Loblolly Pine

Maintaining this Species as a Subclimax in the South-eastern United States

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If there is one basic problem confronting silviculturists the world over, it is the maintenance of a forest cover that will produce the maximum in human benefits consistent with the ecological limitations of the site. Where the natural successional climax is also the best forest cover for man's economic use, there is no conflict. But in many places a subclimax forest is preferred by the timber manager because its components grow faster or have greater commercial utility than the climax species. Where this is true, the silviculturist must know how far he can compromise with ecological laws in indefinite maintenance of the subclimax. Then he must develop the techniques for maintaining the subclimax in the face of ecological trends.

If one were to select the particular ecological trend which has given foresters most concern, it would probably be the natural replacement of pine by more intolerant hardwoods. On the best hardwood sites it is usually uneconomical to fight this trend, for the yield of hardwoods is high in quantity and quality, and they are often very difficult to replace. The major problem arises on sites of medium or lower productivity, where pines tend to be joined or replaced by hardwoods having smaller yield of less valuable timber. In the United States, this trend has been accelerated over extensive areas by selective removal of the pines without provision for their regeneration.

The problem is particularly pressing in the loblolly pine type (*Pinus taeda L.*) of the south-eastern United States. From a point on the Atlantic coast just east of Washington, D. C., the loblolly belt swings south-east in a broadening crescent for a distance of nearly 1,500 miles (2,414 Km.), crossing the Mississippi River and extending into the states of Arkansas and Texas. At the northern end of its range this species is confined to to the flat Coastal Plain. Farther south, longleaf (*P. palustris*) and slash pine (*P. caribeae*) take over the Coastal Plain, and loblolly pine grows primarily on the rolling lands of the interior.

So extensive is this great belt that it conveys the mistaken impression that it is a natural climax forest. On the contrary, it is only a subclimax, which in a state of nature, would be succeeded by hardwoods such as maple, beech, and certain oaks and hickories.

In a large part of this domain, such as the rolling uplands of Georgia, Carolina and the Virginia Piedmont, the forest once almost attained this climax. Here early travelers encountered extensive stands of hardwood. These soon fell to the settlers' axe and were succeeded almost totally by plantings of corn and cotton. This led to serious soil erosion followed by large-scale land abandonment. In these abandoned fields, the exposed mineral soil furnished ideal conditions for rapid natural regeneration by adjacent scattered pines, and the result was a forest largely comprised of pine.

On the sandy Coastal Plain, the first settlers found a forest already predominantly pine. But, since hardwoods were also present, the dominance of pine cannot easily be explained. Perhaps the hurricane winds, as well as tremendous fires started by the Indians or by lightning, produced conditions leading to the establishment of large areas of pine. In any event, burning and clearing for agriculture by the early settlers helped to perpetuate and extend the subclimax loblolly pine. These practices prevailed for more than two centuries.

During this time, a great pine industry was gradually built on the utilization of this subclimax type. In the fifty years from 1900 to 1949, the harvest of southern pine for lumber has averaged 10,000 million board feet (27.2 million m^3) a year, and made up two-fifths of the total softwood lumber production of the United States. Of the southern pines, loblolly is by far the leading source of supply. In 1945, over half the volume of softwood saw-timber in 13 southern states consisted of loblolly pine.

Now a great change is again taking place in this pine region. The effect of human activity on the loblolly subclimax, upon which south-eastern industry depends for its supplies, has been to reverse the previous trend. The strong natural trend toward hardwoods is accelerating at an alarming rate. In the past 12 to 14 years, hardwood areas have doubled in Mississippi, and increased 35 percent in Arkansas. In coastal Virginia, low-grade hardwoods occupy one-fifth of a two million-acre pine site, and in South Carolina, the hardwood types cover a 59 percent larger area than they did 10 years ago.

One reason for the swing of this centuries-long pendulum is that agriculture is becoming more stable, and less land is reverting to forest. Another factor is the logger's preference for pine ; each cutting leaves more hardwoods behind to occupy the site. Another important reason is that organized protection is eliminating widespread uncontrolled fires, thus enabling dense hardwood understories to develop in the pine stands. Harvesting of mature loblolly accelerates the growth of this hardwood understory, and the establishment or survival of loblolly seedlings is often prevented by

A mature stand of Loblolly pine (Pinus taeda L.) in the Atlantic Coastal Plain area.

