U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF FORESTRY—BULLETIN No. 42.

GIFFORD PINCHOT, Forester.

THE WOODLOT:

A HANDBOOK FOR OWNERS OF WOODLANDS IN SOUTHERN NEW ENGLAND.

BY

HENRY SOLON GRAVES,
DIRECTOR OF THE YALE FOREST SCHOOL,

AND

RICHARD THORNTON FISHER,
FIELD ASSISTANT IN THE BUREAU OF FORESTRY.

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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF FORESTRY,
Washington, D. C., March 13, 1903.

SIR: I have the honor to transmit herewith a report entitled "The Woodlot: a Handbook for Owners of Woodlands in Southern New England," by Prof. Henry Solon Graves, director of the Yale Forest School, and Richard Thornton Fisher, field assistant in the Bureau of Forestry, and to recommend its publication as Bulletin No. 42 of the Bureau of Forestry.

The four half-tone plates and thirty text figures accompanying this bulletin are necessary for its proper illustration.

Respectfully,

GIFFORD PINCHOT,
Forester.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE WOODLOT:

A HANDBOOK FOR OWNERS OF WOODLANDS IN SOUTHERN NEW ENGLAND.

INTRODUCTION.

This handbook has been prepared for the use of owners of woodlands in southern New England. Its purpose is to show how second-growth woods should be treated in order to yield larger returns in the long run than are possible under the present methods. There is now a widespread demand for information of a practical, every-day kind, which will enable the average owner to make thinnings and conduct other kinds of forest work for himself. It is impossible to make expert foresters through books; but it is entirely feasible to show the principles of woodlot forestry to men who already understand something of the nature and habits of trees, so that by observation and practice in the woods they can learn to handle their property to the best advantage. It is for the guidance of such owners that this book is intended. It contains the results of extensive experience in handling second-growth woodlands. The aim has been to use these results so as to make them available to everyone. In order not to defeat this object technical language has been avoided, nor has the classification of cuttings commonly found in text-books of silviculture been followed strictly. Methods of cutting are advised which can be applied most simply and with the best results under the conditions now existing in the region for which the work is particularly designed.

THE WOODLAND OF SOUTHERN NEW ENGLAND.

In southern New England the woodlands are, for the most part, in detached, irregular bodies. In parts of western Massachusetts and Connecticut, where the country is hilly and comparatively inaccessible, some thousands of acres of continuous woodland still exist; but elsewhere the forest occurs in the form of wood lots, which alternate with cleared land. This irregular distribution, and the fact that inferior or abandoned lands in many localities are continually growing up to trees, make it difficult to calculate the percentage of forest land. The United States Geological Survey places the percentage of forest in Massachusetts at 52, in Rhode Island at 40, and in Connecticut at 39.

The forests of southern New England are composed chiefly of hardwoods, such as Oak, Chestnut, Maple, Hickory, and Ash. The hardwoods predominate largely, except in eastern Massachusetts and northeastern Connecticut and Rhode Island, where White Pine occurs in solid groves on gravel ridges and on the sandy borders of streams and ponds, with only an occasional hardwood in mixture. Near the coast, as on Cape Cod, Pitch Pine is the principal tree. Pitch Pine is also scattered throughout the whole of southern New England, and in some places is the tree which occupies worn-out and sandy fields. Red Cedar is another evergreen which comes up on old fields, especially in southern Connecticut. It sometimes grows to the exclusion of all other species, with as many as 500 to 1,000 trees per acre when 40 to 60 years old. More often it is mixed with Gray Birch, and later in life with other hardwoods, which gradually creep in among the cedars and birches. Hemlock also grows in all sections of the region under consideration, but it is confined, as a rule, to ravines and cool slopes. In the aggregate it does not occupy over 5 per cent of the total forest area. The other conifers, like the White Cedar in the coast swamps, Spruce and Balsam on the high peaks of the northern Berkshires, and the rare Tamarack and Red Pine, require no particular mention because of their relative scarcity.

The oaks are the most common hardwoods, except in the Berkshires, where they are largely replaced by Hard Maple, Yellow and Paper Birch, Beech, and Black Cherry. In eastern Massachusetts the oaks occupy the best situations, mixed with Maple, Ash, and Hickory, and, on loose sands and gravels, accompany the White Pine. In this section the commonest oaks are the White, Black, Scarlet, and Red, while Scrub Oak is also abundant on old fields and in abused wood lots. Along the coast Post Oak, a southern species, occurs among the Pitch Pines.

Chestnut is one of the commonest trees, except in northeastern Massachusetts and in the Berkshires. In Connecticut it frequently forms 60 to 80 per cent of the woods on rolling land and on lower slopes of the higher ridges. In these places it is mixed with White, Black, Red, and Scarlet Oaks, Shagbark, Pignut, Bigbud, and occasionally Bitternut Hickory, Hard and Soft Maple, Black Birch, Butternut, Slippery Elm, and Ironwood; and, on the very best soils, with Tulip Tree, White Ash, and Basswood. On the shallower soils the most prominent tree in mixture with Chestnut is Chestnut Oak, which often entirely replaces it on stony ridges and upper slopes.

In most swamps throughout southern New England Red Maple is the characteristic and often the only tree. It is accompanied on the wettest ground by Elm, Swamp White Oak, Black Ash, and in some places by Pin Oak. Gray and Yellow Birch, Tupelo, White Ash, and Hornbeam are plentiful in less wet places.

Burned land is frequently occupied by Quaking Aspen and Largetooth Poplar. The latter is also common in mixture with the oaks and Chestnut, usually occurring in small groups.

There are other species of interest to the botanist, but of less value to the forester because of their rarity or small size. These are Red Ash, River Birch, Cottonwood, Sycamore, Black Willow, and Silver Maple near some streams; Persimmon and Sweet Gum in isolated spots in Connecticut; Hackberry, Mulberry, and Juneberry; Dogwood, occurring very generally over the hardwood belt; Pin Cherry, common on burns; and the small Mountain and Striped Maple and Mountain Ash of the high Berkshires.

CONDITION OF THE FOREST.

Practically the whole forest in southern New England is second growth, which means that the area has been entirely cut over at least once. The woods are mostly under 60 years of age. This is due to the fact that owners generally cut their trees as soon as they are large enough for the market. Stands older than 60 years are either in rather inaccessible places or belong to well-to-do persons, who preserve them for their beauty or to produce timber of special size.

The common custom has been either to cut the woods clear, or, in handling small woodlots, to remove from time to time trees for special uses without regard to the effect on those remaining. One result of such cutting has been to reduce the proportion of valuable species in many localities. It is well known that when White Pine is cut, hardwood frequently forms the next growth. This happens when neighboring hardwoods have seeded up the ground under the old pines where pine seedlings could not start on account of the shade. If the hardwoods have not seeded up the ground, a new growth of pine follows the old pine, provided there are trees near at hand to furnish the seed. Another common result of careless cutting is that Black Oak crowds in in place of more valuable trees, such as White Oak and Hickory; Ironwood and Dogwood come in on open places to the exclusion of better trees; Chestnut Oak often replaces Chestnut; Gray Birch and Soft Maple follow Ash; and Hemlock not uncommonly crowds out Red Oak and Chestnut.

Second-growth hardwood forests are composed principally of sprouts which spring from the stumps after cutting. These sprouts are inferior to seedling trees. They are usually short-lived, because the old stumps, from which they have sprung, decay, and finally infect them. This explains why so many sprouts are rotten at the butt when 40 to 60 years old, and also why old sprout forests are filled with dead and dying trees. The rate of annual decay is often so rapid in old sprout woods that the amount of wood added each year by growth is more

than offset by the decay. For example, it was found from a large number of measurements taken in a sprout forest in southern New York that the average yield per acre in cubic feet was less in the 50-year old stands than in those 40 years old, and less in the 60-year old stands than in those 50 years old. To be sure, the sale value of the larger and older stands was increasing, because the sound trees were advancing to more saleable sizes, but the number of dying trees was so great as to more than offset in actual cubic contents the annual increment. When a sprout forest is allowed to grow older than 40 to 50 years, and is then cut, many of the old stumps are capable of sending up only feeble shoots, and many do not sprout at all. For this reason sprout woods under ordinary conditions become open and lose in productiveness after a few cuttings.

Sprouts from high and ragged stumps are generally defective, especially when they start from the sides of the stumps rather than close to the ground. Side sprouts are apt to spread apart and grow crooked to get clear of the old stumps; and being above ground, they have no chance to establish root systems of their own. Again, sprouts are more apt to be crooked than seedling trees because they grow in clumps, and have to crook in order to find room for their crowns. This evil can be avoided by early thinnings.

In a great many places the present poor condition of the woods is due not so much to injudicious cutting and neglect as to damage by fires. Woodlots which do not show some traces of fire are scarce. Trees are quickly infected with rot after severe burning, if they are not killed outright. In every case young growth, which would otherwise help shade the ground and perhaps form the basis of a succeeding crop, is destroyed. The burning of the leaf mold is also an injury, because the soil is then apt to dry out, and this affects the growth of the trees; or the soil hardens and retards reproduction. Moreover, the thinning of the stand through fires encourages the growth of weeds, shrubs, and grass, all of which hinder the development of young trees and in some cases exhaust the soil.

Grazing in woodlots is also injurious, because cattle and sheep browse on young hardwoods and prevent them from developing and filling the gaps made by cutting or other causes.

As the result, therefore, of the ordinary way of cutting, of forest fires, and of grazing, the woodlands of southern New England are not producing as much wood and timber each year, or as good, as they might under proper treatment. The productiveness of the average woodlot is impaired every time it is cut. Its sale value may increase on account of better roads and better market, but its intrinsic value will continue to decline until it is given the care demanded by every growing crop. Such care is within the reach of nearly all woodlot owners.

FORESTRY FOR SOUTHERN NEW ENGLAND.

Broadly speaking, the practice of forestry in southern New England calls for the following operations:

First. Thinning in woods not mature, to improve the conditions for growth and to utilize material, much of which would otherwise be wasted.

Second. Cutting in mature woods in such a way that the succeeding growth will follow quickly, will be composed of good species, and will be dense enough to produce not only trees with clear trunks, but also the greatest possible amount of wood and timber.

Third. Pruning, which is only practicable in certain sorts of stands.

Fourth. Protecting forest property against fire and, in some cases, against grazing.

Fifth. Restocking waste lands by planting or sowing.

IMPROVEMENT CUTTINGS.

The purpose of improvement cuttings is to give to the most promising trees the amount of light and growing space required for their best development. This is secured by cutting out the unlikely trees which are crowding more valuable ones. There is no thought of starting any new growth, as in making reproduction cuttings; the improvement of the stand is the only purpose.

The openings made by improvement cuttings are regarded as temporary; it is expected that the crowns of the remaining trees will spread and come together in a few years, and again completely shade the ground. If the woodsman keeps this in mind, there is usually no danger of making too heavy a thinning.

When the thinning is too severe there is danger that the soil may dry out on account of exposure to sun and wind. The trees will then grow slower instead of faster; or small branches will start on their trunks from hitherto undeveloped buds and sap the strength of the trees, so that they often become top-dry. Weeds, grass, and shrubs spring up in great profusion on account of the increased amount of light admitted, and prevent the germination and development of young trees. Young trees which do spring up under these circumstances are soon suppressed, and may never become of value except in the case of a few species like Maple and Beech, which can live in deep shade. When, later on, it is desired to cut and reproduce the woods, these dwarfed trees interfere with the development of a new thrifty growth in the same manner as weeds and shrubs. These evils follow only where large gaps are made which can not be filled within a few years by the spread of the tree crowns. Sometimes in irregular woods reproduction cuttings and improvement cuttings are made at the same time. In the present discussion the two sorts of cuttings are kept separate to avoid confusion.

IN REGULAR, EVEN-AGED WOODS.

(See Pl. II.)

Even-aged stands are those which have started about the same time, either from sprouts or from seed. In such stands there is a contest between the different individuals for position, and in consequence a mutual crowding of the crowns. The result of this struggle is that some trees are entirely overtopped by their more successful neighbors and are either shaded to death or retarded in growth. Other trees are only partially suppressed, and remain fairly thrifty, but grow slower than the leaders. This mutual crowding and the greater or less success of the different trees in the struggle for position accounts for the wide variation in diameter of trees of the same age. It is customary to classify the trees in an even-aged forest in four divisions: First, the dominant trees, whose tops form the chief cover; second, the intermediate trees, whose crowns are slightly below and crowded by the dominant trees; third, the suppressed trees, which are those entirely covered by the main canopy and which are usually in a puny condition; and fourth, the dead trees. Generally speaking, it is mainly the dominant trees and the larger specimens of the intermediate trees which are to form the ultimate stand, and which are to be helped by the removal of the others.

The general rule for thinning is to remove all dead and dying trees, suppressed trees, and such individuals of the intermediate class as are crowding the dominant trees or the more thrifty intermediate trees. The cutting of intermediate trees allows more space for the remaining trees to spread, and admits more light to the lower parts of their crowns. The trees left standing grow more rapidly and reach a merchantable size much sooner than when the woods are left untouched until maturity. It is estimated that through this kind of thinning the time required for forests to grow from seed to merchantable size may be shortened from ten to twenty years.

The removal of dead and entirely suppressed trees does not affect the growth of those which remain. They are cut in order to use the wood before it decays. Sometimes the dead and dying trees make breeding places for insects, which may attack living trees. This is especially true of evergreens. Moreover, the dead trees fall, and make fuel for forest fires. Suppressed trees should be left if needed to shade the ground.

It is to be emphasized that in improvement cuttings the trees taken out are chiefly the backward ones, and that their removal does not break the even cover of the dominant trees, except temporarily. Sometimes, however, dominant trees have to be cut. This should be done when the dominant class contains straggling specimens of poor species, like Butternut, Sassafras, or Mulberry, which are overtopping healthy specimens of valuable species, such as Oak or Hickory. But

even then the overtopping tree would be cut only when the trees below it would really profit by the release, or when the gap in the stand would be filled in a short time by the meeting of the crowns above it. In the same way a spreading tree or a poor specimen of desirable species, if crowding better individuals, even though of poor species, would be cut, provided the smaller trees are healthy and capable of responding to the new light. In many woodlots which have never been thinned these stragglers, or poor trees, have already so far overtopped and injured the trees about them that the latter will not recover even if set free. In such cases the old trees should be left until the woods are ready to be cut, and to make way for reproduction of a new crop. If the stragglers and poor trees should be cut the remaining trees would be very little helped, and young growth and weeds would spring up in the opening before the stand is ready for reproduction.

The cutting of unlikely trees in the dominant class is attended by the best results if made when the woods are young. This is because the young trees respond quickly to the new conditions of light, and by their rapid growth soon fill up the open spaces. The cutting of straggling trees which are larger than the average is one of the first things to be done in a young forest. (See Pl. IV, fig. 2.) In almost every young stand, particularly where the trees are not absolutely of the same age, there are a number of these stragglers which are usually a few years older than the main crop. Sometimes they are of different species, as when Poplar and Birch spring up as advance growth on fields and later crowd young pines or hardwoods; sometimes they are of the same species as the main stand. If these trees are cut before the woods are 15 to 20 years old, comparatively little harm is done by them. If, however, they are not cut early in the life of the stand, they may kill a number of thrifty trees which, taken together, would have produced more timber of value than their destroyers.

On the other hand, thinnings which remove the subordinate trees are preferably made at about the age of 10 to 15 years. Such early thinnings are of particular value in sprout woods designed to produce straight poles and ties. When these thinnings are not made a large number of sprouts grow curved or crooked, and can not produce sticks straight enough for poles or ties.

While very early thinnings are desirable from the standpoint of high production, it is probable that many woodlot owners will not make such thinnings before the trees are 25 to 30 years old. Sprout forests should be first thinned at least before the age of 30, and seedling forests of hardwoods by the age of 40 years. After the stand has been thinned, and the crowns have come together so that they interfere with each other, another thinning is necessary. To produce the best results, thinnings should be made frequently, and not over 20 per cent of the stock should be removed each time.

These are the general principles of improvement cuttings in even-

aged stands. In this country they are somewhat complicated by the fact that woodlands have suffered from forest fires and other causes, and that in consequence there are a large number of very defective trees in nearly every stand, which it is necessary to remove, even when they are not interfering with other trees. Where the number of such trees is large the thinning partakes more of the character of a reproduction than of an improvement cutting. The gaps thus made in the woods will be too large to be filled up by the spreading of the neighboring crowns, and it is desirable that young growth should come up to replace the old trees; this virtually constitutes a reproduction cutting.

In making improvement cuttings care should always be taken not to expose a stand to danger of windfall. In very dense Black Birch and Soft Maple woods, for example, the trees are very tall and slim, and any severe thinning would certainly be followed by loss from this cause.

It is impossible to explain in a book of this character all of the individual problems which the woodlot owner will meet in making improvement cuttings; but in the diagrams at the end of this bulletin an attempt has been made to show typical cases. It is believed that, with these diagrams before him, any woodsman who has good judgment concerning the health and thrift of trees can learn by himself to make improvement cuttings.

IN IRREGULAR, UNEVEN-AGED WOODS.

As already explained, many New England woodlots contain trees varying in age, size, and condition. Such are the sparse, straggling woods which have come up on old fields and pastures; the Birch woods, in which White Pines are coming up plentifully underneath; woods which have been broken into groups of many ages through having been cut into here and there; Oak and Chestnut woods with a lower growth of Hemlock; neglected sprout woods, and burned woods in which some of the trees have died from time to time and have been replaced by new growth. Woods like these require improvement cutting quite as much as the regular, even-aged stands.

