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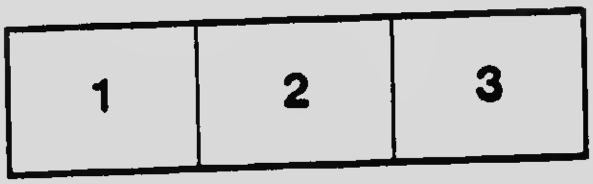
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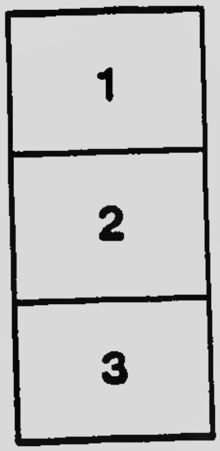
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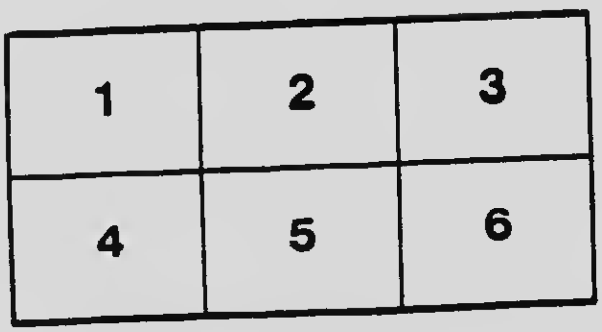
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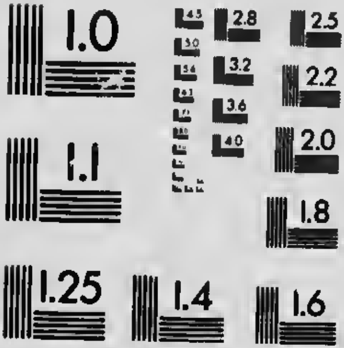

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FORESTRY

Lectures by Prof. Fernow

KINGSTON, 1903.

1903

LECTURES ON FORESTRY

—BY—

B. E. FERNOW, LL.D.,

DIRECTOR OF NEW YORK STATE COLLEGE

OF FORESTRY.

Delivered at the School of Mining, Kingston, Ontario,

January 26th-30th, 1903.

PRINTED BY

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1903.

INTRODUCTION

These lectures are the outcome of the efforts of Queen's University and the Kingston School of Mining to place before the people of Canada the leading principles of forestry in such a way as to make a beginning in forestry education. Dr. Fernow had previously (Jan. 21st, 1901) lectured here at a conference called 'to consider the best means for the preservation and renewal of our forests, for using them to advantage, and for providing proper education to these ends.' The interest aroused by this lecture and the conference which followed it decided the Board of Governors of the School of Mining to proceed with the establishment of a Department of Forestry in connection with the School, a project which had been cherished for several years. The Premier and the Minister of Education of Ontario looked favorably upon the proposal, and substantial aid was promised, to be given as soon as the buildings under construction afforded space for the new department.

The lectures which follow were delivered during the last week of January, and were attended by the advanced students of engineering, economics and biology. They were fully reported by the leading newspapers of Canada, and forestry at once became a subject of discussion in the public press. It was everywhere recognized that the School of Mining had made an important advance in education, and that these lectures, the first course on forestry given in Canada, were to be recorded as a historical event of great significance, marking as they did the beginning of a new outlook upon one of our greatest industries.

At the close of the lectures a committee of lumbermen and other friends of the movement was formed to assist in establishing the School of Forestry. The names of the committee are given below. The local members of this committee decided to print and publish the lectures, and this has now been done with the sanction of the Board of Governors.

The cuts illustrating Lecture X. were kindly lent by the Western Society of Engineers, Chicago. Mr. H. W. Wilson has also supplied a number of illustrations from his unique collection of negatives. Dr. Fernow revised the proof sheets and selected a number of the illustrations. The Committee desires to take this opportunity of thanking him for his cooperation.

Most of the subjects dealt with have been treated more at length in Professor Fernow's lately published work on *The Economics of Forestry.*

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Kingston, March 20th, 1903.

CONTENTS

"WHITE PINE FOREST."

LECTURE I.

THE FOREST AS A RESOURCE.

It may be stated without fear of contradiction that outside of food products no material is so universally used and so indispensable in human economy as wood. Indeed, civilization is inconceivable without an abundance of timber.

The nomad of to-day, who herds over the treeless plains and prairies, is still like the Scythian of ancient times; his life, his culture, his attainments are no more advanced. The successful settlement and civilization of our own treeless regions of the west became possible only through the development of means for the transportation of this most needful material. So general and far-reaching has its use become that a wood famine, however improbable its occurrence, would be almost as serious as a bread famine. We may become less wasteful, both as regards food and wood, but the necessity of wood, so far as we can foresee at present, will always be second only to the necessity of food, and far greater than that of any other material used in the arts.

Our civilization is built on wood. From the cradle to the coffin, in some shape or other, it surrounds us as a convenience or a necessity. It enters into nearly all our structures as an essential part. Over half our people live in wooden houses, and the houses of the other half require wood as an indispensable part in their construction. It serves to ornament them, to furnish them with conveniences, to warm them, to cook the food. More than two-thirds of our people use wood as fuel, and until recent times it was the only or principal means of smelting the ores and shaping the metals with which to fashion the wood itself. For every hundred tons of coal mined, two tons of mining timber are needed, and wood in large quantities is needed to mine our metals.

Every pound of iron, every ounce of gold, requires wood in its mining, wood in its manufacture, wood in its transportation. There is hardly a utensil, a tool, or even a machine, in the construction of which wood has not played a part, were it only to furnish the handle or the mould or pattern.

The articles, useful or ornamental, made wholly or in part of wood, are innumerable. Our houses are filled with them, our daily occupations necessitate them wherever we are. For our means of transportation we rely mainly on wood. Our 260,000 miles of railroad track (190,000 miles railroad in the U. S.), the carriers of civilization, lie on not less than 700,-000,000 of wooden ties and need 140,000,000 annually for renewals; they run over more than 2,000 miles of wooden trestles and bridges, they carry their passengers and freight in over 1,000,000 wooden cars, and much of the millions of tons of freight is shipped in wooden boxes and barrels, and stored in wooden sheds. Ten million telegraph poles are needed to keep up communication between distant markets.

The forest furnishes the cooperage to market our vintage, to store our flour and fruit. The forest furnishes the plough handle and harrow frame to cultivate, the threshing machine and windmill to prepare the crops, the cart to bring them to market, the bottoms in which they cross the ocean to foreign marts, and even the tar and pitch needed to keep the cargo safe. While iron ships have largely replaced the wooden bottoms in ocean travel, our coastwise and inland shipping, which requires in the United States a tonnage twice as large as in the transatlantic trade, is carried mostly in wooden ships. We are rocked in wooden cradles, play with wooden toys, sit on wooden chairs and benches, eat from wooden tables, use wooden desks, chests, trunks, are entertained by music from wooden instruments, enlightened by information printed on wooden paper with black ink made from wood, and even eat our salads seasoned with vinegar made from wood.

The uses of wood, multifarious now, are constantly increasing. With the manufacture of wood-pulp and cellulose, an entirely new direction of use has been opened; originally designed to furnish a cheap substitute for linen paper, its application in many ways is growing daily, and promises for the future the largest drain on our forest resources, the manufacture of wood-pulp having increased more than three-fold in the last ten years.

To give briefly an idea of the extent of our own wood consumption, (including exports), we may say that, if five persons are counted to a family, each family in the United States and in Canada as well, uses on an average about 3,000 cubic feet or about 120,000 pounds of dry wood per year, the annual product of at least 60 acres of forest.

The reasons for this universal and varied application of wood may be found in several directions. In the first place, the general occurrence of forest growth and the ease with which wood can be obtained and shaped directly to the purpose in hand made it, naturally, the material of earlier civilizations; but there are certain qualitites in addition which will make its use always desirable, if not necessary. In the combination of strength, stiffness, elasticity, and relatively light weight, it excels all other known materials. Not only is a stick of long leaf pine superior in strength to one of wrought iron of the same weight, but employed as a beam it will bear without bending a load six to eight times as great as an iron bar of the same length and weight. Moreover, the wooden beam will endure greater distortion than the metals without receiving a "set" or permanent injury.

The ease with which it can be shaped and keeps its shape, the softness and yet unchangeableness, but especially its non-conductivity of heat and of electricity, which makes its use more comfortable than that of metals, in addition to its light specific weight and many other qualities, recommend it for many purposes in preference to other materials.

But above all things, its cheapness recommends it. We are paying now, leaving out fancy woods, at the most, 60 cents per cubic foot for the best wood, shaped, as against $5 to $10 per cubic foot for iron in sheets or bars. Moreover, it is the only material of construction which we can produce and reproduce at will, while we know that most other materials now in use must be sooner or later exhausted.

Other materials have displaced wood in some uses, but other uses have arisen for wood, and often the substitutes have again been displaced by wood, when its superiority or peculiar qualities have been more fully recognized. Even in such nicely balanced structures as the bicycle, for which metal seemed the only proper material, wood has proved itself superior, at least in certain parts.

A remarkable instance of this return to the use of wood instead of metal is that for factory and warehouse construction in order to reduce danger from fire, it having been found that in case of fire iron beams and posts are twisted out of shape by the heat, causing the collapse of the whole building, while with wooden posts and beams the chances of keeping the walls intact are much greater.

Coal has largely displaced wood as fuel, yet according to the census of 1880 more than half of the population relied still on wood for fuel, and there is no reason to believe that the proportion has changed measurably.

In fact, if we may be allowed to consider the figures of the census of 1880 still proportionately true, as far as bulk is concerned, our fuel consumption represents about three-fourths of our total wood consumption; and even in value this part represents nearly one-half of our entire enormous consumption of forest products of the United States, and exceeds in bulk more than ten times the iron and steel handled in that country.

The development of the cellulose and wood-pulp industry with the consequent extension in the use of paper, made from this material for all kinds of purposes where elasticity and durability combined with strength and lightness is demanded, from collars and cuffs and combs to car wheels, has given new and constantly growing employment to wood.

Considering, moreover, the very extensive and the very varied employment of wood, it will be apparent that substitution by other materials cannot be readily accomplished, and means inconvenience, and, in many cases, decrease of comfort. Hence, large wood supplies are, and unquestionably will continue to be, an indispensable requirement of our civilization, almost like water, air and food.

Besides wood supplies, the forest furnishes other material of no small value. Of these, two classes at least give rise to industries of considerable extent, namely, the tanning industry and the naval store industry.

The bark of certain trees, notably the hemlock, and the oaks among our native species, contain the chemical compounds known as tannic acids, which serve for the manufacture of leather.

Thus 1,500,000 cords of tan bark, worth about $10,000,000, which are used annually in the U. S., entailed formerly a sacrifice of nearly 1,000 feet of lumber per cord of bark; of this now probably the larger part is saved.

The naval store industry, concerned in extracting from the living trees of certain kinds of pine, especially the Southern long leaf pine, and from other species, the resinous contents, and by distillation obtaining turpentine, resin of various kinds, and tar, is indebted to the forest to the extent of about $20,000,000 per year in the United States.

A similar industry is the tapping of the maple for sugar, which is peculiar to the United States and Canada, producing with over 50,000,000 pounds of sugar, and 3,000,000 gallons of syrup, values to the extent of $6,000,000 annually.

Finally, by distillation of the wood itself and condensing of the gaseous products, considerable amounts of wood alcohol, wood vinegar, and acetates, creosote, and other tar oils useful in the arts, are derived, adding another $3,000,000 or more to the annual revenue furnished by the forest resource in the United States.

While the value of the raw forest products consumed every year in the United States at places of consumption, roughly shaped for further use, may be placed at $600,000,0001 this is enhanced by their further manufacture to over $1,200,000,000, thus making the result of the forest industries second only to those of agriculture, the value of whose products reached in the census year (1890) nearly $2,500,000,000 while the total production of metals which could in any way replace wood—gold and silver and iron included—reached only $270,000,000, and the entire mining industry (quarries and every kind of mineral or earthy product included) but little over $600,000,000.

As civilization advances so does the use of wood increase, and during the last 40 years this increase has been most remarkable. Great Britain, having hardly any wood lands of her own, stands first as an importer of wood, importing last year wood to the value of $125,000,000 (20 per cent more than her pig iron product). During the last 40 years the amount of wood used in that country has been increased 200 per cent. while her population only increased 42 per cent. France in the last 70 years, with an increase of population of 20 per cent., has increased her consumption of wood 700 per cent. Germany is, next to Great Britain, the greatest importer of wood, increasing its imports by 400 per cent. in the last 40 years, or 3½ per cent. per annum. These remarkable increases are doubtless due in part to increased manufactures of wood for exportation, but the all-around increase is consequent upon the demands of advancing civilization.

Similar increases in per capita consumption can be shown from the census statistics in the U. S., which is probably the largest wood consumer in the world, with 350 cubic feet per capita consumption, while in Germany the consumption is only 43, and in Great Britain about 15 cubic feet.

The statistics of Canada show that the value of the forest products in 1891 was $80,000,000, of which $56,000,000 was used at home while she exported lumber and other products to the value of $24,000,000. This was an export of $15.60 per capita and represented a consumption of 250 cubic feet per capita as compared with Great Britain's 15 cubic feet; moreover, the wood consumption in Canada is increasing very rapidly. Ontario alone derived a revenue of $1,276,000 from timber licenses and dues in 1901, showing that this province can well afford to establish schools of forestry as a business proposition.

Statistics show that Canada has 800,000,000 acres of wood land, but of this vast acreage probably not fifty per cent. may be considered as forest land fit for timber production, the rest perhaps able to satisfy domestic and pulpwood demands, but not to be considered in connection with the timber requirements, which at the present rate of consumption amounts to 5,000-000,000 feet per annum; only under proper supervision will this area of less than 400 million acres, much of it badly damaged by fire, continue to supply growing demands for a long time. With the decrease of supplies in other countries and the increase of their needs for imported wood products, the value of Canada's remaining forest wealth, will appreciate and readily repay the care bestowed on it.

To sum up:—Consumption of wood is so enormously and constantly increasing, that, in spite of substitutes, wood will remain a necessity.

Natural supplies, however abundant, must give out unless we can and do reproduce them.

Nature's reproduction is uneconomic in character, space and time; and hence man's action becomes necessary, giving a more rational treatment to forests everywhere.

Forestry becomes the necessity of every country, and especially for those countries that have large supplies and are bound to be great timber producers in the future.

The natural forest resource as we find it, consists of an accumulated wood capital lying idle and awaiting the hand of a rational manager to do its duty as a producer of a continuous highest revenue.

Such management, however, it does not receive in the crude exploitations to which it is subjected in all newly developed and developing countries; on the contrary, the wasteful use of the soil is only intensified; for these exploitations, the operations of the lumberman, consist in a mere removal of the valuable portions of the growth, a cashing of the accumulated wood capital, without the slightest reference to future revenues which might be derived from it in the shape of wood growth. In fact, he does not recognize or consider that the forest is not merely a mine, but a reproducible resource—a living, growing crop, the product of the soil and climate, which can be reproduced *ad libitum* in even superior quantity and quality to what nature alone and unaided has done.

His methods of removing the standing timber are not only wasteful. but they decrease the capacity of the land for producing valuable timber.

By culling out the most valuable kinds, leaving undesirable kinds and poor trees to shade the young growth that may have developed, he prevents the reproduction of a valuable crop, and hence such culled areas, while they still appear as forested, have often lost their entire value as producers of useful material; the growth on the land being an encumbrance rather, to be got rid of first, before profitable use of the soil, either for agricultural crops or for useful wood crops, can take place.

The rational way in treating the resource of virgin woods, from national economic if not from private pocket interest would be as far as possible to prepare first for a desirable reproduction by cutting out the poor kinds and the useless brush, then logging out first only the largest trees of the better kinds with proper precaution against injury to younger growth. and against fires, then gradually, as younger trees grow on, the older ones may be harvested and as much as possible in such a manner that the young after-growth is given room and light.

Thus, by mere care in utilizing the resource, not only can all the product be harvested, but a new crop, increased in quantity, can be secured. From such simple care we come to the finest methods of forestry, for these are only different in the degree of care, hardly in the kind.

By these methods man makes the forest resource produce easily the treble and quadruple of what it does when left alone; so that merely by the judicious use the capacity of useful production grows.

How much intensive management can increase the yield of the resource may be judged from the experiences of German forest administration. Here the forest resources are nearly if not entirely brought under rational management, and are treated as a crop, constantly furnishing harvests, and being reproduced without diminishing the wood capital.

Thus, the rather more extensively managed Prussian government forests, which with an area of 6,750,000 acres are perhaps also stocked on poorer soils or are less favorably situated, produced as an average for a series of years 42 cubic feet of timber wood (over 3 inches diameter) per acre, those of Bavaria 55, those of Baden 59, of Wurtemberg 67, while the most intensively managed state forests of Saxony, of only 430,000 acres extent, produced 90 cubic feet of wood per acre per year, of which 68 cubic feet was timber wood, the highest production for such a large area.

