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The Authors . . .

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The Need for Treatment

PINE stands, chiefly loblolly pine, form the most valuable forest crops on many sites of Maryland's Eastern Shore, but cultural treatments are required to establish and maintain them in already wooded areas. Pure pine stands have usually developed only on old-field sites. When the pines are harvested, relatively worthless hardwoods tend to take over these old-field sites. Since the hardwoods form the climax type, the natural trend is toward more hardwoods. Only cultural treatments that effectively favor the establishment and dominance of pine can check this trend.

Several cultural measures can be used to accomplish this objective, and since 1951 the Maryland Department of Forests and Parks and the Northeastern Forest Experiment Station have co-

operated in studies to develop and test various possible treatments. These include:

1. A late-summer fire, applicable in certain years in pine stands after a seed-tree cutting (*3*, *5*, *6*).
2. Light winter fires or other treatments to condition pine stands before cutting (*7*).
3. Poisoning individual hardwoods (*1*, *4*).
4. Applying herbicides to the undergrowth with back-pack or tractor-mounted mistblowers (*2*).
5. Mechanical reduction of the undergrowth with heavy machines.

Several machine treatments have been tried in Eastern Shore forests. A small bulldozer, pulling a stump or a Ranger Pal plow to prepare strips 6 to 10 feet apart before a seed-tree cutting, did not provide adequate control of understory trees and shrubs (*3*, *6*). On the other hand, bulldozing with a large tractor (D8 or comparable) has been effective in converting predominantly hardwood stands to pine.

But, because many Eastern Shore soils are poorly drained, the usual bulldozing practice of windrowing the uprooted hardwoods has created problems. In some areas the ridges and mounds of uprooted trees and attached soil have interfered with the surface drainage. And because the ground water level is so high, free water often has stood for extended periods in the cleared patches where the soil surface had been lowered.

Disking is another possible mechanical treatment, and it has the merit of not disturbing the natural drainage. However, up to the middle 1950's, disking had not been tried on the Eastern Shore.

Since disking seemed to offer advantages over bulldozing, a study was started in 1956 to determine its effectiveness. Some of the questions we hoped to answer were:

- How intensively should an area be treated?
- What species and stem sizes of hardwood trees and shrubs are eliminated?
- Which ones are only set back and soon recover?

- How fast do these recover? (i.e., how long after treatment can pine seedlings start and still become dominant?)

This report describes what we learned about these questions and about the role of disking in Eastern Shore timber management.

Study Methods

TREATMENTS

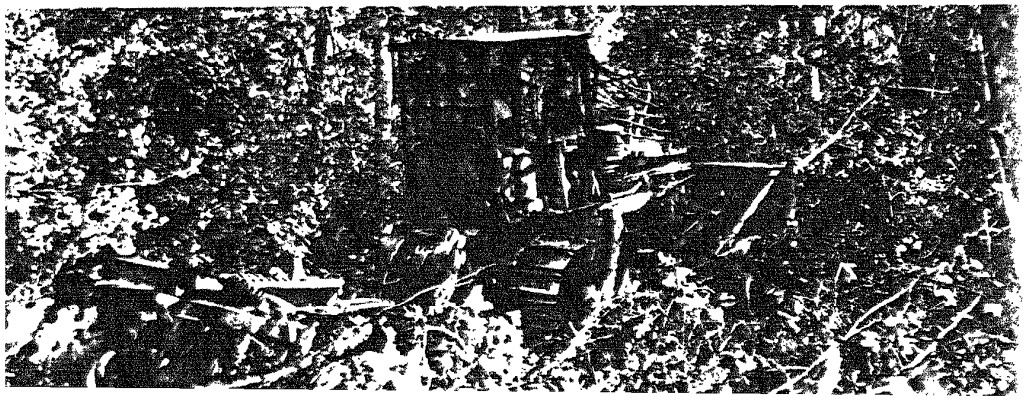
Three treatments were tried, each in two 1.2-acre plots (6 chains by 2 chains) in August 1956. These were:

1. Blading. — A D4 bulldozer was used alone, with the bottom of the blade set 1 to 2 feet above the ground. Only trees that could be uprooted easily, usually on the first attempt, were pushed over. Trees and shrubs that were broken off or uprooted were not windrowed.

