing with which he is working -- the tree.

As one working on the genetic phases of forestry, I certainly do not look at it as a panacea for all forestry's ills. The geneticist is not attempting to produce a super tree for all conditions and for all products. He is trying to produce better trees for specific products, suitable for specific growth conditions. The contribution of the geneticist can be of great value in understanding and manipulating trees and their differences. This contribution must be coordinated with general silvicultural practices if it is to play a major part in increasing quality and quantity of forest products produced.
Physiology is defined as the branch of science that deals with the processes, activities and phenomena incidental to and characteristic of living organisms. Any analysis of these processes and phenomena is based mainly on physical and chemical considerations. One physiologist has stated that plant physiology is a branch of plant science which employs chemistry and physics in developing logical explanations of plant processes and structures under various internal and environmental conditions. A discussion of specific methods for improving the physiological quality of planting stock is extremely difficult, since definite methods or standards for determining optimum physiological processes are not available at the present.

Five kinds of plant characteristics are very closely related to each other, and any modification of one of these may have a very definite, although not always fully understood, influence on the other characteristics. These features are classified as morphological, anatomical, chemical, genetic, and physiological. The genetic characteristic in a large measure determines the variations in physiological activities which, in turn, influence anatomical and chemical development, and morphological appearance.

During the late 1920's and early 1930's, P. C. Wakeley established a set of morphological grades for southern pine seedlings. These grades were based on readily visible features, such as stem length, stem diameter, root length, needle development, and bud development. Several other regions within the United States and in other countries are at present establishing grades for stock based on these morphological features. After testing by field planting, Wakeley found that these morphological grades did not adequately classify seedlings on the basis of survival. Therefore, he suggested that certain physiological characteristics of a plant might have more influence on the plant's survival capacity than simply size or needle development.

However, consideration of morphological features cannot be completely discarded, since they are useful in determining basic size standards for stock. The stem or needles must be long enough to handle in machine planting. The stem must be sufficiently stiff and woody to withstand wind, rain, and possible ice damage. The root should be long enough so that it extends below the zone which is normally dessicated by surface grass roots. As an example, loblolly or slash pine seedlings
should have a stem length of 6 to 12 inches, a stem diameter of more than one-eighth inch, and a root length of 8 to 10 inches.

One of the first steps in improving planting stock is to improve the uniformity of morphological features. This can be partially accomplished by use of proper seed bed densities, use of top mulches to control soil surface temperatures and crusting, better regulation of sowing dates, provision of good soil structure, and maintenance of uniform soil fertility. These activities will also influence physiological characteristics.

Before consideration of physiological functions, let us consider briefly the anatomical, chemical and genetic characteristics.

The anatomical structure of a plant is based upon inherited characteristics which may be modified by environmental factors. A seedling may develop young roots with large epidermal and cortical cells that facilitate the inward movement of water and minerals; or the seedling may develop young roots that become suberized early. The latter plant, when transplanted, would not readily absorb water or make initial new root development. Thus, a genetic characteristic influences the anatomical structure and in turn the physiological functioning of the plant. D. E. Davis, of A. P. I. Agricultural Experiment Station, found that a calcium-deficient loblolly pine seedling has anatomical features different from those of a plant that contains ample calcium. Less primary tissue (cortex and pith) and relatively more secondary tissue (xylem) are developed when seedlings are grown in a calcium-deficient growth medium.

Genetically, a species may have a tendency to be drought resistant, to develop a high carbohydrate content, or to have the capacity to survive under adverse conditions. But, can these inherited characteristics be modified by nursery management practice? The geneticists will probably answer in the affirmative. Therefore, we need to know the physiological differences between genetically superior and inferior seedlings.

Wakeley states that "there exist physiological grades of southern pine nursery stock, which may or may not coincide with morphological grades, but which coincide closely with true grades. . . . . Particularly important causes of differences in physiological grade seem to be: (1) differences in mineral nutrition, (2) differences in stored food reserves of the seedlings, (3) differences in water tension under which the seedlings are grown, and (4) fungicidal sprays, spreaders, adhesives, rodent-repellent sprays or other sprays applied at lifting time and presumably affecting the transpiration of the seedlings immediately after they are planted."

Questions that immediately come to mind are: What are the physiological functions or activities of a plant that cause differences in physiological grades? What effects do these activities have upon plant growth and survival? How can these be controlled? How can they be measured?

Among the more important physiological activities of a plant are (1) absorption of water, minerals, and gases, (2) translocation of water, minerals, and gases, (3) Photosynthesis, (4) carbohydrate metabolism, (5) fat metabolism, (6) protein metabolism, (7) digestion and trans-
location of food, (8) respiration, (9) assimilation, (10) food accumulation, (11) growth, and (12) reproduction. These activities, when modified or controlled by environmental conditions, influence drought resistance, dormancy, and viability of seedlings. With these considerations in mind, methods for improving physiological quality of planting stock may be considered.

The major methods by which a nurseryman can control the physiological activities within a seedling are (1) modification of irrigation practices to control soil water tension, (2) modification of soil nutrient levels, (3) use of sprays or shade to reduce transpiration, (4) lifting at times of optimum physiological development, and (5) storage at low temperatures to retard physiological activities and to induce or maintain dormancy.

Water Control

Few species can be produced profitably in the southern states without irrigation. Soil water not only affects the availability of soil nutrients, but also directly influences the growth of plants. The availability of water to a plant affects transpiration and food accumulation which, in turn, influence drought hardiness and survival capacity. Many studies have indicated that plantable seedlings produced with a minimum of water are more likely to survive than those produced with an excess of water. With a minimum water supply, plants produce denser wood tissue, are less succulent, and are less subject to frost damage and fungus attack. Plants produced under different levels of water availability may be similar in morphological appearance, but widely dissimilar in physiological potential.

Soils vary widely in their ability to hold water. Moisture content of a sandy soil at field capacity may be 5 percent, as compared with 40 percent for a heavier soil. Similarly, the moisture content at the wilting point may vary from 2 to 20 percent. The tension with which water is held in the soil is of more importance than actual moisture content, since it directly determines water availability. Therefore, the optimum soil moisture tensions necessary to produce morphologically and physiologically acceptable stock should be determined for each species. Such a relationship has been very carefully worked out for certain agricultural crops. By regulation of irrigation, the agricultural specialist can influence the production of green matter, roots, fruit, or seed. Generous applications of water to a selected crop may result in an abundance of vegetative matter. Reduction of water may result in cessation of vegetative growth and initiation of fruiting. The forest tree nurseryman has an entirely different problem. Instead of producing succulent growth, fruit, or seed, he is primarily concerned with vegetative growth in a plant that must be capable of surviving transplanting.

Definitely needed in order to develop a watering schedule capable of improving the physiological quality of seedlings is information concerning the relationship between soil-moisture tension and root and top
growth, the relationship between soil-moisture tension and mineral absorption, and the relationship between fluctuating soil-moisture tensions and development of drought resistance.

Charles S. Walsh, graduate assistant in forestry at the Alabama Station, is studying some of these relationships. Growth is being correlated with soil water content and soil-moisture tension. Out-plantings will test the effects of different nursery soil-moisture tensions on field survival. This study should indicate the maximum soil-moisture tensions that may be allowed to develop without inhibiting growth and development. It should also suggest a procedure that can be used by nursem en to decide when and how much to irrigate. In another phase of the study, an attempt will be made to correlate soil-moisture tensions with mineral absorption and the resulting effects on metabolism and growth.

Meanwhile, agencies operating nurseries should obtain basic information about the water relationships of their nursery soils. Permeability determinations and moisture tension-water content curves have been prepared for the soils of only a few nurseries.

At present, the best practice seems to be to withhold watering as long as adequate growth continues. Regulation of seed bed stocking to a uniform density greatly reduces unequal competition among roots and provides for maximum water use.

Modification of Soil Nutrient Levels

A major means of improving physiological qualities of planting stock is by the control of nutrient absorption and the metabolic activities within the plant. Fifteen elements are used by most plants during the period of growth and development. All elements except carbon, oxygen, and hydrogen must come from the soil; and they must be available within at least minimum limits.

Soils vary widely in essential elements, both in available and unavailable form. Even though wood tissue is composed chiefly of complex carbohydrate and nitrogenous material, intensive growth utilizes a relatively large quantity of minerals. In seedling production, the entire plant is removed for distribution. Approximately 8 tons per acre of dry weight plant material is removed for each crop. If such a large dry weight volume were not removed annually, maintenance of soil fertility would be relatively less important than it is now. Good growth is absolutely dependent upon adequate availability of minerals.

Moreover, different amounts of the various elements are required during different stages of development. Distinct periods during the first year of a seedling's development consist of a period of rapid initial growth or expansion characterized by rapid cell division and cell enlargement; a period of lignification or hardening of the secondary tissues; and a period of increasing weight. Roots of the four major southern pines may be expected to be 10 to 12 inches or longer by late June. A period of slow growth during mid-summer may be followed by another period of accelerated growth
in the fall. During the fall and winter months the dry weight of various plant components increase greatly. This increase in dry weight is evidently attributable both to assimilation and to the accumulation of food in the stem, needles, buds, and, in some cases, the roots. Several investigators have studied these changes in chemical composition of other species of plants and have suggested that the accumulation of food reserves may have an important effect on survival after transplanting. Studies are needed to determine the sequence of absorption, synthesis, accumulation, digestion and assimilation; to correlate the mineral content of plants with nursery soil management practices; to correlate the amounts of various mineral elements in tissue of seedlings with highest field survival and growth as compared with those that fail to survive; and to determine the relationship between the amount of food reserves and field survival and growth. A. R. Gilmore, of the Alabama Station, is studying some of these relationships.

Foresters, landowners, and nurserymen interested in improving physiological quality of stock must realize that no appreciable improvement can be obtained without obtaining detailed information regarding the fertility status of the nursery soils. Seedling development and growth at various soil fertility levels in each nursery should be tested against field survival. As tree-breeding advances to the production of elite or superior planting stock, intensified soil management must produce the maximum amount of planting stock with optimum physiological qualities.

Reduction of Transpiration

Any method whereby transpiration is reduced without upsetting the physiological balance within the plant should have a favorable effect on transplanting and survival. T. E. Maki, H. L. Shirley, and others have tested the effects of many different sprays. While the results have been favorable in some instances, unfavorable or non-beneficial results have been more common. Sprays coat the leaf surface and interfere with the inward diffusion of CO$_2$, which is essential for photosynthesis. The ideal transpiration reducer is one that does not interfere with photosynthesis.

R. M. Allen, who follows me on program, found that the clipping of longleaf pine needles favorably influences survival.

The conglomerate effects of spray treatment or foliage reduction on the physiological qualities of seedlings need additional study. Such treatments might offer practical methods of improving certain qualities of planting stock.

Lifting at Periods of Optimum Development

Some investigators have suggested that the optimum development of physiological processes that most favorably effect quality of stock and survival may not be correlated with the customary season of lifting. As an example, root growth of some species is greatly reduced during the period September to November. Development of new root tissue apparently begins
in the early winter. Lifting operations and transplanting usually coincide with and extend beyond this period of new root development. Consequently, the diffusion of water into planted seedlings may be unfavorably influenced by the shock of transplanting during a period of active root tissue development. Therefore, it may be desirable to lift seedlings during the late summer and early fall, heel-them-in in cold storage, and plant them during the winter rainy season when new root development apparently is greatest. New root development occurring after transplanting is apparently related to survival. Examination of seedlings that die shortly after planting usually reveals that no new root growth occurred after planting.

Conclusions

The concept of a classification system for planting stock implies their possession of certain genetic, anatomical, chemical, and morphological characteristics, correlated with physiological processes. All of these factors are highly interrelated and, moreover, are influenced by nursery environment. For example, movement of minerals into plant roots is mainly affected by metabolic activity, interionic effects, and hereditary potentialities. Concentration of minerals in plants is not only controlled by internal and external conditions, but is also a function of the hereditary potentialities. A means by which the physiological quality of stock may be improved is by modification of the following factors: (1) soil-moisture tension; (2) nutrient absorption, assimilation and food accumulation; (3) transpiration rate; and (4) lifting period.

