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METHODS OF INCREASING FOREST PRODUCTIVITY.

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METHODS OF INCREASING FOREST PRODUCTIVITY.

INTRODUCTION.

Proper management of any forest necessitates complete protection from fire, and a market in which wood material of all sizes is salable at a price sufficient to make the practice of intensive forestry profitable. Both of these conditions will prevail in this country in the future. Therefore, they are assumed in this paper.

Productiveness will be treated as the equivalent of growth, for in a properly managed forest the cut is equal to the growth or increase in wood material. In our forests the cut exceeds the present growth, or production of wood by the forest, for we are now cutting annually the growth of many past years. In the near future the cut can not increase unless the growth or productiveness of our forests increases as well.

Increase in both the quantity and the quality of the product of our forests can be secured through proper management. The increase in quantity will result from an increased area of producing forest on absolute forest land, and from having this area stocked with those species of trees which produce in the shortest time the classes of material most in demand. The increase in quality will result from managing these stands so that material of desirable size and shape is produced.

QUANTITY OF PRODUCT.

INCREASED AREA.

PRODUCTION FROM FORESTS NOW VIRGIN OR MATURE.

When settlement began, the forests of the United States were not producing forests, nor are the yet uncut and unburned areas producing to-day. There are growing trees in all our mature or virgin forests, but their growth is merely enough to offset loss from natural causes, such as decay, windfall, lightning, and insects. The forest has produced, and is now merely keeping the amount of its crop at the point reached years, perhaps centuries, ago. It is forest ready for cutting and can be made producing forest only by cutting in a way that will encourage a new crop to grow.

Ultimately the present virgin or mature forests will be cut over, and the land used either for agricultural crops or for new crops of timber. Under proper management the present condition of unproductiveness will never occur again, for the timber crop on any area kept in forest will be cut as soon as, and usually before, it has stopped increasing. The ideal toward which the forester aims may be illustrated by assuming that 100 years are required for a timber crop to become mature, that an area of 100,000 acres is to be handled as one forest, and that each cutting is followed immediately by reproduction. The forest would then be divided into a series of 100 stands, each of 1,000 acres, differing in age by one year, from the yearling trees up to the century old mature timber. Each year the stand which has reached the century mark would be cut, and the crop from that stand of 1,000 acres would be equivalent to the growth for that year on the whole tract of 100,000 acres. Thus the whole forest would be continuously productive.

In our virgin forests it is as if each stand on reaching the age of 100 years had remained stationary until the whole forest is composed of mature timber. There is no increase in the amount of timber on the ground and consequently no productiveness.

In our virgin forests it is usually both unnecessary and undesirable to cut clean and to establish a new crop by artificial means, in order to make the areas productive. In most of our forests there are young trees already present in sufficient numbers to form the basis for a second crop when the trees now mature are cut, and these young trees will grow the faster when they receive increased light and, in the drier portions of the country, increased soil moisture, after a conservative cutting.

There are approximately 188,000,000 acres of mature forest, exclusive of woodland, in the United States, not one acre of which can be classed as producing forest. Some of this land is more valuable for agricultural crops than for growing timber, and will be put under cultivation as soon as cleared. A conservative estimate, however, is that 135,000,000 acres of the present virgin or mature forest are more valuable for growing forest crops than for any other purpose, and may become productive forest land.

PRODUCTION FROM WASTE LANDS.

There is in the United States another class of lands which has no productiveness at present. Worn-out agricultural soils, cut and burned areas which are not restocking, and sand dunes, are examples of what are commonly called "waste lands." Experiments have shown that some of these areas need only protection from fire to become productive. Any of them can be artificially stocked with forest trees, and so made productive, for forests can grow on soils too poor for successful agriculture, and, as a rule, should be allowed to grow only on such soils. Also, it is extremely probable that future experiments will show it practicable to grow forests on land too dry, too acid, or too alkaline for farming.

There are 81,000,000 acres of forest land, exclusive of woodland, which have been cut or burned over, but are not restocking. Possibly 10,000,000 acres can be used for agriculture, but additions from worn-out agricultural soils, sand dunes, and other sources give a total of at least 90,000,000 acres of waste lands in the United States, all of which can be made productive by artificial stocking with forest trees, or in some cases by merely giving protection from fire.

In making this conservative estimate no consideration has been given to the increasingly large areas of plantations on soils which might be classed as agricultural, but which are devoted to tree production for the sake of wind-breaks or farm wood lots. These are not waste lands, but may be classed with them, for they are areas which are not now, but in the future will be, productive forest.

