U. S. DEPARTMENT OF AGRICULTURE.
FORESTRY DIVISION.
BULLETIN No. 5.

WHAT IS FORESTRY?

BY

B. E. FERNOW,
CHIEF OF THE DIVISION OF FORESTRY.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
FORESTRY DIVISION,
Washington, D. C., May 20, 1891.

SIR: The unusual interest shown in the subject-matter contained in the following pages, when presented in the form of public addresses delivered by me as your representative before various bodies (notably before the State Boards of Agriculture of Kansas and Nebraska and the Chamber of Commerce of Rochester, New York), makes it appear desirable to publish the same for a larger audience.

At first sight it may be thought incongruous to present under one cover the two aspects of forestry, the reader from the treeless plains being seemingly not interested in the treatment of the forest cover in wooded country, and *vice versa*.

But while on general principles it is desirable that all citizens should understand the forestry problem as it presents itself in the different parts of the country, the knowledge which is gained in the natural forest is an aid in forest-planting, and the principles which underlie forest planting are also to some extent of influence in forest management. Hence both aspects are best presented together.

Since forest planting in the plains is still largely a matter of experiment, I have deemed it desirable to append two contributions from correspondents relating their experience, and the results of actual though limited practice in the field.

B. E. FERNOW,
Chief of Forestry Division.

Hon. J. M. RUSK,
Secretary of Agriculture.

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WHAT IS FORESTRY?

I. THE FOREST AND ITS SIGNIFICANCE.

The "forest primeval" is our most valuable inheritance. It is the ready cash of nature's bountiful provision for our future. Of all the natural resources reserved for our use it is the most directly useful, for in the forest we find ready to hand, without further exertion than the mere harvesting, the greatest variety of material applicable to the needs of man, the means to satisfy every direct want of life.

The accumulations of centuries are stored in the tree growth of the virgin forest and in the forest floor of decayed foliage. The giants which we cut down to-day are the result of nature's unaided forces, which in the Sequoias have been at work for over 2,000 years, while rarely less than 200 years' annual growth is represented in any of the trees we now utilize.

Nature has taken no account of time or space, both of which were lavishly at her command; nor did she care whether the forest was composed of the timbers most useful to man; tree growth, whatever the kind, satisfied her laws of development.

But when man begins to occupy the ground, when a growing nation has need of the soil for agricultural use and for timber, when the forest gives way to the field and meadow, it becomes necessary in time to introduce economy into the use of our inheritance, to relegate the forest to the non-agricultural soils, and to make the soil do full duty in producing only that which is useful to man.

When this stage of development has been reached in a nation, when increasing population calls for economical use of resources, when it becomes desirable to reserve the soil to that use under which it is best fitted to satisfy human wants, then a new conception of the forest arises.

The "forest primeval" then, together with the young natural growth of the better class, becomes "woodlands;" the brush lands, which result from the careless treatment of the original growth, become "waste lands," and the name of "forest" is reserved to those woodlands, which have become objects of human care, producing to the fullest capacity of the soil the most useful material.

No more convincing argument for the importance of this resource in a nation's economy can be offered than to state the value of the forest product in the United States.

The total annual product of wood material of all sorts consumed in the United States may be valued in round numbers at $1,000,000,000, representing, roughly speaking, 25,000,000,000 cubic feet of wood, or the annual increase of the wood growth of 500,000,000 acres of forest in fair condition. This value exceeds ten times the value of our gold and silver output, and three times the annual product of all our mineral and coal mines put together. It is three times the value of our wheat crop; and with all the toil and risk which our agricultural crops involve they can barely quadruple the value of this product yielded by nature for the mere harvesting.

If to the value of our total mining product be added the value of stone quarries and petroleum, and this sum be increased by the estimated value of all the steamboats, sailing vessels, canal boats, flatboats, and barges plying in American waters and belonging to citizens of the United States, it will still be less than the value of the forest product by a sum sufficient to purchase at cost of construction all the canals, buy up at par all the stock of the telegraph companies, pay their bonded debts, and construct and equip all the telephone lines. The value of the annual forest product exceeds the gross income of all the railroad and transportation companies. It would suffice to pay the indebtedness of all the States, if we leave out New York and Pennsylvania, including that of all counties, townships, school districts, and cities within those States (in 1880); and it would more than wipe out the remaining public debt of the United States. In fact, ranking manufactures of all kinds and agriculture as respectively first and second in importance, as far as production of values goes, the forest product occupies the third place. This was the case according to the census of 1880. It is claimed that since then the lumber industry has enlarged to such an extent as to make its product second, if not first in value.

The capital employed in merely milling this product, aside from that emp loyed in the harvesting, is roughly estimated at $650,000,000, and there are more than 300,000 people occupied in the direct manufacture of forest and sawmill products alone, not to count the employment afforded by its transportation to centers of consumption and its remanufacture.

It would lead us through all phases and employments of human life were we to attempt an enumeration of the uses to which forest products are put.

Not only does the forest furnish the material for the construction of dwellings and other structures, our railroad consumption of 500,000,000 cubic feet of timber included, but countless articles of domestic economy and implements necessitate its use. Not only does it yield to two-thirds of our population the fuel to warm their houses and to prepare their

food, but it gave us the first means of using our mineral resources, and even now 600,000 tons of the iron product depend upon charcoal. Not only does the wood in its natural form serve our needs, but our ingenuity has invented methods by which we can transform it into all sorts of useful materials, like cellulose, paper, and even silk, while lately it has become possible to prepare from the brushwood a feed for cattle more nutritious than straw and equal to hay.

By distillation of the wood numerous new products are derived from it, like alcohol, acetic acid, gas, vanillin, etc., and if we recall that the bark yields indispensable tanning material, that resin and tar to pitch our vessels, and turpentine, sassafras oil, and quinine to cure our ills, rubber and cork for a great variety of uses, maple sugar and cinnamon to flavor our food, all are derived from the forest, it will be admitted that an enumeration of the use of forest products would be almost endless. And in spite of the discovery of substitutes for many uses the application of wood is growing everywhere in direction as well as in quantity.

While this direct usefulness of the forest is patent to everyone, there are to be noted some more hidden indirect phases of utility as important as those which are presented by its material.

The forest, with its decaying vegetation, has furnished the fertility of our fields and waters, for the mineral soil without the humus or vegetable mold would never have produced food enough for mankind.

Another incalculable benefit of the forest cover has impressed itself upon the minds of the observing and thinking portion of mankind only comparatively recently, namely, the part which the forest plays in the great economy of nature, the recognition of which led the most eminent naturalist and philosopher, A. von Humboldt, to exclaim: "How foolish do men appear, destroying the forest cover without regard to consequences, for thereby they rob themselves of wood and water."

It is only within a century or so that the value of a forest cover as a protection against destructive natural forces and as a regulator of favorable cultural conditions, by its influence upon climatic conditions, and upon the flow of water, has been recognized and proved.

Whatever may in general remain unexplained or unproved in regard to these influences of the forest, it is well established by observation, experience, and experiment that under certain conditions of soil, topography, and climate these influences not only exist, but are of considerable importance in preventing the washing and shifting of the soil, regulating the surface and subterranean drainage of waters, breaking the force of and tempering hot and cold winds, and thus acting as a regulator of cultural conditions.

We see, then, that the significance of the forest is twofold. For the private interest it is, in the first place, only a source of profitable products; the more profit it affords the more fully does it satisfy this interest.

For the interest of the community, the State, or Nation, it forms an indispensable basis of material prosperity, directly and indirectly. The more fully, and especially the more continuously, this function is fulfilled, the more fully is the interest of the community subserved.

Forest management, therefore, a proper maintenance of forest cover where desirable, supplies not only profitable employment for private enterprise, but is also an important factor of public economy, and the application of proper forestry principles is hence a matter of public interest.

II. FORESTRY IN A WOODED COUNTRY,

OR

FOREST MANAGEMENT.

If left to itself, without interference of man, nature would keep the entire earth, with few excepted localities, under forest cover. It is only when man interferes that this tendency of nature is either frustrated or turned to advantage for the objects of man. If the latter, then we may speak of forest management, and we understand by "management" the bestowal of care, giving direction and applying economy in the use of natural resources.

OBJECTS OF FOREST MANAGEMENT.

Forest management has two objects in view:

1. To produce and reproduce certain useful material.

2. To sustain or possibly improve certain advantageous natural conditions.

In the first case we treat the forest as a crop, which we harvest from the soil, taking care to devote the land to repeated reproduction of crops. As agriculture is practiced for the purpose of producing food crops, so forestry is in the first place concerned in the production of wood crops, both attempting to create values from the soil.

In the second case we add to the first conception of the forest as a crop another, namely, that of a cover to the soil, which under certain conditions and in certain locations bears a very important relation to other conditions of life.

The favorable influence which the forest growth exerts in preventing the washing of the soil and in retarding the torrential flow of water, and also in checking the winds and thereby reducing rapid evaporation, further in facilitating subterranean drainage and influencing climatic conditions, on account of which it is desirable to preserve certain parts of the natural forest growth and extend it elsewhere—this favorable influence is due to the dense cover of foliage mainly, and to the mechanical obstruction which the trunks and the litter of the forest floor offer.

Any kind of tree growth would answer this purpose, and all the forest management necessary would be to simply abstain from interference and leave the ground to nature's kindly action.

This was about the idea of the first advocates of forest protection in this country: Keep out fire, keep out cattle, keep out the ax of man, and nothing more is needed to keep our mountains under forest cover forever.

But would it be rational and would it be necessary to withdraw a large territory from human use in order to secure this beneficial influence? It would be, indeed, in many localities, if the advantages of keeping it under forest could not be secured simultaneously with the employment of the soil for useful production, but rational forest management secures both the advantages of favorable forest conditions and the reproduction of useful material. Not only is the rational cutting of the forest not antagonistic to favorable forest conditions, but in skillful hands the latter can be improved by the judicious use of the ax.

In fact the demands of forest preservation on the mountains and the methods of forest management for profit in such localities are more or less harmonious; thus the absolute clearing of the forest on steep hillsides, which is apt to lead to desiccation and washing of the soil, is equally detrimental to a profitable forest management, necessitating, as it does, replanting under difficulties.

Forest preservation, then, does not, as seems to be imagined by many, exclude proper forest utilization, but on the contrary these may well go hand in hand, preserving forest conditions while securing valuable material; the first requirement only modifies the manner, in which the second is satisfied.

WHERE SHOULD FOREST GROWTH BE MAINTAINED?

The forest is the most unsatisfactory form of vegetation as regards the maintenance of ruminants, and hence of a large population.

Forest destruction is, therefore, the beginning of all culture and its essential prerequisite.

When, however, the land that is fit for purposes of agriculture and grazing has been secured, it will be found that the most successful cultivation of the soil can be carried on when forest areas are interspersed.

If properly located, the wood lot on the farm is a most profitable property, directly and indirectly.

First of all, the waste places, the thin soils that produce little, the rocky and the wet places should be left to tree growth; because not only does the farm look better with the ugly spots covered, but tree growth is the most profitable crop on them. Trees will grow, thrive, and pay good returns without much work. Not that the forest grows best on such sites, but it can grow where no other crop is possible.

Next, there should be left a wood growth on all hillsides too steep to plow comfortably; on all knolls, and, in patches and belts, along all slopes that are subject to washing and gullying, and also a strip along all water courses.

The reason for this is obvious. Wherever one travels in the United States he will, half the year, find our rivers and streams muddy and chocolate-colored, laden with sand and soil. What occasions this condition? The loss of the best part of your farms; millions of dollars' worth of farm values go down the rivers every year for lack of attention to a proper maintenance of forest growth.

The soil is washed by the rains from the fields into brooks and rivers because you have plowed to the water's edge, instead of leaving a belt of forest cover along the banks; it is washed from the slopes and knolls because you have bared them, and the rain beating down first hardens the ground and then being unable to drain off subterraneously has carried the soil and débris down the slope, gullying the hillside, reducing its farm value, and filling up the rivers, while making river and harbor improvements more expensive, and in these you pay the penalty for not keeping your soil at home. It is computed that in the hill lands of the State of Mississippi alone the loss of agricultural lands from this cause amounts to 10 per cent yearly.

The forest cover with its interposing foliage and undergrowth, its protecting floor of fallen leaves and twigs, its intricate root system and its fallen trunks and branches, first retards the rain on its way to the ground, thus breaking its force, and then retards the surface drainage and prevents the rush of water which takes place over naked soil.