2. Single disking. — In this treatment an Athens disk[1] was pulled behind the bulldozer, with the blade set in the same

[1]All of the later disking in eastern Maryland has been done with Rome disks, and private contractors generally use D6 bulldozers.

Figure 1.—Disking in an Eastern Shore stand similar to the study plots. Note the dense growth of small hardwoods and shrubs in the background, and the absence of any mineral soil showing in the foreground. Note also the absence of upturned root systems of shrubs and small hardwoods; they have been bent down or broken off, not uprooted.



position as in treatment 1; so the single disking actually was a once-over combination of blading and disking (fig. 1).

3. Double disking. — The third treatment differed from the second only in intensity: the area was disked twice, the second passes crossways to the first.

In all plots the operator treated as much of the area as the machine could easily reach. A few spots near large trees were not treated, but about 90 percent of each plot was disturbed to varying degrees.

Hardwoods 4 inches d.b.h. and larger were not usually pushed over. These were treated with 2,4,5-T in ax frills (8 pounds acid equivalent per 100 gallons of No. 2 fuel oil) in late August after the tractor treatments had been completed.

MEASUREMENTS

To provide data on stand composition before treatment, trees larger than 3.5 inches d.b.h. were tallied by species and 1-inch diameter classes on the inner 0.5 acre of each plot.

Within each 0.5-acre plot five 1-chain strips were randomly selected and referenced to large trees before the tractor treatments were made. These strips provided 50 permanently marked milacre-quadrats in each plot.

Data collected on each quadrat before treatment and 1, 3, and 5 years after treatment included:

- A tally of all trees less than 3.6 inches d.b.h., by species and size classes (0.0-0.5 foot tall, 0.6-1.5 feet, 1.6-3.5 feet, 3.6 feet tall-0.5 inch d.b.h., 0.6-1.5 inches d.b.h., and 1.6-3.5 inches d.b.h.). In sprout clumps, only the tallest member was included. In the 1957 tally, the apparent fate was noted for all stems in the original tally.
- A list of shrub species present, an estimate of the shrub cover to the nearest 5 percent, and the height of the tallest shrub.
- Cover and depth of forest floor. Cover was estimated to the nearest 5 percent, and depth was estimated, on the basis of at least 2 measurements, to the nearest ½-inch.

Character of the Stand

The study was located in a hardwood-pine stand in the Pocomoke State Forest, Worcester County, Maryland. Before treatment the stand contained more than 6,000 trees per acre, most of which were small (fig. 1). Only 96 stems per acre were 8 inches or larger in diameter, and only 121 per acre were between 4 and 7 inches. Hardwoods predominated. Holly and red oaks (chiefly water oak and southern red oak) were the most common species, followed by sweetbay, loblolly pine, red maple, white and post oaks, blackgum, and sweetgum (table 1).

Although loblolly pine made up only 8 percent of the stems of all sizes, the 23 pines per acre that were 8 inches or larger in diameter did provide a good seed source. Most of the tallied pines—88 percent—were less than 3.5 feet tall. These seedlings under 3.5 feet tall and the occasional taller pine seedlings and saplings were usually overtopped and deformed by competing vegetation. The amount of pine reproduction, 435 seedlings per acre, was far from sufficient to form a well-stocked stand, even if it could have been easily released.

Although some shrubs in all plots reached heights of 13 to 15 feet, the average heights of the tallest shrubs on the measured quadrats were 6 to 9 feet. Except under hollies, the shrub layers tended to be dense (fig. 1), shading 65 to 85 percent of the forest floor.

