

FOREST WEEDING

WITH SPECIAL REFERENCE TO
YOUNG NATURAL STANDS IN CENTRAL
NEW ENGLAND

By A. C. CLINE



Harvard Forest Photograph

Figure 1. Weeding in Practice on Cut-over Land.

Fast-growing red maple stump sprouts, worthless except for cordwood, cut back in favor of single-stemmed saplings of valuable sawtimber trees. White ash and red oak marked with an X.



Prepared at the HARVARD FOREST, Petersham, Mass.

for the

MASSACHUSETTS FORESTRY ASSOCIATION

4 Joy Street, Boston, Mass.

Fifty Cents Per Copy



The Importance of Forest Weeding

In twenty years of management and experiment on the Harvard Forest, two lessons stand out above all others: first, that no forestry can succeed in the region except by controlling the enormous increase in forest weeds which two centuries of human occupation have brought about; and second, that under present conditions the solution of this difficulty, namely, forest weeding, is the most profitable treatment that can be applied to the woods.

It is the fact that on thousands of acres of recently cut-over land and of abandoned fields there are to begin with more than enough trees of valuable kinds, such as white pine, red oak, white ash, to make a first-class timber crop. It is also the fact that almost invariably the gray birch, poplar, pin cherry, red maple, and other inferior trees kill out or damage the better species (Fig. 2) in five to fifteen years. The final result is a poor stand of cordwood where there might have been good timber worth several hundred dollars an acre. To prevent this loss and save the profit means freeing the good from the bad elements in the crop *when both are young*, a treatment which if properly timed costs less per acre than planting. The present report, based largely upon experience at the Harvard Forest, tells how forest weeding is done.

R. T. FISHER, Director
Harvard Forest.



GENERAL FACTS AND PRINCIPLES WHICH UNDERLIE THE PRACTICE OF WEEDING*

The Make-up of an Ideal Young Stand

In an ideal stand the growing stock consists of but two elements: (1) the crop trees, that is, those individuals which are most desirable for forming the main stand; and (2) trees which are of benefit in protecting and training the crop trees and in helping maintain the productiveness of the soil. The crop trees will be of the best possible species for the site; they will be so spaced as to produce the maximum volume of lumber and other products in a given rotation; they will be straight and single-stemmed, free from defects, and capable of yielding material of the best quality. All other trees in the stand will be so located with respect to the crop trees both in point of spacing and relative height growth as to bring about the best possible quality in the crop trees consistent with satisfactory growth in volume. In other words, one may visualize an ideal young stand as being composed of a relatively small number (a few hundred per acre) of choice trees surrounded by trees slightly subordinate in height, the trainers, which cooperate to restrict



Harvard Forest Photograph

Fig. 2. A Sample of Neglected Cut-over Pine Land.

Pine, which resulted from cutting the lot in a seed year, and good hardwoods suitable for a sawtimber crop are being killed out by stump sprouts, and inferior species such as gray birch, which are worthless except for cordwood.

Ten dollars per acre for weeding would change this stand from cordwood to sawtimber with an increased profit, at the end of 50 years, of \$200 per acre, or more.

*The author gratefully acknowledges the assistance of Professor R. T. Fisher, Director of the Harvard Forest, in the preparation of this bulletin.

the growth of side branches and to hasten the process of natural pruning, at the same time permitting the free upward growth of the crop trees.

Unfortunately such an ideal condition is never even approached in an untreated wild stand, for there a third element, the weed trees, is present and takes possession of the stand at an early age. It is the object of weeding, then, to eliminate this third element; and, where the growing stock permits, to develop a proper relationship between the other two elements, namely, the trees best suited for the crop and the trees best suited as trainers for the crop trees.

Factors Which Determine Trees to be Saved as Crop Trees and Trainers, and those to be cut as Weeds.