And if larger areas are being denuded in a hill country or in the mountains, the chances are that both the flow of springs and the flow of brooks and rivers are made uncertain, because the forest which acts as an equalizer in time and quantity of water-flow is cut off.

The streams that used to keep the ponds well filled for the sawmill and the gristmill and furnished a never-failing supply for the farms, how many of them run dry in summer? And yet with the warm rains of spring and melting snow, they overflow their banks and swift waters carry away fences, bridges, and embankments, and in the larger streams the floods make sad havoc and destroy millions of property.

Thus what the farmer is doing on his farm or leaves undone in the way of forest management is felt not only by himself, but by a large area far away from him, and ultimately the large cities, which depend for power, drinking water, or for navigation upon the regular drainage waters of the country, find themselves in danger and distress.

At first sight to the farmer, who sees only his immediate surroundings, it would appear impossible that his action or inaction should breed such results, but as all great effects are the result of many small causes, so the many little rills and runs and rivulets carrying each its quota of water, earth, and rocks from the denuded slope to the river, make the great floods more dangerous than they were before, because large masses of water run off at once and the débris stows back its flow.

There is another influence of the well-placed wood lot, the absence of

which is felt by the farmers in western New York and elsewhere. It is the shelter which the wood lot offered. Now, with the country unduly opened, spring opens later. The young cattle that used to be turned out into the wood-sheltered pasture about the 1st of April now are kept shut up until the middle of May. Peach orchards in Michigan have become impossible in many sections, and those that were sure to be loaded every year with luscious fruit now furnish a good crop only as an exception, and so it is with apples. Droughts in summer and floods in spring time are more frequent and more destructive because the tempering shelter belt and the forest floor are destroyed.

There are also in all parts of the country large mountain areas which with their declivities and thin soils offer little or no inducement to agricultural use and are best kept under forest altogether, partly because that is the most profitable use of the soil, partly because a forest cover is here of most benefit in regulating water conditions, and for this reason the method of managing here must be such that regard to these conditions forms the first consideration in the use of the forest, production of material and values only the second.

Forestry here carried on with the care which such conditions demand may not prove profitable to the private owner, and therefore such forests should be owned, controlled, and managed by the community or the State as an object of public concern, like roads, canals, harbors, and similar public improvements; the interest of the community being here more concerned than the pocket of the individual.

WHAT FOREST MANAGEMENT IS AND WHAT IT IS NOT.

The popularly expressed idea that forest management consists in cutting the mature trees is about as childlike a conception as if we were to define banking business to consist in paying out money. The lumberman hardly does anything but take the mature trees, and yet he thereby in many cases injures the forest, killing out the desirable species and handing the ground over to less desirable growth, because he does not know how to cut so as to reproduce or favor the desirable growth. Thus the cutting of the spruce in the Adirondacks, done in the manner in which it is now practiced, is a practice to be utterly condemned from the forester's point of view, because it reduces the chances for reproduction of the most desirable species.

Nor does forestry consist in planting trees, after the original growth is removed, although that may under certain circumstances form a part of the forester's task.

Least of all does forestry require the prevention of timber-cutting anywhere and everywhere, for that would be to prevent its very object, which, as we have seen, is to grow a crop, to secure, besides favorable forest conditions, desirable material for utilization.

What is the material which a rational forest management tries to

secure? Not trees merely—which, to be sure, would satisfy the requirement of maintaining forest conditions, and which nature produces without assistance—nor is it wood simply that is sought by the forest manager; that, too, is produced by nature without his interference, but it is useful wood—wood of qualities that make it applicable to his needs, and, further than that, he so directs nature as to produce and reproduce the largest amount of the most useful wood on the smallest area possible and with the least expenditure of energy or money. That is the task of the forester and of forest management.

Forestry in a wooded country means harvesting the wood crop in such a manner that the forest will reproduce itself in the same if not in superior composition of kinds. Reproduction, then, is the aim of the forest manager, and the difference between the work of the lumberman and that of the forester consists mainly in this: that the forester cuts his trees with a view of securing valuable reproduction, while the lumberman cuts without this view, or at least without the knowledge as to how this reproduction can be secured and directed at will. The efficient forest manager requires no other tool than the ax and saw—the planting tools being needed only to correct his mistakes—but he uses them differently from the lumberman.

And what are the methods of forest management?

Admirers of European forest management, as well as the knownothings who consider it inapplicable to our conditions, very often confound the administrative features with the technical management.

To cut a given equal amount of wood yearly, as is done more or less strictly in most European government forests, is a purely administrative measure, just as a mine owner may propose to take from his property annually an equal amount of coal. To cut over a certain area and take out a certain number of trees because it is a seed year and we want to take advantage of it for reproduction, and in order to secure that satisfactorily remove a certain amount of the shade—that is a technical measure, just as the proper proportioning of coal and ore and flux to make iron.

The administrative measures in vogue in European forest management we may perhaps not think desirable or suitable to our country and conditions, but the technical measures as far as they are based upon natural laws and proved by experience proper for the object in view will have to be adopted with the necessary modifications if we wish to attain proper forest management.

Before, however, we may apply the finer methods of forestry management as practiced abroad, it will be well enough to begin with common-sense management, which consists in avoiding unnecessary waste, in protecting against fire, in keeping out cattle where young growth is to be fostered, and in not preventing by malpractice the natural reforestation.

There are three ways of reproducing a forest, which lead to three methods of management. We may either remove the original growth and replant the area, or we may cut it and expect the reproduction by sprouts from the stumps, or else we may so manage our cutting that seed from some remaining trees sows itself and produces a new growth of seedlings. Often any two or all three methods of reproduction may be employed together.

The first method, namely, that of replanting the cleared ground, is simple but expensive, especially in our country, where wages are high.

The method is objectionable, also, because by the removal of the original cover the soil is exposed to sun and wind and is liable to be covered by weed growth, which reduces the chances of successful reforestation. It is, however, largely used in the pine forests of Europe with tolerable success, and has the advantage that the cutting may be done without regard to the seed production.

Planting becomes necessary where all original growth is absent, as in the prairies and plains and on the devastated hill and mountain lands, or where, by lack of proper attention in cutting the forest, undesirable species have gained possession of the ground.

The second method, that of reproduction by sprouts from the stump, familiarly known as coppice management, can be used only, of course, with such kinds as will sprout. The conifers, therefore, are entirely excluded, for although a few of them (sequoia, and some pines) do sprout, the sprouts do not develop into trees of size. Altogether, sprouts, while growing rapidly, remain comparatively short. This management is, therefore, only fit for the production of firewood, charcoal, ties, poles, posts, and wood of small dimensions. Most of the so-called second growth of the forests of New England and elsewhere in the United States consists of coppice growth, and does not promise much for future supplies of dimension timber. In time the stocks lose their vitality and the quality of the forest deteriorates.

The third method, that of natural reproduction by seed, together with artificial planting, produces the timber forest.

There are various ways of applying this method; either leaving seed trees scattered over the entire area, or clearing strips and leaving a neighboring growth of seed trees to supply the seed for the reproduction on the cleared strip.

In these methods one is dependent on the seed-bearing of the mother trees, and it must not be overlooked that most or many of our most valuable trees do not bear seed every year, at least not plentifully.

The clearing of strips, with seeding from the neighboring growth, is perhaps the simplest and on that account may recommend itself to the lumbermen. It is applicable with success, however, only to those kinds which have light enough seed to be scattered over the cleared strip by the winds, and which can sprout and develop satisfactorily

without the partial shade of nurse trees and grow fast enough not to be crowded out by weeds.

To make this method tolerably effective, the width of the cleared strip should not be more than the distance which the wind is sure to carry the seed, say from two to four tree lengths, according to kind, and that the clearing occur in or precede a seed year.

By reducing the size of the clearings to small openings the chances of successful reproduction are increased; and in this manner we come to the next method, which consists in a thinning out through the entire area that is to be reproduced, and letting in enough light to stimulate seed bearing, proper decomposition of the litter to make a seed bed, and to favor the growth of seedlings. The method of reproduction from seed trees standing on the same ground requires perhaps the least change from our present method of utilizing the forest, which consists in culling out trees here and there. The main changes necessary would be to remove first the undesirable trees and the undesirable species, and to utilize the desirable only gradually after seeding has taken place, and in doing so keep in view the requirements of the young growth for either shade or more light. To do this successfully requires considerable knowledge and judgment, and in fact the art of the forester is here called into fullest requisition. Differences of condition necessitate differences of treatment. It would lead us too far to discuss in this paper at length what is required. I may only briefly recite an example, namely, how the beech forests are reproduced in Europe.

The beech, like many other timbers, bears seed only periodically. Seed years occur in different localities at periods varying from 3 to even 20 years, records of their occurrence being kept. A few years before the seed year is expected to occur the forest is somewhat thinned out to admit air and light upon the soil, in order that the litter of the forest floor be more rapidly decomposed and humified, and so may form a suitable seed-bed for the sprouting of the seed, and also to stimulate the mother trees to a plentiful production of superior seed. In this thinning the inferior material and the undesirable kinds are first removed, and such kinds as reproduce themselves easily without aid from the forester. When the nuts fall, pigs may be driven into the woods to plow them under. Under favorable conditions a soft, green carpet of young beech seedlings will be found to cover the ground in the spring next after the seed year. Now comes the critical period. If the mother trees were left, the whole crop would be lost, and while waiting for the next seed crop, under the altered light conditions which invite grasses, weeds, and other species, the difficulties in securing reproduction are increased. By thinning out gradually the proper amount of light is given to the young crop, and when in three or four years the last of the mother or nurse trees are removed, a thicket of young beeches has replaced the old growth. In a similar manner, with necessary modifications in procedure according to species, climate, and soil, the natural reproduction of other species is effected.

IMPROVEMENT OF THE CROP—THINNING.

Having removed all the old growth and secured a young growth, there follows its cultivation. This consists first in improving its composition and secondly in promoting its rapid and desirable development. Both these objects are attained by proper thinning, repeated from time to time.

The young growth is rarely such as we would like to see. Some undesirable kinds are prominent which should be reduced in number; here are some stumpy and bushy trees which prevent the development of their neighbors and are best removed; there a stump has produced more sprouts than it can support and it is wisdom to thin them out, cutting especially the inner ones. Here is a kind especially valuable that we would protect from being smothered by its less valuable neighbors. There may also be larger fail places in the natural reproduction, and if too large to be covered over in a few years we may deem it desirable to plant such places with some valuable kind.

In this way for the first 10 to 15 years, by judicious use of the ax mainly, we try to improve the composition of our crop. These trimmings must be made carefully, however, so that the soil which is shaded by the crown may not remain exposed for more than 2 or 3 years; that is to say, in that time the crown cover must close itself again. When in this manner the crop has been brought into desirable shape, a series of thinnings follows, repeated periodically or going on continually, as may be most convenient, the object of which is to advance the development of the growth, to hasten the formation of valuable wood. In these thinnings a certain number of trees are taken out in order to give the remainder an opportunity to develop more quickly and with the least hindrance to desirable form and size.

The philosophy of these thinnings lies in the observation that light is one of the important factors of life and especially of tree growth. It is under the influence of light that foliage develops and that leaves assimilate food; the more foliage and the more light at its disposal a tree has the more wood it will form. On the other hand, if we compare trees grown in the dense forest with those grown in the open field, we will note a difference in habit and shape; while the latter, grown in full enjoyment of light, have during the same time attained a greater diameter, have in fact made more wood, the latter excel in the length, straightness, and cylindrical form of their trunks; while the former have developed largely into branches, the latter have fewer branches, and altogether, although having made less wood, have produced a more useful quality.

Hence, in order to produce good timber, which is the principal aim of forest management, dense growth is necessary, when the light, needed for the development of branches, is cut off and a clean shaft the result; yet on the other hand, to produce largest amount of material open position is more favorable.

The whole secret of forest management then consists in so balancing light conditions in the forest that the largest amount of wood possible is formed in the trunk without much branching; that is to say, to secure the greatest amount of foliage on the largest number of individuals that may develop on the areas to best proportions.

UNDERGROWTH.

From the soil trees derive mainly that most needful element of growth, water. It is, therefore, very necessary not only to preserve sufficiency of moisture in the soil, but also to keep the soil in such condition that the rains and snows can penetrate it. This is done by keeping the soil shaded and covered with the natural litter and undergrowth, which checks undue evaporation and preserves the granular structure of the soil so favorable to percolation.