INCREASED AREA FROM FULLY STOCKED STANDS.

In the United States few forests, even among those which are now producing, fully utilize the areas on which they stand. Lack of care at the time of lumbering and failure to take steps to secure a fully stocked stand give openings in the forest, some of which are occupied by underbrush.

Many of our forests are naturally somewhat open on account of the inability of certain species to endure the slightest crowding by their neighbors. For example, in an old forest of longleaf pine the crowns of the trees cover hardly more than half of the ground, and yet the stand may be fully stocked in the sense that all the trees of that species which can be produced on the area are already growing on it. It is not such lack of density that is considered here, but rather the failure to have the ground occupied as fully as is possible by the species best adapted to the site conditions.

Examples of this lack of density can be found in every part of the country. On the Pacific coast cut-over areas are frequently stocked with a very scattering stand of trees and a dense undergrowth of chaparral or other brush. This underbrush is not only unproductive, but prevents the forest from becoming more dense, since seedlings are unable to start under its shade or to secure the moisture necessary for their existence. In the Rocky Mountain region the yellow-pine forests are almost invariably badly understocked as a result of fire or excessive grazing. In eastern Pennsylvania and other Middle Atlantic States there are large areas bearing only a very scattering stand of pitch pine and hard woods, while most of the ground is covered with scrub oak and other worthless underbrush.

There are some exceptions to this lack of density. For instance, there are areas of second-growth white pine in New England, second-growth Douglas fir in the Northwest, or redwood sprouts in California which are fully stocked. It has been shown, however, that taking averages by forest regions, our second-growth lands have only from 30 to 51 per cent of the stand necessary to make a fully stocked forest. It is, therefore, safe to assume that at least 80 per cent of our present producing forest of 225,000,000 acres is stocked with only 50 per cent of the trees which should be growing in it, or that our present growing forest could grow on 145,000,000 acres.

Under proper management all of this land will be fully stocked. The vacancies in our present producing forests are, therefore, equivalent to an area of over 80,000,000 acres. If the 135,000,000 acres of unproductive virgin or mature forest and the 90,000,000 acres of unproductive waste lands are added, the total possible increase in area of productive forests is 305,000,000 acres.

INCREASED GROWTH.

RETENTION OF FAST-GROWING SPECIES ONLY.

Some of our native species are among the fastest growing found in the Temperate Zone. White pine and Douglas fir are being used to a large extent in European forests, because their growth equals or exceeds that of any native European species. However, there are about 500 species of trees native to the United States, many of which are very slow growing or fail to attain useful size. The wood of others is of very little use on account of poor mechanical properties. It is certain that under proper management these "weed trees and runts," as Doctor Fernow calls them, will be practically eliminated from our forests. Probably not over 70 species will be purposely retained on account of their value for producing wood material.[a]

In determining what trees shall remain in our forests, one of the chief considerations will be the rate of growth, and this will be considered by stands rather than by individual trees.

If production is considered on the basis of weight rather than volume, for the present, it is obvious that stands of species, which fully utilize the influences which cause tree growth, will have a larger production than those which only partially utilize these same re-

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[a] Fernow, Econ. of Forestry, p. 169.

sources. Consequently on any site a species, or mixture of species, which forms a complete cover and thus utilizes the sunlight more completely will have a greater production than a species or mixture which, from the inability of the trees to stand shading, must have open spaces between the trees which allows a portion of the sunlight to reach the ground. For example, a forest of spruce will have a far greater weight production than a forest of paper birch, for the former shades the ground so completely that there is usually no underbrush or grass, and the energy from the sun's heat and light is almost completely utilized by the spruce, while with the paper birch only a portion of the sunlight energy is used by the trees, and the remainder reaches the ground where it enables the cover of grass or brush to exist. In his "Economics of Forestry," page 158, Doctor Fernow says: "The intensity of utilization of the light is the important factor in weight production, and ceteris paribus, in volume production." Other characteristics of trees, such as the ability to extract moisture from relatively dry soils, affect the weight production similarly.

Volume production and weight production are not interchangeable, for the specific gravities of our native woods vary greatly, but there are many opportunities for replacing species which grow very slowly in weight and volume, as a result of incomplete utilization of natural resources, or which do not attain useful sizes and form, with species which will grow more rapidly to usable dimensions and form. For example, there are many areas in the eastern United States at present covered with red cedar, a relatively slow growing tree. The cedar could be replaced nearly everywhere by some faster growing species, such as red oak or tulip poplar for the better soils, and white pine or Norway spruce for the poorer. Another illustration of increased yield both in weight and volume is the replacement of gray birch on worn-out fields and pastures in New England by white pine—a process which often takes place naturally. Still another illustration is the possible artificial replacement of hemlock by pure stands of white pine. Although hemlock probably utilizes the light resources of any site better than white pine, it grows slowly,[a] and its wood can be used for no purpose for which the more rapidly growing white pine is not suitable.