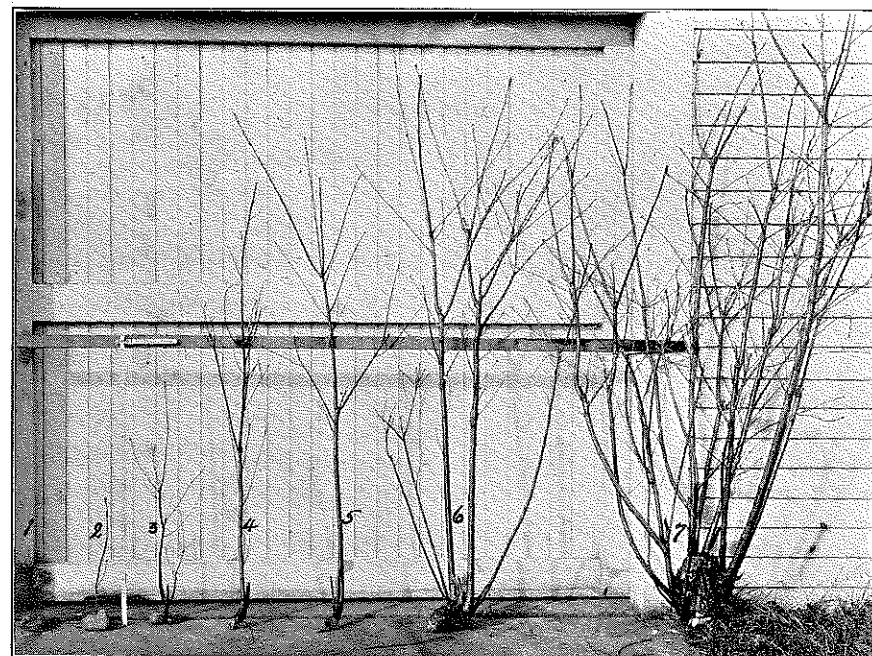
In such cases as plantations overgrown with weeds, or natural stands composed of but two species,—one of them valuable, such as white pine, and the other worthless, such as gray birch—it is easy to determine which are crop trees and which are weed trees; but in mixed stands, especially those on cut-over lands, made up of trees of all kinds, shapes, and sizes, it is a much more difficult matter. As Fisher* says, "The destructive competition that takes place in a young mixed stand is not solely a matter of rapid-growing against slow-growing trees, of poor species against good species. It is a matter of *faulty physical arrangement* of the whole crop." But no matter how good or poor the growing stock on an area may be, no matter how refined or crude the method of treatment warranted, there are certain factors of soil, species, and origin which are ever present, determining the course of action and influencing every decision. The influence of these factors on weeding may be better understood by keeping in mind the three elements which compose every wild, untreated stand, namely, (1) trees suitable for forming the crop; (2) subordinate trees which are of benefit to the crop trees**; and (3) weed trees. Weeding is greatly simplified once one learns how to pick out satisfactory crop trees, for then all other trees in the stand must necessarily fall into one of the other classes, namely, weeds or trainers, depending solely upon whether a given tree in its particular location hinders or helps a selected crop tree.

THE FACTOR OF SOIL. On the rich soils where all species of hardwood grow abundantly and vigorously, it is plain that hardwoods should be favored for the crop. Attempts to destroy hardwoods growing under such favorable conditions, with the idea of establishing softwood plantations, will lead only to disappointment and heavy expense. On the other hand, on the light, sandy soils, hardwood is generally poor in species, slow in growth, and of value chiefly as cordwood. Here white pine and other softwoods which are better adapted to light soil conditions should be favored in place of hardwoods for the main crop. In between these two extremes of heavy and light soil there is a wide range of medium soil, where mixtures of hardwood and softwood may be advantageously grown.

*Fisher, R. T. The Yield of Volunteer Second Growth as Affected by Improvement Cutting and Early Weeding. Journal of Forestry, May, 1918.

**For the sake of brevity these trees will be referred to as "trainers."

THE FACTOR OF SPECIES. The central New England region contains such a variety of valuable species that it is especially important to consider which are likely to be most valuable fifty to sixty years hence, when a stand now of weeding age will be ready for market. Unfortunately there is no reliable way of predicting the value of different kinds of logs or lumber in 1980; but it is safe to assume that the woods which thus far have proved most useful and valuable will continue to be favored. One can hardly go wrong in favoring such species as white pine, white ash, red oak, basswood, paper birch, hard maple and yellow birch as crop trees. On the other hand, all inferior species, such as gray birch, pin cherry, and poplar (the latter is not everywhere considered a weed species), while not valuable enough to be favored as crop trees, are not necessarily weeds. In many cases gray birch and other trees of inferior species may act as trainers for valuable hardwoods, which, when of sprout origin, grow more rapidly than the inferior species from seed. However, gray birch, pin cherry, and poplar oftentimes do play the part of weeds because they grow faster during early life than any of the better hardwoods direct from seed and any of the softwoods as well. For example, at five years of age on the heavy soils the average height of gray birch, pin cherry, and poplar (from seed) is from 6 to 8 feet; of the better hardwoods (from seed), from 4 to 5 feet; and of white pine, about 2



Harvard Forest Photograph

Figure 3. The Importance of Origin Illustrated. Six Red Oaks and One White Pine All the Same Age (3 years).

Sprout clump No. 7 is from a large stump, and is worthless except for cordwood, but it would soon kill out the pine (No. 1), the oak seedling (No. 2), and the other oaks (3, 4, 5, 6) from very small stumps which would make good saw-timber. (The cross bar is 3 feet from the ground).

feet. Thus, because of slow growth at the start, some of the best saw-timber material, namely the better hardwoods direct from seed, and white pine, is overtopped by inferior species and can be saved only by timely weeding.

THE FACTOR OF ORIGIN. The growth and form of hardwoods are greatly influenced by origin. Unlike any of the softwoods native to the region, excepting pitch pine, hardwoods originate both as seedlings (trees direct from seed) and as stump sprouts. A few species also sprout from the roots. Trees of sprout origin grow more rapidly at the start than trees from seed; the larger the parent stump, until old age sets in,* the faster their rate of growth (Fig 3). *Trees direct from seed and sprouts from the stumps of seedlings or small saplings are usually sound, straight, and well-formed, and make the best possible crop trees; but sprouts from large stumps are wholly worthless for anything but cordwood.* Sprout clumps from large stumps may contain at the start 10 to 50 or more stems, the strongest of which quickly forge ahead of the weaker and develop large crowns, big limbs and crooked trunks. Moreover, the stems are liable to become infected with heart rot from the decaying roots and stump of the old tree. Thus, some sprouts, namely those from stumps under 2 inches through, often make excellent crop trees which have practically all the good qualities found in individuals of seed origin, while others from larger stumps make rank weeds.