Many basic studies of physiological processes of tree seedlings have been made. The present need is to correlate the results of the studies with nursery management and planting practices; and to develop methods or standards for measuring this correlation and for maintaining optimum conditions.
NECESSARY PRECAUTIONS IN LIFTING, PACKING AND SHIPPING
SEEDLINGS AND THEIR HANDLING IN THE FIELD

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We have our problems of hogs, our problems of taxes and always our problems of fire, but I believe it is generally agreed that the greatest problem to pine seedling planters today in the South as a whole is the problem of first-year survival. Studies have shown that survival has been much more variable and often lower than generally realized. However, with three consecutive summers of drought immediately behind us and with the trend toward intensive forestry and the desire for nothing less than fully-stocked plantations, many of us fully realize our losses and want to do something about it.

In order to clarify this paper, I would like to state here that it was prepared with only loblolly, slash and shortleaf pines in mind, and with emphasis on loblolly. Although most of it will apply to longleaf, there may be some exceptions.

We foresters are often prone to think only of the money wasted in stock and labor in initial planting when we find seedlings dead in the field. Actually, there are other losses, even though obscure, which must be given consideration.

Assuming that replanting will be done, one year of time is lost. At one time in the progress of forestry in this country, one year of time meant nothing. Now it means to many of us a growth of one cord of wood per acre, or a value of four to five dollars. If replanting is not done, even though survival is fair, the resulting holes in the final stand and the poorly formed, limby trees that inevitably develop are not most desirable and consequently, a partial loss.

To see seedlings die even singly, no less row after row, is discouraging to all who have a part in their establishment whether we are thinking in terms of the laborer, the forester, the company official in charge, or the farmer who dibbles them in by hand and with sweat and hard labor. It is so discouraging at times, especially in the case of the farmer, that the attitude of "to heck with it" is taken and a second attempt is not made. This is not good. All of these losses are not conducive to accomplishing the big job of planting we still have ahead of us in the South.

We have the problem. It is first-year survival. What is the cause? Studies show that the most widespread, frequently occurring and generally feared cause of low initial survival in southern pine plantations is not fire, animals, insects or disease, but drought.
Drought damage is caused not only by the lack of rain, but from other factors which increase transpiration or decrease water absorption so that within the plant water-outgo is greater than water-intake. Some of these factors are: The physiological and morphological conditions of the planting stock, injury to roots during lifting and pruning, too high setting of the seedlings and planting slits left open at the top.

As yet, we cannot do much about providing rain, so our only defense against drought is to give the maximum justifiable attention to all nursery and planting techniques which will enable the plants to take in more water through their roots than they lose through their tops.

If you agree that it is right to boil down our troubles in planting to the problem of water and our only defense we have against it is in our nursery and planting technique, then it behooves us as foresters to take stock of ourselves. It is time to stop sitting around watching the clouds, begging for rain, hoping for a wet season and bemoaning the fact that we are in a dry cycle. It is time to examine our methods to see if we are actually doing all the things necessary all along the line, both in the nursery and in planting to assure this water balance and maximum survival in the field. Most any seedling will live if given a reasonably decent chance in a wet year. The real tests of our methods come in years like 1952 and 1953.

Studies have shown the importance of the physiological grade of the stock upon new root growth on freshly-planted trees. They have also shown the importance of new root growth to water balance within the tree, and finally, the importance of water balance to survival.

Following this line of thinking, the physiological grade of the stock becomes very, very important. However, besides high physiological grade, indications have been found that there are also other seedling characteristics which influence the balance of water intake-and-outgo. These characteristics include good root extent, the presence of numerous lateral roots, the presence of abundant mycorrhizae, the existence of high water tension or degree of hardening off and possibly, good top-root ratio.

Although attempts to tie in mathematical calculations of top-root ratio with morphological grades have apparently failed, I am firmly convinced that all other things being equal, there is a distinct correlation between this ratio and survival. If survival is dependent upon water-intake versus water-outgo, then isn't it logical to assume that the relative sizes of absorption areas and transpiration areas are all important? I am of the opinion that except as it effects the physiological grade of the seedling the top means little. This is indicated by the fact that many freshly-planted seedlings bitten off by rabbits sprout and survive.

The nurseryman may modify all of these things favorably or unfavorably, directly or indirectly in many different ways; the planter has little chance of affecting it except by flagrant abuse of the stock.

What am I doing? Am I suggesting that most of the blame for poor survival should be put on the nursery? I am and I am firmly convinced that our greatest opportunity for improvement lies there.

In my opinion, this situation has developed because the planting
foresters have been clamoring to high heaven for more and more seedlings. They have also accepted these seedlings with full confidence that they were raised by trained personnel and were as good as could be found anywhere. Knowing little about nurseries, they felt unqualified and reluctant to inspect nursery techniques themselves. In most cases, they have assumed losses were their fault, and have set about the following year applying more costly methods of tool manipulation or other refinements to the planting technique which had little, if any, effect upon the ultimate results.

Another reason this situation has developed is that in many cases the nurseryman's responsibility has stopped completely when the seedlings went out the gate. Very, very seldom has a nurseryman been informed of the survival of his stock when planted and how it compared with that of another nursery.

Proof of the pudding is in the eating. Proof of good nursery stock is a high average survival of trees planted. How many times have you seen in print that this or that organization has raised and shipped so many seedlings? How many times have you seen publicity on the survival of these seedlings? The production of a million seedlings means absolutely nothing but waste if survival is zero.

If you go into a restaurant and see a sign, "You are invited to inspect our kitchen," you are confident that that kitchen will be clean. It is high time that the nurseryman invited the tree planter into his kitchen. He should advise him of the average or normal survival he can expect from his stock. If he does this and the survival is not good or does not compare favorably with other nursery stock, I can assure you that he is going to do everything within his power to improve it.

Until now I have said almost nothing about the subject to which I was assigned: "Necessary precautions in lifting, packing and shipping seedlings and their handling in the field." However, in preparing this paper, I attempted to search out the most important problem confronting us who are planting, make a logical approach and search out the solution. In so doing, I found that although my subject was important, it covered only one link in the chain. A chain is no stronger than its weakest link. All the care in the world in handling seedlings will not make them live under unfavorable conditions if they are extremely weak in the nursery bed.

Contrarily, no matter how strong the plant in the nursery, it cannot be expected to live if killed in the process of lifting, shipping or planting. Now, let us take a look at these jobs.

The undercutting of nursery beds should be done in such a manner as to loosen the soil around the seedling roots to a maximum while injuring the roots to a minimum. Extreme care should be taken to run the blade at the proper depth -- not so shallow as to shear or tear the roots above a depth of 8 inches, and not so deep as to fail to properly loosen the soil.

Care should also be taken to prevent the blade from pushing the soil ahead in waves. This action usually results in the breaking of many roots by the cleavage action of the soil.

Lifting should not be attempted when the ground is frozen, or
saturated from rain. Nursery soil treatments should be directed toward the creation of a friable soil which will readily fall away from the plant roots.

Seedlings should be pulled by hand with relative care, taking reasonable precautions to retain as many lateral and mycorrhizae-bearing roots as possible. Pulling seedlings in handfuls brings up balls of dirt which can usually be shaken out and it is better than pulling them singly when many small roots are likely to be stripped.

Practices such as violently slinging or beating seedlings on the ground to free the dirt should not be used.

Assuming that under-cutting has not been done too long in advance and has not exposed many roots, we now find ourselves at the first point where root exposure is possible. Since this type of damage is a constant threat in all operations from the nursery bed to the plantation row, in order to avoid repetition, some general statements can best be made here.

Although studies have shown that short exposures to sun and wind are not damaging to nursery stock, long exposures are fatal and no exposure is beneficial. Therefore, it is advisable to keep all exposure to a minimum. It must be realized that some exposure at the nursery during lifting and packing, in the field during distribution and planting is unavoidable but it should be held well within the limits of the tree.

Some recommend a maximum exposure of 10 minutes, and I see no reason to disagree, however, it must be remembered that the accumulative effect of 10 minutes each in the nursery, during distribution and in the field might be the cause for some of our erratic early mortality. Usually neither the planter nor the nurseryman has any way of determining if the stock he is handling has been or will be given too much exposure by the other party. Stock which has been re-wetted after being fatally exposed, cannot be recognized for several days and then it is usually after planting.

The handling of seedlings in all operations should be accomplished in the smallest bunches or parcels economically practical for the particular operations. In this way exposure will be held to a minimum because of the time required to apply the necessary treatment from the first to the last of any lot. For instance: Only small piles of seedlings should be made on the nursery beds before they are picked up and given cover in tubs or the field-to-shed truck. Small trucks should be used to move the seedlings to the shed. Only small quantities should be allowed to accumulate ahead and behind the graders as a group. Each grader's individual supply of stock should be kept small and replenished often. Minimum loads should be shipped to the planting operation and minimum quantities maintained in the planting trays.

Practices such as constantly taking seedlings from the top and replenishing the supply without removing those from the bottom should be avoided. Of course, it goes without saying in all of these operations that seedlings should be covered when not being handled.

Seedling roots should be pruned to approximately 8 inches. If they are shorter, survival may suffer; if they are longer they may reach the bottom of the planting hole and become turned back into the well-known
"U root." Pruning knives should be kept sharp, and seedlings handled in small bunches so that the cut will be perpendicular to the tap root and clean.

The nursery crop should be handled so that the culling of seedlings will be held to a minimum, however, there will always be some undesirable individuals which should be discarded. These include: Seedlings that are so small that they are mechanically difficult to plant. Seedlings that have roots shorter than 5 inches. Seedlings that are too large. Seedlings that have been severely injured. Seedlings which have been severely exposed and seedlings infected with fusiform rust.

Nurserymen should keep firmly in mind the high cost of plantation mortality as described earlier. They should remember that even though throwing away a good tree in the nursery may be bad, planting a bad tree is even worse. If there is any doubt that the seedling is a poor risk, it should be thrown away.

There seems to be two ways of shipping seedlings in use in this area. One is to stack them in bulk in truck beds and cover them with sawdust. The other is to pack the seedlings in quantities of from one to two thousand in sphagnum moss and wrap them in water-proof paper and steel strapping to make standard Forest Service bales. The Forest Service bales are by far the best, and considering the costs to the planter as well as the costs to the nurseryman, the overall additional cost is very small. It is so small that it is offset several times by lack of risks to exposure and mechanical injury.

Consider the differences in handling and the possibilities of these two types of injuries in using the two methods. In the bale method, after seedlings are lifted, graded, pruned and packed, they remain in the bale through the transportation phase until the planter is ready to place them in the tray or in the planting machine. In fact, some planters are carrying the partially broken bale on the planting machine so that handfuls can be pulled directly out of the bale by the planter as he puts them in the ground.

In the bulk truck bed method, after the seedlings have been graded and pruned they are heeled-in in the nursery. They are later placed in the truck bed and heeled-in again. They are hauled to the purchaser's central distribution point where they are heeled-in for the third time. Many of them are taken to the planting area and heeled-in for the fourth time.

The packed bale makes the handling of seedlings by untrained persons almost fool-proof. For instance, farmers are accustomed to handling more hardy plants such as sweet potatoes and cabbage and often do not realize the dangers of prolonged exposure to pine seedlings. Bale-packed seedlings can be kept in the bale for a week without any attention and as long as three weeks with good aeration and occasional watering. There is no reason to remove them from the bale or subject them to any exposure before planting.

Besides exposure to sun and wind, seedlings should always be safeguarded against freezing and heating. The greatest possibility of freezing usually occurs in temporary storage, and consequently, the best
protection is to either heel them in or keep them in a shelter where an above freezing temperature can be maintained.

Heating may occur to stock packed in bales. It can be best prevented by stacking the bales in a cool place where there is a gentle air movement among them, by watering them from the ends and by moving them out of piles as soon as practicable.

Seedlings should not be stored in water for any length of time. Even overnight storage by this method may cause injury.