Undergrowth, therefore—not, however, the grass and weeds which transpire more water than their shade prevents from evaporating—should be fostered, and the protection of the soil, especially of poor soil, against sun and wind must also be kept in view in the amount of thinning to be done.

MIXED GROWTH—LIGHT INFLUENCES.

To understand technical forest management, especially the practice of thinning, it is necessary to realize that in the vegetable world, as in the animal world, there is a constant struggle for supremacy going on between the different species as well as among the individuals of the same species. The methods used in this warfare are various, and both offensive and defensive. One species seeks to gain a foothold by prolific production of seed, and perhaps of light-winged seeds which the winds will carry everywhere, like those of the ubiquitous aspen. Another species "shades out" its rivals by dense foliage. Firs and spruces are examples of this class. Others again develop a superiority of the root system, enabling them to endure shade and other privations until the overtopping rivals succumb to the influence of time. The oak is an example of this kind. In this way the alternation of forest growth, so often remarked upon, finds a natural and rational explanation.

Now, the task of the forest manager is to interfere in this warfare in favor of the species which he desires to propagate and have specially develop for his own objects by reducing the chances of reproduction and supremacy of the undesirable species.

Mixed forest growth is the rule in the world; in the natural forest, with few excepted localities, there are usually several species occupying the ground together. The forester knows that there are various advantages resulting from this arrangement, and he fosters the mixed growth, although the management of a mixed forest presents more difficulties and requires more knowledge and judgment than the forest

formed of a single species. In the management of both there is, as we have seen, one condition which requires the most careful study and consideration, namely, the dependence of tree growth on light, by which in the forest the ultimate domination of this or the other tree or species is determined.

Especially the varying amounts of light which the different species either need or can be satisfied with,* and also the rapidity with which they grow in height and which gives them a chance of escaping the shading exerted by their neighbors, are of interest to the forest manager.

Go into the dense forest and see what kinds of trees are vegetating in the dense shade of the older trees, and then go into an opening recently made, an abandoned field or other place, where the full benefit of light is to be had by all alike, and you will find a different set altogether occupying the ground and dominating. In the first case you will find, perhaps, beech and sugar maple or fir, and spruce; in the second case you may find aspen, poplars, willows, soft maple, oaks, or pines, tamarack, etc.

All trees thrive ultimately best in full enjoyment of light; the leaves exercise their functions under its influence and feed the tree by assimilating the carbon of the air and transpiring the water of the soil, but some, like those first mentioned, can at least subsist and their foliage functionate with a small amount—they are shade-enduring kinds, they usually have a dense foliage, many leaves, and each one needs to do but little work—and exert considerable shade when fully developed, while those last named can not exist long without a considerable amount of light, having less foliage—they are light-needing kinds.

To offset this drawback in the constitution of these latter nature has endowed them as a rule with the capacity of rapid height growth, to escape their would-be suppressors, but again, what they have gained in the rapidity of development they lose in the length of life; they are mostly short-lived species, while the shade-enduring are generally slower growers, but persistent and long-lived. Some kinds, like most of the oaks, stand between the two; while exhibiting a remarkable capacity of vegetating in the shade, they are really light-needing species but comparatively slow growers and long-lived. One and the same species behaves also somewhat differently under different soil and climatic conditions; for instance, as a rule, the light-needing species can endure more shade on moist soils and the shade-enduring require more light on drier soils.

In the earliest stages of life the little seedlings of most trees require partial shade and are quite sensitive in regard to light conditions. Some have such a small range of light and shade endurance that, while there may be millions of little seedlings sprouted, they will all perish if some of the mother trees are not removed and more light

* See also p. 36 of this bulletin.

given; and they will perish equally if the old growth is removed too suddenly and the delicate leaf structure, under the influence of direct sunlight, is made to exercise its functions beyond its capacity.

Left to itself, as the forest grows up and as the individual trees develop, each trying to hold its ground and struggling for light, there is a natural thinning taking place, some trees lagging behind in growth and being shaded out, until in old age only as many trees remain as can occupy the ground without incommoding each other.

This struggle among the individuals goes on during their entire life. Some few shoot ahead, perhaps because of a stronger constitution or some favorable external cause, and overtower their neighbors; these, lagging behind, fall more and more under the shading influence of their stronger neighbors until entirely suppressed, when they only vegetate until they die, while the struggle continues among the dominant class and is never ended in a forest that is utilized at the proper time by man.

The differentiation into dominant growth and laggards takes place in general earlier and more decidedly on strong soils, also in light-needing sooner than in shade-enduring species, which last keep up an even struggle much longer than the former, so that it is difficult to say which will finally win.

It is to give direction and assist in this struggle, to hasten its results, to obviate, if possible, useless expenditure of energy by timely interference, that the forester steps in with the ax. For the natural thinning, as a rule, does not progress satisfactorily for the best quantitative and qualitative development, and hence it is assisted by the forester, it being well understood that there is a larger total and more valuable product to be had with a smaller number of individuals through better development of the latter.

It is the number of trees that yield the best result, not the greatest number that we try to keep growing. What this best number is depends naturally on the kind of trees; it changes also with age, as the trees need more room, and with soil and situation.

In the average we would not be far out of the way to require per tree in the twentieth year 10 square feet, in the fortieth year, 40; in the sixtieth year, 100; in the eightieth year, 125, and in the one hundredth year 160 square feet growing space, or 4,300, 1,100, 435, 350, and 270 trees per acre, respectively, at the ages noted, would represent about the proper average condition of growth. There are from 50 to 75 per cent more shade-enduring trees possible on an acre than light-needing; more trees on poorer soils, sometimes two to four times as many, than on good soils, and more in the valley, sometimes double that of the higher elevations; so that while a pine growth of, say, 60 years may show 500 trees to the acre, a beech growth may contain 750 trees under the same conditions.

SPECIAL CONSIDERATIONS IN THINNING.

The three questions in thinning which always confront the forest manager are: When to begin and how often to repeat the thinnings; how severely to thin at one time or how many trees to permit to grow; which trees to take out.

These questions of course can only be answered according to the special conditions of each case. As a rule it will be best to begin this series of thinnings when the signs of the struggle for light begin to show themselves unmistakably; that is to say, when a decided difference in individual development can be seen and the dominant growth be discerned from the laggards.

On strong soils and with light-needing species this occurs sooner, and the time for interference is more easily determined; but in these cases assistance is also less urgent than on poorer soils, where more individuals are struggling in an even fight, and usually the separation into dominant growth and suppressed or laggards does not take place easily and early, and here, therefore, it is more needful to give timely assistance.

In practice a consideration for beginning these thinnings is also the possibility of using or marketing the material cut out. But this is a proper consideration only because we do not know yet when it is profitable to spend time or money for thinning merely for the benefit of the remaining growth.

As a rule the thinnings are begun in light-foliaged, rapid-growing trees with the fifteenth to twenty-fifth year, while with shade-enduring species one may wait until the twenty-fifth to thirtieth year; that is, the time when the greatest annual height growth is attained and diameter development is desirable.

The questions how much to cut out and how soon to repeat the operation are somewhat interdependent.

In small wood lots, where the owner uses perhaps the thinned out material himself, a continuous gradual thinning is best, while on large areas it may not be practicable to do otherwise than to subject a larger area to the operation at once and repeat it in a few years. In such a case enough must be taken out to avoid crowding until a second thinning, and yet not to cut so severely as to interrupt the crown cover too long and lay bare the soil.

The oftener the thinnings are repeated the better for the remaining growth. The repetition may be made every 2 or 3 years in pines and rapid-growing soft woods, while in shade-enduring and slow growers every 5 years may be sufficient. Condition of the growth and judgment alone can determine this. The same is true as regards the amount to be thinned out.

I repeat that there are always three considerations to be kept in view and their requirements balanced, namely, conservation or improvement

of favorable soil conditions, which requires dense shading, while large yield in quantity requires room and loose position, and trunk development in quality requires moderate crowding.

A study of crown development is necessary to form a judgment as to what is required. Here we have the predominant few, with an exceptionally full crown, while the majority of the trees have only a moderately developed head. We next discern quite a number which have still a normally developed crown, yet form only a subordinate part in the main crown canopy. These three classes form the dominant growth and the active crown cover. Underneath these we find trees with small undeveloped crowns, suppressed, dying, dead. These last classes are, to be sure, out of the struggle, and their removal means nothing to the superior or dominant growth; they may be taken or left as their wood can be made useful or not. The question can only be which of the other three classes to favor and how much to open the crown canopy.

As to the latter question, soil conditions are to be consulted first. On poorer soils less opening is preferable; the same rule is good on steep hills, southern exposures, and where windfalls may be invited by too severe thinning. The age of the growth also has a bearing. Later on, when the principal height growth has been attained and the trunks are clear of branches to a sufficient height, and the formation of clean boles is not any more to be considered, the thinnings may be made severer. As a rule the crown cover should not be interrupted more than the remaining growth is capable of closing up again within 3 to 5 years; this would take rarely more than one-fifth to one-third of the growth if the crown cover was normal at the time of thinning. As to which class to favor and which to remove opinions are at variance just now. The old conservative school permitted the removal of the first or second class only, when either a more valuable kind was threatened to be overgrown and killed out by a less valuable, or when the latter had an abnormally spreading crown, overpowering more neighbors than it could possibly supplant in amount and quality of growth, or when malformed or diseased, or else when a growth showed too large a number of individuals developed equally, in which case the natural differentiation into dominant and overgrown takes too long a time to be accomplished naturally.

The new, more radical school argues that when the time for severer thinning has arrived the foremost trees should be utilized first, because they yield the most valuable material and the next two classes are thus given opportunity to develop still into superior material, which they will do under the increased light influence, and that with more profit than if the stoutest trees had been given further advantages.

In the opinion of the writer this question can not be decided for all cases alike, but species, age, and soil conditions may require one or the other principle to prevail.

In mixed growths it should especially not be overlooked that the

light-needing species (like ash, oak, pine, larch) must have much more light than the shade-enduring (like maple, beech, spruce, hemlock) in order to develop at all satisfactorily.

It may be of interest here to state that through the means of thinnings the product per acre in the same time may be increased from three to five times of what the result would be were the forest left to itself.

Enough has been stated in the foregoing remarks to give an idea of what the object and in general the methods of forestry management are. The owner of a small wood lot can apply it to his few acres as well as the lumber king owning thousands of acres; the private citizen and the town or county as well as the State may carry on forest management. Only, as shown before, where, as in extensive mountain regions, a very conservative policy is necessary in order not to disturb advantageous natural conditions of soil cover and water flow, and where on that account forest management becomes more difficult and less profitable, communal or State ownership will be preferable.

EUROPEAN GOVERNMENT FORESTRY.

Contrary to the ideas prevalent in the United States, European governments hold but a small fraction of the forest area and do not control, except in special cases and within certain limitations, the forest property held by private owners. In Germany less than one-third of the forest area is managed by the government, and 19 per cent owned by communities and corporate institutions is under more or less direct control (mostly advisory) of the government. Nearly one-half, therefore, is in private hands and beyond control.

Since, however, much of this private forest area has been held for centuries in large estates, its management is of a conservative kind, and being administered by trained foresters, is often as good and sometimes superior to the government management; the efficient officers of the government frequently aiding, with their counsel, the private owners. In the western provinces and southern states the farmer owns his wood lot in fee simple, just as the American farmer does, but having learned the value of keeping his wood lot in a continually paying and reproducing condition, he reaps from it as regular an income as from his other crops.

In *Austria* not more than 13 per cent of the forest area is under government administration. The sad and disastrous consequences which the reckless devastation and abuse of these mostly mountain forests by their private owners has brought upon whole communities adjoining have lately led to a more stringent and general supervision of the management of communal and private forests by the government than elsewhere. In *Switzerland*, since 1874, the federal government,

while owning but little over 4 per cent of the forest area, exercises supervision over the 66 per cent of communal forests. Private forests, when not classed as protective, are only prohibited from being cleared.

In *Italy*, where the government owns only 1.6 per cent of the forest area, a new law was passed in 1888 by which reforestation of the desert mountain lands is made obligatory, the government contributing three-fifths of the cost and expert advice, or else reserving the right to expropriate and reforest on its own account.

The law is drawn in a liberal spirit toward the owners, but with full recognition of the need and justice of restricting the foolish and willful exercise of their property rights, where this is bound to injure the community at large.

In *France* 10 per cent of the forests is held by the government, and 27 per cent owned by communities are under its control. Private property is only under supervision where special reasons can be shown that indiscriminate cutting is dangerous to the community. .