In the majority of cases the most troublesome weeds may be classified under one of the two heads already indicated; (1) *rapidly-growing trees of inferior hardwood species (factor of species); and (2) sprouts from large stumps of all hardwood species (factor of origin).* But while the factors of species and origin are undoubtedly the most important, there are others which cannot be overlooked.

THE FACTOR OF LOCATION IN THE STAND. The spacing of the crop trees after weeding may vary from 6 to 15 feet in different stands, depending largely upon composition and density. Thus in well stocked stands there may be an overabundance of good crop material, and trees which otherwise might be saved will be cut down as weeds because they are too close to other good crop trees, and are too far advanced in height to act as trainers. The relationship of crop trees to trainers becomes more definite as the stand develops and is particularly evident at the time of the last weeding and thereafter during the thinning stage.

OTHER FACTORS. Trees which in every other respect are satisfactory for crop trees may be discarded because of injuries or disease which cause defects or retard growth. Under such may be included the destruction of buds and branches by deer and squirrels, the loss of leaders due to the white pine weevil, breakage by ice and snow, and numerous kinds of damage caused by fungi. Such trees, however, are not necessarily weeds, oftentimes being useful in the role of trainers for the crop trees.

*Cline, A. C. and Lockard, C. R. Mixed White Pine and Hardwood. Harvard Forest Bulletin No. 8, 1925, p. 21.



Harvard Forest Photograph

Figure 4. The Reason Why Hardwood Follows Pine.

Note the thick undergrowth of red oak, white ash, and other hardwoods which has come in underneath this 60 year old "old field" pine stand. This hardwood forms the bulk of the next stand.

From the above consideration of influencing factors, three rules may be laid down:

- (1) *First select to favor or set free trees desirable for the final crop (crop trees), those of good species and form.*
- (2) *Cut back all trees (weeds) which are overtopping or are likely to overtop the selected crop trees.*
- (3) *Leave all subordinate trees of slower growth (the trainers) which are needed to help prune the crop trees and keep the soil productive.*

THE APPLICATION OF WEEDING

Depending on origin and past history, areas of young forest may be converted by weeding into one of the following kinds of timber crop:

- (1) *Stands entirely of hardwood.*
- (2) *Mixed stands of pine and hardwood.*
- (3) *Pure stands of softwood.*

(1) Conditions from Which Stands Composed Entirely of Hardwood May Be Developed

On the richer soils throughout the region sawtimber cuttings of both pine and hardwood almost invariably come in to stands having a preponderance of hardwood. Only where a pine lot is cut in a seed year is there an appreciable amount of pine in the new stand. In the case of cut-over "old field" pine lands the prevalence of hardwood is largely explained by the fact that an undergrowth, or advance growth,



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Figure 5. Mixed Hardwood (12 years old) Which Has Resulted from Weeding a Cut-over Pine Lot.

Well-formed oak and ash now dominating weeds and less valuable trees which are acting as trainers to control straightness and natural pruning, and improve soil condition.

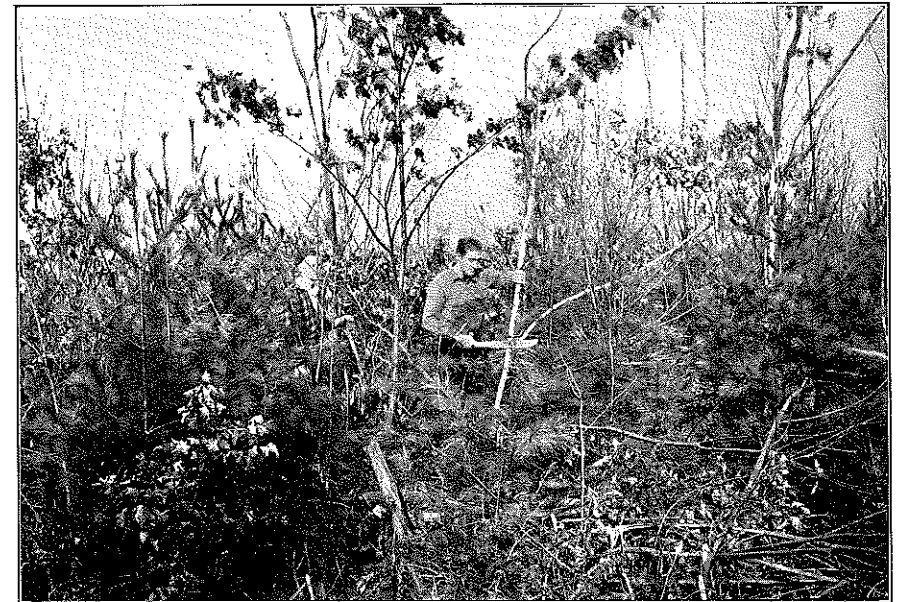
of hardwood becomes established underneath the pine before it is ready to log (Fig. 4). Then, during the process of felling trees and hauling out logs, much of this undergrowth is cut back with the result that a dense sprout growth appears on the cutting area the very first growing season after logging. The sprouts together with any hardwoods which seed in after logging constitute the new hardwood stand. On the rich, heavy soils the advance growth is usually dense, and its composition runs strongly to the better hardwoods. Thus, there is plenty of good material *at the start* for developing a crop of hardwood sawtimber; but in the absence of weeding, the most promising trees are overtopped and suppressed by sprout clumps and inferior species.