If heeling-in of seedlings is necessary, some precautions should be taken. Layers of seedlings should not be over three inches thick. Soil should be placed well up on the stem to exclude air from the roots and the bed should be watered often enough to keep it continually wet. Care should also be taken to see that tap roots are not heeled-in in a turned back position for after a time they will become warped and will be very difficult to plant without forming a "U" root.

Although it may be beyond the scope of the title of this paper, I would like to make a few comments concerning the planting job. In the past too much blame for the lack of survival has been put on this job. Consequently, we became too exacting in our requirements. Close adherence to such standards as one-quarter inch tolerance in variation in depth of setting has been costly and entirely unjustified. The use of the planting machine with its irregular motions has dispelled this and other ideas.

We now believe that if a seedling has good qualities, is planted to a depth somewhere between the root collar and the first primary needles, with its tap root not forming a "U" and with the hole packed reasonably tight, it should have every chance to live and develop into a merchantable tree.

In conclusion, I would like to say that I have not gone into the details of the various jobs required to get seedlings out of the nursery and into the plantation but have attempted to point out those things where errors are most likely to occur.

As foresters responsible for the planting job, let us put emphasis where emphasis is due. Let us demand well-formed, strong or super-strong stock from our nurseries. Let us treat this stock with due care in transportation, handling and planting and we will have fulfilled the responsibility which is ours.
INCREASING THE SURVIVAL OF PLANTED LONGLEAF PINE SEEDLINGS

By
R. M. Allen, Research Forester
Southern Forest Experiment Station
Gulfport, Mississippi

Seedlings must not be allowed to dry out if we are to have successful field plantings. Mr. Sentell has told us how to pack and handle seedlings before planting. These methods should reduce moisture loss from the seedling and thus increase field survival. There is another important source of moisture loss; transpiration after planting. At the Gulfcoast Research Center in south Mississippi we have been investigating ways of reducing the water loss of seedlings after planting. Two methods of reducing transpiration which offer great promise in increasing field survival are needle clipping and wax foliage coatings. Since most of our work has been with longleaf pine I shall confine my remarks to that species, although some of these comments would apply to the other species.

Of the two methods of reducing transpiration, clipping the needles of longleaf seedlings to five inches, has increased survival more consistently than has the use of wax foliage coatings. In tests involving some 8,000 longleaf seedlings planted on a wide variety of sites during a period of three planting seasons, differences in survival between clipped seedlings and untreated seedlings have ranged from 0 to over 50 percent. In no test was the survival of the clipped seedlings lower than that of the unclipped seedlings. These tests show you should generally get an increase in survival from 10 to 30 percent resulting from clipping longleaf.

Clipping to five inches works well on average sites, but is not necessarily best for all soils. A heavier degree of clipping, or even total clipping, may be worth while on very harsh sites. However foliage much shorter than five inches would be hard to handle in machine planting and may increase the number of seedlings planted high.

The best time to clip appears to be at the time of lifting. In a test where seedlings were clipped at different dates before lifting it was found that those clipped in September or October had lower survival than seedlings clipped in November, or just before lifting, in December.

The other method of reducing transpiration being tested is the coating of the needles with a wax. In most of the tests the trademarked product, Dowax, has been used although in one test a lanolin coating increased the early survival of planted longleaf seedlings.

In most of the tests dipping the tops of longleaf seedlings in a 1:3 concentration of Dowax has given about the same degree of response as was obtained by clipping. There have been several exceptions however. In one test the dipping treatment actually reduced survival below that of the untreated controls. In several other tests the dipped seedlings
survived no better than the untreated controls. The conditions which cause these occasional failures of the wax coating are yet unknown.

Actual tests of transpiration showed that the combination treatment of clipping and dipping reduced transpiration more than either clipping or dipping alone. In field survival tests there are some instances where clipping and dipping gave the best results. In other tests clipping and dipping was no better than clipping alone. If the occasional depressing effect of wax can be overcome the clipping and dipping treatment offers the most promise as a method of increasing early survival of planted longleaf pine seedlings.

It must be realized that these foliage treatments by themselves do not guarantee good survival. On very dry sites or in drought years survival may be poor regardless of foliage treatments. Clipped longleaf seedlings, and under certain circumstances, dipped seedlings can be expected to survive better than untreated seedlings planted under the same conditions.
DISCUSSION, SECOND SESSION

Comment (R. T. Clapp) on spot-dying condition in loblolly plantation following the showing of Dr. Campbell's slides by Dr. Toole (Delta Station pathologist).

"We have no ideas which you haven't already heard. We first discovered it in 1948 about the same time it was found in South Carolina. At that time we only knew of two 1/4 acre patches. Frankly we thought it was some kind of beetle at work. Then we found more and now we think it may be quite widespread on poorly-drained soils in Mississippi. Probably it is associated with eroded soils, too. We have arranged with Mississippi state forester to have his area rangers to be on the lookout for this condition. By this we may be able to get some idea of the extent and importance of it.

We've noticed reproduction coming in on areas being killed. So far the reproduction looks healthy. All examples we've seen have been in stands about 15-20 years old and nearly all in plantations but where natural seeding was mixed in with planted trees."

Q. (John McCullough) "Haven't there been some experiments on the collection of seed from good and poor quality parents?"

A. (Maisenhelder) "I suspect that someone has done this but I'm not certain. Any of us who do work along this line should let other foresters know what's being done.

Comment: (Wakeley) "There has been a wealth of work on inheritance of parental characteristics in European hardwoods but not much in this country except for geographic race. We know geographic races exist in hardwoods. Several papers by Wright on ashes and one in press on maple but not much on southern hardwoods."

Q. "Dr. Bateman referred to slash-loblolly mixtures studied by Hal Townsend in north Louisiana. What was the seed source of that loblolly?"

A. (Dr. Bateman) - I don't know the source of the seed. They were the result of mixed plantings put out by the Soil Conservation Service."

Comment: "Then we can say that slash does not compare with loblolly of an unknown seed source."

Comment: (Sentell) Some of those plantations were on our land at Hodge. It was interesting to me that in some cases slash was outgrowing loblolly. We then put in our own plantations using local loblolly seed and slash from Picayune, Mississippi. Within four or five years our local loblolly was keeping up with and moving ahead of slash. In one particular lot of slash we are ready to run a mowing machine through it. It won't grow. I think we have some south Florida slash, but when you compare species without comparing
seed sources, you can't compare loblolly of an unknown source with slash."

Comment: (M. B. Smith) "The depth of planting very significantly affects the survival of longleaf. Shallow planting is very bad."

A. (Sentell) "If I said that, it was an error on my part. Seedlings should be planted between the root collar and the first primary needles. I tried to emphasize that exposure and planting too shallow is bad.

Q. (Arnold Lewis) "Would you explain why you are planting longleaf?"

A. (Charlie Lewis) - That's a controversial thing. They've been planting slash pine on the Kisatchie National Forest for 20 years, and it's a mess. After four or five sleet storms there are some 100 trees per acre that aren't crooked or deformed. Perhaps another sleet storm will take care of the last 100. That's a very good reason I think for not planting slash. Loblolly is the most susceptible of any southern pine to fire damage, a serious factor in Beauregard Parish. Tip moth infestation is also severe and rate of growth on dry sandy sites is quite disappointing."

Comment: (Hugh Redding) We've had three bad ice storms and also Cronartium that infects up to 75% of the trees in places. Our loblolly plantations have been very limby and shortleaf plantings have made very poor growth. We have 30,000 to 40,000 acres of natural longleaf on the Kisatchie, but planting is admittedly a problem."

Comment: (Cassady) "I would like to say a word in defense of slash. Industrial has some good slash and they're not far from Vernon Parish. Also Redding has been cutting and getting some income from his slash plantations which he hasn't gotten from longleaf yet."

Q. (R. H. Clark) "What's the answer to producing nursery stock of local seed source?"

A. (Sentell) - "We should stress nursery stock quality rather than quantity, no matter who raises it. Think of the surviving tree in the plantation and not how many were shipped out. Foresters should demand trees that will live in drouth years and not just the good wet years. Getting local stock is a local problem. If the state can't take care of it I'd suggest growing your own.

Comment: (Jack May) - To get your local-source stock you can put in your own nursery and collect your own seed. Otherwise you can have custom-grown stock from state nurseries. You can collect your own seed and ask the state to do the rest. Most of the state nurseries in the South are carrying out such programs now. As many as 10 to 15 separate seed lots have been produced in Forest Service nurseries at one time. Any nursery can do the same if a qualified nurseryman is in charge.

Q. (H. D. Story) - With reference to seed orchards and the use of genetically superior trees, aren't we apt to weaken the tree or
make it malformed in the attempt to get it to produce larger quantities of seed?"

A. (Dr. Zobel) - The answer is no because it is an inherent thing. It doesn't matter what is done to the parent, the seed and the parent will be genetically similar. As for the bob-tailed dog, it is inherently bob-tailed. But if you took a dog and chopped its tail off, it wouldn't have bob-tailed pups. You could produce a thousand generations, but the pups would still have tails even though all the parent's tails were chopped off. It doesn't matter what we do to the tree once we have proven it genetically better.

We can get certified seed now, certified as to purity and germination. I hope sometime soon we can get it certified also as to geographic race, source, and genetic qualities of the parents.

Q. "How many generations would a tree have to go through before changing an inherent characteristic?"

A. (Dr. Zobel) - That can't be answered directly for trees, but we know we can cause such changes in crops such as corn in eight to ten generations by a process of selection.

Q. (Roland Rotty) - "Have you ever pulled needles off instead of clipping longleaf seedlings?"

A. (Allen) - "No. Those were completely clipped down to the needle sheath."

Q. (Millar) - Isn't some of the poor survival due to mishandling of stock in the field? Ordering too much stock, etc."

A. (Sentell) - I advise the packing of stock in Forest Service type bales. These bales can withstand considerable rough treatment. Every time seedlings are heeled-in, unless under trained supervision, you're apt to develop trouble. Put a man out there who know what he's doing.

Comment (Millar) - "The man in the field should advise nurseryman immediately of any irregularity in stock."

Q. (Gipson) "What time interval elapsed between lifting and planting of longleaf seedlings?"

A. (Allen) "Within several days."
At the start of the planting program in the South, most planters began with their easiest and best sites. Obvious analogies between forest and farm planting led them to prepare these sites by furrowing and the like. Good plantation development on such sites in the absence of any preparation subsequently caused many foresters (1, 2, 3) to feel that site preparation was generally unnecessary. Today, however, with their best sites planted, many forest managers have sites on which planting without preparation is all too likely to fail.

Where, then, is site preparation required?

We are all familiar with plantations that have not developed to acceptable yield standards. Quite often, this has been attributed to an

Underscored numbers in parentheses refer to Literature Cited, at the end of this article.
"adverse" site. What is an adverse site? It is one with too much or too little moisture; too strong or too weak a concentration of mineral salts; too high or too low acidity -- or it may be none of these.

A site may be totally adequate for pine growth, but its potential may be so completely utilized by existing vegetation that when seedlings are planted they do not have a chance. It is such sites that I would like to discuss today.

There are ten million acres of sandhills sites in the Southeast, and on these we know that ordinary planting methods fail. I will talk mainly about them, because most of my knowledge was gained there, and because this information--extended to other areas--may help explain some failures or examples of poor growth that have occurred in the past.

The Sandhills As An Adverse Site

The sandhills once supported a moderate stand--up to about 3,000 board feet per acre--of high quality longleaf pine sawtimber. The soil is characteristically a deep medium sand. Some areas have as little as 3 percent clay and silt. After the virgin stands were removed, scrub oak and wiregrass took almost complete possession of the land. Most efforts toward natural or artificial regeneration have failed.

To casual observation, one of the outstanding features of the sandhills is the sparse vegetation. Especially after a fire, it seems as if very little of the surface area is being used. The many bare spots appear to indicate that the land is idle--that it is too poor to support plant growth. Nothing can be further from the truth. Every place you dig you can lift a sod. If you shake the sand from that sod, you will find an intricate mass of roots. Every foot of the sandhills is working. Unfortunately, most of the effort is going toward the production of useless weed plants.