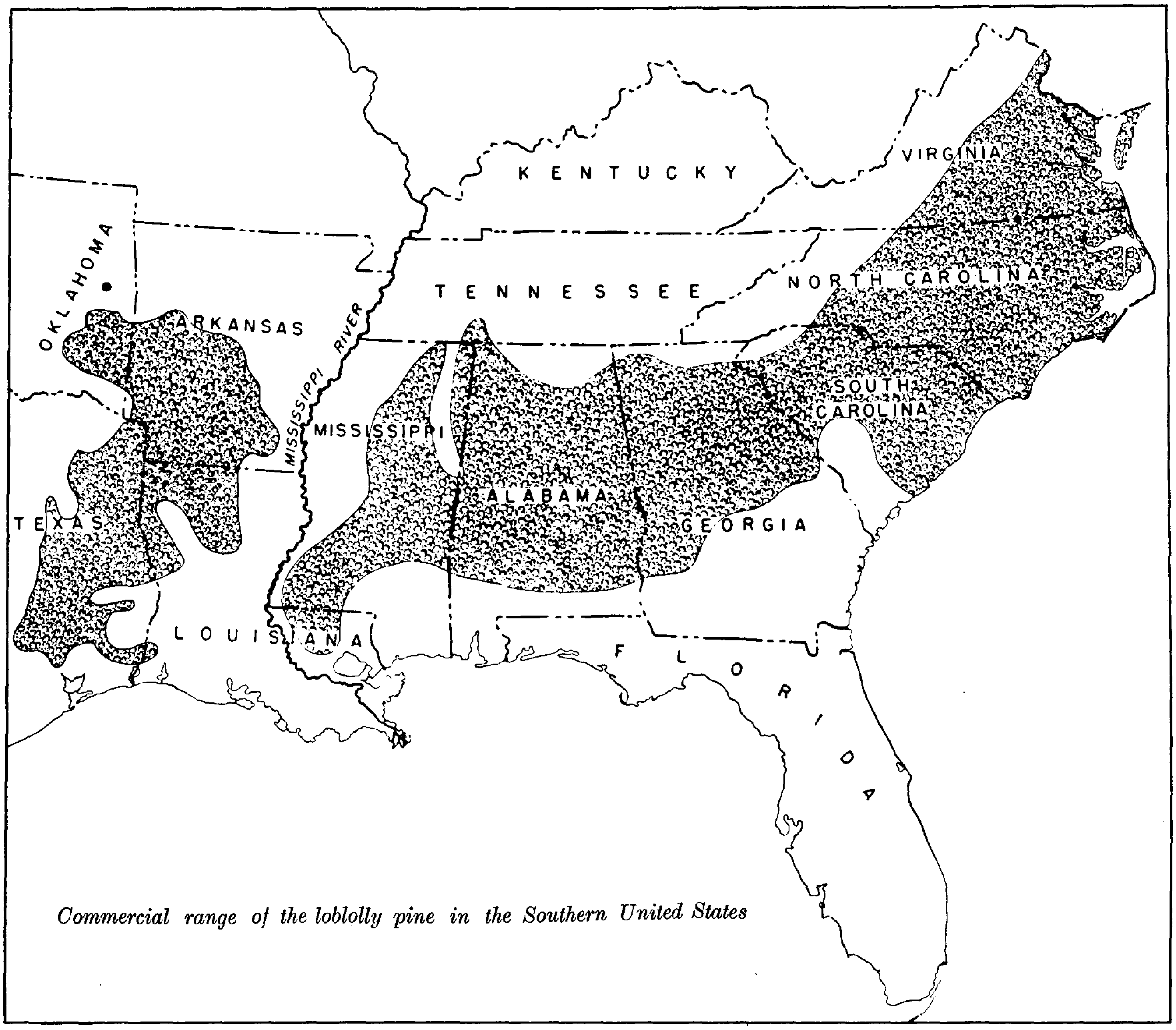
aggressive hardwood stems. Thus, thousands of acres, bought and held primarily for pine production, have become converted to hardwoods.