Common members of the shrubby understory were sweet pepperbush (*Clethra alnifolia*), fetter-bush (*Leucothoe racemosa*), and catbrier (*Smilax rotundifolia*). Somewhat less common were high-bush blueberry (chiefly *Vaccinium corymbosum*), azalea (*Rhododendron* sp.), winterberry (*Ilex* sp.), teaberry (*Gaultheria procumbens*), chokeberry (*Pyrus* sp.), shadbush (*Amelanchier* sp.), huckleberries (*Gaylussacia frondosa, G. baccata*), inkberry (*Ilex glabra*), maleberry (*Lyonia ligustrina*), bayberry (*Myrica pensylvanica*), and low-bush blueberry (*Vaccinium vacillans*).

As the composition of the shrub growth indicates, the site was poorly drained. Wherever a tree had been windthrown, the

Table 1.—*Stand composition before treatment, by species and size class*

(In number of stems per acre)[1]

Size class	Pine	Red oaks[2]	White oaks[2]	Sweet-gum	Black-gum	Red maple	Holly	Sweet-bay	All species
0.0-0.5 feet tall	274	1,467	50	—	3	13	820	400	3,027
0.6-3.5 feet tall	163	350	47	10	37	53	943	100	1,703
3.6 feet tall to 1.5 inches d.b.h.	30	130	23	57	140	100	437	57	974
1.6-3.5 inches d.b.h.	3	3	13	13	10	27	100	13	182
3.6-5.5 inches d.b.h.	4	13	14	1	6	15	20	5	78
5.6-7.5 inches d.b.h.	1	8	13	2	4	11	4	—	43
7.6-9.5 inches d.b.h.	5	6	10	1	1	11	5		39
9.6-13.5 inches d.b.h.	6	5	10	—	2	9	3	—	35
13.6-23.5 inches d.b.h.	12	1	5	—	1	3	—	—	22
Subtotals:									
Less than 4 inches d.b.h.	470	1,950	133	80	190	193	2,300	570	5,886
4-7 inches d.b.h.	5	21	27	3	10	26	24	5	121
8 inches d.b.h. and larger	23	12	25	1	4	23	8	—	96
Total, all sizes	498	1,983	185	84	204	242	2,332	575	6,103

[1]Includes all seedlings and the largest member of each sprout clump in the size classes below 3.6 inches d.b.h. All multiple stems more than 3.5 inches d.b.h. are included in this table.

[2]Chiefly water and southern red oaks in the red oak group; white and post oaks in the white oak group.

resulting hollow in the soil surface held standing water except in extended dry periods. The forest floor was relatively deep—slightly more than 4 inches on the average.

Results

EFFECT ON HARDWOOD TREE SPECIES

Advance Reproduction

The three treatments differed surprisingly little in their effect on advance hardwood tree reproduction. The blade treatment eliminated 37 percent of the stems 1.6 feet tall to 3.5 inches d.b.h., single disking eliminated 44 percent, and double disking 50 percent. Or if reduction of stems of this same original size class to heights of less than 1.6 feet in the first year is used as the criterion, the difference among treatments was still slight: in the blade treatment 60 percent of the stems were either eliminated or had sprouts less than 1.6 feet tall in 1957; in the single disking, 65 percent; in the double disking, 75 percent.

The treatments affected all species similarly, except sweetbay: 11 to 24 percent more stems of this species than of the other hardwoods were eliminated.

Size of the advance hardwood reproduction had no appreciable effect on the proportion of stems eliminated by a treatment.