This replacement of species by those which grow more rapidly, and the elimination of "weed trees and runts" will be a very long process, and it will be impossible on account of the need for heavy, dense woods to have all of our forests contain only the most rapidly growing trees. For example, cottonwood is one of the most rapid growing

[a] The specific gravities of white pine and hemlock are, relatively, as 4 to 5.

of our native species. However, white oak, which grows much more slowly in volume, but as fast or faster in weight, will be retained on many soils on which cottonwood could grow, because there will always be a demand for its strong, tough wood.

Furthermore, the wide differences in site conditions in this country will render it necessary to retain some of our relatively slow-growing species, since they are the only ones which can thrive in certain localities. For example, it will probably be impossible to replace our western yellow pine throughout a large part of its range with any faster growing species, for at present no faster growing species is known which will thrive on most sites now occupied by western yellow pine.

As European foresters have taken some of our species to secure increased growth in their forests, so it will be possible in some instances to increase the yield of our forests by introducing exotics. Norway spruce makes a faster growth than the red spruce of Maine and the Adirondacks, and is now being used in plantations where fire or reckless cutting have made it necessary to replace a spruce stand. The wonderful growth both in weight and volume of eucalyptus in California indicates that this tree is capable of utilizing favorable site factors to a degree far greater than any of our native species, and only its inability to stand frost will prevent its being used to replace our native species over large areas. Unfortunately, it will be confined almost wholly to areas which are not now forested.

INCREASED PRODUCTION OF MIXED STANDS.

The differences between species in their ability to endure shade will make it possible, where soil conditions admit, to grow shade-enduring species under or with species which only partially utilize the sunlight. The method is analogous to the growing of agricultural crops under fruit trees in orchards. To make this possible, it is necessary that the intolerant or light-demanding species be started before the trees of shade-enduring species, or that the intolerant species grow much faster in height. Natural examples of this condition are numerous. On the Pacific coast there is almost always a heavy growth of western hemlock and red cedar under stands of Douglas fir. In the Rocky Mountains Engelmann spruce and white fir are frequently found growing under lodgepole pine when the stands of the latter species are no denser than they should be to secure good growth. In the hard-wood region beech and maple are frequently found growing under stands of more intolerant species, such as tulip poplar. Throughout the country pines and spruces are found coming up on old burns under the aspen which first occupied the ground.

Under natural conditions this situation is only temporary, since intolerant species can not reproduce under the shade of the more tolerant species, and consequently the stand in time comes to be composed wholly of the more tolerant trees. Under careful management, however, cuttings will be so arranged that the land is kept constantly producing its maximum amount. In many cases the deliberate mixing of light-demanding, rapid-growing species with shade-enduring, slow-growing species at the time a crop is started, or the underplanting of the crop of light-demanding species, after they have grown to some size, with some shade-enduring species will be practiced. The total growth on an area so treated will be greater than if either species were grown pure, and incidentally the quality of the product is frequently much improved and soil conditions maintained. An experiment in Silesia showed that a mixture of spruce and pine produced 18 per cent more than if the spruce were grown in a pure stand on the same site, or 28 per cent more than if pine alone had been grown.[a]

INCREASED FERTILITY OF WASTE LANDS AND OPENINGS.

The soil on areas which are covered with forest is constantly improving, largely through the beneficial action of the humus or leaf litter. This action is well known to farmers, especially in the South. Frequently forest growth starts on worn-out fields, grows to maturity, is cut, and the soil on the field found to be sufficiently improved to grow good agricultural crops for a few years. The improvement is the same relatively on soils which are kept under forest continuously. Consequently the producing power of the 90,000,000 acres of waste lands in the United States will improve as successive crops of timber are raised on them. The same is true of many areas of our present producing forests, or even some of our mature and virgin forests, which have in the past been burned and have not been under forest a sufficiently long time to reach their maximum fertility. This gain in producing power is, however, slow, and varies greatly with species and localities, consequently no figures for it can be given. It is mentioned merely to emphasize the conservatism of the estimates of the increased productiveness possible in our forests.

POSSIBLE AVERAGE PRODUCTION PER ACRE.