A further illustration of the increase in yield which comes with proper management of this resource is furnished by the Prussian state forest administration: while during the years from 1829 to 1867 the cut was increased from 28 to 37 cubic feet per acre, and to 46.7 cubic feet in 1880, nearly double what it was in 1829, yet the proportion of old timber over 80 years,or stock of merchantible timber on hand, increased during the last 20 years of the period from 23 per cent. to 27 per cent., showing that the cut remained below the production. In the most intensively managed state forests of Saxony, the cut has been doubled in the last fifty years, and yet the stock of wood capital standing has increased over 16 per cent.; while in 1845, of the cut per acre of 56 cubic feet, 11 per cent. was saw timber; in 1893, of the 90 cubic feet cut, 54 per cent. was timber fit for the mill. The gross revenue increased during that time 234 per cent., and the net revenue over 80 per cent. A financial calculation shows that the state's property has not only paid 3 per cent. continuously in revenue, but has appreciated in value 24 per cent. by mere accumulation of material.

According to a conservative calculation based upon these experiences, the forest resource of Germany represents, in round numbers, a capital value of $180 per acre ($25 for the soil and $155 for the stock of wood) paying a constant revenue of 3 per cent. on such capitalization; or since there are somewhat over 35,000,000 acres of forest, their capital value is equal to $6,340,000,000, producing a continuous annual income of $190,-000,000. The state properties are, moreover, constantly improving, and the revenue constantly increasing.

While, to the casual reader, this showing may hardly appear as a very profitable business, we must not forget that the result is obtained for the most part from soils which would otherwise be unproductive.

It is apparent that we are bound to exhaust our stores in less time than they can be replaced, that we are not living on interest, but are rapidly attacking our wood capital—a process fully in keeping with the development of any new country, but also one against which reaction must set in in time, if serious consequences are to be avoided.

Such reaction may be secured first through a more economical use of the timber resources, for the per capita consumption in Canada falls hardly short of 300 cubic feet, nearly eight times that of Germany, and twenty times that of England, and hence a large margin is left for such economies.

Finally, however, forest management, as practiced in other countries, will become an unavoidable necessity to secure the continued production of needed wood supplies.

There is one factor of national importance resulting from the industries concerned in the conversion of our virgin forests, which does not at all, or not to the same extent, attach to them in other countries, and which, in the end, is of more moment than estimates of stumpage or land values or values of products can express. Not only does the lumberman with the systematic development of his business, which has enabled him to supply a superior article as cheaply as the inferior one is sold in Europe, give rise to many manufactories and industries, and render possible the development of distant agricultural regions, which in turn renders profitable the building of railroads and the employment of labor, but he has been the pioneer in bringing the wilderness itself within reach of civilized influences; and while this has often been done at an unnecessarily extravagant sacrifice of much of our natural forest resources, the opening up of these back woods must nevertheless be considered as a potent influence for good, resulting from his business.

Per aspera ad astra, through rough work to civilization, is the history of the settling of the backwoods, which the logger has accomplished.

CORDUROY ROAD, NORTH HASTINGS.

Photo by Houghton W. Wilson.

Such settlement is necessary before forest management can be profitably applied to the remnants of woodlands; and while we may regret the wastefulness with which this settlement has been made, we must consider it as a necessary step toward an extension of civilized conditions.

LECTURE II.

WHAT IS FORESTRY?

DEFINITIONS AND PRIMARY CONCEPTIONS.

At this time, when the necessity of preserving the forest wealth of the world arises to prominence, general interest in Forestry should be aroused Canada, on account of climatic conditions and the extent of non-agricultural land, is, and will continue to be, one of the great forest countries of the world, and rational management should succeed the mere exploitation hitherto practiced in her forests.

The word "Forestry" in its present sense is of recent usage, but in its origin a Latinized Teutonic word, originally meaning a portion of the land of a tribe held by the king or first man—the "Furst." From such use come the old definitions of the forest as a large, uncultivated tract of country, wooded in places, under certain laws—a legal term. The English kings thus reserved the right to hunt on stretches of country, over which forest-laws prevailed, and in charge of "Foresters," who were more properly the game-keepers of the king and his nobles. As understood now, we may call "woodland" the natural condition, land covered with woody growth, while in the term "forest" we add economic considerations, namely a woodland under man's care for forest purposes and exhibiting forest conditions.

As they supply different purposes, forests may be classified as *Luxury Forests*, for *Park Purposes*, reserved for game protection, *Protection Forests*, for the protection of mountain slopes and watersheds from erosion, and *Supply Forests*, which furnish material for the lumberman. This last forest purpose is the most important and direct one, while the second function is of moment only in certain locations, and all three can be subserved simultaneously.

In the pioneer days of a country there is first a rapid destruction of forests to clear the land, but, when the natural timber supply has diminished beyond a certain point, Forestry—the rational treatment of the forests as timber producers, becomes necessary, under which they are used and cultivated continuously for a wood crop as agricultural land is for food-crops.

The technical side of forestry is based on natural science, the economic side on mathematics and on political economy. The technical art of forest crop production, silviculture, calls for knowledge of botany and especially dendrology, or the physiology and biology of trees, as well as a knowledge of soil physics and chemistry to make the art an improvement on nature's methods producing the best form and largest quantity of wood in the shortest time possible. But as the forester, like the lumberman, harvests his crop, considerable engineering knowledge must be added to business knowledge to carry on the business of forestry. While, then, forestry is to the statesman a policy of national interest, to the student a science, to the forest producer an art, it is in the end a business, to make revenue from the use of the soil through timber production. In Europe forestry has long been practiced, forest laws existing as early as the sixteenth century, but our modern forestry has been practiced in Germany over 150 years. In America forestry is a new word and a new art, which has come to the front as the shortage of the natural timber resource made it apparent as a necessity. In the United States the government has recognized this necessity for forestry, has instituted a Bureau of Forestry with annual appropriations reaching now the sum of $185,000 merely for investigation, and has set aside 60 million acres of forest reservations. Several of the States have adopted the same policy, notably the State of New York, which has reserved over one million acres under a forest commission and has also instituted the N. Y. State College of Forestry at Cornell University. Several other forestry schools have followed.

While in the United States large tracts of the timber land are held by private individuals and corporations, in Canada the Provincial Governments have displayed great foresight in retaining control of these lands, and the conditions are excellent for the organization of a system of forestry.

LECTURE III.

HOW TREES GROW.

The technical part of the art of forestry is called silviculture—the art that produces the wood-crop for the management of the forester. For an understanding of the treatment of trees *en masse*, the forester needs a knowledge of dendrology, the knowledge of trees in all details, and especially their life history, individual and in association. Often wrongly defined in terms of size, the tree is potentially existing already in seed and seedling—it is a woody plant, the seed of which is capable of producing a single stem from the ground with a definite crown.

Trees, growing from seed, are built up from cell growth, division and multiplication like other living organisms, and they have similar requirements. Unlike other plants, they have longer life and attain greater height, to lift their foliage to the light. Their remarkable height is built up, storey by storey, by shoots, which push out from buds and elongate from the tips of stem and branch. The age of the tree may thus be told, at least in young specimens, by counting the annual shoots, which are marked off from each other by a swelling of the stem.

Buds are developed at the end of the year's growth, the terminal bud or one near the end of the shoot annually continuing the height growth. Each class of tree has a different habit of bud development, and trees can be identified by their buds alone. The Conifers, with fewer lateral buds, than the deciduous trees, persistently develop the main stem at the expense of the branches, the shoot from the single terminal bud making rapid height growth. If the terminal bud of a pine be destroyed, the side buds usually carry on the growth and cause forking of the stem. Among hard woods the majority of the buds do not develop, but are either lost or remain dormant, the shape of the tree being dependent upon this bud development, so that the dense crown of the Beech from the development of many buds has a different appearance from the open crown of an Oak. The dormant buds remain undeveloped, continually pushed out beyond the wood of the surface each year, ready in case of necessity or accident finally to develop into shoots.

As the new buds are formed at the ends of the shoots each year, the tree might grow on forever, if each species did not grow within certain definite height limits, which depend on [illegible] of soil, climate and species. The moisture from the soil, the tr[illegible] raise to its foliage against gravity, and the height to which the wate[r c]an be lifted is limited; some species offering more friction to the water current, cannot grow as high as others.

DENSE BEECH CROWN

OPEN OAK CROWN.

Light is an important factor in tree growth, and the form of the tree varies with the light supply. In the forest the trees grow tall, with long, clear trunks and few branches, while in the open the tree is short and branchy with a large crown. The belief that the growth of the tree pushes its branches higher up on its trunk is erroneous; the bareness of the forest tree is caused by the loss of the lower branches for want of light. The open-ground tree retains its branches lower on the trunk, and consequently does not produce as good lumber, the limbs, that all start from the centre of the tree, each year's wood growth burying their beginning deeper and deeper, if not killed and shed early, produce knots, which injure the strength and value of the sawn lumber. In dense forests the lack of light causes the lower branches to die and fall and the trunk is left clear. In forest planting, trees are set densely to shut out the light and kill the lower branches, in order to produce later, clear, valuable lumber.

Trees grow not only in height, but also in diameter, the growth taking place in the soft cambium layer between bark and wood. Every spring this layer of living cells begins to grow and divide, at first very rapidly with the rapid height-growth, but gradually more slowly as summer advances. The first quickly-formed wood cells are thin-walled with large openings, forming the pores seen in the spring wood of the oaks and ashes. The later summer-formed cells are closely crowded and compressed, with thick walls and small openings, the wood appearing denser and darker colored from this crowded condition of the cells. This succession of different spring and summer wood zones allows the easy recognition and counting of the annual layers or rings of wood, and the variation in the ring structure serves to identify various species of trees, and to indicate the comparative strength of their wood. After cutting a tree, therefore, its age can be found by counting the annual rings on the stumps, and from the record preserved in these rings the history of its growth can be read.

The annual ring is formed in all countries where there is a temporary cessation of growth, caused by distinct summer and winter seasons. Exceptionally trees fail to deposit wood over the whole trunk on account of loss of foliage, etc., and no ring is formed, or, where the growth has been disturbed during the season, a second ring may form, which can mostly be readily distinguished from the true rings.

To the forest manager the study of ring growth is of great importance, because from the rings of growth the progress of the crop may be seen—the amount of wood formed, and the time when it is most profitable to harvest calculated. Since also the proportion of spring and summer wood largely determines the quality of the timber, the ring growth furnishes an index for regulating the quality of the crop, since, by management of species, and adapting them to soils, the proportion of the spring and summer wood may be influenced. It is a mistake to consider that the lumber of the more rapidly grown trees of any species is weaker, for it is apparent that

LONE PINE

WHITE PINE, MICHIGAN

the dense, thick-walled summer wood cells make stronger wood than the thin-walled spring cells, and in a year of rapid growth the summer wood formed in some species exceeds in amount that formed in years of slower growth.

The food necessary for a tree to increase its solid substance is obtained from the soil and from the air. Most of this food substance is formed in the green parts of the plant—the foliage, in the presence of light and air by the union of water with the carbon derived from the carbonic acid of the air. From the soil, water is constantly being lifted by the tree up into its foliage; from which a part passes off into the air as vapor, the amount of transpiration varying with the climatic conditions, water supply, season and species. While in a vigorously growing tree there is from 40 to 65 per cent of water, the amount given off from its leaves in a season is many times greater than that retained, but trees require from one-half to one-quarter of the water which agricultural crops need.

Mineral substances are taken up only in very small amounts, and mostly of the commoner kinds, such as lime, potash, magnesium and nitrogen. Hence, wood crops do not exhaust the soil of its minerals, and even improve its fertility, as the greater part of the minerals are returned to the soil in more soluble form by the annual fall of the leaves and the small brush, in which the minerals are most abundant, and which decompose and form a rich humus layer on the surface of the soil.

As the soil moisture is the greatest requisite for tree growth, its conservation and distribution is most important. No tree grows to best advantage in very wet or dry soil, although some species endure and appear thrifty in such unfavorable situations. The soil most suited for all trees is a moderately but evenly moist soil, porous and well drained, but capable of conducting water up within reach of the roots of plants.

For the conservation of the soil moisture, the forest grower cannot rely on the methods of the agriculturist, which are usually impracticable and too expensive. He can only employ such methods as shading and mulching the soil—shading by close planting, and by maintaining the crown cover dense through the life of the crop to protect the soil from sun and wind; mulching, by the annual fall of twigs and leaves, which remain and decay, forming a rich mold, increasing the absorption and retentiveness of the soil, and retarding the evaporation of moisture and the run-off from the surface.

While with a moderate and even supply of moisture all trees thrive best, some like the Conifers, and especially the Pines, endure drier soils, and others like the Bald Cypress, excessive moisture. This adaptation, however, is modified in different regions by drier or more humid climate.

LECTURE IV.

THE EVOLUTION OF A FOREST GROWTH.

Last night we took a glimpse into that part of dendrology—the study of trees—which concerns itself with the development of the single individual. To-night we will look into the communal life—the sociology, as it were, of trees, as exhibited in forest growth.

For, in order to practice forestry, there is, first of all, need to understand the natural history of the forest. How does nature produce her forests? What are the laws, what is the progress in the evolution of a forest growth? These questions I shall endeavor to answer to-night.

The earth may be said to be a potential forest. A cover of tree growth more or less dense is, or has been, the natural condition of at least the larger portion of the *habitable* earth, and, of the entire land surface, not less than 60 per cent. may be classed as actual or potential woodland; 7 per cent prairie, and 33 per cent. plains or barrens. (In North America the proportion is about 45-5-50; in Asia, 45-3-52; in Europe, 84-10-6).

In the struggle for existence and for occupancy of the soil between the different forms of vegetation, tree growth has an advantage in its perennial nature and in its elevation in height above its competitors for light, the most essential element of life for most plants. These characteristics, together with its remarkable recuperative power, assure to the arborescent flora final victory over its competitors except where climatic and soil conditions are not adapted to it.

The entire absence of the tree growth from some localities, such as the northern tundras, the high peaks above timberline, and the arid plains, is due to temperature, moisture and soil conditions, either one or the other, or the unfavorable combination of them. On the high peaks, the two characteristics, of perennial life and persistent height growth, become unfavorable, since the extreme winter temperatures above the snow cover, droughty winter storms, and frosts every month in the year can be endured only by those plants which have a rapid cycle of development, or are sheltered near the ground by the snow cover. The wet soil on the tundras, frozen for most portions of the year, or the thin soil on the Alpine peaks, add to the difficulties for deep-rooting species in their contest with the lower vegetation. Again, in the interior of continents and other localities unfavorably situated with reference to the great sources of moisture and moisture-bearing currents, deficiency of water, scant rain-fall or low relative humidity, or both, and excess of evaporation, are inimical to tree growth, occasioning plains, which although not always and by necessity treeless, do not permit any forests to establish themselves unaided.

Occasionally, soil conditions, especially with reference to drainage, may be more favorable to the graminaceous vegetation, at least for a time; giving rise to pampas, prairies and savannahs; or else all the unfavorable conditions combine to give rise to deserts.

In addition, there are hostile agencies in the animal world, which prevent the progress of forest growth, and tend to preserve the prairies; locusts, rodents, ruminants, like the buffalo, antelope and the horse, impede the growth and spread of the trees, and especially where compact soil and deficient moisture conditions are leagued with these animals, the change from prairie to forest is prevented, at least for a time.

Woodlands are the most unfavorable form of vegetation for the life of ruminants, and, there fore, for the support of the largest number of men. For food production, for agricultural pursuits, man must subdue and remove tree growth. Hence, forest devastation, forest destruction, is the beginning of civilization in a forested country, its necessary requisite, and the persistency with which in forest regions the forest tries to re-establish itself calls for continued effort to protect pasture and field against its re-establishment.

So impressed was Dr. Asa Gray with the persistency of individual tree life that he questioned whether a tree need ever die; "For the tree (unlike the animal) is gradually developed by the successive addition of new parts. It annually renews not only its buds and leaves, but its wood and its roots; everything, indeed, that is concerned in its life and growth. Thus, like the fabled Aeson, being restored from the decrepitude of age to the bloom of youth—the most recent branchlets being placed by means of the latest layer of wood in favorable communication with the newly formed roots, and these extending at a corresponding rate into fresh soil—why has not the tree all the conditions of existence in thousandth that it possessed in the hundredth or the tenth year of its age?

The old central part of the trunk may, indeed, decay, but this is of little moment, so long as new layers are regularly formed at the circumference. The tree survives, and it is difficult to show that it is liable to death from old age in any proper sense of the term."

However this may be, we know trees succumb to external causes, insects, fungi, fire, windstorms, etc. Nevertheless, they are perennial enough to outlive aught else, "to be the oldest inhabitants of the globe, to be more ancient than any human monument, exhibiting in some of its survivors a living antiquity, compared with which the mouldering relics of the earliest Egyptian civilization, the pyramids themselves, are but structures of yesterday." The dragon-trees, socalled, found on the island of Teneriffe, off the African coast, are believed to be many thousand years old. The largest is only 15 feet in diameter and 75 feet high. The sequoias or Big Trees are more rapid growers and attain more than double these dimensions in 3,000 to 4,000 years, which may be the highest age of living ones. Their long life is undoubtedly due to the fact that they are not liable to attacks by insects, fungus, and hardly by fire.