Weeding should be delayed until individual differences in rate of height growth, form, and quality are well established, and the desirable trees can be readily separated from the undesirable,—usually from 4 to 6 years after logging. *Seedlings, and sprouts from very small stumps (not over 2 inches in diameter) of valuable hardwoods, such as white ash, red oak, and paper birch, should be favored for the crop trees.* The principal weeds to cut back will be rank-growing sprouts from the larger stumps, and inferior species such as gray birch and pin cherry. It is seldom advisable to use sprouts from the larger stumps as crop trees, even though they are well formed. It has been found* that sprouts from stumps around 2 inches and over in diameter “form a root system independent of that of the previous generation. Portions of the old

*Leffelman, Louis J. and Hawley, R. C. Studies of Connecticut Hardwoods. Yale School of Forestry Bulletin No. 15, 1925, p. 13.

root system may be incorporated in the root system of the new plant, but never the entire old system. The portions of the old root system not so incorporated decay quickly, and carry decay back into the heart of the new tree.” Cutting back all but one of the best sprouts in a clump to make a crop tree is also to be avoided, both on account of the danger from rot and because the sprout retained makes a spurt in growth and usually becomes a large-crowned “wolf tree.” Care should be taken not to cut too much. Practically all trees, regardless of species, which are subordinate in height to the selected crop trees, should be left as trainers. Since only from 150 to 200 dominant trees per acre, 17 to 15 feet apart, are required for a satisfactory hardwood stand at 60 years, it is often possible, by using the inferior trees to fill in the gaps between the crop trees, to make a good sawtimber stand out of what at first glance appears to be all weeds. One, and sometimes two more weedings, ordinarily 3 or 4 years apart, will be found desirable, depending chiefly upon the number of sprout clumps from large stumps which happen to be present.

The same principles apply when weeding young hardwood stands which follow the clearcutting of sawtimber hardwood. The amount of weeding, however, is somewhat increased, and the prospects of developing the highest quality of stand oftentimes lessened, due to the large number of sprout clumps from large stumps, except in cases where the previous stand has passed the period of effective sprouting (usually 70



Harvard Forest Photograph

Figure 6. Weeding a Cut-over Pine Lot with the Aim of Developing a Mixed Pine-Hardwood Stand by Groups.

Note the weeds being cut back to free a pine group,—a worthless red oak sprout clump on the left, a gray birch on the right, and pine underneath.

years or more). The new hardwood stand will be recruited from the best stems of the advance growth supplemented by such desirable material as may seed in after logging.

Weeding will ordinarily be needed inside of 5 years, and will consist almost wholly in cutting back sprout clumps (see frontispiece). Three weedings are usually needed to permanently reduce the stump sprouts to a subordinate position.

Well stocked hardwood stands originating under the conditions cited above, if properly weeded and thinned, will yield from 12,000 to 15,000 board feet of high grade sawtimber per acre at 60 years, (Fig. 5) and give promise of netting a highly satisfactory return on the investment.

(2) Conditions from Which Mixed Stands of Pine and Hardwood May Be Developed

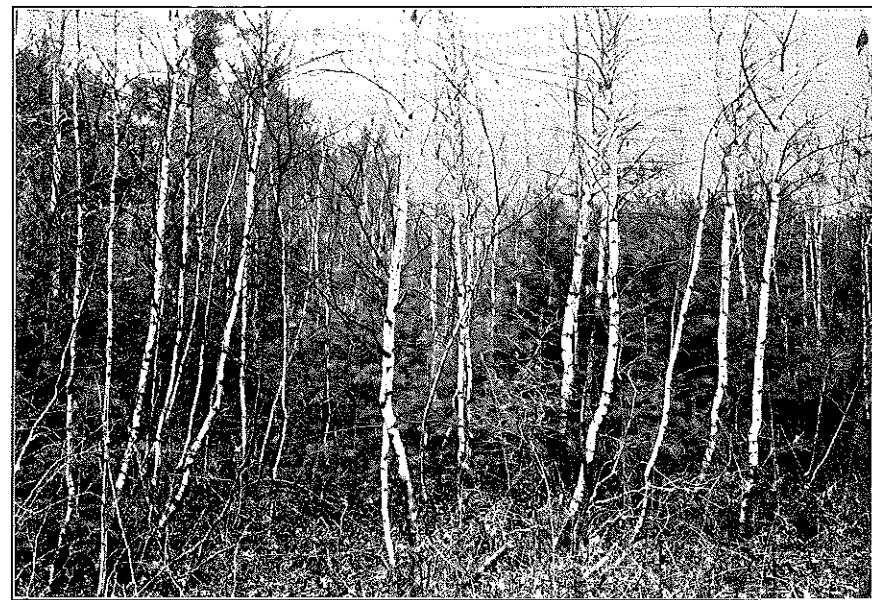
In the majority of cases where "old field" pine, or hardwood stands have been cut clear, especially on the medium soils, there is insufficient hardwood of suitable species and quality to make a completely stocked sawtimber stand. In such cases the presence of enough pine to complete the stocking is highly desirable, as then a mixed pine-hardwood stand may be developed.* The pine may owe its presence to the lot (if a pine lot) having been cut in a seed year, or to reproduction following partial cutting, or to planting. The hardwood element in the new stand consists of sprouts from the small stumps of the advance growth, and of seedlings of light seeded species which come in after logging. Where the pine starts as a result of clearcutting in a seed year, the new stand is exactly even-aged; where it originates through partial cutting, the pine is a few years older than the hardwood; where it is planted, in accordance with the method used on the Harvard Forest,** it is two years older than the hardwood.