The present growth of fully stocked, growing stands ranges from 30 to 110 cubic feet per acre per annum, with an average of 70 cubic feet for the whole country. The actual production per acre is, however, much less, due chiefly to the absence of fully stocked stands, and

[a] Graves, Forest Mensuration, p. 332.

when applied to the small proportion of our forest land which is now productive gives a total annual production of only 6,500,000,000 cubic feet.

The estimated growth per acre of fully stocked stands is already higher than for European countries, for our forests as a whole are in regions extremely favorable for tree growth. As an illustration, on over 75 per cent of our forest area the annual rainfall exceeds 35 inches, and in some localities is over 100 inches. Also, large areas of our forests are already covered with fast-growing species, such as white pine, which, on fair sites, shows a mean annual growth at the age of 60 years of over 140 cubic feet, or double the average for the country.[a]

Any attempt to predict an increase in the growth in cubic feet of fully stocked stands for the country must be purely an estimate. Such an increase is possible, however, and a conservative figure for it is 10 cubic feet per acre, making a total annual production of 80 cubic feet per acre.

TOTAL INCREASE IN QUANTITY POSSIBLE.

The possible increase in growth in cubic feet is equivalent to an annual growth of 80 cubic feet on the 135,000,000 acres of our virgin or mature forests, on the 90,000,000 acres of our waste lands, and on the 80,000,000 acres of land unproductive on account of lack of density in our producing forests. This gives a total of 24,400,000,000 cubic feet. To this must be added an increased growth of 10 cubic feet per acre on 145,000,000 acres (the area on which our present producing forest could be grown), or 1,450,000,000 cubic feet. This makes the total possible increase 25,850,000,000 cubic feet.

QUALITY OF PRODUCT.

INCREASED YIELD OF USEFUL MATERIAL.

RETENTION OF WELL-SHAPED AND LARGE-GROWING TREES ONLY.

It is not enough that our forests can produce an increased volume of wood. To be truly productive, in the sense of supplying an increased amount of material suitable for use, the wood produced must be of good size and shape. In bringing our forests under proper management, not only will slow-growing species be eliminated, but also those which fail to produce stems of a size sufficient to make them capable of use, or of a shape to render possible their use for the objects most desired by the owners of the forests. For example, the redbud of the central hard-wood region, although classed as a tree, very rarely

[a] Present Timber Production, Ziegler.

attains a size sufficient to make its use possible, and will probably survive only as an ornamental tree in parks and gardens. On the Pacific coast the knobcone pine, even if the poor quality of its wood is disregarded, seldom attains a size sufficient to enable it to be used for saw timber, and consequently it will be especially discriminated against and its reproduction discouraged by foresters. In the Middle West the common catalpa is almost always crooked, and consequently it will be eliminated in time from our forests and replaced, where wood of the same quality is desired, by the straighter growing hardy catalpa. The process of eliminating undesirable species will render usable a greater proportion of the total growth of our forests, and so increase their productiveness.

CONCENTRATION OF GROWTH ON BEST TREES.

In a fully stocked stand of any species a definite amount of wood will be grown on a given area each year, or each period of years. Under proper management the proportion of this growth which will ultimately be used can be greatly increased. If a stand is growing annually at the rate of 80 cubic feet per acre, the proportion of this 80 cubic feet which will ultimately be taken from the forest and used will vary according to whether the wood is placed on tree stems which have attained or will attain a size suitable for use, or whether it be distributed partly on these tree stems and partly on branches or on trees which will die before reaching a usable size. Therefore, the actual productiveness of the forest can be increased by concentrating as much as possible of the growth on trees which are to remain in the stand until they have attained the most useful size and form.

In this country the benefit of thus concentrating the growth is accentuated by our usual unit of measure of wood products. For practically all saw timber the unit used is the board foot instead of the cubic foot, and timber is sold according to the amount of lumber which can be sawed from the trees. Consequently the larger the tree the greater is the proportion of its actual cubic contents which is paid for and used. It is therefore especially desirable to concentrate growth on a relatively small number of trees to force them to large size at the expense of many small trees in the stand.

In fully stocked stands there are always many trees which must soon die from the crowding of their neighbors, consequently their increase in volume is practically wasted. In the meantime they are occupying space and securing light and moisture which could be utilized by the trees which are to remain in the stand, and will be so utilized when the weak trees are finally killed. However, in properly managed stands this process is hastened by the removal of the weak trees, and the growth of the better trees is increased correspondingly. This process is known as thinning.