While this persistence of life is one of the attributes which in the battle for life must count as of immeasurable advantage, the other characteristic of arboreal development, its elevation in height above every living thing, is no less an advantage over all competitiors for light, which is the source of all life; and in this competition, size must ultimately triumph.

Endowed with these weapons of defensive and offensive warfare, forest growth has endeavored, and no doubt to a degree succeeded through all geologic ages, during which the earth supported life, in gaining possession of the earth's surface.

As terra firma increased, emerging in islands above the ocean, so increased the area of the forest, changing in composition, to be sure, with the change of physical and climatic conditions.

As early as the Devonian age, when but a small part of our continent was formed, the mud flats and sand reefs, ever increasing by new accumulations under the action of the waves and currents of the ocean, were changed from a bare and lifeless world above tide-level to one of forest-clad hills and dales with quaint forms, like the tree rushes and the prototypes of our pines, the Dadoxylon.

The same class of flowerless plants, known as vascular cryptogams, with colossal tree ferns and the Sigillarias added, became more numerous and luxuriant in the Carboniferous age.

This vegetation probably spread over all the dry land, while other forms made the dense jungle in the marshy places and lakes with floating islands; the thick deposits of vegetable remains from these forests were finally, in the course of geologic revolutions, turned into the great coal fields.

During these geologic revolutions some of the floral types vanished altogether, and new ones originated, so that, at the end of Mesozoic times, a considerable change in the landscape is noticeable. In addition to coniferous trees, the palms appeared and the first of Dicotyledons, such as Oaks, Dogwood, Beech, Poplar, Willow, Sassafras and Tulip tree. Species increased in numbers, adapted to all sorts of conditions, the forest in most varied form and luxuriance climbed up the mountain sides to the very crests, and covered the land to the very poles with a flora of tropical and semi-tropical species in profusion, and large mammals roamed over the open spaces.

Then came the levelling processes and other changes of post-Tertiary or Quaternary times, the glaciation of mountains and nothern latitudes, with the consequent changes of climate, which brought about corresponding changes in the ranks of the forest, killing out many species around the north pole, the hardier races alone surviving; and these were driven southward in a veritable rout by the icy blasts.

When these boreal times subsided in a degree, the advance of the forest was as sure as before, but the battle order was somewhat changed to suit the new conditions of soil and climate. Only the hardier tribes could regain the northernmost posts, and of those who followed, many found their former places of occupancy changed by fluvial and lacustrine formations and by the drifts borne and deposited by icy sheets, while some, by their constitution, were entirely unfitted from engaging in a northern campaign, or found insurmountable barriers in the refrigerated east-west elevations, as in Europe and Western Asia.

PETRIFIED TREE

In addition, there had come new troubles from volcanic eruptions, which would again and again wrest the reconquered ground from the persistent advance guards of the arboreal army, annihilating them again and again.

Finally, when the more settled geologic and climatic conditions of the present era arrived, and the sun arose over the world, ready for human habitation, man found what we are pleased to call the virgin forest—a product of long-continued evolutionary changes—occupying most, if not all, the dry land, and ever intent upon extending its realm.

I may not leave this prehistoric story of the battle of the forest without giving some historic evidences of its truth. Paleobotanists have unearthed the remnants of the circumpolar flora which give evidence that it resembled that of the present tropic and semi-tropic countries; they have also shown that Sequoias, Magnolias, Liquidambars and Hickories existed in Europe and on our continent in regions where they are now extinct. We have also evidences of the repeated successes and reverses of the forest in its attempt to establsh itself through long geologic transformations.

One of the most interesting evidences of these vicissitudes in the struggles of the forest to establish itself is presented in a section of Amethyst Mountain in the Yellowstone Park, which exhibits the remains of 15 forest growths, one above the other, buried in the lava. Again and again subduing the inhospitable excoriations, again and again the forest had to yield to superior force. The face of the mountain includes over 2,000 feet of strata resting upon granite. The trees, or rather parts of them, stand upright and lie prostrate in good preservation, 10 to 50 feet in length, and not a few as much as 5 and 8 feet in diameter. (Note the ancient and modern vegetation in company.) The largest, uncovered by the action of water and soil movement, rising 12 feet above the enclosing strata, is 10 feet in diameter, and belongs to the Sequoia tribe.

Among these petrified witnesses of former forest glory, Magnolias, Oaks, Tulip trees, Sassafras, Linden, Ash, have been identified, accompanying the Sequoias, while now only the hardiest growth of pines and spruces find a congenial climate here.

Reversals of this kind are taking place even in our own time, before our very eyes. In Alaska, and elsewhere, glaciers carry large masses of soil and rock, depositing it in moraines at lower levels. On these moraines vegetation soon establishes itself, and finally the forest grows to the very edge, nay, upon the very back of the mighty icesheet. But as the ice river ebbs and flows, recedes and pushes forward, the existence of the forest cover is precarious and of temporary duration—sooner or later it will be pushed over by the moving ice and buried by the moraine material. Again receding, the glacier river carrying off the melted ice in a rapid stream, this stream cutting through the moraine, may uncover the buried forest, as is the case near the celebrated Muir glacier, exhibiting to us a bit of the earth's history and of the methods of making it, and the forces at work in past eras.

Just as the forest formed and spread thus during the course of ages, so does it form and spread to-day, unless man, driven by the increasing needs of existence, checks its progress and reduces its area by the cultivation of the soil. This natural extension of the forest-cover takes place readily wherever soil and climate are favorable, but it is accomplished just as surely, though infinitely more slowly, in unfavorable situations. On the naked rock, the coarse detritus and gravel beds, on the purely siliceous sand deposits of rivers and oceans, or in the hot, dry plains, the preliminary pioneer work of the lower vegetation is required. Algae, lichens, mosses grasses, herbs and shrubs must precede, to cultivate the naked rock, to mellow the rough gravel beds, to make the soil, to increase the soil moisture by shading the ground and gradually render it fit for the abode of the forest monarch. The army of soil makers and soil breakers, the pioneers, as it were, of the forest, are a hardy race, making less demand for their support

MUIR GLACIER FOREST

than those who are to follow. They come from different tribes, according to the climatic conditions in which they have to combat. As soon as they have established themselves, they begin their cultivatory activity, which consists in withdrawing from the rock or soil and from the air the nutritive elements, returning them to the soil when they die and decay in a form much more suitable for the support of the higher plants. Not only are thus, by the repeated growth and decay of these pioneers, the nutritive elements of the soil improved and augmented, but also the physical properties; the soil is deepened and becomes mellow and its capacity for moisture increases. The waters, charged with carbonic acid derived from the decay of the vegetable humus, hasten the decomposition of the underlying rock.

and thus also the fertile soil layers increase, until the more fastidious plants can subsist. The humblest workers, algae, lichens, cacti and mosses, are followed by sedges, dry grasses, herbs and shrubs, or, in the drier and warmer climates, by agaves and yuccas; then come ferns and other representatives of the lower vegetation, succulent grasses and herbs gradually covering the soil with a meadow or prairie, the shrubs become more numerous, by degrees closing up, shading the ground and overshadowing the grasses and finally the time is ripe for the arborescent flora. Nor does then the forest appear at once in its fullness and variety of form. Single trees,

FERNS, SCELERAT LAKE, ALGONQUIN PARK

Photo by Houghton W. Wilson.

stragglers or skirmishers in small numbers, and shrub-like, and stunted forms first arrive, gradually increasing in number and improving in form. These, by their shade and by the fall and decay of their foliage and litter, improve the soil for their betters to follow.

The Aspen is one of these fore-runners, which, thanks to its prolific production of light, feathery seed, readily wafted by the winds over hundreds of miles, readily germinating and rapidly growing under exposure to full sunlight, even now in the Adirondacks, the Rocky Mountains and elsewhere, quickly takes possession of the areas on which man has ruthlessly destroyed all vegetation by fire. This humble, ubiquitous, but otherwise almost useless tree, is nature's restorative, covering the sores and scalds of the burnt mountain side. Though short-lived, with its bright summer foliage turning into brilliant autumn hues, it gives grateful shade and preserves from the thirsty sun and wind some moisture for the better kinds to thrive and take its place, when it has fulfilled its mission.

In other regions, as on the prairies of Iowa and Illinois, hazel bushes, or, in the mountains of Pennsylvania and the Alleghanies in general, ericaceous shrubs, like the Laurels and Rhododendrons, or Hawthorn, Vi-

ASPEN LAKE, UTAH

burnum and Wild Cherry are the first comers, while along the water courses Alder and Willows crowd even the water into narrower channels, catching the soil which is washed from the hillsides and increasing the land area.

One of the most interesting soil makers, wresting new territory from the ocean itself, is the Mangrove along the coast of Florida. Not only does it reach out with its aerial roots, entangling in their meshes whatever litter may float about, and thus gradually building up the shore, but it pitches even its young brood into the advance of the battle, to wrestle with the waves and gain a foothold as best it may.

Not less interesting in this respect is that denizen of the southern swamp, the Bald Cypress, with its curious root excrescenses known as

Cypress Knees, which are most helpful in expediting change of water into land sufficiently dry to be capable of supporting the more fastidious in regard to moisture conditions.

Here we should note the remarkable adaptation to divers conditions of some of the tree species. Trees of the swamp, or at least many of them seem to indicate their independence of moisture conditions by the range of climate and soil in which they are found. In fact, they grow in the swamp, not because it is their most suitable locality, but because they are the ones that can do so, to the exclusion of other competitors. The Bald Cypress, in Lake Drummond itself, will grow in the dry soil and droughty atmosphere of Texas and Mexico; the Oaks, which associate with it in the

THE SKIRMISH LINE OF THE FOREST, ARIZONA.

swamp, will occupy almost any soil or site; the Red or Sweet Gum or Liquidambar, which has lately become an important lumber producer, is found in similar ranges of habitat; the same Juniper or Red Cedar which in the swamps of Florida is a large tree and makes the soft material for our pencils, covers also the driest ridges of the Rockies and Interior Basin west of the Rocky Mountains, with a gnarly growth and hard texture, supplying the most lasting poles and posts. Thanks to the taste of the birds for its berries, it finds ready dissemination over a wide field of distribution from New Brunswick to Florida and westward beyond the Rockies, forming with the equally frugal Aspen and Cottonwoods the very foremost advance guard of the forest.

The skirmish line of first comers, different ones in different climates, frugal in their needs, prepare the conditions for the more fastidious birches, elms, maples, ashes, oak, hickories, magnolias, spruces, firs, pines, and the whole host of the varied forest flora. Which of these will occupy certain territory depends in the first place on temperature conditions, and in the second place on moisture conditions of air and soil and the various combinations of these factors, which determine the geographical distribution of species.

As far as temperature is concerned, there is no highest limit, provided sufficient moisture be present. The forest of the tropics gives evidence of this fact. On the other hand, low temperature extremes set a limit to tree growth, as the northern tundras and the well-known timberline of high mountains show, varying in altitude according to latitude, i.e., temperature conditions.

As regards moisture, we have seen that many species live in the swamps of the South, with their feet in water for months, and their heads in a humid atmosphere all the year, while the plains and deserts, deficient in soil moisture and humidity of the air, are treeless, or at least forestless. Within these extremes we find species adapted to every clime and site.

As we go from the tropics to the pole, there is a change in the type of the forest with each change of climate. From the evergreen, broad-leaved forest of the tropics and subtropics, we may journey northward through the deciduous leaved forests of the Carolinas and Pennsylvania, of oaks, hickories, chestnut and tulip tree, or traveling along the Pacific Coast, through a mixed forest of firs, spruces, pines, in most magnificent development. Then (continuing our journey on the Atlantic side) we reach the Northern forest, in which maple, beech and birch are predominant, with spruce and white pine intermixed. Beyond, the number of species decreases, and generally coniferous growth predominates; finally only eight hardy species can take a stand against the frigid breath and icy hands of Boreas.

Finally, we reach beyond the 62° of latitude in the interior of Canada —in Alaska, much further north—the last outposts, short, tousled and dwarfed, the Exquimaux of tree growth. Then the treeless tundra is reached, where ice and snow abound all the year, the home of winter. ere the soil is frozen for all but two months in the year, when only a low vegetation of willow and birch and of flowers can subsist. Just as we observe these changes in a long journey, we can trace them in a day's ride, if we were to ascend some mountain in the tropic or sub-tropic regions of Mexico or Jamaica. We begin our journey under the palms. Again we pass through the evergreen tropic forest, composed of an endless variety of luxuriant species. As we ascend 2,000 or 3,000 feet the composition changes and we have come into the deciduous leaved forest, not unsimilar in general aspect to that of our middle latitudes. We reach a sandy plateau and find it occupied with pines and saw palmetto as underbrush, just as we see it in the Carolinas. As we ascend to the 5,000 foot level, we enter into the dominion of spruces and firs, and we may find the open meadows with a profusion of flowers. These openings, in Colorado and other parts of the Rockies, are characteristically called parks. Here a depression has filled up with water, forming a lovely mountain lake, with the spruces and firs in spiral shapes surrounding the shores, just as you find them in British Columbia at lower levels. Another 2,000 to 5,000 feet, and the forest opens as in our northward journey, the trees stand in groups, and the grass and flowers occupy intervening spaces, competing for the ground. As we pass out of this lovely park-like region, we come in sight of the peak and of the skirmish line of the forest; singly and in small groups the trees try to brave the blast, hugging the ground and each other for protection, tousled and dwarfed as their northern counterparts. Ice-laden with the frozen humidity of these high altitudes for months the branches break. This leads to misshapen form. Finally we have passed the timberline, where icy blasts and hard frosts occur every month in the year and hence no persistent life can exist; and, if we are quick about descending, we may again rest under the palms at night.

While, then, certain territory is assigned to the different tribes of tree species, which are adapted to the climatic and soil conditions, struggling to occupy the ground and to wrest it from the lower vegetation, there is by no means an end to the evolutionary struggle, for, as soon as the soil is conquered, the battle begins between the conquerors themselves. Though not fought with claws and teeth, the struggle is as fierce, as persistent and as disastrous to the one or to the other species as in the animal world, each trying to occupy the ground to the exclusion of the other. The weapons and the warfare are offensive and defensive, but relative endurance of one or more unfavorable conditions, adaptation to surroundings, insure mostly the final victory and secure the survival of the fittest. The characteristics of development from the seed to old age influence the character of the distribution.

Prolific and frequent production of light-winged seed, carried by the wind to all open spaces, germinating readily and growing rapidly, gives an advantage to the one species. The heavy nut of the walnut or acorn must wait for squirrels, mice, birds and water to extend its territory.

The seed of the willow loses its power of germination within a few hours or days; hence it is confined mainly to the borders of streams, where favorable opportunities for sprouting exist. The acacia and others of the leguminous tribe, like the black locust, preserve their seed alive for many years; nay, the seed of the former will often lie buried in the ground for years until a fire that destroys all other vegetation breaks their hard seed coat and calls to life the dormant germ; the cones of some pines remain closed, and release the seed only when fire, which has probably destroyed all competitors, opens them. The peculiarities of the seed, then, account for much in the distribution of plants.

Next comes the peculiarity of growth. The long-leaf pine, which, for the first four years, does not grow more than two or three inches above the ground, is at a disadvantage in that first period, during which it has occupied itself with forming a stout root system; but thereafter, by virtue of this root system, it may endure what a faster growing neighbor could not. The thickly growing aspen covers large areas, but its reign is of short duration, for, as with most of the rapid growers, its life is short. The slower growing spruce or pine, which could support itself under the light shade of the aspen creeps in, and remains on the field, the victor by sheer persistency.

While rapid, persistent height-growth enables these to escape the would-be suppressor, endurance of drouth or of excessive moisture, of heat or cold, and of shade favors others; windstorms and decay, in our primeval forests, acting as allies now to one, now to the other side, and thus changing the balance of power again and again.

In this struggle for supremacy between the different arborescent species, the competition is finally less for soil than for light, the most important factor of life, especially for tree growth. It is under the influence of light that foliage develops and that leaves exercise their functions and feed the tree by assimilating the carbon of the air and transpiring the water from the soil; the more foliage and the more light at its disposal a tree has, the more vigorously it will grow and spread itself.

Now, the spreading oak or beech of the open field finds close neighbors in the forest, and is narrowed in from all sides and forced to lengthen its shaft, to elevate its crown, to reach up for light, if it would escape being overshadowed, suppressed and perhaps finally killed by more powerful, densely-foliaged competitors. From the shape of the tree and of its crown we can judge whether it had to wrestle with neighbors. The important fact, which predicts the issue and the final result, is that the various species are differently endowed as regards their ability to tolerate the shade or as to the amount of light which they need for their existence.

Go into the dense forests and see what kinds of trees you find there in the deep shade, 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. 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, willow, soft maple, oaks or pines, tamarack, etc.

