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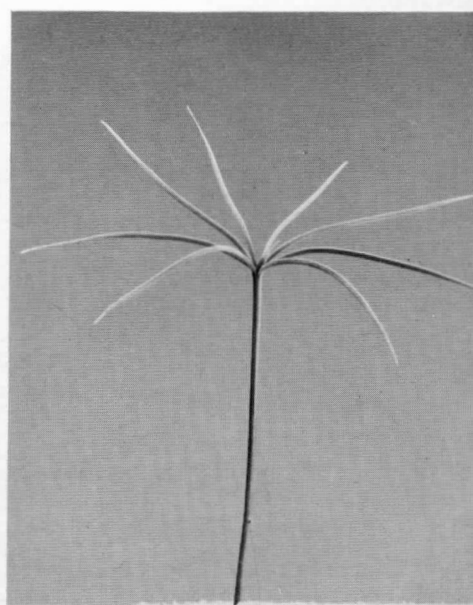
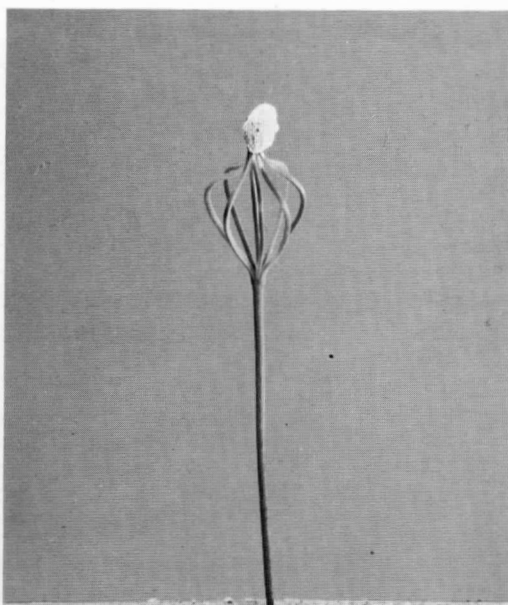
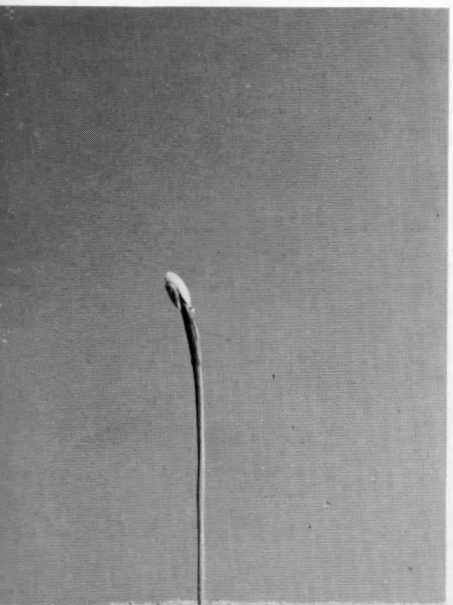
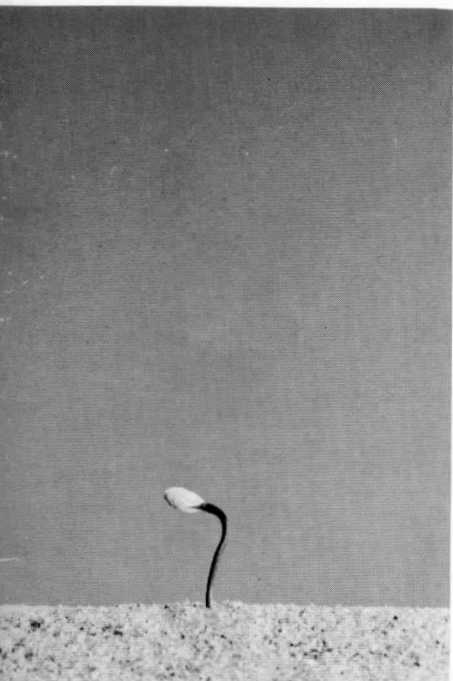
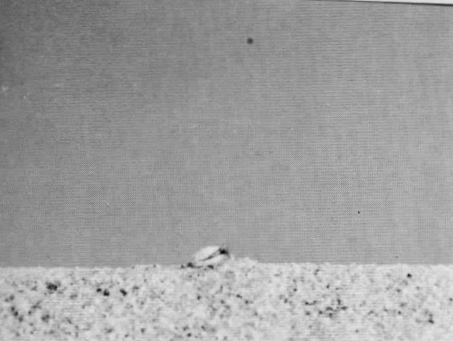
DIRECT- SEEDING SLASH PINE

W. F. Mann, Jr.

and

H. J. Derr

SOUTHERN FOREST EXPERIMENT STATION
W. M. Zillgitt, Director
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE



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Guides for DIRECT-SEEDING SLASH PINE

This paper summarizes recommendations for direct-seeding slash pine. Guides for seeding longleaf and loblolly pine were published in 1959 and 1961 as Occasional Papers 171 and 188 of the Southern Forest Experiment Station. The southern pines vary in their requirements for successful establishment, and recommendations given here for slash pine should not be applied to other species.

The Southern Forest Experiment Station began intensive study of slash pine seeding at Alexandria, Louisiana, in 1947. For 10 years, research was concentrated on seedbed requirements, seasons of sowing, presowing seed treatments, and predators of seed and seedlings. Simultaneously, a search was carried on to find a repellent coating that would protect seed of all southern pines from birds, rodents, and insects. By the time an effective combination of repellents was introduced in 1957, enough information had been assembled to permit formulating broad prescriptions for seeding slash pine operationally.

Commercial operations began immediately. At first, they were largely confined to Louisiana and adjacent States, but successes stimulated a gradual expansion of large-scale seeding throughout the lower Coastal Plain. These guidelines, then, are based on detailed research supplemented by observations over a broad area of the South.

The difficulty of formulating hard-and-fast rules for seeding probably is greater with slash

than with any of the other southern pines. One reason is that slash pine is grown on a broader array of sites than loblolly or longleaf; sites range from wet flatwoods soils to deep, dry sands of the rolling uplands. Methods of seeding often differ from one soil type to another. Second, climatic conditions—especially summer rainfall, which diminishes in a westerly direction—vary widely over the east-west range of slash pine. Finally, requirements for seed treatments, seasons of sowing, and seedbed preparation are not always clear cut. The fact that sharp definitions cannot always be made does not imply, however, that slash pine is especially difficult to seed.

The purpose of this paper, as of previous ones, is to cover all phases from initial planning to final appraisal of results. Each phase is treated in sufficient detail to permit a forester who is inexperienced in the technique to seed a stand. Recommendations for further reading will be found at the end of the text.

PLANNING

Areas to be seeded should be chosen and inspected at least 8 months in advance, so that plans can be made for seedbed preparation, drainage, hardwood control, and protection. Especially on large tracts, the examination will be facilitated if a map and aerial photographs are available. Special items to record are areas to be burned; the need for mechanical



Direct seeding is effective on a wide variety of sites, including some that are not readily plantable. These slash pines are on organic coastal soil requiring intensive presowing site treatment.

seedbed preparation; location of ponds or flats that require draining; areas where livestock congregate; infestations of town ants, harvester ants, and pocket gophers; the need for hardwood control either before or after sowing; approximate stocking of desirable reproduction already established; and accessible prominent points for flagging crews if aerial sowing is anticipated.

Protection must be planned well ahead of sowing, for seed and seedlings are food for many different animals. The repellent coating safeguards seeds from most of the major predators, but it is ineffective against others such as town ants, harvester ants, short-tailed crickets, and squirrels, which may be numerous on localized areas.

Town ants, found in portions of east Texas and Louisiana, destroy both seed and seedlings. Colonies must be fumigated in advance of sowing, and until the pines are 10 feet tall the area should be checked periodically so that new nests can be treated.

Harvester ants occasionally take large quantities of repellent-treated seed, but they do not attack seedlings. They are found only on sandy soils. Nests are easily poisoned individually with common insecticides, but poisoning is impractical for areas more than several acres in size. Where nests are numerous, the most expedient course is to seed on a limited scale and make frequent checks for ant depredations. On deep sands, covering seed with soil is the recommended procedure and will probably give good protection.

The short-tailed cricket may be a serious predator on certain sites. On heavy, wet soils cricket burrows sometimes number more than 10,000 per acre. Seed and portions of seedlings are frequently found in their underground chambers. The repellent coating seems neither to deter crickets from carrying away seed nor to harm them. Nevertheless, many successful seedlings have been carried out on areas with high cricket populations. Present recommendations are to maintain high sowing rates where crickets number 1,000 or more per acre.

Squirrels may cause severe losses on localized areas, especially in hardwood stands. Spot sowing seems particularly susceptible, probably because the cleared spots are easy to find. Laboratory trials clearly indicate that squirrels are not repelled by the chemical coating and suffer no ill effects from eating it. The best protection is to sow as hardwood leaves are falling, so that seeds will be covered and hard to find.