Improvement cuttings in irregular woods are governed by the principles already described for improvement cuttings in regular stands. But the very irregularity of such woods makes them present a wider range of problems to the owner. They require more knowledge and judgment in selecting trees for cuttings. For an illustration of the general nature of these problems we may take the common case of old oaks and chestnuts which have been left in isolated positions, and underneath and about which a relatively even-aged stand of younger trees has grown up, which are being injured by the shade of the other trees. Improvement cuttings in such a place would call for the removal of these old trees, as well as the thinning out of the younger ones.

Many places would be found where the old trees have already injured the younger ones about them so much that the latter could never recover. Then both the old and the suppressed and injured trees would be cut clean (except for what might be needed to shade the ground) to make way for an entirely new growth. This work, however, would be essentially reproduction cutting. Extensive cuttings of exactly this kind have been made on the Biltmore estate, in North Carolina.

Another kind of irregular forest is found when a dense growth of Cedar, Birch, and other trees forms an uneven stand on old pastures. In such a forest there are always stragglers crowding smaller trees of better species and better form; intermediate trees crowding up against thrifty dominant ones, and a great many suppressed trees. In such cases the dominant stragglers can usually be removed with safety to the forest, because of the large amount of small growth beneath them. The removal of the other trees follows the general principles already set forth.

Still another common case is that of an old pasture covered with Cedars, ranging in age from 20 to 50 years, almost to the exclusion of other trees. Here improvement cuttings should be very heavy. All suppressed and the majority of the intermediate trees should be removed, leaving only the dominant trees which have large crowns, with an open space of about 5 feet between the crowns. The reason for this is that a Cedar grows very slowly when crowded at all, and in order to produce posts within forty years requires a full crown and abundant light.

Still another example of an irregular stand is a sprout wood on a north slope, under which a dense growth of Hemlock has come up. These sprouts can be removed as soon as they show signs of deterioration, leaving the Hemlock in their place. The same rule applies to the Birch and Poplar stands of Massachusetts, under which White Pine grows so abundantly.

The improvement cuttings which accompany the selection method of reproduction cuttings described below consist in taking out suppressed trees which could never recover, even if the shade above them were removed, and such trees of the intermediate class as are crowding thrifty dominant individuals.

REPRODUCTION CUTTINGS.

THE SELECTION METHOD.

Cuttings made with the expectation that a new growth of trees will replace those removed are classed as reproduction cuttings. In the so-called selection method the woodlot owner selects and cuts trees here and there which may suit his purpose. After the trees are taken out a young growth of sprouts or seedlings, or both, springs up in the

openings. The result is that after a time the woods become very irregular, with trees of many ages and sizes. The reproduction takes care of itself, seed being furnished by the neighboring trees. This method is often very successful, especially with trees capable of living in shady places, like Beech, Maple, Spruce, and Hemlock. With Oak, Chestnut, and Hickory, which can not endure as much shade as the species just mentioned, the young trees are apt to be so shaded from the side, and in some cases from above, by the older trees that they are unable to develop into good specimens. Where this method is used in southern New England, therefore, the woods frequently deteriorate.

Ordinarily in southern New England the selection method of cutting is practiced with little intention of producing or favoring reproduction. It is often unsuccessful because the owner selects the best trees and leaves the poorest, not only of the merchantable class, but of the smaller trees used for cord wood. The result is that the woodlot runs down into undesirable species and poor individuals. Moreover, damage is frequently done to the small trees when the older ones are cut. Much of this could be avoided by care in getting out the wood, but ordinarily this care is not exercised, and a great deal of young growth of large prospective value is either destroyed or badly damaged.

The selection method of cutting is recommended for home woodlots where the inferior wood can be utilized for fuel and the better trees either used or sold for special purposes. In making the cuttings, however, great care must always be taken not to injure young growth in felling the trees, to select the inferior species and poor individuals first, and at the same time to make also an improvement thinning, on the principles already explained, among the remaining trees. If the owner will take these simple precautions the woodlot will, after a time, be well stocked with good trees.

THE SPROUT METHOD.

A still commoner method of reproduction cutting is the simple sprout or coppice method. This, however, is not often practiced in its best form. It consists in periodically cutting the hardwoods clear and allowing them to sprout up again. This method is very extensively used on woodlots in Europe. The woods are cut at shorter periods than in this country—usually in from twelve to twenty years—and are always kept fully stocked by planting up the open places where necessary. One reason why the Europeans cut their sprouts comparatively young is that after the trees are from 20 to 40 years old the sprouting power of the stumps is apt to fall off. After forty years some of the stumps may not sprout after cutting, and others sprout only feebly. When it is desired to raise larger trees in coppice woods, some individuals are allowed to remain over one or more cuttings. In the United States the sprouts are usually cut from 25 to 60

years old, and no effort is made either to rejuvenate the forest when it becomes thin or to provide for thrifty crops. The result is a forest which deteriorates from generation to generation. If cord wood alone is desired, and the plan is to cut the woods clear every twenty to thirty years, the owner should keep the following rules in mind:

First. Stumps should be cut low, in order that the sprouts may become independent of the old root system as soon as possible.

Second. Stumps should be cut smooth and slanting, so as to permit the water to run off, as from the roof of a house. If the stumps are cut trough like, water collects in them and they are apt to rot and infect their sprouts.

Third. Care should be taken not to tear the bark from the stumps, since this often prevents buds from developing at the root collar.

Fourth. The sprouts should be cut when the sap is down, or else in early spring. When they are cut in midsummer, new shoots are apt not to complete their growth and harden their wood before frosts. If sprouts freeze before completing their growth they usually die down during the following year.

Fifth. If the new crop is thin through the failure of some stumps to sprout, it may be filled in by transplanting small seedlings or by sowing acorns or other nuts in the openings.

When sprout woods have been allowed to grow fifty to sixty years, a good way to insure a full second crop is to take them off in two cuttings. First, the woods are thinned rather heavily in the manner described on page 16, so as to permit the seeding up of the ground; when a good crop of young seedlings has come in, as would usually occur in five or six years, the older trees are cleared away. The second crop will then be composed of a large number of seedlings in addition to the sprouts which come up from old stumps, thus rejuvenating the forest.

METHOD OF SUCCESSIVE THINNINGS.

The "Method of Successive Thinnings" consists in cutting and at the same time providing for the reproduction of a merchantable stand by a series of rather heavy thinnings. A period of ten to twenty years elapses between the first thinning (see Pl. I) and the time when the last old trees are finally cut away from above the new crop of seedlings. It is a good method for those owners who do not wish to cut their woods clear at one time, but prefer gradually to transform them into a new and thrifty crop of desirable trees. The Method of Successive Thinnings is also applicable to stands of such kinds of hardwoods as bear heavy seed, like Hickory and Oak, because the seed will then be dropped in abundance all over the ground; whereas if the land is cut clear the seed must be brought by animals, and a longer time will be required for reproduction.

This method is well suited to tracts belonging to water companies, where a constant forest cover is required for the protection of the watershed. It may be used also by owners of country estates who maintain woodlands as parks, and therefore prefer, as soon as the woods become mature, to have them cut gradually rather than all at once. After the first thinning a young growth of new seedlings and sprouts from the stumps of the old trees will come in. As soon as the ground is well covered with this young growth the remaining trees can be removed in several successive cuttings, stretching over a period of ten to fifteen years. This method is particularly applicable to hardwood stands which are relatively even aged, like old sprout woods 60 to 80 years old.

The woodsman would make the cuttings in the following way: In the first thinning he would take out the dead, dying, and defective trees. Defective trees include those having frog stools or canker scars on their trunks, hollow trees, those partly girdled at the base by fire, those whose trunks have been attacked by borers, top-dry trees, and those badly broken or bent by ice and snow. Suppressed trees and those crowding more thrifty trees are also cut, just as in improvement cuttings. Very small trees are cut because they are usually suppressed so badly that they would never recover, and it is therefore better to remove them and make way for a new crop. The largest-crowned trees are also cut, because later on they would injure the new seedling undergrowth much more than the trees with smaller crowns. The removal of all these classes of trees would take away about 30 per cent of an average second-growth hardwood stand and leave about 125 to 150 trees per acre.

The woodsman would make the second thinning as soon as the young growth is well established and begins by retarded height growth to show the need of more light. In the second thinning some small growth would necessarily be broken, but with care the damage would be very slight and undoubtedly would be remedied by new growth from seed of the trees still standing. The young growth might be so far advanced at the time of the second thinning that the whole stand could be cleared. On the other hand, it might be desirable to make a third thinning before the removal of the last old trees. Many owners would prefer to prolong the successive thinnings over as long a time as possible, so as to keep the older trees for their beauty. In such a case the woods might be left after the first thinning until the trees again began to deteriorate, which would probably occur within ten years in the average wood lot. The second thinning would then remove simply the dying and defective trees, which might amount to 5 to 8 cords per acre in a 70-year-old stand. This process would be continued until all of the old trees were cut, the entire period of the thinnings covering about twenty-five years. On account of the length

FIG. 1.—A 50-YEAR-OLD WOODLOT NEAR NEW HAVEN, CONN., WHICH IS TO BE REPRODUCED BY THE METHOD OF SUCCESSIVE THINNINGS.

The picture was taken immediately after the first thinning.

FIG. 2.—THE SAME WOODLOT IN ANOTHER PLACE.

Shows appearance immediately after the first thinning.

FIG. 1.—A DENSE STAND OF HARDWOODS ABOUT 40 YEARS OLD, WHICH NEEDS IMPROVEMENT THINNINGS, NEAR NEW HAVEN, CONN.

FIG. 2.—A HARDWOOD STAND AFTER AN IMPROVEMENT CUTTING, NEAR NEW HAVEN, CONN.

of this period, however, many young trees would have been suppressed or spoiled. This could be avoided by shortening the period and getting the old timber all cleared off in about ten years, as already described. This hurting of the new growth by letting the old trees stand too long is one of the sacrifices the owner must make if he chooses to keep the old trees so long for the sake of their beauty, but in adopting either method he gradually transforms and greatly improves the character of his woods.

METHODS OF SEEDLING REPRODUCTION AFTER CLEAR CUTTING.

In some cases the methods of cutting for seedling reproduction described in the previous pages would not be successful. For example, the system of successive thinnings would not be practicable with very tall, slim trees, which would be liable to windfall when thinned out. To be sure it would be possible under this system to make a number of very light thinnings at frequent intervals, in order to accustom the trees gradually to the more open positions which they must occupy during the progress of the reproduction underneath; but in most instances it would not pay to make numerous thinnings in this way. Therefore some method of reproduction cutting must be used by which the woods may be cut practically clear at one cutting.

A still more common case in which a method of clear cutting must be used is where the seed of the desired species can not germinate or the seedlings live under the shade of the older trees. Reference has already been made to the fact that only a few small pine seedlings are found in groves of older pines, if the stand is at all dense. They are, however, often abundant in gaps and on the edges of the woods. This indicates that clearings must be made for good reproduction of White Pine. One method of reproducing Pine under these circumstances is to make a clear cutting, with the exception of judiciously located seed trees, left singly or in groups. If the seed trees are large and have full crowns, which is necessary for the production of ample seed, and are evenly distributed, five trees per acre should furnish fairly good results. A larger number of seed trees will render abundant reproduction still more certain. This may be conveniently called the "Scattered Seed Tree Method."

Another method is to leave a still larger number of medium-sized trees instead of a few large ones. Thus, if a 60-year-old forest of White Pine is to be cut and reproduced, 20 to 25 trees of medium size may be left standing. They will then serve to furnish seed for reproduction, and are also useful in affording shade for the seedlings and in preventing excessive drying of the soil. Moreover, they will grow very large, living as they do through two generations and enjoying for many years full light for their crowns. Of course such trees must be healthy and wind firm. The trees might be prepared to withstand

exposure to the wind by thinning about them several years before the main stand is cleared. If there is unusual danger of windfall several trees may be left in a cluster, or, still better, if there are any hard woods in the stand, one or two may be left next to each Pine. This method is called the "Method of Reserves."

Still another system is to cut clear in strips, beginning on the lee side of the forest, so that the successive strips may progress against the wind. Seed for reproduction will then be furnished from the trees standing on the uncut areas to windward of the clearings. When the final strip is cut and no trees remain on the windward side of the forest, seed trees must be left on the area in the manner described on page 17. Fairly good reproduction is secured if the strips are 200 or 300 feet wide. The best results follow when the strips are not wider than the neighboring trees are high and when the cutting of a new strip is not started until the last preceding strip cut is seeded up. The method is applicable only where a number of years can be occupied in thus gradually clearing the tract. It is called the "Strip Method."

A good way, also, to reproduce Pine is to cut clear in small patches. To secure the best reproduction these patches should not have a greater diameter than the height of the surrounding trees, which are relied upon to furnish the seed. When these patches have been seeded up the trees between them can be cut, leaving seed trees scattered here and there for reproduction. This may be called the "Patch Method." In India it is called the "Well Method."

In applying these methods to Pine, hardwoods will often spring up on the cleared areas. If, however, the seed trees are at hand, Pine seedlings quickly follow, coming up under or with the hardwoods. They will survive under a low cover of hardwoods having light foliage, such as Oak and Birch. The woodsman should then look out for the young Pine seedlings and assist their growth by cutting away any poor specimens of hardwoods which are injuring them. In this way the Pines can be helped to start; later they will take care of themselves.

It sometimes happens that Pine seeds do not germinate on a dry matting of needles and leaves. Under these circumstances reproduction is assisted by burning off the surface litter. Of course it would be better if this material could be saved to enrich the soil by mixing it in with grub hoes or having it trampled by hogs, as is sometimes done in Europe, but in southern New England it is not practicable to save the litter in either of these ways.

These same methods may be used with birches which grow in solid stands. As a rule, they seed more profusely than Pine and fewer seed trees are required. An example of Black Birch cut by the Patch Method is illustrated by Pl. III, fig 1. Poplar is worth reproducing only where there is a market for pulp, or excelsior, or when limekilns are near. It seeds profusely and often, and its seeds are blown to

great distances. The burning of the ground after cutting would insure reproduction of Poplar if seed trees were at hand.

These clear cutting methods might sometimes be used to advantage in handling Black Ash and Soft Maple in swamps, in place of the more common Sprout Method.

MARKING FOR CUTTINGS.

In making thinnings it is necessary to mark the trees which are to be cut, as a guide for the choppers. Where the work is done by trustworthy choppers, a simple blaze on the trunk is all that is necessary. When the cutting is done by contract, it is always a temptation for the choppers to cut an occasional tree which is not marked, if it is easy to split and near a stack. To avoid this, without constant watching, a special mark may be made on the butt of each tree which will show after cutting whether it was marked or not. The best tool for this work is a shingle hatchet with a raised letter or other mark on the head. The blaze, made close to the ground, can be stamped with this mark. It is always a good plan to blaze the trunks in addition, so that the choppers can see the marked trees at a glance.

The most rapid and convenient way to mark the trees is for two or three men to work together and to pass back and forth over the tract, marking the trees in strips 20 to 25 yards wide. With wider strips or more men together the marking is less accurate, because there is greater chance of overlooking trees which ought to be cut. If two men work together, trees for improvement cuttings can be marked at the rate of 4 to 6 acres per day.

PLANTING.

On most farms and country estates there are open areas of more or less useless land, such as worn-out fields and pastures, undesirable either for crops or forage. Brush gradually creeps over them, and they grow up to a stand of trees of irregular age and poor quality. They have a very low value as woodland, because the majority of the trees are usually Birch, Poplar, Cedar, or some other poor species, and such good kinds as do occur generally have sprawling crowns and short, knotty trunks. It often takes from ten to twenty years for trees to get fairly started on these lands and from fifteen to twenty years more before they take full possession. The first crop is rarely of much value. It is not until the second generation of trees that a good stand of valuable species and individuals is established, and often not until the third and fourth generation.

It is a simple and comparatively inexpensive undertaking to plant up such areas in the beginning, and so save the time now lost in waiting for a valuable self-planted crop. The owner will not get any immediate return from the trees he plants, but his land is no longer

waste land, but promising woodland, correspondingly increased in value. Ultimately it will return a fair interest on his outlay.

Planting or sowing should be done also on cleared sprout land where the new crop of sprouts is thin. (See Pl. IV, fig. 1.) A good rule is to plant or sow wherever there are openings 15 feet square. Planting should also be done when trees of certain sorts are wanted which otherwise would not come in, and also when it is necessary for any reason to clear the land at once. Planting can be done far more cheaply than is commonly supposed. White Pine, one of the most profitable trees to raise, can be planted for $10 per acre, even when transplanted trees are brought from a nursery and the labor hired. If the plants are raised in a home nursery, the cost can be reduced to from $6 to $9 per acre, and if they are obtained from the fields near by, to from $3 to $6 per acre. Wild seedlings, however, are less apt to thrive than nursery plants. As for hardwoods, they are very easily started by planting nuts or acorns, an abundance of which can be gathered in the woods. The cost of planting them, especially to one doing the work himself, would be trifling, since it would be necessary only to walk back and forth over the area and plant the nuts 1½ to 3 inches underground at the proper season. White Pine, Red Oak, and Chestnut in suitable situations are all cheap and profitable trees to plant, and capable of yielding merchantable woods in thirty to fifty years. The planting need not be done all at once. It is often better, especially at first, to plant a small area each year.

The chief drawback to planting is the danger from fire, to which large plantations are particularly exposed. On small tracts, protected by their location and conveniently watched, this danger does not exist. It is, therefore, the small owner for whom planting is most practical.

The details of planting are not within the plan and scope of this bulletin, which is more directly concerned with the treatment of existing woods. Those who wish to familiarize themselves with the details of planting are referred to "The Forest Nursery" (Bulletin 29 of the Bureau of Forestry).

PRUNING.

The pruning of forest trees is not always practicable. It is entirely out of the question in sprout woods where only cord wood is to be produced. On the other hand, many owners of pine woods would find it profitable to prune their trees in order to obtain a greater percentage of clear lumber. In such a case the pruning can be done along with improvement cutting. It is a universal rule that only such trees should be pruned as are expected to form a part of the final crop. The pruning of small, suppressed, or sickly trees is a waste of time, because they will die or will be cut out in improvement cuttings.