In *Spain*, which has perhaps suffered more from the effects of forest destruction than any other country, the state owns only 4.5 per cent, but controls the communal forests, representing 80 per cent, to some extent.

In the *Scandinavian* forests, 15 to 20 per cent of which are owned and managed by government, there is hardly any more forestry practiced than in Maine, where some owners restrict the cutting of trees to certain sizes.

The same may be said of *Russia*. The crown, however, owns about two-thirds of the forest and has begun some management. The private owners are entirely unrestricted, and cut their timber imprudently and improvidently, without regard to reproduction, and, as far as methods of using their forest property are concerned, stand about on a level with the American timber-land owner.

England has practically no forests of extent, only 3 to 6 per cent covered by plantations. Its equable climate and configuration have not made this deficiency felt, but public interest has lately been directed to the profitableness of forest growing on waste places and more attention is being paid to sylviculture. In India the government has established a full forest administration, which nets annually several million dollars.

ADMINISTRATIVE CONSIDERATIONS.

In carrying on forest management on a large scale and over extensive areas there is, as in every such business, need of a well-organized administration, which involves the organization of a service, the preparation of working plans, determining the manner in which the crop is to be harvested and disposed of, the expenditures for desirable roads, and other improvements, etc.

To give an insight as to what government forestry involves, a brief description may be of interest, especially as in several States, notably, in New York, and also for the United States timber lands, forest administrations are proposed.

As far as organization of a service is concerned, this must, of course, vary according to social conditions, and in a State administration, according to political methods; furthermore, according to the size and location of the forest areas and the intensity and thoroughness with which they can or are to be managed and many other local conditions.

Taking the Prussian forest department as an example of a first-class, tolerably intensive forest administration, we find it thoroughly systematized. Each province has a fully equipped separate administration, and all of these are under the general central direction at Berlin.

The latter is connected with the ministry of agriculture and consists of one director and four subdirectors, each acting for a definite section of the empire.

The director, with the advice of the subdirectors, determines the general policy and principles of administration, looks after the personnel and directly after the forest schools, and has practically the final decision on all matters that can not be settled by the provincial boards.

In each province there are two or three government seats, and at each seat there is a local direction, inspection, and control under one director, the over-forestmaster, with a number of forestmasters to assist him, each of these being charged with the inspection and control of the administration of a number of forest districts.

The latter, being forest areas ranging at from 5,000 to 30,000 acres in extent, are under the direct charge of the resident local managers (Oberfoerster), who are directly responsible for the execution of working plans and everything connected with the management of their district. Under their command there are a number of foresters, each in charge of a subdistrict, to act as guards and to superintend the work in the forest. This force is increased by guards temporarily employed and by numerous aspirants for positions, who are also temporarily employed as assistants.

All money transactions involving cash are carried on through the agents of the treasury department, upon the draft of the district manager with reference to the particular position provided in the working plans, so that no forest officer handles any money.

There exists also at the central direction a special bureau for revision of working plans.

In this way, for the forest property of about 6,000,000 acres belonging to the state of Prussia, there are employed, besides some clerks, etc., nearly 5,000 officers, namely, 5 directors, 125 supervising inspectors or controllers, 680 resident managers, and 4,000 foresters and guards, nearly 900 of this number having received a high technical education, the

total cost of this service being about $2,500,000, or 34 per cent of the total expenditure, and not more than 20 per cent of the gross receipts.

WORKING PLANS.

In making up working plans for a large forest area, considering the fact that the crop matures only in 60 to 150 years, more or less, it stands to reason that a general plan for the whole time of production and a special working plan from year to year is necessary. And in planning both technical and financial considerations must be consulted.

For a forest administration on a large scale, and especially for a state forest administration, the management should produce from year to year about the same amount of revenue and involve the same amount of expenditure.

Especially is it desirable, although technically by no means necessary, that neither less nor more wood be cut than grows annually, so that there is a continuous production of about the same amount forever.

To determine what that amount is requires a considerable knowledge of the conditions of the forest and the rapidity with which the annual wood growth accumulates.

As stated before, it is not wood, but wood of certain quality, and the largest amount at least expense per acre, that forest management is after. Now, the quality as well as the greatest quantity of wood is to be found in a tree of certain age, and while this age may vary for different kinds of trees and different localities, it is approximately determinable when it is most advantageous, alike for quality, quantity, and cost of production, to cut the tree or the forest. The time from the seedling stage to the mature tree ready for the ax is called the "rotation." If we say this pine forest is managed under a rotation of 100 years, it means that we allow each tract to grow to 100 years before we cut the trees, or that we expect to return for a new crop within 100 years to the same acre we have just cut. Now, if we desire to cut an even amount every year, say, for instance, one acre of 100-year-old pine, we would need to have 100 acres of pine, each acre differing in age by 1 year.

This would be an ideal or normal forest, in which we also suppose an equal annual normal accretion. In such a normal or ideal forest there must be at the outset a certain amount of wood standing, which is the stock upon which the yearly accretion accumulates, and may be called the normal stock or normal reserve. It consists, of course, of the sum total of wood on each acre from the 1-year-old to the 100-year-old, and its amount is readily figured out if we know the difference in amount of wood between each acre or the normal accretion per acre from year to year; for it is one-half this amount multiplied by the number of acres, or what is the same, the years of rotation. In our example, for instance, with a pine forest, which we work under a 100-year rotation, if we assume that there is an annual normal accretion of 50 cubic feet per

acre, the normal reserve would figure $100 \times 50 \div 2 = 2{,}500$ cubic feet per acre. This, then, is the average amount per acre which we should strive to keep in stock in order to insure an equal annual amount of growth or an equal annual cut.

In reality this ideal of course is never reached, but it serves as a guide in the working plans, and the conception is a most important and useful one.

Thus in bringing a mismanaged forest growth under management for continuity we may find the stock of reserves to be either above or below the normal, and hence we may either cut more or less than the normal accretion, until the reserves are brought down or up to or near the ideal.

The working plans must also include the propositions for improvement for new cultures on denuded areas, etc. One of the most important improvements is the construction of properly situated and well-kept roads or other means of transportation. In European forests the "road net," as a rationally disposed system of roads is called, is considered of prime importance. Accessibility to markets, easy, cheap, and permanent means of transportation furnish the keynote of profitable forest management.

The method of marketing the crop is another matter of administrative consideration. This can be done either by selling the crop on the stump or by shaping it and placing it on the market either in the woods or in the stores.

To the first method there is considerable objection for the reason that in cutting for reproduction there is need of careful handling of the timber, and it requires much undesirable supervision if private parties do the logging, while the administration, logging on its own account, can better control the manner in which it is done. In most European administrations the cutting is done by the administration; each log is measured and numbered and each cord is also numbered, and after public announcement the wood cut in a certain district is sold at auction by numbers to the highest bidder, lumbermen and other wood consumers having an equal chance.

The surveying and mapping and the districting, manner of employing labor, leasing privileges, etc., are other administrative matters.

This will be enough of the principles and detail of forest management to give an idea of what it is and what it involves.

PROFITABLENESS OF FOREST MANAGEMENT.

The question whether forest management is profitable can no more be answered in general than the question whether agriculture or any other business is profitable. It depends upon many conditions which differ in each case.

Broadly speaking, when we consider that the forest occupies or ought to occupy ground that is not good for anything else, that after being

started it grows without involving work, except such as yields valuable material, it will be conceded that the small exertion necessary to prevent the soil from being laid waste or occupied by inferior brush must be well repaid.

There are examples enough to be found in the United States where even forest planting in a small way has proved profitable; forest management on a large scale does not as yet exist.

To show what the financial results of management on a large scale are abroad, it may be of interest to add a few illustrative statistics, and it will be especially noteworthy in these what wide differences in expenditures and results there are to be found over so small a territory. These differences are due to differences of market facilities and intensity of management and also to forest conditions.

Countries.	Forest area.	Total expenditure.	Revenue.		Expenditures and revenues per acre of forest.							
			Gross.	Net.	Expenditures.							Net revenue.
					Total.	Per cent of gross income.	Administration and protection.	Marketing crop.	Cultivation.	Roads.		
	Acres.											
Prussia	6,000,000	$8,000,000	$14,000,000	$6,000,000	$1.33	58	$0.48	$0.30	$0.14	$0.06	$0.96	
Bavaria	2,300,000	3,150,000	5,880,000	2,730,000	1.37	53	.64	.37	.11	.11	1.19	
Würtemberg	470,000	1,025,000	2,260,000	1,235,000	2.17	45	.87	.92	.22	.33	2.63	
Saxony	416,000	1,040,000	2,750,000	1,710,500	2.50	37	.65	.81	.11	.21	4.11	
Baden	235,000	404,000	1,050,000	686,000	1.54	40	.22	.83	.15	.12	2.90	
City of Zurich	2,760	14,000	26,000	12,000	5.00	54	1.14	2.10	.16	1.14	4.40	

In fourteen state forest administrations of Germany, covering 10,000,000 acres, the cut during 10 years was 55 solid cubic feet per acre per year, of which 27 per cent, or about 15 cubic feet, was lumber-wood, equal to about 120 feet board measure.

Figured on such basis of 55 cubic feet of normal annual accretion and a rotation of 80 to 100 years, the total normal wood reserves on these state forest lands would be in round numbers 24,750,000,000 cubic feet, worth, at 5 cents per foot, the average stumpage value, $1,250,000,000. The net income from these lands averages $31,500,000, namely, $29,000,000 for wood and $2,500,000 for other uses, or $3.15 per acre, or only 2½ per cent on the value of the wood reserves figured at $125 per acre. From this it will be seen that a considerable amount of capital is tied up in the wood reserves and brings only a moderate income. On such a large area, to be sure, there are many parts that produce but little and which depress the general results, areas which are managed for cultural and economic reasons and for the protection of watersheds, but which do not produce such revenues as would tempt the majority of private men, and hence the more reason for state ownership of these.

That, however, it is more profitable than otherwise to the farmer to keep his wood lot in fair producing condition, and to the timber-land owner to avoid all wasteful use of his property which prevents natural reforestation must be as patent as that a herd of cattle producing calves is more profitable than one which is barren.

[There followed in the original address, of which this paper forms a part, a discussion of the problem now before the State of New York of reserving the Adirondack forest lands as a State domain.

The proper organization, involving an expenditure of $400,000, or 18 cents per acre as against 48 to 87 cents in German states, and the net financial results were stated. It was shown that the stumpage of the 2,500,000 acres to be reserved would be worth now $25,000,000, and that an annual net income above expenses of administration and improvements of over $1,000,000 should result from a conservative management.]

III. FOREST PLANTING IN A TREELESS COUNTRY.

To see the prairie and the plains is to know their needs. To travel over them, even for a day, will make you feel their greatest want—the want of trees. Wind swept every day, every hour, the comparative calm which even a single row of trees creates affords relief from the perpetual activity of the air beyond the influence of the wind break. Man, beast, and plant are constantly being dried out; evaporation can hardly keep the thirsty, ever-moving atmosphere supplied with moisture, and many a rain only touches the ground to be at once evaporated and returned to the clouds.

The "treelessness" of the central plains has been explained by the deficient rainfall and consequent arid conditions of these localities, and until lately it has been doubted, and even now there are people who doubt the possibility of growing trees and forests in those localities without irrigation.

For a large part of this region I do not share these doubts, nor do I believe that original aridity alone accounts for the condition in which we find this large region at present. As everything in nature is the result of a complication of conditions, so we may not dismiss such a phenomenon as a forestless area of several thousand square miles with the simple explanation that it was too dry for tree growth. The fact that this area is not absolutely treeless goes far to support the proposition that it was not always forestless; and the mining of pine timber out of the sand hills of Nebraska proves the proposition beyond doubt for that section at least.

It is not the speculation of mere curiosity to inquire into the causes of the absence of forests in this region; it is a practical question; for if we understand the causes which produced the present conditions we gain an insight into the possibilities of remedying them; we may learn whether nature decreed that this area shall forever be exposed to the heating of the sun and sweeping of the winds or whether we may reasonably expect to cover its nakedness, and what are the difficulties in the way; we shall have a basis for our methods in the attempt to reclothe these areas with forest growth.

