THE RURAL SCIENCE SERIES

BY L H·BAILEY

THE FARM WOODLOT

CHEYNEY AND WENTLING

The Rural Science Series

EDITED BY L. H. BAILEY

THE FARM WOODLOT

The Rural Science Series

The Soil. *King.*
The Spraying of Plants. *Lodeman.*
Milk and Its Products. *Wing. Enlarged and Revised.*
The Fertility of the Land. *Roberts.*
The Principles of Fruit-Growing. *Bailey.*
Bush-Fruits. *Card.*
Fertilizers. *Voorhees.*
The Principles of Agriculture. *Bailey. 15th edition, revised.*
Irrigation and Drainage. *King.*
The Farmstead. *Roberts.*
Rural Wealth and Welfare. *Fairchild.*
The Principles of Vegetable-Gardening. *Bailey.*
Farm Poultry. *Watson. Enlarged and Revised.*
The Feeding of Animals. *Jordan.*
The Farmer's Business Handbook. *Roberts.*
The Diseases of Animals. *Mayo.*
The Horse. *Roberts.*
How to Choose a Farm. *Hunt.*
Forage Crops. *Voorhees.*
Bacteria in Relation to Country Life. *Lipman.*
The Nursery-Book. *Bailey.*
Plant-Breeding. *Bailey. 4th Edition, revised.*
The Forcing-Book. *Bailey.*
The Pruning-Book. *Bailey.*
Fruit-Growing in Arid Regions. *Paddock and Whipple.*
Rural Hygiene. *Ogden.*
Dry-Farming. *Widtsoe.*
Law for the American Farmer. *Green.*
Farm Boys and Girls. *McKeever.*
The Training and Breaking of Horses. *Harper.*
Sheep-Farming in North America. *Craig.*
Coöperation in Agriculture. *Powell.*
The Farm Woodlot. *Cheyney and Wentling.*

FIG. 1.—The Ohio buckeye (*Æsculus glabra*).

THE FARM WOODLOT

A HANDBOOK OF FORESTRY FOR THE
FARMER AND THE STUDENT
IN AGRICULTURE

BY

E. G. CHEYNEY

DIRECTOR OF THE COLLEGE OF FORESTRY OF THE
UNIVERSITY OF MINNESOTA

AND

J. P. WENTLING

ASSOCIATE PROFESSOR OF FORESTRY
UNIVERSITY OF MINNESOTA

New York
THE MACMILLAN COMPANY
1914

Set up and electrotyped. Published June, 1914.

Norwood Press
J. S. Cushing Co. — Berwick & Smith Co.
Norwood, Mass., U.S.A.

To

THE LATE

DEAN SAMUEL B. GREEN

TO WHOSE ENERGY AND FORESIGHT THE PRESENT DEVELOPMENT OF FORESTRY IN MINNESOTA IS LARGELY DUE, THIS BOOK IS DEDICATED

PREFACE

It is the purpose of this book to aid the farmer in the establishment, care, and utilization of such small patches or plantations of timber as may be maintained in connection with the farm. The actual operations and the information necessary to conduct them are described accurately, we hope, but in a brief and popular style. The history and significance of the forests are briefly sketched as a background for the more specific data which apply directly to the woodlot, but the complicated and technical problems which are encountered only in the management of large tracts of forest have been carefully avoided.

It is hoped that the volume will prove of value to the woodlot owner as a handbook in the proper management of his tree crop, and as a textbook for the agricultural student, who should be familiar with the possibilities of all his farm lands.

The authors are under obligation to the United States Forest Service for plates 1, 2, 10, 11, 12, 14, 18, 24, 25, 27, 29, 30, 33, 34, 36 to 54, and 56 to 62 inclusive.

E. G. CHEYNEY,
J. P. WENTLING.

UNIVERSITY FARM, ST. PAUL, MINN.,
May 1, 1914.

CONTENTS

THE FARM WOODLOT

THE FARM WOODLOT

CHAPTER I

THE SIGNIFICANCE OF THE FOREST

FARM forestry is the raising of a timber crop on a farm or in conjunction with usual agricultural operations. It differs from other or general forestry only in the extent of its operations. In a broad way, all forestry is agriculture because it is the rearing of a crop from the land. The United States Forest Service is one of the divisions or parts of the Department of Agriculture. Forestry is taught in the colleges of agriculture. Professional forestry is only that large application requiring all of one's time and demanding special preparation as a life work.

Farmers must undertake to grow timber crops with as much care and forethought as they produce other crops. In many parts of the United States and Canada the forest must be planted outright; in other regions it is a question of maintaining and improving the natural forest. In any case, the farmer must recognize not only the value of wood and timber to himself, but also the importance of the forest to the country and to mankind at large.

It should be understood at the beginning that forestry has to do with woods, and not with city planting, shade trees, or home lawns or parks. Separate trees do not make a forest any more than separate buildings make a city. The term "city forestry" is a contradiction. A wood or forest has its own life, and it produces and it meets a certain set of conditions. The cultivation of separate trees is arboriculture; if the subjects are fruit trees, the cultivation of them falls in the domain of pomology.

FOREST ECONOMICS

The forests have never received the proper credit for the great part they have played in the rapid development and civilization of this country. So strenuous was the struggle of the early settlers to subdue the forest and wrest from it the land necessary for their farms, and so omnipresent was that forest, that it came to be considered as an enemy to be fought; the benefits accruing from it were lost in the sum of injuries.