Pruning does the most good in the early life of a forest, between the ages of 15 and 30 years. In such cases pruning will add to the

cost of the first improvement cutting not more than $2 per acre. The best way to prune is to cut off the limbs smoothly and as close to the tree as possible, taking care not to tear off the bark. With young trees still growing vigorously, this will insure the healing over of the cut before the wood rots. In forest pruning only dead branches are cut as a rule. They are ordinarily taken off only as high as the woodsman can reach with his ax.

PROTECTION OF THE WOODS.

FIRE.

Every year many hundreds of acres of woodland in Connecticut, Massachusetts, and Rhode Island are burned over. The sources of these fires are chiefly locomotives, careless hunters and picnickers, and neglected brush fires. Small wood lots surrounded by cleared land or near houses are easily protected. If by any chance fire starts in them, it is promptly seen and put out. The watchfulness of an owner or caretaker and of the men working about a place is the surest safeguard against fire. There are, however, many tracts distant from any house where such protection can only be obtained by hiring a special ranger during the dry season. If it is not practicable to hire a special ranger, such tracts can be best protected by means of fire lines. Fire lines are strips cleared of leaves and other refuse which check the progress of surface fires. Light fires are usually either stopped by fire lines or so checked that it is easy to put them out. Fire lines serve also as good starting points for back firing when that becomes necessary. Dirt roads make the best fire lines; for very light surface fires narrow trails answer the purpose. In the majority of wood lots an adequate network of fire lines can be made by clearing the leaves and other inflammable material from all the regular roads and wood roads. Frequently, however, a tract has no roads of any sort that can be cleared and utilized as fire lines, or it borders a dangerous stretch of brush or a grassy meadow where fires are apt to start. For such a tract special fire lines must be constructed along the border of the woods and in convenient places across them. A good rule is to have the fire lines, preferably dirt roads or trails, divide the land into lots of not over 25 to 30 acres each. The way to construct a fire line through the woods is to rake away the leaves and other rubbish from a narrow strip 3 or 4 feet wide, and then to burn a broad fire line 10 to 20 feet wide on one side of the strip. The purpose of first clearing off the narrow strip is to provide a side check in burning off the broad fire line. The fire is always started away from the narrow strip and allowed to burn toward it. There is then no danger of losing control of the fire. A plowed furrow is also a good side check when the land can be plowed. The same purpose is served when sand is at hand,

which can be quickly thrown on the leaves. One shovelful of sand will make a satisfactory side check fully 5 feet long if thrown by a practiced fire fighter.

There is no need of clearing away the old trees on the strip unless it can be plowed, or at least sown to grass, rye, or the like. Otherwise it is better to remove only the small growth which would burn. The old trees help to shade the ground, retarding the growth of brush and also preventing excessive drying of any material that may still be on the ground. A cultivated strip is the next best fire line to a dirt road, and if wide enough may be a better one. The cost of an ordinary fire line is about $10 per mile.

GRAZING.

If cattle and sheep are allowed to graze in the woods they eat the young hardwood seedlings. If, therefore, reproduction is desired in any specified lot, cattle and sheep must be kept out. There is no harm, however, in grazing in woods where reproduction is not desired and in which the crowns of the trees are out of the reach of the animals.

INSECTS.

There are a number of insects which seriously damage the trees of southern New England. Young White Pines are often attacked by the pine weevil and older pines by the pine bark-beetle. The weevil bores into and kills the young top shoot, so that the tree has to substitute a side branch for the main leader, thus producing a crooked trunk. The pine bark-beetle often attacks sickly trees and sometimes thrifty ones, girdling and killing them. Sugar Maple suffers severely from the maple borer. The grub of this insect gnaws spiral galleries around the trunk, killing the live wood and often almost girdling the tree. Hickory borers kill the small twigs near the top of the tree. Their injuries frequently affect whole groves. The gypsy moth is destroying great numbers of trees of all kinds in Massachusetts. This insect defoliates the trees year after year until they die. These are the most serious of the insect pests. They are difficult to combat by any practical methods. They usually begin their work before they are discovered, and even if spraying would then kill them this is seldom practicable. Single trees of special value in parks or on lawns could perhaps be saved if the insects were picked off or dug out of their holes, as is done on fruit trees; but this is not feasible in a forest. Under most conditions the only thing to be done is to destroy the infested trees or parts while the broods of insects are in them. With young Pine this can be done by cutting off and burning the leading shoots as soon as their faded color shows the presence of the weevils. After cutting Pine the pine bark-beetle is apt to breed under the bark of the tops and stumps. The burning of the tops and the brush on the stumps kills the broods or prevents their breeding.

WIND.

Woods often suffer from windfall after being thinned. If a stand of timber is situated on an exposed flat or hillside, and if it is to be cut clear in strips or patches, it is best to begin the cutting on the lee side and move toward the prevailing wind. If the cutting moves away from the prevailing wind, the trees left standing on the exposed edge of the woods are frequently thrown down or bent over. To avoid windfall, thinnings should be very light on exposed slopes or summits and in swamps where the soil is soft.

It is a good plan in making thinnings to leave the woods very dense on the edge exposed to the wind, and also on the edge exposed to the hottest rays of the sun. The purpose is both to prevent windfall and to protect the soil from the drying effect of the wind and sun, the force of which is broken by a dense fringe of trees and brush. Often ice storms damage trees, particularly Chestnut and Chestnut Oak. The principal cause of the injury is the wind, which breaks the limbs and tops when they are laden with ice. The measures advised to prevent damage by wind serve also to prevent damage by ice storms.

THE PRACTICABILITY OF FORESTRY.

Forestry always involves some present outlay, either of money, labor, or time. This outlay may be represented by extra care on the part of the choppers in protecting young growth; it may consist in a curtailment of present gains through leaving some merchantable trees for seed or through slightly increased cost of cutting; and it may be a direct outlay of money for protection against fire, for marking the trees to be cut, for planting, for pruning, or for other work of improvement. These sacrifices incident to practicing forestry are, however, insignificant when compared with the net returns certain to result from them in the end.

The writers have advised several different methods of cutting, each requiring some slight present sacrifice or outlay. In using either the Scattered Seed Tree Method or the Method of Reserves, the only outlay demanded is the time necessary to select the seed trees or the reserves and the cost of marking them to prevent their being cut with the others. These seed trees or reserves could, if cut, be sold and realized upon at once. Left standing, they represent an investment equal to their present stumpage value. The reproduction which these seed trees insure and the wood yearly added to them by growth will be an ample return on the investment.

In the Strip and the Patch method the only cost of forestry is the cost of locating and marking the strips or patches to be cut, and in some cases the extra cost of cutting and hauling due to limiting the area cut over in a single year to small strips or patches.

The Method of Successive Thinnings can not be carried out as

cheaply as the clear cutting methods. The trees which are to be cut must be marked individually, the average cost of which is 10 cents per cord when men are hired to do the marking. In many cases the cost of cutting and piling is 25 cents per cord greater than where the woods are cleared. However, the writers have carried out this method on several estates without any extra cost for cutting and piling. Thus on a tract in southern New York the wood was cut and piled by contract for 75 cents per cord, the usual price in that section when the woods are cut clean. On a tract near New Haven, where the amount cut was only 6 to 7 cords per acre, the cost of cutting was $1.15 per cord as against a customary price of 85 cents to $1. When, later on, the trees left at the first cutting are cleared off, the price of cutting and piling will still be slightly above the ordinary, because of the care that must be taken to protect the small growth.

The extra cost of the Selection Method is chargeable to the care which must be exercised in felling and hauling out the selected trees so as not to injure valuable young trees, and in marking the trees to be cut when this is necessary.

The Sprout Method, carried out as recommended, would sometimes involve the extra cost of supervision to guarantee the cutting of low and smooth stumps, and of higher wages for this kind of careful work.

Improvement cuttings must be looked upon as necessary work of improvement, even if there is no immediate profit. They should always be made if the sale of the wood will pay for their cost. Improvement cuttings, even when they do not pay for themselves, are desirable, and should be made whenever an owner can make them himself or can afford to hire the work done. They cost about $3 per acre in stands 10 to 20 years old. Just what the increased value in the future will be as the result of them can not be deduced from actual tests. In case of sprout growth, however, it is certain that the number of straight trees will be several times greater than if there were no thinning. The greater value of the trees for poles and ties would fully pay for the cost of thinning. In the same way the increased rapidity of growth after thinning has not yet been determined accurately. The writers have, however, measured single hardwood trees which have grown in diameter after thinning more than twice as fast as before. While the average growth of all trees would, perhaps, not equal that of the few which were measured, nearly all would grow considerably faster as the result of thinnings. This increase in the rapidity of growth, taken together with the higher quality of wood resulting from the improvement cuttings, fully warrants an expenditure as great as $3 per acre.

In all these kinds of cutting the choppers must take more than ordinary care. Commonly they do not consider anything a tree unless it is big enough for cord wood. Consequently they break down or clear

FIG. 1.—AN IRREGULAR STAND OF BLACK BIRCH WITH SCATTERED OAK AND CEDAR IN MIXTURE.

It is being reproduced by the patch method.

FIG. 2.—A STAND OF SPROUTS IN WHICH PATCHES OF BURNED TIMBER HAVE BEEN CLEARED.

These patches will be planted to Pine.

FIG. 1.—CHESTNUT SPROUTS 3 YEARS OLD, NEAR HARTFORD, CONN.
A stand too dense in some places and too sparse in others.

FIG. 2.—WORTHLESS CHESTNUT SUPPRESSING WHITE PINE SEEDLINGS, NEAR HARTFORD, CONN.

away much valuable young growth, when they could save it with scarcely any extra trouble—often, indeed, with none, since some men "brush out" around their work more from habit than from necessity. But this destruction of young growth will stop as soon as the woodsman can be made to see its value and to take a deeper interest in the future of the woods.

Not every owner of woodland in southern New England can apply all the methods of treatment discussed in the foregoing pages. The land of some owners is located at such a distance from a market that it will not pay to practice forestry upon it at all. Other owners can use only some of the proposed methods. Holders of woodland to whom forestry is most necessary, and who can secure the most satisfactory results, are farmers, owners of country estates, water companies, sporting and country clubs, and cities and towns.

Nearly every farmer owns a home woodlot, from which he gets his own supply of posts, rails, and firewood; often he has additional land, from which he cuts wood for the market. As he expects to cut successive crops of trees from this land, he should make every acre of it produce as much wood as possible. The average sprout forest grows at the rate of only 0.6 to 0.7 cord per acre per annum; and on account of the excessive crowding, many of the trees are crooked and unfit for poles or ties. By using forestry, the actual annual production of wood per acre can not only be raised from 20 to 40 per cent, but the quality of the wood can also be correspondingly improved, for the reason that most of the trees will be straight. The farmer can obtain more and better wood from his tract, and by improving his woodland enhance the sale value of his farm. The market value of scrubby open forest is certainly less than that of a dense growth, that of Birch less than that of Oak and Hickory, and that of old pasture less than if the land were timbered. The farmer has, therefore, a strong incentive to care for his woods. Moreover, he is in position to use careful methods not practicable for many other proprietors, because he can employ odd days and hours in working in his woods. The farmer has the additional advantage of a knowledge of trees, so that he can be his own forester. If he should give the same study and thought to the treatment of his woods that he does to his cornfield, there is no reason why his woodland should not be brought to a high state of productiveness in a short time. Young growth may be thinned when necessary; waste places upon the farm may gradually be planted to young trees; and the old woods may be cut according to the methods of reproduction cuttings herein recommended.

Owners of country estates usually maintain woods as private parks and as sources of supply for fuel and timber. They do not wish to cut their land clear, but to improve the woods by thinning and planting and, as the trees become mature, to utilize them gradually or to

retain them for their beauty. The majority of such owners have caretakers, who, like the farmer, can devote odd days and hours to work in the woods. Many, too, can easily afford to invest money in improvements which will not yield returns for a long time. In any case, forestry for such owners is common sense, since the value and usefulness of their land largely depends upon the condition of the woods, whether the property is to be held permanently in the family or sold. For the same reasons country and sporting clubs and cities and towns should practice forestry.

For water companies forestry is virtually compulsory. They buy land primarily to keep off undesirable occupants. As a rule they prohibit grazing, and the land is not tilled on account of the manures and fertilizers which must accompany agriculture. Unless forest or fruit trees are raised, the land lies idle. Moreover, if the watershed is entirely wooded, the best possible natural conditions exist for the protection and regulation of the water which feeds the reservoirs. The practice of forestry by a water company is a far-sighted business policy, because any money invested in improvements, as in planting up waste places or in thinning young growth, will be returned with interest in the increased value of the property and in the present and future sale of the wood. The water companies or municipal water boards of New Haven, Conn., Hartford, Conn., Middletown, Conn., and Clinton, Mass., are practicing forestry to-day.

There are two classes of owners for whom forestry is not always practical. Forestry would not be recommended to a lumberman or a wood dealer if he had no intention of holding the land after cutting as a permanent investment, and could not realize a higher price in selling it in consequence of its having been lumbered by other than destructive methods. Forestry may not be advisable for owners who live at a distance from woodlands acquired by inheritance, foreclosure of mortgage, or otherwise, and which they are prepared to sell whenever a fair price can be obtained. Forestry has most to offer when property is regarded as a permanent investment. It can be applied to small tracts with the greatest certainty of profit when a resident owner, with the necessary intelligence and good judgment, is prepared himself to undertake or direct the operations. Even for those whose interest in woodland is only speculative, the question of forestry always deserves consideration, for the prospective value of the future crop may be a matter of decided interest to the purchaser, though to the seller it is a matter of no direct concern.

THE PROBLEM IN DETAIL.

EXPLANATION OF DIAGRAMS.

To illustrate the actual application of the methods of cutting which have been recommended, a series of diagrams has been sketched from nature for typical problems in second-growth woods. The sketches were made in Massachusetts, Connecticut, Rhode Island, and southern New York. Their purpose is to show for typical stands of various ages and conditions exactly which trees should be cut. In each case a strip has been taken 15 to 30 feet wide and from 20 to 200 feet long. The exact length is stated on each diagram. To give some idea of how the trees are placed with reference to each other, the ground is shown in rough perspective, but the crowns are drawn only in outline, so as to keep them distinct without obscuring their vertical relations. The variation in the shape of crowns, so far as it indicates the relative vigor of the trees, is also represented. The name of the species is printed on each tree, and the condition, whether top-dry, fire scarred, or unsound, is designated by conventional features which explain themselves. The individual trees are referred to in the text by name and number. In each sketch the trees to be cut are marked with a heavy line at the base.

THIRTY EXAMPLES OF TYPICAL CUTTINGS.

FIGURE 1.

DIAGRAM OF STAND IN BERKSHIRE COUNTY, MASS.

Dense, thrifty young stand of seedling Beech with a little Sugar Maple. Diameters, 2 to 5 inches; heights, 30 to 40 feet; age, 25 to 30 years. The stand has been hitherto so thick that even the dominant trees have not been able to develop as large crowns as they needed. The removals, therefore, include, besides all dead and suppressed trees, those which are completely overtopped and will not live long in the heavy shade, and such of the intermediate trees as are restricting the crowns of leading individuals. Beeches 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, and Sugar Maples 2 and 3 are either dead, or so seriously suppressed as to be nearly so. Beeches 19, 5, and 12 are overtopped and, though living, certain to be shaded out in a few years. Beeches 2, 6, 11, and 13 are intermediate trees unmistakably falling behind. The adjacent dominant trees will profit by their room. Ironwood is a small tree of little value, which is a profuse seeder and capable of enduring heavy shade. It is cut to prevent its spreading in the woods and occupying the ground when the time comes for reproduction. The trees left will be seen to form an almost complete cover. The yield in thinnings amounts to 4 or 5 cords per acre.

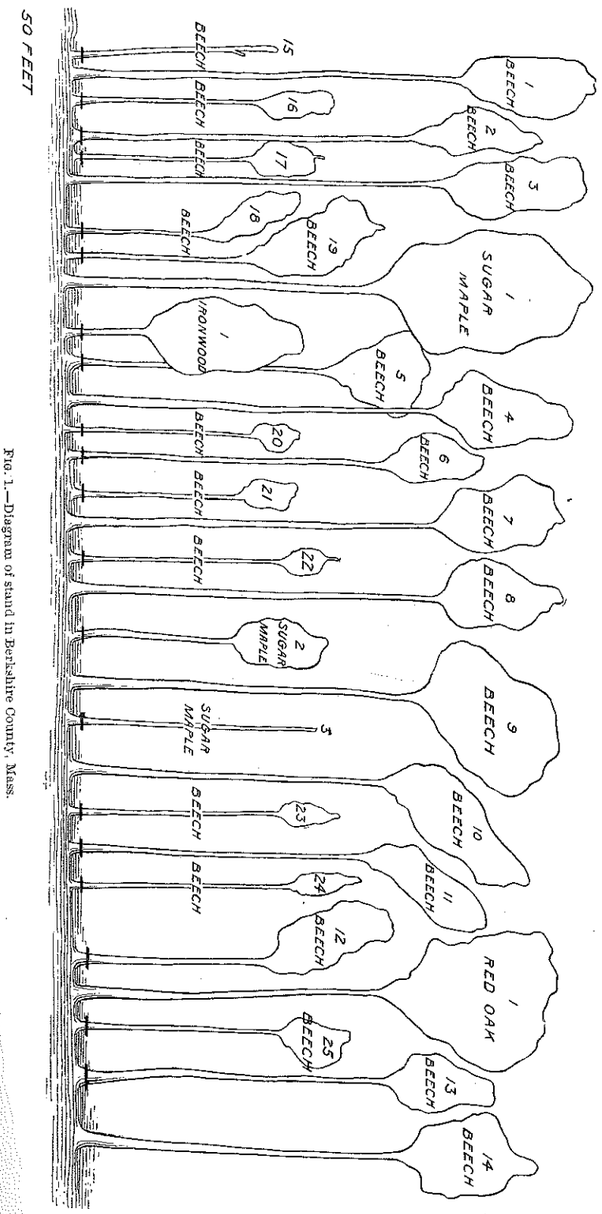

Fig. 1.—Diagram of stand in Berkshire County, Mass.