Size class and treatment did affect the proportion of stems that survived without any appreciable loss in height. As table 2

Table 2.—*Proportion of advance hardwood reproduction that survived without dropping in height class*

Treatment	Hardwoods 0.6 to 3.5 feet tall	Hardwoods 3.6 feet tall to 3.5 inches d.b.h.
	Percent	*Percent*
Blade	58	20
Single disking	42	18
Double disking	34	14

Table 3.—*Effect of treatments on number of pines and hardwoods less than 3.6 inches in diameter (b.h.)*

Number of seedlings and sprout clumps per acre

Treatment	Time	Pine	Oaks	Black-gum	Sweet-gum	Red maple	Holly	Sweet-bay	All hardwoods
Blade	Before treatment	230	1,530	270	120	170	1,140	430	3,660
	After treatment[1]	6,820	1,480	710	290	6,820	1,100	220	10,620
	Change	+6,590	−50	+440	+170	+6,650	−40	−210	+6,960
Single disking	Before treatment	600	2,980	190	60	220	3,060	580	7,090
	After treatment	19,810	2,440	320	200	12,220	2,830	290	18,300
	Change	+19,210	−540	+130	+140	+12,000	−230	−290	+11,210
Double disking	Before treatment	580	1,740	110	60	190	2,700	700	5,500
	After treatment	21,850	1,560	300	210	22,660	3,380	300	28,410
	Change	+21,270	−180	+190	+150	+22,470	+680	−400	+22,910

[1]In August, about 1 year after treatment.

shows, drops in height class were 20 to 38 percentage points less among hardwoods under 3.5 feet tall than among taller ones up to 3.5 inches d.b.h. Furthermore, differences among treatments were considerably more for the smaller than for the larger hardwoods, as demonstrated by the 24-point spread in column 1 of the table versus the 6-point spread in column 2.

The results indicate that the blade and track action of the bulldozer itself accounted for most of the elimination of advance hardwood reproduction, and for much of the reduction in height of surviving stems. Disking increased the numbers eliminated, but had its most marked effect in reducing the height of the small hardwoods (less than 3.5 feet tall), most of which were not broken by the blade.

Subsequent Hardwood Reproduction

The treatments greatly encouraged the establishment of new hardwood tree reproduction, especially of certain species. Red maple was by far the most prolific (table 3), and the amount of new reproduction increased with intensity of treatment. Probably because of a poor seed source, sweetgum establishment was not markedly favored. However, it responded more than oaks or sweetbay.

Regrowth

Recovery of the hardwood understory has been rapid. After 3 years the intensity of treatment still was reflected in the average height of the tallest hardwoods on the study quadrats: 4.0 feet after only blade treatment, 3.6 feet after single disking, 2.9 feet after double disking.

But in 2 more years these stems had reached 5 to 7 feet in all plots, and the effect of treatment intensity was largely obscured. Then the only noticeable differences among treatments in the amount and size of hardwood growth were those associated with differences in the frequency of spots so severely disturbed that little advance hardwood reproduction had survived. Frequency of these spots of course increased with intensity of treatment.

EFFECT ON SHRUBS

Although none of the treatments eliminated any shrub species, all treatments greatly reduced shrub cover and height. After 1 year the cover was 65 percent of the initial amount in the blade treatment, 54 percent in the single-disking treatment, and 43 percent in the double disking. By then, all treatments had reduced the average height of the tallest shrubs by 4 to 5 feet.

On most of the area, shrubs regained their original density within 3 years after treatment. After 5 years, the tallest shrubs on the quadrats were still somewhat under their original height, but the average level of shrubs was as high as before treatment. Though the recovery of shrubs was slower after disking than after the blade treatment, the only noticeable difference after 5 years was in the severely disturbed spots. Shrub recovery there was still slow, and since the area in these spots varied with intensity of treatment, so did the reduction of shrub competition.

EFFECT ON FOREST FLOOR

The three treatments had little effect on the cover and depth of the forest floor, even though at the time of treatment some modification apparently occurred. Intensity of treatment seemed initially to affect the amount of mineral soil showing, but after 1 year no difference was discernible. The quadrat data indicated a reduction, after 1 year, of only 2 to 4 percent in area covered by forest floor, and a reduction of only 0.4 to 0.8 inch in depth.