Pocket gophers, often called salamanders, kill seedlings by eating the roots. Damage may start after the first year and continue until pines are nearly 10 feet tall. Damaged seedlings usually turn brown; and when uprooted they are found to have only a short section of the taproot. Smaller seedlings may completely disappear, for the gophers pull them into tunnels to feed on the roots. Gophers prefer sandy, well-drained soils, and occasionally tracts up to several hundred acres in size will have heavy concentrations. The usual indications of their presence are mounds of earth about 8 inches high and 12 inches across. Gophers should be controlled as soon as they are detected. An effective method is to treat milo maize with strychnine and place a small handful in the tunnels at 1-chain intervals within the infested areas.

Rabbits destroy both seed and seedlings, but, since the repellent coating ordinarily protects the seed, the greatest danger is to trees up to 3 or 4 years old. Young, succulent seedlings are often eaten completely; older ones are clipped off at varying heights. Rabbits are game, and hence assistance of State wildlife officials should be sought when populations are high enough to be a problem.

Young stands are vulnerable to damage by cattle, sheep, goats, and hogs. These animals are rarely a serious problem when concentrations are light. Seedbed preparation and hardwood control, however, attract animals from several miles away. Congregation of animals is apt to be most troublesome on small tracts, where a few animals may result in heavy overuse. Therefore, it is necessary to appraise the number of animals using nearby land, as well as those on the area to be seeded.

Control of livestock under open range conditions is sometimes difficult. Burning more acreage than will be sown, or burning nearby tracts as a diversionary measure, will often lessen the hazard from cattle and sheep. Prescribed burning of 4- and 5-year-old slash pine plantations has also minimized hog rooting. Temporary fencing is sometimes needed in severe situations.

SELECTION OF SITE

One of the first questions in planning for direct seeding, as well as for planting, is which species is best adapted to the site. Definition of slash pine sites is complicated, for the species

has been planted with good success on a wide variety of soils beyond its natural range.

Originally, slash pine grew almost exclusively in wet "flatwoods" soils of the Coastal Plain from eastern Louisiana to southern South Carolina. It is undoubtedly the best species for these moist sites, which are characterized by a shallow clay pan or a high water table. Large-scale plantings 100 to 200 miles west and north of the natural habitat have extended the species into east Texas and the northern portions of Louisiana, Mississippi, and Alabama. Since many of these sites are relatively dry, it appears that slash pine is well adapted to a broad array of soils. Recent evidence strongly suggests, however, that it should not be chosen for very dry soils, like those in the sandhills of western Florida.

Probably the best criterion for judging the suitability of a site for slash pine is the performance of nearby planted or natural stands on comparable soils. Factors other than height growth should be considered. Of primary importance is the hazard from fusiform rust, which in some areas damages slash pine stands severely before they become commercially operable. The incidence of glaze ice must also be considered, for slash pine is subject to greater damage than any other of the southern pines. Finally, the hazard from woods hogs must be appraised because they often root slash pine as freely as longleaf.

Once it has been decided to regenerate slash pine on an area, a choice must be made between direct seeding and planting nursery-grown trees. Direct seeding is practical under

Slash pine has been direct-seeded successfully on a wide variety of soils and site conditions. This 4-year-old stand was established on open longleaf land by broadcast sowing on disked strips.



a wide variety of soil and cover conditions, but in some situations it requires more seedbed preparation than planting. The best example of this requirement is on dry sites with a heavy cover of grass, especially in the western Gulf region where summer rainfall is apt to be deficient. On these sites, reduction of competition by disking or other mechanical methods is necessary to assure consistent high survival during the critical first growing season.

Seeding has been done on some sites that would be difficult or costly to plant. Dense stands of hardwoods or brush often prohibit machine planting and substantially increase costs of hand planting. Such areas are relatively easy and inexpensive to seed. Similarly, seeding may be preferable on areas where standing water limits mobility of men and machines.

Even though slash pine seeding has proved feasible on soil and cover conditions of a wide variety, two common situations must be avoided. First, broadcast sowing must not be attempted on sandy soils where the surface dries out so rapidly that germination is unusually low. Lakeland, Kershaw, and Eustis soils are in this category. Machines have been developed to bury seeds from $\frac{1}{2}$ to 1 inch deep, but they have not been tried extensively. The other situation to avoid is where seed is apt to be submerged in water, including slowly

draining surface water on uplands. Brief submergence weakens the repellents, and periods of several weeks or longer sharply reduce viability. Delaying until surface water is gone or danger of flooding is past, and mechanically elevating seedbeds in advance of sowing, will often circumvent this problem.

A general rule with any species is to avoid sites on which survival of planted pines is likely to be low. There is a tendency to try direct seeding where planting has been unsuccessful, but it is not a panacea for regeneration problems. A logical way is to begin on average or better sites and gradually expand into more difficult ones as experience is gained.

SEEDBED PREPARATION

The type of seedbed to prepare depends largely on site and cover conditions, distribution of summer rainfall, and the value placed on fast growth and early returns. The method of sowing also must be considered, because it may be desirable in some situations to use special machines that prepare a seedbed and distribute seed simultaneously. In this section, only presowing site treatments are discussed.

Open, treeless areas that normally have a heavy stand of grass should be disked for consistent success in establishing a stand and to obtain fast growth.

Cutover longleaf sites in the West Gulf region are difficult seeding chances, because the summers are dry and the grass competes with the pines for moisture. The sod must be destroyed in advance of sowing.



On wet sites with a high water table, as in the flatwoods of the Southeast, disking elevated strips (often referred to as bedding) is necessary to keep seed from being killed by submergence and to increase growth. Where the water table is excessively high, drainage ditches are needed in addition to the disked beds. If there is a dense cover of palmetto and gallberry, some landowners burn and chop in advance of disking.



Gallberry and palmetto often abound in the flatwoods of the Southeast. Their control is prerequisite to pine seeding.

Optimum height for disked seedbeds has not been determined. Many landowners use a Rome bedding harrow with six 28-inch disks, pulled by a D-6 crawler tractor; it makes beds about 8 inches high. Disked strips ordinarily abut, leaving no balks, to prevent excessive spacing between rows. About 20 acres can be disked daily. Costs average between \$4.50 and \$5.00 per acre.

On poorly drained flatwoods soils, disked seedbeds are elevated to improve seedling growth.



Elevated seedbeds, disked in strips, are also recommended for heavier flatwoods soils of the West Gulf region. They are characterized by shallow claypans that make them wet in winter and very dry in summer. Consequently, disking reduces competition from grasses that abound on these sites, lessens the hazard to seed from flooding, and promotes growth.



When elevated disked strips on wet sites are sown broadcast, seedlings on ridges quickly outgrow those in balks. These slash pines are 2½ years old.

Several companies in the Southeast have used fireplows to elevate seedbeds in stream bottoms that are subject to flooding. High ridges are formed by two adjacent passes with a middlebuster plow. Plowing is done in the summer when sites are dry enough for operation of tractors.

Stream-bottom site bedded with a fireplow in preparation for sowing.



Another unique method devised by a company to regenerate sites that have standing water much of the year involves pushing up small hills of dirt with a bulldozer. Each hill is about 18 inches high, and 300 to 400 per acre are made when the land is dry enough for tractor operation. Sowing is done by hand in the winter.



Tussocks made with a bulldozer on an extremely wet flatwoods site.

On the rolling uplands, disked strips can be prepared with a flat bed. A heavy-duty offset disk, cutting about a 7½-foot swath, does a good job at a reasonable cost. It can be drawn by a light crawler tractor, similar to those used for planting or to pull fireplows. In most commercial operations strips are spaced 6 to 8 feet apart to reduce costs. With this arrangement, about 20 acres can be disked daily at a cost of about \$2.00 per acre.

Spring and summer disking is preferred for both flat and mounded strips, for the best kill of grass roots is obtained if the sod is turned over when the weather is hot. Moreover, allowing 4 to 6 months for the soil to settle minimizes seed losses from silting, which have been as high as 50 percent on freshly disked seedbeds. Burning off the accumulation of dead grass and other vegetation facilitates pulverization of the soil by the disk. The burn may be made immediately before disking or during the preceding winter.



Disked strips, whether flat or mounded, need 4 to 6 months of weathering to settle the loose soil.

As pointed out previously, reduction of competition by disking often serves a dual purpose of stimulating growth and protecting yearling seedlings from drought. If drought is not a hazard, disking may be justified solely by



On rolling uplands, a light offset disk prepares satisfactory seedbeds.

improved growth. This fact was clearly illustrated by a Louisiana study comparing various seedbeds on a moderately well-drained soil with a dense grass cover. Rain was ample the first year, and survival on all plots exceeded

95 percent. At the end of 5 years, slash pine heights averaged 8.2 feet on disked strips and 5.4 feet on a light grass rough. The difference of 2.8 feet is equivalent to 1 year's growth, or more than enough to offset the cost of disk-



These slash pines are 6 years old. Those in the upper photo were sown on disked strips, those below were seeded in a grass rough.