FIGURE 2.

DIAGRAM OF STAND IN BERKSHIRE COUNTY, MASS.

Mixed sprout hardwoods 30 to 40 years old, 4 to 8 inches in diameter, and 30 to 40 feet in height. The stand is in need of thinning, which shall free the best trees and utilize those which are declining. Hemlock 1 and Beech 1, though of shade-enduring species, have both been so thoroughly shaded that their tops have been killed and their growth practically stopped. Red Maple 1 is in the same condition. Red Maple 3, though living, has been partly overtopped by Red Maple 2, which it is crowding needlessly. White Birch 3, though a dominant tree, has lost its top in an ice storm, and is therefore not worth preserving. Hemlock 2 below it will be able ultimately to fill its place. White Birches 5 and 6 are, respectively, dead and nearly suppressed by the dominant White Birch 4. Beech 2 is crooked, partly suppressed, and beginning to crowd Hemlock 3, which is a promising tree. The remaining thrifty trees, thus thinned, will be able to profit by and fill the added growing space. The trees cut in this case will yield 5 or 6 cords of firewood per acre.

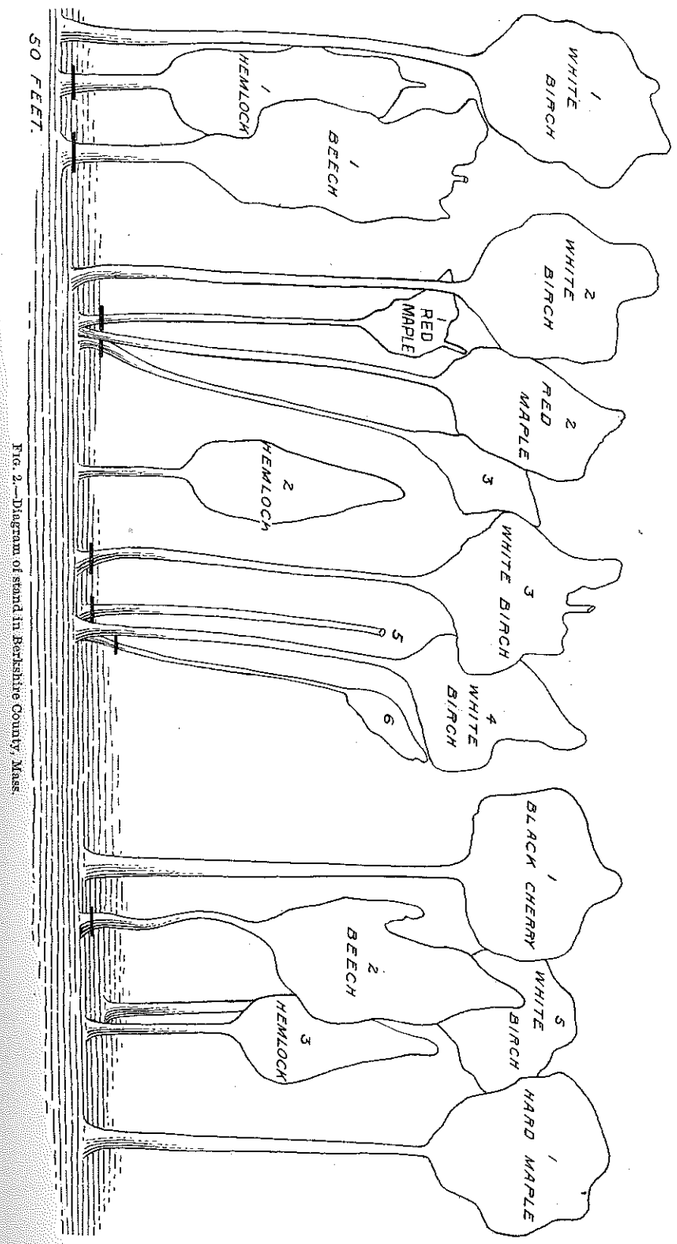

FIG. 2.—Diagram of stand in Berkshire County, Mass.

FIGURE 3.

DIAGRAM OF STAND IN BERKSHIRE COUNTY, MASS.

Mixed hardwood stand of the swamp type; 4 to 8 inches in diameter; 30 to 40 feet in height; 30 to 40 years old. The treatment needed is to cut out the dying and suppressed trees, the crowding intermediate trees, the occasional unhealthy dominant tree under which young growth has started, and small, worthless species, such as Blue Beech, which may produce an undesirable underwood. The markings show how this is to be carried into effect.

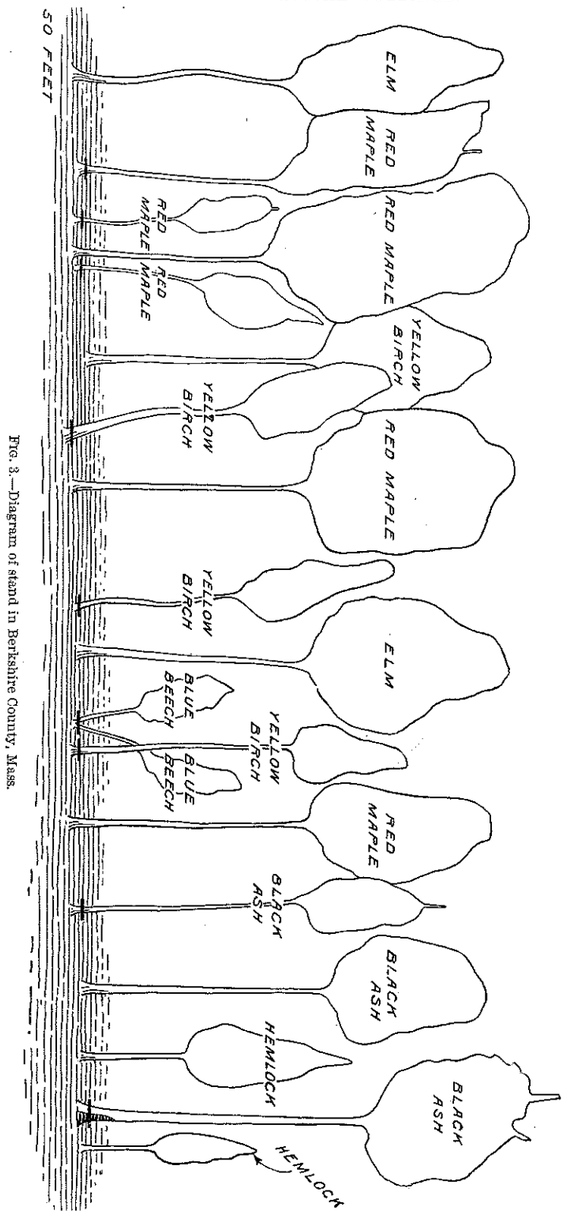

FIG. 3.—Diagram of stand in Berkshire County, Mass.

FIGURE 4.

DIAGRAM OF STAND IN NEW HAVEN COUNTY, CONN.

Young hardwood stand of the swamp type composed largely of Black Ash. Average height, 30 feet; average diameter, 4 inches; average age, 30 years. The treatment to be applied is simple improvement cutting, in which the declining subordinate stand, trees overtopped and partially suppressed, are removed. In this case there is no young growth to be expected or favored, and except for White Oak 1, which is badly fire-scarred at the base, all the leading trees are in good condition.

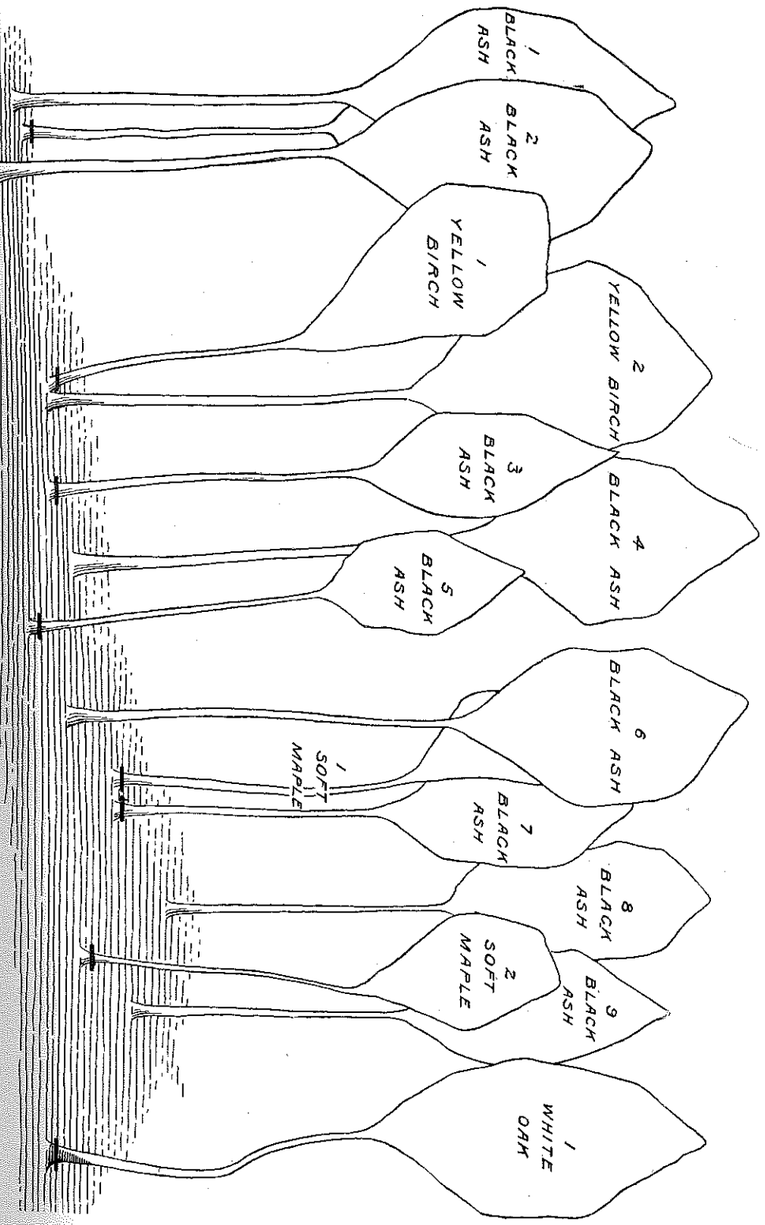

FIG. 4.—Diagram of stand in New Haven County, Conn.

FIGURE 5.

DIAGRAM OF STAND IN HARTFORD COUNTY, CONN.

Mixed hardwood growth; age 35 years; diameter 4 to 6 inches; height 35 to 40 feet. The treatment required is light improvement thinnings. Red Cedar 1 is cut because it is crowding Hickory 1 and White Oak 1, which will eventually kill it out. Hickory 2 should be removed to relieve Hickory 3 and White Oak 1. White Oak 2 is slowly giving way to Hickory 4 and White Oak 3. Ironwood 1 is cut to prevent its seeding up the ground (as it often does) to the exclusion of better species.

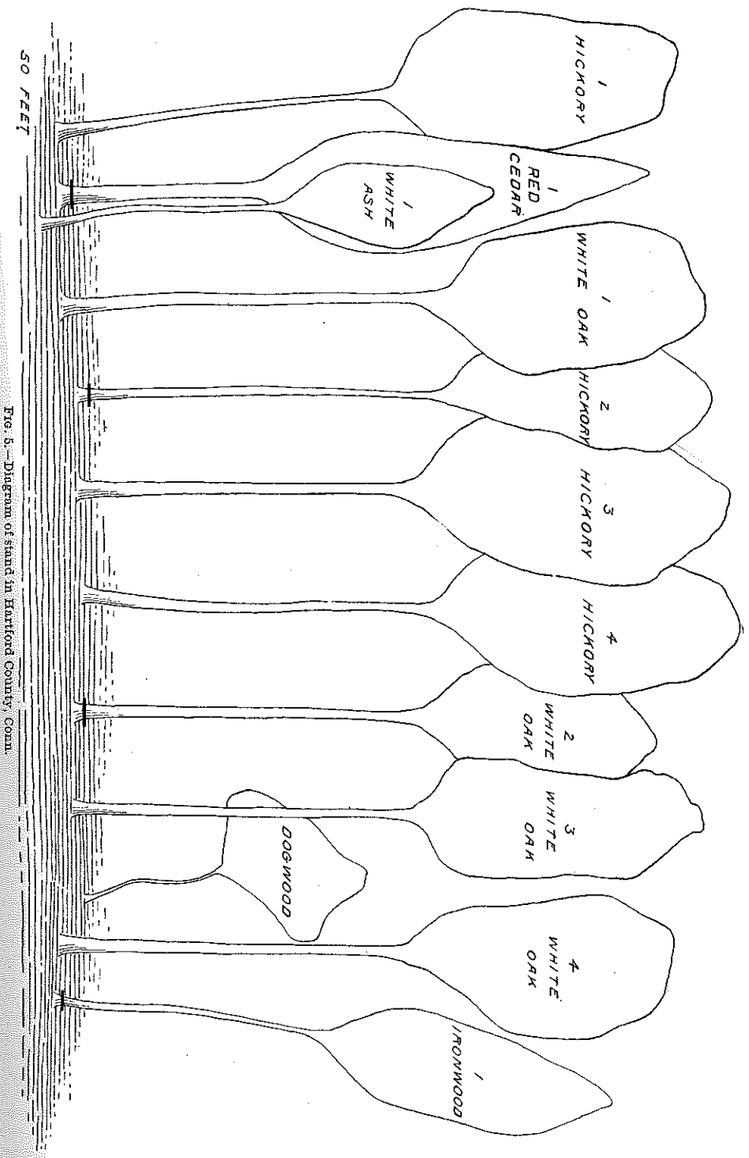

FIG. 5.—Diagram of stand in Hartford County, Conn.

FIGURE 6.

DIAGRAM OF STAND IN HARTFORD COUNTY, CONN.

Mixed hardwoods 25 years old, 3 to 5 inches in diameter, and 30 feet in height. This is a case where the fact that nearly all the trees are of comparatively equal health and vigor, but of unequal value, slightly modifies the method of improvement cuttings. White Oak 3 is already partly suppressed and should on that account be cut. But Red Maples 2 and 3, though dominant trees, are cut because each is crowding two White Oaks which are still vigorous enough to respond quickly to release from the Maples. In each case the two White Oaks will ultimately be more valuable than the Maples which would have suppressed them.

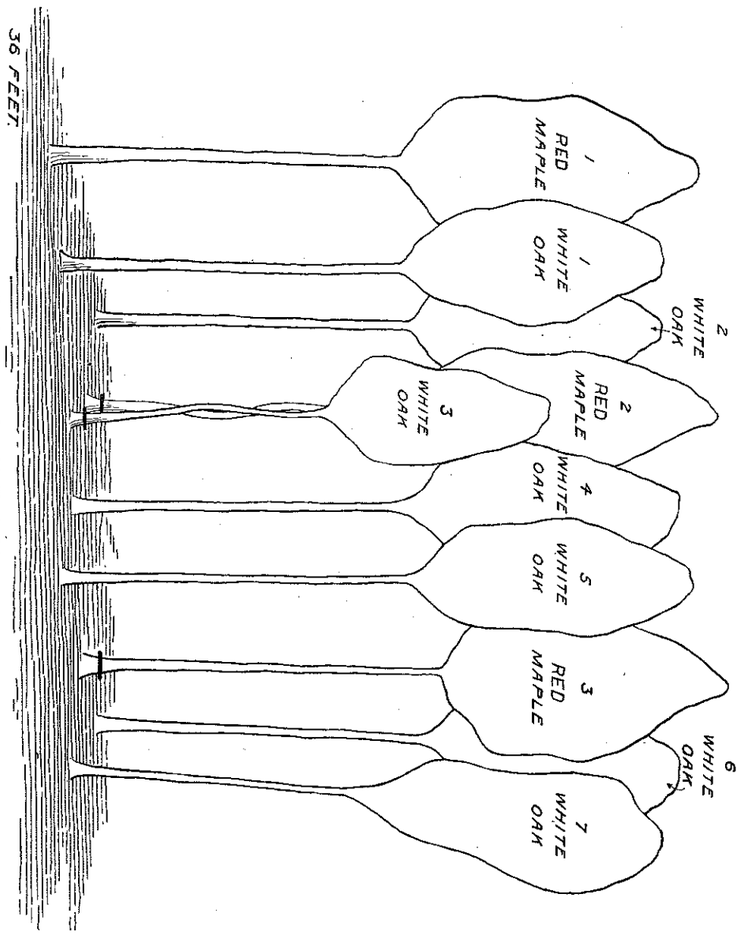

FIG. 6.—Diagram of stand in Hartford County, Conn.

FIGURE 7.

DIAGRAM OF STAND IN MIDDLESEX COUNTY, MASS.

Pure stand of White Pine. Diameter, 5 to 10 inches; height, 45 to 55 feet. The stand is in need of simple improvement cutting. The trees to be removed on this principle are numbers 2, 4, 5, 7, and 9, all of which are either suppressed or partially suppressed, but still restricting the crowns of the better trees beside them. The trees left are vigorous enough and thick enough to restore the cover in a few years.