Every soil has its root capacity (4). Contrary to popular opinion, in deep, excessively drained sands the root system is very shallow (5, 6, 7). In the sandhills, almost all of the feeder roots are in the first six-inch layer of soil. This is true for pine roots, for oak roots, and for grass roots.

A pine seedling on such a site is forced to compete from the day it is planted with an established root community that already utilizes almost all the food and water available. Under these conditions, survival and growth are poor. Only some form of site preparation can ameliorate the situation.

Effect of the Root Mass

Do we have any evidence of the effect of this root competition? Over thirty years ago, in 1921, I. F. Eldredge (8) described some sandhills plantations. He said, "The seedlings are scrubby, unhealthy, and practically dormant as far as growth is concerned...... Apparently, it is due to soil dryness, caused by root competition with the scrub oak
which grows abundantly on the planting site.

In the mid-forties, pines were planted among the scrub oak in South Carolina (9). Five years later they were twelve inches high. In west Florida, in 1943, slash pines were planted in a similar scrub oak-wiregrass site. Some of these trees, ten years later, are barely three feet high. But during the same planting season of 1943, in the same deep sand soil, slash pines were planted in an old field. These trees have produced over 12 cords per acre. Why? Was there something magic about that old field? No. Competing vegetation was absent when the seedlings were planted. Moisture and nutrients were available and adequate for good pine growth.

In 1937, another planting test was made (10). Slash pine was planted on both sides of a road. The left-hand site of the road had been thoroughly denuded by harrowing, now it has a good stand of slash pine poles. The right-hand side of the road was not cleared, and today looks as it did when it was planted.

P. C. Wakeley, in his Planting the Southern Pines, recognized the problem in 1951 when he said, "On some adverse sites, site preparation may be more important, . . . . than it is on the commoner sites on which it has been systematically studied." (1) Our research program in west Florida (11) is systematically studying the effect of site preparation on this adverse site.

How can we change the competitive conditions of the planting site? It is important to remember that the object is not simply to make planting easier, not to make a mineral seed bed, not to curtail erosion. It is to conserve, for the use of the planted seedling, the moisture and nutrients available in the soil.

We have today three principal means by which the competitive conditions of a planting site may be changed:

1. Fire.
2. Chemicals.
3. Mechanical methods.

Use of Fire

Fire, as a silviculturist's tool, has had wide acceptance throughout the Gulf South (12, 13). Its value for brown-spot control (14, 15), hazard reduction, and seed bed preparation (16) has long been recognized. Methods for making prescribed burns during the dormant season have been established (17, 18).

The use of killing fires to reduce competition, however, has not been thoroughly explored. In South Carolina (19), repeated summer fires permanently eliminated about 50 percent of the small hardwood population in the flatwoods. The higher air temperatures of the growing season and
coincidence of fires with the period of lowest food reserves was believed to be a primary cause. Backfires in a 10-inch grass rough are 85° to 140° F hotter than headfires (20). Scorching is severe when fire burns in calm air (21). Research is needed to correlate the factors of repetition of burns, air temperature, food reserves, wind, and the method of burning, so as to produce the most effective and permanent reduction in competition.

At best, fire reduces root competition indirectly. Its great advantage, however, is its low cost. Fire burns for pennies per acre. It may prove of greatest value as a preliminary treatment to other methods. It is possible that a killing burn, used under the most advantageous conditions, may so deplete the vigor of the competing vegetation that the knockout punch can be supplied very easily and cheaply by either chemical or mechanical methods.

**Chemicals**

Forestry has used chemical phytocides for years, mostly in timber stand improvement and, more recently, in seed-bed preparation in the Northwest (22). On western ranges, mesquite and sagebrush have been eliminated in favor of range grasses (23, 24). But the use of chemicals in the South for broadscale preparation of planting sites is an unexplored but challenging field.

Chemical manufacturers are competing today to produce cheap and effective phytocides and soil sterilants. Although production is aimed to satisfy agricultural needs, the weed plants of the sandhills are killed by the same compounds.

Modern methods for applying dusts, sprays, and fogs have been developed for use in fields, in orchards, and on rights-of-way. Ground application is indicated. Aircraft, both fixed and rotating wing, show costs of $5 to $10 per acre (25, 26), not including the costs of flagging and ferrying, or the chemicals themselves. Broadscale airplane application of chemicals is limited by the danger to existing timber stands.

Other problems must be solved. When soil is sterilized, the toxic period is unknown. Safe methods of handling corrosive chemicals must be found. Some chemical applications, although destroying living vegetation, do not affect the dormant seeds already in the soil.

When an effective chemical treatment is found, however, it will have many advantages over other methods. It will leave the shallow and easily damaged topsoil layer of the sandhills intact. Moisture-holding capacity and nutrient supply will be relatively unchanged. Roots of the present vegetation will be left to add organic matter to the soil. Light, farm-type equipment can be used for applying the chemicals. Seedlings should do well on a site thus prepared.

**Mechanical Methods**

On the loose sandhill soils, any tractor of medium power, using
almost any blade, scalper, disk, middlebuster, or brushchopper, will knock down the standing oaks or tear out the shallow root systems. However, complete eradication of the vegetation, beyond possibility of sprouting, is not simple. Light treatments that disturb only a small part of the root formation are often followed by heavy sprouting of weed plants. Even on bulldozed sites, small pieces of oak root will sprout, and grasses will reseed quickly. Complete eradication by mechanical methods is costly.

Last year in Liberty County, Florida, the St. Joe Paper Co. embarked on a ten-year program (27) under which it plans to reforest 60,000 acres of sandhills. This operation is probably the most intensive and extensive site preparation job ever attempted in this country.

After the stumps and remnants of commercial timber are sold, the land is completely scalped. This first treatment is with an 80 h. p. crawler-type tractor, on which is mounted a scalper blade. The blade is a comb-like, skeleton dozer blade with an undercutting bar fixed on the out-swept forward teeth.

Next, windrow centerlines are staked 140 feet apart. A windrow strip 14 feet wide is then cleared along the staked lines. These strips are cut twice with a 5,000-pound disk harrow pulled by a 60 h. p. wheel tractor. On these 14-foot strips, the vegetative debris from the entire clearing job is windrowed. Windrowing is done with a long-toothed rake mounted in front of a 40 h. p. crawler tractor. The cleared areas between the windrows are then worked with an undercutting tool or the heavy disk harrow. Either tool is pulled by a 100 h. p. tractor converted from crawler type to wheels, at a speed of about 5 miles per hour. This high speed is maintained in order to throw the oak roots as far as possible onto the surface of the soil. Later, another cutting is made with the heavy harrow, again at the highest speed possible. Between each of these operations, the Company attempts to delay about 6 to 8 weeks, so as to allow oaks to resprout and annuals to reseed. After the second and final disking, the land is smoothed with a road grader. The grader's wheels are set seven feet apart to mark the planting rows and pack the soil in them (the seedlings are planted in the wheel tracks.).

When the St. Joe crews have finished, they have changed the wiregrass and scrub oak of the sandhills into what is probably the most completely prepared planting site possible.

What does this intensive job cost? It undoubtedly is expensive. Equipment development, design, and trial have been costly, and methods on the sixth thousand-acre stretch are greatly different from those on the first thousand. Rubberized heavy equipment accompanied by lowered maintenance is continuing to reduce the cost. For example, the 100 h. p. tractor that pulls the heavy harrow wore out two sets of rollers, pins, and bushings a year when used as a crawler. That cost close to $5,000 for replacement. The rubber tires are being depreciated on a 5-year basis. A high-speed tilling machine was tried. The rotating blades were supposed to last 30 days. They did not last 30 hours. The machine was rejected.

When the going is good, the job is done at the following approximate
rates:

<table>
<thead>
<tr>
<th>Job</th>
<th>Equipment</th>
<th>Hours Per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scalping</td>
<td>80 h.p. crawler tractor with scalper blade</td>
<td>1.0</td>
</tr>
<tr>
<td>Windrowing</td>
<td>40 h.p. crawler tractor with rake</td>
<td>1.0</td>
</tr>
<tr>
<td>Undercutting and harrowing</td>
<td>Rubberized 100 h.p. tractor and tool</td>
<td>0.5</td>
</tr>
<tr>
<td>Leveling and marking</td>
<td>Road grader</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Charges for supervision, layout, and casual labor are not available.

At the Sandhills State Forest in South Carolina (28), successful survival and early growth has followed similar but less intensive site preparation. There a tandem brush cutter is used in May or June to reduce the scrub oak cover. This is followed during July and August by double plowing with a heavy, disked firebreak plow. Then, during September or October, the area is leveled with a gang disk plow and farm tractor. Again, a period of one to two months between treatments is recommended.

The reported per-acre figures are: Brush cutting 0.62 equipment hour; and plowing 0.71. Total commercial costs for this operation are estimated at $25.00 per acre.

There may also be possibilities in a single machine now being used for row-crop site preparation in the palmetto flats in south Florida. This machine digs up the competing vegetation, chews it thoroughly, and spreads it as a surface mulch behind. It is reported to have been custom-built at a cost of $20,000. It operates for about $40 per acre.

Site Preparation Trials on the Chipola Experimental Forest

On the Chipola Experimental Forest in west Florida, exploratory site preparation comparisons were made during the summer of 1952. The sites were planted the following winter and first-year survival counts were made last fall.

Several different methods of reducing the root competition were used. The extreme treatment was to bulldoze one site clean. Intermediate mechanical treatments included the use of a deep-running Mathis-type fireplow with seedlings planted in the center of a four-foot open furrow. A fire-plow harrow was used in the same manner. A combination treatment used a single-drum brush chopper to cut down the oaks. After the oaks had sprouted, the area was burned. A growing-season burn alone killed many of the oak stems. On another site, all woody vegetation was killed with a
basal spray of 2, 4, 5-T in oil, so that only the grass was left to compete with the planted seedlings.

First-year survivals in these sites are given in table 1.

Table 1. -- First-year survival in pine site-preparation study, Chipola Experimental Forest

<table>
<thead>
<tr>
<th>Site Preparation</th>
<th>First-year survival</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Slash Pine</td>
<td>Longleaf Pine</td>
</tr>
<tr>
<td>Bulldozed</td>
<td>91</td>
<td>51</td>
</tr>
<tr>
<td>Open fire-plow furrow</td>
<td>69</td>
<td>42</td>
</tr>
<tr>
<td>Brushchopper plus hot summer burn</td>
<td>54</td>
<td>10</td>
</tr>
<tr>
<td>Hot summer burn</td>
<td>52</td>
<td>11</td>
</tr>
<tr>
<td>Bush and bog harrow</td>
<td>46</td>
<td>17</td>
</tr>
<tr>
<td>Chemical kill of woody vegetation</td>
<td>37</td>
<td>7</td>
</tr>
<tr>
<td>Check - no treatment</td>
<td>34</td>
<td>20</td>
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</tbody>
</table>

A glance at this table shows 91 percent survival for slash pine and 51 percent for longleaf on the bulldozed areas, as compared with 34 percent and 20 percent on the untreated sites. On open furrows slash pine survival was 69 percent; on areas prepared by making a single trip with a bush and bog harrow, 46 percent. Fire treatment gave about 50 percent slash survival, and brush chopping in advance of burning was apparently of no help. Also worthy of note is the result of the treatment that killed the woody competition but left the grass. The pines did no better here than in the oakgrass rough. We are becoming convinced that wiregrass root competition is more important than oak-root competition to survival and growth of pine seedlings in the sandhills.

This study is one year old. Growth response to different site treatments has not yet developed. But all our information to date emphasizes the importance of the removal of root competition to the establishment of pine plantations in the sandhills.

Before closing, I want to mention very briefly the preparation used in west Florida on another kind of adverse sites. These are wet, poorly drained, grassy flats, known locally as savannahs. Areas of 400-500 acres are not uncommon. Pine timber once grew along the edges and on
the higher, better drained portions. These trees transpired a considerable volume of water. Once they had been cut, poor drainage left the soil so wet that a new crop of pines could not become established.