And yet that very abundance of forests — so often considered as a curse — was an enormous factor in the civilizing of the country, in the rapid rise in the American standard of living. Lumber was at that time by far the cheapest building material. This cheapness of lumber brought a neat house within the reach of every man, and with the neat house comes the increased pride in the home, the increased self-respect and with it the rise in the standard of living.

Men with no capital at all could hew themselves a home from the forests. With an ax they built log cabins. In the winter they worked in logging camps and earned the money on which they could live while they cleared the land and started their farms. Fence material grew in the fields. Fuel was everywhere.

Later, settlement moved westward to the prairie and the plains. Sod huts for years were the only homes they knew. The dread of the winter was acute because of the scarcity of fuel. The building of good homes and towns was slow on account of the lack of building material. It was only the construction of railroads that carried civilization and comfort rapidly across these treeless areas, and much of the freight in the earlier days was wood in one form or another. Even the rapid building of the many railroads was due to the abundance of tie timbers. The railroads, the great civilizing highways of the prairies, are laid on millions of wooden ties.

Nor does wood play a much less important part in the world to-day. In spite of the innumerable substitutes that have been brought into use, the wood consumption is greater per capita than it was in the days of early settlement. For every substitute introduced, many new uses for wood have been discovered. While it is possible by care and economy of use greatly to reduce the per capita consumption of wood, the experience of European countries has shown that no nation can enjoy the highest prosperity without the produce of forests.

While there are certain parts of this country in which the timber supply has run far short of the demand, the development of our transportation facilities has been such that other timbered sections have always been able to supply the want without hardship to the denuded section. Thus it is that the sources of lumber have been pushed far back into the mountainous regions of the West and the less densely populated parts of the Southeast, without the knowledge being very painfully impressed upon the people of the East and the Central States, their own timber supply having long since fallen far below their needs. This cannot continue and the time will come, and that at no very distant future, when there will not be enough forests left in the whole United States to supply the demand. Nor is there much hope of very lasting supplies being available for us in other countries. America is the last great treasure-house of virgin timber in the northern hemisphere. The timber of South America, the only southern continent that has a great excess, is not suitable to our needs. The much talked-of forests of Canada are wholly inadequate to supply the demands of two nations for any length of time.

It is imperative that the United States shall grow the timber necessary for its own use, and that a beginning be made at once. Already the time necessary to grow the timber for our own needs is short. We may call our country an agricultural country and a manfacturing country; but classify it as we may, it must be a timber-producing country or our other interests will inevitably suffer.

At present, the care of our forests, reproduction of our old forests and the creation of new ones are neglected, because it is said that such work will not pay. The experience of European countries, most of which have passed through exactly the same stages of development as ours, proves conclusively that it does pay. It goes back directly to the old question of supply and demand. It is necessary only for the demand sufficiently to exceed the supply to make it pay to raise trees on what is now our most valuable agricultural land. This condition, however, will never obtain except in peculiar districts, because, and only because, we have enough poorer land to produce all the timber we shall need.

Germany at one time had a much larger area of forest than she needed. At that time, as with us now, they cut the timber needed without reference to the future. It did not pay them to grow new forests while there was a sufficient supply from the old ones. This continued until the area of timber land was reduced to a low percentage. As the supply diminished, the price increased until it was apparent that some of the poorer qualities of land being used for ordinary agriculture would produce more revenue if devoted to the growing of forests. When the forested area became again too large, the prices fell and some of the forest land reverted to general agriculture. These trial balances showed plainly that about twenty-six per cent of the entire land area had to be devoted to timber growth if the proper balance was to be utilized to the greatest financial advantage.

The classification of lands

Here is the crux of the whole question of the development of our country, — the classification of our lands so that they may be used in the most productive capacity. Up to the present time this has not been done. All efforts in this direction have been unsatisfactory because they have not been based on the proper data. A chemical analysis of soil establishes certain facts in regard to its chemical constituents; in certain rare instances it determines the possibility or impossibility of that soil supporting a certain kind of plant growth; it may indicate that a soil is chemically suited for certain crops; it shows the effects of different vegetation on the soil, the elements used by different plants, and indicates the best method of increasing fertility; but as a means of determining the true economic value of that soil it is wholly inadequate.

The result is the same with the physical geological analysis. It brings out certain facts regarding the soil that are of value in testing the different theories of growth, and in determining the results of various cultural operations. It does not touch the question of economic values.

Reconnaissance, biological and ecological surveys determine the kind of vegetation that the soil now supports, and the data secured in this way may be used by the application of certain empirical laws to predict what kind of commercial crops may be grown more or less successfully on that quality of soil. But even then, although they give more reliable data on the possibilities of plant growth, they do not determine the economic value of the soil.

Why, then, are all these methods inadequate? For the very sufficient reason that the economic value of the land depends only partly on its quality, and is in many cases entirely independent of it. The value depends wholly on economic conditions that may or may not involve the quality of the soil as a factor; it may be a negligible factor to-day and of vast importance to-morrow, and *vice versa*. A piece of land in Nebraska ideal for the production of corn had no economic value a hundred years ago; to-day its corn-producing capacity is worth $100 per acre. And yet there are parts of that very corn land that are to-day more valuable for other purposes, wholly independent of its quality.