All trees ultimately thrive best in full enjoyment of light and then only develop their characteristic form. But, just as some species can adapt themselves to excess or deficiency in moisture conditions, so some can subsist and even thrive with less light than others, and we can classify and grade the species accordingly into tolerant or shade-enduring and intolerant or light-needing.

The dense spruce and fir forest shows by the number of trees that can occupy an acre the capacity of the species to thrive in the shade of neighbors, while the open pine forest gives an indication that the species requires larger amounts of light to thrive.

The densely-foliaged crown of the hemlock, with the branches beset with leaves into the very interior, attests its extreme shade endurance, while the light-foliaged, open-crowned larch or poplar, ash or birch, or even pine, show their extreme sensitiveness to the absence of light by the very openness of their crowns, by losing their lower branches early and by the inability of their seedlings and young progeny to endure the shade of neighbors or even of their own parent trees.

To offset this drawback in their constitution, they have usually some advantage in the character of the seed and are mostly endowed with a rapid height growth in their youth, so that, at least when the competition for light starts with even chances, they may secure their share by growing away from their would-be suppressors. They can keep themselves in a mixed forest only by keeping ahead and occupying the upper crown level, as the White Pine does. The tolerant species, on the other hand, able to thrive in the shade of light-foliaged species, usually increases more slowly in height; but their capacity of shade endurance assures to them a permanent place in the forest.

Many of them are characterized by a height growth which, though slow, is persistent; while the light-needing species, by falling behind in their rate of height growth, often lose in the end what they attained in their youth. As a result the shade endurers finally become dominant and the light needers occur in the mixed forest only sporadically, the remnants or single survivors of groups, all the outside members of which have perished; and only when a windstorm or insect pest creates an opening of sufficient size is a chance for their reproduction given.

Thus the composition and general appearance of the mixed forest is largely influenced by this difference in light requirements of the species present and its numerical make up also depends upon the requirements by each individual and its capacity to get ahead of its neighbor.

Just as in the mixed forest the species are distributed according to their shade endurance, so in the pure forest of one species, or of species of equal tolerance, will the different-sized or different-aged trees develop side by side according to available light, each crowding the other, the laggards being finally killed by the withdrawal of light.

The victory comes to those, who by virtue of inherited superior vigor or owing to the chance of finding better soil, domineer the community, just as in the human world the weakest are driven to the wall.

But, finally, even these victors must give way, for, as Hercules, the unconquerable, succumbed to the poison that penetrated to his bones, so do the mighty giants of the forest fall a prey to the insidious work of rot and fungus and insects and storms. When its heart is riddled and weakened, first the dry branches crumble and gradually give opportunity for the young aftergrowth of shade-enduring kinds, waiting patiently for light, to strengthen; then break the large limbs and the dry top, and, having weathered the onslaught of the storms for centuries and the guerillas of the fungus tribe for decades, finally the giant falls, with its decaying substance enriching the soil for future generations. Into the breach rush the young epigones, each struggling to supplant their progenitor and to preserve the forest.

It is in consequence of these changes in light conditions that the alternations of forest growth take place, oak following pine, or pine following oak; poplars, birches, cherries, apearing on the sunny burns, and spruce, hickory, beech and maple creeping into the shade of these light-needing species and, in time, supplanting them.

While, in the Eastern forest, under natural conditions, the rotation of power is accomplished in from 300 to 500 years, the old monarchs of the Pacific, towering above all competitors, have held sway 2,000 or more years. And, in this warfare, with changes in climatic and soil conditions going on at the same time, it may well occur that a whole race is crowded out and exterminated. The virgin forest, then, is the product of long struggles, extending over centuries, nay, thousands of years. Some of the mightiest representatives of old families, which, at one time of prehistoric date, were powerful, still survive, but are gradually succumbing to their fate in our era.

The largest of our Eastern forest trees, reaching a height of 150 feet, and diameters up to 12 feet, the most beautiful and one of the most useful —the Tulip tree (Lirodendron)—is a survivor of an early era, once widely distributed over the world, now confined to Eastern North America, doomed to vanish soon from our woods owing to man's improper partisanship. Others, like the Torreyas and Cupressus, seem to have succumbed to a natural decadence, if we may judge from their confined limits of distribution. The colossal Sequoias too, remnants of an age when things generally were of larger size than now, appear to be near the end of their reign; while the mighty Taxodium, the Bald Cypress, the Big Tree of the East, still seem vigorous and prosperous, weird with the grey Tillandsia or Spanish moss, being able to live with wet feet without harm to its constitution.

So far we have considered the evolution of the forest only from the geographical and botanical point of view, and the history of its struggle for existence against the elements and against the lower vegetation and other forces of nature. A new chapter of its life history, a new relation, a new point of view, began when man came upon the scene, and finally man has become the most influential factor in the evolution of the forest, changing it in composition and character of development.

FELLING TIMBER.

LECTURE V.

SILVICULTURE, OR METHODS OF FOREST CROP PRODUCTION.

The main business and concern of the silviculturist is contained in the reproduction of the wood crop, and his one obligation is that he must reproduce the crop which he has harvested in any year.

As the farmer sows and reaps so the forester harvests and replaces, although the methods of the two have little in common; nor are the methods applicable which are used by the orchardist or the landscape gardener. The tree which satisfies these does not at all satisfy the requirements of the forester, for his point of view, his aim, is a different one, and hence his methods are his own. In fact, single trees are not his object any more than the single grass-blade is the object of the farmer; the largest amount of wood in the most saleable and profitable form is his aim, logs rather than trees, and the financial results from their harvest. The final aim of the silviculturist is, therefore, attained only when he has removed the old trees and replaced them by a young crop. He grows trees in masses and for their substance. Not only does he deal with trees in masses, but with trees in natural conditions, being by financial considerations often limited in the use of artificial aids and methods, such as the other tree culturists and the farmer in his crop production may employ.

Restricted as he is, or finally will be, to the poorer soils and conditions, those least favorable to agricultural production, he is forced to the most conservative management of the natural conditions in order to secure a desirable result without too much expenditure, which his long-maturing crop cannot repay.

In every productive industry there can be recognized two branches:—namely, the business branch and the technical branch.

The silviculturist is the one who handles the technical branch of the business, namely, the production of the crop or material.

The technical branch is divided into several sub-branches, the chief among which are:—Silviculture, Forest Protection, Forest Exploitation. Silviculture is a branch of arboriculture. Forest Protection is the art of protecting the forest from adverse agencies such as fire, storms, pests, etc. Forest exploitation is the art of harvesting the forest growth to the best advantage.

It is incumbent upon the silviculturist to secure continuity of favorable conditions in order to secure continuity of the crop. The forest manager who looks after the revenue may often be found at odds with the silviculturist, the pocket interest preventing the ideals of silviculture.

The character of the wood crop differs from that of the agricultural crop, especially in the fact that it takes many years before it can be harvested. If the agriculturist makes a mistake in planting one year he can rectify his error the next year, whereas the forester can never rectify any such error until the next crop. Therefore it is necessary for the silviculturist to make closer study of the life history of his material than the agriculturist needs to make. He must be more circumspect in planning his crop, so that it will become self-sustaining.

The silviculturist, as before noticed, must make a selection from the 300 to 500 species of trees that occur naturally with us, to grow. He must grow those varieties which are reasonably sure of a market when they mature. These 500 species may be divided into those which are useful and those which are but tree weeds. What is a weed? It is a plant the use of which has not been found out yet. In order to select those species which we are going to reproduce we must have a relative value of the various species established. A glance at the market reports shows us that not more than 70 of these 500 species are being used and sold. Changes; however, will occur. Some species will fall into disuse, and other species that are now in disuse will become their substitutes. The case of the Hemlock might be cited as an example. The silviculturist must therefore forecast the future. One thing we are fairly sure of is that the timber at present in use in largest quantity will be sure of a market in the future. Among this last class we can place the conifers and especially the white pine, which furnish the bulk of our lumber. We must also suit our trees to the climatic conditions of the country, there being little chance for acclimatizing them, hence native species are mostly preferable. The choice of soil must also be considered. The trees rely less upon the mineral constituents than upon the physical conditions, and hence we relegate the best soil to the agriculturist. Water, however, is the important factor, and thus the silviculturist tries to secure favorable water conditions, the depth of soil being of much importance in this respect, especially with deep-rooted species.

Other considerations also influence his operations, such as the preservation of soil and moisture, which is the most essential contribution of the soil to tree growth, and which requires the soil to be kept shaded.

In fact, there is nothing that a forester guards so jealously, next to the light conditions at the crown, as the soil conditions: A soil free of weeds and grass and covered as amply as possible with a heavy mulch of decaying leaves and twigs, and if this best protection of the soil moisture be deficient, a cover of shrubby undergrowth which requires less water than weeds and grass—this is the character of a desirable forest floor.

Altogether it will have appeared from the previous study of tree growth and forest development that the entire silvicultural operations with an established crop resolve themselves into one, namely, proper management of light conditions, which is secured by the judicious use of the axe.

Let us now examine the best way of forming a forest. A mixed stand is best for all purposes, but it requires more skill in its management. In a mixed stand we combine the tolerant and intolerant varieties, the deep-rooted with the shallow-rooted varieties, thus using all the available root and air space. This arrangement is also a protection against insects, fires, winds, snow and other destructive agencies, and, moreover, such a stand furnishes a varied product.

There are two methods of starting a crop: artificial re-forestation and natural regeneration, secured by the proper use of the axe. In harvesting the old crop the new crop may be reproduced.

Most of our deciduous trees will sprout and thus replace their fore-runners by a *coppice* growth, consisting of sprouts from the stumps. The simplest and crudest method of reproduction which results naturally when the old hard woods are cut, is applicable only to the broad-leaved trees which are capable of producing valuable shoots in this manner. The capacity for sprouting is possessed in different degrees by the different species and is more or less lost by all in old age; and especially after repeated harvests the stumps become exhausted and die, so that the forest is apt gradually to deteriorate in composition as well as in density, unless fresh blood is added by reproduction from seed. Thus in Pennsylvania, where the system has been in vogue for a century or more to furnish charcoal for the iron furnaces, the valuable white oaks and hickories have been crowded out by the chestnut, which is a superior sprouter.

Another disadvantage of this coppice system, under which the woodlands of deciduous trees in almost all New England and Atlantic States are produced, is that, although the sprouts develop much faster than the seedlings from the start, they soon fall off in their growth, and are capable merely of furnishing small dimensions and firewood. The coppice, therefore, is useful only for certain purposes, but cannot be relied upon to furnish material for the great lumber market.

The deterioration consequent upon the continued application of the coppice is best studied in Italy and in certain parts of France where serviceable timber is almost unknown, and fagots of small firewood are precious articles.

All other methods of regeneration, both artificial and natural, depend ultimately upon the use of seed. In order to reproduce with any degree of success the silviculturist must secure good seed, good seed bed, good light, and good protection for his seedlings. The choice of method depends upon financial as well as silvicultural considerations.

In protection forests and luxury forests in which the requirement of a continuous soil cover may be paramount, methods in which the old crop is very slowly removed and replaced by the new crop are indicated, even if financial and silvicultural results would make other methods desirable.

In supply forests the cheapest method which secures desirable proportionate results in the crop is to be chosen. This must vary according to local conditions, such as climate, soil, species, cost of planting and of logging.

The clearing process followed by artificial replacement entails a money outlay for the latter from year to year; the gradual removal methods with natural seeding avoid, to be sure, this outlay, but since, to secure the same amount of harvest, a larger territory must be cut over, they entail large initial investment for means of transportation, which must be maintained for all the years of removal and they occasion also otherwise greater expenses in the harvest than the concentrated logging in the clearing system, which may be done over temporary roads.

Over 80 per cent. of the forests of Germany are managed under a clearing system and rapid removal systems, and only 20 per cent. under slow removal and other systems.

Where, as in our culled forests, the valuable species have been removed and the weed trees have been left in possession, it stands to reason that no regeneration method will re-establish the better species; they must be restored by artificial means.

These slow removal methods consist in opening small spaces or narrow strips so as to prepare the soil and let in sufficient light to cause the germination of the seeds which fall from the trees left standing.

Trees seed only in periods, for example, the white pine seeds only every three or five years, and we must know when the seed year is going to occur. Some species have seeds every year, and if they are not desirable we must cut so as to get rid of them.

In our virgin woods the seedbed often is undesirable. The litter must be decomposed to furnish a good seed bed so that the tiny fibrous roots of the seed may reach mineral soil. Some species require more light than others in youth, and hence the parent trees must be removed more or less rapidly.

One of the simplest methods of regeneration is the strip method. This consists in cutting a strip of trees from the land in such a way that the wind will blow the seeds from the trees standing on to the cut part. Another strip is cut the next year, and so following. Another of the crude methods is an improvement on the lumberman's method of cutting old trees here and there and thus giving light to the young volunteer aftergrowth; the so-called "selection" method. The lumberman culls, to be sure, only the trees he can use, but the forester works from the standpoint of the young crop, i.e., he cuts with a view to the best interest of the young crop. The best method, where practicable, consists in the gradual but more rapid removal of the whole crop so that the young crop will have a clear new field to start on.

NURSERY, CORNELL COLLEGE FOREST, ADIRONDACKS.

In this so-called "nurse-tree" method the periods of cutting must receive consideration. A preparatory cut secures better seed production and also a better seed bed and better light; the next cut is made to secure full seed production; this is followed by two or more removal cuttings, as the young crop demands; until finally, in 3 to 20 years, the whole old crop is removed.

In Germany, over 50 per cent. of the reproduction is done by artificial means, and this is found to be most satisfactory. After the crop is produced there is still a chance of improving it by accelerating its development. It is possible to increase the production 2 to 3 fold by a proper use of the axe.

As in the natural methods the axe is the only tool which is used to secure the regeneration, so is the axe the only tool which cultivates the young crop, such cultivation consisting in the judicious removal of surplus trees

GERMAN SPRUCE FOREST.

by the so-called thinnings, by which the quantity and quality of the crop is increased. To understand this, it is necessary to know that trees form wood by the function of the foliage under the influence of light.

Hence, a tree with much foliage and unimpeded access of light is bound to make much wood. These conditions are fulfilled when the tree is allowed to grow in open stand, as on a lawn, without close neighbors, who would cut off some of the light supply.

But trees under such conditions grow mostly into branches, the crown being developed at the expense of the bole, which remains short and more or less conical in shape, of little commercial or technical use, except for fire wood. When the trunk is sawn into boards, every branch appears as a defect, known as a knot, which makes it unfit for use in the better class of work, and thus while the total quantity of wood in the tree is increased by the open stand, it is done at the expense of quality.

The object of the forester, however, is not simply to grow wood, but to produce wood of such form and quality as is useful in the arts. The ideal tree for him is one with a long, cylindrical, branchless trunk, bearing its crown high up, which when cut into lumber produces the largest amount of material clear of knots, of straight fibre, and giving the least amount of waste or fire wood.

His aim, therefore, must be to so place his trees that, while the largest possible amount of wood shall be produced, it shall be deposited in the most useful form also.

By a close position, when each tree cuts off the side light from its neighbors, the formation of branches is prevented, or the branches which were formed, being overshadowed, soon lose their vitality, die, and finally break off, leaving the shaft smooth, and, if this clearing was effected before the branches had reached considerable size, the amount of clear lumber is increased.

But again, if the trees are kept too close, if too many trees are allowed to grow on the acre, each one having the smallest amount of foliage and light at its disposal, the amount of wood produced by the acre may be fully as large as it is capable of producing, but it is distributed over so many individuals that each develops at the very slowest rate, and hence does not grow to useful size in the shortest time.

To secure his object, producing the largest amount per acre of the most useful wood in the shortest time, the forester must know what number of trees to permit to grow so as to balance the advantages and disadvantages of close and open position.

This number differs not only according to the species composing his crop, but also according to soil and climatic conditions and to the age of the crop.

Some trees having considerable capacity of enduring shade, like the beech, sugar-maple, or spruce, may require many more individuals to the acre than the more light-needing oaks and pines; on richer soils fewer individuals will produce satisfactory results, when on poorer soils more individuals must be kept on the acre. The question of the proper number of trees to be allowed to grow per acre at different ages is one of the most difficult, on which practitioners differ widely.

In general, however, the practitioner has recognized the necessity of preserving a dense position for the first twenty to thirty years of the young crop, sacrificing quantitative development to quality and form. The close stand secures the long, branchless, cylindrical trunk, which furnishes the clear saw-logs of greatest value. Then, when the maximum rate of height growth has been attained, a more or less severe thinning is indicated, in order to secure quantitative development, and these thinnings are repeated periodically, to give more light as the crowns close up, and also to utilize such of the trees as are falling behind in this wood production.

As a result of judicious thinnings, the rate at which the remaining crop develops may be doubled and quadrupled, the heavy, more valuable sizes are made in shorter time, and, where the inferior material removed in the thinnings is salable, a much larger total produce is in the end secured from the acre, for many of the trees which were removed and utilized would have died, fallen, and decayed in the natural struggle for existence.

In German forest management the amount utilized in thinnings amounts to 25 per cent. and more of the final harvest yield.

