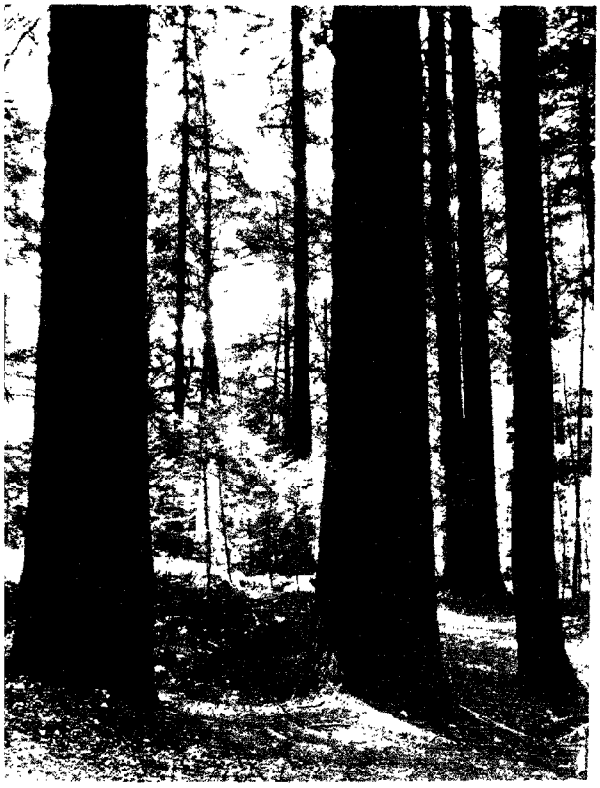
A SILVICULTURAL GUIDE FOR WHITE PINE IN THE NORTHEAST



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Abstract

This practical guide for managing eastern white pine points out special measures required to regenerate and to grow white pine. Treatments are prescribed for seedling and sapling, poletimber, and sawtimber stands. The effects of soil-site relationships are considered in preparing stand prescriptions.

INTRODUCTION

SINCE COLONIAL TIMES, eastern white pine has made significant contributions to the economy of the Northeast. For many years, this species was the primary building material in that region.

Although its economic importance has diminished in recent years because of limited volumes and quality, white pine is still in strong demand for use in construction lumber, furniture, doors, window sashes, and other products. Because it is relatively strong, light, stable, and easily worked, white pine will always have a prominent spot in the marketplace.

It is believed by some that white pine cannot succeed itself. This is partially true, for white pine usually does not replace white pine without the application of management practices. White pine seedlings grow very slowly; few exceed a height of 1 foot in 5 years. By contrast, hardwood seedlings and seedling sprouts grow rapidly; this gives the broadleaf species an immediate advantage that results in complete dominance on most sites—especially on the better ones—after a harvest.

It is well known that after the initial period of slow growth, white pine grows faster, sustains rapid growth over a longer period, and yields more volume per acre than stands of other species. But we are not capitalizing on this potential. Too many of our pine stands are harvested with little regard for the particular needs of white pine reproduction. As a result, the very existence of white pine as an important component of our forests is threatened.

This guide points out special measures required to regenerate and to grow white pine, and encourages a wider application of these rarely used management practices.

GROWTH AND DEVELOPMENT OF WHITE PINE

Seed production

White pine begins to bear cones before it is 20 years old. Its optimum seed-bearing age is between 50 and 150 years. Abundant cone crops may occur only once every 3 to 5 years; white pine cones require 2 years to mature. By the fall of the first year, the cones are 1 to 2 inches long. The cones reach their full length—5 to 11 inches—early in the summer of the second year, if there is no infestation by the white pine cone beetle, which can cause extensive damage to the second-year cone crop. By knowing a year in advance that there will be a seed crop, the land manager gains valuable lead time in scheduling harvest cuts.

Seedling development

Good seed germination and seedling growth do not require full sunlight. Although seedlings grow rapidly under full light, many may die because of high surface-soil temperatures. Seedlings under a full canopy of pine, the shade of hardwood seedlings, or tall vegetation such as goldenrod or fire weed, also have a high mortality rate because of insufficient light and an inability to compete for available moisture.

A light intensity greater than 20 percent of full light—but less than full sunlight—will prevent seedling losses due to high surface-soil temperatures, yet support vigorous seedling growth.

A seed bed of exposed mineral soil is the best medium for the germination, growth, and survival of seedlings because of the capacity of mineral soil for holding moisture. Seedlings that develop in a seed bed of mineral soil that is protected from full sunlight rarely die because of high temperatures or insufficient moisture.

Height growth

An inherent weakness that places white pine at a disadvantage in competing with other species—particularly hardwoods—is the slow height growth of seedlings during the first 5 years. The average height growth of white pine seedlings for the first 10 years is: 1 year: 1 inch; 2 years: 1.5 inches; 3 years: 3.5 inches; 4 years: 7 inches; 5 years: 11 inches; 6 years: 17 inches; 7 years: 24 inches; 8 years: 32 inches; 9 years: 45 inches; 10 years: 61 inches (Frothingham 1914).