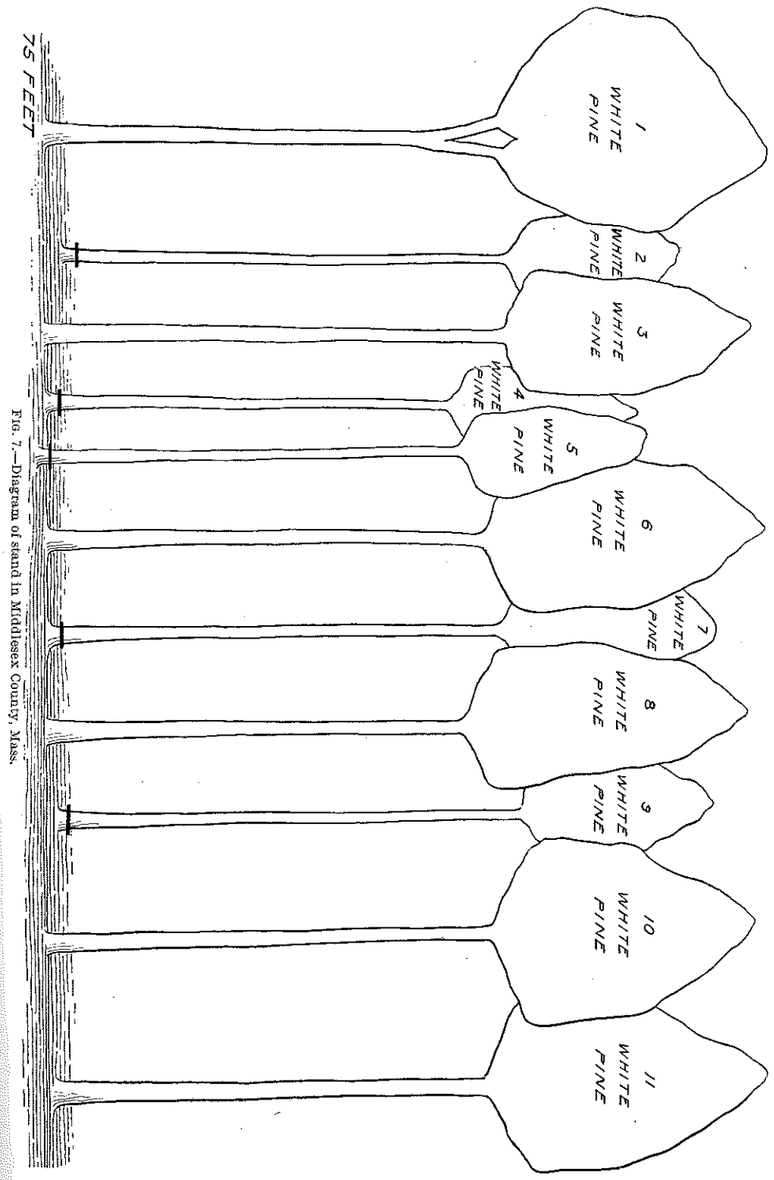

FIG. 7.—Diagram of stand in Middlesex County, Mass.

FIGURE 8.

DIAGRAM OF STAND IN MIDDLESEX COUNTY, MASS.

A stand of White Pine mixed with Gray Birch. Age, 25 to 30 years; diameters, 4 to 7 inches; heights, 30 to 35 feet. The treatment is the removal of inferior trees which are crowding the better individuals. The Gray Birches, besides having almost reached their maturity, are crowding the more valuable Pines. White Pines 2, 3, and 5 should be cut to relieve 1, 4, and 6; 9 to relieve 8 and 10; 11, 12, and 14 because they are either overtopped or falling behind. Gray Birches 1, 2, and 3 should be taken out to release the better trees which they are crowding.

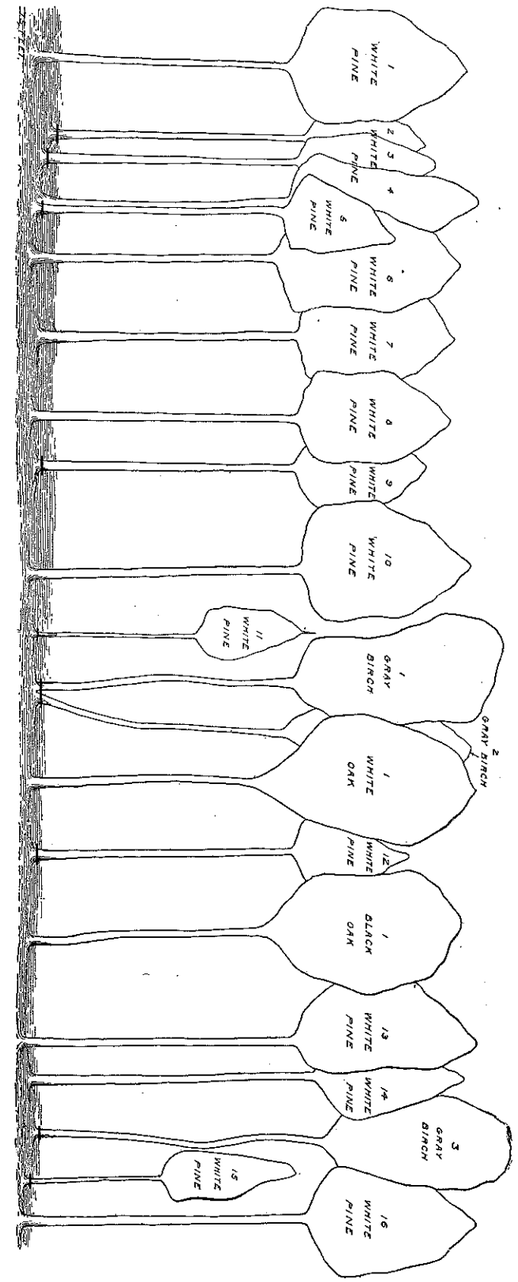

FIG. 8.—Diagram of stand in Middlesex County, Mass.

FIGURE 9.

DIAGRAM OF STAND IN MIDDLESEX COUNTY, MASS.

Mixed stand of White and Pitch Pine, in which the leading trees are 5 to 9 inches in diameter and 35 to 40 feet in height. The object of cutting here is to relieve the better species—White Pine—and where the only trees are Pitch Pine, to relieve the better individuals. Pitch Pine is of slower growth and requires more light than White Pine. Thus Pitch Pines 1 and 2 are already falling behind the adjacent White Pines, and at the same time checking White Pines 2 and 3, which are thrifty and probably capable of living to take a place in the main crop. Pitch Pine 3, though fairly thrifty, is yet better cut for the sake of White Pines 4 and 5, which will profit by its room. Pitch Pine 6 is already partly suppressed by a thriftier individual of its own species. The cutting of these trees will improve the composition as well as the growth of the stand.

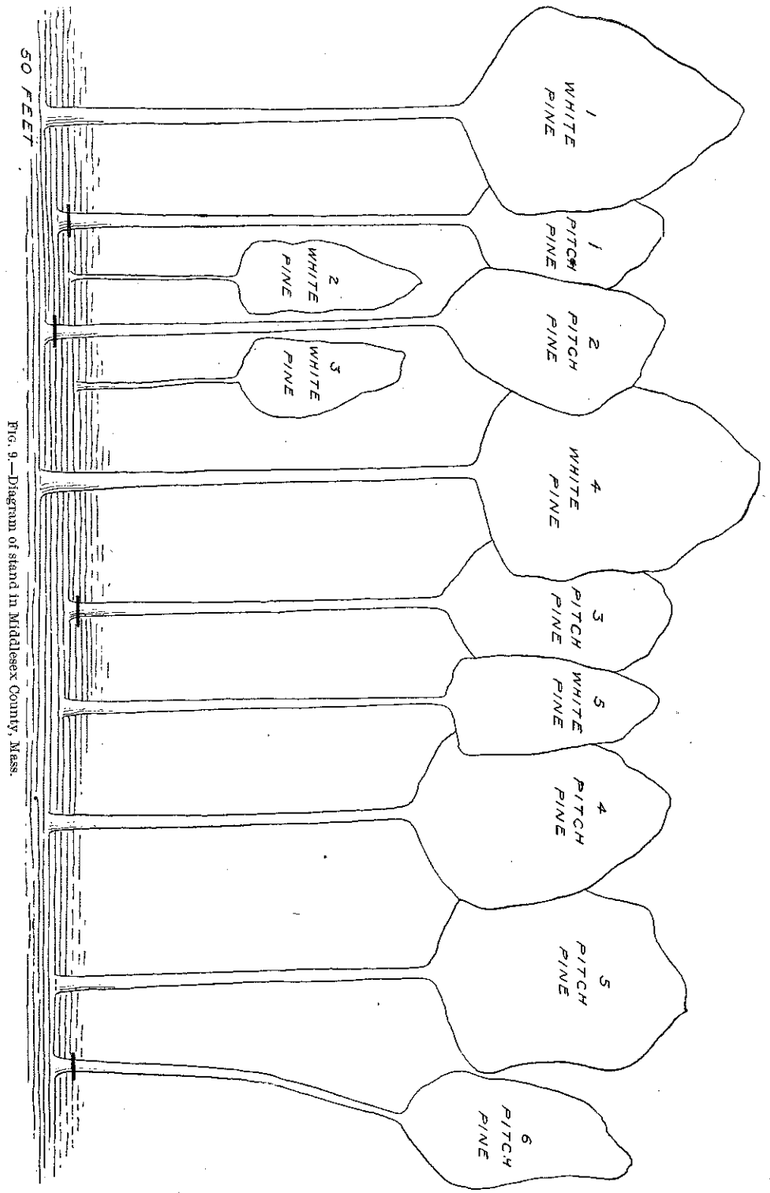

FIG. 9.—Diagram of stand in Middlesex County, Mass.

FIGURE 10.

DIAGRAM OF STAND IN MIDDLESEX COUNTY, MASS.

Mixed White Pine and Oak. Diameters, 5 to 8 inches; heights, 30 to 35 feet; age, 30 to 40 years. This stand furnishes a good example of the common need for cutting both in the dominant and the subordinate classes of trees. Of dead, suppressed, or partially suppressed trees, the best of which are already succumbing to the main crop, White Pines 1, 2, 3, 5, and 8 and White Oaks 1 and 2 are cut to relieve the leading individuals beside them and to utilize the wood before it decays. Of the dominant trees, Red Maple 1, a comparatively inferior species, is cut because it is beginning to overtop White Pines 6 and 7, both thrifty trees, and together more valuable than the Maple. The decision in such cases must depend on the relative health and value of the upper and lower trees.

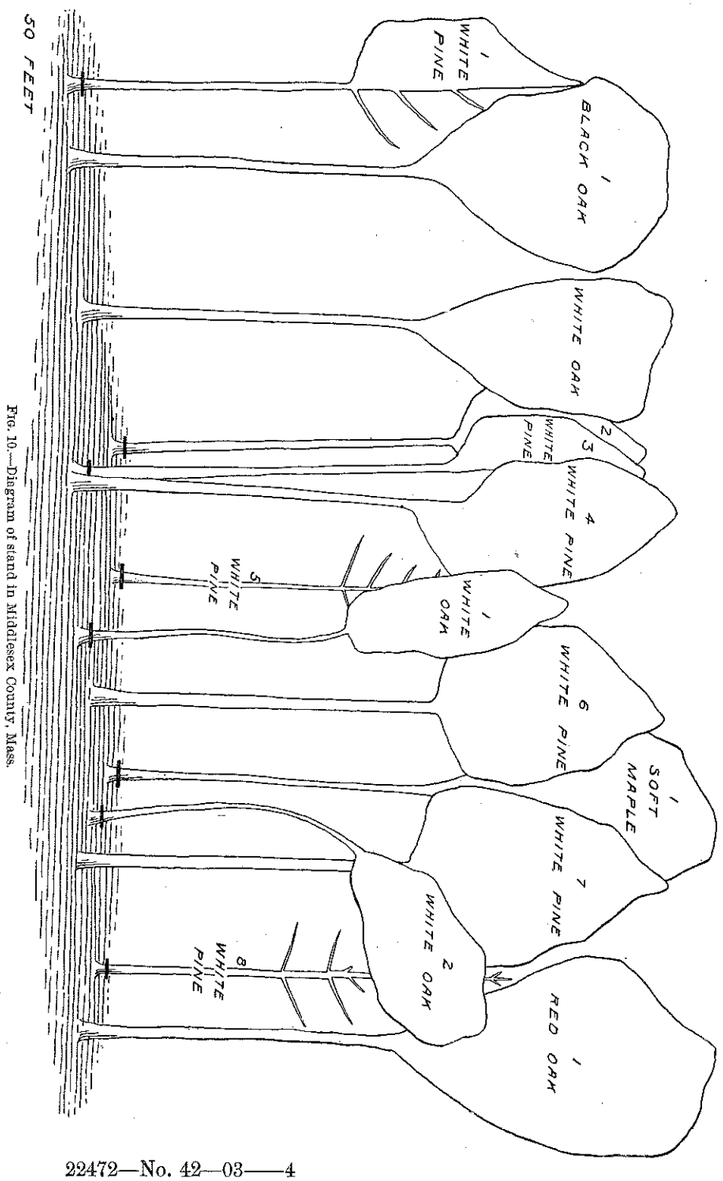

FIG. 10.—Diagram of stand in Middlesex County, Mass.

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FIGURE 11.

DIAGRAM OF STAND IN MIDDLESEX COUNTY, MASS.

Mixed White Pine and Oak. The need here is for simple improvement thinnings. The cutting is confined to the subordinate trees, White Pines 2, 4, 5, 6, and 7, inasmuch as none of the dominant trees have more valuable thrifty individuals growing beneath them.

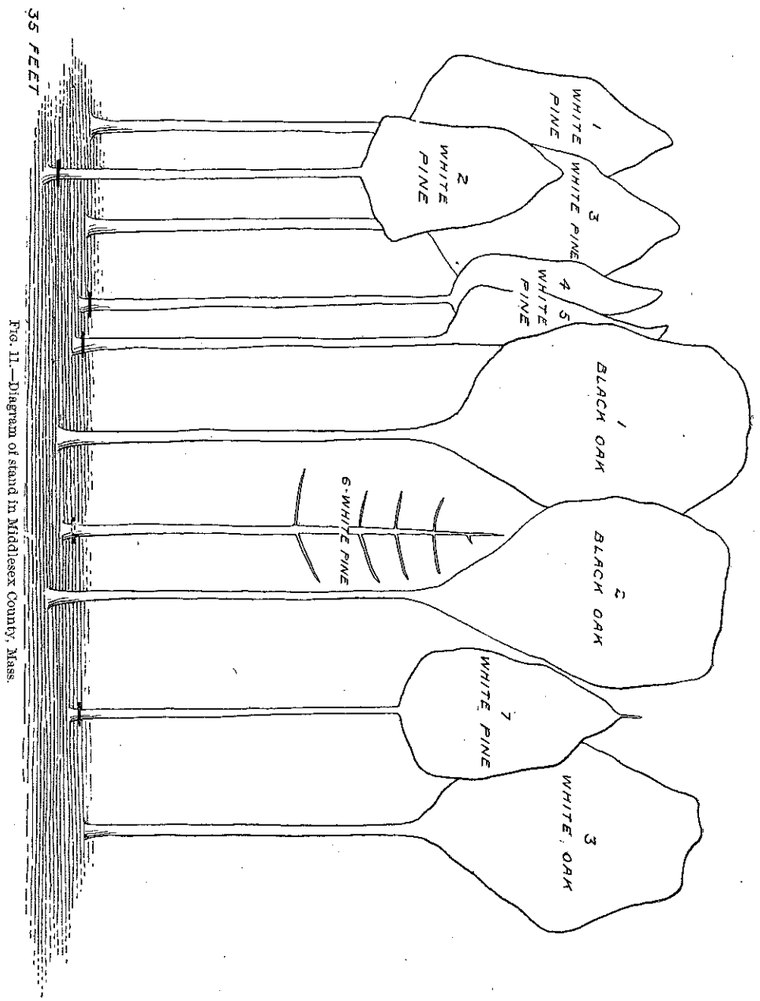

FIG. 11.—Diagram of stand in Middlesex County, Mass.

FIGURE 12.

DIAGRAM OF STAND IN MIDDLESEX COUNTY, MASS.

White Pine in mixture with White Oak. Dominant trees 4 to 7 inches in diameter, 30 feet in height, and 25 to 30 years old. The treatment required is light improvement cutting of a stand too thick for its best development. Such are White Oaks 1 and 3, Black Oak 1, and White Pine 6. In all these cases the trees cut are not sufficiently behind the others in height and development to be unmistakably in need of removal, but they are all either defective or so placed that the crowns of adjacent trees will be able to utilize this room.