It is now clear that over large portions of the south-eastern United States, pine stands can be perpetuated only by reversing the present trend toward hardwoods. Foresters in this region must first decide how far they should go in maintaining the pine subclimax on different sites. With the permanent hardwood types in the better bottomlands there is no particular problem because hardwood management is profitable, and conversion to pine very expensive. The problem centers on the majority of the remaining sites, which are clearly capable of yielding higher returns from pine than from hardwood. These sites vary from badly eroded clay hills of the Piedmont, where a hardwood component may be needed to rebuild the soil, to flat sandy soils of the Coastal Plain where successive generations of pine apparently have no adverse effect. Intensive forest management is centered for the most part on the latter area. This paper concerns primarily the techniques that have been developed for maintaining the pine subclimax in the Coastal Plain of Virginia, North Carolina, and South Carolina.

The fight against conversion to hardwoods is usually won or lost during the regeneration stage. Research on the problem has followed two major lines: first, the study of the regeneration habits of loblolly pine so as to allow prompt and adequate pine reproduction in the face of hardwood competition; and second, the study of methods for controlling the hardwoods sufficiently to allow pine regeneration to win through.

Regeneration of Loblolly Pine

The South-eastern Forest Experiment Station is now assembling the basic facts about the regeneration of loblolly pine. Information has been collected on seed production, seed dispersal, and seedbed requirements, and research in this field is directed towards obtaining pine reproduction at or before harvest time, since hardwood sprouts will often fill the openings within one year.



Commercial range of the loblolly pine in the Southern United States

Seed Studies

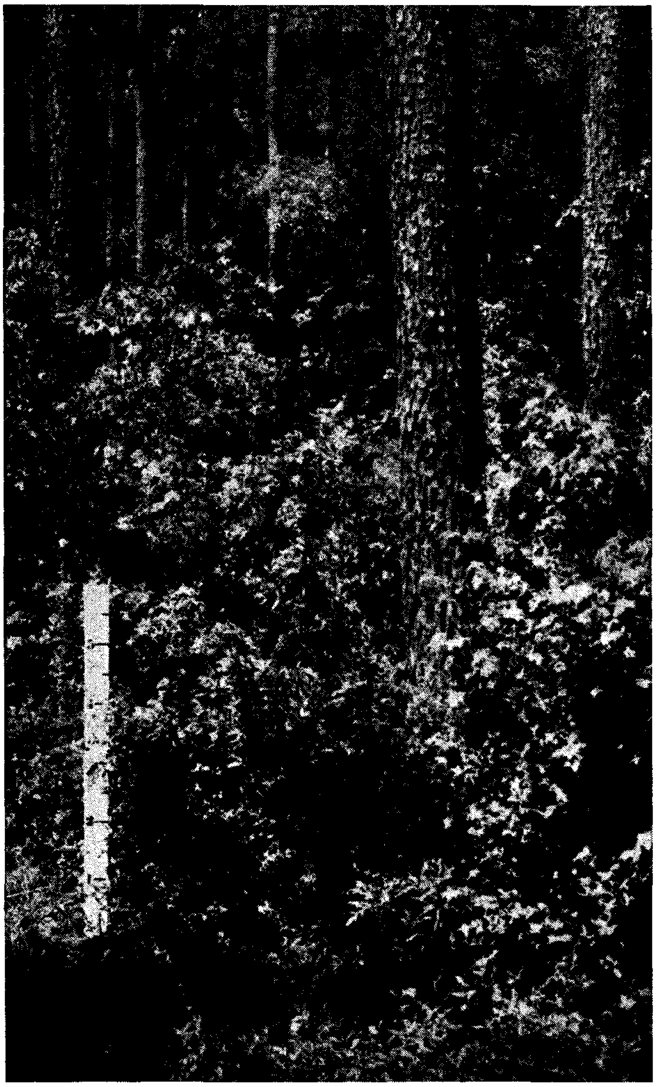
Seed trap studies show a tremendous annual variation in loblolly pine seed production. The same average mature loblolly seed trees, which in a good year have produced between 9 and 15 thousand sound seed, will in a poor year produce less than 600 sound seed. On a fairly uniform level over a large part of the range of loblolly pine, a heavy crop occurs at irregular intervals of from one to five years. Records for one stand showed that about 50 percent of the seeds were empty when a total of 200,000 per acre (81,000 per hectare) were produced, but that only 25 percent were empty when the stand produced a crop of 500,000 seeds per acre (202,000 per hectare). Also, it was found that seed loss caused by insects is proportionately much heavier in a poor year than in a good one.