The entire earth may be said to be a potential forest. That is to say, if the interference of animal life and man were excluded in the struggle for existence among the different forms of vegetable life, wherever sufficient depth for its roots exists and winter cold does not preclude

it, arborescent growth would ultimately prevail on account of the perennial character of this kind of vegetable life and its power to shade out the lower vegetation. In a large part of the world this victory is seen to be attained in a few years, or at least in a lifetime. In other parts it may take geological ages to establish the arborescent growth against the lower vegetation and against unfavorable climatic conditions. Such are mainly the interiors of large continents and those localities which, for cosmic and orographic reasons, have a climate unfavorable to vegetation in general. This unfavorableness, as a rule, is mainly to be found in moisture conditions—not necessarily deficient rainfall, but an unfavorable balance between the factors of conservation and of dissipation of moisture. In such localities the progress of the forest growth contending for supremacy must be a gradual advance from the more favored border land, but the extension of its area, if not interfered with by man and beast, though slow, is as certain as in the more favored localities, where it proceeds rapidly.

It is conceivable, then, that while admitting the unfavorable rainfall and moisture conditions in parts of this region as a potent cause in making forest extension difficult, this extension would yet have taken place if fire and the tramp and browsing of buffaloes had not prevented it; or, since the scattered tree growth found on this area suggests that forest growth once existed, it would now exist if fires had not destroyed much of it, thus disturbing the conditions which were favorable to the conservation of the scanty moisture, reforestation being prevented by continued fires and countless herds of browsing and soil compacting buffalo.

Where, during the months of vegetation, May to August, the relative humidity of the air sinks as low as 50 per cent and the rainfall is less than 2 inches, it may be questioned whether tree growth could maintain itself before the conditions of the surrounding country have been in a measure modified; or unless we may be able to find and introduce species not native, which, like some of the desert trees, the tamarisk, for instance, can exist for several years without rainfall.

There is a very peculiar and intimate connection between vegetation (especially forest vegetation) and climatic conditions. Most naturalists will tell you that vegetation depends upon climate. So it does; but there is also a reaction of vegetation upon climatic conditions, and this truth is strikingly expressed by the poet, who speaks of "Africa's arid sands, where nothing grows because it does not rain, and where it does not rain because there nothing grows." This sounds like a paradox, and yet it is true; there is such a relation between the forest cover which shades the ground, and the changed temperature and water conditions of soil and air under its cover, as to favor its own development, so that we can say "the forest creates its own favorable conditions of growth." But it is not the single tree that has such an effect, nor a few scattered trees; it is by effective shading of the ground that the

change of conditions under the forest cover is brought about, it is by masses of trees that the sun's power is broken, and it is by large areas distributed over the vast expanse that ultimately the force of the winds will be broken.

I can not too strongly impress you with this idea, that it is a mass effect which we expect from the forest cover. Not only will our plantation be more successful if we start it with this idea fully before us, that it must create "its own favorable conditions of growth" and soon become selfsupporting, but its effects upon the surroundings will be more readily felt the denser, the larger it is, and the closer the neighboring plantations which add to the general effect. Where the single tree perishes the forest may live; here, too, "in union is strength."

FOREST COVER AND MOISTURE.

For a large part of this now almost treeless area moisture conditions will not necessarily be a check to tree growth.

We know by experience that a naked soil loses by evaporation more than six times the amount of moisture that it would under the shade of a forest cover. Hence, if we have once established a proper forest cover, if we have succeeded in effectively shading the ground by either the foliage of the trees or the litter and mulch of the decayed leaves, and a check to the sweep of the winds, the amount of water available for the tree growth is increased in proportion. What we must never lose sight of is the fact that evaporation is the great dissipator of moisture, and that a dense shady forest growth reduces this evaporation.

I must stop long enough to point out what evaporation means to the arid or subarid, or, shall I say in deference to my friends who do not want to be regarded as quite dry, subhumid regions. If we compare the rainfall during the season of vegetation in eastern and western stations, it appears that there is not much deficiency, if any, during that season on our western plains, and quite sufficient if evaporation were not such a rapacious robber. This enormous amount of evaporation is not alone due to heat and direct insolation, but mainly to the constant movement of the air, the incessant winds which take up and disperse the moisture.

From the interesting experiments recorded in the annals of the Weather Bureau the dependence of the rate of evaporation on the velocity of the wind has been established. With the air at a temperature of 84 degrees and a relative humidity at 50 per cent the evaporation under a wind of 5 miles an hour will be 2.2 times as rapid as in the calm air, at 10 miles 3.8 times, at 15 miles 4.9 times, at 20 miles 5.7 times, and with a wind at 25 miles velocity the rate of evaporation will be 6.1 times as great as in the calm air. And as the average velocity of the wind on the plains may be set down as 12 miles an hour, there is probably at least four times as much water evaporated and

dissipated as where the winds are checked. Hence the value of the windbreak which reduces both the evaporation from the soil and the transpiration from the plant, for transpiration is also accelerated by the motion of the plant under the influence of wind.

The hot winds, which are equally as characteristic of this forestless region as the blizzards, sap the moisture out of the soil as well as out of plant, beast, and man, for both are dry. It is summer drought as well as winter drought that we have here to contend with; and since at least the hot winds have been proved to originate within this very region (see a very full paper on the "Hot Winds of the Plains," by George E. Curtis, Kansas State Board of Agriculture, report 1890) and are undoubtedly due to its nakedness, we come to the conclusion that forest cover will not only check the sweep of these winds and thereby the excessive evaporation, but the very cause of these winds may eventually be wiped out.

What do we learn from these considerations to help us in forest-planting on the plains? Plainly at least these two propositions:

(1) That forest plantations in large blocks have more chance of success than small clumps of single trees, since large plantations alone are capable of becoming self-sustaining and of improving their conditions of growth by their own influence upon moisture conditions of the soil and air.

(2) That we must not only plant densely—much more densely than is the common practice—but in the selection of kinds give predominance to such as are capable of quickly and persistently shading the ground, creating an undergrowth and cover that will prevent evaporation and thus make the planting of the light-foliaged, quick-growing valuable timbers possible.

NEED OF COÖPERATIVE ACTION.

I can not here refrain from expressing my sympathy for those in the front, who struggle to conquer single-handed these vast and fertile but climatically ill-favored regions. While their reclamation certainly does not appear to me an impossible undertaking, it seems almost hopeless to expect it from the pygmy efforts of the pioneer settler, lost almost in this endless treelessness.

Without means, without knowledge, without a systematic organization, without a well-conceived and methodically executed plan, without coöperative effort in close battle front, victory, if attainable, must be bought by many repulses, disappointments, failures, and even those that might gain a firm foothold may in the end succumb, because their neighbors failed to support their flanks.

I believe that forest-planting is one of the necessary requisites to permanently reclaiming this vast domain; I believe that reforesting this large area, deforested by fire, buffalo, and consequent desiccation, is not impossible. But I also believe that success can be forced only

by coöperation, by a well-conducted army, attacking the enemy under a comprehensive plan, systematically and methodically carried out by generalship, commanding knowledge, means, and power, such as a government alone, be it State or General Government, can command. The present plan of allowing the skirmishers to waste their energy, their lives, is cruelty and bad generalship.

HOW TO PLANT.

Volumes might be written on the proper methods of forest-planting on the plains. I shall confine myself to only one chapter, and of this give only the merest synopsis, namely, the one on the selection of species for planting, with reference to the preservation of soil humidity. For in this chapter we learn the difference between tree-planting and forest-planting, a difference which I fear has not found much consideration by nurseyman and planters.

To establish forest conditions must be the first aim of the forest planter.

Forest conditions, as we find them in the natural forest, consist in dense growth, mixed growth, undergrowth. By so much as any one of these conditions is deficient or lacking, by so much is the forest short of the ideal. Reduced evaporation is forest condition. Shade reduces evaporation. Dense growth furnishes not only straight clear timber, but shade. Mixed growth alone can preserve a continuous shade for a long time. Undergrowth assists in keeping the ground shaded.

The forest planter, then, may learn a lesson from nature in recognizing these conditions as desirable ones and worthy of imitation; but he will also not forget that man is wiser for human ends than nature; that he works with an object which nature does not recognize; that he must intelligently improve on nature's methods to reach his own end, which is the economical production of material or conditions. The value of time, which is no factor in nature's calculations; the value of land, of which nature has an abundance, make it necessary for man to intensify his methods. Thus he will reduce the dense growth from the maximum of nature's planting to the "optimum" (most favorable) of most rapid and plentiful production; he will substitute for the chance mixture of species, which in the natural forest is the result of a free fight for existence among the different occupants of the ground, a combination which is chosen with intelligence and to produce the most desirable results in the shortest time.

In this selection from among the species which are capable of thriving in this locality and soil, and which are yielding the most desirable material, three points must guide the planter:

(1) Their relative capacity for preserving and increasing favorable conditions;

(2) Their relative dependence for development on light and shade;

(3) Their relative rate of height growth.

The first point is possessed in the highest degree by the evergreens and by those deciduous trees which have a dense foliage and preserve it dense through all time. There are not many of these latter, for a large number which in their younger years have a full foliage thin out with increasing age. Besides, by the suppression of the lower branches, which are not capable of living under the shade of the crown, the latter is removed farther and farther from the soil, and lateral crowding also kills out many individuals; so that with all this, sooner or later (according to species and soil conditions), the crown cover is more or less broken, and weed growth, rapid humification of the litter, and increased evaporation is the consequence; *e. g.*, all the cottonwood plantations outside of the wet bottoms. The same deterioration of the soil will be noticed under the ash and the black walnut, which thin out rapidly. Soil conditions will, to be sure, modify this capacity of retaining a dense foliage, and on a fresh deep soil even the thinly-foliaged trees will carry a fuller crown.

It is a matter of observation that as a rule the trees which preserve a full dense crown are the ones which are capable of thriving under shade, or at least with less light than the thinly-foliaged ones; thus, a yew, a spruce, a box elder, a beech, will thrive under shade where a pine, a birch, or a locust can hardly exist. There are some exceptions, and some of the thinly-foliaged trees, like the oak, can vegetate though not thrive under the shade of some "foregrown" tree. In fact, one may, according to the different degree of light which is necessary for a thrifty development, range the species so that those at the top of the scale may be called light-needing and those toward the bottom shade-enduring.

I do not want to be understood that any of our forest trees thrive better for being shaded. Excepting in their earliest stages, when protection against heat and cold, rapid evaporation and transpiration, is needed by some, they all grow best in full enjoyment of sunlight; in fact, the rapidity of their development is proportionate to the amount of foliage which is at work, and this again depends upon the amount of sunlight at its disposal. But some can get along with less sunlight; they can endure without much detriment a more or less dense shade for a longer or shorter period, while others, under the influence of their own crown even, thin out soon, and, if shaded by neighbors, are arrested in their growth and killed sooner or later. The time when the influence of light conditions is most potent varies with different species and according to the site, so that, for instance, on a rich, moist soil a light-needing species like the birch will endure for a long time considerable shade, which on a poorer soil would have proved detrimental.

As a rule you will not find among the undergrowth of our forests any species that is a light-needing one. Hence culling any of our

thinly-foliaged light-needing trees, such as the white oak or tulip tree, means killing it out, since it can not reproduce itself and thrive in the shade of its foregrown companions.

It is evident that favorable soil conditions can be preserved only by a persistent close crown cover, such as the leafy species furnish. It is, however, not necessary that the crowns should all be on the same level, all of one story, so to speak; on the contrary, a denser cover can be secured if individual trees or groups of varying heights are placed together. Here, then, comes in the consideration of the relative rate of height growth. And it is an important one when we select a mixture or combination, for if we were to place together on an equal footing a light-needing with a shade-enduring kind, of which the latter is a more rapid grower, the former would soon be killed out. Now, as a rule, the light-needing species—but by no means all—are at first more rapid growers in height than the shade enduring; but what they gain in initial rapidity they lose in persistency; that is to say, they do not grow to as great a height as the leafy kinds, or at least after the first period of rapid growth they grow only slowly.

Each species has its characteristic curve of height growth, characteristic especially in regard to the beginning of rapid ascent, to the position of the points at which the rates of growth change and to the point of culmination. This curve is, of course, modified for each species, according to the site upon which it grows. But as it is possible to construct a scale in which the various species can be ranged according to their relative capacity of shade endurance, so for given conditions and periods of growth they can be ranged in regard to their relative rate of height growth. In this way I have, for instance, ranged twelve kinds that are used in prairie planting according to their shade endurance and their rate of height growth during their youth:

As to shade.	*As to rate of height growth.*
1. Box elder.	1. Cottonwood.
2. Mulberry (?).	2. Soft maple.
3. Elm.	3. Elm.
4. Black cherry.	4. Locust.
5. Osage orange.	5. Honey locust.
6. Catalpa.	6. Black cherry.
7. Soft maple.	7. Catalpa.
8. Locust.	8. Osage orange.
9. Honey locust.	9. Box elder.
10. Black walnut.	10. Black walnut.
11. Ash.	11. Ash.
12. Cottonwood.	12. Mulberry (?).