Plowed furrows give excellent control of competing vegetation, but their utility is limited to special conditions. Their main drawbacks are that seed is washed away on sloping ground and killed by flooding on flat, poorly drained sites where water accumulates in the furrow. Furrowing has been highly effective on flat, well-drained sandy soils where danger from flooding and washing are minor. Furrows can be made with a fireplow and light tractor. At a spacing of 8 to 10 feet between centers, furrows will cost \$2.50 to \$3.00 per acre. They can be plowed at any time prior to sowing. Furrow seeding, an entirely different technique, will be discussed in a later section on methods of sowing.

Many cutover lands have irregular or patchy stands of low-grade hardwoods, with the grass light beneath trees but fairly dense in openings. In these situations, the kind of seedbed to prepare will depend upon soil type. Sandy or droughty soils should be disked, at least where the grass is heaviest. On soils with good moisture, disking may be unnecessary and burning to reduce grass and litter will be adequate.



On sites with scattered hardwoods, seedbed requirements vary by soil type.

Areas with a dense stand of hardwoods are easy and inexpensive to seed, but the hardwoods must be removed after the pines are established. Ordinarily they are the best seeding chances, for survival is high even in dry years, while planting is laborious and costly. The hardwood canopy shades out most of the



Full stands of low-grade hardwoods shade out competing grasses, so that mechanical seedbed preparation is unnecessary.

grass, making mechanical seedbed preparation unnecessary. Burning is required only if the litter is deep enough to prevent seed from reaching mineral soil. As a general rule, 1 year's accumulation of leaves is not serious, but heavier litter should be burned.

The best time to burn is in the autumn when about half the leaves have fallen from the hardwoods and when the litter is dry. Newly fallen leaves help carry the fire where the old litter is matted down. If the weather is wet at this season, burns can be made at any time during the winter.

Landowners who lack equipment for burning or are unwilling to risk fire spreading to adjacent land may resort to seed spotting, which is described in the section on hand sowing.

Brush and dense thickets of small hardwoods often necessitate presowing site treatment, because the cost of treating numerous small trees individually is prohibitive. Mass methods like disking, cutting with a KG blade, chopping, chaining, and spraying foliage with herbicides are all in commercial use. These treatments are prescribed primarily for control of hardwoods, however, and not as part of the direct-seeding technique. The point here is that hardwoods can be eliminated in advance of sowing if there is reason for doing so. Ordinarily, the best course is to establish pines before killing overtopping hardwoods.



Where hardwoods are small and numerous, they are often treated before pines are sown.

SEED PROCUREMENT

It is important to plan early for seed procurement. The best time is immediately after the site has been selected and inspected, when the amount of seed can be ascertained from the acreage and the sowing rate. A landowner may collect cones and extract his own seed, collect cones and have them processed in a commercial kiln, or buy cleaned seed.

Purchasing from a dealer avoids uncertainties of cost and seed quality. Prices have ranged from \$1.90 to \$4.25 per pound, depending on the abundance of seed and the quantity purchased.

Buying on the open market has two chief disadvantages. First, seed from a local geographic source is difficult to obtain unless a commercial cone-collecting and kilning operation is nearby. Although seed source may not be as important with slash as loblolly pine, there is growing evidence of north-south races. If nonlocal seed must be used, it is probably safest to obtain supplies from sources in the same general latitude. A second disadvantage of buying seed is the probability that cones will come from trees of poor form and growth rate. Commercial dealers buy most of their cones from small collectors who pick largely from inferior trees removed in improvement cuttings or rough, limby trees that are easy to climb.

When purchasing seed, minimum standards for viability, soundness, purity, and moisture content should be specified. They should be verified by current tests in the U. S. Forest Service's Eastern Tree Seed Laboratory (P. O. Box 1077, Macon, Georgia). The buyer should also request the geographic source of the seed, and the year of collection.

There is no objection to stored seed, provided viability is high. Whether fresh or stored, seed should have a minimum of 80 percent viability on a sound-seed basis. Not more than 5 percent of the seeds should be empty. Trash and other impurities should not exceed 2 percent by weight. It is very important to remove cone scales, pine needles, string, and other debris that may clog machines and thus cause poor distribution. A moisture content of 10 percent or less should be specified to obtain a reasonable number of seed per pound, and to avoid the need for drying if the seed is to be stored.

Costs for stratifying and coating with repellents should be agreed on separately from the price of seed. Frequently, treated and untreated seed are offered for the same price. Since the treatments add substantially to the weight, it is usually cheaper to purchase the seed and pay an additional charge for treatment.

Collecting cones and having them processed in a commercial kiln is a common practice, especially among large landowners who want better seed than can be purchased. This method permits procurement of local stock, and collections can be confined to trees of above-average form and vigor. Cost of drying cones and dewinging and cleaning seed ranges from \$0.75 to \$1.00 per bushel of cones.

It is also quite feasible for a landowner to process his own cones. Although specialized equipment is required, its cost can be recovered if a total of 4,000 bushels are processed. A small, forced-draft kiln now available for about \$1,500 will efficiently handle 1,000 bushels in a single season. Equipment for dewinging and cleaning costs an additional \$400. Improved facilities are rarely satisfactory—they are usually inefficient, and they are likely to damage the seed.

Collecting or buying cones may be expensive unless certain precautions are taken. Seed yield per bushel of cones varies widely, and low yield inflates costs substantially. It is pos-

sible to forecast yields several months before collection, however, by cutting sample cones longitudinally, counting the full seeds on the exposed surface, and determining the average yield per bushel of cones from the following tabulation:

Number of full seeds exposed	Seed per bushel of cones in pounds
1	0.17
2	.28
3	.37
4	.48
5	.58
6	.69
7	.79
8	.90
9	.99
10	1.10
11	1.20
12	1.31
13	1.41
14	1.52
15	1.61
16	1.72
17	1.82
18	1.93

Yields tend to vary directly with the abundance of seed, ranging from $\frac{1}{2}$ to $1\frac{1}{4}$ pounds per bushel. When the average is appreciably less than 1 pound per bushel, it may be best to purchase seed or defer cone collection.

Slash seed can be kept almost indefinitely. High viability can be maintained by promptly drying it to 8 or 10 percent moisture content after it is extracted and storing it in sealed containers at a temperature between 0° F. and 32° F. Cones must be picked only after they ripen, stored in a well-ventilated building with free air circulation around each sack, and processed within 60 days after collection. They should be inspected periodically for molding, which is detrimental to cone opening and seed quality.

The ease of storing slash pine seed makes possible substantial savings. Cone production is irregular, with heavy crops occurring unpredictably about 3 to 5 years apart. Since cones are cheapest when they are plentiful and seed yields are greatest, savings of about 50 percent can be obtained by collecting in good and bumper years, and storing for use in lean years.

SEED TREATMENT

Cold Stratification

Speed as well as completeness of germination is important. Prompt, fast germination reduces the time seed is exposed to predators and minimizes the chances of adverse weather. Consequently, it is necessary to stratify lots that are slow to germinate or that germinate over extended periods.

Usually fresh seed or lots that have been properly stored for a year require no presowing treatment. Dormancy is most common with lots that have been mishandled, as by prolonged storage of cones before extraction, or with those stored for several years. Stratification requirements differ from lot to lot, and consequently it is advisable to have germination tests conducted with sublots stratified for varying periods. Reduction in total viability is most common with highly dormant lots, which are in greatest need of stratification. But rapidity of germination is so important that stratification is essential even though it lowers viability.

If advance tests are infeasible, a rule of thumb is to leave fresh seed unstratified and to give 15 to 30 days of stratification to lots stored for a year or more.

Cold stratification is easy and inexpensive. Large lots can be handled as follows:

Take any large metal container without a top, such as a 55-gallon steel drum, and punch drain holes in the bottom. Stand drum in a tub or pan, placing three or four bricks under the drum to permit free drainage.

Weigh out 25-pound sublots, and put each in a separate cloth sack tied loosely so that seed can be spread to a uniform thickness in the drum. Dip each sack in water to wet the seeds thoroughly.

Pulverize granulated peat moss, soak it, and gently squeeze out excess water.

Put a 4-inch layer of moss in bottom of container and tamp firmly.

Place a sack of seed on top of the moss, spreading the seed evenly in a layer not more than 2 inches thick.

Continue to build up alternating layers of seed in the drum, with moss 4 inches thick when tamped. Top layer should be moss.

Place drum and tub in cold room with a constant temperature between 34° F. and 36° F.

Pour several gallons of water into the drum about every 2 weeks to keep the moss wet but not saturated.

About 150 pounds of seed can be stratified in a 55-gallon steel drum. Smaller lots can be stratified in smaller containers.

Seed lots up to 10 pounds can be stratified in a home refrigerator operating at 38° F. They should be soaked in water for an hour or two, placed in polyethylene bags, and refrigerated while they still have surface moisture. The bags are tied, but when the surface of the seeds becomes dry enough water should be added to rewet them.