This shows that the economic value of land cannot be permanently fixed, nor its use determined once for all time. The use, the value, and hence the classification of all land is subject to change with differing conditions in the commercial world, and no inherent qualities of the soil can bind it permanently to one particular use. What, then, is the true basis of land value and hence land classification? Clearly, the productive capacity of land is governed by economic conditions only, — conditions that are subject to change and that may change completely the productive capacity, and hence the classification. It is these changing conditions that are ignored by ordinary methods of classification. More depends on the price of timber and the price of grain than on the quality of the soil. If these premises are true, — and no evidence can be produced against them, — a permanent classification of land is not practicable.

In the near future, — in fact it is already upon us, — the question of the division of our lands into the two great classes of tillable and forest land will be a pressing one. How shall we meet it? On what shall the classification be based? Once and for all it must be clearly understood that such classification is only temporary and subject to correction at any time. With this in mind, we must proceed on the only just basis: a comparison of the net revenues obtainable from the land under other crops and under forestry. The revenue from farm crops is usually available from pieces of similar land in the immediate vicinity. The production of the forest is a little harder to determine and a little less certain, but it can be secured. A study of the forest growth on the nearest similar land will furnish the data for calculating the future value of the forest crop, and the conversion of these figures into terms of annual revenues will make possible comparison with usual agricultural revenues. Since the forest data are not based on actual results obtained on that land, a margin of safety must be allowed. On the other hand, the trend of lumber prices is upward and the tendency toward increased cost of producing other agricultural crops must be carefully studied. We find ourselves involved in studies of growth, fertility, market and labor conditions. This is a complicated problem, but it must be solved if we are to realize the best possible returns from our land in the future.

The greater part of our land, when considered in the mass, is too clearly of either one class or the other for its use to be questioned. There are, however, two classes of land that are near the border line, the use of which must be decided by careful study: these are the farm lands that are so run down as to produce little revenue or that have lost out in the competition with cheaper land in the West, and the undeveloped land that was originally forest land and has not yet been cultivated. The disposition of these lands is very important, for its improper use means a tremendous loss to individuals, and more especially to the nation.

As an example of this doubtful class, the "hill lands" of New York or some of the poor farm lands of New England may be considered. Some of these lands have never yielded an income under tillage and should never have been cleared; others yielded a small net revenue when first cleared, but have since ceased to be profitable.

Some of these lands have been known to yield as high as $1.50 per annum net profits to the acre under forest, even without care. Under proper management, this could be doubled or trebled. The capital invested is next to nothing and the labor expended is small. This, it is to be remembered, is true of lands that will not pay any net returns under usual agricultural crops, and it is true of practically all such lands that are not swampy.

Another example of doubtful land classification is the jack-pine land of the Lake States. It will yield a small but respectable yearly revenue under timber. Under other farm crops the yields are so small as to make profits doubtful.

But even in such cases, the classification cannot be more than temporary; and is often reversed by outside influences. Some of the "hill lands" near the railroad stations may show profits from usual agricultural crops, while those farther away are no longer cultivated. Some of the jack-pine land which can be fertilized and is properly located may yield a large revenue in vegetables. A change in the location of a railroad might upset the whole scheme.

There are many sections — usually the poorer ones — which consider it a disgrace to have any of their lands classified as non-agricultural, or more strictly as non-cultivable. They think that it gives the section a bad name, that it will keep away settlers. This is a mistaken idea. It would be much better frankly to divide the land into classes and devote each class to its proper use. How much better for the community is a thrifty forest yielding its steady income, than a farm on which some poor man is wearing away his very soul and growing poorer every year!

The prevailingly unprofitable farm lands

In some cases, there are farms on which all the land is of a high tillage quality, too valuable as a crop-producer to be devoted to other purposes. There would be no place for a woodlot. But even under these conditions, if they extend over a large enough area, a point will be reached

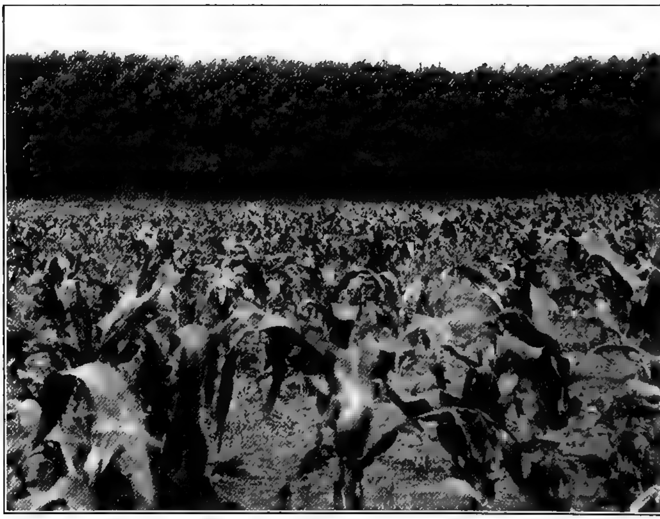

FIG. 2. — Two crops — maize, and the farm forest.

at which the products of the woodlot will become so high-priced that it will pay to raise forest trees on a certain proportion of that good cultivable soil. That is, the products of the woodlot would be more valuable than the other crops that could be raised on that same land. Should the area devoted to woodlots become too large, the prices would fall and some of the lots would revert to other agriculture. That is true no matter how valuable the land may be.