After the initial 5-year period of slow growth, white pine that is free to grow begins to grow rapidly, but it is still at a disadvantage compared to hardwood species. On medium and better sites (hardwood site index 60 or greater), and for an initial period of 10 to 25 years, the height growth of hardwoods far exceeds that of pines; so hardwoods can easily dominate these sites during this period.

MANAGEMENT IMPLICATIONS

Regenerating white pine

We know that to regenerate white pine successfully, that is, to provide sufficient stocking to generate a future stand of pure pine, it is essential that pine seedlings become established before or almost immediately after the overstory is removed. This means that a regeneration cut should be made during, or immediately after, a seed year. To provide ideal conditions for seed beds (and seedling development), it is necessary to disturb the forest floor to expose mineral soil and to break up the accumulation of litter. These conditions usually are created by scarification that results from logging during the snowless months.

To ensure that seedlings do not receive too much light during the first critical years, and to protect them against drying winds, the tops of harvest trees should be lopped so that branches are close to the ground.

Advance vegetative growth of broadleaf species, and a rank growth of grass and weeds, will seriously interfere with the development of white pine seedlings and, in most cases, guarantee failure in regenerating pine.

Nature, other than providing abundant seed, usually cannot be depended upon to meet all of the requirements of young pine seedlings. Reestablishing white pine is possible, especially on lighter soils, but it requires the application of forest management practices at crucial times during the development of the stand.

Regeneration cuttings

Clearcutting, strip cutting, seed-tree cutting, and shelterwood cutting are the methods available to the land manager in regenerating white pine. Although each method has advantages and disadvantages, experience has taught us that a two-cut shelterwood system is the most successful.

The first cut is made during or immediately after an abundant seed year (a cardinal rule), and consists of removing 40 to 60 percent of the overstory. It is essential that the first cut results in the disturbance of accumulated litter and the exposure of mineral soil so that white pine seed can germinate and grow.

The second cut, to remove the shelter trees, can take place after the seedlings have entered the period of rapid growth, usually after the first 5 to 10 years.

If the choice is to perpetuate pine, the following corrective measures must accompany the harvest to ensure the success of the shelterwood system and the ultimate dominance of pine.

1. Before the first cut, remove advance regeneration of hardwoods; this is done most economically by applying herbicides with a mist blower. Applications of herbicides also will prevent the resprouting of the hardwoods that usually follows a cutting. If this measure is not taken, hardwoods will be released when the stand is opened.

2. Before the second cut, examine the area to determine whether white pine has become adequately established. If broadleaf species have become established to the extent that they would interfere with the rapid growth of or threaten the survival of pine, they should be removed before or immediately after the second cut. If sufficient numbers of seedlings have not become established, delay the overwood removal. In some instances, another preparatory cut or site-preparation measure might be necessary to improve conditions for seed beds (expose mineral soil).

In the past, these measures were applied inadvertently by light to moderate grazing by livestock; this resulted in the removal of grasses, weeds, and hardwoods, which would have hindered the development of white pine. In fact, grazing accounts for many of the pure stands of pine we have today.

Site consideration

White pine can be grown on nearly every soil within its range; the heavy clayey soils are exceptions. Because competition from hardwoods is an important factor in establishing pine, the choice to manage for pine must be made with this consideration in mind. Hardwoods offer the least competition on excessively drained and well-drained sandy soils, and on droughty, loamy sands. On stony loams, silty loams, and glacial tills with good or impeded drainage, hardwoods are more aggressive and usually will predominate unless special measures are taken.

There are no hard and fast rules for selecting a forested site for hardwood or white pine management. Over a rotation, white pine will outgrow the hardwoods on the poor and the good sites. But, because of unfavorable economics of trying to grow pine on good hardwood sites, the wisest decision might be to manage for pine on the poorer or lighter soils (strong pine land) and for hardwoods on the heavier soils (strong hardwood land). This practice not only will provide good representation of hardwood and white pine, but also will ease the task of developing a greater proportion of white pine (Lutz et al. 1947).

The literature suggests that the breaking point between strong pine land and strong hardwood land falls close to a site index of 60 for hardwoods. This value is not fixed or exact because there are indications that pine lands in some areas of the Northeast have a site-index value close to 65. There also are areas with a lower value.

The important point is that, for sound management, a breaking point should be established, and that it is safe to expect that this point will fall within site indexes 55 to 65 for hardwoods. The two broad site classes established here serve as a guide in deciding to manage for white pine or hardwoods; they should be adjusted for local conditions. The site indexes for hardwoods include northern hardwoods and oaks.

Site class 60+ (site index 60 or greater)

On the best sites—site index 70 or greater—stands should be allowed to revert to hardwoods, and cultural measures that favor the development of quality hardwood sawtimber should be used. The medium sites, site index 60 to 69, are best suited for growing mixtures of pine and hardwoods. Without management, medium sites will revert to hardwoods regardless of the amount of pine in the existing stand. To develop a new mixed stand, a shelterwood cut applied at the time of the final harvest should ensure that some pine is established. What usually happens is that white pine becomes established in groups mostly on those areas that are less suited for hardwoods (Lutz et al. 1947).