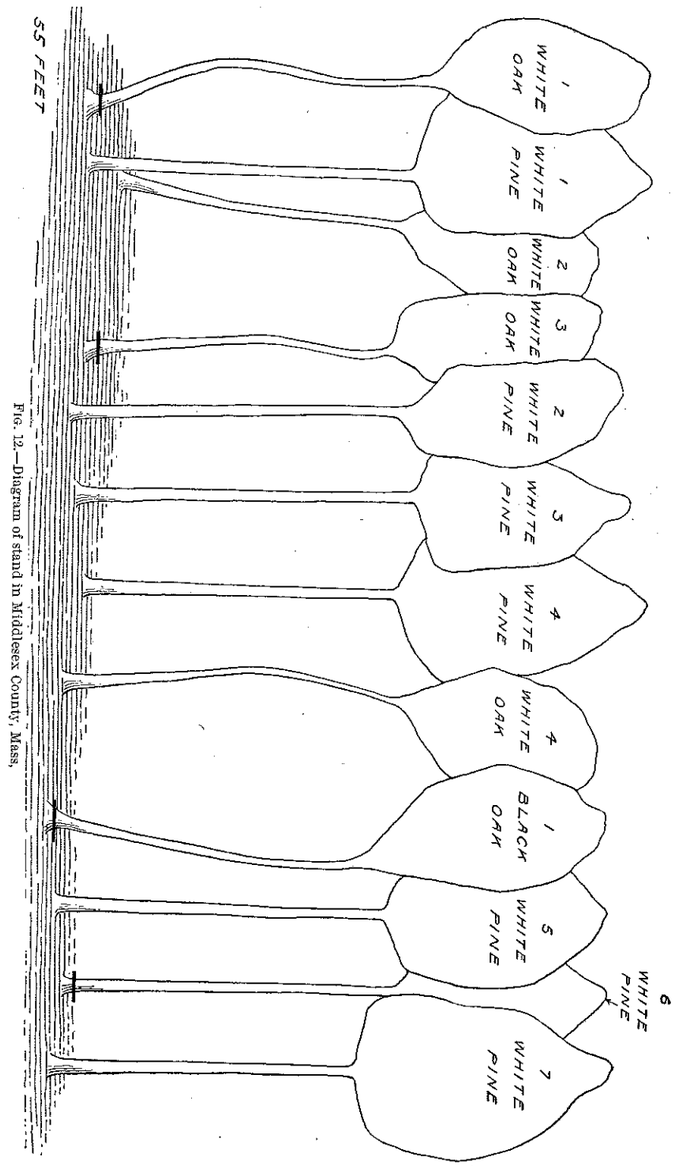

FIG. 12.—Diagram of stand in Middlesex County, Mass.

FIGURE 13.

DIAGRAM OF STAND IN HARTFORD COUNTY, CONN.

Irregular, uneven stand of mixed hardwoods in which wide-crowned, nearly mature trees are on the point of checking healthy young saplings below. White Oak 1 and Hickory 3, both of merchantable size and respectively 20 and 12 inches in diameter and 45 and 55 feet in height, should therefore be removed. This will instantly stimulate the growth of the younger trees without seriously interrupting the forest cover.

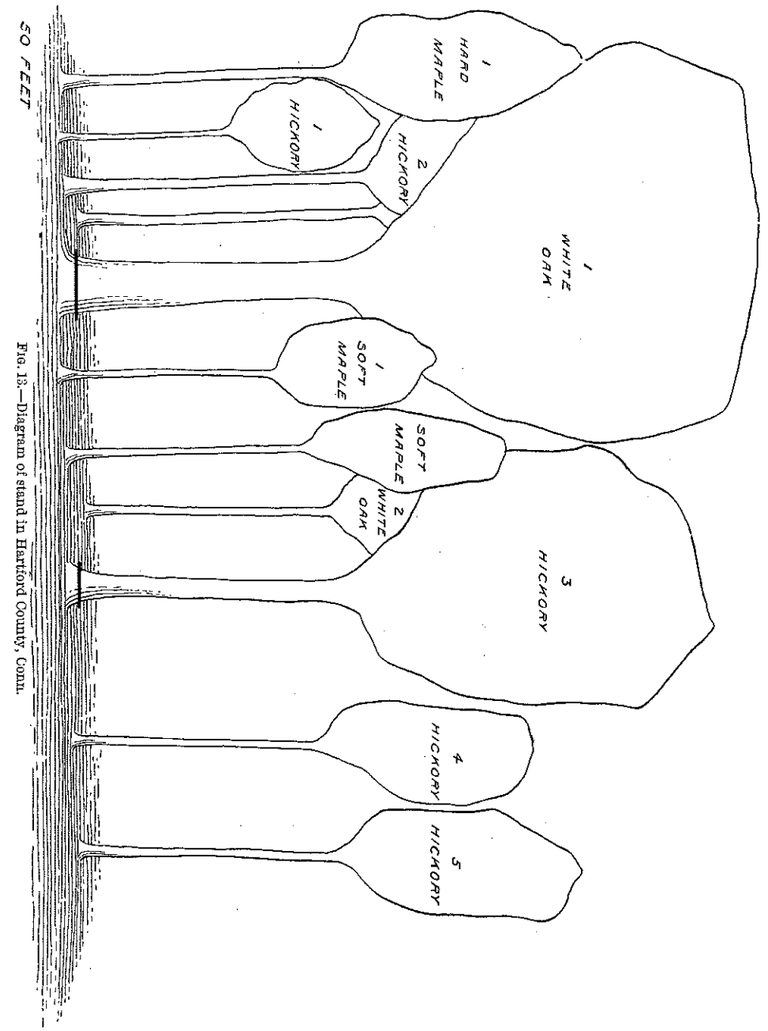

Fig. 13.—Diagram of stand in Hartford County, Conn.

FIGURE 14.

DIAGRAM OF STAND IN NEW HAVEN COUNTY, CONN.

Irregular, uneven-aged stand of mixed hardwoods. White Oak 1 (16 inches in diameter and 50 feet in height), although not suppressing any other trees, is large enough to cut, and Black Oaks 1 and 2 are defective. These three are all that could well be cut in the present stage of growth, since the rest of the trees are well spaced and developing fast. The gap will easily be seeded up by the surrounding trees.

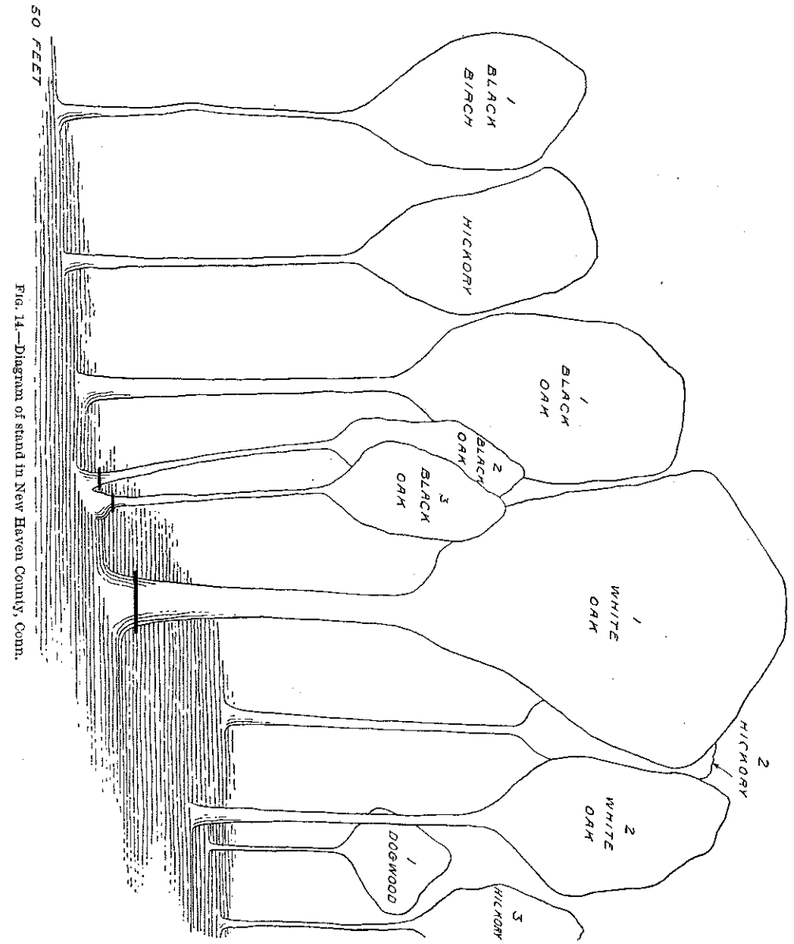

FIG. 14.—Diagram of stand in New Haven County, Conn.

FIGURE 15.

DIAGRAM OF STAND IN NEW HAVEN COUNTY, CONN.

Irregular, uneven-aged, mixed hardwoods. A forest from which merchantable trees can here and there be removed with benefit to younger trees which remain. Chestnut 2 and Tulip Poplar 1, of this class, will each make a pile. Chestnut 1, which is dead, could be used in mixed cordwood, and Hickory 5, which is crowding Hickory 4 and Black Birch 2, both better trees, will serve the same purpose. Blue Beech 1, also fit only for cordwood, is cut to prevent its spreading and producing an obnoxious undergrowth in the forest. The rest of the forest can remain to grow under better conditions.

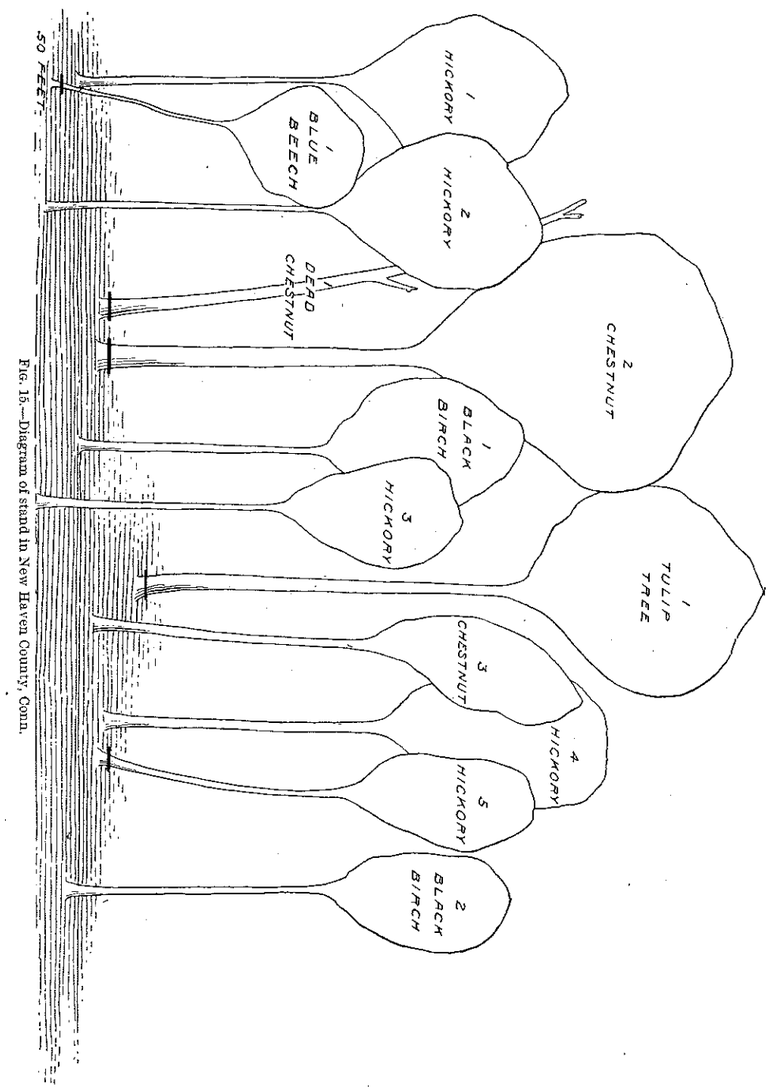

Fig. 15.—Diagram of stand in New Haven County, Conn.

FIGURE 16.

DIAGRAM OF STAND IN HARTFORD COUNTY, CONN.

This diagram shows a wood characteristic of old pastures. It represents the growth of about forty years, and the largest tree is 12 inches in diameter and 35 feet high. In this case a desirable stand is already nearly established. It is only necessary to take out scrubby, worthless trees, like Pitch Pine 2, which are beginning to suppress promising young growth, and dead or subordinate trees like Canoe Birch 2 and Pitch Pine 1, where the stand is thick enough and better without them.

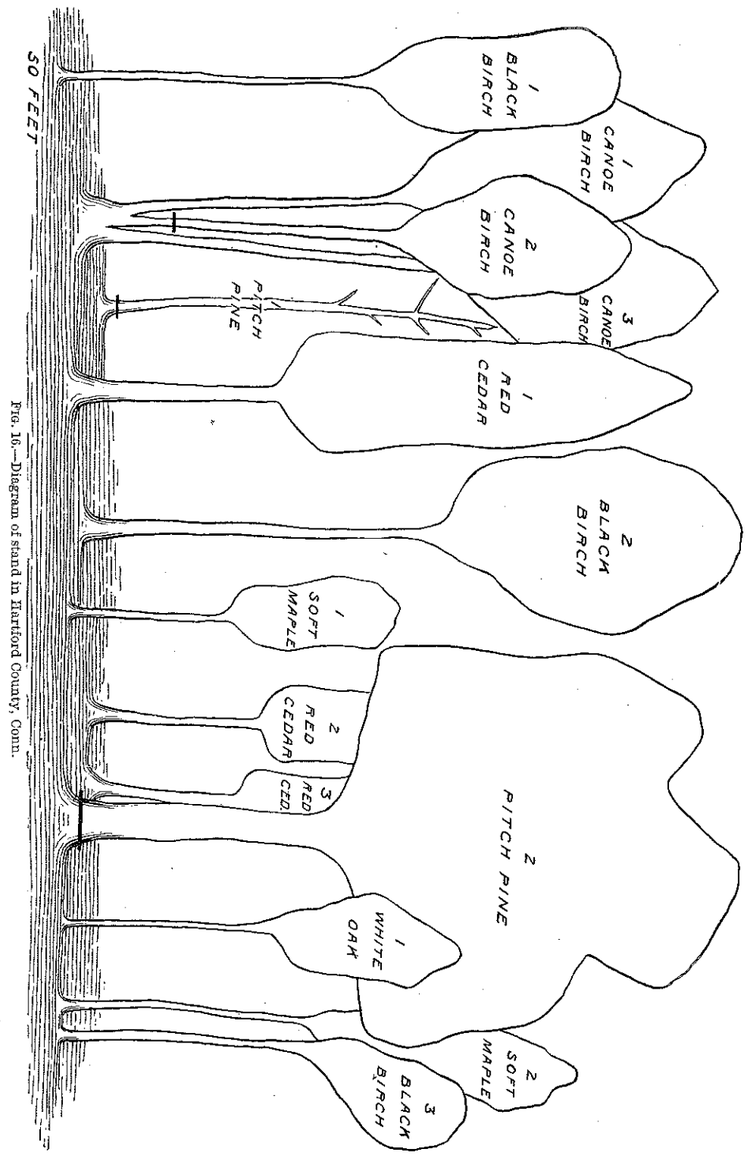

FIG. 16.—Diagram of stand in Hartford County, Conn.

FIGURE 17.

DIAGRAM OF STAND IN HARTFORD COUNTY, CONN.

Mixed hardwoods with an under story of Hemlock. Hardwood 50 to 60 years old, 6 to 8 inches in diameter, and 35 to 40 feet high. Hemlock 15 to 20 years old. As some of the dominant trees are in poor condition, it is best here to cut certain individuals so as to release the thrifty Hemlock below. Thus, Chestnut Oaks 1 and 2 and Hickory 1, injured in the crown by recent storms, are all taken out. The result is a stand almost as well stocked as before and, moreover, free to grow.

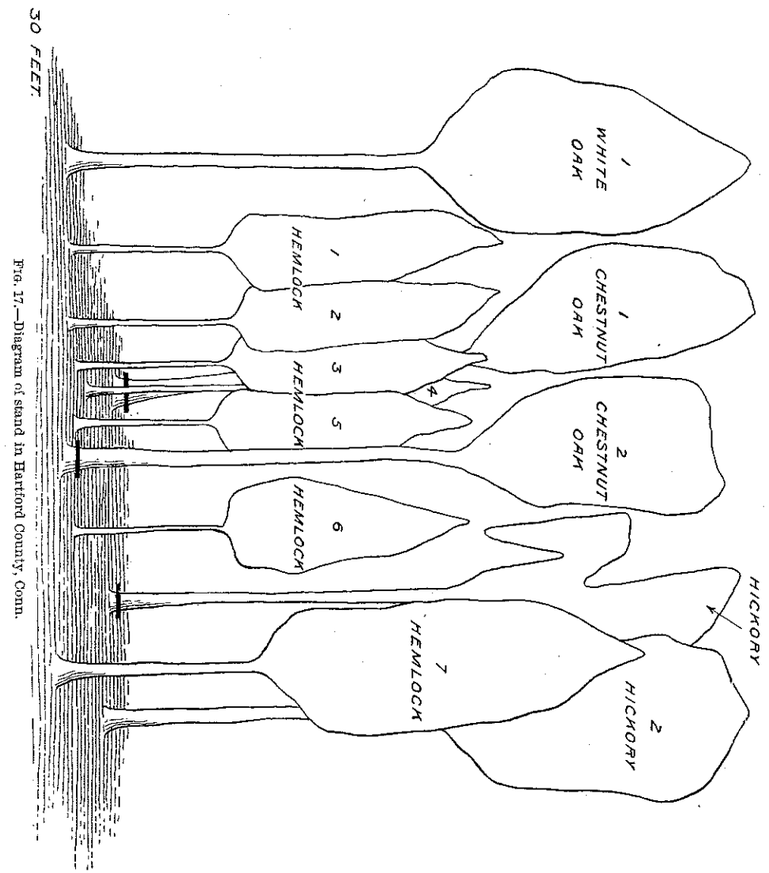

FIG. 17.—Diagram of stand in Hartford County, Conn.

FIGURE 18.

DIAGRAM OF STAND IN BERKSHIRE COUNTY, MASS.

Neglected, irregularly culled stand of old hardwoods (12 to 20 inches in diameter, 40 to 50 feet in height), in which scattering White Pines and Hemlocks have produced a valuable young crop of saplings. As the hardwoods are nearly all in bad condition and many of the saplings about to be suppressed, most of the overwood must be removed. This includes Red Oak 1, Red Maples 1 and 2, and Sugar Maple 1, all of which are in poor condition. White Pine 1, which is not seriously crowding younger trees, may be left a few years for further seeding or until needed.