Of course, on drier sites with thinner floor, or in more open stands (where there were fewer stems for the disk to ride on), disking has turned under a much higher proportion of the organic mat.

EFFECT ON PINE REPRODUCTION

All treatments eliminated most of the advance pine reproduction. No pines in the 3.6-feet-tall to 3.5-inch-d.b.h. size range survived on the quadrats. Pines shorter than 3.6 feet were less susceptible: 12 to 20 percent of these were living in 1957.

All treatments greatly increased the amount of new pine reproduction. Even the blade treatment resulted in 6,590 more pine seedlings per acre at the end of the first growing season, and adding a disking treatment nearly tripled the increase. Doubling the amount of disking did not favor additional pine reproduction so much as it did additional hardwood reproduction (table 3).

Though new pine reproduction stocked 93 to 99 percent of the quadrats in all treatments during the first year, seedlings were both more numerous and taller in the disked areas. Seedlings taller than 0.5 foot in their first growing season were found on 19 percent of the quadrats after the blade treatment, on 52 percent after single disking, and on 57 percent after double disking.

In the following 4 years the amount of pine reproduction dropped markedly, but all treatments still had more than 3,000 seedlings per acre (table 4). However, only in the disked plots were nearly all quadrats still stocked with pine seedlings. Much of the surviving pine reproduction was overtopped by hardwoods and shrubs, especially in the blade treatment. Pines free to grow were about twice as common in the disked plots as in the blade treatment (figs. 2 and 3), and slightly more common in the double-disking treatment than in the single-disking one (table 4). But even in the disked plots some release of pine reproduction will be needed if it is to form a relatively pure stand.

Table 4.—*Amount of pine reproduction, milacre quadrats stocked with pine seedlings, and quadrats with pine free to grow 5 years after treatment*

Treatment	Pine seedlings per acre	Quadrats stocked by pine	Quadrats with pine free to grow[1]
	Number	*Percent*	*Percent*
Blade	3,190	63	20
Single disking	7,250	94	36
Double disking	6,170	91	47

[1]When questionable quadrats are included, the values become respectively: 28, 53, and 62.

Figure 2.—Typical view after 6 years, in area treated by blading. In spots, as in the center, pines are becoming dominant. Elsewhere regrowth of shrubs and hardwood sprouts has captured the site.

Discussion of Results

Though the treatments created conditions that were very favorable for the establishment of pine reproduction, the favorable conditions did not last long. Seedbed conditions, although modified only slightly and temporarily, were good enough to enable an abundance of seedlings to start. But regrowth of hardwood trees and shrubs was so rapid that usually only the pine seedlings starting in the first spring after treatment had a chance of becoming dominant.

This chance increased with intensity of treatment. Single disking, as compared to the blade treatment after 5 years, almost

doubled the amount and the dominance of pine reproduction (table 4). Double disking resulted in still more dominant pine reproduction. However, the increase from double disking was comparatively small — not enough to warrant the extra expense.

Thus, even though much of the initial disturbance was created by the tractor blade and tracks, the addition of the disk was highly worthwhile. The blade and tracks of the tractor were responsible for most of the uprooting or breakage of hardwood trees and shrubs taller than 3.5 feet, and also for some of the disturbance to the smaller growth and to the forest floor. Much of the disk's effect was in reducing the height and cover of shrubs and trees that were less than 3.6 feet tall. This effect, plus some slight influence of the disk on taller plants and on

Figure 3.—Small pines dominate the new stand in portions of the disked plots, especially where disturbances were relatively severe. This shows a double-disked area 6 years after treatment.

the forest floor, greatly favored the establishment, rapid growth, and eventual dominance of pine reproduction.

Even so, release of the pines is needed on our plots, as is true of many areas that have been disked on the Eastern Shore. Without release, only partial restocking to pine usually is obtained, especially on wet, poorly drained sites like our study area. On drier sites hardwood tree and shrub competition is less aggressive, and disking alone is frequently proving adequate.