On most farms, in no matter what section of the country, a certain percentage of the land yields but a small profit — or none at all — under farm crops. In ninety nine cases out of a hundred, such land is abandoned and lies absolutely idle and a drag on the remainder of the farm, for it does not even pay its own taxes. That is poor economy. Why abandon a piece of land merely because it does not yield quite so high a revenue as the remainder? Why narrow our scheme of management by confining it to the land best suited to certain crops? Abandoned land on a farm is always a sign of shiftlessness or of an undeveloped plan. Each plat should be devoted to the purpose for which it is suited, and rare indeed is the land that is best suited to idleness. The farmer's problem includes the management of his whole farm, not of some one particular crop, and his scheme of management should include as careful a plan for the poor land as for that of the best quality; in fact the poorer lands usually require more careful planning.

The best general solution for the utilization of this unprofitable farm land is to make it a woodlot. This fits readily into any scheme of farm management, produces a good profit and adds to the value of the farm in many ways. No land on the farm is of such poor quality that it will not support tree growth, and some land of the poorest fertility will produce excellent crops of certain species of trees. The little work connected with it comes in the winter, when it does not interfere with any of the farm work.

When the forest is already standing on the waste land, as is usually the case in natural forest regions, the handling of the woodlot becomes a question of proper management to improve its sylvicultural condition and to increase the growth. In a prairie region, or where the original forest has been cut away, it is a question of selecting the proper species for planting and caring for the plantation so as to get the greatest profits. All those operations are described in the chapter on sylviculture.

Products of the woodlot

As already stated the woodlot increases the value of the farm in many ways. Probably the most important feature of the woodlot in most sections is its production of fuel. Most farmers use wood entirely for fuel. If this fuel is not produced on the farm, it usually must be bought at cash outlay — we are considering a settled community in which all the wild lands are under private ownership (for that will soon be the condition everywhere throughout the country) — and in addition will have to be hauled for long distances. The bulkiness of the material makes this hauling alone very expensive. A woodlot under proper management will easily yield a cord of wood to the acre yearly for an indefinite period.

Besides the production of cordwood, proper handling will produce a limited amount of sawlogs. The profit from these is usually very high, because only selected logs are taken and the quality of the timber is very high. Usually the market is close at hand and the cost of logging consequently very low. Even now the woodlots of the country produce some 80,000,000 ft. B.M.[1] of sawlogs. This could easily be doubled by proper management; and it is safe to say that the present area of the woodlots would be much more than doubled if the farm lands were all put to the use for which they are best adapted.

Posts, most of which are now shipped from long distances at great expense, can be grown at home, and the cost of fencing be very much reduced. Telephone poles for local lines can be grown; railroad ties are eagerly bought by the railroads. Nor must it be forgotten that all of these products yield more or less by-products in the form of cordwood. All of them, also, can be cut in the winter when men are otherwise idle and expensive horses are standing in the stable.

In many cases, this woodlot can be so located as to furnish shelter from damaging winds to the farm crops or homestead. The difference between a cozy home nestling in the shelter of a neighboring woodlot, and a house exposed to the winds of winter and the hot dry winds of summer, may not be calculated exactly in dollars and cents, but it certainly means much to those living therein.

The esthetic feature of the woodlot is also incapable of exact valuation, but it certainly adds much to the attractiveness of the country. It does away with the appearance of shiftlessness always accompanying waste land. Further, it is yielding a revenue from land that otherwise would be a drag on the remainder of the farm; and it is preparing the way for still greater profits later on — for a generation or two of forest growth will rehabilitate farm

[1] B.M. is the customary abbreviation for board measure, *i.e.* for square feet of surface of boards 1 in. thick.

land that has been run down beyond the possibility of successful cropping. The fertility of the land is renewed and increased by forest growth.

Lastly, but not of the least importance commercially, all these features greatly increase the sale value of the land. There is no doubt that a well-regulated woodlot with its appearance and its possibilities for production will increase the attractiveness of a farm sufficiently to raise its sale value several hundred dollars.

A few examples of the results of forest management in Europe and parts of America will assist in showing the possibilities of the woodlot as a money-producer. Large areas of the German forests, artificially planted and carefully tended, yield a net annual revenue of $4 to $8 per acre. Only a few of them yield less than $2.50 per acre. One forest in Switzerland yields as high as $14 per acre. Such large profits as these, in many cases higher than the revenues from our good farm lands, are not yet possible in this country owing to the low cost of lumber, but already plantations of white pine in New England have yielded six per cent on the investment annually, and that under rather careless management. It will be some time, possibly, before such profits can be realized on our large forest areas, but, owing to the ready market and the possibility of more complete utilization, the woodlot can already be made to participate in them.

The initial expense of establishing a woodlot is small, the expense and care of conducting it are almost negligible, and the returns, considering the quality of the land on which it grows, highly satisfactory. There are very few farms that can afford to be without a woodlot.