But regardless of the origin of the pine, the procedure in weeding is essentially the same. As the hardwoods, both sprouts and seedlings, grow so much faster at the start than the pine (Fig. 3), it has been found necessary to segregate the two elements into groups. Thus the plan is first to go over the cutting area for the purpose of locating suitable groups of pine (unless planted) and of hardwood (Fig. 6); then by weeding, to more definitely segregate them with a view towards developing separate groups. The areas covered by these pine groups will usually vary in size from 30 to 75 feet across and will be irregularly distributed over the area. Groups of hardwoods will occupy the intervening spaces.

Where the pine is of natural origin, the first weeding will be needed somewhere between 3 and 8 years after the cutting of the previous stand; but in the case of planted groups, it should seldom be delayed longer than 4 years. In the pine groups any scattered hardwoods should be kept in check by "topping back", and in the hardwood groups worthless stump sprouts and other overtopping weeds should be cut in favor of de-

*See Harvard Forest Bulletin No. 8, Mixed White Pine and Hardwood, p. 37.

**Thrifty, 4-year transplants are set out in groups where the hardwood is scanty, or of poor species, at the beginning of the third season following logging. The delay is necessary on account of the pales weevil. (See Harvard Forest Bulletin No. 3, The Life History and Control of the Pales Weevil, by H. B. Peirson, 1921).



Harvard Forest Photograph

Figure 7. A Typical Case of Pine Overtopped By Gray Birch on An Old Field.

Thousands of acres like this could be converted to sawtimber by simply cutting back the birch. Otherwise, the pine is killed out and the owner gets nothing but cordwood.

sirable crop trees. When weeding the outer edges of the hardwood groups care should be taken to select crop trees which will do the least damage to the pine by crowding. Less damage is done to the pines by small-crowned hardwoods such as white ash, black cherry, and birch than by large-crowned, space demanding hardwoods such as red oak and basswood. No attempt should be made to reduce the level of the canopy in the hardwood groups to that of the pine groups, as one of the chief advantages of the group-wise mixture over the stem-wise* lies in the opportunity for each of the two elements to take its own pace without interference from the other. Though the pine grows more slowly than the hardwood at the start, the total height attained by the end of a 60 year rotation will be about the same for both. Thereafter, the pine remains in the lead.

Second and third weedings, spaced a few years apart, are usually necessary in order to permanently free the new stand from overtopping weeds, and to perfect the formation of the groups. There are many cases, however, where even a single weeding will pay for itself many times over (Fig 2). Mixed pine-hardwood stands are ideally suited to the region, provide the maximum security against insect damage, assure favorable soil conditions, yield the highest possible quality of both hardwood and softwood products, and in all probability will net a higher return than any other crop.

*A more or less indiscriminate mixture of different species by individuals rather than by groups.



Figure 8. White Pine Released from Gray Birch.

U. S. D. A. Photograph

A stand of prospective sawtimber for the cost of cutting the birch. In some cases the material removed may be sold for cordwood at a profit over and above the cost of cutting.

(3) Conditions from Which Pure Stands of Softwood May Be Developed

Inasmuch as pure softwood stands may be developed under a wide range of conditions, including both natural and artificial origin, cut-over land and abandoned farm land, heavy and light soil, it is desirable to resort under this heading to a consideration of typical cases.

A. Releasing Pine from Gray Birch

One of the most common forest types found on abandoned fields and pastures is "Pine and Gray Birch" or "Pine and Inferior Hardwoods" (Fig. 7). The pine and birch usually seed in at about the same time forming an even-aged stand; but due to the more rapid early growth of the birch, the pine is soon overtopped, and through a combination of root competition, shading, and abrasion, is eventually killed. So commonplace is this condition and so obvious the remedy that a special term, "releasing," has come into use. Releasing is merely a form of weeding. Where a well stocked stand of pine may be had for the cost of cutting down the birches, the advantages of releasing can hardly be questioned. The operation is most profitable where the pine is sufficiently thrifty to permit the cutting to be delayed until the birch has reached cordwood size, providing it can be marketed, or at least given away for the cutting. In many cases, however, the high density of the birch or the lack of a market will make it necessary to cut the birch and leave it to rot on the ground. Owing to irregularities in the spacing of the pines, it is impossible to specify the minimum number per acre

necessary to justify release or to make a fully stocked stand at maturity. Moreover, the timing of the operation must be varied to suit different conditions. It has been found possible, however, to approximately set the time when a single cutting back of the birch will permanently free the pine.* For medium quality, upland soil this is when the pines average 15 feet, if gray birch is the principal weed; and 12 feet, if red maple predominates. According to Spaeth**, "For average conditions in central New England, the period during which release cuttings are possible is roughly from the 10th to the 25th years in the life of the stand, and the most profitable age is the lowest age at which the hardwood product is merchantable (Fig. 8), between the 18th and 20th years on average sites."