Our results differ somewhat from those described by Trousdell and Wenger (*8*) for North Carolina. They found that initial stocking was a good criterion of third-year stocking of free-to-grow seedlings. Although stocking levels varied with differences in soil texture and in basal area of residual hardwoods larger than 4.5 inches d.b.h., this relationship generally held: that high initial stocking portended high third-year stocking and vice versa. In our study, high initial stocking (93 to 99 percent) did not assure good stocking of free-to-grow seedlings 3 years later.

The soil relationships reported by Trousdell and Wenger also are different than in our region. They found that hardwoods are slower growing and form less competition on heavy-textured soils than on light-textured soils. The reverse is true on the Eastern Shore.

Since our disking study was established in 1956, important developments have occurred in the use of chemical herbicides in silviculture. Mistblower treatments with 2,4,5-T are proving to be particularly effective and practical for the selective release of pines from shrubs and small hardwood trees (*2*). Larger trees require poisoning by frill or injector treatment. The pines on our disked plots undoubtedly could be released sufficiently by mistblower treatment to assure a predominantly pine stand.

However, the combination of disking and chemical treatments is not cheap; it is fully as expensive, or more so, than bulldozing (which costs about $35 an acre). Disking costs from $15 an acre (on large tracts) to $26 an acre (on small tracts); poisoning the larger hardwoods left after disking runs about $10 an acre; and the later mistblowing about $12 an acre — for total costs of $37 to $48 an acre where all three measures are needed.

One alternative in converting hardwood-pine stands may prove to be somewhat less expensive; namely, a combination of mistblowing and subsequent injector treatment of surviving hardwoods, without disking. However, chemical treatments cost more where understories have not been reduced by disking. With no prior understory reduction, mistblowing costs may be about $15 an acre and injector treatment costs about $18, adding up to total costs in the range of $30 to $35 an acre.

Another use of disking, besides its use in converting hardwood-pine stands, could be in conditioning essentially pure pine stands for regeneration. Here the treatment would be applied in thinned or shelterwood-cut stands before a seed-tree cutting. However, unless the hardwood understory were naturally rather sparse or had previously been reduced by fire, disking probably would be followed by so much regrowth that later release of the young pines would be required. Mistblowing, therefore, might better be used in the first place. In most situations on the Eastern Shore, it would be a more effective conditioning treatment than disking.

Summary

In August 1956, three treatments for converting mixed stands to pine were tried in a hardwood-pine stand on Maryland's Eastern Shore: (1) blading with a D4 bulldozer, with the blade carried 1 to 2 feet above ground, which broke off or uprooted the smaller trees and larger shrubs; (2) single disking with an Athens disk drawn by the same bulldozer with blade as in treatment 1; and (3) double disking, done as in treatment 2 but twice over, with the second passes made crossways to the first ones. Each treatment was applied on two 1.2-acre plots. After these mechanical treatments, residual hardwoods larger than 3 inches d.b.h. were frill-poisoned on all plots.

Much of the effect in all treatments was from the action of the blade and tracks of the bulldozer. The bulldozer was responsible for most of the uprooting and breakage of hardwood trees and shrubs taller than 3.5 feet, and it also had some effect

on smaller vegetation and the forest floor. The disking eliminated some more of the hardwoods, but its main effects on the understory were to reduce the density and height of stems in the 3.5-foot and shorter height classes. Disking also greatly increased establishment of pine seedlings. Double disking had still more effect, but not enough to warrant the additional expense.

So many hardwood trees and shrubs survived, and their regrowth was so rapid, that treatment effects in reducing competition to small pines were very temporary. Pine seedlings have to be promptly established, either naturally or by planting, if they are to have a chance of becoming dominant after such treatments. Except on some of the drier sites, disking alone is inadequate preparation for establishment of nearly pure pine stands; it has to be supplemented by later selective release, such as can be done by application of an herbicide with a mistblower.

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