A number of landowners and at least one dealer stratify large lots in polyethylene bags. The procedure is the same as for small lots, except that 25 pounds are put into an individual bag. Bags, whether of cloth or polyethylene, should be inspected and turned weekly.

Repellents for Coating Seed

The seed coating consists of a sticker, a bird repellent, a chemical for controlling rodents and insects, and aluminum powder to facilitate flow through sowing mechanisms. Since 1955, when the first bird repellent was employed operationally on longleaf pine seed, Morkit, sublimed anthraquinone, Arasan and Arasan-75 have all been used successfully. Until recently, anthraquinone was suggested for hand sowing (for it is not irritating to the skin and mucous membrane). Arasan-75, a dry powder containing thiram, was suggested for machine sowing.

Arasan 42-S, a liquid thiram formulation, is now recommended as the bird repellent for all types of sowing with all species. It provides a durable, dust-free coating that is far superior to any previous formulation. Moreover, it is easier and more foolproof to apply. Endrin must still be added, as well as a latex sticker and aluminum powder.

Knowledge of the repellents and how they act against predators will give an appreciation of proper seed handling and of the need for prompt germination. Arasan 42-S is manufactured primarily as a seed disinfectant and

fungicide. Thiram has a very low order of toxicity, although it is highly irritating to man. Some birds are immediately repelled by the seed coating; others begin to reject treated seeds after sampling one or two. Rabbits, too, are repelled. Mice and other small mammals will eat Arasan-coated seed, although they appear to give it low preference. Insects and large mammals do not seem to be repelled.

Endrin is a poisonous insecticide that requires careful handling. Rodents ingest a sublethal dose (three to eight seeds, depending on the size of the rodent) and then reject treated seed. With the number of seeds normally ingested, birds are unaffected by the endrin. Insects vary in their reaction. Certain species are repelled, while others are not; some die after contact with treated seed and some are immune.

Applying Repellents

Arasan 42-S contains 4 pounds of thiram per gallon. Two gallons will treat approximately 100 pounds of dry seed or slightly more stratified seed. When the latex sticker and endrin are added to Arasan 42-S, the total quantity needed to coat 100 pounds of seed is 2.4 gallons. The following procedure has proved to be effective for 5-gallon lots, though smaller amounts can be prepared similarly:

Place 5 pounds of Stauffer's Endrin 50W in a clean 5-gallon container, add 2½ gallons of Arasan 42-S, and stir with a paddle until the powder is so wet that no dust rises. This is the most difficult step in the entire process. **CAUTION: Wear rubber gloves, use a respirator or work out-of-doors where inhalation of endrin dust can be avoided. Dispose of empty containers so that animals and humans cannot come in contact with them.**

Beat with a paint mixer powered with an electric drill running at 1,200 r.p.m. until the mixture is smooth and free of lumps. This operation takes about 2 minutes.

Mix 25 fluid ounces (about 1½ pints) of undiluted Dow Latex 512-R with another 2½ gallons of Arasan 42-S.

Blend the two mixtures together by pouring from can to can about 10 times.

Directions for preparing repellents and applying them to seed.



Add 5 pounds of Endrin 50W to 2½ gallons of Arasan 42-S.



Stir with wooden paddle.



Beat with paint mixer.



Add 25 fluid ounces of undiluted Dow Latex 512-R to another 2½ gallons of Arasan 42-S.



Blend by pouring from can to can about 10 times.



To 50 pounds of seed, add 1.2 gallons of the repellent as mixer is turning. Tumble for about 2 minutes.



Add aluminum powder and tumble for another minute.



Seed is fully coated; it should be spread out to dry.

The final mixture totals about 6 gallons. It is a stable suspension, but if it is prepared several days beforehand it should be stirred thoroughly before application.

The rolling-tumbling action of a small concrete mixer is very effective for coating seeds. Fifty-pound batches can be treated in a 3¼-cubic-foot mixer in approximately 3 minutes.

About 1.2 gallons of the total repellent mixture are needed for 50 pounds of seed. The first batches should be examined carefully to determine if all seeds are fully coated. The best procedure is to start with a slight excess of repellent, then gradually cut back until a complete coating is obtained with no surplus.

Treating is accomplished by placing a weighed amount of seed in the mixer, then adding the measured amount of the liquid repellent while the mixer is turning. After 2 minutes of tumbling, aluminum powder is added at the rate of 8 tablespoons per 50 pounds of seed, and the mixer is allowed to turn for another minute. Stratified seeds can be treated wet, but a better coating is obtained if the surface moisture is dried beforehand. Treated seed should be spread out 3 to 4 inches deep for drying and stirred periodically. In clear weather, the coating will dry thoroughly in 3 to 4 hours.

Lots of 2 to 5 pounds can be treated by mixing with a ladle in an open container such as a lard can. Approximately 3 fluid ounces of repellent mixture are required per pound of seed. An aluminum overcoating can be obtained by adding 1 or 2 teaspoons of the powder to the seed and stirring for another 30 seconds. Seed should then be spread out to dry.

Whether it is applied by the landowner or a commercial dealer, the repellent coating should be checked for durability before sowing begins. The test is made by putting several hundred dry seeds in a small wire basket and running a full stream of cold water from a faucet over them for 2 minutes. If two-thirds of each seed remains coated, the repellents will weather satisfactorily in the field. If the loss is greater, application was improper and the seed should be re-treated.

Certain precautions are necessary when storing the sticker and the chemical repellents. The latex sticker is a suspension that is easily

broken if stored in an uncoated metal container or subjected to temperatures below 32° F. or above 110° F. If the suspension is broken, the latex loses all adhesive properties and the repellents are quickly washed off in rains. Several serious failures have been traced to improper handling of latex. Arasan 42-S and Endrin 50W should be stored in their original containers, which should be tightly closed. It is a good policy not to keep these chemicals for more than 1 year. Unused chemicals that have been mixed together should be discarded each season.

Holding Repellent-Treated Seed

Operations should be carefully scheduled to minimize the elapsed time between treating and sowing. Some delay is unavoidable, however, especially when seed must be shipped or bad weather interrupts sowing.

Unstratified seed treated with repellents can be stored for several weeks in sacks in a well-ventilated, unheated building. Sacks should be placed so air circulates freely around each one. Stratified seed can be held for a week in the same manner, but for longer periods it should be placed in a cold room with temperatures of 34° F. to 42° F., and with good air circulation around individual sacks.

SEASON OF SOWING

The most difficult question in direct-seeding slash pine is the optimum time for sowing. For some areas fall is probably best, while in others late winter is to be preferred.

If other factors are comparable, fall germination is preferred to spring because seedlings develop better root systems before the weather turns hot and dry. Sowing in fall for germination in spring subjects the seeds to hazards for an excessive time, and overwinter exposure weakens the repellents. Since slash will germinate at temperatures as low as 60° F., fall germination is obtainable in the extreme southern portion of the range. Where temperatures are unlikely to be this high, except for short periods, spring seeding is advisable; this situation is found in the central regions of Louisiana, Mississippi, and Alabama.

Many newly germinated seedlings are often clipped off at the groundline by unknown predators. This inconspicuous damage occurs dur-

ing the coldest part of the winter, when other foods are scarce. It is most prevalent beneath hardwoods, but it can also be serious on open sites.

Fall sowing is recommended for the southeastern region, including the entire flatwoods as well as central and northern Florida. Winters in this region are mild, heavy overwinter clipping has not been reported, and the prevalence of early spring droughts makes February sowing risky.

Slash seedlings are fairly resistant to direct winterkill, but, with other southern pines, are vulnerable to frost heaving on disked strips. If the chances for such an occurrence are great, spring sowing is indicated.

General recommendations can be summed up as follows: (1) sow in October and November on sites within 50 miles of the Gulf Coast, and in interior Florida; (2) sow in mid-February in the upper Gulf Coastal Plain; and (3) if in doubt sow in mid-February, provided that early spring droughts are not common.

METHODS OF SOWING

Slash can be sown by hand, by seed-spotting tools, by hand-operated "cyclone" seeders, by tractor-drawn machines, by airplane, and by helicopter. The method often depends on the size of the area, soil and cover conditions, and

the pattern of stocking desired by the landowner. In many situations several methods are applicable, although costs and manpower requirements may vary.

Hand Sowing

Distributing seed by hand is most practical on small areas disked in strips. It can be broadcast on the prepared ground or placed on spots tamped firm by foot. One man can cover about 15 acres daily when scattering seed, and half this area when placing it on spots. Both methods conserve seed by confining it to disked portions. Men handling treated seed should wear rubber gloves.

For open grassy sites and beneath hardwoods, spotting is growing rapidly in popularity. A spot about 1-foot square is raked or kicked free of leaves or grass, and five or six seeds are dropped on it and very lightly pressed into mineral soil. To prevent blowback, leaves raked from spots should be scattered, not left in a pile on the edge of the spot. Spots larger than a square foot may be necessary where leaf litter is exceptionally heavy. From 1,000 to 1,200 spots per acre are needed, depending on environmental conditions and stocking objectives.