This is not an immutable scale, but only a tentative proposition, and for the purpose of illustration in which the kinds placed widely apart will alone really retain their relative positions. We will find at the top of the first scale the most shade-enduring and at the head of the second

scale the most rapid growers among those named. If we can make, therefore, a combination of these, we will succeed in obtaining the two points to be gained, the densest crown cover in varying tiers, and the light-needing kinds overgrowing the shade-enduring, which allows the largest number of individuals on the area.

I must once more caution you against accepting the above scale as definitely correct. Many conditions of soil and climate modify the behavior of trees. For instance, the black walnut has a tolerably dense foliage when quite young, but except on rich bottom lands it thins out very soon, and, since it leaves out late in the season and loses its foliage early in the fall, it must be considered as one of those which do not furnish desirable shade conditions. In regard to its height growth, too, it may vary; but, as far as my observations go, while it shoots up rapidly at first in the prairie, it almost stops growing when 12 or 15 years old. On the whole we must study the behavior of our trees still further before we can speak with assurance as to the best selection and combination. But we can formulate the principles upon which proper selection and combination rests, and having then concluded never to plant one kind by itself—which is the unfortunate practice in most prairie planting—nor to plant several species in combination without knowing why they should be combined, we can lay down the following rules for making the selection:

HOW TO MIX.

Rule 1.—The main growth, *i. e.*, the one that occupies the larger part of the ground, must be of a kind that improves soil conditions, namely, a densely foliaged, shade-enduring kind, which does not lose its shading capacity with age.

Rule 2.—Densely foliaged kinds may be grouped together, if the slow grower will endure the shade of the rapid grower, or can be protected against its supremacy by being planted in larger specimens, or in advance of the former, or in larger numbers, or if its gradual killing out after it has served its function of soil cover is not objected to.

Rule 3.—Thinly foliaged kinds should never be grouped together where soil humidity is to be preserved, unless no leafy tree can be found to fit the locality.

Rule 4.—In grouping light needing with shade-enduring kinds, the former must be more rapid growers or must otherwise be given an advantage.

Rule 5.—The mixing in of the thinly foliaged trees is preferably done singly and not in groups, unless special soil conditions necessitate the latter method.

With such rules and considerations in mind, the proper practice in prairie planting is indicated.

The first and main object to be attained there is to create a soil cover. In Russia, under very similar conditions to those of our prairies, it has

become the practice to first plant a shrub of little or no value—a low willow (*Salix pruinosa*)—as a first soil cover or undergrowth into which the desirable forest trees are planted afterwards. As this can be done only by hand labor, it is not a suitable practice for our conditions. We might use the common bullberry (*Shepherdia argentea*) for such an undershrub, or the sand plum, which I know has done good service as undergrowth. But we have in the box elder, or Russian mulberry, or Osage orange (objectionable on account of thorns) sufficiently hardy and shady kinds, and not entirely devoid of value for their wood, that can be used for the purpose. Of these not less than 6,000 to 8,000 plants should be set to the acre, making rows 3 feet apart and 2 feet in the row; even 10,000 would not be too many, for rapid shading of the ground from the influence of the sun and wind is the key to success.

Any more valuable timber that is to be planted must be as fast a grower as or faster than the underwood and can be introduced at the same time, setting the plants in the same rows at the ratio of not more than 200 to 300, or every 12 to 15 feet, alternating in the rows. For this planting the very best rooted stock should be chosen: Black locust, honey locust, catalpa, and the oaks, and special care taken in planting it. In deeper, specially favorable situations, the black walnut would answer for this selection. The black cherry also promises to be a most valuable addition. Of course a great many variations may be suggested.

CONIFERS.

Of all trees, the most suitable for prairie planting and for planting in the dry plains are beyond doubt the conifers, and especially the pines.

There are two reasons why they should be chosen preferably to others. First of all, they furnish not only a denser cover, lateral and vertical, but a cover all the year around, being evergreen. Secondly, they require less water, from one-sixth to one-tenth of what most deciduous trees transpire, and are, therefore, less liable to succumb to drought. In winter they will hold the snow more efficiently than the naked, leafless kind, thus preserving the moisture on the ground.

Nature has given us indications in that direction. The driest soils everywhere are occupied by the pines, and the arid slopes of the Rocky Mountains and the interior basin support only conifers, especially pines and juniper. From Professor Bessey I learned only to-day that my theory regarding the former forest cover of the plains is borne out by the discovery of pine forests buried in the sand hills of northern Nebraska, and that he found the same kind of pine naturally growing in eastern Nebraska, which covers the Black Hills and Rocky Mountain slopes, namely, the bull pine (*Pinus ponderosa*).

I am also assured that in artificial plantings, after the pines are once established, they rarely succumb to the severities of climate in Nebraska; and I have certainly seen young seedlings of the bull pine thrive

most wonderfully in a dense growth of weeds and grass at Franklin, Nebraska, where Mr. C. S. Harrison is the pioneer of conifer growers.

The difficulty in their use lies in starting the plants; for as little seedlings they are remarkably tender, especially as regards light conditions. Under strong light their foliage transpires more moisture than their roots can supply. On the other hand, if left in the nursery until they have developed the strong root system they need, difficulty in transplanting is experienced, and the greatest pains must be taken not only to preserve the roots uninjured, but to bring them into the ground before they have a chance of drying out.

Yet I believe all pains in this respect will be crowned by success, and if I were to direct planting in Nebraska I should use largely the bull, the Scotch, and the Austrian pines, with the Douglas spruce, and for undergrowth the hardy and shady juniper; the Scotch and the Austrian pines mainly because they can be had more cheaply than the others, and because so far they have been tried the longest with assured success. This list may no doubt be extended to others (such as given in the foot-note below.)*

OTHER CONSIDERATIONS.

Besides the capacity of shading the ground effectively and of developing satisfactorily in mixture, other considerations which should influence the selection of plant material are adaptability of the plants to climate and to soil, root system, ease of propagation, utility, etc.

The first two considerations, namely, the possibility of the plant to live in the situation in which it is placed, are matters of course.

As far as climatic adaptation is concerned, nothing but trial will answer the question. Since we found that the bald cypress, which occurs naturally in the swamps of the humid Gulf States, was the only class of seedlings that withstood the drought of a Texas summer two years ago, and since we are informed that the bull pine, which covers our most arid plateaus and mountains, suffers from drought in Germany, and the hardy green ash from frost, we may admit at once that we know but little as to climatic adaptation, and trying is our only method of determining.

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*At the present writing an experimental planting with ten kinds of evergreens and six kinds of deciduous trees in varying combinations has been undertaken under direction of the forestry division in Holt County, Nebraska, on the sand hills of that region. The evergreens used are: Bull, Banksian, red, white, Scotch, and Austrian pine, Engleman and blue spruce, Douglas fir and arborvitæ. With these are mixed the following deciduous trees: Locust, box elder, cherry, birch, hackberry, and red oak.

There are planted four plats of different mixtures and distances, with from 6,200 to 10,830 plants per acre, the wider planting to be cultivated, the closer to be partly mulched, partly left to itself for the sake of comparing the three methods under exactly like conditions. The planting (in the loose sand with good supply of subsoil moisture) was done in furrows without previous preparation of the soil. Planting with the spade or other tool without any plowing would also have been tried had time and opportunity been favorable.

This much, however, may be maintained, that seeds procured from driest and coolest localities in the range of the species promise seedlings of greater hardiness than those from the more humid and warmer climates.

We need in our treeless regions several arboreta for trials, carefully conducted, of adaptation of new kinds.

The list of trees which have been tried and found capable of more or less extended use is already quite considerable and includes the following: Of conifers, white cedar, white, red, Scotch, Austrian, and bull pine, Douglas spruce, and farther south red cedar and bald cypress. Of deciduous trees the hardiest seem to be white and green ash, white elm, white and yellow birch, box elder, soft maple, basswood, besides the cottonwoods, Lombardy poplar, and white willow; and as we go southward the choice increases with black locust, catalpa, mulberry, black cherry, walnut, some oaks, chestnut, with the further addition of honey locust, Osage orange, pecan, and lastly acacias and eucalyptus in the extreme southwestern latitudes.

As regards adaptability to soil, we need consider only the physical conditions of the soil, for forest trees require such small amounts ot mineral matter that it is questionable whether a soil could be found that does not contain in sufficiency those that seem necessary.

Of physical conditions, it is especially the depth, the grain, and moisture that determines adaptability of kinds. While we may say that all trees will grow best on any soil which is deep (that is, where no impenetrable layer of rock or hardpan or soil water is to be found within, say, 3 to 6 feet of the surface), of medium grain (not so compact that water and roots can not easily penetrate, nor so loose or coarse-grained that it can not hold water), and with an even, continuous supply of water, there are some trees which can thrive under less favorable conditions.

This adaptation is probably due to the development of the root system of these trees, but at the same time no doubt to the amount of water required by the foliage to satisfy transpiration.

For planting in the dry regions no doubt those kinds recommend themselves which develop naturally a vigorous root system into the depth, because this enables them to utilize the percolating moisture through a longer space of time and over a larger area. The black locust and catalpa, black cherry, the oaks and maples, and the pines, with a number of other conifers, have such root systems as to insure success where more shallow-rooted kinds would fail.

It would lengthen this paper beyond the bounds of the present intention were I to attempt to discuss in detail the merits and demerits of those species which have proved themselves so far adapted to use in these regions, and still further of the many which still await trial. Suffice it to admit that this chapter needs still much more material, derived from experiment and experience, before we can finish it.

METHODS OF PLANTING.

One word as to the method of planting. I do not think that we have by any means found the best, cheapest, and surest way of planting, and experiment in that direction also would pay. The well-recommended method of breaking the sod in June and plowing thoroughly in the fall for planting in the following spring is open to several objections, among which not the least is the time and expense of this cultivation.

I should propose, for trial, to sim ply break the sod in June and sow millet or oats thickly to make a close stand; this will secure a return for the labor of breaking. The millet should be cut with a high stubble, which may be expected to catch the winter snow, keep down weed growth, and act as a mulching the next season.

Plant next spring, as early as possible, in trenches, without disturbing the ground between trenches, and most likely cultivation will not be necessary the first season, while the second season, with our dense planting, the trees should be able to help themselves. In this manner I would expect to reduce the work, and also to reduce evaporation and to secure the maximum of moisture in the trenches, where it is most needed.

Let it not be overlooked that there is this difference between a tree crop and an agricultural crop: The latter we want to stimulate as much as we can to produce the utmost in one season, while the former we only want to establish. Thorough cultivation no doubt does this effectively, but is it the best and the only method?

It also stands to reason that what is best to do under one set of conditions is not so under another set. While in the sand-hill region of Nebraska, with a moist substratum at 6 to 12 inches, we had much better leave the ground undisturbed for the reason that it has the tendency to blow out, and on the other hand its capillary conductivity is such as not to favor evaporation from below, a heavy loam, which is apt to bake, shutting itself against ready percolation of water from above and conducting the subterranean supplies to the surface and dissipating them, necessitates some method to keep its granular structure more favorable, either by cultivating or, much better, by mulching.

Certainly systematic experiments in the method of forest-planting are now at least as much needed as in the selection of trees.

The mechanical tree-planter, of which I exhibit an illustration, has proved that you can go even on the raw prairie and start a successful plantation by setting the trees in trenches, leaving the rest of the ground undisturbed, the precipitation draining into the trenches.

I do not wish to conclude without suggesting some practical application of my remarks which it would be well for such a body as your State board to consider.

If I am right in believing the establishment of forest belts in your State an indispensable aid to permanently successful agriculture; if I am right in assuming private efforts in this direction unavailing or at least accompanied by much waste of energy and time; if the climatic amelioration which comes from a systematic disposal of such forest areas is a matter which concerns the general welfare of your State, then I contend that it must be a work of internal improvement which it is the duty and function of the State to undertake.

It may not be the present policy of the State of Nebraska to look after the needs of internal improvement—even the United States does but little in that direction,—but the time is not far distant when we shall have a higher conception of the functions of the State than to consider it merely a policeman; when the State, the coöperative association of all citizens, will do whatever is desirable for the general welfare, and what, if left to private enterprise, is not done, because impossible for the single individual, or directly unprofitable, or leading to undesirable monopolies.