The group arrangement of white pine and hardwoods provides a preferred method of management whereby treatments are directed toward releasing the entire group rather than individual stems. This approach will ensure good representation of pine in the new stand as long as the white pine groups are freed of overtopping hardwoods periodically during the first 25 years.

Site class 59 or less (site index 59 or less)

These poorer sites are best suited for growing white pine rather than hardwoods. Because hardwoods are less aggressive and easier to control on these sites, managing for pure stands of white pine is economically feasible.

Many of these sites have reverted to hardwoods (usually oak) because of an absence of management. The use of cultural measures that ensure the development of white pine rather than hardwoods on poorer sites is a paying proposition that should rate top priority.

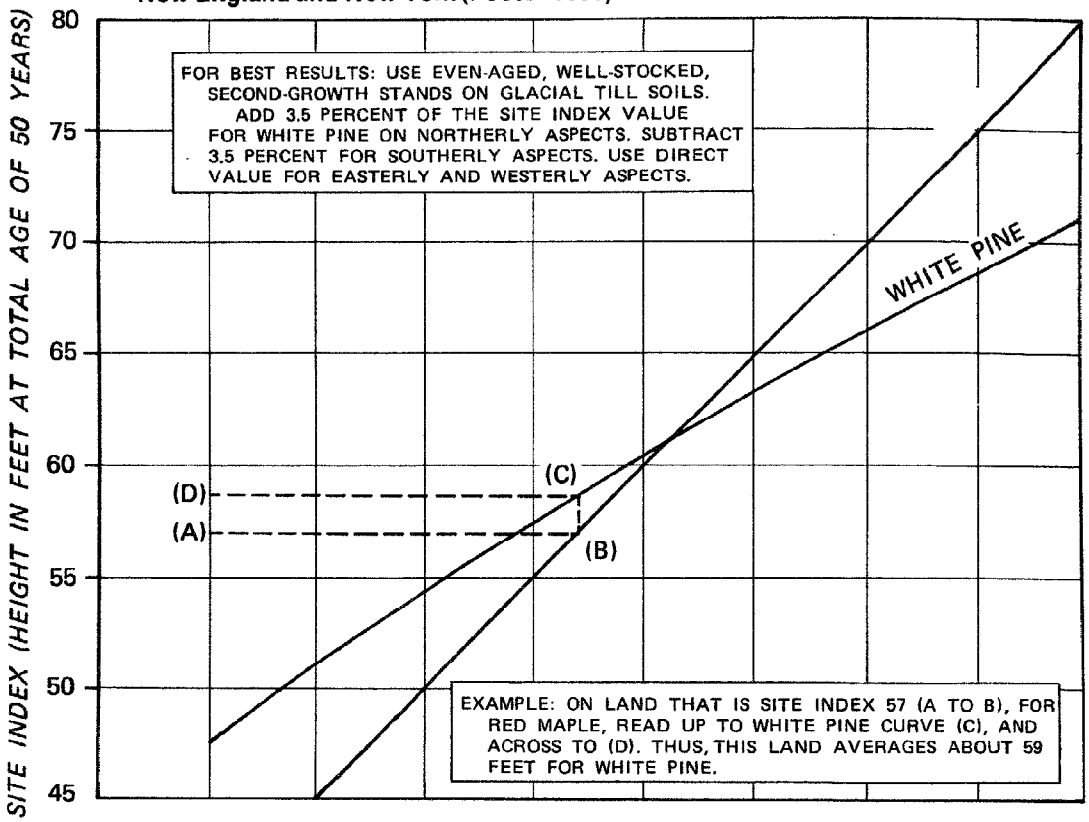
Site-index comparisons

Although a comparison of site indexes for white pine and hardwoods would be useful in making good decisions in the field, there has been little work in this area. Foster's (1959) comparison of site indexes for red maple and white pine indicated little difference between the species (Fig. 1). As an example, his comparison curves show a white pine site index of 59 at age 50 (number of rings at breast height) compared to a red maple site index of 57. The curves cross at a site index value of about 62.

Doolittle (1958) found a difference in site index of 9 to 12 between oaks (including northern red oak) and white pine in the southern Appalachians. His study also showed a broad site-index range for white pine—from 66 to 98.

Barrett et al. (1973) noted that white pine stands in New Hampshire have a narrow site-index range—from 64 to 71. These data plus Foster's (1959) work indicate much smaller differences in site-index values between white pine and the hardwoods than those that Doolittle found. In the Northeast, a difference in site index of about 5 in favor of pine probably would be more applicable

Figure 1.—Comparison of site indexes for white pine and red maple in New England and New York (Foster 1959).



in the more northern states; the difference probably would increase farther south, for example, in West Virginia.

Stocking

The term "stocking" in this report refers to the relative density of a stand, or the degree of crowding or competition among the trees that comprise a stand. Control of stocking is the most common and feasible way of controlling the development of a stand. Therefore it is important to have standard guidelines for evaluating stocking.