The above statements apply especially to stands on the medium and heavy soils. Pine is also commonly found overtopped by birch and other inferior hardwoods on the light, sandy soils, on both cut-over lands and abandoned farm land. Following the cutting of pine they often seed in together, forming approximately even-aged stands; but on open land the birch may be present several years in advance of the pine, acting as a "nurse tree" in that it makes conditions favorable for the establishment of the pine. In the former case the two elements are more or less evenly distributed over the area; but in the latter the pines are apt to be concentrated in groups under the thickest birch clumps. Owing to the reduced competition between pine and hardwoods on the light soils, releasing can generally be postponed for a longer period than on the heavy soils, other factors being equal. One releasing, properly timed, should permanently free the pine and in many cases yield material large enough for cordwood.

In all weeding or releasing on light, sandy lands the value of hardwoods in improving soil conditions should be a constant warning against cutting more than necessary. Partial release, that is, cutting back only a part of the overtopping weeds in the first treatment is being practiced on dry, exposed sites, or where the trees to be released are badly suppressed. In some cases it may be advisable to leave small groups of birch here and there over the area in places where the pine is least promising.

Except in cases of extreme suppression little concern need be had for the recovery of the pine after releasing. Even trees which have been reduced in height growth to a few inches per year, when once given freedom to grow, will quickly build up and within a few years attain a normal rate of growth.

B. Plantations on Brushy Fields and Pastures

A great amount of planting has been done on old fields and pastures which have grown up to brush and scattered, scrubby trees of no value. Numerous plantations set out under such conditions have already lost the major part of their original stocking; others are in urgent need of liberation, if the investment in planting is to be saved.

*An unpublished study of the effect on white pine of removing the inferior hardwood overstory by John Minuse, Harvard Forest.

**Spaeth, J. N. Notes on Release of White Pine in Harvard Forest. Journal of Forestry, February, 1922.



Harvard Forest Photograph

Figure 9. A Properly Weeded Plantation on Cut-over Cordwood Land.

Note the hardwoods in between the pines. This hardwood "filler" is keeping the side branches small on the pines, hastening the pruning of dead branches, and improving the soil.

Photograph taken after the third, and last, weeding.

In the case of old pastures grown up to brush and scattered trees, costs of establishing a plantation may often be greatly reduced by clearing up the area in advance of planting.* Otherwise, any hardwoods overtopping the plantation must sooner or later be cut down, scattered pines girdled after the plantation has reached a height of 4 feet or more** and brush patches opened up so that the plants can come through. Where trees have been set in brush patches, openings should be cut around each tree, instead of cutting back all the brush. Where hardwood sprout clumps are fairly numerous, two weedings may be needed in order to free the plantation. Success in establishing plantations on brush land will depend fully as much upon choice of planting stock and care in setting each plant where it will have a chance to grow as upon subsequent weeding treatments.

C. Plantations on Cut-over Cordwood Land

Where hardwood stands composed entirely of inferior species are cut clean for cordwood, the resulting new growth consists almost wholly of sprout clumps which are worthless except for another crop of cordwood. In other places where some valuable species such as oak and ash

*In cleaning up an area preparatory to planting, scattered pines should be cut or girdled 2 years in advance of cutting the hardwoods, or left until the plantation has passed the danger point (See Pales Weevil). Poplars should also be girdled along with the pines, thereby eliminating root sprouting.

**See Harvard Forest Bulletin No. 3, The Life History and Control of the Pales Weevil, by H. B. Peirson. 1921.

form a part of the stand, groups of young advance growth suitable for making sawtimber may have developed. Depending upon the presence or absence of satisfactory advance growth, the planting of softwoods on the area will be either partial (by groups) or complete. In either case the abundance of hardwood of one sort or another for "filler" (Fig. 9), makes possible a wide spacing of the planted stock, and consequently a much smaller outlay for planting than in the case of open lands.

On the heavy soils, even where the plantation has been properly put in,* weeding will be needed inside of 3 years. It can best be done in the spring before the leaves come out. Practically all rank-growing sprout clumps should be cut back to the ground, and care taken not to throw the brush on top of the plants. The second weeding follows 2 to 4 years after the first, and is slightly less thorough. All rank-growing sprouts should again be cut back, but much of the more slowly growing hardwood (seedlings, and sprouts from very small stumps) left. No matter how poor in species or quality the hardwood may be, it is of benefit in maintaining a high density of stocking necessary to insure high quality, in protecting white pine and Norway spruce from attack by the white pine weevil,** and in improving the soil.*** A third weeding, a few years after the second, is usually sufficient to free the new crop. During the last weeding any scattered pines left because of the Pales weevil should be girdled or cut down. The new stand, because of the wide spacing, may go without thinning for 30 years or more, and straight, small-knotted butt logs will be produced, even where white pine is planted.

With the light, sandy soils, plantations set out on cut-over cordwood areas likewise require weeding, but not so early as with better soils. Care should be taken not to cut back other than rapidly-growing sprouts which are seriously hampering the growth of the planted stock, since with the light soils it is particularly desirable to bring along a hardwood "filler," if only for purposes of soil improvement.

In the case of *underplanted* cordwood stands on the light soils, weeding will be needed after the overwood has been cut and the resulting sprout growth has commenced to retard the development of the plantation. One or two weedings will suffice to free the new stand.****

*The spring following the cordwood cutting, with thrifty, 4-year stock, wide spacing (about 8 x 8 ft.) and no plants set closer than 3 feet from a sprouting stump.