CHAPTER II

THE PLACE OF THE FOREST IN FARM MANAGEMENT

THE time has come when the woodlot should be given its proper place in every scheme of farm management. There was a time when every man in the prairie country considered it good farming to put all of the land he could plow into wheat; that time has passed. Even in the old East, the early farmer too often thought of his farm in terms of tillage and mowings and pasturage rather than including forests. All land is not suited to the production of wheat, nor can the best wheat land maintain its fertility if planted to wheat continuously for a long series of years.

The key to successful farming to-day is the careful classification of land (see page 19) and the no less careful selection of the crops best suited to each class. The enormous yields secured in some parts of the older countries are partly due to very intensive methods, but are more largely dependent on the detailed study of the same piece of land through several generations so that every peculiarity of the soil is known, the crop exactly suited to it selected. These methods will bring the highest yields, but of course the cost of production and the market must be carefully considered in order to obtain the highest net returns. The high cost of labor may in one case prohibit the crop which will bring the highest yield; the lack of a market may prevent it in another.

This proper choice of crops seems simple enough, but the idea makes its way very slowly against the customary practice. Because there was no market for a crop ten years ago, it is still avoided to-day, although conditions may have changed so completely that it would now be the best-paying crop on the farm.

It is this misplaced conservatism that has for so many years kept the woodlot from its proper place in the scheme of farm management. When there were large areas of natural timber, the woodlot products were so plentiful that they had no value, and no one could even imagine the time when they would be scarce. The settlers who occupied the treeless prairie all came from the regions of plentiful timber. They still remembered the back-breaking labor of clearing up the forest, and hesitated to sacrifice any of that beautiful open land to the growth of such a worthless crop — for so it was in their country — as forest trees, even though they were paying excessively high prices for lumber, posts and all the fuel they used. To them every square foot planted to trees was a sacrifice of good, productive land, — land which might be producing what they considered a valuable crop, — to produce something which had no intrinsic value.

These conditions have changed now in the timbered area, and they never really existed in the prairies. The woodlots in the hills of the forested East to-day yield as high net revenue as some of the more fertile cultivated lands of the valleys, in spite of the utter lack of care and the violent abuses they have suffered. And even the fertile prairie lands of the West, owing to the exigencies of the market, will sometimes yield a higher revenue when planted to trees and properly cared for than any other crop will average for the same period, while at the same time the woodlot will be of inestimable value to the rest of the farm in other ways.

CAPABILITIES OF THE WOODLOT

A few illustrations will demonstrate this very clearly. In New England, plantations of white pine made forty years ago on poor gravelly land, depleted by a long series of cropping, have yielded as high as forty thousand feet of box boards to the acre, worth ten dollars a thousand on the stump. This was sufficient to pay 6 per cent interest per annum on the value of the land and the cost of establishing the plantation. That was from a quality of land which would not at that time have produced any other crop which would have paid nearly as high returns. Yet the owner looked upon this as waste land and so little appreciated the value of the crop that he sold it for half its value without taking the trouble to investigate its true worth.

There are throughout the New England states many neglected, run-down farms that have grown up to volunteer crops of white pine. These crops have established themselves without expense to the owner and have never had care of any kind. In spite of this neglect, they have produced crops more valuable than farm crops and have at the same time rejuvenated the soil.

Warren, in Bulletin 295 of the Cornell Experiment Station, records an abandoned field in New York that had grown up to such a volunteer crop of trees. This field of thirty-five acres not only received absolutely no attention, but was even mistreated. At the end of twenty-two years the timber crop was sold for $106 per acre, a return of $4.82 per acre per annum from land which would not sell for $15 per acre. This is not an isolated case; there are acres of others which have done as well.

In the prairie sections of the Middle West, where there is no natural timber, there have been very few plantations made for commercial purposes. There are thousands of plantations, but they are so small and so highly valued for their protection and æsthetic effect that they are seldom cut. A conservative estimate will show, however, that they have a high intrinsic value for timber, posts and cord wood, entirely apart from the valuable protection they afford to homes, stock and crops.

Consider, for example, the following data collected from a windbreak plantation near Crookston, Minnesota: The plantation is two rods wide and contains five rows of cottonwood trees planted four feet apart in the row. This means 1650 trees per acre. These trees will all make one post, and half of them two. This means 2475 posts which have a value of .08 apiece for treating purposes, — a yield of $198 per acre in twelve years, or $16.50 per annum, over the cost of production. This is almost as much as the gross returns from a wheat crop. Should there not be a market for so many posts, the forty cords of wood will find a ready sale at $5 per cord, and the profits will be practically the same. The wheat crop so highly valued and universally planted in this section will not yield a third of this, and there is no grain crop that will average such a high revenue for such a long period of years. Yet there are millions of acres of wheat planted every year, and not an acre of forest except for the protection of less valuable crops.

These examples (and they are typical of thousands of other cases) show clearly enough that the farm woodlot deserves a definite and respected place in every scheme of farm management.

LOCATING THE WOODLOT

It is clear, then, that there should be a woodlot on every farm. The next thing is to choose the proper location for it. For convenience we shall discuss this under two heads: the hilly country of the East, and the level prairies of the West.