Plantations were made as early as 1930; some have been successful. Between 1936 and 1939 (29) the Florida National Forests made trials on the Coline Flats of the Apalachicola National Forest. All were aimed at drying the site. Ditches were plowed on 18-foot centers and the rows of trees were planted between the ditches. Other trees were planted on top of the double spoils from ditches on 10-foot centers. The semi-permeable layer that holds surface water on the savannahs was dynamited in a few places. Successful pole stands of slash pine are growing on these areas today.

During the past few years, the St. Joe Paper Co. has been planting similar flats after ditching them with a specially built plow. The plow is heavily constructed, has a coulter and a middlebuster, and is drawn by two 60 h. p. tractors at a speed of about 1 mile per hour. It prepares a ditch about 20 inches deep, 3 feet wide at the top, and about 1 foot wide at the bottom. On several thousand acres, these ditches have been made at 660-foot intervals and slash pine has been planted between. After three years, survival and growth seem adequate.

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Many thousands of acres of successful pine plantations in the Gulf South are living proof that site preparation is not always required. But, as the better planting sites are filled, and as growing demand for timber makes the adverse sites more important to the economy, foresters must learn to prepare them so that they, too, will produce the wood we need.
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UNDERPLANTING OF SOUTHERN PINE

By
Robert H. Clark, Chief Forester
Fordyce Lumber Company
Fordyce, Arkansas

Nearly every landowner is confronted with the problems of converting cull hardwood stands to pine. Wakeley (1) has stated that thirty percent, or four million acres, involves complex problems of underplanting or interplanting to some degree. It can be stated that abandoned fields in the South have comprised over ninety percent of the total area planted. Most of the progressive landowners are gradually completing their open-field planting. This has turned their attention towards the more difficult task of converting non-productive scrub hardwood stands to pine and, in doing so, has surprisingly made them realize the extent of the problem. A large percent of these areas has been successfully converted to pine through different degrees of cull timber removal by various methods of girdling and tree chemical application. The greatest success has been accomplished when reproduction was established prior to any type of release.

The question arises, What are we to do with areas of heavy scrub oak that lack the necessary advanced reproduction? Many landowners have been very successful in various methods of ground preparation. Burning has been the answer on some areas. (2, 3) On other areas the hardwood problem has been solved by various mechanical means such as dozing, discing, and scarification. (4, 5) Regardless of the methods of ground preparation used, the successful jobs were planned in conjunction with an adequate seed source.

We, as well as many other landowners in the South, have areas of scrub hardwoods lacking sufficient seed source to insure us of adequate stocking, regardless of the method of hardwood control. Therefore, areas lacking this natural seed source will have to depend on planting or direct seeding for successful conversion to pine.

Types of Underplanting and Results

In February, 1948, we approached the problem by underplanting loblolly 1-0 stock. Three areas were hand planted using the bar slit method. These areas averaged 236 hardwood stems to the acre, 6.0 inches in diameter, consisting of red, post, and blackjack oaks. One area received complete release at the time of planting; the second area received partial release following the second growing season; and the third was a check
area with no release. The area receiving partial release was girdled with the removal of 225 stems per acre, thus leaving 11 hardwood stems to the acre which were mostly 10" and up in diameter.

The response to release was excellent both as to survival and growth. The survival was in proportion to the intensity of release with the difference becoming greater after each growing season. After the fourth growing season the survival remained 100 percent on the area receiving complete release, 80 percent on the released plot, and 57 percent on the check plot. Likewise, the growth rate showed the same comparison with 10, 7, & 7 inches after the first growing season, as compared to the total height of 102, 46, and 22 inches after the fourth growing season for the three types of release. (Table 2)

Table 1. - Six Survival Periods of Loblolly Pine as Affected by Types of Release, Planted February, 1948

<table>
<thead>
<tr>
<th>Release</th>
<th>Growing Season</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
</tr>
<tr>
<td>Complete &amp; Immediate Release</td>
<td>100</td>
</tr>
<tr>
<td>Release after 1st Growing Season</td>
<td>100</td>
</tr>
<tr>
<td>No Release</td>
<td>100</td>
</tr>
</tbody>
</table>

* Area released after fourth growing season.

Table 2. -- Six Periods of Growth of Loblolly Pine as Affected by Types of Release, Planted February, 1948

<table>
<thead>
<tr>
<th>Release</th>
<th>Growing Season</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
</tr>
<tr>
<td>Complete &amp; Immediate Release</td>
<td>10</td>
</tr>
<tr>
<td>Release after 1st Growing Season</td>
<td>7</td>
</tr>
<tr>
<td>No Release</td>
<td>7</td>
</tr>
</tbody>
</table>

81
If the girdled plot had been released prior to the first growing season and chemical used to control sprouting, both the survival and growth would have been more comparable to the area receiving complete release. The check area received release after the fourth growing season. However, the spread in survival and total height continued for the two additional growing seasons. It was also evident that in order to obtain the best results, release should be done immediately following planting. This was also pointed out in a study made by Muntz (6) in 1941.

The success of the 1948 underplanting encouraged additional projects in hardwood conversion. A total of 165 acres was completed in the period from 1951 through 1953 and during this period three types of hardwood underplanting sites were recognized.

First - Cull pole hardwood stands free of small brush.
Second - Cull pole hardwood stands with small underbrush in density sufficient to compete with the planted seedlings.
Third - Cull saplings and brush hardwood stands.

On the first type-cull pole hardwood free of brush-plantings were made on 57 acres followed immediately by release with the use of Ammate. The application of the chemical was deemed necessary to insure the best possible control of sprouting, particularly in the smaller two to eight inch diameter classes. Planting was done in 1951, 1952, and 1953 with good results. (Table 3) However, in comparing them with our original underplantings in 1948, the average survival by growing periods was lower. This lower survival may be attributed to the lack of rainfall during the past two growing seasons. (Tables 1 & 3)

Table 3. - Average Survival and Total Height of Underplanting by Growing Seasons and Degrees of Brush Control, Released by Girdling with Ammate *

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Percent</td>
<td>Inches</td>
<td></td>
<td></td>
<td>Percent</td>
<td>Inches</td>
</tr>
<tr>
<td>First</td>
<td>57</td>
<td>79</td>
<td>10.2</td>
<td>First</td>
<td>37</td>
<td>76</td>
<td>8.0</td>
</tr>
<tr>
<td>Second</td>
<td>42</td>
<td>73</td>
<td>21.5</td>
<td>Second</td>
<td>20</td>
<td>58</td>
<td>15.4</td>
</tr>
<tr>
<td>Third</td>
<td>14</td>
<td>60</td>
<td>32.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A comparison, after one growing season, of the average height growth between the Ammate areas released at the time of planting and the 1948 underplanting release shows an increase of 3.0, 6.5, and 14.0 inches for the 1st, 2nd, and 3rd respective growing seasons. This may be attributed to the release immediately following planting plus more intensive release through the use of Ammate. (Tables 2 & 3)

The second cull hardwood type—a pole hardwood stand with heavy underbrush presents two problems of hardwood control. These areas were first approached by girdling the larger cull hardwoods with Ammate; secondly, by use of a prescribed burn to kill back the smaller underbrush. Burning was made just prior to planting and followed by girdling with Ammate. Thirty-seven acres were underplanted by this procedure during 1952 and 1953.

One of the areas had 2,340 hardwood stems per acre, one inch or larger in diameter. In February, 1953, a burn killed 1,770 stems representing 75.6% of the total. However, after one growing season, sprouting occurred on 56.4% of the original stems killed by fire. The sprouting was heaviest in the two-inch class with 66% of the total class having vigorous sprouts. No kill, so likewise no sprouting, occurred in the four-inch diameter class. (Table 4)

Table 4. - Degree of Kill and Sprouting after One Growing Season Resulting From Prescribed Burn Prior to Planting

<table>
<thead>
<tr>
<th>D. B. H.</th>
<th>Stem Killed</th>
<th>Stems Sprouting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent</td>
<td>Percent</td>
</tr>
<tr>
<td>2</td>
<td>90.3</td>
<td>66.1</td>
</tr>
<tr>
<td>4</td>
<td>23.1</td>
<td>23.1</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total Average</td>
<td>75.6</td>
<td>56.4</td>
</tr>
</tbody>
</table>

The burn did reduce the existing competition of small underbrush to the point of equal competition with the loblolly planting stock.

The average survival and height growth for the first two growing seasons on thirty-seven acres of underplanting with burning is somewhat lower as compared with areas of no brush control. However, if a comparison is made for the two identical years of 1952 and 1953, they are about equal, with a survival of 75 and 77 percent for prescribed burn areas as to 79 and 77 percent on areas with no treatment. (Table 3)
It is interesting to compare the average open-field plantings with that of the average underplanting for identical years. The last two growing seasons, 1952 and 1953, were very hot and dry which caused severe losses in our open-field planting. This was not the case in our underplanting as the survival percentage after one growing season ranged approximately 75 percent as compared with the open-field plantings of 24 percent. (Table 5)

Table 5. - First Year Survival Comparison Between Underplanting and Open-Field Planting.

<table>
<thead>
<tr>
<th>Year</th>
<th>Open Field</th>
<th>Underplanting</th>
<th>Average Survival Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948</td>
<td>80</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>1949</td>
<td>76</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1950</td>
<td>72</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1951</td>
<td>70</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>1952</td>
<td>24</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>1953</td>
<td>25</td>
<td>77</td>
<td></td>
</tr>
</tbody>
</table>

The third type—cull hardwood saplings and brush—was approached with the assumption that girdling with Ammate would be impractical and too costly, and a cleaning by some mechanical means would be the answer for the small brush problem. In February, 1954, a D-6 bulldozer was used on 22.5 acres. A 5.0 acre tract was dozed by uprooting and scattering the brush. A 17.5 acre tract was dozed clean by piling the brush in windrows. The two areas were then planted with 1-0 loblolly seedlings. The purpose of the different types of dozing was to compare costs and, also, to see if a difference in survival and height growth existed between two intensities of hardwood clearing.

Cost of Underplanting

The cost of the various types of hardwood conversion under discussion varied with the methods of release, the density of the stand, and the degree of brush control. The highest cost per acre was that of dozing and planting which ranged from $19.68 to $37.73, and the lowest was those
areas receiving no brush control treatment with an average cost of $15.39 per acre. The planting cost ranged from $7.10 per acre to a high of $10.40 per acre. The cost of girdling with Ammate ranged from a low of $4.37 per acre to a high of $11.93 per acre on the individual areas girdled. The average cost of girdling was approximately $9.00 per acre. The cost per acre of dozing was $27.43 for clean dozing in windrows, as compared to $7.44 for dozing and lopping brush. (Table 6)

Table 6. - Average Cost Per Acre of Underplanting

<table>
<thead>
<tr>
<th>Item</th>
<th>Acres: Planted</th>
<th>Preparation: Cost</th>
<th>Planting: Cost</th>
<th>Release: Cost</th>
<th>Total: Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total &amp; Average</td>
<td>100</td>
<td>None</td>
<td>$7.10</td>
<td>$8.29</td>
<td>$15.39</td>
</tr>
<tr>
<td>Burning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total &amp; Average</td>
<td>47</td>
<td>$0.78</td>
<td>$8.92</td>
<td>$10.99</td>
<td>$20.69</td>
</tr>
<tr>
<td>Dozing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1954 (Clear)</td>
<td>17.5</td>
<td>$27.43</td>
<td>$10.30</td>
<td>-</td>
<td>$37.73</td>
</tr>
<tr>
<td>1954 (Lopping)</td>
<td>5.0</td>
<td>$7.44</td>
<td>$10.40</td>
<td>$1.84</td>
<td>$19.68</td>
</tr>
</tbody>
</table>

Conclusion

The results of this work definitely indicate that scrub oak stands can be successfully converted to thrifty growing pine stands by underplanting. Our early 1948 work clearly indicated that the time of release was very important, and the deferring of release definitely retarded growth and decreased survival. Good results were obtained in stands having small hardwood brush by a prescribed burn prior to planting, followed by girdling with Ammate. The mechanical means of reducing hardwood competition greatly increases the initial cost, but no future cleaning may be necessary, which probably would be required in the other operation.