While the crop is developing it is, of course, necessary to protect it against damage of various kinds. The young seedlings of some species are apt to suffer from frost or drouth, which is avoided by growing them under shelter of older trees, by draining wet places, securing opportunity for cold air to draw off, etc.—mostly preventive measures. In prairie and plain it may be possible to assist their resistance to such damage by cultivating the ground as the farmer does, but in the real forest country such means are excluded by the character of the ground and the expense.

Animals, and especially insects, are frequently injurious to the new crop, and insects also to old trees, by their defoliation. This damage, too, can be largely obviated by preventive measures.

Since many, if not most, injurious insects feed on one species, or at least one genus, mixed forests resist their danger better, since the number of host plants is reduced and the intermixed trees impede progress and development of the pest.

Wind-storms are a danger to older timber, especially of shallow-rooted species, like the spruce, and on soft soils and exposed slopes or mountain tops. Here, care must be taken in keeping the stand well thinned, so that the trees may get accustomed to the swaying of the winds in more open stand. In this way they are induced individually to form a better root system and become wind-firm, while in the dense stand their strength was only in the union with neighbors.

The greatest danger to forest properties, however, is fire, and the protection against this most unnecessary evil resulting mainly from man carelessness, absorbs a large part of the energy of the forester. Proper police, but also silvicultural measures, reduce the amount of danger and damage. Young crops, during the seedling and brushwood stage, are readily killed, while older timber may stand scorching without much or any damage.

A damage even greater than the loss of the crop is experienced in the loss of the soil cover, the litter and duff, which is the forester's manure. This loss may become irreparable in localities where only a thin layer of mineral soil overlies the rock, and the opportunity for starting a new crop may be entirely destroyed. The fire danger in Canada, while much reduced, is still so great that in many localities it almost prohibits the practice of forestry; for who would want to invest money and energy in a property which is exposed to extra risks from fire by the absence of proper legislation, or by the lack of police and moral support on the part of the community in enforcing it, by the unpunished negligence or malice of incendiaries, and by the populational conditions of the country, which prevent the economical disposal of the debris from logging operations?

Partial burning and piling of the brush reduce the danger somewhat, but hardly in proportion to the expense. The readiest remedy, where forestry is to be praticeu under such conditions, is to make a clean sweep, that is, clearing, burning up the debris, and replanting, or else, if natural regeneration is to be relied upon, adopting the strip system, when the opportunity of burning the debris totally is still possible.

The only hope here, in the absence of a paying home market for fuel from the inferior material, is to establish chemical works for its conversion on a large scale into charcoal, acetic acid, wood alcohol, and other useful manufactures.

In fact, the application of silviculture, i.e., the systematic production of wood crops as a business proposition in our culled, mismanaged woodlands throughout Canada is, in most cases, possible only where the means exist of utilizing this inferior material; for the risks from fire are too great, or else the cash which would otherwise have to be spent in making room for the young crop will surely exceed reasonable proportions. Only the state or other long-lived corporations can afford to spend money now in the hope of adequate returns in a distant future.

Forest crop production as a business, silviculture, will become practicable and profitable in this country only when reasonable forest protection is assured by proper exercise of state functions.

Until this is secured, lumbermen will continue to exploit the natural forest without much regard to its fate after they have secured its present valuable stores, for they cannot afford to assume the hazard of the fire danger.

Before positive silvicultural methods are applied by them, they may find it advantageous to cut the virgin forest more conservatively; they may find that it pays in the long run better not to cull too closely, that it is advantageous to leave more of smaller sizes, i.e., to limit the diameter to which they remove trees, so that they may return sooner for a second cut, and also to avoid unnecessary damage to the young volunteer crop. At present the limitation of size to be cut or to be left uncut is based upon calculations of immediate profits to be derived, and does not take into account any future considerations, since the lumberman does not cut with a regard to the future, but attempts to secure the largest present gain. He views the forest as a mere speculation. To curtail his present revenue for the sake of a future revenue by abstaining from cutting all that is marketable is the first step toward changing this point of view, introducing the idea of continuity, and treating the forest as a permanent investment.

It must be understood, however, that the limitation of the size of trees to be cut or to be left uncut has not necessarily any bearing on the replacement of the crop; it is not silviculture. It is in the main a financial measure, it being demonstrable that it pays better to leave small sized trees to accumulate more wood before utilizing them; or else a device to prevent over-cutting of a valuable species, so that it may not be eradicated too soon, a wise measure whenever systematic attention to positive silviculture cannot be given.

RAPIDS, UPPER MADAWASKA

Photo by Houghton W. Wilson.

LECTURE VI.

LUMBERMAN AND FORESTER.

All the great diversity of activities, of industries, of commodities, of sources of wealth which characterize the modern civilization and give employment to the millions, have their origin more or less directly in that primary source of wealth and comfort, nay of life itself, the soil.

And next to it stands water: Water is the best thing, sang Pindar of the Greeks.

But without soil to use it, it is of little avail. And yet again, soil without water to support useful plant production would be an empty treasure, for it is water that makes the soil available. So intimately are soil and water connected that the one cannot be disassociated from the other. Just as in a chemical compound, inert and separately useless or obnoxious elements, combine to form active, most valuable and beneficent bodies, so does water and soil impart, each to the other, its value by their combination.

Soil and water, then, are man's richest treasure, and if he be rational he would guard them more than any other sources of material wealth and use them with discretion; yet in all countries and in all ages man has been careless and wasteful of these most important bases of his well-being. He has squandered them lavishly, has allowed them to dissipate and to slip away or to be destroyed, seemingly in utter ignorance of their important bearing; whole peoples have been impoverished, practically wiped out through mere neglect or abuse of these primary sources of wealth and through ignorance as to the conditions and relations influencing their preservation.

"Man goes over the earth and leaves a desert behind him." "Precisely that portion of the earth's surface which about the commencement of the Christian era was endowed with the greatest superiority of soil and climate is now completely exhausted," says Geo. P. Marsh, in his classic volume, "The Earth as Modified by Man." "A territory which in bygone centuries sustained a population scarcely inferior to that of the entire Christian world at the present day has been brought into desolation almost as complete as that of the moon."

Nor is this destruction of naturally favorable conditions confined to that portion of the earth and that era. We can trace it over the globe and through all ages, progressing only less intensely and now arrested here and there by intelligent man.

It has been reserved for the present era, with the development of natural science, to find and appreciate the reasons for this loss and deterioration of our great sources of wealth; and finding the reasons, to suggest the remedy and prevention of further loss.

We have learned only in modern times to appreciate that all things are in relation, that, therefore, we cannot take away anything from the complex conditions of nature, that we cannot destroy or modify one condition, without affecting more or less all other conditions.

With regard to the soil, we have learned that its stability and its fertility are in most direct relation to the water conditions and the topography of the land. But a third important factor that enters into the problem of the conservation of the soil and of water is its cover. This was perhaps most definitely expressed by that great exponent of natural philosophy, A. v. Humboldt, when he exclaims in his Cosmos: "How foolish does man appear in destroying the mountain forests, for thereby he deprives himself of wood and water at the same time"; and he should have added: Of soil, also!

The importance of the forest cover of the earth has only lately been fully realized, not only as a furnisher of a material most needful to civilization, next to food, but because of its relationship to soil and water conditions.

Last night we learned how forests form and change in their aspects under the laws of evolution without the interference of man.

To-night we propose to take up the history of the forest at the time when man came upon the scene and became a factor in the further evolution of forest growth.

The history of the forest in all parts of the world has been the same.

During the age of the hunter—and these ages are not separated by long distances of time, but occur simultaneously in different parts of the world—the forest served as a harborer of the game besides furnishing the small amount of fuel needed.

Perhaps, too, portions of it were carefully burned over to subdue the undergrowth and facilitate the pursuit of the game without destroying the shelter.

When the hunter became a farmer portions of the better soils had to be cleared of their forest growth for fields and pastures, and increased demand for wood materials to construct barns, sheds and stables, and for family use necessitated further inroads upon the neighboring forest. Fires used in the clearing of farm lands probably often ran beyond their boundaries through carelessness and harmed the forest more than the hunter's fires.

Finally, when the age of modern civilization arrived, cities were built and demands for wood materials arose beyond the needs of domestic uses, the first lumberman found his calling, cutting and marketing the crop of timber, which he found accumulated in the virgin forest.

At first carried on in a crude manner, the exploitation was confined to the woods along the water courses and along the seashore, where ready means of transportation were at hand, but with the growth in population, in civilization, in industrial activity, the development of railroads and improved means of transportation, the need for forest products grew, and the art of the lumberman and the wood-worker experienced the wonderful development we know to-day, so that in magnitude of interests the business of exploiting the forest, manufacturing and purveying its products is next to the business of producing and handling food materials, the largest in all fully civilized countries.

I have dilated yesterday on the enormous and ever increasing needs for wood materials in our modern civilization, but in order to accentuate the great importance of the business of the lumberman, the necessity of his existence, I am tempted to add just one way of stating what the lumber business means in comparison with other interests, at least to the people of the United States, and I dare say a similar comparison could be made for Canada, a comparison which was made on the basis of the Census of 1880 by Prof. James, but holds probably still approximately true:

LOG JAM, MADAWASKA.

Photo by Houghton W. Wilson.

"If to the value of the total output of all our veins of gold, silver, copper, lead, zinc, iron and coal, were added the value derived from the petroleum wells and stone quarries and this sum were increased by the estimated value of all steamboats, sailing vessels, canal boats, flat boats, and barges, plying in American waters and belonging to the citizens of the United States, it would still be less than the value of the annual forest crop by a sum sufficient to purchase at cost of construction all canals, buy at par all the stock of the telegraph companies, pay their bonded debts and construct and equip all telephone lines in the United States. It exceeds the gross income of all the railroads and transportation companies, it would pay the indebtedness of all the States, counties, townships, school-districts and cities included, excepting New York and Pennsylvania." What do we conclude from these considerations and facts? That the lumberman, the purveyor of these forest products, is a most necessary and important factor in our civilization, that the Arbor-day oratory of "Woodman, spare that tree," with opprobrium thrust at the wood-choppers is puerile and inappreciative of the proportions which a reform in methods of forest exploitation must assume.

KATCHEWANOOKA LAKE.

Photo by Houghton W. Wilson.

I have shown you these illustrations of the activities of the lumber trade to impress you with the fact that forests grow to be used, trees must be cut to supply our needs of wood materials, wood-choppers and lumbermen must be active; only one other activity is to be added to theirs; that of the forester, modifying their manner of cutting and of using the forest. Both forester and lumberman are in the business of providing our requirements for wood materials, both are concerned in the utilization of the forest, both are harvesters, but while every forester must be a logger, the logger does not proceed in the same manner as the forester.

The difference between the logger and the forester is that the former is a harvester of nature's crop, an exploiter of the natural resource, cashing the accumulated wood capital, a mere converter into useful shape of a crop to the production of which he has contributed nothing and to the reproduction of which he does not give any thought, while the forester is a producer of wood crops, just as the farmer is the producer of food crops; when he harvests the naturally grown wood crop it is with the view of reproducing again and again systematically another crop from the same ground. The main difference, then, between forester and lumberman is their *attitude towards the future.*

The lumberman treats the forest much like a mine from which he removes the pay-ore, leaving the less valuable rest to its fate and nature's care. To him the forest is not an investment but a speculation from which he tries to withdraw as soon as possible both capital and profit. Hence, all his appliances, his camps and shanties are only temporary structures which he allows to collapse or which he removes when he has cut out what will pay him at present to take.

His roads, if he makes any, intended only for temporary use, namely, until the present harvest is secured, are made as cheaply as possible. In many parts they are passable only in winter time, when snow has covered the uneven ground and by means of water sprinklers an ice road can be secured.

Even the railroads, the modern means of conveying the harvest to main lines and to mills, are only roughly built, for they are in a few years to be abandoned or shifted, unless their location is such as to warrant their change into regular carriers.

The harvest is made without regard to the fate of the young growth present or any possible aftergrowth, the interest of the logger being only in the present. There is often little care and thought given to a thorough utilization of even the valuable parts, but certainly whatever is not saleable at present, is neglected, despised, destroyed. We do not say ruthlessly, or recklessly, which implies absence of all reasonable consideration, for the logger reckons and he has ruth or regret—he reckons, however, only from one point of view, namely, that of present profits, and he regrets merely that there is not more profit to be had from the part destroyed. Whatever curtails profits must be avoided, cheap production of the harvest is his only hope of satisfactory margin; his business is to reap the present harvest, and only that part which pays; the future must take care of itself. The standpoint of the logger is properly and consistently chosen, whatever may be the point of view of the economist.

The lumberman, like any other business man, chooses first of all or altogether to consider his private pocket interest, which lies in the present; he cannot afford or does not choose to include a distant future in his calculations, for the future belongs to others.

What is the result of his operations in the forest?

Since nature produces mostly mixed forest and does so without any economic considerations as to composition, quality and quantity, producing weed trees with the valuable, old and young, large and small, the merchantable with the unmerchantable, in careless mixture, and since the lumberman takes only the desirable kinds and the best sizes, cutting here and there, his operations may leave the forest in such a condition that a layman may not even see a change has taken place—the forest cover is hardly interrupted, the few trees taken are not missed, the debris soon decays, and seemingly no damage is done. This is often the case where a hardwood forest contains a few conifers, and these alone are taken. If the desirable kinds are more frequent, and hence the openings larger and more frequent, the debris more plentiful, the interference becomes more readily visible. Finally, where, as in the pineries, in the Redwoods, in the coniferous forest generally, the mercantile kinds and sizes cover the ground nearly entirely, the lumberman's selective cutting becomes almost or entirely a clearing, a real denudation.

In each of the three cases, there is one damage that is likely to result, namely, an undesirable change in aftergrowth.

If, as is customary, he culls from the mixed forest only those species which are useful to him, and leaves in possession the less desirable, the weeds, these necessarily provide for the succession of their own kind. If it be a shade-enduring species which he values, like the spruce, its reproduction may still be possible, provided the openings are large enough, and enough seed trees are left to provide the new progeny, although necessarily the amount of the useful reproduction must be curtailed. If it is a light-needing species, like the white pine, that he has culled, its reproduction is practically prevented in many cases by the mere presence of the unused portions of the stand. In the competition with other, especially shade-enduring, trees, the light-needing species is placed at a disadvantage and disappears from the woods, unless man himself actively assists in its re-establishment.

If he clear the entire native growth, but leave a neighboring stand untouched, the species with light-winged seeds and capable of developing in full sunlight without the protecting shade of mother trees, will soon recover the bared ground.

If he remove all that he desires and destroy the rest by fire, the re-establishment must pass through nearly all the phases of evolution, which the virgin woods had to pass. Where the denudation had been complete, the lower vegetation of weeds and brush must occupy the ground first, and only after long struggle can tree growth re-establish itself.

Thousands of acres are in this condition; wooded, sometimes densely wooded, but the value gone, from the supply point of view. With the timber of present value gone, the interest of the lumberman is gone, and with the slash left on the ground and the carelessness to which our people are bred with things that are apparently useless, the almost unavoidable sequence in such slashings is the forest fire.

While the direct damage to the future which the lumberman inflicts by his harvesting process, in reducing valuable aftergrowth, is considerable, it is altogether small in proportion to the much greater indirect damage which is the consequence of these fires. And here again let me impress you with the thought that, from the standpoint of the community, the least damage of these fires is the destruction of the standing timber, although many millions of dollars worth of timber are annually destroyed; the much greater damage is that to the future, to the coming generations. A light fire running over the ground, if it were confined to the slash itself, during a season when it is burning with the least fury, as in the early spring when snow is still on the ground, might be even a benefit in reducing the brush and thus giving better chance for an after-growth. But usually these fires start at the most dangerous season, dry and drouthy, and are not confined, but run into the green timber. In the deciduous-leaved forest they run slowly, injuring the mature trees at the base and causing decay to set in, which may finally result in death. In the coniferous forest, some species, with a thick bark, will withstand a light running fire without injury, but usually in dry seasons the timber is killed outright, and if not cut at once, insect pests, the secondary result of forest fires, will finish it. In many cases the first fire does only partial damage, but a repetition is then so much more disastrous, and finally, with windstorms throwing the damaged trunks, the repeated fires not only clean up all the timber, but burn up the surface soil itself, at least the fertile surface portion of it.

The carelessness of hunters and farmers continues, burning over again and again the scanty vegetation until finally the bare rock is reached and nothing grows—a man-made desert is the result.