A number of special tools have been developed for spotting. Most have a device for baring mineral soil and a mechanism for meter-

Seed spots can be prepared with a short-handled firerake or with special tools that release a predetermined number of seeds.



ing a predetermined number of seeds on the prepared spot. They sell for \$15 to \$30. Each model has features that adapt it to special soil and cover conditions. For most small operations, a short-handled firerake and an apron for carrying seed are adequate.

A hand-operated cyclone grain seeder is well suited for tracts up to 200 acres in size. It is especially useful on irregularly shaped areas that are difficult to sow from the air, and on tracts where patches of established pines are to be bypassed. Crews can be trained quickly to broadcast seed uniformly, and one man can cover 15 acres daily where brush or terrain is moderate.

This broadcast method is efficient in dense brush where hand-operated seeders are impractical and on other areas where manpower is limited. It is infeasible on steep terrain.

Tractors have also been equipped to sow in rows on strips disked in the summer. Ordinarily twin grain hoppers are mounted on the rear of a tractor, and the metering plates are activated by a drive wheel that is in contact with the ground. Packing wheels are sometimes mounted to firm the soil in front of and behind the seed drop. Rubber-wheeled and crawler tractors have been used.

Tractor-drawn machines have been developed to prepare beds and sow in rows in a single



Hand-operated grain seeders will distribute slash pine seed accurately at a rate of about 20 acres per man-day.

Formerly, a major disadvantage of the hand-operated seeder was exposure of personnel to the chemical dust from the repellent coating. With Arasan 42-S, however, the coating is essentially dust-free.

Tractor Seeding

Many tractor seeders have been developed over the past 10 years. Since they are numerous and diverse, only those that have been tried extensively will be described.

Power-driven cyclone grain seeders are sometimes mounted on a tractor. The swath width is generally about 40 feet, and a small tractor can cover from 30 to 40 acres daily.

operation. They form beds by plowing furrows, disking, or rotatilling narrow strips.

Furrow seeders are the most common. They are of two types: one has a middlebuster plow pulled by a tractor; the other has a plow mounted on the front of a tractor.

Those pulled by a tractor plow a shallow furrow and elevate a narrow mound in the center of the furrow with a set of hillers. Seeds are dropped from a hopper at predetermined intervals onto the mound and pressed firmly into the soil by a packing wheel. The slight elevation of the bed prevents seeds from being washed away or submerged for long periods; pressing the seed into the soil surface improves



This model of the H-C Furrow Seeder operates behind a conventional fire-plow. Adjustable hillers elevate a ridge in the center of the furrow to prevent washing or flooding of the seed.

germination. The method is not suited to poorly drained soils, for the furrows flood in heavy rains. It is also impractical in dense stands of hardwoods.

In another model designed for deep, sandy soils where seed must be covered to obtain complete germination, the hillers are replaced by an agricultural sword. The sword opens a narrow slit for the seeds within the furrow, but up the slope and away from the bottom where water runs, and a packing wheel covers them with soil. This machine is limited to open, grassy areas, as the sword is easily bent or broken by tree roots.

Front-end furrow seeders also work best on sandy soils with good internal drainage. They are more rugged, however, than the trailing type and operate well in brushy hardwood stands. One model, used extensively on the Savannah River Project of the Atomic Energy Commission in South Carolina, sows directly in the center of a furrow. Seeds are dropped from a hopper into a very narrow trench cut about ½-inch deep. Subsequent rains wash sand over the seed, and this light covering facilitates high germination. In dense brush the machine uproots and kills 50 to 70 percent of the hardwoods while sowing on an ideal bed.



Light, compact seeders are designed for sandy soils. Most models drop seeds in a narrow furrow and cover them lightly.



This front-end model has the seed hopper just behind the point of the V-blade. It operates effectively in dense brush.

It is one of the most successful machines developed so far for sandy soils.

Another front-end furrow seeder has a cut-away V-plow that pushes the soil directly into the path of the tractor tracks. The weight of the tractor packs the loose soil, and seeds are sown on each ridge from hoppers mounted on the rear of the tractor. A hopper just behind the plow point can be operated to drop seed in the furrow as well.

Furrow seeders are capable of sowing from 15 to 20 acres per day. Their main advantage is low cost per acre, resulting from efficient distribution of seed and from the combination of bed preparation and sowing in one operation. Establishing trees in rows may also be an advantage, but close in-row spacing may be

detrimental to growth. Disadvantages include: (1) high capital outlay for tractors and machines, (2) low average daily production of seeders, which cannot operate in severe weather, (3) the temptation to sow far beyond the optimum date to utilize machine fully and to meet production goals, (4) rough condition of the ground after seeding, (5) displacement of topsoil—a particular drawback on sites where fertility is low, and (6) limitation to sandy, level sites, and with some models to cleared or open sites.

Disk seeders that prepare flat beds were first developed to sow two rows simultaneously with the same tractor power required for a one-row furrow seeder. Later a single-row model was made for maneuverability in hard-

Disk seeders prepare a narrow bed and sow seed in a single pass. Two-row models have been developed; the one shown here makes a flat bed.



wood stands. Two offset disk units, each about 1½-feet wide, are mounted about 4½-feet apart, edge to edge. A packing wheel and seed hopper and funnel are located behind each set of disks. Behind a light crawler tractor the dual unit can sow about 30 acres per day. This machine is adaptable to a broad array of soils. Sowing rates must be higher than with furrow seeders, because considerable seed is lost by silting even where disked soil has settled for several months. Moreover, disking in the cool, wet part of the year fails to control competing grasses satisfactorily. Otherwise, advantages and disadvantages are the same as with furrow seeders.

The most recent development is a large disk seeder that mounds a strip about 6 feet wide and sows in one pass. It was designed to elevate a bed on sandy flatwoods soils with a high water table, and may be equally applicable to heavy, poorly drained soils. The unit has two sets of disks, each of which throws soil to the center of the strip, a seed hopper,



Two-row seeders are also available for sites requiring elevated beds.

The units can be operated in pairs behind a light crawler tractor.

Aerial Seeding

Aircraft seeding is a widely used and a proven method for reforesting large acreages rapidly and at minimum cost. It requires the least effort and capital outlay by the landowner; in most cases he is only required to furnish accurate maps of the area to be seeded, technical supervision, and personnel for ground control of the aircraft. Accurate work has been done consistently both with small fixed-wing airplanes and with helicopters.

Aircraft of both types require special distributing equipment, which must be calibrated accurately to handle the small volume of seed required per acre with slash pine. In addition, accuracy requires uniform flying speed and altitude, and constant checking by the pilot for stoppage or malfunction of equipment. The landowner must establish, in advance, flagging positions that will insure straight flight lines.

Fixed-wing airplane.—The light monoplane is the only type of fixed-wing aircraft that has been used extensively. It is highly maneuverable and it can operate from short unimproved runways—often constructed on the area to be seeded. Depending on the size and shape of the areas, and on the distance from a landing strip, planes can seed from 150 to 200 acres per hour.



This heavy-duty seeder elevates a bed 12 inches high and 6 feet wide.

and seed funnel between two packing wheels. One packing wheel firms the bed, while the other presses seed into the soil. This machine, which must be pulled by a heavy tractor, is too new for a full appraisal.

For wet soils that require thorough preparation by chopping and disking, a modified disk seeder has been developed. This unit elevates a narrow ridge that prevents flooding. It consists of a pair of two-blade disks set in a hilling position, two packing wheels, and a seeder that is positioned to drop seed between the wheels.

A light plane, based on the area to be seeded, can sow 1,000 acres a day.



Most planes used in agricultural work can be adapted for pine seeding at a cost of less than \$50. Modification is needed because the long, adjustable opening between the distributor and the hopper is too narrow at low sowing rates for an even flow of seed. Plates set in the bottom of the hopper block off part of the aperture, permitting a wider setting.

Flight strips should not exceed 66 feet in width because at normal flying speeds and altitudes the distributor throws seed about 40 feet each side of the plane. Some overlapping of adjoining flights is necessary to prevent skips and to even out the distribution near the outer edges of the seed pattern.

Helicopter.—A light helicopter can operate from a small clearing on the area to be seeded.

It thus has an advantage when a fixed-wing would have to travel a considerable distance to a landing strip. Otherwise the differences between the two types of aircraft are small and the choice often depends on the bid price. The helicopter's landing capability gives it a higher average production rate of 250 to 300 acres per hour, which reduces the cost of flagging and other services provided by the landowner and permits a slightly higher contract price per acre.

A helicopter must be equipped with a power-driven centrifugal slinger for distributing the seed. It must also have a positive, motor-driven meter for dispensing seed from the hoppers into the slinger. The types in use will cover a 99-foot swath. When properly adjusted they distribute seed accurately.

Operating from small clearings, helicopters can sow 200 to 300 acres per hour.