Predicting Good Seed Years

The next step was to find ways of predicting good seed years far enough in advance to enable foresters to take advantage of abundant seed in planning timber harvests. Means of predicting the size of the next seed crop several months in advance of seedfall have been tested in a number of coniferous types. In the case of the loblolly pine a method of cone "rations" has proven quite dependable for a six months' forecast; the forecast is made by counting cones on a three-foot section taken from the tops of cone-bearing trees. There are three sets of cones on each tree: old empty cones that have shed seed the previous year, green cones that will produce the current crop, and small, immature conelets that will not ripen till the following year. A cone ratio for the current crop is obtained by dividing the number that will ripen this autumn by the number that shed seed the previous year. The ratio indicates the relative sizes of the two crops. This technique used 12 months in advance of seedfall has proved reliable in limited tests, but forecasts for a longer period are unreliable because many immature conelets do not complete their development.

Stimulating Seed Trees

When young stands 35 or 40 years old are harvested for pulpwood, there usually is not enough seed avail-



Understory hardwoods in loblolly pine stands in the Coastal Plain are a constant threat to continued production of pine. Some idea of the density of the hardwood understory can be had from this photograph of a typical stand.

able for regeneration. One remedy may be to stimulate seed production by injury, fertilization, or release cutting. Injuries of various kinds have been the least effective means of treatment; fertilization is effective but very expensive because of the large quantities of fertilizer required; release cutting appears to be of the most immediate practical use because no expense is involved and no other treatment tested to date has produced greater stimulation. It has not yet been put into operation on a commercial scale, but it can probably be applied most conveniently as a partial cut three full growing seasons before a stand is to be reproduced. Trees threatening to crowd out potential seed trees are felled to allow their crowns ample room in which to develop. Such seed trees released in this manner on experimental plots produced seven times as many cones as paired unreleased trees. Saleable wood products can be produced in large enough amounts to make this cutting profitable.

Dispersal of Seed

Dispersal of loblolly pine seed is effective under usual conditions to only about twice the height of the seed trees. Cleared strips 200 feet (61 meters) wide in mature timber have been reproduced promptly when about 100,000 seeds per acre (40,000 per hectare) ripened the first year after cutting. Wider strips may seed in satisfactorily when the seed supply is somewhat greater. Volume of seed rather than the distance between trees will dictate requirements for scattered seed trees. In managed forests four to eight seed trees per acre (7 to 13 per hectare) are commonly left in clear-cutting operations, but experience and research are still too limited to permit recommendations for a specific set of conditions.

Selecting Seed Trees

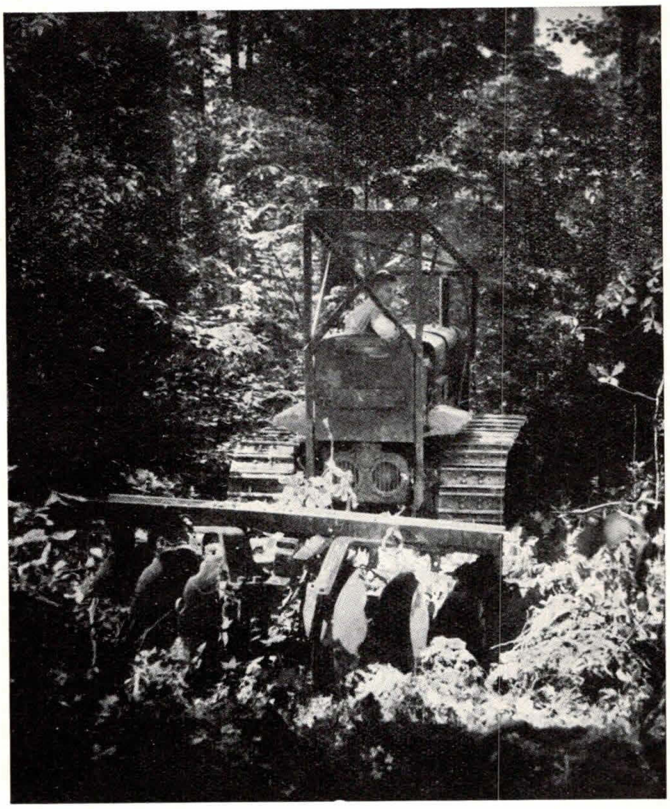
Possibilities for abundant seedfall in the first season following the reproduction cut are increased by a careful selection of the trees to be left. Those 12 inches (30 cm.) in diameter, or larger, with a large number of old cones in the crown have been found to be most prolific. Other characteristics, such as total height, crown development, and the ratio of crown length to total height, have not provided a consistent clue to future yield of seed, although they should be considered in the selection of parent stock.