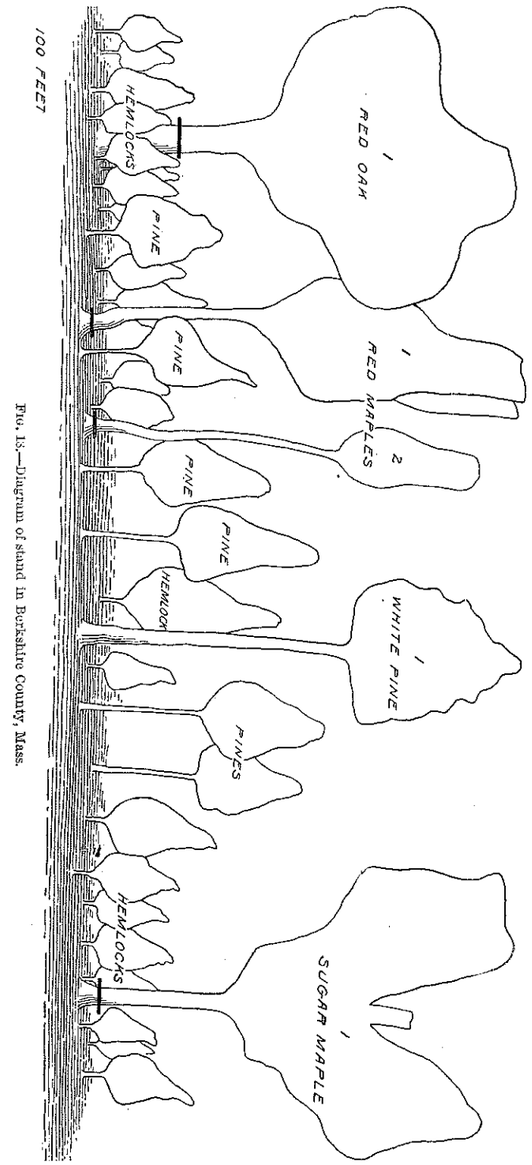

FIG. 18.—Diagram of stand in Berkshire County, Mass.

FIGURE 19.

DIAGRAM OF STAND IN BERKSHIRE COUNTY, MASS.

Nearly mature stand of Poplar (8 to 12 inches in diameter, 40 to 50 feet in height), under which a full reproduction of Spruce has taken place. As the Spruce saplings are in some cases already suffering from suppression, the Poplar should be at once cut clear. This would usually be a profitable undertaking, since the market for Poplar at excelsior mills and limekilns is good.

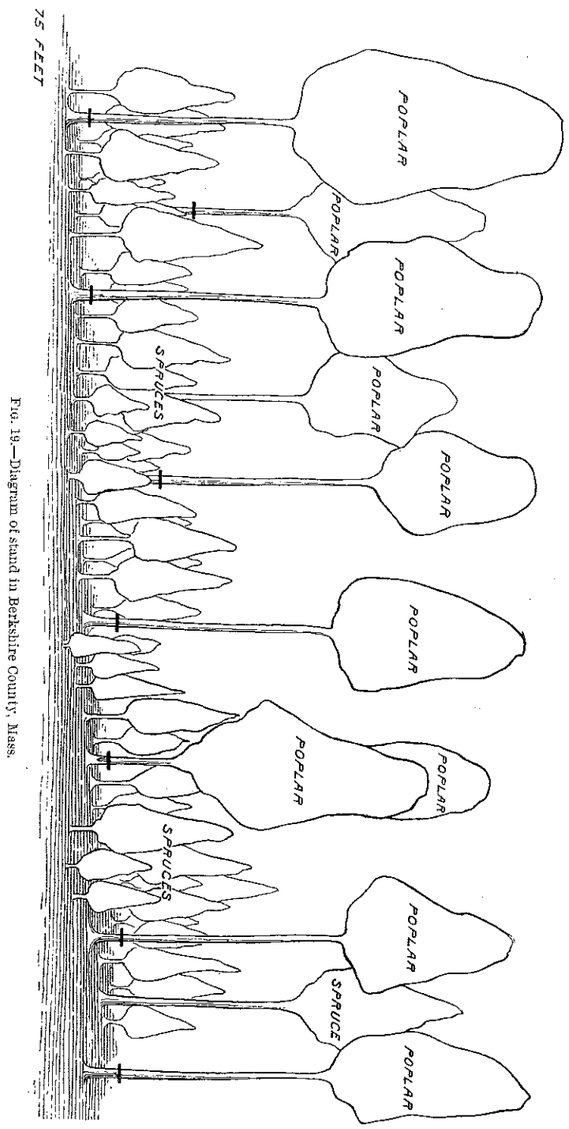

Fig. 19.—Diagram of stand in Berkshire County, Mass.

FIGURE 20.

DIAGRAM OF STAND IN NORFOLK COUNTY, MASS.

Mixed young growth on neglected land. Gray Birch and Pitch Pine retarding the germination and growth of White Pine and Cedar. Gray Birch, 5 to 7 inches in diameter, 30 to 35 feet in height. Pitch Pine, 8 inches in diameter, 35 feet in height. As the Pitch Pine and the Birch are of little value except for fuel, they should be cut to release the young crop of White Pine and to allow further reproduction. White Pine germinates well in plenty of light, and with the reproduction already well started there is no need of leaving any of the obstructing overwood for cover. Only the scattered old White Pines which are furnishing the seed need be spared.

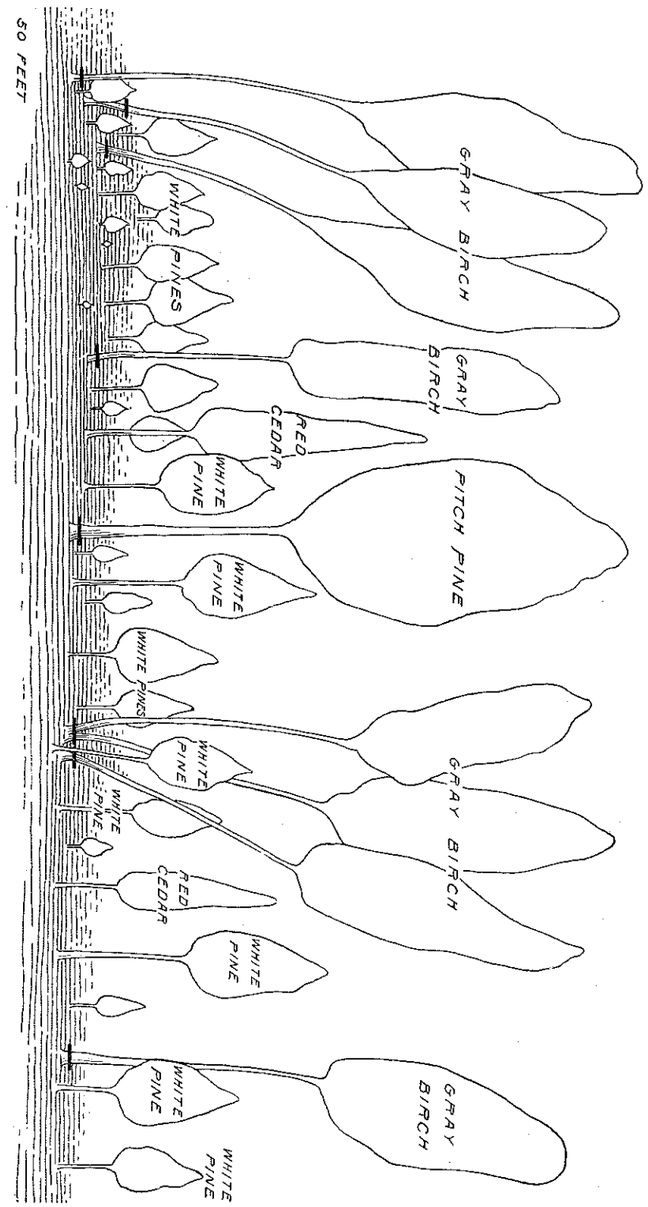

FIG. 20.—Diagram of stand in Norfolk County, Mass.

FIGURE 21.

DIAGRAM OF STAND IN NORFOLK COUNTY, MASS.

Mixed young forest on neglected land in need both of reproduction and improvement cuttings. Diameter of the dominant trees, 4 to 6 inches; height, 25 to 30 feet. The stand represents the growth of about twenty-five years, and as a good deal of the Pine started with the hardwoods, some of it is approximately as large, and some of it has already been injured by suppression. The treatment required is to set free all young growth by the removal of the hardwoods, and where Pine alone has formed dense stands, to thin it. Removals are made on principles already illustrated.

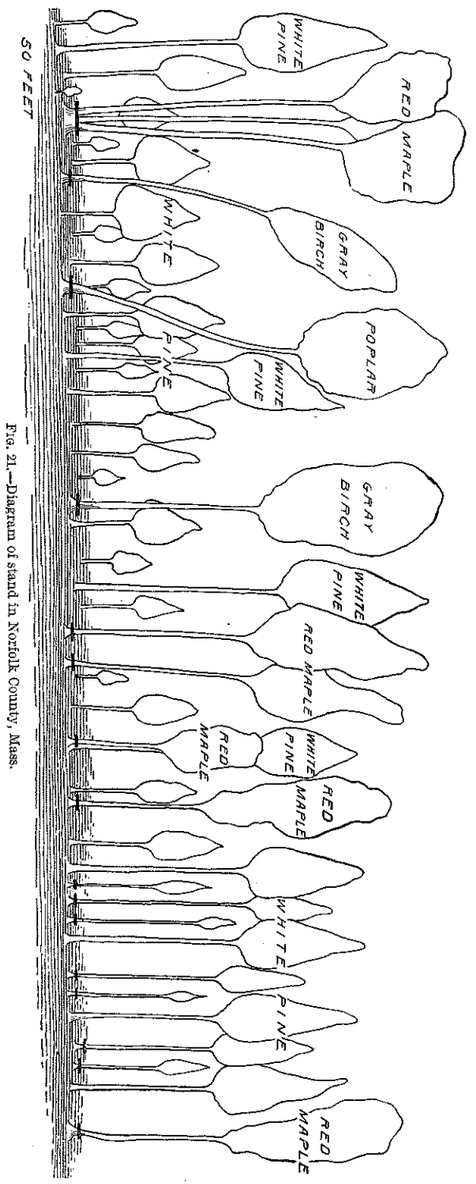

Fig. 21.—Diagram of stand in Norfolk County, Mass.

FIGURE 22.

DIAGRAM OF STAND IN MIDDLESEX COUNTY, MASS.

This diagram shows the varied and largely inferior growth of Pitch Pine, White Pine, and Gray Birch which gradually fills up old pastures. Occasional judicious improvement cuttings will do much to help along the valuable species which would otherwise often be suppressed or kept out altogether by the worthless kinds. Pitch Pine 2, in this example, is already injuring White Pines 1 and 4, and if left where it is will suppress White Pines 2 and 3. To a less degree Gray Birches 1, 2, and 3 are working the same sort of harm, and they are such profuse seeders that, if allowed to stand, they will only cover still more ground. With these injurious trees taken out, enough will remain to form a forest cover in a short time.

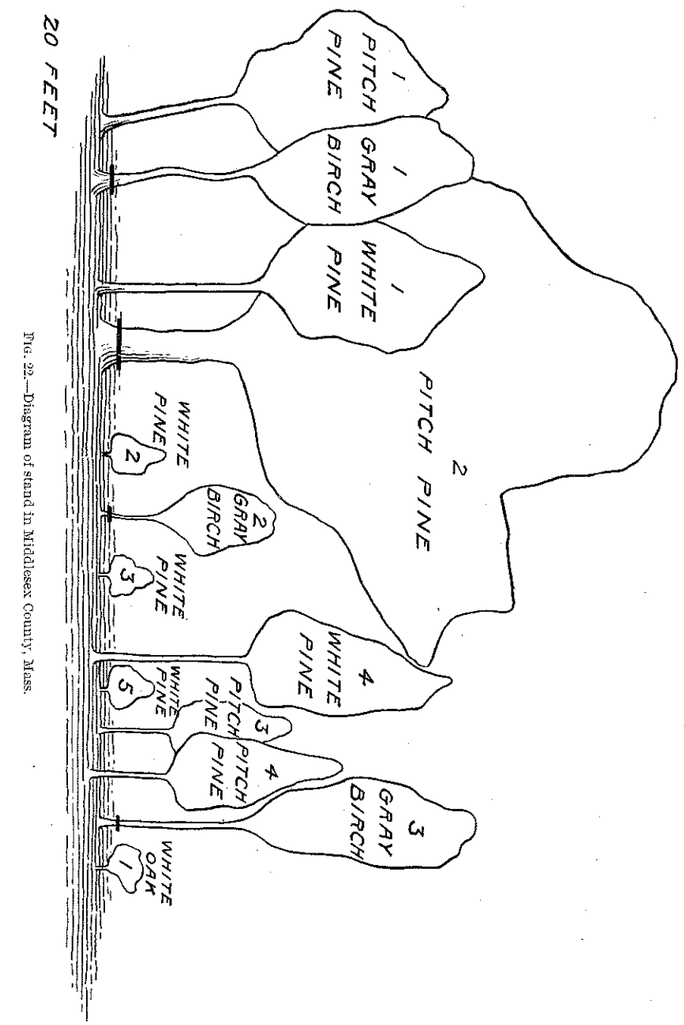

FIG. 22.—Diagram of stand in Middlesex County, Mass.

FIGURE 23.

DIAGRAM OF STAND IN ORANGE COUNTY, N. Y.

Sparse stand of crooked, stagheaded Chestnut (6 to 12 inches in diameter, 35 to 45 feet in height), in which young seedling hardwoods (1 to 3 inches in diameter, 15 to 20 feet in height) have come in from seed trees on a neighboring slope. The young growth is nearly all valuable and thrifty, but needs release from the inferior overwood which will soon check it. All the Chestnuts should be cut, as well as Black Oak 1, which is already too much suppressed to recover.

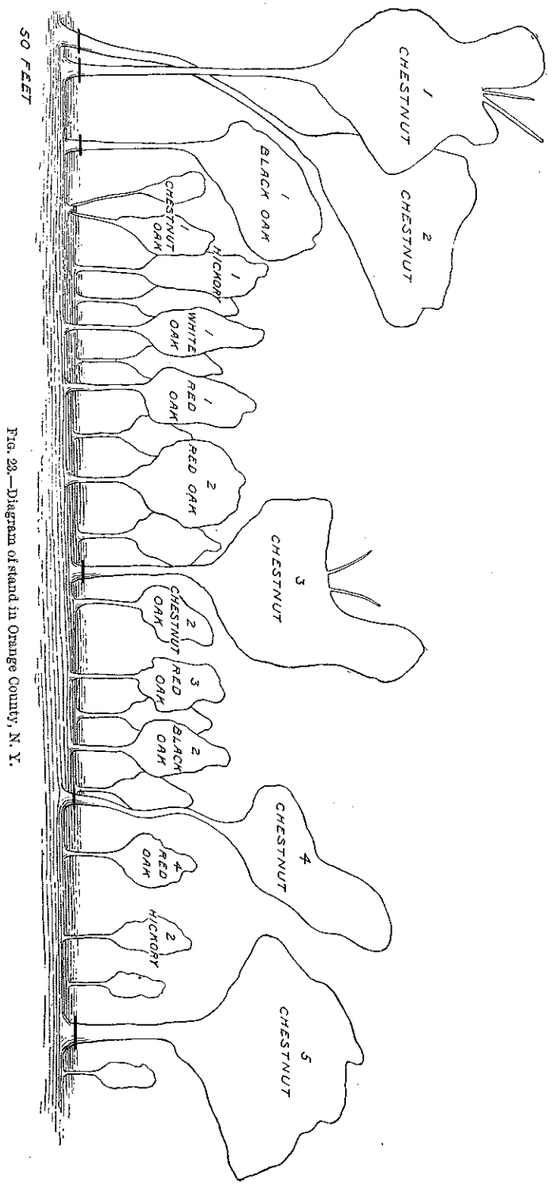

Fig. 23.—Diagram of stand in Orange County, N. Y.

FIGURE 24.

DIAGRAM OF STAND IN ORANGE COUNTY, N. Y.

Mixed hardwoods with Chestnut predominating. Dominant trees 8 to 12 inches in diameter by 40 feet in height. Subordinate trees 1½ to 3 inches by 15 to 20 feet. The Oak and Hickory trees have been carelessly culled from high stumps and inferior Chestnuts have been left. Hence the sprout growth is bushy and unsound and constantly being injured by the shade of the poor trees above. Almost the entire stand needs renewal. The required treatment is clean cutting, except where occasional straight saplings, preferably in gaps among the stumps, can be left to fill in the expected new crop. Stumps should be cut back when possible. White Oak 1 and Hickory 2 are thrifty, straight, and should be left.

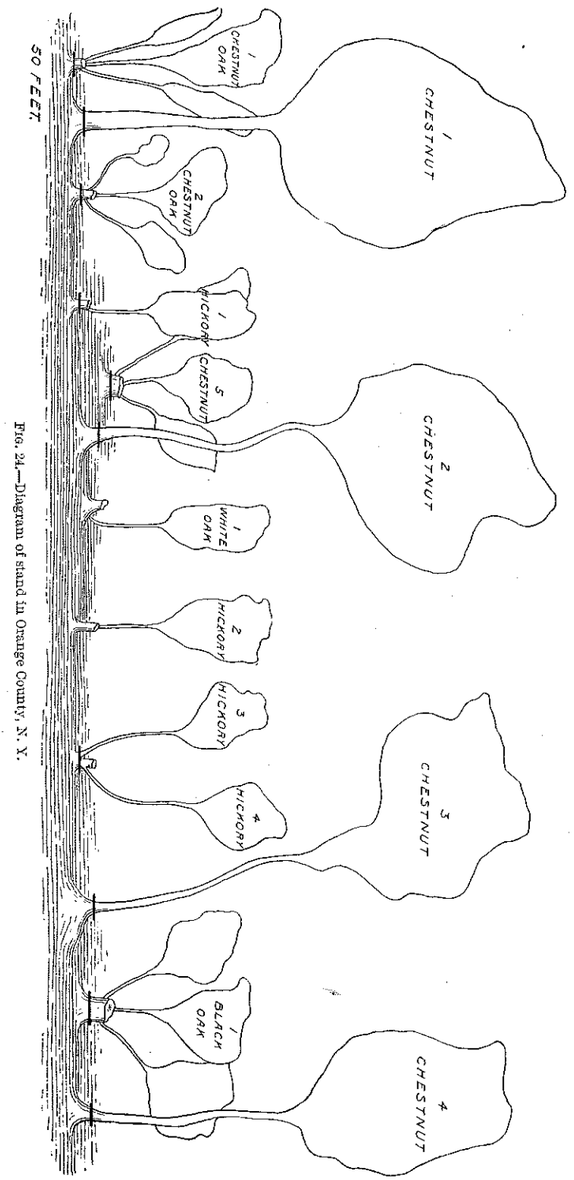

FIG. 24.—Diagram of stand in Orange County, N. Y.