RATE OF SOWING

Optimum sowing rates vary by method of sowing, site, cover, bed preparation, local hazards such as livestock, stocking goals of the landowner, and climatic conditions. A few large landowners have started prescription sowing. Some vary the sowing rate as conditions seem to indicate, but most employ a single rate for all conditions. As experience accumulates, sowing rates tailored to individual situations will be developed.

In the West Gulf region, recommended rates per acre for initial trials are 1 pound for broadcast sowing, $\frac{3}{4}$ pound for disk seeding, and $\frac{1}{2}$ pound for furrow seeding. The rates can be reduced about 35 percent on moist sites in the Southeast, where initial establishment and first-year survival are generally higher.

These weights are for seed that has not received stratification or been coated with repellent. They assume viability of at least 80 percent, and must be increased proportionately if germination is lower.

Well-cleaned slash seed averages about 14,000 per pound. In commercial operations over the past 6 years initial establishment has ranged from 30 percent in Louisiana and Mississippi to 50 percent on good sites in Florida and Georgia. This is equivalent to 4,000 to 7,000 seedlings per acre from 1 pound of seed.

While such initial stocking may appear high, first-summer mortality sometimes reaches 80 percent in dry years. The best insurance against failure from drought is to maintain sowing rates high enough to offset losses. To cut costs and to avoid overdense stocking in favorable years, some landowners have reduced sowing rates by 30 to 50 percent. Such reductions should be made only if it is clearly understood that they lessen the chances for success.

Sowing rates are sometimes increased to offset probable losses from livestock or to substitute for mechanical site preparation. For example, on grassy, cutover sites in Louisiana excellent success was achieved with $1\frac{1}{4}$ pounds of seed per acre on a 1-year rough. Disking was impractical because large numbers of cattle would have been drawn to the areas, and fencing was infeasible.

CALIBRATING SOWING EQUIPMENT

Faulty distribution of seed may result in irregular stocking and partial failure even though seedling establishment and survival are high. All of the machines described in the previous section can be adjusted to sow slash pine accurately and uniformly if the repellent coating is dry and if the seed is free of trash. Screening seed through $\frac{1}{4}$ -inch hardware cloth immediately before placing it in the hopper will insure against clogging, which is the most common cause of poor distribution. Wet or sticky seed will not flow freely; hence the repellent coating must be dried thoroughly and kept dry in the field.

Sowing rates should be based on the weight of unstratified, uncoated seed. Lots with 10 percent moisture content will absorb enough water during stratification to increase their weight by 25 percent. The repellent coating will further increase weight by 10 to 12 percent. Consequently, it is necessary to sow almost 1.35 pounds of stratified-coated seed to obtain a 1-pound rate. Because weight gains vary with the initial moisture content of seed and the method used to dry the repellent coating, it is desirable to determine the weight ratio of dry to treated seed for each project.

Tractor-drawn machines are calibrated by checking the number of seed dropped on 100-foot segments of prepared beds. For example, a rate of $\frac{1}{2}$ pound per gross acre on plowed furrows spaced 8 feet apart (center to center) requires 128 seeds on a 100-foot segment, provided that the lot contains 14,000 seeds per pound.

Machines for broadcast sowing—aircraft and cyclone seeders—are calibrated and checked by a system of area control. A predetermined quantity of seed is sown on an area of known size, and it is assumed that distribution is uniform over the entire area. An advantage of the method is that a constant check can be kept of the sowing rate as the job progresses, provided that the area in each flight strip is known. Seed-trap boxes, hoed spots, and other methods of appraising distribution have never been satisfactory in regulating rates, because it is seldom practical to secure an adequate sample.

Fixed-wing airplanes can be calibrated as follows:

Determine the weight of treated seed to be broadcast per acre.

Select three tracts, each 20 to 40 acres in size and with regular boundaries, for calibration trials. Mark 1-chain flight strips on two ends of each area to guide flagmen. A 66-foot swath gives excellent seed distribution with all types of airplanes now available.

Carefully check to determine if hopper gate opens the same width each time it is opened. Loose linkage has been a common cause of erratic distribution.

If the pilot has experience with all species and rates, let him choose the size of hopper opening.

Weigh seed for 20- or 40-acre trial. Add 20 pounds extra for a buffer. Screen all seed before it is put in the hopper.

Sow the area, flying crosswind at a steady, normal speed. Flying parallel to the wind is undesirable, as the variation in ground speed will cause differences in sowing rates. Never calibrate when winds are gusty, shifting, or above 10 m.p.h.

Weigh seed remaining in the hopper to determine if rate was accurate. Adjust gate opening accordingly and sow another test area. Ordinarily the correct setting will be obtained in two or three trials.

After calibration, begin regular operations and steadily increase area sown on each flight to about 100 acres. Because mistakes in the sowing rate are impossible to correct, seeding more than 100 acres per flight is an unnecessary risk. Costs of flying will not be increased appreciably by limiting the acreage per flight to a reasonable level.

Other broadcast machines are calibrated in the same manner. The effective swath is 99 feet for helicopters, 16 feet for hand seeders, and about 40 feet for tractor-mounted seeders. A trial area of $\frac{1}{2}$ acre, or a single swath $\frac{1}{4}$ -mile long, is adequate for hand machines. Five acres, which are equivalent to a 40-foot swath 5,450 feet long, are needed for tractor-mounted seeders. A hopper opening of $\frac{3}{16}$ inch, which is the approximate width of a

coated slash pine seed, is a good starting point when calibrating cyclone seeders.

Minor adjustments in hopper openings often become necessary during the day because moisture in the repellent coating varies with changes in relative humidity. If the coating becomes too wet the seed will not flow freely even if openings are increased, and the only recourse is to stop flying until the coating can be dried.

Flying crosswind is the only way to achieve the steady ground speed essential for good distribution. Crosswinds have no appreciable effect on the swath width, but they change the pattern by shortening the distribution upwind and lengthening it downwind. Sowing should not be attempted when winds are gusty, because then the course of the aircraft is likely to be irregular and differential drift of seed gives erratic distribution.

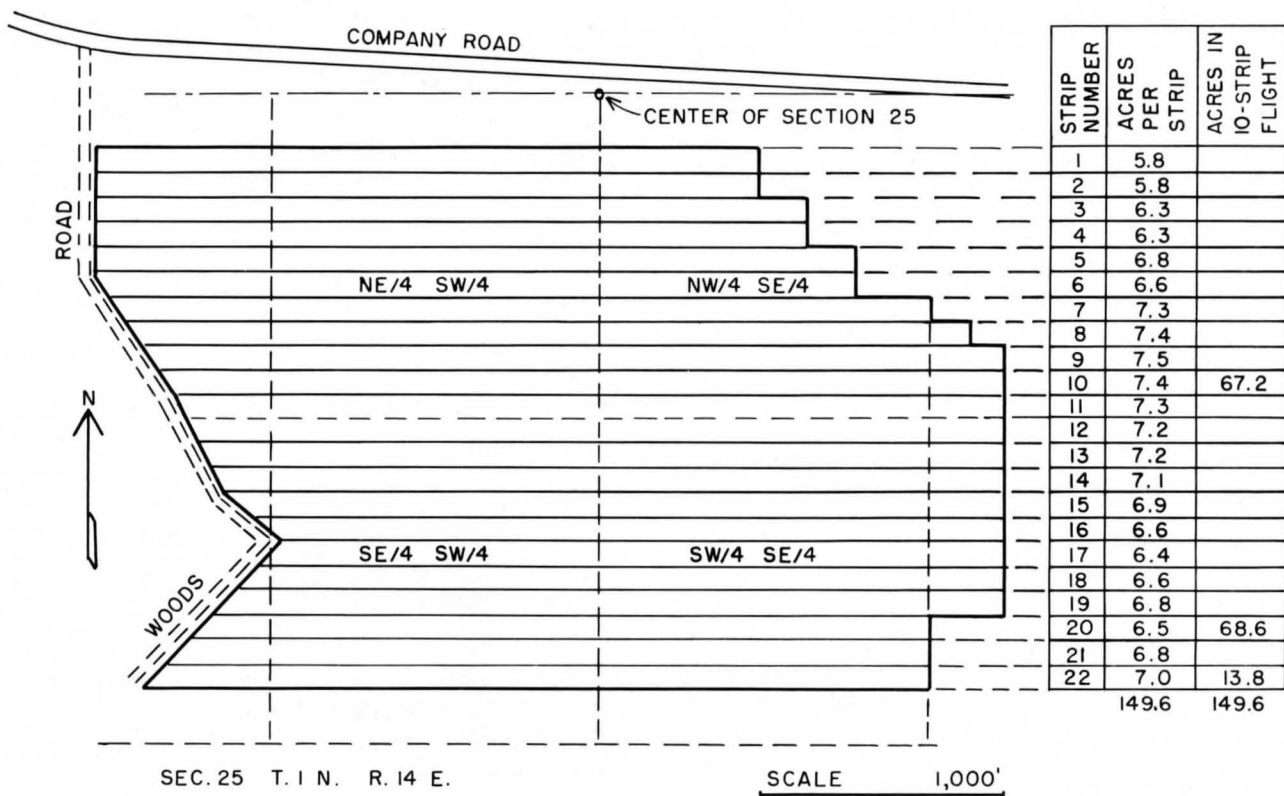
The landowner should retain sole responsibility for specifying the amount of seed to be broadcast on each flight and for determining when the weather is unsuitable for sowing. Contracts for aerial services should state these facts clearly.