Seedlings and saplings

The quadrat system is usually used to determine the stocking of white pine of this size class. A series of 1/700-acre quadrats (4.45-foot radius) are used in determining the stocking of the area. One plot per acre up to a maximum of 50 will provide the necessary data for a reasonable decision.

Each quadrat is classed as:

Stocked with white pine and free to grow (+).
Nonstocked with white pine (0).
Stocked with white pine, release needed (−).

The condition of the tallest white pine in each plot is considered. The results of the survey are recorded as percent of 1/700-acre quadrats that fall within each classification.

A suggested tally sheet for recording this information is shown in Appendix I; counts are converted to percentages by dividing by number of plots and multiplying by 100.

Poletimber and sawtimber stands

A stocking chart for white pine that defines stocking in terms of basal area per acre (square feet), mean stand diameter (inches), and number of trees in the main crown canopy is shown in Figure 2 (Philbrook et al. 1973). Any two of these measures will determine the placement of a stand on this stocking chart. These necessary measurements can best be obtained with a 10-factor prism or angle gage, using the cumulative diagnostic tally sheet (Appendix II). At each of several ran-

domly or systematically located points within the stand, tally by diameter class the overstory trees that fall within the range of the prism. To calculate the basal area and number of trees per acre, follow the instructions on the tally sheet.

Average basal area and trees per acre, as found by averaging the results for each point, are used to enter the stocking chart. The position of the stand on the stocking chart gives the mean stand diameter. As a shortcut, basal area per acre can be measured with an angle gage, mean stand diameter can be estimated visually, and numbers of trees can be determined by the stand location on the chart.

As an example, suppose the average basal area is 120 ft^2 and the total number of trees is 450. The mean stand diameter would be about 7.0 inches. Or suppose the average basal area is 140 ft^2 and the mean diameter is estimated about 8 inches. The total number of trees would be estimated from the chart at about 400 (Fig. 2).

Figure 2.—Stocking chart for nearly pure even-aged white pine stands (Philbrook et al. 1973).

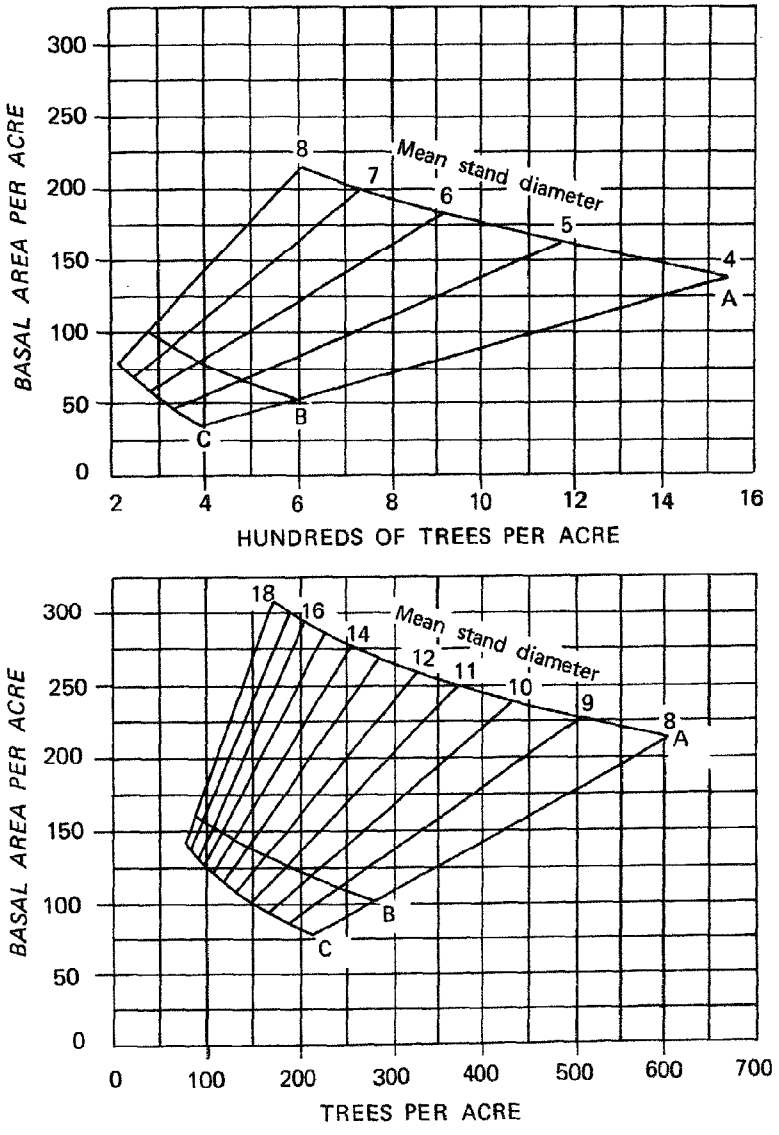


Figure 3.—Site-index curves for eastern white pine in New England (curves corrected to breast-height age of 50) (Frothingham 1914).