If natural seeding alone must be depended on to regenerate loblolly pine, the seed supply will often be inadequate, regardless of the number of seed trees left or of the care exercised in their selection. We estimate roughly that, on a favorable seedbed, from 20 to 37 thousand seeds per acre (33 to 61 thousand per hectare) must be produced in the first year to ensure adequate stocking. In a poor year a full stand of mature timber may not produce this amount of seed. At such a time, proper selection of seed trees will be an ineffective aid to reproduction, and cutting may as well be deferred to a more favorable time.

Seedbed Preparation

It is widely recognized that exposed mineral soil is a favorable seedbed for pine. Research at one of our experimental forests has shown that, on the average, 83 seeds are needed to produce one seedling on a surface covered by slash, 29 seeds per seedling on undisturbed litter, 12 seeds per seedling on a burned surface, and only seven seeds to establish a seedling on mineral soil.

Preparation of the seedbed by exposure of mineral soil can be accomplished in a number of ways. Logging itself may be quite effective. Where mature stands had been removed with tractors, several logging units were found to have half the area scarified satisfactorily. Fire can be used either before or after the stand is cut to provide a good seedbed. Mechanical scarification with a crawler tractor and heavy disk or with bulldozers has also proved satisfactory. All of these treatments reduce hardwood competition as well as prepare the seedbed, and some of them are more fully discussed in this respect in the following section.



Two methods of reducing competition from hardwoods are seen here. On the left, a crawler tractor with disk attachment is used successfully to break down the young growth and also prepare a good seedbed. On the right, application of 1 percent 2,4,5-T emulsion in " frills " has considerable promise for large-scale use in hardwood control.

Hardwood Control

Hardwood control on pine sites offers outstanding opportunities for applying modern technology in reversing an ecological trend. The premise for hardwood control on the upland soils of the Coastal Plain is that the hardwoods here are low in quantity and quality of timber yield, but will supersede the more valuable loblolly pine in the absence of cultural measures. Opportunities for influencing the succession by utilizing the hardwoods more intensively than the pine are extremely limited at present. For example, the volume of cull hardwoods alone in the South is sufficient to support the pulp and paper industry of the entire country at the 1947 rate for 15 years, if all pulp could be manufactured from hardwoods.

Control of hardwoods does not imply their complete elimination from the stands. Valuable species, such as yellow poplar, sweet gum, and white oak, are often retained as minor components of the pine stands where the soil is fertile enough for good growth of these species. The real object of hardwood control is to keep the height and stand density of inferior or off-site species down to a level where pine establishment and survival is not hampered.

The most critical control problem in the South-east is the removal of large hardwoods, or the reduction of understories and sprouts of hardwoods, at the time of regeneration of the pine. A second problem is that of keeping hardwood understories in check during the rotation so that they can be dealt with economically during the next regeneration period. The methods developed in the South-east for meeting these problems may have wide applicability to other areas where not only hardwoods but brush and scrub of various types may have to be controlled. The techniques being developed in the South-east include the use of fire, chemicals, and mechanical equipment of various types.

Prescribed Burning

Prescribed fire, which is used in the longleaf-slash pine region mainly to reduce hazardous accumulations of fuel, is now being extended to the loblolly pine region for the control of hardwoods and for other purposes. To keep the hardwoods in check under pine stands, the first fire can be prescribed when the pines are 10 to 20 years old, or when the crowns are high enough to be safe from scorching. Both backfires and headfires have been used. In either case burning, which is only done for a definite purpose, is carried out in accordance with a prepared plan, and under predetermined weather conditions. It is usually done in the winter when the cured vegetation and weather conditions provide a fairly long burning season.