One of the main advantages of underplanting is the absence of a wait­ ing period, which is required when you have to rely on a natural source of seed for reproducing a stand. This waiting period sometimes extends from three to five years. Another advantage is that you have lowered the risks of a failure, which become very important as the cost of hardwood control increases. The studies have definitely indicated that you may expect success even during years of drought, which has been fatal to much of the
open-field plantings. In other words, you can usually get what you want when you want it.

**Literature Cited**


MACHINE PLANTING TECHNIQUES WITH THE HEAVY DUTY PLANTER

By
Raymond E. Gipson, Chief Forester
The Lutcher & Moore Lumber Co.
Orange, Texas

Mr. Forester, this company has 10,000 acres of barren pine lands which we want to make productive with a crop of timber. On this land you will encounter steep ridges, flatwoods, and seepy slopes meandering the creek drainage areas. There are recently stumped areas and areas with dense growths of vegetation ranging from blackjack and sandjack to wax myrtle and palmetto. We want you to make your recommendations for the type of tree planter and power unit to do this job. Remember to standardize your equipment, keeping your planting and maintenance costs to a minimum, and above all, plant the trees properly!

In increasing numbers management is making similar statements to its foresters over the south today. The Lutcher & Moore Lumber Company of Orange, Texas, only commenced its artificial reforestation activities in the fall of 1949. Many companies have not commenced their land improvement programs and will soon be faced with the questions of planting techniques and policy. Regardless of past activities, everyone should be informed of new developments or ideas that may possibly be used to advantage now or in the future.

My company's planting is being carried on in areas very similar to those just mentioned. Our first step in this work was to select our power units. We elected to use a track type tractor, the John Deere MC. Our reasons for doing this were as follows:

1. The 18.26 drawbar horsepower machine, providing a maximum pull of 4226 pounds, would not be required to operate under strain.
2. The 14" track provided the maximum bearing surface for the seepy sites and traction for the steep slopes.
3. A complete stock of parts and trained maintenance personnel were conveniently available.
4. The tractor is versatile for other uses, such as fire lane construction and fire suppression power units.
5. The tractor is safe and well balanced, thus minimizing the tendency to turn over and injure personnel.

With the advantages of this power unit and a knowledge of the terrain, we elected to use a standard Lowther heavy type planting machine. Our experience has been that light farm machinery, constructed and designed for use in cultivation and soil preparation duties is a poor risk for the rugged demands of forestry work. I am almost sure you have all
heard the weatherman's expression, "weather conditions are unfavorable for outdoor operations". I am positive that you know this statement seldom applies to tree planting activities. Naturally, when working in such weather conditions, especially in inaccessible areas, the tractors and planters are constantly bogging or operating in a sea of mud. For these reasons we looked for the most rugged planting machine that could be towed behind the power unit of our choice.

The following mechanical features are most essential for a typical heavy duty tree planter:

(1) Rugged drawbar adapted for towing behind all tractors and automotive equipment. The planter drawbar should be constructed of metal not less than 1/2" in thickness. That portion of the drawbar that connects to the tractor hitch should be hinged to permit immediate upward or downward movement.

(2) Heavy reinforced cast frame. A bent frame in a tree planter renders the machine useless.

(3) Bolted-on parts for all wearing surfaces. Welding of fixed wearing surfaces often requires taking the entire planter out of the field to the welding shop. Under the best of conditions there are enough trips of this nature. Eliminate many of them by your choice of planters.

(4) Standardized tires, bearings, and bolts.

(5) Tractor-operated hydraulic lifting device for raising the tree planter plow.

(6) Sturdy seedling carrying trays.

(7) Grease fittings for all bearings.

Planting and Site Problems:

We occasionally encounter difficulties at the start of the planting season with new tree planters planting in heavy second or third year roughs. The difficulty is the failure of the dull coulter and plow point to cut matted layers of long stemmed grasses. This situation is corrected by commencing operations in very light roughs or burns, so that the dulled parts are sharpened by wear.

Timber cuttings operations should be completed at least two years prior to planting operations. The presence of green tops and limbs on the ground hinders mechanical planters and frequently results in the area being left unplanted or planted improperly.

Stump holes in planting areas should be accorded a most healthy respect. Tractor operators driving into stump holes, or narrowly skirting a stump hole, are asking for trouble and, in most cases, find it. Remember, every bogging of one machine usually means the stopping of another planter to provide a tow.

In carrying out an extensive machine planting operation, breakdowns of power units or tree planting machines are inevitable. Regard-
less of the proficiency of our machinery, the human element of carelessness and indifference is responsible for many of these breakdowns. This past season on one of our reforestation projects the practice was employed of having dibbles available for the tree planting crew whose machine had broken down. It may be just a coincidence, but there were surprisingly few stoppages after the practice of providing dibbles had been employed.

**Field Planting Techniques:**

The presence of four to eight planting units in one area presents many problems that are not evident in smaller operations. The primary thought in managing this mass of machinery is to concentrate it in such a manner that the supervision of planting, dispersal of seedlings, refueling and servicing can be carried out efficiently and thoroughly. One must bear in mind that the machines must be dispersed in such a fashion that each machine operator will know on which row to return.

There are many varied techniques employed in the arrangement or disposition of the planting units in the field. We employ the principle of planting in straight rows. In relatively remote areas where planting conditions are adverse, we attempt to use a minimum of two machines. By doing this, comparatively little time is lost by one of the units in the event of bogging. Three planting units are, as a rule, worked side by side. Four to six planting units are generally split into two groups, one on each side of a firelane or road. Each group plants at right angles to the firelane or road and progresses in the same direction, enabling all units to be serviced with fuel and seedlings at one point. Generally, a forester or foreman supervises two to six planting units, assisted by one man who keeps the planting units provided with seedlings, fuel, and field maintenance. All daily greasing of all planting units is done by one man. We do this to insure a thorough inspection and greasing operation.

Our planting costs and production figures for the past season under the following conditions are:

<table>
<thead>
<tr>
<th>Trees planted per Machine day</th>
<th>Planting costs per acre</th>
<th>Planting cost per 1,000 trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small planting areas, 10-160 acres</td>
<td>8,000</td>
<td>$6.94</td>
</tr>
<tr>
<td>Large planting areas, 160 acres and up</td>
<td>9,580</td>
<td>$5.65</td>
</tr>
</tbody>
</table>
The Rice Land and Logging Company in southwest Louisiana employs the use of a D-2 Caterpillar towing in tandem two heavy duty planters. By this technique full use is made of the 32 drawbar horsepower of the D-2, and only three men are required for the dual planter operation. The disadvantages are as follows:

1. The planting unit is not highly maneuverable, therefore limited to open planting sites.
2. In the event of planter or power unit breakdown, two planting units are stopped instead of one.

The costs and production figures for this type of operation are as follows:

<table>
<thead>
<tr>
<th>Planting costs per acre</th>
<th>Planting costs per 1,000 trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large planting areas</td>
<td></td>
</tr>
<tr>
<td>160 acres and up</td>
<td>$7.57</td>
</tr>
</tbody>
</table>

The Edgewood Land & Logging Company in southwest Louisiana employs the use of Ford type tractors with heavy duty planters. In the last four years of planting they have used contour planting instead of the straight row method previously discussed. As many as seven machines lined abreast follow natural features, firelanes or roads, following a pattern which can best be described as a modified concentric circle. As the planters commence to tighten the circle, several of the machines are removed and sent to other areas, leaving the little remaining center area for one or two machines.

The advantages are realized by the elimination of the "end of the row" conversations and by the resulting increased planting time. The turns made by the planting units are not abrupt but gradual and, from all observations, have not affected the tree survival. The planting sites are well stocked, and complete utilization of the areas is evident. Unfortunately, the cost and production figures for this particular operation are not available.

In selecting your planting equipment correspond at length with the manufacturers and acquaint them with your particular problems. Modifications and major style changes are being made with the passing of every planting season. These photographs depict several ideas and different pieces of equipment that may be just the thing you are looking for.
MACHINE PLANTING WITH LIGHT FARMER SIZE PLANTERS

By

Ford Fallin, Area Forester
Soil Conservation Service
Ruston, Louisiana

It is a pleasure for me to be at this third annual meeting and take a part on the program. I would first like to give a word of thanks to everyone who has thought enough about reforestation to spend time and effort to build, help build, or render helpful ideas to improve the tree planters.

A recent inventory made in my work area pointed out that there were three times as many small pickup type planters in operation as heavy duty ones. The pickup type planter is designed for operation with tractors having three-point type hydraulic lift, such as Ford, Ferguson, etc.

The number of trees planted per day varies with the planting site and operators and not so much with the type planter being used. There are advantages and disadvantages to both types of planters. The initial cost of the light planter is less, you can purchase two or three light ones for the price of one heavy duty Lowther, and also the light machine is much easier to handle in small fields where a great deal of turning is involved. The hydraulic lift on the tractor lifts machine and operator clear of the ground for turning around and transporting. However, the light machine requires close supervision in order to keep it in adjustment and replace worn or broken parts. The heavy duty Lowther machine will plant in rougher terrain, leaves the soil in a more natural condition, does a good packing job and the planter operator is more comfortable and probably safer since he is not picked up each time the machine is turned around.

The first experience I had with the light machine was five years ago when the D’Arbonne and Dugdemona Soil Conservation Districts purchased seven Illinois Central planters. These planters were too light and folded up the first season, but by rebuilding and reinforcing with heavier material these planters are still in use. However, five of these machines were rebuilt to the extent that Gladney-Murphy trenchers were put on in place of the original trenchers. This was done so as to enable planting in heavy sod and clay gall areas as well as sandy soil. The Gladney-Murphy trencher is shorter and narrower than the Illinois Central therefore the total length of the machine was reduced and the width of the trench was less.

The Forester tree planter now on the market is designed after the Illinois Central but is of heavier construction, weighing 425 pounds. The last price I had was $310.00 f. o. b. Marion, Wisconsin. The
Forester is manufactured by Utility Tool and Body Company, Clintonville, Wisconsin.

In my work area in Northwest Louisiana there are fifteen Gladney-Murphy tree planters in operation. These planters were made at Minden, Louisiana, by Leaky Manufacturing Company and sold for about $350.00, however, they have discontinued the making of tree planters. The Gladney-Murphy planter weighs about 475 pounds and has a 24" adjustable coulter. The opening plow or trencher can be adjusted for different depths and makes an opening about 1-1/2" wide. When the point and wings are worn off the whole plow is removed, repointed, rewinged and hard surfaced. Hardsurfacing really pays off; a new point without hard-surfacing will usually last two or three days whereas one properly hardsurfaced will last for nearly a season or will plant about 200,000 trees.

The Gladney-Murphy has iron packing wheels which do a good job of packing in many cases, but when you have rocks, recently cultivated fields and deep sand they will frequently lock. Five out of fifteen of these Gladney-Murphy machines have been reworked and rubber packing wheels were installed which is certainly an improvement.

This machine does a fairly good job except in heavy soils which have heavy sod, in this condition the packing is not too good since the opening is made from sideward pressure by the wedge shaped trencher. There is a possibility that the pack wheels do not sufficiently pack the lower root area. It has been noticed during the first growing season that the soil has cracked along the trencher furrow which would indicate insufficient packing. Also in soils where the subsoil is hard and near the top of the ground additional weight is necessary in order to get a trench deep enough to prevent crooking the tap root.

I have heard comments from contractors who have used both the heavy duty Lowther and the light pickup type machine. They have stated, "The Lowther is the best machine but it is too heavy and too hard to turn around in small fields." Harry A. Lowther Company, Joliet, Illinois, manufactures a pickup type planter called the TM Planter that looks good, however, I have not seen one of these machines in operation. According to the photographs and information I have, the machine has the same coulter, opening plow, packing wheel assembly, and additional weights as the standard heavy duty Lowther. It sells for $595.00. Maybe this is the machine we need.