In comparison with the prairies, nearly all of the eastern farm lands may be considered hilly. On almost every farm there is a tract of land ill suited to cultivation, either on account of the steepness of the slope or the poor quality of the soil. In some cases it is so poor that it is not cultivated at all; in others it can be forced to yield a slender crop which is often produced at a loss. In either case it is the place to choose for the woodlot. The steepness of the slope does not in any way interfere with the growth of the trees, which require little, if any, cultivation in that country, and the roots of the trees hold the soil in place, prevent the hillside from eroding and burying the richer soils of the valleys. Nor is the poor quality of the soil much hindrance, for trees may do well on soil which is too poor to support any other crop. Every one of these so called "waste places" on the farm is capable of producing a very respectable revenue from the growth of forest trees.

Even in the prairie districts (and with the prairies are here grouped all the flat lands of fairly uniform quality), there are patches of land, some large and some small, which are poorly suited to cultivation and naturally suggest themselves as woodlot locations.

In the comparatively few cases in which the land is of uniformly good quality throughout, the necessity for windbreaks may aid in the location of the woodlots. In all the prairie sections this will be true, no matter what the character of the land. The cold winds of winter and the hot, drying winds of summer are now recognized as great obstacles to successful farming in these exposed regions. Homes are made uncomfortable, stock suffers and excessive supplies of forage are made necessary by the bitterly cold winds of winter. Soil moisture is evaporated, and, in many cases, the immature crops are burned up in the fields by the hot, dry winds of midsummer. Dry-farming methods and the selection of drought-resistant species are far from successful. Windbreaks are an absolute necessity.

These harmful winds blow consistently in a definite direction. Windbreaks should be placed at right angles to them and at sufficiently close intervals to protect the intervening spaces. These spaces should not much exceed a quarter of a mile in width, as a windbreak cannot be expected to extend its influence over a distance much greater than ten times its height. A number of such breaks would, however, prevent the formation of the diurnal[1] winds which do so much of the damage. The

[1] Winds which rise with the sun each day and go down with it; local winds made possible by large unbroken areas of overheated surface.

location of these windbreaks is dictated by the necessity for protection, and there is no reason why these same breaks should not serve the double purpose of protection and wood production. An increased width of windbreaks will greatly increase the efficiency of the break and make it an adequate source of wood supply without withdrawing nearly so large an area from cultivation as would be necessary if the windbreaks and woodlots were separate.

The land thus devoted to tree growth should never be less than 5 per cent of the farm, and in many cases 20 per cent of it can be so used to advantage. In the case of patchy land, the size of the woodlot should be governed by the area of the non-tillable land, provided always that it did not go below the minimum, as stated above. If the proper soil classification has been made, it cannot exceed the maximum, — for there is no money in farming poor soil. The land for this purpose should not be grudgingly set apart or considered a loss to the farm. It forms as distinctly legitimate a part of the scheme of farm management as wheat, oats, corn or any of the other cultivated crops, and in wood products alone will pay a higher rent on the quality of land it occupies than any of them, entirely apart from, and in addition to, its value as a windbreak, a harbor and breeding place for insect-eating birds, and a most pleasing feature in the landscape.

SUMMARY OF PREVIOUS DISCUSSIONS

Every farm should have a woodlot, — some large, some small, according to the quality of the soil, but there is no land so valuable that it will not pay to put a small part of it in a woodlot.

The woodlot should not be used as a pasture. No farmer would pasture his wheat crop; why then should he pasture a crop that is even more valuable? If shade is needed in the pasture, let him plant some good shade trees there and fence them off until they are large enough to take care of themselves. If the trees are taken care of, they will be worth a great deal; if they are injured by grazing animals, they will be worth much less. The value of such pasturage is comparatively nothing.

The woodlot should be located on the poorest land on the farm. The quality of the soil is very important in the production of grain crops; for the growth of trees it is unimportant. In this respect many of the woodlots in the East are now poorly located. In the original clearing of the farms very little attention was paid to the quality of the soil, and the woodlot was often left on the most fertile part of the farm. On the prairies the plantings should be so located as to furnish the best protection to the cultivated crops, the stockyards and the homestead.

Heretofore, the idea of protection has been too much restricted to the homestead. This is important in increasing the comfort of the home, but the protection of the crops is far more important from the financial viewpoint. The increase in yield within the influence of the windbreak will often exceed 50 per cent. It is often objected that such a break destroys the fertility of the adjoining field for a rod on either side of it. This objection is easily overruled when we stop to consider that an increased yield of 10 per cent in the area influenced by a thirty-five-foot break will compensate for a total loss on a two-rod strip next to the break. Moreover, there is always more or less of a loss along any boundary, whether it be a fence or a row of trees, so the windbreak should not be charged with too much waste. In any case the wood produced in the break will more than pay for all the land it occupies or wastes entirely aside from the protection it affords.

Lastly, the profits from groves already harvested show that there is not a section of the northeastern United States or Canada where a farm woodlot of the proper size will not produce a crop more valuable, that is, yielding a higher net revenue per annum, than any grain crop. Therefore the woodlot should always be given a prominent and definite place in any plan of farm management, not for any sentimental or æsthetic reason, but because it is a money-maker, the best one on the farm.

THE CLEARING OF A FARM

There is one type of farm on which forestry must necessarily play a much larger part than it does on the older and more settled parts of the country or on the windy prairies, yet it has so far received absolutely no attention. This type comprises those farms that are now being cleared in the timbered or cut-over regions.