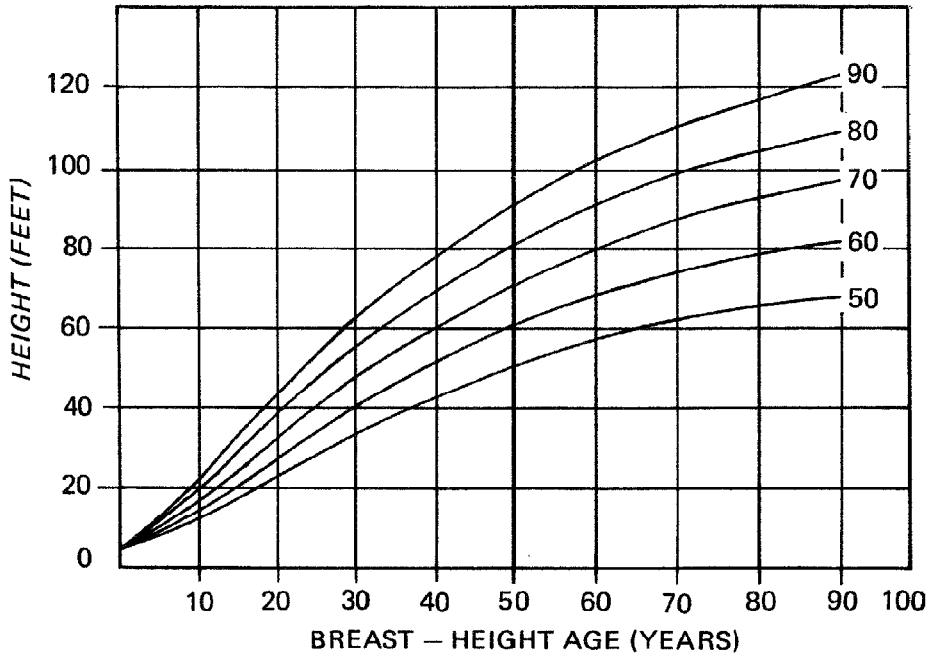


Table 1.—Yields, by stand age and site index, for stands of New England white pine at A-level stocking, in board feet per acre (to 6.0 inches inside bark—International 1/4-inch rule), and in cubic feet per acre (3.0-inches inside bark top). (Leak et al. 1970)

Stand age	Site index									
	50		60		70		80		90	
	fbm	ft^3	*fbm*	ft^3	*fbm*	ft^3	*fbm*	ft^3	*fbm*	ft^3
20	—	1,423	—	1,667	—	1,952	—	2,286	—	2,677
40	7,729	3,526	10,748	4,129	14,948	4,836	20,788	5,663	28,909	6,632
60	16,858	4,771	23,444	5,587	32,604	6,543	45,342	7,663	—	8,974
80	24,898	5,550	34,625	6,499	48,152	7,611	66,965	8,914	—	10,439
100	31,460	6,077	43,752	7,116	60,845	8,334	84,617	9,760	—	11,431

Stands near the A line on the stocking chart are considered at the upper limit of stocking for practical management. The trees are quite crowded, and diameter growth is not rapid. The B line, on the other hand, represents minimum stocking for full site utilization. Diameter growth is rapid, and volume growth per acre remains high. Stands that lie much below the B line would show diminished volume growth per acre though diameter growth would still be rapid.

Stands near the A line could support a thinning operation. In thinning such stands, stocking could be reduced to but not below, the B level.

Yield

The yield of white pine stands varies with soil conditions and other factors that influence overall site quality. Site quality is determined from site-index curves (Fig. 3), which show the height of dominant trees plotted over age for several site-

index classes. The site-index curves are corrected to a breast-height age of 50.

Volumes by stand age and site index are given in Table 1 for pure white pine stands near A-level stocking (Leak et al. 1970). The yields—in board feet (fbm) and cubic feet (ft^3) per acre—increase markedly with age and site index, and will be higher or lower depending on whether the stand is above or below A line. Also, yields in white pine will drop as the proportion of hardwood increases.

Growth rates in white pine stands may vary greatly with site condition and stocking density. The average white pine stand will grow from 300 to 800 fbm per acre per year. Study plots on exceptionally good sites have shown yearly growth rates as high as 1,200 fbm per acre for site index 60, and as high as 1,600 fbm for site index 80. However these growth rates represent optimum conditions in small, well-stocked stands.

PLANTATION CULTURE

Growth and yield

Volume yields from plantation-grown white pine may not be the same as those from natural white pine stands. Because plantations are established quickly and uniformly, and contain few if any weed species, yields tend to be higher. However planted stock may suffer initial setbacks in growth and additional damage from pests such as the white pine weevil, and may exhibit stagnation (mutual suppression of growth among trees of nearly the same size and age). One of the most important factors that influences merchantable volume production is the initial spacing at planting.