A winter fire is effective in killing hardwoods up to about one inch in diameter. The treatment should be repeated at intervals of four to ten years to keep the hardwoods small enough for continued control by fire. The cost may range from 25 to 50 cents per acre (41 to 82 cents per hectare). Winter fires do not burn deeply into the litter ; consequently, they probably have little or no effect on the soil, particularly in the Coastal Plain. Pine still predominates and general site quality is high even after centuries of repeated fires and at least several generations of pine.

Summer fires may be needed to kill hardwoods that are too large to be killed by winter fires. High rainfall limits the number of good burning days in the summer. When summer fires do burn, they are often hot enough to kill large hardwoods, but great skill is required to avoid excessive damage to young pine stands.

At the time of regeneration, the pine seedbed can be prepared and the hardwoods checked simultaneously by a " pre-seedfall burn. " Here the high overstory and the long interval between fires of this type minimize the possibility of damage to timber and soil alike. The most favorable season for treatment is in September and October, just prior to seedfall and in anticipation of a removal cut during the winter after the seed is down. Should fuel or weather conditions not permit burning in these two months there is the alternative of burning wherever possible during the period mid-July to mid-December with the likelihood of less satisfactory results. Another alternative is to adhere to the September-October schedule, but to begin treatment about three years before the harvest cut. This variation is still in the experimental stage but holds considerable promise. If the burn is unsuccessful or is not followed by adequate reproduction the first year, it can still be tried again in two succeeding years, with the advantage of seedfall from the entire stand instead of from scattered seed trees.

Chemical Treatments

Much of our research in hardwood control has been with chemical silvicides. The most promising of these up to now are 2,4-D (2,4- Dichlorophenoxyacetic acid), 2, 4, 5 - T (2, 4, 5, - Trichlorophenoxyacetic acid), and ammonium sulfamate (which is most commonly called by the trade name " Ammate "). In addition to being effective silvicides, these chemicals are non-poisonous to man and animals, a quality lacking in sodium arsenite, which otherwise is a good tree killer. There are three basic ways of applying these chemicals : to foliage, to cut surfaces, or to bark, although there are many possible variations.

Our current recommendation for a foliage spray is 0.25 percent emulsion of 2,4,5-T ester (acid equivalent by weight). Some of the oaks will resprout, but control in other species is very good except for early spring applications. The usual procedure involves a winter fire followed by spraying the sprout foliage during the subsequent growing season. The cost of this treatment is fairly high, ranging from about \$ 7.50 to \$ 10 or more per acre (\$ 18.75 to \$ 25 per hectare). Mostly on account of this high cost, the technique does not yet have wide acceptance as a silvicultural tool. Prospects may change with decreased costs brought about by future reductions in the price of 2,4,5-T, but for the present at least,the best of this technique appears to be in the control of woody plants along rights-of-way.

The best results in the use of Ammate are obtained with cut surface application of the chemical, as shown by the work of the Southern Forest Experiment station. One of the methods used there involves the application of about $^3/_4$ ounce of the chemical in crystalline form to notches or cups chopped into the base of the tree. The number of notches required is determined by dividing the tree's diameter by 2. A second method requires an aqueous solution of Ammate, 2 to 4 pounds per gallon of water (0.2 to 0.5 kg. per liter). This is poured into a frill or single-hack girdle chopped into the tree at a convenient height. The first treatment yields the best results but costs more — about three cents per 10-inch (25 cm.) tree. There is usually more basal sprouting when the second method is used, but the chemical costs only one to two cents per 10-inch tree, depending on the concentration. Both methods have attained considerable popularity, especially as an alternative to axe girdling where the objective is the release of young pine from larger over-topping hardwoods.

For this same purpose the use of 1 percent 2,4,5-T emulsion holds considerable promise as a substitute for the Ammate solution in frills. The emulsion costs only ½ to 1 cent for chemicals per 10-inch tree, and, unlike Ammate, has no corrosive action. The results are slower than those of Ammate but there seems to be a more complete kill.

On some of our sites the small hardwoods are so aggressive that two or more weedings are necessary before the pine is free to grow. Therefore a method that will do the job in one weeding is more desirable. We have found that 3 percent 2,4,5-T in fuel oil or kerosene, when sprayed on the tops and sides of recently cut hardwood stumps, will practically eliminate any respouting. The total cost of this control is less than that of two conventional weedings.