It is very natural that little attention should have been given these farms in a forestry way. These districts have always had a superabundance of timber. Logging has been the principal business. Most of the settlers have taken the claims for the sake of the timber on them, or because they were cheap stump land. Many of them have worked in the logging camps and have the logger's contempt for anything except big, clear saw timber. They care nothing for young growth and have no conception of the land ever being able to produce valuable timber again. To them the forest is a mine, not a growing crop.

None of these men has ever cleared any land, and he has no idea of what it means to clean up a hundred and sixty acres of stump land so that it can be cultivated.

The wrong way

Without any definite plans, or any estimate of costs, persons pick out the place that seems the easiest to clear and build a small shack in the middle of it, absolutely regardless of the character of the soil. Most of them know very little of farming. They have never actually figured on the results they expect to attain, and have an indefinite idea that they are going to clear the whole farm in two years. They have a still hazier, but more strongly rooted, idea that the more often a piece of land is burned over, the easier it is to clear.

Under these conditions it is natural that they should not only take no precautions against fire, but should even use every effort to have the land burned over as often as possible. In a very few years every growing thing on the farm is destroyed except the almost indestructible and rapidly growing brush. The land is reduced to a tangle of worthless "bush," and all tree seed and tree seedlings have been destroyed. The density of the brush soon makes the volunteer growth of trees impossible and even successful planting very difficult and expensive.

Less than an acre is the average area cleared the first year, and the man who has ten acres of cultivated land at the end of five years is the energetic exception. He has had but little time to work on his own place. He had no capital to start with, and must live. Clearing land is hard, discouraging and lonesome work. He finds more immediate returns and more congenial work in the logging camps in the winter, on the drive in the spring and in the harvest fields of the established farms in the fall. This enforced absence from home makes it impossible for him to keep stock of any kind or have a garden, the only two lines of work open to him with the land at his disposal.

Should he stick to the place long enough to clear up ten acres, he almost invariably plants it up to the grain crop most popular in that section. Distance from market, forced neglect and lack of facilities generally destroy the possibility of profit; he cannot eat the crop himself and is no nearer self-support and prosperity than he was before.

In nine cases out of every ten the settler becomes disgusted or completely discouraged, lets the so-called "farm" go for taxes and moves on, probably to repeat the performance at some other place.

Such methods, or lack of method, have broken the hearts and discouraged the lives of thousands of men. It has delayed the development of our timbered cut-over lands a half a century and has left our country burdened with thousands of abandoned claims, worse than worthless waste lands which might just as well be producing millions of revenue and supporting countless, prosperous homes if the tree value of the land had only been considered in the first place.

The right way

The first necessity for a man who is attempting to clear a cut-over or timbered claim, unless he has unlimited capital and does not have to depend upon the farm for his livelihood, is the realization that land devoted to the growth of timber is capable of producing a good revenue if protected from fire. Without that realization his success must necessarily be very limited and very uncertain.

Next, he must bear in mind that not all land is worth clearing. Many a man has devoted his whole life and sacrificed his family in the effort to clear a farm which proved to be useless when it was cleared. Select good land; a poor farm is worse than none. That same land will produce good profits in timber; as a farm it will be only an expense to the owner.

A piece of good land chosen, the next thing needed is a definite and comprehensive plan of operation. Five acres is more than the average man can clear alone in a year. Eighty acres is more than he ought to attempt in a lifetime. If he is going to accomplish anything, he must be on the place all the time; if he is going to be there all the time, the place must support him from the very start. This means that the first crops must be such as he can eat. Fortunately these can be raised on a small patch of the right kind of land.

The first step, then, is clear. The first clearing should be made in the place best suited to a garden. From this he can easily raise enough to support him and sell enough more to buy the mere necessities of life.

The brush land furnishes good pasture for cattle and sheep, especially when it is seeded between the stumps, and advantage should be taken of it. Eighty acres will suffice for cultivated land and pasture for the first generation at least. This area should be selected at the start and fenced off. There should be a definite plan of development for this eighty acres covering the next forty years, but the details of it lie beyond the province of this book.

Our business lies with the other eighty acres. It has been explained above that this eighty acres will not be needed in the plan of farm development for at least forty years. If this land is burned over and pastured, as is the common practice, it will steadily deteriorate and will produce absolutely nothing. In the meanwhile the taxes are piling up and the eighty acres of unused land — producing no revenue — is hanging as a lifeless burden on the rest of the farm. The tract cannot pay its way, and the rest of the farm must not only pay the taxes, but must eventually pay for the clearing of the land as well.

This is almost the universal custom, but it is quite as foolish as it is universal. Experience has proven conclusively that any of this timber land and cut-over land — if the soil is good — will grow up to a volunteer crop of timber, provided it is protected from fire and grazing, and that without any work or expenditure on the part of the owner. Just how valuable the crop of timber is will depend on the character of the soil and the consequent character of the forest. It will vary from forty cords of firewood in some types to forty thousand feet of valuable box board lumber in others. In either case it will be sufficient to pay the taxes for the forty years, pay the expenses of clearing the land, if this seems desirable, and often in addition will pay a higher net revenue per acre than the rest of the farm has averaged in these early stages of development.

A very conservative estimate of the value of this eighty acres of volunteer timber crop at the end of the forty years would be $6400, and in some sections of the country it would be three times as much. This is an unearned increment which is not to be despised, and yet it is being absolutely ignored and thrown away on tens of thousands of farms in the United States and Canada to-day.