Table 2 shows yields (in cords per acre) for plantations in Pennsylvania, where white pine was planted close together—4x4-foot spacing. To convert cords to cubic feet, multiply by about 100 ft^3 per cord. In comparing some of these figures with those in Table 1, notice that plantation yields seem to be slightly lower than those from natural stands. Where the original spacing was wider than 4 x 4 feet, which is usually the case, current volumes in cords or in cubic feet should be only slightly lower than those shown in Table 2. However board-foot volumes 30 to 50 years or more after planting generally are much higher with wider spacing, because the trees are larger. Conversions from cubic feet to board feet vary greatly; from about 2 fbm/ft^3 in 40-year-old stands on medium sites to 7 fbm or more per cubic foot in older, larger stands.

Table 2.—Yields, in cords per acre, (to a 4.0-inch top) for white pine planted at 4 x 4-foot spacing. (Delong 1955)

Stand age	Site index					
	40	50	60	70	80	90
15	—	—	—	0.2	0.9	1.9
20	—	0.2	1.4	3.6	6.2	8.5
25	0.5	2.6	5.9	10.4	15.1	19.5
30	2.6	6.3	12.1	19.5	26.5	33.5
35	5.6	10.4	19.8	30.0	40.3	50.6
40	9.4	16.2	27.9	40.1	52.5	64.1
45	13.8	22.2	35.0	48.6	62.3	74.5
50	17.1	27.6	41.4	56.0	70.4	83.4
55	19.3	32.5	47.0	62.7	78.2	91.3

SELECTING A STAND PRESCRIPTION

To prepare a prescription for a white pine stand, identify the condition of the stand; then follow the suggested treatment for that condition. The key to the prescription is the letter (A, B, C, etc.) to the right of each description of conditions. Details of the prescriptions are presented on pages 9 through 11.

WHITE PINE SEEDLINGS

(mean dbh up to 1.5 inches or average seedling height of 1 to 10 feet)

1. 50 percent or more of the plots (4.45-foot radius) stocked with white pine
   2. 50 percent or more of the plots stocked with white pine free to grow ..... A
   2. 50 percent or more of the plots stocked with white pine not free to grow:

3. Hardwood overstory of seedling to sapling size ..... B
3. Hardwood overstory of poletimber or larger size C
1. Less than 50 percent of the plots (4.45-foot radius) stocked with white pine ..... D

WHITE PINE SAPLINGS

(mean dbh 2 to 4.5 inches)

1. 50 percent or more of the plots (4.45-foot radius) stocked with white pine
2. 50 percent or more of the plots stocked with white pine free to grow ..... E
2. 50 percent or more of the plots stocked with white pine not free to grow:
3. Hardwood site index 60 or greater ..... F
3. Hardwood site index less than 60 ..... G
1. Less than 50 percent of the plots stocked with white pine ..... H

WHITE PINE POLES

(mean dbh 4.6 to 8.5 inches)

1. Hardwood site index 60 or greater
2. Stocking of white pine in the main crown canopy at C level or above:
3. Total stocking including all species in the main crown canopy above the halfway mark between A and B lines I
3. Total stocking below the halfway mark between A and B lines ..... J
2. Stocking of white pine less than C level ..... K
1. Hardwood site index less than 60
2. Stocking of pine at C level or above; including in the count all white pine 4 inches in dbh and larger in the understory and overstory L
2. Stocking of pine below the C level including in the count all white pine 4 inches in dbh and larger in the understory and overstory ..... M

WHITE PINE SAWTIMBER

(mean dbh more than 8.5 inches for overstory trees)

1. Stand mature—mean stand diameter objective has been met. Suggested diameter objectives:

Site index	*Mean stand diameter (From stocking guide) (inches)*
64 or less	12-14
65 or greater	16-18

2. 50 percent or more of the basal area of the main stand is pine, including those trees in the main crown canopy:
3. Hardwood site index 60 or greater ..... N
3. Hardwood site index 59 or less ..... O
2. Less than 50 percent of the basal area of the main stand is pine:
3. Hardwood site index 60 or greater ..... P
3. Hardwood site index less than 60 ..... Q
1. Stand immature—diameter objective for white pine has not been met
2. Stocking of white pine in main stand at C level or above ..... R
2. Stocking of white pine in main stand below C level:
3. Site index of hardwood 60 or greater ..... S
3. Site index of hardwood 59 or less ..... T

STAND PRESCRIPTIONS

The following prescriptions are directed toward increasing production of white pine sawlogs. Emphasis is placed on measures for increasing the proportion of white pine on the better sites, and on developing pure stands of white pine on the poorer hardwood sites.

A. Survival of white pine is not at stake, so weeding can be delayed. Reexamine in 5 years.

B. *On the better sites* (hardwood site index 60 or greater), strive to develop a mixed stand of hardwood and white pine rather than a pure stand of pine. Weed out the hardwoods in areas where white pine reproduction is most abundant. This will result in a mixed stand with a group arrangement of the hardwood and pine components. In areas where this group arrangement does not develop naturally, manage for hardwoods.