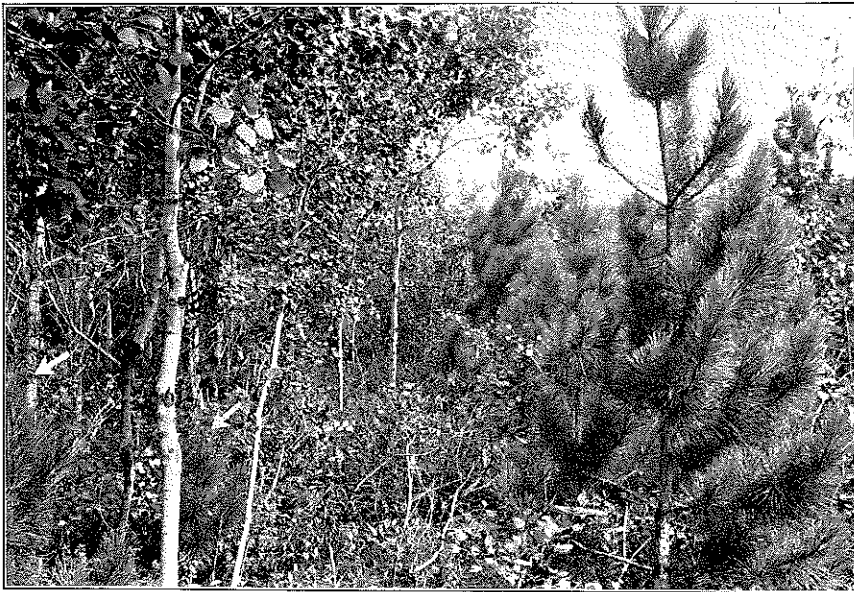
**See Harvard Forest Bulletin No. 5, Control of the White Pine Weevil by Forest Management, by H. B. Peirson, 1922.

***See Soil Changes and Silviculture on the Harvard Forest by R. T. Fisher, Ecology, Vol. IX, No. 1, p. 6.

****The underplanting of gray birch and other inferior hardwoods has been extensively practised on the Yale Forest at Keene, N. H. The overwood is removed within 5 years after the plantation is established, and one or two subsequent weedings are required.

D. Plantations Overtopped by Scrub Oak.*

In extreme contrast to the conditions under which stands composed entirely of hardwoods should be favored are those commonly found on the very lightest soils of Cape Cod and Martha's Vineyard, where only a feeble growth of true scrub oak is present. Planting is plainly the only possible method of establishing a valuable stand. Several species of pine have been set out under scrub oak of varying density and from 2 to 6 feet in height. In some instances where the areas have been repeatedly burned over before planting, the planted pines (white, red and Scotch) have come up through the oak without any aid whatever. But under conditions more favorable for the oak the plantations have sustained some losses early in life which will result in incomplete stocking and reduced income at the end of the rotation. It is under the latter conditions that weeding comes into use. Weeding in scrub oak consists in cutting holes for the planted trees to come through, instead of cutting all of the oak, and can be done cheaply, except where the "scrub" is so thick or so high as to retard travel through it. In this work it has been found advantageous to wait until there is some snow on the ground in order that the workmen may track themselves. Otherwise, owing to



Harvard Forest Photograph

Figure 10. The Results of Weeding and Lack of Weeding Demonstrated within the Same Plantation.

An even-aged plantation of red pine on cut-over, light, sandy land. On the right-hand side weeding was done in time; on the left-hand side no weeding has been done. Note the difference in height between the pines on the right and those on the left. (See arrows.)

*The author is indebted to Lincoln Crowell, District Fire Warden, Sandwich, Mass. and to Hollis A. Smith, formerly Superintendent of the State Forest Reservation at Martha's Vineyard, for much of the information given under this case.

the practice of making small holes by just cutting the tips of the oak branches, one would have difficulty in telling where he had already worked. One weeding, properly timed, should be all that is required.

WHEN AND HOW CUTTING SHOULD BE DONE

Best Time For Weeding

Weeding, if it is to yield the greatest return for the least outlay, must be done at the proper time. If delayed too long, it costs more than when done earlier because of the larger size of the stems to be cut, except where the cuttings are marketable, and causes a loss in desirable crop trees which could have been avoided by timely treatment. Even a delay of one year where plantations are overtopped by a dense thicket of weeds may cause considerable loss in growth by the planted stock. Furthermore, the longer the delay, the larger the root systems of the weed hardwoods become, and the faster the rate of growth of sprouts when the weeds are finally cut. But it is also possible to weed too early, before individual differences in growth and quality are easily seen, thus spoiling trees (by cutting them back) which later inspection shows should have been left. This applies particularly when weeding in stands of mixed hardwoods. It is also advisable to delay in the case of poorly stocked stands on cut-over land which are not worth weeding more than once, and in stands on old fields where the weed trees may be allowed to reach merchantable size for cordwood without too much damage to the trees desired for the final crop. (See Releasing Pine from Gray Birch).