The technique of control by bark or basal sprays promises to be a cheap but good method. Research is still in progress but we have weeded small hardwoods from pine at about the same cost as cutting only. Indications are that good results can be obtained from 2 or 3 percent 2,4,5-T in fuel oil, sprayed on the bark in a 2-foot (0.6 meter) band around the base of the tree, but the killing action is slow and some hardwoods may not die before the second growing season.

Use of Mechanical Equipment

In the past few years, the rapid development of heavy forest equipment has opened up new horizons in the control of hardwoods by means of bulldozers, tractors, disk plows, and brush-cutting rollers. Their best use is in mature stands just before or after logging, for the combined purpose of hardwood control and seedbed scarification. Another use is in the reconversion to pine of lands recently invaded by hardwoods.

Bulldozers of 80 to 160 h.p. are used by one industrial organization on lands that have failed to regenerate to loblolly pine. Under average conditions the bulldozer blade is raised just high enough to clear the ground. Two large stumps are dragged behind the tractor, and as the equipment lumbers along covering $^1/_2$ to $^3/_4$ acres (0.2 to 0.3 ha.) per hour, brush, shrubs, and trees up to five or six inches (12.7 or 15.2 cm.) d.b.h. are uprooted and left where they fall. This procedure exposes mineral soil over much of the ground. In dense stands of hardwoods the stump drag is disconnected and the operation becomes one of hand-clearing. In this case the debris is left in windrows about 100 feet (30.5 meters) apart, or pushed into depressions that are not good pine sites. After salvaging saleable trees and crediting this amount to the operation, the net cost is estimated at less than $ 10 per acre ($ 16 per hectare).

Establishment of loblolly pine seedlings on soil surfaces, churned up by heavy equipment during logging in wet weather, is greatly inferior to that on ground that has been disturbed less severely. The subsequent height of growth of seedlings in these "puddled" areas, at least for the first two years, is less than half that of seedlings on other surfaces. It was feared that the same result might occur on land cleared by bulldozer, but this has not been the case. Growth of seedlings on areas treated three years ago has been excellent. However, a much longer period of observation will be required before the full effect of this practice upon the site can be evaluated.

Another organization has used a multiple-disk plow with stump drag attached to treat areas immediately before harvest cutting. This disturbance, plus that normally associated with tractor skidding, exposes mineral soil on nearly all the ground surface not covered by slash pines. Progress varies from 1 to $1^1/_4$ acres (0.4 to 0.5 ha.) per tractor hour.

A third company experimentally used two tree tops dragged behind a tractor on areas previously logged. Satisfactory scarification was accomplished at the rate of 0.63 acres (0.25 ha.) per tractor hour. A more thorough job of scarification has been done by substituting for the tree tops a heavy farm disk plow pulled by a 26 h.p. tractor. Several types of very heavy rollers with brush-cutting knives have also been used in the South to reduce heavy stands of small hardwoods.

Future Outlook

Where do we stand in maintaining loblolly pine as a subclimax type ? The techniques described here are largely the result of recent research and have not yet been widely applied. The next forest inventory will probably show some additional shift from pine to hardwood types. However, the area under forest management is steadily increasing, particularly through the land acquisition and forestry activities of large pulpwood and lumber companies in the Coastal Plain. The growing scarcity of pine land available for purchase, combined with the increasing value of timber in relation to other commodities, provides a direct stimulus to the efforts of large landowners to maintain the loblolly pine subclimax.

The use of new chemicals and new mechanical equipment promises to spread at a rapid rate. These new methods offer wide possibilities for the manipulation of the forest far beyond what might have been accomplished earlier, with repeated and expensive hand-cutting methods.

On farm woodlands and other small ownerships, it is expected that there will be a certain time lag in application of some of the new techniques. The proper use of fire is beyond the competence of many small owners, and most of them lack heavy mechanical equipment. These methods are best suited to the growing of even-aged stands on large industrial ownerships. Farmers, on the other hand, can exercise closer utilization of the low value hardwoods for fuelwood and other farm uses, and have shown interest in chemical methods for controlling undesirable species.

The problem of maintaining the loblolly pine subclimax will ultimately be greatly eased by more intensive utilization of, and greater demand for, hardwood species for chemical conversion and other new uses. Unless history fails to repeat itself, time should in some measure catch up with the "inexhaustible" supply of mediocre hardwoods in the loblolly pine-hardwood type of forest.

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