FIGURE 25.

DIAGRAM OF STAND IN BERKSHIRE COUNTY, MASS.

Mature hardwoods beginning to deteriorate; diameter, 10 to 20 inches; height, 60 to 70 feet. A plentiful reproduction of White Pine and Hemlock has come in from neighboring seed trees. The old stand should be gradually removed, so as to stimulate the sapling growth already on the ground and at the same time allow more seed to germinate where the reproduction is sparse. Red Maple 2, Black Cherry 1, and Yellow Birch 2 should be taken out to give plenty of light to the sapling Pines below, which require more than the Hemlocks. Red Maple 1 is split in its main fork, and its removal will start the Hemlocks underneath without drying out the ground. Yellow Birch 1, which does not cast very heavy shade, should be left several years to seed up possible blanks, after which the remaining overwood can be cleared away, or, at the owner's pleasure, left until the young wood is actually in need of release.

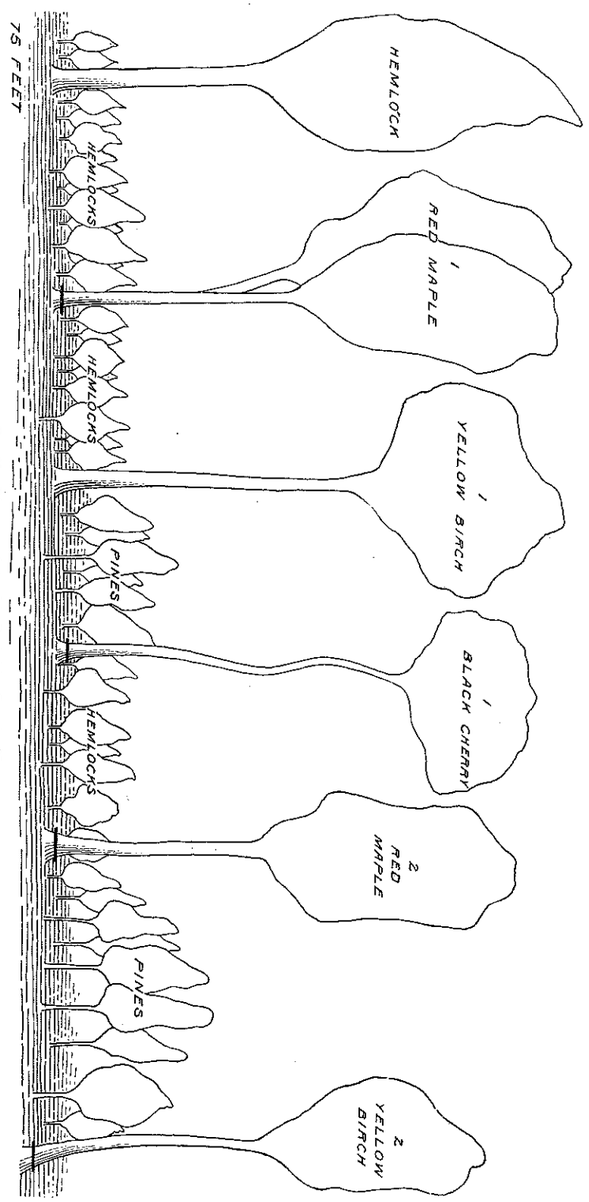

FIG. 25.—Diagram of stand in Berkshire County, Mass.

FIGURE 26.

DIAGRAM OF STAND IN BERKSHIRE COUNTY, MASS.

Mixed forest of varying age, in which younger generations are abundantly represented under the dominant crop. Diameters, 6 to 24 inches; heights, 20 to 50 feet; ages, 20 to 90 years. The shade-enduring species, Sugar Maple, Hemlock, and Beech, have reproduced and thriven under the light-demanding species, White Birch and Red Maple. The result has been an approach to a selection forest which should be cut so as to relieve and supplement the young crop. Of the dominant trees, Sugar Maples 1 and 4, which are still thrifty and growing, are to be left. Then, when Red Maple 1 and White Birch 1, both overmature, are taken out, the younger stand beneath, which has not suffered in their moderate shade, will be further replenished with the seedlings of a very tolerant species, namely, Sugar Maple. Of the subordinate trees only Sugar Maple 2, which has had both crowding and severe shading, is to be cut. Red Maple 2, though of less tolerant species than the other young trees, has been saved from suppression by the natural sparseness of the Birch crown above it. These cuttings will make a beginning in the production of a selection forest, as described on page 13.

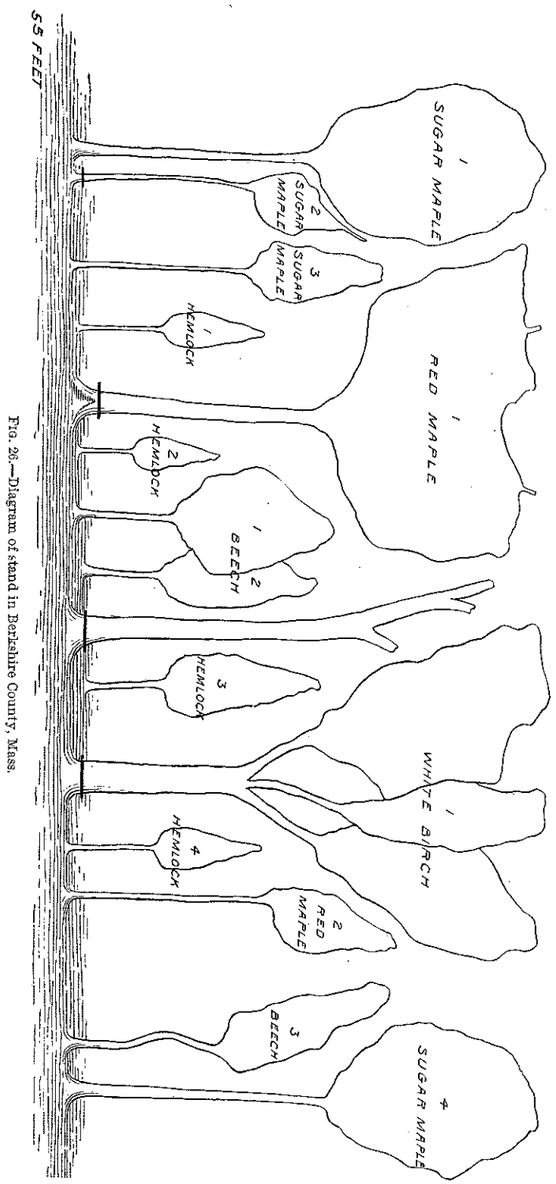

FIG. 26.—Diagram of stand in Berkshire County, Mass.

FIGURE 27.

DIAGRAM OF STAND IN BERKSHIRE COUNTY, MASS.

Overmature Sugar bush in need of reproduction, which has so far been kept out by grazing. Diameters, 8 to 24 inches; heights, 50 to 70 feet. The intention is to reproduce the wood without destroying its appearance, which can be done easily with such shade-enduring trees as Sugar Maple and Beech. The immediate treatment should be to exclude the cattle, and slightly open up the stand by removing the suppressed and declining trees. Maples 2, 4, 5, 7, and 9 and Beech 1 should be cut. All of these are either dying in the tops, badly injured by the maple borer, or too suppressed for recovery. The increased light let in by their removal will stimulate seedling growth, which will then be ready to replace the old trees as they decline.

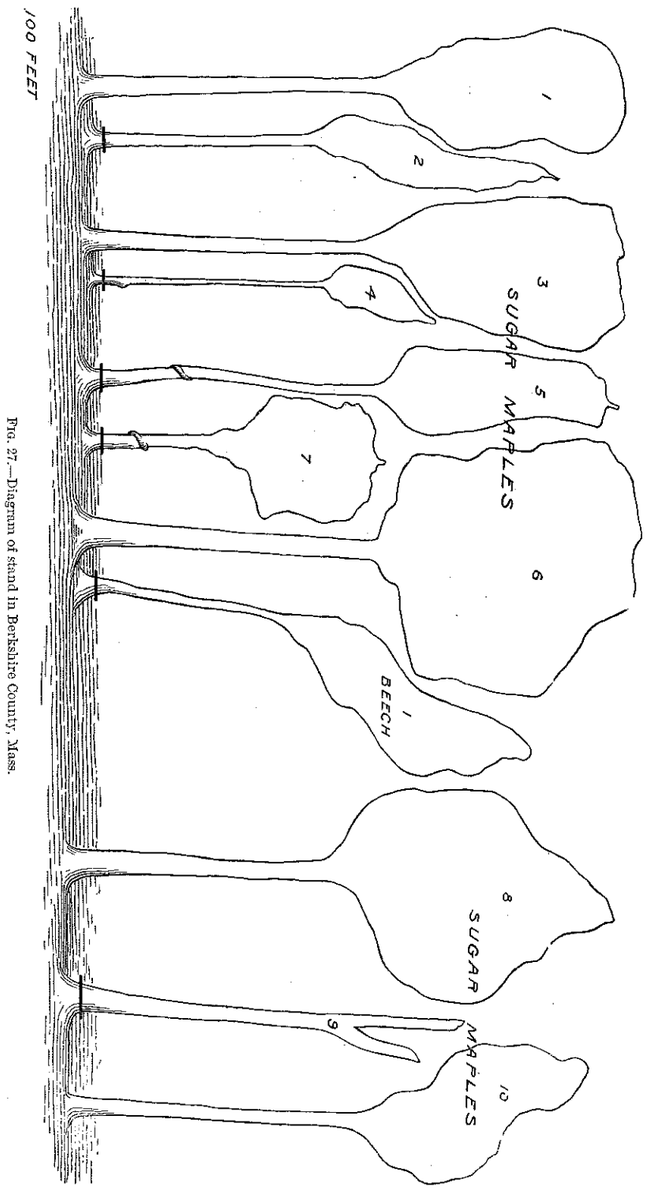

FIG. 27.—Diagram of stand in Berkshire County, Mass.

FIGURE 28.

DIAGRAM OF STAND IN NEW HAVEN COUNTY, CONN.

Mixed forests of sprout hardwoods. Diameters, 3 to 8 inches; heights, 35 to 40 feet; ages, 40 to 45 years. The treatment required is a heavy improvement cutting, which will be followed in this case by a certain amount of reproduction. Injuries from fire have spoiled a number of the dominant trees whose places can not always be filled by young growth already on the ground. Thus, Black Oak 5, Chestnut 2, 4, 5, 6, and 7, were leading trees, but being either dead topped or fire scarred will no longer develop valuably. When they are cut, Black Birches 1 and 2 and Hard Maples 1 and 2 will help to fill some of their places. Of the subordinate trees to be cut, Black Oaks 2 and 4 and White Oak 1 are not only overtopped, but dead in the tops as well. Hard Maple 3 must be cut because it is infested by a borer and will ultimately be killed out by White Oak 2. The resulting stand will be somewhat more open than it should be after a normal improvement cutting, but the young growth which will begin to come in will partially replenish it and serve at the same time to supplement the reproduction after later cuttings.

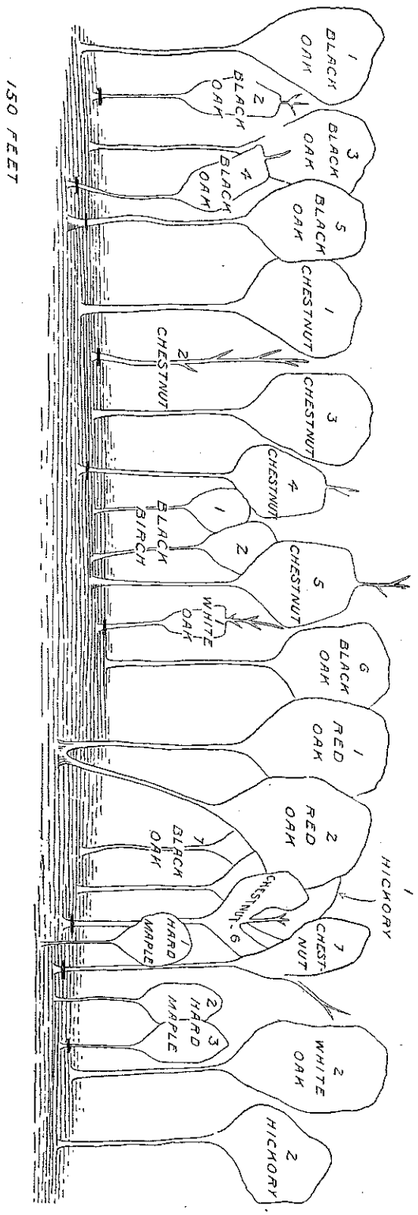

FIG. 28.—Diagram of stand in New Haven County, Conn.

FIGURE 29.

DIAGRAM OF STAND IN ORANGE COUNTY, N. Y.

Mixed hardwood forest, which has passed the period of most rapid growth and which, owing to ground fires, ice storms, and neglect, is in poor condition. The average age is 50 years, the height and diameters 40 to 50 feet, and 6 to 10 inches, respectively. This is a case where a heavy improvement cutting should be made with a view not only to releasing the main crop but also toward encouraging reproduction. Under present conditions little of the subordinate sapling growth is thrifty enough to leave, since it has usually been too long suppressed. Thus, as will be seen in the diagram, all trees but the leading individuals are taken out, including stray specimens of Ironwood and Witch Hazel, which threaten to spread undesirably in the forest. Dogwood, being an ornamental shrub, is here and there allowed to stand. Occasional Hemlocks, whose capacity for enduring shade has kept them vigorous, are also left. The resulting stand, freed of defective and declining trees, is opener than it should be for a pure improvement thinning, but as it is approaching maturity this openness is what is needed to stimulate the germination of seedlings. With a crop of these started it will be possible either to remove the matured stand entirely, or, if it is desired to preserve the old trees as long as possible, to cut it gradually as the trees die or the young growth requires release.

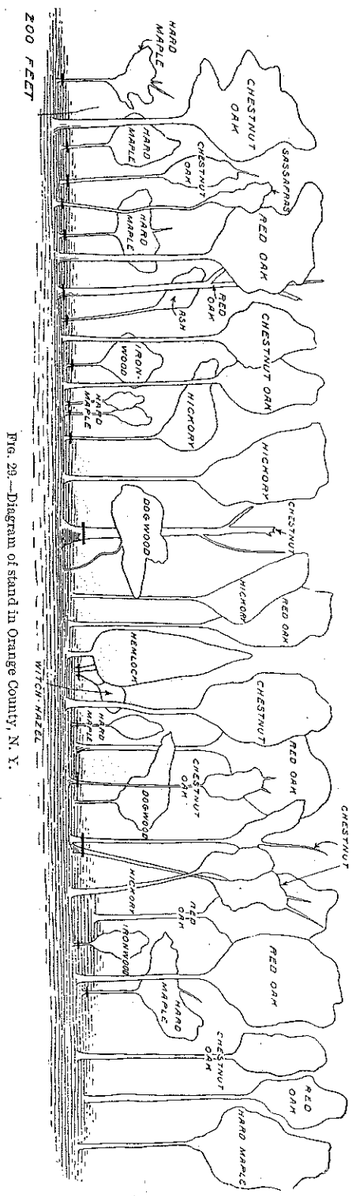

FIG. 29.—Diagram of stand in Orange County, N. Y.

FIGURE 30.

DIAGRAM OF STAND IN ORANGE COUNTY, N. Y.

The accompanying diagram shows the appearance of such mixed hardwood growth as was described in fig. 29 after being thinned.

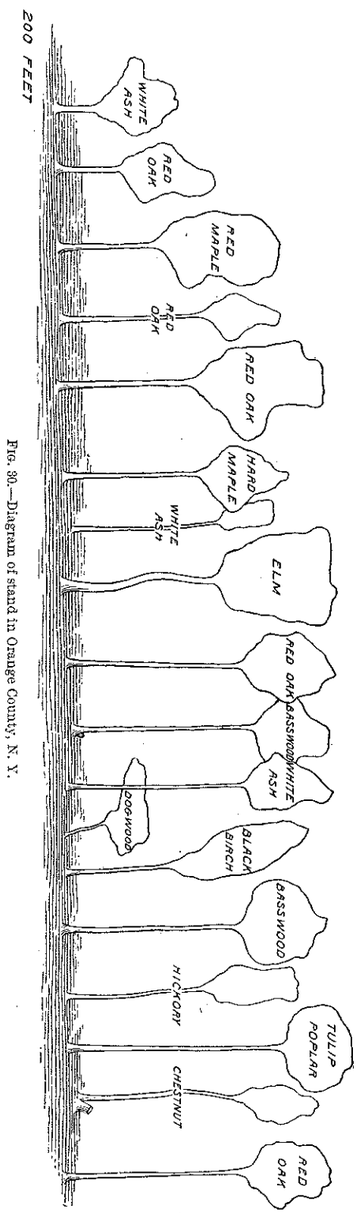

Fig. 30.—Diagram of stand in Orange County, N. Y.

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