On the poorer sites (lighter soils—hardwood site index 59 or less), the goal is to grow pure stands of pine if possible. Remove the hardwoods that are interfering with the height growth of the pine, or those that are interfering directly with the amount of light that reaches the pine. Release should be on an individual-tree basis or by group where groups are present. Hardwoods that are not competing with the pines should be retained in the stand as protection against damage from snow or the white pine weevil. Reexamine the area in 5 years.

C. This situation usually develops after the previous stand of pine has been removed and the hardwoods have voluntarily taken over the site. There is usually a good pine seed source, either from an adjacent area or from old remnant "bull pines" left on the site. On the poorer, lighter soils it occurs frequently, especially where the overstory hardwoods have been subjected to partial cuts. On the better sites, where there is an abundant seed source, pockets or groups of white pine are found in drier areas—such as knolls and small ridges—that are less suited for hardwoods.

On the better sites, manage for hardwoods; favor the development of groups rather than individual stems of white pine when thinning the hardwoods.

On the poorer sites, encourage the development of white pine by maintaining light stocking of the hardwoods through frequent thinnings. Favor the development of areas that are heavily stocked with pine by thinning more heavily in these areas. If the hardwood overstory is sawtimber size, use a two-cut shelterwood system to remove it.

D. Manage for hardwoods.

E. This situation usually develops naturally on the poorer sites, but rarely on the best sites without previous management. As survival of white pine is not at stake because of competition, the thinning can be delayed until the white pine averages 20 feet in height. To improve the distribution of white pine where required, release the crowns of the tallest and best white pine trees. For the practice to be worthwhile, at least 60 well-distributed trees per acre should need the release; if fewer than 60 per acre require release, do nothing.

F. The hardwoods are more aggressive on these better sites, so they usually overtop most of the pine. The choice is to work for a mixed stand, concentrating on groups of pine rather than individuals. Where there are natural groups of pine, weed out the hardwoods in these groups to provide overhead release. If the groups are large, about 1/2 acre or larger, leave a few hardwoods spaced about 15 feet apart for protection against weevils. Small dense groups of pine less than 1/2 acre in size can be completely released. Manage for hardwoods if small groups of pine are not present.

G. The goal here is to grow pure stands of pine if possible. Remove a minimum of 50 percent of the hardwood overstory, concentrating on the release of individual crop trees or groups. Use the crop-tree selection method and release about 200 white pine trees per acre. Remove only those hardwoods that interfere with sunlight to the tops of the pine. For protection against weevils, retain the light-crowned species, if possible, rather than the coarse-crowned species such as oak. Reexamine in 5 years.

H. Manage for hardwoods; use the appropriate management guide. Favor the development of white pine in thinning the hardwoods.

I. Manage for white pine. Apply a commercial thinning to reduce the basal area to B-level, removing the hardwoods in favor of pine. If there are no markets for small wood products, for example, firewood, apply a noncommercial thinning.

J. Do nothing unless the hardwoods are beginning to overtop or otherwise threaten the height growth of the pine. If the height growth of pine is threatened, consider thinning the hardwoods to favor at least 150 to 200 white pine per acre. Apply a commercial sale if feasible; if a sale is not feasible, apply timber stand improvement.

K. Manage for hardwoods using the appropriate silvicultural guide. Favor pine crop trees that are dominant or codominant.

L. On these poorer soils, white pine is the preferred species and potentially the dominant crop tree. Every effort should be made to increase the proportion of pine. Timber stand improvement rates low priority in thinning the hardwoods, but high priority in thinning or releasing white pine.

In stands with a total stocking—including hardwoods and white pine—about halfway between A and B levels or higher, reduce the stocking to B level, favoring pine in all instances.

In stands with a total stocking below the halfway mark between A and B levels, do nothing unless timber stand improvement is needed to release at least 150 to 200 white pine crop trees per acre.

M. Because stocking of white pine is below what can be considered a management unit, do nothing unless timber stand improvement will release 100 white pine crop trees or potential crop trees per acre.

N. Make a shelterwood cut during or immediately after a good seed year. If the mature stand is heavily stocked and was not thinned frequently in the past, leave the overstory trees in groups to promote windfirmness.

These are mostly hardwood sites, and should be managed for hardwoods, because hardwoods take over the site quickly and vigorously after this first cut. However, variation in soil fertility may result in white pine being established on areas less favorable for hardwoods; this would result in a group arrangement of hardwood and pine. If this arrangement develops naturally, manage as a mixed stand, favoring the pine groups.

The second cut—the removal of the overstory—should not be made until the pine seedlings have become fully established, usually 5 to 10 years after the first cut. If hardwood vegetation has become established within the pine groups and threatens the pine, weed out the hardwoods before or immediately after the second cut.

O. Strive to establish a new stand of white pine by making the first of two shelterwood cuts during an abundant seed year. The harvest should be made during the snowless months for adequate scarification of the site.

If hardwoods are well established in the understory, apply herbicides before the first shelterwood cut.

Delay the second cut until the area has become fully stocked with pine. If an excess of hardwood vegetation has become established, it should be removed before or near the time of the second cut. If the second cut is made during or immediately after a seed year, more pine can be expected to become established.