A plane's altitude has limited effect on swath width. At heights of 80 to 125 feet distribution is good if ridges are cleared by 60 feet. Below this level, strip width narrows excessively. Helicopters can operate as low as 10 to 20 feet, because the seed is thrown out by the slinger.

Flight strips are guided by flagmen on the ground. Three flagmen are usually enough, although more may be needed if strips are long, terrain is rolling, or trees obstruct the pilot's vision. One flagman should be stationed at each end of the flight strip. Insofar as possible, flagmen should be on ridges and along roads or other openings. Flags, mounted on long bamboo poles, should be a distinctive color and should be moved back and forth as the aircraft approaches.

It is best to measure and mark flagging points on the ground in advance. Flagmen often get out of alignment if they are required to pace off distances between strips as the operation progresses.

A map showing flight lines and the acreage in each swath facilitates the entire operation (see drawing). With this information the acreage to be sown during each flight and the



seed needed can be quickly determined, and the pilot can be told how many strips to fly before returning for more seed.

Despite careful precautions, hoppers will sometimes become clogged and the aircraft will return with an excessive amount of seed. The question, then, is where the stoppage occurred. As this can rarely be determined, the best recourse may be to refly every second or every third strip, depending on the quantity of seed to be sown; altitude should be 200 to 300 feet. Such refflying requires good communications with the flagmen.

CHECKING SEED AND SEEDLING DEPREDACTIONS

Systematic inspections during the germination period are recommended for a landowner starting a direct-seeding program. They are needed to determine if unusual predators are present and to help ascertain the cause of failure if stocking is low. These early inspections may be omitted if seedlings on nearby lands have been successful. They can be discontinued after several trouble-free trials.

Seed distributed in the normal course of sowing is difficult to locate—it is widely scattered, and after a few rains much of it is covered with soil and debris. A series of small observation stations, sown with extra seed, is the only practical way to chart the progress of germination and to appraise losses. A satisfactory station consists of an identification

Mice and other small mammals occasionally damage treated seed and new seedlings, especially when populations are high. Hence, frequent inspections of seeded areas are advisable.



A typical observation station, consisting of screened and exposed seed placed near an identification stake.



stake, 50 seeds sown within 18 inches of the stake, and one or two spots screened to exclude birds and rodents. Screened spots should be on level ground where the seeds cannot wash away. Window screening or $\frac{1}{4}$ -inch hardware cloth makes a satisfactory cover if pinned down firmly. Stations should be well distributed over the seeded area. Ten or 15 are sufficient for areas up to 100 acres; 50 are needed for tracts of 1,000 acres or larger. One man can usually examine 50 in a day.

Stations should be checked weekly until most of the seeds have germinated. Progress of germination, number of intact seeds and seed hulls found, type of damage to seed and seedlings, insect activity, and condition of the repellent coating should be noted for each station. Germinating seeds should be monumented with pins to detect losses that might occur during advanced stages of germination.

Birds, some insects, crayfish, and large mammals take slash seed whole, leaving no remnants for identification. Tracks or droppings may afford a clue to their identity. Most rodents and shrews crack seeds in half to get the endosperm. Frequently they nip off the tip of the seed, apparently to facilitate cracking open the coat. Some rodents carry seeds a few yards to protective cover; characteristi-

cally, they leave a neat pile of seed hulls where they have been feeding.

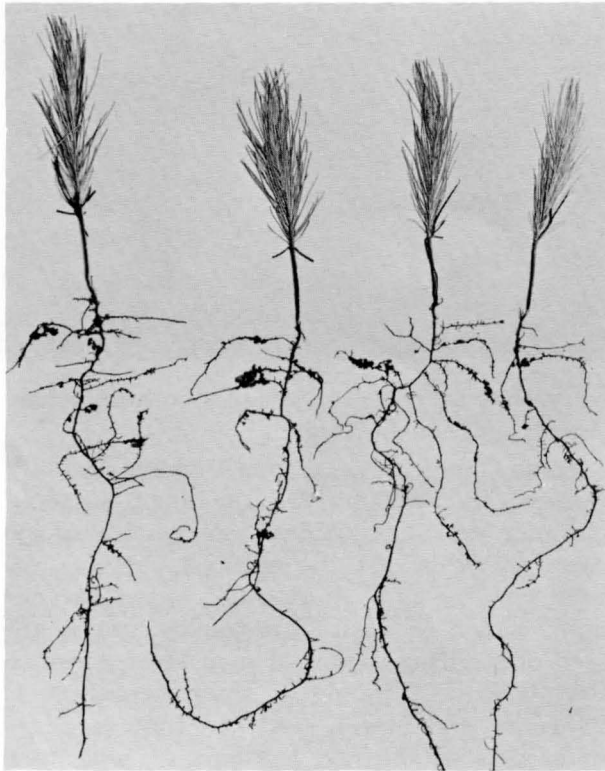
Some predators, among which rabbits, shrews, and crickets are the chief suspects, clip new seedlings off near the groundline and carry away or eat the severed portion. All that remains is a short stub, $\frac{1}{8}$ to $\frac{1}{4}$ inch high, which is easily overlooked unless the seed or seedling is pinned soon after germination begins. Clipping is most prevalent in February and March, and the first seedlings to become established are hardest hit. Total losses usually are less than 15 percent, but occasionally they may go to 80 percent. If crickets are the cause, pieces of the cotyledons can be found in the upper food storage chamber of their burrows. Rabbits and shrews consume seedlings immediately after clipping them.

Harvester ants carry large numbers of seed into their nests. Town ants take portions of germinating seed and sections of seedlings to their colonies. Several other species of ants cause minor damage by feeding on radicles or on endosperms after the seed cracks open in the early stages of germination.

Caterpillars, centipedes, and millipedes occasionally feed on seed and seedlings, but their combined damage is ordinarily less than 5 percent.

RELEASE FROM HARDWOODS

Where the pines are overtopped by hardwoods, they must be released early in the first growing season. Delay until late in the first year or until the second year retards growth and increases mortality. Unreleased 1-year-old slash pine seedlings rarely exceed 6 inches in height, while those freed from competition before July range up to 16 inches. If the hardwoods are not treated, complete loss of pines may occur in a dry year.



On sites free of competing hardwoods, slash seedlings develop rapidly. These were excavated 100 days after germination.

Hardwood control should be started as soon as the May or June inventory is completed, provided stocking is high enough. It is desirable to complete the job before the onset of hot, dry weather. If this is not possible, the driest sites and densest hardwood stands should be scheduled first, with more favorable sites left until last.

Methods that prevent hardwood sprouts are preferred because they lessen the chances for resuppression of pines. Most of the conventional methods are suitable, except foliar syraps. The young, succulent seedlings are highly vul-

nerable to herbicides that are applied with aircraft, mist blowers, and ground-spraying equipment. Herbicides applied to the soil are satisfactory if confined to a narrow band at the base of each unwanted hardwood.

APPRAISAL OF STOCKING

Until experience is gained, it is advisable to make two systematic seedling inventories that are separate from observations during germination. The first is needed in May or June, after germination is complete, to appraise the effectiveness of repellents on local predators and the impact of weather on seedling establishment. This inventory is also useful on areas with hardwoods, because release should not begin until it has been determined that sufficient pines are present to justify the cost.

A second inventory is necessary after the first summer to appraise mortality and overall success. Additional inventories are rarely required, because losses after the first year are negligible, except on severe sites in dry years. The same sample plots should be used in all inventories.

The number of plots depends on the accuracy desired and the plot-to-plot variation (expressed as the coefficient of variation) in number of seedlings. Size of area seeded and size of sample plot influence the coefficient of variation. Experience indicates that, with plots 0.001-acre in size, a coefficient of variation of 100 percent may safely be assumed for areas up to several thousand acres. The formula for computing intensity of sampling with 67-percent reliability is:

$$\text{Sample plots needed} = \left(\frac{\text{coefficient of variation}}{\text{accuracy desired}} \right)^2$$

If a landowner chooses to sample for ± 10 percent accuracy, the number of plots would be:

$$\left(\frac{100}{10} \right)^2 = 100.$$

On a large area, 100 plots give an overall appraisal of stocking but no information on the location or prevalence of areas that are inadequately stocked. If, for example, it is desired to know whether stocking is sufficient on each 40-acre tract on a 1,000-acre area, each forty must be inventoried with 100 sample plots. The usual procedure is merely to sample the

entire area, and wait until the trees are 3 or 4 years old to visually detect tracts that need supplemental planting or seeding.

When seeding rates, methods of sowing, or sites vary within an area, it is desirable to inventory homogeneous subblocks separately.