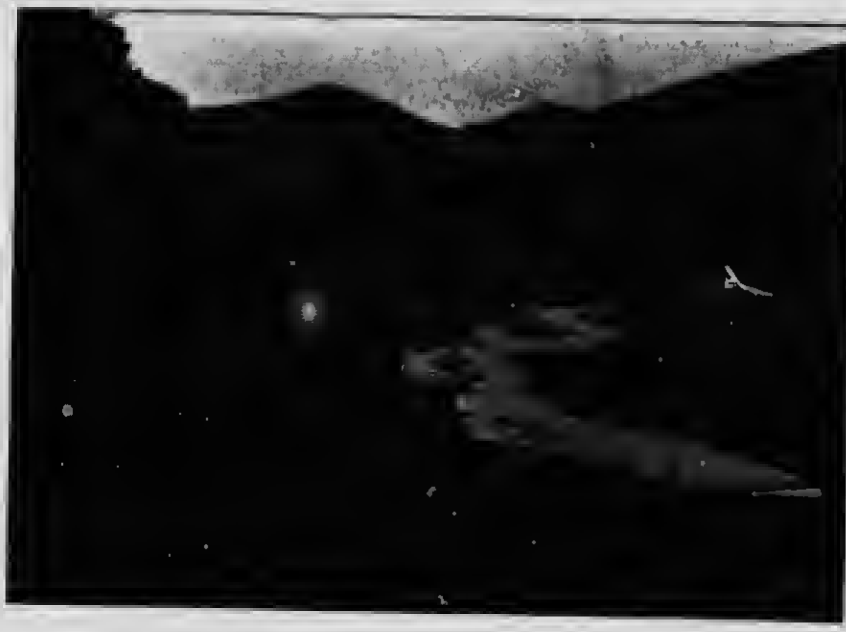
In Wisconsin at least 8 million acres have thus been reduced to waste and now efforts are being made to recover the land by reforestation.

Erosion of soils, landslips filling rivers, floods, and drifting sands, are some of the consequences of this devastation.

One evil which has hardly ever been pointed out is the increase of windfalls. By opening up the forest, the trees which had learned only to stand up in union, become exposed directly to the sweeping winds and are laid low. Insects follow.

MAN MADE DESERT.
Burnt slope after seven fires.

MAN MADE DESERT.



SOIL EROSION.

That all young after-growth falls a victim to the forest fire, be it ever so slight, stands to reason, and, with the changes in condition of the soil, the soil cover, and the light conditions in the crowns, a growth of valueless species, shrubs and tree-weeds occupies the ground.

The lumberman, then, in so far as he supplies us with the necessary wood materials, is a legitimate factor in our civilization; in so far as by his methods he destroys, indirectly or directly, the soil, the after-growth, and the chances for re-habilitating it, he is from the standpoint of political economy a dangerous element, at least to future generations. We must, to be sure, admit that peculiar economic conditions have forced his methods upon him, and he is left without proper assistance in reducing the danger, by lack of proper appreciation of the damage inflicted, on the part of the public and the state authorities which alone are the representatives of the community and should especially guard the interest of the future.

Not until this appreciation of the duties of the community has led to proper effort in reducing the fire danger, is there hope in changing the methods of the logger materially; not until forest properties are rendered comparatively safe from incendiarism will it become rational and practicable to apply forestry methods to their management.

The forester also is a lumberman; he, too, harvests his crop; his business, too, lies in supplying wood materials to the community, as you may see in the German forest. The only difference between lumberman and forester is that the latter must provide for a new crop as valuable, or more so, than nature made it.

You will see that the forester is not after the beauty, but after the substance of the tree; he, like the logger, uses the axe to harvest the crop, nay he utilizes the forest even more closely than the lumberman; for he must in some way make use of the inferior kinds and parts, the tops and branches, and even, if necessary, he must spend some money in making useful or else removing the brushwood. This is often impracticable, and by so much the forester is impeded in his main business by the economic and market conditions. He must do some "dead work," in order to create conditions favorable for his main business, and his main business is to secure a new and better crop of wood from the same soil for the future. He is not satisfied with the mere harvest of what nature has accumulated, leaving it to nature to do as it pleases in replacing the harvest; but he feels himself obligated to provide systematically for a future and better crop than nature alone could produce.

The forester's song is not "Woodman, spare that tree," but "Woodman, cut that tree judiciously," so that a new generation may arise where it stood.

Under the forester's care, then, the trees will be cut and removed, but the forest will persist. He is the preserver of the forest, not in the manner in which the public is often made to believe, namely, by preventing the use of the wood, but as all life is preserved, by removing the old and fostering the young growth. He is a sower as well as a reaper, a planter as well as a logger, for forestry is, with regard to wood crops, what agriculture is, with regard to food crops.

He may secure this new crop either by cutting off and removing all the old crop and replanting the ground, a method which is often the only possible one with our mismanaged virgin woods, where the useful species have been eliminated or where fire has destroyed all the old timber. Or else he may secure it from the seeds of the trees already on the ground, by skilful management of the light conditions, gradually removing the mother trees and securing what is called a natural regeneration.

In the latter case, before he utilizes the kinds for which he wishes to perpetuate the forest, he culls the inferior and leaves, until they have reproduced, only the more useful; he gives direction and assists in the struggle for supremacy the most fit; he substitutes artificial selection for natural selection, assuring the protected survival of the most useful. The forester's forest, then, differs from nature's forest, developed under the laws of natural evolution; for he introduces the economic point of view. And, when he finally gathers the harvest, he secures not only a larger total and more valuable product for the present, but a reproduction of only the best kind for the future.

By these means the German forests of to-day have been produced, which, while they may lack in picturesqueness, are of superior economic value, producing, on soils which are not fit for agriculture, in half the time, double the useful material that nature's forest has produced. This is done by reserving the soil for useful species only, by thinning out from time to time, and thus benefitting the remaining stand, securing the largest amount in the most useful form on the smallest number per acre. And, finally, the harvest is made, as thoroughly as the farmer makes it, to make room for a new crop, and thus successive crops are harvested and reproduced.

On this continent for the present, and for some time to come still—owing to our peculiar economic and populational conditions—our national forest resources will be to a great extent merely exploited; the lumberman will continue, for some time, to treat his forest property as an object of speculation, possibly treating it more carefully. The forester, who looks at the forest as an investment, to be perpetuated and renewed forever, comes when civilized permanency, stability of conditions warrants it, when he can make his home in the woods.

The first step towards making his business possible is adequate protection of forest properties against fires, a subject of legislation and morals. The next step is the possibility of a more thorough utilization of what we cut, and care in not unnecessarily destroying young growth, a matter depending on the development of cheap means of transportation and distribution of population.

Finally, the application of the skill of the forester is called for, such as you propose to educate in this institution.

LECTURE VII.

METHODS OF BUSINESS CONDUCT—FOREST ECONOMY.

As in every technical industry concerned in production, so in forestry the methods of the technical art are distinct from the methods of the business conduct. "Silviculture" represents the technical art of forestry; while under the comprehensive term "forest economy" we may group all that knowledge and practice which is necessary for the proper conduct of the business of forestry.

Besides the purely technical care in managing the productive forces of nature to secure the best attainable production of material, best in both quantity and quality—the highest gross yield—there must be exercised a managerial care to secure the most favorable relations of expenditure and income—the highest net yield, a surplus of cash results without which the industry would be purposeless from the standpoint of private enterprise and investment. Moreover, an orderly conduct and systematic procedure to secure this revenue is necessary.

It is possible to practice the art of silviculture incidentally, as the farmer does, or can do, on his wood lot, without special business organization and elaborate planning, the owner harvesting and reproducing and tending his crop whenever needful; but the case is different if forest growing is to be carried on as a business by itself with a view to continued and regular procedure, to continued and regular revenue; in that case more elaborate planning becomes necessary.

The one peculiarity which distinguishes the forestry business from every other business is the time element. The forester cannot harvest annually what has actually grown (the current increment); the forest crop, as we have seen, must accumulate the accretions of many years before it becomes mature, i.e., of sufficient size to be useful; hence, unless special provisions are made in the management of a forest property, the crop and the revenue would mature and be harvested periodically only, and that in long periods; from twenty to a hundred years and more would elapse from the sowing to the reaping.

The farmer may be satisfied to practise on his wood lot attached to his farming business what is technically called an "intermittent" management, harvesting and reproducing from time to time without attempting to secure regular annual returns. But when forestry is to be practised as an independent industry, it becomes desirable, as in any large mercantile establishment, to plan, organize, and manage the business so as to secure, continuously and systematically, a regular annual income nearly equal or increasing year by year.

The lumberman or forest exploiter also plans and organizes his business for annual returns, not, however, to be derived continuously from the same ground; he seeks a new field, he changes his location as soon as he has exhausted the accumulated stores of his forest property, which he then abandons and devotes to other purposes than wood-cropping.

The forester's business is based upon the conception of what is technically called the "sustained yield," a continued systematic use of the same property for wood-crops, the best and largest possible; this is secured by proper attention to silviculture, reproducing systematically the harvested crop. Finally, when the industry is fully established, he is annually to derive this "sustained yield" as far as practicable in equal or nearly equal amounts forever, under an "annual sustained yield management." This is secured by means of *forest regulation,* the principal branch of forest economy, which comprises the methods of regulating the conduct of the business so as to secure finally the ideal of the forester—a forest so arranged that annually, forever, the same amount of wood product, namely, that which grows annually on all his acres, may be harvested in the most profitable form.

As in every business, there is an ideal, a standard in conduct and condition, which the manager more or less consciously recognizes and follows, or seeks to establish, yet, on account of uncontrollable circumstances can never quite attain, so is the ideal of the forester never quite attainable, although it is his obligation to attempt and approach it as far as practicable.

The ideal conduct of the management "for annual sustained yield" is possible only under the ideal condition, which the forester recognizes in the "normal forest," the standard by which he measures his actual forest and to which he desires, as nearly and as quickly as circumstances permit, to bring his actual forest. The latter will usually be found abnormal in some one direction, or in several directions, and hence makes the ideal conduct impossible. The object of forest regulation, then, is to prepare for the change of an abnormal forest into a normal forest.

In simplest terms, the normal forest is a forest in such condition that it is possible to harvest annually forever the best attainable product; or to secure continuously the largest possible revenue.

While we have assumed, for the sake of simplicity of conception that the stands of different age, the age classes, are separate in area the one from the other, it is readily conceivable that all, or some of them, may be mixed together, on the same area, as in the selection forest, where all age classes, from the seedling to the matured timber, are mingled; and if there are enough trees in gradation from the older to the younger, allowing for losses, so that the younger age class can replace in amount the older as it is removed or is growing out of its class, we would have arrived at normal condition for the selection forest.

In the actual forest some one condition or all conditions will usually be found abnormal. The normal accretion may be deficient because the area is not fully stocked or the timber is past its prime, old timber growing at an inferior rate, or rot off-setting increment. The age classes are usually not present in proper gradation and amount; some of them are probably entirely lacking, others are in excess, either too many stands of older or of younger timber, so that even if the normal stock of wood in *amount* be on hand, it may be in abnormal *distribution*.

The normal accretion can, of course, be established only by silvicultural methods. The other two conditions are attained or approached by regulating the felling budget in area and amount, so that gradually the age classes and the normal stock are established.

The simplest method would be to divide the forest into as many areas as there are years or periods in the rotation, and cut one, or the equivalent in volume, every year or during every period, when after one rotation the age classes are established. If proper attention has been given to the reproduction and to keeping the reproduced areas fully stocked, the normal conditions are attained after the forest has been once cut over, i.e., during the first rotation. But this would burden the present generation with the entire cost of securing the normality; at the same time necessitating not only unequal felling budgets, as better or poorer stands are cut, but also requiring that the harvest of timber past its prime be deferred, if the forest is largely composed of old age classes, or that immature timber be cut prematurely if young age classes predominate—in either case a financial loss. Indeed, the greatest practical difficulty which confronts the forest regulator is found in gauging the sacrifices which the present must make for the sake of the future.

Altogether, the principle of the "owner's interest" must be the guiding one in the management of any property; and it would first have to be demonstrated that a sustained yield management, either annual or intermittent, and sacrifices of revenue in the present for the sake of a future improved revenue are in his interest. For it must always be remembered that financially forestry means *foregoing present revenue or incurring present expenditure for the sake of future revenue;* it involves gauging present and future advantages, and the time element, as we have seen, is the prominent element in its finance calculations.

Before an annual sustained yield management will appear profitable in Canada, many changes in economic conditions will have to take place, among which we may single out reduction of danger from fire; opportunity for utilizing inferior material; increase in wood prices by reduction of the natural supplies on which no cost of production need be charged; the development of desire for permanent investments instead of speculative ones; an extension of government functions, leading to the practice of forestry by governments on a large scale.

Meanwhile, all that can be expected from private forest owners is that they may practise more conservative and careful logging of the natural woods, avoiding unnecessary waste, and as far as possible paying attention to silviculture, the reproduction of the crop, leaving to the future the attempt to organize a sustained yield management. Only governments and perpetual corporations or large capitalists can afford to make the sacrifices which are necessary to prepare now for such a management.

In order to secure the data upon which the felling budget may be regulated, a *forest survey* is necessary, which will embrace not only an area and topographic (geometric) survey, serving for purposes of subdivision, description and orderly management, but also an ascertainment of the stock on hand in the various parts of the property, and of the rate of accretion at which the different stands are growing.

After having determined upon the general policy of management, with due consideration of the owner's interests and of market conditions, general and local; and after having decided upon the silvicultural policy, including choice of leading species in the crop for which the forest is to be maintained, and silvicultural method of treatment, as coppice or timber forest, under clearing system or gradual removal or selection system—the most important and difficult question to be solved is that of the rotation, the time which is to elapse between reproduction and harvest, or the normal felling age, that is, the age, or, so far as age is in relation to size, the diameter, to which it is desirable to let the trees grow before harvesting them.

There is no maturity of a forest crop as we know it in agricultural crops; wood does not ripen naturally, and trees do not even die a natural death at a given period, but death is with them a gradual process of decay, the result of exterior damage, of insect and fungus attacks; trees actually die by inches in most cases, and it may take hundreds of years before the trunk is so weakened that its own weight or a wind-storm may lay it low.

The question of ripeness, or the proper felling age, wherever forest growth is an object not of mere pleasure, as in a luxury forest, must be determined by economic considerations.

There is sense in the proposition that the felling age be determined by a diameter limit below which timber is to be considered immature; in fact, the forester bases his calculations of the rotation in part, at least, upon size of crop. But the proposition, frequently advocated, to restrict a forest owner to an arbitrary diameter limit, below which he is not to cut his crops, anywhere and everywhere, is not only unsound as an exercise of state policy, but also mistakes the economic questions involved in the determination of that limit, and entirely misjudges the value of the limitation as far as silvicultural results, the perpetuation of a valuable forest, are concerned. In fact, from this last and most important point of view it might be wiser, under certain conditions, to impose upon the owner the cutting out of everything below a given diameter. For, as we have seen, in nature's mixed forest, valuable timber and weed trees are growing side by side, the diameter restriction indiscriminately applied might prevent the removal of the objectionable portion, the weed growth, putting a premium on the decimation of the more valuable portion. Without silviculture, i.e., attention to systematic reproduction, a diameter restriction is of little value. With silviculture it is not necessary, for even the entire removal of the whole, crop-denudation, and its replacement by planting or sowing, would accomplish the object sought, namely, the continuity of the forest, and in many cases might be preferable to other methods.

In other words, the determination of the rotation or felling age, or of the felling size, is largely a matter of financial calculation. This calculation is, however, influenced by silvicultural and technical, as well as purely, financial, considerations.

An estimation of value requires numerous mathematical calculations. The forester must know the current accretion or increment of each year and from this determine the average accretion, that is, an average of several current accretions. The value of a stand depends upon the size as well as the volume and quantity among other things.

The forester must in a large way be a prophet. He must forecast what wood will have the largest sale in the future and also predict if the price will increase at all. The only basis upon which he can judge is the history of the past and he will be tolerably correct unless some unforseen accident occurs. In Prussia for 65 years back the prices of wood have advanced 1½ per cent. per annum. In Canada White Pine sold for 4½-5½ cents per cubic foot 50 years ago, whereas in 1893 it sold for 16-42 cents per cubic foot and to-day commands 60 cents per cubic foot. This is a very large advance.

Besides capital and time there must be present an economic spirit such as no other business requires. The product can be differentiated from the capital, but forest management is dangerous in private hands especially with little capital behind it. Hence, from the standpoint of the future this is a business which rather belongs to the state or a persistent corporation. In Germany, forestry has been practised for over a hundred years, and the statistics of the German states will show the financial results.

Let us take a glimpse at the results of forest management in Saxony from a business point of view:

	1824-33	1854-63	1884-93
Gross Revenue..	$1.75 per acre	$3.71 per acre	$6.67 per acre
Expenditure....	80 "	1.15 "	2.30 "
Net Revenue....	95 "	2.59 "	4.37 "

Saxony owns 130,000 acres, so by multiplying 130,000 by 1.37 we can find her net revenue from forests alone. Besides this we find the felling budget to be an average of 60 cubic feet per acre in the first period, 70 in the second, and 90 in the third, and while 17 per cent. of total cut was serviceable for lumber in the first period, 79 per cent. was serviceable in the last. These figures show what forestry when carried on properly can do for a country.

Prussia can show similar statistics, and we find that in this State the revenue has also risen in direct proportion to the expenditure, and consequent better management. There is no better investment to be had.

In Germany often the towns or villages own forests, when to be a citizen, means securing a dividend instead of paying taxes.

LECTURE VIII.