P. Manage for hardwoods.

Q. In stands with a fair representation of white pine (30 to 49 percent of the basal area), strive to convert the area to pine. Remove the hardwoods commercially using a two-cut shelterwood system. The cuts should be made during an abundant seed year for white pine and at a time of year when some site disturbance is possible. Plant pine seedlings in areas where natural regeneration has failed (Wendel 1971). It is imperative that hardwood regeneration be controlled to protect the pine seedlings.

In stands where pine is a minor component, 20 percent or less of the basal area, converting to pine is more difficult. In most cases, it will be necessary to plant 100 to 400 seedlings per acre, depending on the success of the natural seedlings after the first cut. On sites where white pine is a minor component, the shelterwood system should be tried to increase the representation of pine in the new stand. Planting can be used to fortify the stocking if natural reproduction is not sufficient after the first cut.

On the poorest oak sites, another approach is to remove the remaining overstory before planting, or planting after the second of two shelterwood cuts. The white pine can keep pace with or outgrow the hardwood sprouts on these sites.

R. If total stocking is at or above the midpoint between A and B levels, thin to the B level in one

operation. In stands with a higher initial stocking A level or above, reduce to B level in two operations

S. Manage for hardwoods, but favor white pine in the main crown during thinning.

T. Manage for hardwoods. Where pine makes up 30 percent or more of the basal area, strive to create site conditions that are favorable for regenerating pine. This can be done by thinning the hardwoods by groups and by patches.

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APPENDIX I

Sample tally sheet for white pine seedlings and saplings

Plot No.	Stocked[a/]		Nonstocked (0)	Remarks: Size and species of overtopping vegetation, damage from insects and disease, etc.
	Free to grow (+)	Need release (-)		
1	X			
2	X			White pine weevil damage
3	X			White pine weevil damage
4			X	
5	X			
6	X			
7			X	
8	X			
9		X		Overtopped with aspen regeneration (S+S)
10		X		Overtopped with aspen regeneration
11		X		Overtopped with aspen regeneration
12			X	
13	X			
14	X			
15		X		Overtopped with red maple poletimber and larger
16		X		Overtopped with aspen poletimber
17		X		Overtopped with aspen poletimber
18	X			
19	X			
20		X		Overtopped with red maple clump (poles)
Total plots	10	7	3	
Percent of plots stocked	50	35	--	

[a/] Stocked quadrat contains at least one vigorous white pine seedling and sapling.

APPENDIX II

DIAGNOSTIC TALLY SHEET
FOR
EASTERN WHITE PINE

Cumulative Tally - Number of Trees Per Acre (B.A. Factor 10).

Number of Trees	Diameter Breast Height 2	4	6	8	10	12	14	16	18	20	22	24	26+
1	458	115	51	29	18	13	9	7	6	5	4	3	3
2	917	229	102	57	37	25	19	14	11	9	8	6	5
3	1375	344	153	86	55	38	28	21	17	14	11	10	8
4	1834	458	204	115	73	51	37	29	23	18	15	13	11
5	2292	573	255	143	92	64	47	36	28	23	19	16	14
6	2750	688	306	172	110	76	56	43	34	27	23	19	16
7	3209	802	357	201	128	89	65	50	40	32	27	22	19
8	3667	917	407	229	147	102	75	57	45	37	30	25	22
9	4125	1031	458	258	165	115	84	64	51	41	34	29	24
10	4584	1146	509	287	183	127	94	72	57				
11	5042	1260	560	315	202	140	103	79	62				
12	5501	1375	611	344	220	153	112	86	68				
13	5959	1490	662	372	238	165	122	93	74				
14	6417	1604	713	401	257	178	131	100	79				
15	6875	1719	764	430	275	191	140	107	85				
Totals # Trees													
B.A.													

Tally Legend	Number Plots
/	
0	
X	

Total Number of Trees Per Acre - Add the last figure used in each block and divide by the number of point samples tallied.

B.A. Per Acre - Add the total number of entries by species or groups of species, multiply by 10, and divide by the number of point samples tallied.

BASAL AREA PER ACRE

Acceptable Species

White Pine _____ Sq Ft

Other Acceptable Species

_____ Softwood _____ Sq Ft

_____ Hardwood _____ Sq Ft

Total Acceptable Species _____ Sq Ft

Undesirable Species and Cull

_____ Softwood _____ Sq Ft

_____ Hardwood _____ Sq Ft

TOTAL BASAL AREA PER ACRE _____

Stand Prescription:

STAND DESCRIPTION
(Even-Age Management)

Number of Trees Per Acre _____

Mean Stand DBH _____

Total Basal Area Per Acre _____

Basal Area, B Level _____

Basal Area, C Level _____

Site Index:

Species: _____

Age			
Height			
Site Index			

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Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. Field laboratories and research units are maintained at:

- **Beltsville, Maryland.**
- **Berea, Kentucky, in cooperation with Berea College.**
- **Burlington, Vermont, in cooperation with the University of Vermont.**
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