In conclusion, my observation is that the quality of the tree planting depends on the planting site, the skill of the operators, and the adjustment of the machine being used. I have seen many good planting jobs and good survivals resulting from the light farmer type tree planters. These planters have been a great help toward getting many idle acres back into production.
PROTECTING THE YOUNG PLANTATION

By
George W. Stanley, Chief Forester
Kirby Lumber Corporation
Houston, Texas

Introduction

We have reached a point in our discussion that should cause us to "stop" and evaluate the investment. In the South, we have been responsible for the establishment of some 3,500,000 acres of plantations. This acreage could easily represent a minimum investment of some $35,000,000.00. The responsibilities are evident to us, nevertheless, the problem is no longer "selling" reforestation but one of protecting the older plantations and developing successfully new plantations. Plantations have a very "popular" appeal to all of us and the needs for artificial reforestation are indisputable; however, we should not lose sight of the investment in natural reforested timberlands as this investment, dollar wise, is gigantic. When we say "Protecting the Young Plantation", we are also saying "Protecting the Young Timber".

We have heard excellent speakers during this 3rd Forestry Symposium present many technical and practical considerations before "Protecting the Young Plantation" is a factor. The importance of properly evaluating the seed, the planting stock, the planting policies, the plantation site, and the techniques of tree planting cannot be overemphasized. We are realizing that our problems in planting and protecting the plantation are becoming increasingly more complex as we acquire greater knowledge of the trees we are to manage and the locality in which these trees are to be grown. In fact, forest management in the South is becoming so unbelievably intensified that our tree problems and our land use problems are inseparable.

Plantations are so called "man made". We foresters should not allow ourselves to become so enthusiastic with our "creations" that we develop our plantation policies independently of our overall timberland and land use policies. "Protecting the Young Plantation" and "Protecting the Young Timber" are synonymous and, therefore, should be developed conjointly under a unified company policy. The economic

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Projected from tables published in 1950 by the U. S. Forest Service. Includes Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee and Texas.
demands upon our timber growth will require us to place every acre of
our timberlands in a high productive state and in the shortest length of
time. To accomplish this goal, we cannot continue to be reconciled to
all destructive forces. To the contrary, the demands upon the forester
to "grow timber" will increase - not decrease; the demands for the
forester's wisdom to recapture the lands from the customs of local
land users and modify these old "usages" to timber production are ever
increasing; the demands upon the forester's patience to investigate,
analyze and interpret his recommendations to the management as well
as to his local neighbors are exacting; the demands upon the forester's
ability to interpret a timberland policy and share in the making of such
policies are inescapable. All of these demands and responsibilities will
ultimately be placed upon the forester, and this is the beginning of our
"Protecting the Young Plantation".

What are some of the destructive forces that require our attention
in "Protecting the Young Plantation?" Fire, animals, local customs,
insects, diseases, and weather are briefly some of our problems. A
quick review of these destructive forces will certainly emphasize to you
that all of these problems in each locality cannot be resolved before you
expect to establish and "Protect the Young Plantation". To the contrary,
you must study your own timber and land holdings, select a locality that
has a resolvable problem, resolve the problem, establish the plantation
and truly protect it against the destructive force. Remember, you need
at least one or more successful and well established plantations before
you are ready to "attack" the more complex areas. On our holdings in
East Texas, our "attack" has been to select locations known to have a
low fire risk, minimum land use problems, which means minimum animal
problems and minimum insect problems. By using this approach, we
have planted some 27,000 acres of slash, loblolly and shortleaf planta-
tions with, I believe, excellent results. Some of our plantations are
now 13 years of age, and our total losses from all of these destructive
forces are less than four per cent. However, we are rapidly approach-
ing an end to our more selective areas and consequently our problems in
"Protecting the Young Plantation" are increasing.

I think it well that we discuss briefly these destructive forces,
and I will confine my discussion to my knowledge of our holdings in
East Texas.

FIRE

From the management viewpoint, I believe wild fire is our
greatest destructive force. Fire is in turn interlocked with our local
land use problems. The local land use problems are related to animals.
The condition of our plantable lands and soils is related to our "old
usage" of the land and, I believe, contributes much to our insect and
disease problems. Our feelings run strongly to fire protection. Our
longleaf lands, which are our plantable lands, are rapidly converting,
with the aid of fire protection, to mixed stands of longleaf, loblolly, and shortleaf species. It is now estimated that we will plant some 50,000 acres. However, we feel that given better fire protection, above the level now experienced, our plantation acreage will not be 50,000 acres but somewhat less. It is for this reason, we are prolonging our planting program into 1962. There is a strong question in my mind, particularly in the face of such rapid conversion, as to whether we can afford to perpetuate pure longleaf stands by the use of fire and at the expense of our overall pine management program. Our feelings are strong toward the reforesting of our open lands, and no doubt we will continue to use loblolly, slash and shortleaf species in the establishment of our plantations. In addition, we feel the necessity of underplanting selected stock in our natural timberlands. All of these objectives can best be obtained by depending upon good fire protection.

We are leaving the door open as to the use of controlled fire as a silvicultural tool. When the time comes, we will know best its use in light of our several years of adequate fire protection, and perhaps our local neighbors will then understand our technical motives.

We feel that one of the first steps in "Protecting the Young Plantation" is to provide access to the area and protect the plantation from "wild fires" spreading onto the area. Prior to planting, or immediately following, we move into the area and establish permanent roads and fire breaks. Our primary fire breaks are constructed with a bulldozer and plow unit. These breaks are some 15 to 20 feet in width, and the fire lanes are maintained with a John Deere Tractor Unit equipped with a disk. Our initial establishment cost varies from $10.00 to $20.00 per mile and our maintenance cost varies from $3.00 to $5.00 per mile. Our permanent roads, 30 to 40 foot rights of way, cost approximately $500.00 to $1,000.00 per mile, as constructed on longleaf lands. There are numerous methods in constructing fire breaks. The exact type constructed and the equipment used for maintenance, aside from cost, is not so important as the fact that precautionary measures have been taken and you have demonstrated your intent to "Protect the Young Plantation".

ANIMALS

It is well that we study the land use problems in each locality before we attempt to establish our plantation. Such a study would include the animal population and the basic conflicts, if any, of the land and the manner in which the land had heretofore been used. Our overall problem is the grazing of beef cattle upon the open range. To this end, I believe we can attack the the problem with good pasture leases, encourage the lessee to develop good stock by fencing and other accepted range management practices, and at the same time grow good timber conjointly. This will require the lessee to not burn the range and increase the herd up to but not exceed the range capacity. After this major step is accomplished,
we can look for better range management to minimize our tree damage around water holes and other points of congregation. Technically, it is always desirable to wait one or two years before grazing the young plantation; however, at times our desire must yield to practical application and consequently grazing will begin sooner. The damage to young plantations from good grazing leases is negligible compared to the damage caused by fire. Also this approach is being successfully developed on holdings other than Kirby's. I prefer to call this approach "neighborly". That is, we invite their use of the land, they respect our property and timber program, and we respect their cattle.

A word of caution is advanced insofar as dairy cattle are concerned. The eating habits of dairy cattle, particularly during winter months, is to "bunch" and also "feed or browse" directly on young pines. The mortality of the young plantation from this source is severe. Fortunately, this problem is centered in few localities, and we are seriously considering requiring the lessee to provide winter pasture off the range, and not leasing the plantation areas as quickly after planting as would be available with beef cattle.

You will no doubt encounter some mules and horses along with your cattle, however, we have found no appreciable damage from these animals and usually count them in with beef cattle.

After you have studied your planting locality and find, in addition to the animals above, hogs, sheep or goats, it is not too bold to say that you truly have your problems in "Protecting the Young Plantation". These animals, in the early years after planting, are as equally destructive as wild fire. The affinity of hogs to longleaf roots is well known. If this is the species selected, then "hog proof" fencing and consequent exclusion of this animal from the plantation is a must. Such fence, including mesh wire plus two or three strands of barbed wire will probably cost some $1,000.00 per mile. It is well to observe at this point that all hogs are not of the so called "razorback" ancestry. I believe the "razorback" ancestry not only shows affinity to longleaf, but to slash pine as well; however, it is well to carefully study your own timber location and endeavor to determine the type and number of hogs causing your problem. It is conceivable you will have areas in which hogs are not a menace, and, in addition, represent the principal livelihood of your neighbors. If you can conveniently live with the "hog" and proceed with the growing of other species of pine, your timber problems will be minimized. On the other hand, should the hogs be of the "razorback" ancestry and longleaf or slash pine is the species of your choice, you have no alternative but to fence, encourage cattle pastures, and truly assert your ownership of the land.

Sheep and goats will kill loblolly, slash and shortleaf seedlings during the first one or two years after planting by "browsing". They will also deform most of those trees not killed by "nipping" out the terminal buds. Sheep and goats also retard the height growth of longleaf seedlings by biting off terminal buds. In protecting the young plantation,
it is highly advisable to exclude sheep and goats from the planted area until sufficient height growth has been attained. Again, it is well to study your locality. If the sheep or goat population is not dense nor concentrated, and it is possible to regulate the number on the range, a few years of intensive range regulation may see species other than longleaf beyond the damaging stage. In this instance, you may save the cost of fencing, wire mesh and barbed wire, and the exclusion of fire would be a must. On the other hand, it is questionable that the sheep and goat population can be adequately regulated on the basis of acres per head on longleaf plantations except for many years after planting. Again, if longleaf is the species chosen for management, you have no alternative but to fence, encourage cattle pastures, and truly assert your ownership of the land.

Texas has another animal, the "cotton tail rabbit" (Sylvilagus floridanus alacer - Bangs) that causes frequent light to occasional severe injury to loblolly, slash and shortleaf seedlings. Rabbits will bite off the side branches, buds, or entire seedling. The attack is usually concentrated during the winter. Sometimes the attack is made upon the newly planted trees, and occasionally the winter following. Usually, if you are planting "old fields" or "sandy areas" in the general territory of "farming" areas, the rabbit population is high. Repellant solutions have been successful; food poisoning has not proven too satisfactory, whereas intensive hunting and killing of the rabbit appears to be a possible solution. Rabbit damage may be reduced by (a) substituting longleaf species, which rabbits seldom injure, (b) by planting in late winter and using large seedling stock of suitable species, and (c) burning off the area prior to planting.

There is another animal, the 'eastern pocket gopher" (Geomys breviceps - Baird), that causes frequent light to occasional severe damage to all species of pine trees. Gophers eat the roots of the pines as encountered in tunnelling. They consume part or all of the roots of trees, often times they will pull the small seedling bodily into the tunnels and consume them utterly. Gophers are slow workers but if you are not alert you will suddenly realize that these gentlemen have reduced your plantation down to the level of a "first thinning". Gophers may be controlled by trapping or dropping poisoned food into the tunnels. Maize grain treated with strychnine is one effective type of food poison. Gophers are usually found in deep sand areas and in the general vicinity of "old fields" or farming areas. Burrowing or tunnelling is most noticeable from November to May. Should you plan to plant an area that is inhabited by gophers, it is well to start your "attack" at least a year before the planting.

You gentlemen in the east may have some problems from the "Cotton Rat", whereas we in Texas may have missed the "pest". However, we have "armadillos" that are beginning to receive our attention as a suspect, however, there is nothing conclusive.
INSECTS

We place the "Texas leaf cutting ants" (Atta texana - Buckley) within this restricted range as a very serious hazard. These "pests" are well organized into the various depredator trades; humorously named "cutters", "haulers", "loading and un-loading crews", "patrolmen" to regulate the traffic, and "warehousemen" to store the material depredated, and the "queen"; all combined they thoroughly remove needles, buds, and often the bark of planted pines. Slash pine may possibly be more susceptible, but frankly, when these pests start depredating they are not always selective as to species. Ant "towns" should be attacked at least a year before planting, and preferably during the wet, cold winter months, at which time the pests are hibernating. Fumigation by Methyl Bromide and Chlordane powder or solution are the two most effective chemicals; and I refer you to the Texas Forest Service - Research Note No. 1, July, 1952, "The Use of Methyl Bromide and Chlordane for the Control of The Texas Leaf-Cutting Ant". Their publication develops the treatment in detail and deserves your further study. Generally, the town ant "strips" the seedling and removes the material to their underground chambers, and ultimately the material is the source of fungi growth and the fungi is the food and not the pine material.