The timing of weeding with regard to season is also important. In stands of hardwood, or mixed hardwood and softwood, weeding should be done when the leaves are off. Otherwise the dense hardwood foliage hides the softwoods and many of the smaller and most desirable hardwoods (from seed and small stumps), making the operation slow, uncertain, and costly. An exception to this rule may be made where two hardwood species closely resembling each other form an important part of the stand, for example, paper birch (a good crop tree) and gray birch (a weed tree). Here weeding may be delayed until the leaves come out in order to facilitate identification. Where softwood crop trees have been growing underneath hardwoods, the weeding should be done in the spring rather than in the fall, in order to give the former an opportunity to become stronger, and more resistant to snow and ice damage the following winter. Where hardwood weeds are few and their foliage therefore does not hide the trees favored for the crop, weeding may be done satisfactorily at almost any season. However, small trees are easily damaged by breakage of limbs or tips when the cutting is done during extremely cold weather.

Regardless of how effective cutting in late summer may be in weakening sprout growth, any advantage so gained will be more than offset by the slow progress made when the trees are in full foliage.

Tools and Method of Cutting

Various tools, including brush scythes, sickles, machetes, hand axes, and short and long handled bush hooks have been used in weeding and releasing. In most cases weeding, if properly done, requires selective cutting and consequently a tool which can be handled with accuracy



Harvard Forest Photograph

Figure 11. Three different Sizes of Machetes as Used on the Harvard Forest Compared in Size with a Light Axe.

and precision. For all around use on small stems up to about 2 inches in diameter a machete is considered the best tool. It is short and light, and can be easily handled in the densest thickets of saplings. Machetes are obtainable in many different shapes and sizes (Fig. 11) to fit a wide range of use and personal choice. They should be kept in good condition by frequent sharpening. For this purpose a round pocket stone, about half an inch thick and with two grades of abrasive is very satisfactory. Hand axes and cutting tools of the cleaver type are used to some extent on the smaller stems, while still heavier tools, such as axes and bush hooks, are found most suitable on larger or tougher stems. The bush hook is favored by some for cutting back such material as scrub oak. For releasing work which involves the cutting of cordwood-size stems, the axe is of course the best tool. An axe also comes in handy for girdling work in connection with weeding.

Partial severance of the stem, followed by the bending down to the ground of that portion of the stem above the cut, is considered good

practice, as it results in a slower growth of sprouts starting from below the cut than in the case of cutting clean through. Cutting back, either partially or completely, seldom results in the death of the tree. Partial severance works out best with stems which are too large to completely sever with a single blow. With very small stems, especially when in dense clumps or thickets, it is impractical to carry out partial severance.

The height above ground at which stems should be cut will vary considerably with the density of the stand and the relative heights of weeds and crop trees, making it impossible to lay down any general rules.

COSTS OF WEEDING

The cost of weeding may best be shown in man-hours. The actual cost in dollars and cents will vary with the prevailing wage rate. For example, weeding mixed hardwood or pine-hardwood stands on cut-over land requires approximately 8 man-hours, or one day, per acre.

TIME REQUIRED FOR WEEDING

Cases	Number of Weedings Needed	Total Man-Hours Per Acre*
1. Weeding mixed hardwoods following "old field" pine	1 to 3	12 to 24
2. Weeding mixed hardwoods following sawtimber hardwood	2 to 3	20 to 30
3. Weeding mixed pine and hardwood following "old field" pine	1 to 3	12 to 30
4. Releasing pine from gray birch	1	8 to 24
5. Weeding plantations on brushy fields and pastures	1 to 2	10 to 20
6. Weeding plantations on cut-over cordwood land (heavy soil)	2 to 3	20 to 30
7. Weeding plantations on cut-over cordwood land (light soil)	1 to 2	10 to 20
8. Weeding plantations on scrub oak land	1	4 to 10

*Cost of Supervision not included.

The range in weeding costs for a given case varies with factors of composition, origin, age, and density of stocking, because they largely control the kind, size, and amount of material to be cut. Where, as in cases of releasing pine in "old field" stands, material large enough for cordwood may be removed, the net cost may be little or nothing; or, under very favorable conditions, even a profit may be realized. In most cases, however, the material removed has no merchantable value, and the cost of weeding is a direct charge against crop production.

Weeding has a greater and, when properly applied, a more beneficial effect on the make-up of a stand than any other silvicultural operation. A few dollars wisely spent in improving a stand in its youth, when the least effort produces the greatest improvement, will result in a greatly increased net income from the final crop. In some cases a single weeding may be the means of converting a stand which would naturally produce only wood worth but a few dollars per acre to one of sawtimber worth several hundred dollars per acre. But considerable knowledge of growing timber crops is necessary in order to avoid unnecessary expense, and to realize the greatest possible return. In most cases the owner will find it profitable to obtain the advice of a forester before starting the operation.

This bulletin is published by the Massachusetts Forestry Association as a part of its Research and Educational Program, the purpose of which is to bring to woodland owners valuable technical information in simple form. The Association cooperates with public and private forestry organizations in the preparation of these bulletins. It has already published two bulletins in this series; "Pruning for Profit As Applied to Eastern White Pine" in cooperation with the Harvard Forest, and "The Cape Cod Forest Fire Prevention Experiment" in cooperation with the Massachusetts Division of Forestry. Several other bulletins on subjects of special interest to woodland owners will be published in the near future. Contributions to the Research and Educational Fund are earnestly solicited.

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4 Joy Street,
Boston, Mass.
May 15, 1929.