THE CHARACTERISTICS OF WOOD.

The forester's business is not so much to produce trees, or even forests, but the chief material which they furnish, wood; and not only wood merely, but wood of certain quality, fit for use in the arts. He must, therefore, not only be able to recognize the different woods and know their qualities' and their applicability for various uses, but more! he must know how differences in quality are produced and apply that knowledge in the production of his crop. All the technical qualities—weight, hardness, strength, appearance, and even color to some extent, and the behavior of wood can be more or less directly traced to their variable structure—the varying combination of the cells, with thinner and thicker walls, larger and smaller lumina (openings), and cell systems, which make the wood.

Without going into details and microscopical distinction, a mere microscopic inspection with the magnifying glass of the gross features reveals much of the characteristics of the wood. A cross section (across the bole) serves the purpose best although tangential sections (parallel to the central axis) and radical sections (in direction of radius of the cross secton) reveal also special features.

Comparing cross sections of our northern trees of various kind, we find that they can be classified in three classes differing clearly in appearance of structure. The distinction is found by examining each annual ring in itself, and the change from one ring to the other.

This examination reveals that in each case there are two zones defined in the ring of the year's growth, in most cases recognizable by color distinctions, namely the lighter colored interior part—the spring-wood, so-called because it is the first wood formed in spring—and the summer-wood, the last wood formed in the season. The former is lighter colored, because formed of thin-walled cells with wide lumina, forming a loose, open structure, while the latter is dark colored, because of thick-walled cells with small lumina, which reflect the light differently, forming a dense, compact structure. The wide-lumened cells or cell fusions may become so conspicuous that they appear like larger or smaller pores—cut-through "vessels" —and according to whether such pores occur, whether they are found distributed more or less evenly throughout the annual ring or whether they are more or less distinctly grouped in the spring-wood, the distinction is made into non-porous, diffuse porous, and ring porous woods.

The ring porous woods, like the oaks, ash, elm, concentrate their large-lumened vessels or "pores" into the spring-wood so that each ring is prominently visible. These woods are mostly the hard woods of the broad-leaf trees, their compact summer-wood being the hard part. The diffuse-porous woods, which have their vessels and pores of smaller size but larger number, more or less evenly distributed, are mostly the soft wood like poplar, aspen, tulip tree; the summer-wood being also porous, and only the last one or few layers of cells being made up of thick-walled, small-lumened, compressed cells, making distinction of the annual ring difficult. The conifers represent the non-porous woods, that is to say, they have no pronounced large-lumened vessels or "pores." Their structure from beginning to end is the most simple and uniform. The only difference between summer-wood and spring-wood is that the former has the cells (or tracheids, so-called) thicker-walled and compressed in radial direction. Here, too, we will find soft and hard woods. The hard woods being represented by the Yellow pines and the Douglas fir, which form many summer-wood cells—the harder, dark-colored part of the annual ring—while others, like the White pines, cedars, etc., have only a few such compressed summer-wood cells, the annual ring being less pronounced.

The varying distribution of large and small pores in the broad-leaf trees permit not only further distinction of genera and species, but also judgment of qualities. It stands to reason that a larger percentage of the thick-walled elements, *ceteris paribus*, means heavier, stronger wood, so that by mere physical inspection at least a comparative judgment of the value of wood may be formed.

Since according to species the proportion of summer-wood and spring-wood varies with the rapidity of growth (width of ring) and since the forester can make trees grow faster or slower, he has it partially in his hand to produce difference in quality.

Another feature of the structure which are both used for purposes of identification and exercise an influence on technical qualities, are the so-called medullary or pith rays. While most cell tissues and wood fibres lie with their longest diameter in the direction of the length or axis of the tree or branch, the pith rays, aggregates of cells, lie with their greater diameter in radial direction interrupting the straight course of the wood fibre. They are, therefore, points of weakness. On the cross section they appear as radial lines, finer or broader, sometimes so fine, as in the conifers, as to be hardly distinguishible, again so broad, as in the sycamore and the oak, as to form a most prominent feature of the structure. It is especially in the radial and tangential cuts, which are the ones mostly exhibited in structures, that the pith rays play a role, appearing as different colored plates in the quarter-sawed maple, beech or oak, and as narrow indentations on the tangential cut. The absence or rather scanty development of pith rays in conifers is one of the reasons of the uniform quality and behavior in shrinking of these woods, while the difficulty in seasoning oak without checks is largely due to the presence of many highly developed pith rays.

In seasoning, the wood loses the water stored up in it; as it evaporates from the cell wall on the outside it is supplied from the cell-lumen on the inside—no shrinking of cell-walls takes place until the water of the lumen is exhausted and then the cell-wall must give up its water, the molecules composing the cell walls draw closer with the water molecules removed by the dry air—the cell or cell-tissues shrink. The thicker cell-walls of the summer-wood contain of course the most water and hence shrink also more than the spring-wood cells. Hence, the ring-porous woods, like the oak, shrink more unevenly, and are liable to warping and checking. The pith ray cells lying in different directions also shrink in different direction more, and other source of season checks is due to them.

While then the complicated structure of the ring-porous woods furnishes greater strength structurally, it also imposes greater care in their handling.

In general, the heavier wood is also the stronger, and the quality of the wood, with trees of pronounced summerwood zones, varies from the centre of the tree to the periphery, according to the rapidity of its growth. Since, as a rule, the rate of growth in diameter is greatest between the 10th and 80th year, the heaviest and strongest wood would lie in that part of the tree. And as the wood does not change in structure it was also strongest when it was still on the outside of the tree, i.e., when it was "sap-wood." In old age, to be sure, the tree growing slowly makes poorer wood and hence in old trees the sap-wood, not because it is sap-wood, but because it is old wood, is weaker.

LECTURE IX.

PRINCIPLES AND METHODS OF FOREST POLICY.

The forest cover is of more importance to the household of a nation than many other of its resources, it bears a peculiar relation to national prosperity, and its management for continuity offers various unique and peculiar aspects, which call for special active interest by the community at large and by its representative, the state.

Briefly summarizing the arguments for such special interest and exercise of governmental activity, we recall that the forest is a natural resource which answers simultaneously three purposes of civilized society; it furnishes directly materials used in very large quantities and almost as needful as food; it forms a soil cover which influences, directly and indirectly, under its own cover and at a distance, conditions of waterflow, of soil, and of local climate; it has, in addition, an aesthetic value, furnishing pleasure and recreation and benefitting health.

The exploitation of this resource for private gain is apt to lead to its deterioration or eventual destruction, especially in a country where population is relatively small and unevenly distributed, when only the best kinds and the best cuts can be profitably marketed. Hence, since profit is the object of private enterprise, exploitation under such conditions must be by necessity wasteful. By the removal of the useful kinds and of the desirable individuals, leaving the ground to be occupied by tree weeds and runts, the reproduction of the desirable and useful is prevented, and since the forest, by changing its composition and quality is deteriorated in value, the future is injured as far as material interests are concerned.

Since, with the removal of marketable timber, the interest of the individual in the forest is gone, it is naturally neglected, and conflagrations which follow the wasteful exploitation, with the accumulated debris left in the woods, kill or damage, not only the remaining old timber, but more especially all the young growth. Even the soil itself, often formed only by the mould from the decay of leaves and litter accumulated through centuries, is destroyed, and thus, not only the practicability, but the possibility, of restoration is frustrated.

In many localities the consequences of such destruction are felt in deterioration of climatic conditions, and in uneven waterflow, floods and droughts being exaggerated; in this way damage is inflicted on portions of the community far removed from its cause and unable to protect themselves. The private individual can hardly be expected to appreciate these distant interests of his own motion in the management of his forest property; hence the state must guard them.

The desire to get the largest present profit from his labor, which is the only incentive of private enterprise, will be also a constant incentive to curtail the wood capital necessary for a sustained yield management, and to let the future take care of itself.

The interest in the future lies with the state; the state must interfere, wherever the interests of the future clearly demand it.

The state is to protect the broad interests of the many in the community, against the inconsiderate use of property by the few; and special stress is to be laid upon the necessity of including the interests of the future community in this consideration, calling for the exercise of *providential* functions on the part of the state.

There is, however, one great generic difference between the forestry business and all other productive industries, which places it after all on a different footing as far as state interest is concerned; it is the time element, which we have again and again accentuated, and which brings with it consequences not experienced in any other business.

The result of private activity which is supposed to come from self-interest is closely connected with the working of the well-known economic law of supply and demand which regulates the efforts of the producer. This law and the self-interest can be trusted to bring about in most cases a proper balance rapidly, but in the forest business this balance works sluggishly; before a shortage in supplies is discovered and appreciated, stimulating to productive effort, years will have elapsed, years which are needed to prepare for a supply to become available in a distant future. How difficult it is to get conditions of forest supplies recognized and appreciated, we in the United States have experienced in regard to our White Pine supply.

We must, then, admit that, even with regard to supply forests, the position of the state may be properly a different one from that which it would be proper and expedient to take toward other industrial activities.

When, in addition to the more material function, the immaterial benefits of a forest cover enter into the question or become paramount, there can be no doubt that both principle and expediency call for timely exercise of state activity. The so-called protection forests, therefore, which by virtue of their location on steep mountain slopes or on sand dunes, or wherever their influence on soil conditions, waterflow, and climatic factors can be shown to be superior to their natural value, must claim a more intimate and direct attention by the state.

There are *three different ways* in which the state can assert its authority and carry out its obligations in protecting the interests of the community at large and of the future against the ill-advised use of property by private owners: namely, by persuasive, ameliorative, or promotive measures, exercising mainly its (1) *educational* functions; by restrictive measures or indirect control, exercising (2) *police functions;* and by direct control, i.e., (3) *ownership and management* by its own agents.

First, we have to discuss educational measures, taxation and tariff duties, bounties, and other aids in promotion of private industry.

The educational function of the state is now recognized as one of the most prominent and beneficial in all civilized nations, although the degree and generality of its application still vary.

We believe that finally, in each country, it will be considered a part of proper forest policy for some public institution of learning to furnish *instruction in forestry.*

The only danger is that multiplication in number rather than increase in efficiency of a few such institutions will be the rule of the day, when the fever sets in.

In the European forestry literature a lively discussion has continued for years as to whether the higher education in forestry should be given at separate special academies or forestry schools, or whether these should be connected with universities. There are advantages and disadvantages in either arrangement; but the better facilities which can be had at a university, with its concentrated intellectual and laboratory apparatus, give the preference to the latter.

Besides the establishment of schools, there are other means open for the state to exercise its educational functions. The endowment of *scholarships,* especially travelling scholarships, has been of greatest value in increasing capacity and intelligence for promoting communal interests.

Next, no more efficient means of education in practical arts which, like forestry and agriculture, rely still largely on empirics, can be devised than the establishment of *experiment stations.*

If, as has been practically conceded, experimentation in agricultural lines is best done by state institutions, this is still more true in forestry lines, on account of the time element involved in most forestry experiments. In agriculture the answer to an enquiry may be often secured in inexpensive ways, and may be given in one season; while in forestry, years of patient waiting and observation, wholesale methods of measurements, large areas, and a large number of cases, are required to permit generalization.

The advantage of connecting such experiment stations with institutions of learning needs hardly an argument; the mutual increase of educational facilities and opportunities is patent. These educational means can, of course, be extended by proper methods of publication of results, by organization of meetings for their discussion, by so-called university extension, and, finally, by the *promotion of associations* which have for their object the increase of application of knowledge in the actual forestry practice. Such associations give opportunity of impressing and driving home what is desirable in practice, and also, of finding out what are the needs of the private owner, and what the state should do to further his interests.

A more direct and far-reaching influence upon private activity, still of an educational character, is properly exercised by the state in securing and publishing *statistical information.*

In the well ordered state the soils most fit for agriculture should be devoted to systematic food production, but just so should the non-agricultural soils, the *absolute* forest soils, be devoted to the systematic production of wood-crops; moreover, as we have seen, the forest in certain situations, exercises a potent influence on cultural conditions. Hence the knowledge of the extent of forest area of a country is by itself meaningless; the character of the soil the forest occupies, its topographical location, and its relation to the hydrography of the country, must be known to permit an estimate of cultural conditions, to prognosticate likely change in area and the desirability of interference in its use.

To get an idea of the amount and value, present and prospective, of the existing resource, there must be known the composition, i.e., relative occurrence of merchantable kinds and conditions as to density, age, and character of growth, damage by fire, etc., and, most difficult of all to ascertain, conditions and stages of development of the young crop.

In addition to these educational methods which incite private activity in the right direction by indirect means, namely, by increase of knowledge, there are more direct ameliorative or promotive measures to be found in bounties which are given to aid private endeavor in the pursuit of private industry.

These may take the form of assisting by money gifts, by furnishing plant material, by giving land as in our timber claim planting, by making working plans or otherwise specifically assisting in private forest management beyond the gift of general information, and finally by tax release and tariff duties.

Within the last few years the Federal Government of the United States has inaugurated through the Forestry Bureau of the Department of Agriculture another method of encouragement which is also practised in the old countries, namely, to give to private owners specific advice as to the management of forest properties, the government bearing the larger share of the expense of securing the data for these so-called working plans. But for the educational feature involved, this would be a violation of our principle that the state should not do for the private citizen what he could do for himself. If, however, the benefit to be expected for the community at large is thereby secured, expediency would lend countenance to such a method. The probability, however, is that in the absence of an obligation to follow the working plan, and in the absence of technical supervision in its execution, the results will be hardly commensurate.

The one promotive action of the state, which is pre-eminently required to establish a proper forest policy, the propriety of which cannot be questioned for a moment, and which arises from the primary function of the state, its police function, is to afford *protection to forest property*, at least equal to that afforded to any other property and adequate to the peculiarities and needs of such forest property.

Such protection is the unquestioned right of the forest owner, and without it he cannot be expected to maintain a "sustained yield" management which requires maintainence of a large wood capital subject to depredations and to destruction by fires unless properly guarded.

It is not sufficient for the state to legislate, but, at least wherever broad communal interests are at stake, it must provide the machinery to carry out this legislation.

The principles most needful to keep in view when formulating legislation for protection against forest fires are:

(1). A well-organized machinery for the enforcement of the laws must be provided, in which the state must be prominently represented, since the damage done by forest fires extends in many cases far beyond immediate private or personal loss.

(2). Responsibility for the execution of the law must be clearly defined, and must ultimately rest upon one person, an officer of the state; but every facility for ready prosecution of offenders must be at command of the responsible officer.

(3). None but paid officials can be expected to do efficient service, and financial responsibility in all directions must be recognized as alone productive of care in the performance of duties, as well as in obedience to regulations.

(4). Recognition of common interest in the protection of this kind of property can come only by a reasonable distribution of financial liability for loss between the state and local community and the owners themselves.

Generally speaking, restrictions and supervision of private forest industry have proved themselves mostly undesirable and impracticable; their only justification would appear when protection of neighboring properties or of general communal interests demonstrably require them.

The recognition of the fact that the removal of the protecting forest cover may give rise to shifting sand and sand dunes, which may encroach and despoil larger areas beyond, is sufficient call for the exercise of the police functions of the state to prevent such damage, if we admit the providential character of such functions.

The experience that the deforestation or even bad management of the forest cover, forest devastation, on mountain tops and hills, leads to excessive water stages, to destructive floods, filling channels, thereby impeding navigation and silting agricultural soils, damaging neighboring or distant interests, again makes the exercise of the police function of the state, in a wider sense in which I have defined it, necessary in order to prevent the consequences of mismanagement of the protective forest cover in such particular situations.

The sugar planter in Louisiana, whose crop is endangered or destroyed by overflows due to causes a thousand miles away, has a right to protection through the government.

Finally, however, it will be found that control and supervision of private property is an unsatisfactory, expensive, and only partially effective method of securing conservative forest management, where the necessity of maintaining a forest growth may exist and the financial margin that can be had from it is but small. Experience in the old countries has shown that, in spite of the much more perfect machinery for enforcing laws, and in spite of the much more ready disposition to submit to laws, than we are accustomed to see in this country, the attempts to control private property have been largely without the desired result.

It then becomes preferable for the community to own and manage such forest areas.

Such ownership may rest either in the state or else in the country, the town, or other political subdivision which seems most nearly interested in the maintenance of the protective cover. To obtain possession, if it cannot be had by purchase, the necessity of exercising eminent domain is now recognized in most civilized states where public objects, public safety, or public utility require it; usually, however, the objects for which this power may be called into requisition are definitely stated by law.

Finally, when the ideal, the socialistic, co-operative, most highly organized state will have developed, the policy will be that the community shall own or control and devote to forest crops all the poorest soils and sites, leaving only the agricultural soils and pastures to private enterprise.

LECTURE X.

THE FORESTER, AN ENGINEER.

The object of this lecture is to show the variety of directions in which the forest engineer must expend his energies. The harvesting and marketing of the wood crop requires the services of men with engineering education and ability, and they are best educated where practical sciences and engineering are taught.