Forest planting for climatic amelioration in Nebraska will eventually be one of those public works, and your State board could even now do nothing better for forestry than to formulate and advocate a plan for public forest planting. Such work, such State action I do not conceive to be carried out on the "paternal" plan, although even this would be better than the present inactivity, but it can be carried out on purely business principles. After the general plan has been elaborated, let each county by a commission of competent men designate the areas that ought to be put into forest, and the areas should be as far as possible nonagricultural, the poorest soils. Let the State exercise its right of eminent domain and withdraw such lands temporarily from the ownership of the individual for purposes of public utility and transfer it to the county, the latter taxing itself for the interest and funding on this expenditure as also on the expenditures by the State for planting, etc.

Where the county is still too thinly settled to sustain such a charge, the State may well distribute the interest and funding charges in such a manner that they are made proportionate to increasing population.

Let the State by its own officers, under direction of the State board or other control, or else by contract with private parties, establish an efficient forest cover. The State can command the necessary funds probably at 5 or 6 per cent, while the private individual must pay from 10 to 20 per cent; the State engaged in this enterprise on a large scale, can also do the planting, etc., more cheaply and more efficiently.

After 10 or 15 years, when the plantations have become self-supporting and begin to yield valuable material, the former owner of the land or his successor may be given opportunity of reclaiming his property by repaying price received for the land with interest and cost of plantation less share of the taxes paid toward the forest improvement fund; submitting, however, in the use of the forest growth to such regulations as seem necessary to insure continued value as a cover.

By some such plan, in which I can not see anything impracticable, the advantages of coöperation and State credit are secured, and yet those who are directly benefited have paid for it; at the lowest rate, however.

What I have seen of the enterprising spirit in your State, and especially what I have heard of the management of your board this afternoon, has inspired me with the belief that it is not chimerical to expect action of this kind from your public spirit.

IV. EXPERIENCES IN TREE PLANTING ON DAKOTA PLAINS.

[The two communications which are here appended were received from two correspondents of the division, who have had some experience in tree planting on the prairies of Dakota. While it will be found that some of their statements and deductions are not, at least in their general application, in harmony with the preceding representations, they are nevertheless given in full just as they were written, and will be found interesting as giving brief and, on the whole, safe detailed directions which may well supplement the preceding general considerations.]

1. TREE CULTURE ON THE WESTERN PLAINS.

By A. M. THOMSON.

I am asked to give the results of my observation and experience in tree culture during a residence of 6 years in North Dakota. I assume that what the Department wants is such knowledge of practical experiments made on the ground as will aid the settler on these wind-swept prairies in starting and maintaining a grove of trees that will afford him protection in winter, and ultimately fuel and timber for domestic purposes.

While scientific men are seeking for the causes that prevented the natural growth of timber on the barren plains of the West, the hardy pioneer who has gone there with his family to stay and to help on the development of the country and the stability of the Government by making a home is much more interested in the important question, "How can I raise trees to supply my wants?" Any man who can state a single fact which will throw a ray of light on the general subject will confer a lasting benefit upon tens of thousands of farmers beyond the Mississippi River who have been trying for years to solve this problem without any satisfactory results thus far.

THE TREE-CULTURE LAW.

It is an open secret that the tree-culture act, now repealed, has almost totally failed to meet the expectations of its authors; that not one claimant in a hundred in the two Dakotas, and the remark will hold good equally well when applied to other Western States, has ever succeeded in raising trees, and that it has simply been made the convenient and lawful cover for speculation in government lands by both residents and nonresidents. Both the law and the speculator were to blame for this result.

The Government offered the settler 160 acres of land for doing precisely what any thrifty man on the prairies would naturally do on his own motion, though perhaps on a smaller scale, the cultivation of a grove of trees for shade, shelter, ornament, and use; but the defects of the law are so numerous that the liberality and good intentions of Congress have utterly failed to accomplish any good result.

Only one quarter section can be entered as a tree claim on each section, leaving the three other settlers on the three remaining quarters without any chance to be benefited by the law and having no stimulus to raise trees beyond what their own necessities suggest. The first man at the land office gets the chance of the Government's liberal offer, and those who come after him get nothing. It would have been infinitely better for all concerned if the Congressional gift had been smaller in size and extended in some way to every man who settled on the public domain. To properly plant and cultivate 10 acres of trees has been found to be an undertaking that has cost the farmer more than any other method yet invented to acquire 160 acres of Government land. The reasons will appear further along in this paper. The number of acres ought to be limited to 5 and the farmer ought to have been allowed to start his trees in the nursery, and cultivate them there until 2 or 3 years old before setting them out in the grove, and the time that they were growing in the nursery ought to have been allowed to count the same as if grown on the claim. No non-resident ought to be allowed to enter a tree claim. He has used it in this way: A, in Ohio or Vermont, enters a tree claim in North Dakota. He breaks 5 acres the first year, according to law, crops it the second, but does not plant it the third, because in the 2 years that he has had a filing upon it, it has advanced so rapidly in price that B, of New York or Indiana, offers him a round sum for his relinquishment, and he accordingly relinquishes his right to the claim and B files upon it. B does not begin where A left off, but treats the entry as an original purchase and has 8 years in which to break, sow, plant, and raise trees, the same as if A had never seen it. At the end of 2 years B finds himself with the same opportunity for selling out that A struck, and he sells out to C, and he obtains possession by the purchase of B's relinquishment. Four years have already elapsed since the first entry was made by A and not a seed has been planted. Nor was it the intention of either A or B to raise trees at any time. They dickered in the land for the sole purpose of gain, and they merely took advantage of the loopholes in the law.

Those who unfortunately can not sell their claims before they are required by law to plant with seeds, cuttings, or trees adopt the shortest and cheapest method of complying with the letter of the law without regard to its spirit. One man came to me in November to borrow money and offered the relinquishment of his tree claim as security for the loan. When asked if he had strictly complied with the requirements of the law as to tree claims he said he had; that he had plowed 5 acres the first year, cultivated a crop upon it the second year, and had planted it with seeds the third. Being questioned more closely he admitted that the tree seeds were sowed broadcast with an oat crop and that he had not seen the land since the oats were harvested. He did not know whether there was a tree on his claim or not, but he had planted 5 acres of seeds as the law required, and could no doubt have obtained witnesses of the fact of other tree claimants around him who had dodged the law themselves in a similar manner. A large majority of the settlers in some localities are in the same boat, and they stand by each other. They are not intending to raise trees, but to hold the land until they can sell out to advantage. Many of the first filings on tree claims are sold to newcomers, who enter them as homesteads or preëmptions.

In Dakota, before the admission of the two States, the Territorial legislature made an honest effort to supplement the act of Congress to encourage the growing of trees, and passed a law exempting from taxation $1,000 worth of property from the assessment of any farmer who would plant and cultivate a certain amount of ground in trees on his homestead. Some settlers have availed themselves of the privileges of the law, and in the course of time it may stimulate landowners generally to plant trees.

The man who removes from any of the Eastern States or Canada to the treeless plains of Dakota and imagines that it is an easy matter to raise trees will be very much disappointed and perhaps disheartened before he cuts his own firewood or fences his fields with posts grown under his own eye. Nothing turns out as he anticipates. His experience in Ohio, Pennsylvania, or Wisconsin goes for naught. There is something in the soil or in the climate or in both combined that seems adverse to tree culture, and his earlier efforts only convince him that there is "no excellence without great labor." The same care and industry that produce a grove of trees in Illinois or Iowa 20 feet high in 10 years will often do very little towards that result in Dakota. One old squatter once said to the writer that "tryin' to raise trees on these prairies is agin natur," and added that "if natur intended trees to grow here they would have been here before the country was settled." The answer was made that the same might be said with equal truth as to the growing of wheat.

My first attempt at tree-raising was on a piece of ground that had produced two crops of wheat, and it was prepared by a thorough plowing 8 inches deep. Then it was marked out 4 feet apart each way with a corn-marker and planted with box elder tree seeds, the work being done about the middle of October. I had no experience in the business, neither had my neighbors, so I struck out by guess and planted the seeds 2 inches deep, or about the depth that corn is usually planted. This was my first mistake, and it is sufficient to say that I never saw the sign of a tree on the 3 acres thus planted. I suspect that poor seed had something to do with it, but subsequent experiments convinced me that very few tree seeds of any kind will germinate if buried at a depth of 2 inches. In the woods, of the very few seeds that sprout of the millions that fall to the ground each season, they get but a very slight covering, consisting of a few wet leaves or a little dust blown over them by the wind. My only success has been with the slightest covering that it was possible to make. One planting that I made I instructed the men to use no hoes, but simply cover the seeds with a little dirt drawn over them with the foot. They were instructed to cover as shallow as possible, and on the ground thus planted I had the best stand of trees. So far as seeds are concerned their use is undoubtedly the cheapest for the farmer on the start in helping him to keep within the requirements of the law, but with the general average of people I incline most decidedly to the opinion that cuttings or small trees are the best and most economical in the long run.

It is still a dispute concerning the length of time that tree seeds will retain their vitality, but I would not plant seeds that were more than a year old. By far the safest way is to gather the seeds as soon as ripe and plant them at once, or at least before the ground freezes. Large amounts of box elder and white ash seeds, the two most common varieties that are used on tree claims in the two Dakotas, have been sold to planters after having been kicked about the nurseries and seed stores for years; and to this cause alone many failures may fairly be attributed.

Here, for example, is a man who has put off planting until the last moment; he must plant at once or his claim is liable to be contested on account of his failing to comply with the law, so he buys the first seeds he can lay his hands on, summons his neighbors, and plants his 5 acres of trees. He may know or suspect that the seeds are worthless and that he is throwing away his work, but he is complying with the law (apparently), and his neighbors who help him do the planting are all ready to swear that they are witnesses of the fact and aided in doing the work. He may never see a tree, but his claim is safe from the grasp of those who are land hungry, and he can get the time extended "on account of the drought," or any other alleged misfortune.

If the planter will take proper care of his young trees and cultivate them as he ought the use of seeds is undoubtedly the best plan, as the loss of about 1 year in their growth from transplanting is obviated; but the ordinary farmer usually has his hands so full of other work which can not be postponed that the trees are neg-

lected and are smothered with weeds. If seeds are used the question arises whether it is as safe to purchase those grown in another State and in a different climate as those raised at home? My own failures have been with seeds that were purchased of the dealers, and my success has been with those picked at Devil's Lake by my own men. Seeds raised in the same region where they are to be planted are most assuredly the safest and best. If the law would permit it, the best way to proceed with a tree claim would be to plant the seeds in nursery rows and cultivate them properly until of sufficient age and size to transplant. The planter would gain at both ends by this plan; first, his trees would be getting a good start while his land is being subdued from its wild state to become a suitable habitation for so fine and beautiful a thing as a graceful tree. There is something almost pathetic in the disappointment of the Eastern man who digs holes in the tough prairie sod and plants a few shade trees in front of his Dakota sod shanty, hoping that they will grow as they do "back home" and afford a fine shade in the "sweet bye and bye" when prosperity has enabled the hopeful farmer to build a new house. They may put forth leaves in May, but are sure to die in August.

My second attempt was with 5 acres of wheat stubble thoroughly plowed and dragged and planted 4 feet each way with seeds, mostly white ash and box elder. The planting was done late in the fall, and in the spring I had the satisfaction of seeing as fine a stand of trees as one could wish. During the summer they were cultivated both ways twice and hoed once. The field was kept as clean as a field of corn, and in fact the trees were treated the same as is usually accorded to corn or potatoes. The planting was on the open prairie and exposed to the fierce winds from all quarters of the compass. The fall of snow that winter (1886–'87) was very slight in that section and in the spring I found that thousands of my young ash trees had been winterkilled. This surprised me very much, as the white ash is considered perfectly hardy even in the hyperborean climate of Dakota, and the seeds for my planting had been gathered at Devil's Lake, as above stated. Here was another revelation. The box elder had also suffered, but not so badly as the ash. What was the matter? The previous summer had been quite dry and the growth of wood had been short, but that I supposed to be favorable to ripening the wood and preventing winterkilling. Then I asked myself the important question: If the season of growth in Dakota is too short to sufficiently ripen the wood of the ash so that it will withstand the winters, how are trees ever to be grown successfully in this climate? It was a question without an answer. And yet there was a partial solution.