Towns of ants are easily detected. The "town or colony" consists of groups of mounds. Each mound may vary in size from 8 to 24 inches in diameter and crater like shaped, until washed down by rain. The size of these "towns or colonies" vary and to relate the largest one observed would sound like a truly "Texas yarn"; however, "towns" cover areas of 100 square feet up to 3 acres in size. The ants travel from the mounds up to possibly 1,000 feet, and, of course, within the radius serious damage is caused, depending upon the size of the "town". Fumigation of the "town" is rather intensive and repeat treatments are highly advisable. If the winged queen is not killed, she can easily fly great distances after mating and start a new colony.

Mr. Ralph Law at Nacogdoches, Texas, is trying a new approach that may have merit; that is, after fumigation, plant rye grass as a trap food during the winter months and endeavor to lead the ants to this type of food rather than pine seedlings. However, I understand the recent winter drouth did not allow sufficient rye seeds to germinate and consequently the pines were "stripped". However, I am sure that Mr. Law will not relax his efforts on our little "pest" and we will be interested in the outcome next year.

Weevils (Hylobius pales - Hbst and Pachylobius piciuorus - Germ) attack planted loblolly and slash seedlings in the spring following planting. These "pest" start with the tender bark near the bud and work downward to strip the bark from the stem and even the roots. We have not observed this "pest". However, our pre-planting procedure requires us to review the "old growth" timber and there is no doubt that our "logging slashes" should be treated or our planting area delayed for several years after
such cutting.

There are other insects such as the Nantucket Tip Moth (Rhyacionia frustrana - Comstock), Sawfly (Neodiprion lecontei - Fitch), Pine Web Worm (Tefralopa robustella - Zeller), Adults of Colaspis (Colaspis pini - Baker), and the customary bark beetles. The insect attacks in plantations have heretofore been minor, however, we recognize the threat. Chemical sprays will aid considerably in control. In addition, should the plantation be injured by fire, hail, ice or wind storm, there is no substitute for augmenting chemical attack with a well organized salvage program. I should not pass without mentioning that the "tip moth" has been under observation in several of our plantations in lower Newton County. I believe its presence is due to the poor site upon which the loblolly pine is planted. We have, within the past two years, mixed loblolly with slash and the results of such mixtures upon the "tip moth" attacks are not conclusive. Perhaps the study will be available at a later date.

**DISEASE**

The southern fusiform rust (Cronartium fusiforme, Hedgecoch and Hunt) is no doubt the most serious disease so far encountered in southern pine plantations. Thus far, this disease has not been a major factor in our East Texas area. We attribute much of this to the care given the seedlings at the State nursery. I am most hopeful we will continue to be passed by insofar as this disease is concerned.

Brown Spot (Scirrhia acicola - Dearn), Needle Rust (Coleosporium), Needle Cast (Hypoderma lethale - Dearn), enlarged lenticels and chlorosis have been observed in our plantations, but thus far no serious injury has developed.

**WEATHER**

Abnormal weather conditions in recent years have caused us to classify weather as a destructive force and one that cannot be accurately evaluated. It is well to study your own timberland areas in light of the long range weather cycles, as the decisions prior to planting definitely influence the degree of destruction by weather in later years. I feel that we have been reconciled to weather, nevertheless, weather will undoubtedly receive more of our attention in ensuing years. Studies such as "cloud seeding", drouth cycles, wind patterns, lightning intensities and ice storm frequency will be pursued.
SUMMARY

In summary, we should all realize that the responsibility of "Protecting the Young Plantation" is or will be vested in the forester. The responsibilities today may be in some cases assumed or in other cases implied, or in most cases placed upon us by our top management. The details of forest management are definitely passing to the forester. If we are to accept this responsibility, then we cannot allow ourselves to be reconciled to the destructive forces.

I believe wild fire is our greatest overall destructive force and, of course, wild fire is interlocked with our local land use problems, insects and diseases. Domestic animals and timber may be grown together but with limitations. It is certainly advisable to pretreat plantation areas known to have a high population of rabbits and gophers.

Insects are as equally capable of inflicting damage to our timber as any single item heretofore discussed. Our insect problems have always been present, but we are just beginning to "attack" this problem forcefully. In addition, the "mortality" of our timber caused by these pests can no longer be accepted as inevitable, but rather we must seek the means to salvage the timber and reduce the rate of our "mortality". It is encouraging to note the emphasis that is now being placed upon our insect and disease problems.

"Protecting the Young Plantation" is more than a challenge to our technical ability, it is a challenge to our human relations with the mass of individual minds that influence the destructive forces.
THE MANAGEMENT OF YOUNG SOUTHERN PINE PLANTATIONS

By
P. M. Garrison, Chief Forester
Gaylord Container Corporation
Bogalusa, Louisiana

Let me make my position eminently clear, I speak only for one industrial management. While we have been establishing pine plantations for 34 years and operating them to some degree for the past 27 years, the technical management, at least in my mind, is still somewhat nebulous.

Even though I know very little about the management of southern pine plantations this fact will not deter me from talking fluently on the subject.

Before we attempt to discuss the mangement of any forest property we should first determine and define definitely but not rigidly the objectives of management. These are as widely varied as are the properties themselves, and almost as changeable as the wind. Basically I believe the objectives of management fall into two fundamental categories, and I am not sure but that these two categories merge and become one when properly interpreted.

These fundamental objectives of management are:

1. Production of the greatest volume of raw material:
   (a) The integrated use of forest products:
       Christmas trees, pulpwood, poles, piling, sawtimber
   (b) Development of special products:

2. The greatest financial return:
   (a) Control of run-off
   (b) Maintenance of water supply
   (c) Development of game cover
   (d) Recreation

The greatest financial return may mean different things to different people. The greatest financial return to a company such as mine may not necessarily mean the greatest number of dollars in the value of the raw material; the stabilization of a great industry and the benefits to all levels of our economy from such stabilization may be far greater than the individual value of the products. The greatest financial return is reflected in stability of community, volume and continuity of employment, stabilization of the tax base and the support of all degrees of government, the peace of mind of management and employees, and in many other intangible values.

I recently had the opportunity of spending a day going over extensive young pine plantations in Southwest Louisiana. These plantations varied in age from 1 - 6 years. The young foresters in charge of these areas were doing some serious worrying as to how they were going to manage
these plantations in the immediate future. Here again I must reminisce a bit for I had started going through the same procedure some 20 years ago and for that matter I am still going through it. I think it will always come as a considerable shock, particularly to foresters who have established plantations and have literally sat up with them during their development, to arrive, where, for the first time, good forest management dictates the use of the saw and axe. My first experience along this line was on a direct seeded loblolly plantation which at the time was approximately 7 years old. The stand amounted to some 3,000 trees per acre, was thinned with a machete and the severed trees having no value were left on the site. The stand was reduced to about 1,000 trees per acre and since that time has been thinned twice more. The total usable volume removed amounts to 11 cords, the volume remaining when this plantation was 30 years old amounts to 34.6 cords per acre, or a total production during its first 31 years of 45.6 cords per acre. This on a not too favorable loblolly site and the plantation severely retarded by Nantucket tip moth during its early years.

My next experience was also accomplished under difficulty, an 11 year old hand planted slash pine plantation. I and many other foresters literally beat a path around every tree in this experimental area before we gained courage enough to embark upon a thinning program. This plantation was thinned 3 times in a 26 year period, first when it was 11 years old, the second thinning when it was 16 years old, and the third thinning when it was 25 years old. The first thinning removed 25% of the stand, the second thinning removed 10% of the stand, and the third thinning removed 15% of the stand. The total usable volume removed in 3 thinnings amounts to 16 cords per acre, the remaining stand at 26 years was 37 cords, or a total of 53 cords.

Our next attempt at management was the establishment of 4 - 20 acre experimental areas in a plantation which was 14 years old at the time of the first operation. These experimental areas were designed as follows:
- To remove 15% of the stand
- To remove 20% of the stand
- To remove 30% of the stand
- And to remove 40% of the stand in the first thinning.

Ten years later the 15% thinning was repeated, and the 20% thinning was repeated. The outstanding result of these two thinnings was the fact that the volume remaining at the end of the second thinning operation was almost identical on the two experimental areas, yet the volume removed from the 20% thinning area was just twice the volume removed from the 15% thinning areas. At the conclusion of the first thinning operation on these experimental areas it was definitely determined that neither the 15 or the 20% original removal was heavy enough. Those of us who worry with the future management of the stand were of the opinion that 40% removal in the original thinning was proper, but that we erred as all foresters are inclined to do, our conservative thinking dictated the removal of 30% in the original thinning rather than the more severe 40%.
At the moment we have established and are carrying on detailed studies on 35 (?) areas. About the only thing that we can say with any degree of surety is that the original thinning to accomplish our purpose should be at least 30% of the stand, secondly that a greater volume is produced and recovered by frequent light thinnings, and this surely is no astounding new discovery insofar as the management of forests is concerned.

Our original thinking insofar as the maximum producing capacity of our southern soils indicate a residual volume to be maintained of between 15 and 25 cords per acre. This residual volume that the soils are capable of maintaining is indicated to us now as being in the neighborhood of between 30 and 50 cords per acre. We are personally thinking of 40 cords as the minimum residual stand to be maintained.

The management of plantations never becomes static. You, who are not familiar with plantations would perhaps not dream of a hardwood problem in a plantation stand that had had a full canopy of pine over a period of 25 to 30 years, yet we find that on areas which have been maintained in such a condition that there are presently as many as 400 hardwood stems per acre. We, and you, are faced with a cull hardwood removal problem which becomes more serious every time the pine component of the stand is partially operated. It is not hard to realize that without proper management the entire stand can be converted from pine to hardwood. We hear much of the control of this particular problem through utilization, and this is definitely in the picture, but I fear not for many years to come on a scale which will alleviate the cull hardwood problem on pine lands.
Q. "How many trees are you planting per acre?"
A. (Clark) "About 8' x 8' on underplanting but about 6' x 6' on cleared area. On some areas we leave hardwoods we think may have a potential value. All has been hand-planting using road crews and spotting crews at about 88¢ per hour."

Q. "Have you ever used single-frill girdle without ammate?"
A. (Clark) "Yes, we started with that but found stems 2" to 8" with prolific sprouting and we lost ground. Ammate gave us less competition and is applied in cups less than 12" of the ground. So far we are not satisfied with control of sprouts using 2, 4-D even though we know it is cheaper."

Q. "Have you tried this over established natural reproduction?"
A. (Clark) "Yes, underplanting is only used on areas where we didn't have a seed source and didn't want to take a chance. Our regular girdling program covers 6,000 to 10,000 acres per year."

Q. (Molloy) "What was your kill with the single-frill method?"
A. (Clark) "Immediate kill was good. We apply ammate on trees 2" - 6" and frill those larger. Gum and hickory are ammated regardless of size."

Comment: (Wakeley) "There are at least 4,000,000 acres in need of underplanting or interplanting and that figure is a conservative estimate."

Q. (Don Young) "How much of a problem is hardwood debris?"
A. (Clark) "There has been some damage to larger saplings. The burning helped to clean out brush and made it easier to plant. We prefer to girdle after planting."

Q. (Joe Burns) "How many hours did you plant per day?"
A. (Gipson) "We averaged about seven to seven one-half planting hours. The men change off between machine and planter."

Comment: (Lewis) "The ideal planting season only lasts 35 to 40 days. We had only two planters so hired additional crews and planted four 10-hour days on through Saturday and Sunday. We planted 1,300,000 seedlings in a month and a half."

Q. "What were your criteria for beginning your thinnings?"
A. (Garrison) "Every tree in the plantation was different. There was an even distribution of crown classes, and growth had not slowed down. There was no research that dictated the need for a thinning. I think with a 6' x 8' spacing such as we use the first thinning should take place at 15-20 years of age."