There is hardly any business concerned in the manufacture or production of materials which does not require some knowledge on the part of the producer as to how to adapt means to ends, how to use mechanical and physical properties of matter in construction and locomotion; and in applying this he fulfills the definition of an engineer. The forester's business is one in which the need of engineering gumption and knowledge appears in various directions so prominently that he can without impropriety be called a specialized engineer, and in fact the title of "Forest Engineer" is given to the graduates of forestry schools in several countries.

The one thing in which the forestry business differs from all other business is the long-time element, for it takes a hundred years and more to grow trees fit for the use of the engineer, the builder and the architect; hence the dollar spent now in its first start must come back *with compound interest* a hundred years hence. This long-time element entails careful planning, entails economy and prevision. Hence, all the forester does must be done with permanency in view. And here again the lumberman and forester differ in objects, and therefore in methods; the one treats his property as a speculation, a *temporary* occupancy; the other treats it as an investment; *permanent* management, continuity of occupancy, is the basis of his actions.

The first step in taking hold of a forest property is, therefore, a survey of the same, not only of its boundaries, but of its topography and character, as well as of its contents. Surveying, both line and topographical surveying, are requisites of a competent forester. While such a first survey might be made by regular surveyors, as the work of the forest manager progresses and needs recording on the maps, it will be found useful if he can do his own surveying, and thereby become competent also to interpret readily topographic maps. Such surveys, being not for general map purposes but with engineering work in view, must be made with more care and on a larger scale than is usual wth such field maps as, for instance, those of a Geological Survey.

Subdivision is necessary for more easy systematic procedure. Fire-lanes, or cleared strips for protection against fire must be kept clean.

The next direction in which engineering knowledge is required is in the locating and laying out and constructing of roads and other permanent means of transportation, for to be accessible in all its parts is finally of greatest importance in managing a property for permanency. In our undeveloped conditions, especially in the absence of local markets, we may still be satisfied with a minimum of permanent road system, substituting temporary roads and means of transportation, and leaving to future generations their further development; but the plans should be made for permanency from the start, even if their execution is delayed. Cheap but efficient road building and railroad building, I am afraid, is a matter with which even few engineers are well acquainted; it is a subject in which the

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forester is intensely interested. Building of bridges in a cheap and effective way is part of the forest engineer's work. These means of transportation are, of course, needed to remove the harvest, and to handle this bulky material cheaply requires no mean engineering skill.

The first task of the forester, then, in beginning the management of a forest property is to provide cheap and efficient means of transportation for the removal of a bulky crop, of which much is inferior, and if possible to so arrange this harvest that it may be made gradually and continually, logging over the same area for a number of years.

Here, in the harvest, logger and forester have similar, yet not identical interests, for the logger lacks the requirement of logging over the same area gradually and continually, of having to remove cordwood, weeds and

LUMBERING RAILWAY.

BURNT PINES, CARSON LAKE, C. A. R., RENFREW CO.

Photo by Houghton W. Wilson.

debris, of caring for the young aftergrowth. Nevertheless, the forester must naturally do much the same as the lumberman, and utilize the engineering skill which has been developed in the logging business.

According to the size and location of his property and the working capital at his disposal, he will resort to old fashioned methods of logging—skidding the logs by horses or mules to skidways, and hauling them on wagons or with sleds on ice roads to the landings; or using lumber slides and water flumes to bring the material either to rivers, which he may have to dam and regulate in their course in order to float and drive the softwoods, or to rail if hardwoods; or else he may benefit from the development of steam logging devices in connection with steam railroads.

DAM AND TIMBER SLIDE, McGILLIVRAY LAKE, COULONGE, QUE.

Photo by Houghton W. Willson.

Whether the transportation is by rail or water, or by sled or wagon, the locating of the roads is one of the most important functions of the logger. Be it that temporary winter roads or permanent summer roads are to be used, a well planned system of main roads and branches must be located. So important, for financial reasons, is the question of road location considered in German forests, that a permanent road system forms most important initial investment—on our undeveloped lands the only plan is temporary roads.

In logging operations, as now conducted, engineering structures and operations are constantly employed.

Even the *felling* of such trees as the great western pines is a piece of engineering requiring the greatest skill and judgment. The long shaft must fall so as to clear the surrounding trees, and not destroy its own value and that of others by crushing or lodging. Skidding is now in some forests done by an engine and wire rope. First successfully applied in the cypress swamps of the South, then on the mountains of the Pacific Coast with the ponderous pines and firs, these steam skidding methods promise to supercede the old-fashioned horse and mule wherever large enough masses, especially of hardwoods, are to be lumbered, and where railroads can be profitably employed to bring the log harvest from the forest to the mill.

TIMBER SLIDE, HIGH FALLS, MADAWASKA.

Photo by Houghton W. Wilson.

The present *steam-skidding* system, first suggested by Mr. J. H. Dickinson, relies upon a stationary hoisting engine, and brings the logs from shorter or longer dstances to the cars by wire ropes running over drums, the ropes being disposed in various ways according to the lay of the ground. One of the essential devices is the cast steel nose or cone (Baptist patent), which caps the log automatically when the rope is pulled taut, and steers the log over any stumps, stones, or other impediments.

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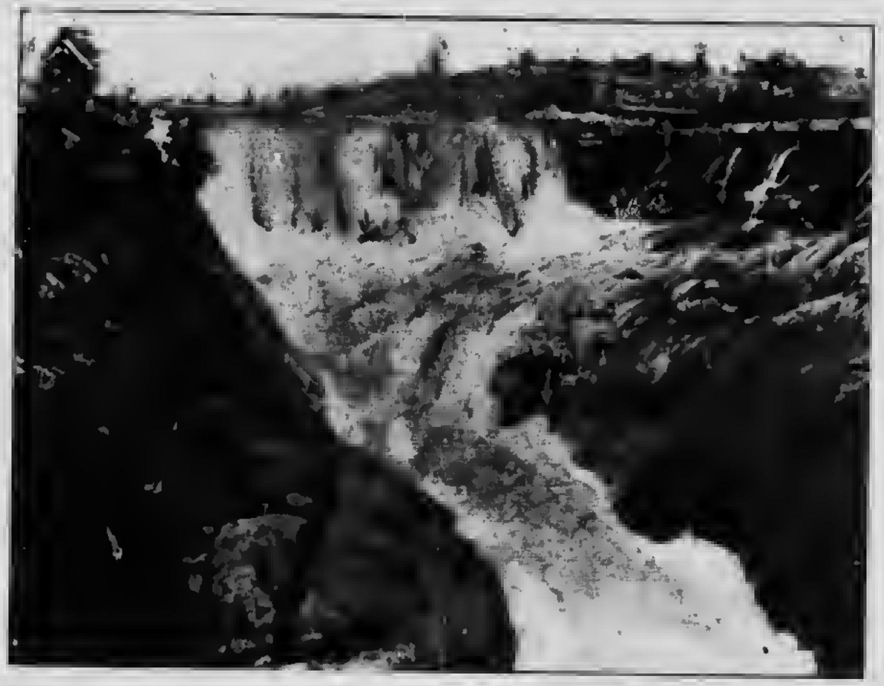

FALLS AND SLUICEWAY, WHITEFISH RIVER, ALGOMA.

Photo by J. W. Wells.

CATARACT AND TIMBER SLIDE, WHITEFISH RIVER, ALGOMA.

Photo by J. W. Wells.

There are now four different methods of steam skidding used. The simplest, applicable to flat lands, consists in snaking the logs over the ground and assembling them at the cars by means of a hoisting engine and drum, a horse returning the rope with a grappling hook or tongs at the end; the loading is done by a separate rope and drum.

The distance to which this skidding may be done is, of course, dependent upon the length of rope which it is practicable to wind on the drum or drums and to have the horse return. Usually this is not more than 800 to 1,500 feet, when the machine may make from 150 to 250 pulls per day, the cost on the average with a crew of eleven men and three mules being about

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$34 per day, and the output, of course, dependent on the character of the timber and the log size, which determines the number of feet coming with each pull.

Where the ground is less flat and simple in contour, and where it is preferable to return the rope and grapple automatically, the "slack rope system" may be employed. In this system a wire cable is strung from a head tree near the engine to a stump in the woods, on which travels a carriage (Miller patent), with a specially designed block (Butler's patent) through which the skidding rope with logging tongs works, so as to allow sidewise extension; an outhaul rope, running over a separate drum of the hoisting engine, returns carriage and tongs to the woods, where the tong men pull the rope slack and attach the tongs to the logs lying along the line shorter or longer distances.

The loading on cars is done by a separate set of drums and rigging. To use this system, which may extend to a longer distance than the snaking system satisfactorily, the ground must be tolerably free from rocks and obstructions. According to conditions and distances, from 80 to 120 pulls may be made in a day. A later improvement provides for a number of side lines working simultaneously, by which the efficiency is greatly increased; otherwise horses or mules gather the logs to the pulling line.

In the cypress swamps, where this method is largely used, the machine is placed on a large scow, moving in canals prepared to float the logs. Here the distance to which the skidder works is 2,500 to 4,000 feet, the ponderous logs moving at the rate of 500 to 600 feet a minute, breaking through the timber with thundering noise. Such a pull boat is capable of landing 30,000 to 50,000 feet per day in the water.

In more mountainous districts, where narrow valleys and coves with steep slopes are to be lumbered, the log-gathering system finds its conditions. In this a cable is stretched from slope to slope across the railroad track in the valley, and the logs are gathered to the track by the skidding rope and carriage. The distance to which the system may work, depending somewhat on the degree of slope, may be up to 1,000 feet, when from 120 to 150 pulls per day may be made.

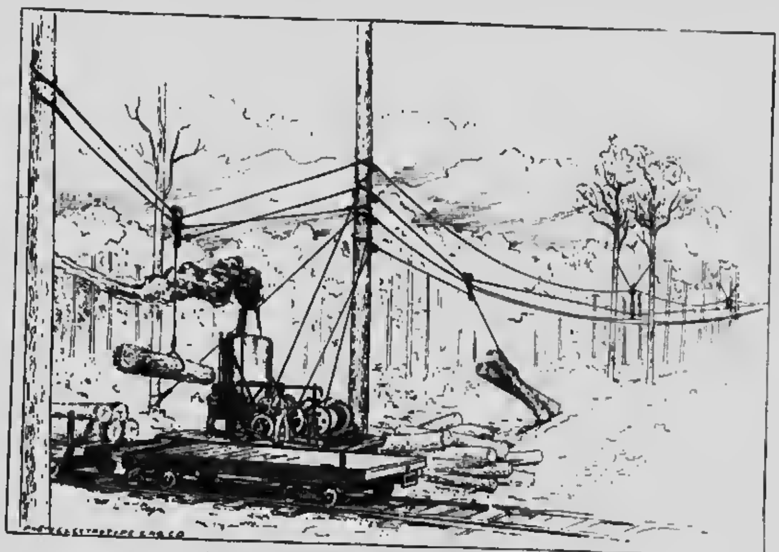
In these last two systems up-hill skidding is, to be sure, as easy, or even easier, than down-hill. According to conditions, either of these systems, or any combination of them, or a combination of skidding by horse and steam, or a relay system with several engines placed one after the other reaching out long distances, will give the best results.

The first steam logging railroad was built in Michigan in 1876 by W. S. Gerrish, who was called a hare-brained enthusiast for his innovation, which, however, proved successful. Ten years later many such logging roads of 25 and even 45 miles in length; and altogether over 3,000 miles were in existence; in Michigan alone over 720 miles. Now the logging railroad has become so general that the mileage may be estimated to exceed 25,000 miles.

There are still three different kinds of logging railroads in use: The pole road, the tramway with sawed wood rails with or without strap iron capping or flat bar iron rail, and the iron or steel T railroad. Each road has its merits and advantages of its own in given situations, although the regular steel T railroad, all things considered, seems to have found most favor.

In the Cornell College forest a standard gauge with 40-pound steel rail has been used on spurs, and a 46-pound rail on the main road, with a 27-ton engine.

The economical construction of logging roads which are designed to serve only a temporary requirement is one of the engineering problems which more and more interests lumbermen, and even to a greater extent foresters, who are forced to secure even greater economy, since the margins from their business are for a time at least necessarily smaller. In such roads cuts and fills must be avoided as much as possible, while heavy grades, numerous and sharp curves are necessarily to be extensively used and it takes a careful weighing of saving in cost of first construction against losses in maintenance and efficiency, such as no engineer is called upon to make in constructing standard roads. It stands to reason that to secure the least expensive logging roads, the main effort must be made in the location of the road, for this influences not only the cost of constructing but of operating it. No rules but engineering gumption must determine. Where wood is cheap and right at hand, it is often indicated to use imperfect and unmarketable logs instead of earthwork, or matting of brushwood and cribbing for crossing swamps, and similar devices which do not commend themselves for main lines.



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In Europe portable tramways and *wire rope* ways are much employed —the longest, five miles, being in the Alps. Portable railways are sometimes employed in connection with more permanent roads, 2 rails attached to steel ties; each yoke, 10-15 feet long, with 10-24 lb. rail, weighing 75-100 pounds, hook into each other. The newest type has been invented by a forester, and is laid without rails. The log-slide, with or without water, is a device well-known in mountainous or broken regions where water is available. One such in the Sierra Nevada is an incline 1,000 feet long and with a 1,400 feet elevation. It delivers 10,000 cords a day.

Altogether *landing places* and terminals must be located with circumspection, to take care of the bulky material and secure the cheapest handling of it, which, with cordwood even more than with logs, depends upon the character of the landings.

There are now very generally employed steam loaders; hoisting engines with outhaul ropes running over drums, which pick up the logs alongside the track. Various devices are resorted to to facilitate the passing of cars and to locate the loader with reference to cars and landing places.

In the "Barnhart" and in the "American" Loader this is accomplished by having rails laid on the cars on which the loader travels, pulling itself along as needed, the latter on two short portable sections of track, the former on permanent track. Such a loader of the Barnhart type as used in the College forest, will pick up and load from 600 to 800 logs per day, the logs being banked to within 100 feet or so from the track. It is able to move on a pivot in all directions, and the character of the landing place is of little importance.

In the "Decker" log loader the clearing of the track for bringing empties to the loader is accomplished by allowing them to pass underneath the loader over a three-rail section of track, which rises from the main track and is carried by the loader on its lower story.

In forestry work, where the care for the young aftergrowth must be taken into consideration, modification of the methods of procedure will be required. They are, however, directly applicable where clearing with artificial planting is practiced, or where the strip system is used, which consists in clearing strips and securing the reproduction by seeds from the neighboring old timber which is left standing. When the forester shall be a fully recognized and established institution in Canada we may expect that he will develop these methods of exploitation to suit the additional requirements of silviculture.

In mechanical engineering, also, there is still a wide field unoccupied, the development of which would aid the business of the forester. We are still relying on brute force for felling trees, sawing them into logs and cutting and splitting cordwood. Attempts to apply steam or electric power in tree felling have so far failed to bring out any practical method. There are now on trial cordwood cutting machines, but they are so far only applicable for very special conditions which can be rarely met.

In entirely different direction is engineering skill demanded, and a special line of *forest engineering* has developed in connection with the reclamation and reforestation of sand dunes and denuded mountain sides. This has been especially developed by the French foresters, the French government having spent many million dollars in covering the lands and sand dunes of Gascony, and in safe-guarding Southern mountain ranges against torrential action induced by deforestation. This forest engineering is now practiced in all countries where forestry is developed and the necessity for this work has been recognized.

The fixation of sand dunes has also been begun in the United States by the Harbor Commissioners of Massachusetts at Cape Cod and elsewhere. It is a simple operation, which consists in first quieting the sand by mechanical means, fences and brush, or turf cover, and by cutting off or breaking the force of the wind by means of an artificially induced forward dune. Then grasses and other deep-rooting and root-creeping plants are used to bind the sand together, and finally tree growth can be established to give permanent protection.

On the denuded mountain slopes it is also first the mechanical quieting of water and soil movement which must precede the work of the forester. This work must begin at the top of the mountains, where the waters gather their momentum into torrents which carry soil and debris to lower levels. By fascine works, revetments and retaining walls the waters are obstructed

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in their direct descent, and the violent rush over steep slopes is changed into gentle falls, when the pockets behind the breastworks are filled up with the debris and soil. Then when the waters are directed into proper channels and the soil has thus become quieted, sodding and sowing with grass restores the meadow on the gentler slopes, while on the steeper slopes a forest growth is planted and the equilibrium of nature's forces, which man had disturbed to his own detriment by the reckless devastation of the mountain forests, will be gradually re-established.

These glimpses into the problems of an engineering character which are presented to the forester will suffice to justify the claim that he is in need of a considerable amount of engineering knowledge and gumption, which is to be applied under conditions in which it is not usually practicable to employ an engineer.

While for main constructions it may be advisable to call in an engineer, at least in consultation, in smaller constructions and in operating roads, railroads, etc., the forester can hardly afford not to be his own engineer. He must have the knowledge which will make him independent of the professional engineer. Students of forestry, therefore, need a course in engineering which will make them acquainted with principles and methods of construction of special interest to them in their business. On the other hand engineers may find a field in solving engineering problems for the forester, and in improving his methods, without becoming professional foresters.

LOGGING