For broadcast sowing, circular milacre (0.001 acre) plots equally spaced over the area are satisfactory. Average plot stocking multiplied by 1,000 provides an estimate of seedlings per acre. Distribution is expressed as the proportion of sample plots with one or more seedlings. These two statistics are closely related: adequate distribution is rarely obtained with less than 750 seedlings per acre.

Estimates on broadcast-sown disked strips require a modified technique. Two milacres—one on a disked strip and one on an undisked balk—are used at each sample location. The edge-to-edge distance between disked strips at each location is measured to determine the proportion of the area that is disked. To calculate overall stocking, average stocking on disked and undisked milacres is weighted by the area represented by each.

Where sowing is confined to rows, as on plowed furrows or on disked strips, inventories are made differently from those on broadcast areas. Sample plots, located over the entire area, consist of a 13.2-foot segment of a row or strip. Each plot is divided into two 6.6-foot subplots and the number of seedlings on each is recorded separately. Distances from the center of the sample strip to the center of each adjoining strip are measured at each location to adjust average stocking to a gross acre. Seedlings per gross acre are estimated by multiplying the average stocking for 13.2-foot plots by

$$3,300$$

average distance between row or strip centers

Thus, if average stocking per 13.2-foot plot is 5 and row centers are 10 feet apart:

$$5 \times \frac{3,300}{10} = 1,650 \text{ seedlings per acre.}$$

The constant, 3,300, is derived by dividing 43,560 (square feet per acre) by 13.2. If the size of the sample plot is changed, a new constant must be calculated.

Stocking percent based on 1,000 perfectly spaced seedlings per acre is obtained by multi-

plying the percent of subplots stocked (6.6-foot segments of strip) by

$$6.6$$

average distance between strip centers

With this method, full plot stocking is less than 100 percent when the average distance between strip centers exceeds 6.6 feet. Maximum stocking obtainable with strips on 10-foot centers is:

$$100 \times \frac{6.6}{10.0} = 66 \text{ percent.}$$

The effect of strip spacing on subsequent tree distribution should be carefully weighed when planning a seeding operation.

In seed-spot operations the simplest method of inventory is to determine the proportion of spots with at least one seedling. As more than one seedling per spot is excess stocking, it is unimportant to calculate the stand per acre. If the spots cannot be found readily, stocking can be estimated from mechanically spaced milacre plots.

COSTS

Costs given below are approximations. They will vary with the price of seed, acreage to be sown, and individual efficiency. Generally, they will average 20 to 25 percent less in large than in small operations. Economies in bigger jobs result from lower costs for seed, flying, and seedbed preparation.

Seed prices, one of the largest items of expense, are highly variable. In the past 5 years they have ranged from \$1.90 to \$4.25 for large lots. An average of \$3.00 per pound is used in the following estimates. Ten cents per pound for cold stratification and \$0.30 per pound for the repellent treatment are added for a total of \$3.40 per pound.

A small landowner who hand-seeds only a few acres can usually do the work cheaper than industrial landowners. He may have to pay higher prices for seed, but will save on outlays for travel, supervision, Social Security, insurance, and the like.

Data given here are for tracts of 300 to 1,000 acres. Labor rates are \$1.25 per hour plus \$0.35 per hour for insurance, Social Security, and transportation. No allowance is included for supervision or overhead. All costs are on a per-acre basis.

**SPOT SOWING ON HARDWOOD AREAS,
PLACING SIX SEEDS ON EACH OF 1,000
SPOTS. COSTS OF HARDWOOD CONTROL
NOT INCLUDED:**

Seed	\$1.70
Distributing seed (2½ acres per man-day)	5.12
Total	\$6.82

**BROADCAST SOWING 1 POUND OF SEED
PER ACRE AERIALY ON HARDWOOD
AREAS BURNED FOR SEEDBED PREPARA-
TION. COSTS OF HARDWOOD CONTROL
NOT INCLUDED:**

Burning	\$0.30
Seed	3.40
Aerial sowing	.65
Flagging aircraft	.20
Total	\$4.55

**AERIAL SOWING OF 1 POUND OF SEED
PER ACRE ON DRY, OPEN AREAS DISKED
IN STRIPS:**

Burning	\$0.10
Disking	2.00
Seed	3.40
Aerial sowing	.65
Flagging aircraft	.15
Total	\$6.30

**FURROW SEEDING OPEN AREAS WITH
½ POUND OF SEED PER ACRE, AT A RATE
OF 15 ACRES PER DAY:**

Burning	\$0.10
Seed	1.70
Furrowing and seeding	2.50
Total	\$4.30

**DISK SEEDING OPEN AREAS WITH ¾
POUND OF SEED PER ACRE, AT A
DAILY RATE OF 25 ACRES:**

Burning	\$0.10
Seed	2.55
Disking and seeding	1.50
Total	\$4.15

REFERENCES

Barnes, O. L., and Nerney, N. J.
1953. The red harvester ant and how to
subdue it. U. S. Dept. Agr. Farmers'
Bul. 1668, 11 pp., illus.

Bennett, Wm. H.
1958. The Texas leaf-cutting ant. U. S.
Dept. Agr. Forest Pest Leaflet 23,
4 pp., illus.

Burns, R. M.
1961. Seed sowing tool. U. S. Forest Serv.
Tree Planters' Notes 45, pp. 3-4,
illus.

Cobb, H. C.
1959. Seed collection and processing. Direct
seeding in the South, 1959, a sym-
posium, pp. 40-43. Duke Univ.

Crocker, T. C., Jr.
1960. The H-C furrow seeder. U. S. Forest
Serv. Tree Planters' Notes 43, pp.
15-16, illus.

1964. Two H-C furrow seeders. U. S. Forest
Serv. Res. Note SO-5, 4 pp., illus.
South. Forest Expt. Sta., New Or-
leans, La.

Derr, H. J.
1959. Time of year for direct seeding. Di-
rect seeding in the South, 1959, a
symposium, pp. 114-118. Duke Univ.

1963. Better repellent for direct seeding.
U. S. Forest Serv. Tree Planters'
Notes 61, pp. 26-30, illus.

and Mann, W. F., Jr.
1959. Guidelines for direct-seeding longleaf
pine. U. S. Forest Serv. South. For-
est Expt. Sta. Occas. Paper 171, 22
pp., illus.

Ervin, R. G.
1959. Helicopter application techniques for
direct seeding. Direct seeding in
the South, 1959, a symposium, pp.
147-150. Duke Univ.

Evans, T. C.
1959. Field technique for evaluating the
success of establishment. Direct
seeding in the South, 1959, a sym-
posium, pp. 161-166. Duke Univ.

Ferguson, E. R., and Duke, W. B.
1956. Competition affects first-year growth.
U. S. Forest Serv. South. Forest
Expt. Sta. South. Forestry Notes
106.

- Koenig, R. L.
1962. Comparison of early development of planted and direct seeded slash pine. Union Bag-Camp Paper Corp. Woodland Res. Notes 13, 4 pp., illus.
- Lehto, T. V.
1960. Stratifying pine seeds in plastic bags. Amer. Nurseryman 111(7): 15, illus.
- McLemore, B. F.
1960. Small, fast-drying cone kiln. Forest Farmer 19(13): 10-11, 15, illus.
- McLintock, T. F.
1942. Stratification as a means of improving results of direct seeding of pines. Jour. Forestry 40: 724-728.
- McReynolds, R. D.
1960. Mortality of newly germinated southern pine seedlings following inundation. U. S. Forest Serv. Tree Planters' Notes 43, pp. 23-25.
- Malac, B. F.
1960. More on stratification of pine seed in polyethylene bags. U. S. Forest Serv. Tree Planters' Notes 42, pp. 7-9.
- Mann, W. F., Jr.
1957. Direct-seeding the southern pines. Forest Farmer 17(2): 8-9, 12, 16-18, illus.
- _____
1959. Preparing seed for direct seeding. Direct seeding in the South, 1959, a symposium, pp. 52-59. Duke Univ.
- _____, and Derr, H. J.
1955. Not for the birds. Forests and People 5(3): 32-33, illus.
- Miller, S. R.
1957. Germination of slash pine seed following submergence in water. Union Bag & Paper Corp. Woodland Res. Notes 3, 2 pp., illus.
- Russell, T. E.
1960. Why gamble on pine seed? Forests and People 10(3): 35, 42, 46-47, illus.
- _____, and Meanley, Brooke.
1957. Listen for the crickets. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 110.
- _____, and Rhame, T. E.
1960. Disk before seeding slash pine. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 130.
- Scott, Louis.
1959. Fixed wing aerial application techniques for direct seeding. Direct seeding in the South, 1959, a symposium, pp. 143-146, illus. Duke Univ.
- Wakeley, P. C.
1954. Planting the southern pines. U. S. Dept. Agr., Agr. Monog. 18, 233 pp., illus.
- Woods, J. B., Jr.
1945. The direct-seeding gun. Jour. Forestry 43: 39-40, illus.