Examples of the need of thinnings are common. Lodgepole pine in the Rocky Mountains comes up in exceedingly dense stands on old burns. For a time all the trees grow rapidly, but as soon as their crowns begin to interlace the struggle for existence begins and natural thinning follows. The growth of the large trees is retarded by the lack of space in which to develop their crowns, and growth in diameter soon becomes very slow. The ultimate result in such stands when left to themselves is very frequently that at the age of 150 years there are no trees large enough for saw timber, but many trees of small diameter and good height. If from the start the best trees could have been given an opportunity to develop freely as a result of thinning, there would have been fewer trees to the acre, but these trees would have practically the same volume in cubic contents as the present stand, and would be of sufficient size to furnish a large amount of saw timber. Also, if only fuel wood were desired, a larger proportion of the total cubic contents would be of a size suitable for that purpose.

In this country the demand for saw timber makes the size of the trees on a given area, rather than the total volume of the stand, the basis for determining whether the stand is ready for cutting. Since this is so, the concentration of the growth of the comparatively large trees shortens the time required to grow a crop of timber. A crop can be grown, harvested, and a new crop started and grown to some size in the same length of time required for the crop to grow without the aid given by thinnings.

Natural thinning is always extremely wasteful, since if the stand is left to thin out itself the trees which die usually rot in the woods. Under proper management this material is utilized and forms from 10 to 50 per cent in volume of the total product of any timber crop.

Throughout the United States it is the exception that more than a small percentage of the material cut from our second growth or producing forests is of sufficient size, shape, and quality to render possible its use as saw timber, ties, poles, or any use other than fuel. The cut of cord wood in this country is approximately 100,000,000 cords a year, the greater portion of which is cut from the forests of the eastern United States. These eastern forests are the ones which have been cut over in the past and are now our productive forests. By far the greater part of our saw timber comes from virgin forests. In cubic measurement the cut of cord wood is greater than that cut for any other purpose. This makes it plain that our producing forests are in reality producing only a very small quantity of saw timber as compared with the fuel wood which they supply.

Proper management by means of thinnings will greatly increase the proportion of large-sized material produced. Many of our cut-over lands are to-day in practically the same situation as were the forests in parts of Germany at the beginning of the nineteenth century. At that time only 17 per cent of the total amount of timber cut from the forests of Saxony was classed as timber wood. For the period from 1884 to 1893, 79 per cent was timber wood. Similar improvement can be made in our producing forests. At the same time that this increase in the proportion of desirable material was made in Saxony, the annual cut was increased, largely through the use of material removed in thinnings, from 60 cubic feet per acre to 90 cubic feet.

INCREASE IN PROPORTION OF USEFUL MATERIAL POSSIBLE.

If we assume that the total area of our absolute forest land is to be fully stocked with desirable species growing at the rate of 80 cubic feet per annum, the total yield will be 36,000,000,000 cubic feet. Under present conditions, however, an exceedingly conservative estimate would place the proportion of this yield which would be of sufficient size for use as saw timber, ties, poles, or other large-sized products at 25 per cent, or 9,000,000,000 cubic feet. Allowing for waste in logging and milling, this would be equivalent to about 27,000,000,000 board feet. However, by proper care of the forests, the proportion of large-sized material can be raised to at least 50 and possibly to 75 per cent, which would be equivalent to from 54,000,000,000 to 72,000,000,000 board feet per annum; in addition the demand for fuel and other small-sized material would be met by the product of thinnings and the utilization of those parts of the trees which are too small for saw timber.

SUMMARY.

There are 225,000,000 acres of producing forest in the country. On this area the stand is so open that all the trees could be grown on 145,000,000 acres, which would be producing at the rate of 70 cubic feet per acre annually. By growing only the best species this growth can be increased to 80 cubic feet, an increase of 1,450,000,000 cubic feet.

There is an unutilized area of 80,000,000 acres within our present producing forest. There are 135,000,000 acres of absolute forest land within our virgin or mature forests now unproductive. There are 90,000,000 acres of waste lands which can be made productive by planting or fire protection. All of these areas can be made to produce annually an average of 80 cubic feet per acre, or a total of 24,400,000,000 cubic feet.

The total increase possible in the productiveness of our forests is, therefore, 25,850,000,000 cubic feet.

Only 25 per cent of the yield of our present producing forest is saw timber. It can be made from 50 per cent to 75 per cent saw timber through the concentration of growth on the best trees by thinnings, and the holding of the crop till it reaches good size. This would mean an increase, if all our forest land were productive, from 27,000,000,000 board feet to between 54,000,000,000 and 72,000,000,000 board feet per annum.

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