I had seen large ash trees at Fort Totten and along the banks of the Cheyenne River, but always in sheltered positions. Under the bluffs along the banks of the Cheyenne many varieties of native trees can be found of considerable size, while only 12 miles away along the banks of the James River, whose course is through the almost level prairie for many miles, there is not the sign of a tree of any kind, not even the burr oak, which puts in an appearance and holds its own wherever there is a chance. Then I found that some of my trees that were sheltered on the north and west by a weed that had made a snow bank had not been killed. Some small trees that had grown under the lee of larger ones on the north had escaped while the larger ones were dead. One of my neighbors had a planting of white willows and box elders 4 years old, the rows running east and west. The willows had been allowed to grow quite bushy, and so thick as to present considerable of a wind-break. I noticed that only two or three of these bushes on the west end of the rows were dead; the others, having the advantage of the shelter afforded by these outposts, were green to the very tips of the smallest boughs. Another man had planted corn among his trees and let it stand all winter as a protection to his trees with good results. His opinion is that as soon as groves of forest trees are sufficiently grown to afford shelter, apple trees of the hardy varieties may be successfully cultivated in all parts of Dakota. Others are hoeing about their trees, but letting the weeds grow between the hills to help protect them in winter. If some sort of shelter is needed for young trees in winter—and it seems to be imperative—the importance of first

planting one's trees in the compact nursery rows so that they can be protected by a board fence, or a barricade of manure on the west and north such as I have often used, can not be overestimated. The settler could plant his nursery on the start so that his trees would be ready for planting by the time the ground was fully prepared.

VARIETIES.

The average settler who has been reared where natural forests abound knows as little concerning the best trees to plant on the plains as he does of many other facts connected with the business. If he takes the unsolicited advice of those who have trees to sell that have been grown in some distant State he runs a risk of spending his money for nothing, and will meet with disappointment in the end. Many kinds of trees that are indigenous in northern Iowa, Wisconsin, and Illinois, and are even hardy in those latitudes, have been found too tender for Dakota unless in some sheltered position where the case is so exceptional that the example is not of universal application. What the western farmer wants at first is two or three sorts that are perfectly hardy, if any such there be, and stick to them until he gets a good start. Hardiness, rapid growth, and utility are the three most important characteristics that should govern him in making his selection for field planting, leaving the nurserymen and the experiment stations to make tests with different varieties. As far as my observation extends, and it is corroborated by the experience of many others, the three varieties that have succeeded best on the prairies, under all circumstances, are the box elder, cottonwood, and white willow. White ash does well and is a more valuable wood when grown than either of the others, but it is of too slow growth to meet the requirements of this go-ahead generation. I have tried black walnut, basswood, burr oak, wild cherry, hard and soft maple, yellow locust, chestnut, and others, only to be disappointed in the result. The black walnuts grew luxuriantly the first year and were the admiration of all beholders, but alas, the second year they did not respond to the invigorating touch of the south wind and the genial May sunshine. They were well named black walnuts. Dead as a doornail. Hard maple I dismissed because of its too slow growth, and its half brother, the soft maple, had to be abandoned because it is too tender unless protected. I have still strong hopes of it after thorough acclimation, because its rapidity of growth, which is the chief objection to it in Illinois and Wisconsin, makes it a most desirable variety, besides being so easily propagated. The yellow locust that has been raised so extensively in many of the Middle States, and which is so valuable for fence posts, had to be given up with great reluctance after a thorough (?) trial.

I now confine myself exclusively to box elder, white willow, cottonwood, and white ash, and have a fine stand of each of these varieties. In my opinion the box elder has little to recommend it except its hardiness, for I have seldom seen a straight, graceful tree of that species in any country, and why they are planted in latitudes where the maples and elms are easily cultivated is a mystery. But on the western plains they flourish where most others fail, and it is vastly better than nothing. The cottonwood, with which the Northern Pacific Railroad Company has been most successful in securing a growth for hundreds of miles along its road to defend its line against snowdrifts that fill its cuts, is a rapid grower and a handsome tree when young, but an unsightly thing in its old age. The white willow bids fair to become a general favorite because of its rapid growth and its perfect hardiness, more danger to it being apprehended from summer drought than from winterkilling.

PREPARATION OF THE SOIL.

In regard to the preparation of the soil, that has been pretty much settled by the terms of the Congressional act relating to tree claims, but I am by no means certain that the course therein marked out is the best. The law is imperative that the first 5 acres shall be planted the third year after filing, while some farmers are of the

opinion that it is better to plant as soon as the land can be properly prepared after breaking. My own personal experience leads me to coincide with this view, as the best stand of trees on my own place was treated in that way. The land had been broken in the spring and was planted with potatoes, the seed being dropped in the furrows after the breaking plow, a method often adopted by lazy farmers on the frontier. After the potatoes had been dug in the fall the land was plowed or "backset," and marked out with the plow 4 feet apart one way. Into these furrows box-elder seeds were sown and a little dirt scratched over them with a garden rake. I called it the most slovenly job I had ever done in Dakota, but the trees from that planting have flourished better than any others on the place, and I am not sure but the newer the ground, if it is fit, the better. Of course the trees were hoed and kept clear of weeds every year. The trees have defied summer's drought and winter's cold, and are now large enough to take care of themselves. I may add that the seeds thus carelessly planted were what remained after planting 5 acres on well-pulverized ground where no tree is to be seen to-day, so that the failure on the old ground can not be attributed to poor seed.

A DISCOURAGING BUSINESS.

From the above brief and imperfect presentation of the subject it will readily be inferred that tree culture on the western prairies is a very discouraging undertaking and one that has no poetry at all in it. The great obstacles in the way of success are the natural perversity of the soil and climate; the dry, hot summers; the intense, cold winters; the windstorms; the late frosts in the spring that cut down the young trees; the early frosts in the fall that prevent the sufficient ripening of the wood; the cutworms; poor seed; worthless varieties of trees; and last, but not least, neglect on the part of the owner. And yet, notwithstanding all these obstacles—and I appreciate their force to the fullest extent—I declare my belief that the time will come when these vast treeless areas will be ornamented with fine groves of timber that will shade the farmhouse from the burning rays of the summer's sun and afford shelter from the fierce blizzards of the pitiless winters.

2. FOREST-TREE CULTURE IN DAKOTA.

By J. W. Smith.

In giving my experience in tree-culture, after planting 60,000 trees in Central Dakota within the past 6 years, I will try to be brief and practical, dividing the subject as follows:

First. Selection and preparation of soil.

Second. Kinds of trees; how and where to plant; trees or seeds.

Third. Aftercare and culture.

Fourth. Errors of the past; the teachings of experience, and suggestions for the future.

Almost any soil will produce trees under favorable circumstances, but soils differ greatly and the proper preparation of any soil is essential to success. Deep cultivation and the total destruction of the prairie grasses and weeds is also necessary to secure the best results. An Iowa cultivator of evergreens once remarked to me that "only time and thorough tillage could get the rawness out of new prairie soil so that evergreens would thrive." This truth doubtless also applies to most deciduous trees. Thorough and deep preliminary cultivation, then, are essential to successful tree-growing on the prairies.

The kinds of trees to be selected must vary with the climate, soil, locality, etc., experience being the only sure guide. Native trees growing near in similar soil can hardly fail. Beyond that, where possible, it is best to be guided largely by the experience of others. White and green ash, water or white elm, and box elder seem about

equally hardy. Cottonwood and white willow are not hardy except in moist soils, each usually failing after a few years' growth. A limited experience with some other willows and several poplars leads me to think some of these may prove more hardy. The larch, basswood, wild black cherry, native white birch, and some other trees, mostly American, promise well in places, and deserve further trial. Soft maple does not seem very hardy. It may, like some other kinds, be more hardy when older and where protected by other trees. The nut-bearing trees, black walnut excepted, and that grown from seed, killed wholly the first winter. Only a few evergreens have been tested. Small red cedars have been partially killed at times, not always, and never entirely. Few others appear as hardy. White pine may be, and grows faster.

Trees should always be planted in spring, summer, or autumn, according to kind. I have usually planted trees of 1 to 2 years' growth; think 1 year preferable, and with few exceptions prefer them to seed, if in good condition. Some good cultivators prefer planting seed, and if it germinates well, the great difficulty in dry soil, it is preferable to trees, as the roots of trees must be more or less injured in digging, handling, and transplanting. Small trees can be planted very rapidly with a spade, if the ground is marked, or by a hoe in a plowed furrow. Mr. R. Douglas, of Waukegan, Illinois, gives admirable instructions for planting upon a large scale. The essential things with any method are (1) to have the ground properly prepared; (2) to have good trees or seeds; (3) to have the work well done at the proper time; and (4) to have the trees well cultivated and protected in after years. It is preferable to have some trees watered and even mulched when planted, though with small trees this is not usually necessary.

The after care and culture is as important as proper planting. If 4 by 4 feet distant and in rows each way, the most common method, they can be cultivated like corn, and the kind of culture they receive will be as visible by their growith, condition, and even the life of some of them in after years, as it is upon a crop of corn. If the land was deeply plowed and cleanly cultivated for several years before planting the trees will not be likely to suffer from drought unless their culture is neglected.

Frequent shallow cultivation of the whole surface soil, while destroying weeds, will also prevent the injurious effects of excessive dryness. Cultivation should cease by about August 1, to prevent too late growth and consequent winter killing. After that date all large weeds and any near to a small tree should be removed by hand work. Only clean culture for several years and protection of the tree from the tramping and browsing of live stock will secure healthy and rapidly growing trees. Prairie fires are dangerous if the land is very weedy, or if the trees are so large that cultivation has ceased. To be safe, a sufficient breadth of land should continue to be cleanly cultivated, it may be with some suitable crop.

The growth of trees is variable, owing to many causes, as soil, season, cultivation, etc. Cottonwood, where hardy, grows faster than most trees. All the ashes are slow growers. In 8 years the average growth of cottonwood is 6 inches in diameter, of soft maple and box elder 4 inches, and of ash not over 2 inches. If pruned or thickly planted, trees grow taller than where growing more scattered or singly, nature always adapting the shape of trees to their surroundings.

Some woods being so much more valuable than others, it is wise to try the cultivation of the more desirable kinds and to increase the planting of such as fast as found to succeed. When a wind-break is of the first importance it is best to plant for that object mostly rapid-growing kinds; elsewhere chiefly those of more value for fuel, fencing, building, and lumber. Some of the oaks are hardy and should be early planted, the acorns being preferable to trees.

Among the common errors of the past have been the hasty and imperfect manner in which prairie tree-planting has been done—preparation of the soil, quality of trees or seeds, and the neglect of proper care. The "tree-claim" or timber-culture act is partly responsible for many of the failures under its requirements. Thus it specifies that the prairie must be "broken" one season; the next year it must be

cultivated with or as for a crop; and the third year it must be planted with trees or seeds of forest trees, the usual result being that the land was not sufficiently cultivated to secure a good growth of trees by the proper cultivation in future years, it being nearly impossible to remedy what was lacking by ordinary cultivation, so that many trees are dwarfed or lost by weeds or drought.

It is also to be feared that quite a proportion of those who entered "tree claims" thought more of complying with the letter of the law, to obtain the land, than with the spirit of it, to secure a good growth of trees. To even look at some claims is sufficient proof that something is wrong. After a few years such parties are frequently glad to sell their claims, often without trees, for a trifle. If reëntered as a tree claim it was often by an inexperienced party, who in a few years was also glad to "relinquish" or give away his or her claim to some other party, and who, if experienced, will often enter the land as a preëmption or homestead. Such is the history of hundreds if not thousands of tree claims, and it will continue to be until the act is amended or repealed. Happily, in contrast with those described, some model tree claims can be found in nearly every county.

The writer respectfully suggests that if the preëmption and tree-claim acts are to be repealed, as now appears likely, the tree-claim act in some modified form should be ingrafted upon the homestead law, so as to require at least 5 acres of timber trees to be successfully cultivated upon each 160-acre homestead in future, but requiring two crops where one now, and thorough cultivation before planting trees or seeds.

Five acres of forest trees upon a homestead is only a reasonable requirement. It would also soon greatly modify the climate of the prairies; could be made valuable as a wind-break about the farm residence and other buildings; could afford desirable shelter belts for live stock at different places on the farm; in a few years would furnish considerable fuel, fencing and building material, besides adding wealth and comfort to the owner, health to the community, and beauty to the landscape.

FAULK COUNTY, DAKOTA.