Nor should all of the timber ever be cut from the farm, even where the height of its development has been attained. In these regions of plentiful timber it is but natural that the value of the woodlot should be underestimated or altogether ignored. But there could not be a greater mistake. It is an economic impossibility to cultivate all the land in any section. Part of it must be in timber. Many illustrations of the truth of this can be seen in the older settled districts. Take, for example, the most highly developed portions of the country, places where farm land has reached a ridiculously high figure and waste space is done away with. These sections in the timber belt show from 10 to 25 per cent still in forest; in the prairies the established woodlot is the farmer's most cherished possession, and the acreage devoted to this purpose is steadily increasing. It can never be otherwise.

Why, then, should the pioneer struggle to clear all of the timber from his farm when he or his descendants will most certainly be obliged to replace some of it? The correct handling of the woodlands of an uncleared claim is the most important factor in the management and development of such farms and should receive the attention it deserves.

CHAPTER III

THE GROWTH OF THE TREE

No book on forestry, no matter how "popular" it may be, would be complete without a brief sketch describing the parts of a tree and how it grows, — for on that knowledge is based the management of the woodlot in all its phases.

A tree is a plant of upright growth which usually attains a height of at least fifteen feet. It consists of an upright branching stem, roots, leaves, buds, flowers and fruit. The stem is usually unbranched below, when the plant is grown, forming a trunk or bole.

The leaves, the most evident part of the tree in summer, are the factories where the food for the nourishment of the whole tree is prepared. In this process they take in carbonic acid gas from the air, and give off oxygen as a waste product. They may be almost any shape, from the feather-like compound leaves of the honey locust to the needle-like leaf of the pine or the mere scale of the arborvitæ, and the size varies greatly. No matter what their shape or size, they perform the same functions of manufacturing the raw materials taken from the air and soil into carbohydrates for plant-food.

If the leaves remain on the tree over winter, this tree is called an evergreen; if the leaves all fall off in the autumn, it is called deciduous. Even the evergreens do not keep the same leaves all the time; they are only called evergreens because they never lose all their leaves at the same time. The white pine needles remain on the trees from two to four years, the red cedar seven or eight and the other evergreens range between these two. In falling, they give back to the soil chemicals that the tree has drawn from it, and more besides. It is this which causes the continued growth of forest on a piece of land to increase the fertility of the soil.

The roots supply most of the raw material with which the leaves work. They are underground branches specially adapted to absorb moisture from the soil.

Some trees, such as the oaks, hickories, walnuts and some of the pines, have practically only one root, a large one called a tap-root, running straight down into the ground. This is an inherited quality and cannot be modified very much by a change in the environment.

Others, such as the spruce, tamarack and balsam, have a lateral system of roots which lie on or very near the surface of the ground, while still others, like our maples, ashes and elms, have a combination of the two, or a mixed system. These are a little better able to change and adapt themselves to new conditions.

These roots, by reason of very fine rootlets, or root hairs, suck up water from the soil and in solution with it certain small quantities of lime, magnesia and potash, — the raw materials for plant-food. This water passes through the roots, up the stem of the tree and out the branches to the leaves. Here the excess water evaporates through the pores, and the leaves work up the mineral salts and the elements obtained from the air into sugar and starch from which the wood tissues are made. This passage of the water up the stem in the early spring is known as the "rising of the sap." Since this is the only way the tree has of securing food, it is absolutely essential that these necessary materials be in soluble form. Should they be present ever so abundantly in insoluble combinations, or poisoned by salts or acids, the tree would nevertheless starve. This often happens with all kinds of plants, and is well known by most farmers.

The roots also fulfill the further purpose of holding the tree upright. Naturally the trees with the long tap-root running deep into the ground are the firmest, because they have the best grip on the soil. Such trees are practically never uprooted, — they break off first. Those having the mixed root systems are also fairly firm and not easily blown over unless they have been grown in a very protected location and then suddenly deprived of their protection, — for, as explained above, they easily adapt themselves to conditions and would not take a deep hold on the ground unless forced to it by constant strain. The shallow-rooted species have a still weaker hold, and are easily upset even when most carefully trained to withstand the wind. The roots are much quicker to respond to the necessity of giving stronger mechanical support than to the exigencies of a new moisture or soil condition.

The stem, trunk or bole. — The trunk of the tree answers the double purpose of transporting the water supplied by the roots, and supporting the crown; its branches spread the leaves to the light.

If a cross-section of the stem is studied, its structure may be quite plainly seen. In the center is a small spot of pith varying from a mere pin point in the pine to a half inch in diameter in some of the sumacs and elders. This was the original live tissue from which the rest has grown. Surrounding it are a number of concentric rings, very distinct in the oak, almost invisible in the black gum. Each ring represents the growth of a year. The inner portion of the ring is usually of a lighter color and softer texture. This is the spring wood. It is formed in the spring when the tree is living on the food stored over from the preceding season, and the walls of the cells, of which all wood is composed, are very thin. The wood of deciduous trees, the hardwoods, is usually full of little holes, the cross-sections of hollow cells; in the conifers, or softwoods, the holes are so small that they cannot be seen with the naked eye. The outer portion of the ring is of darker color and harder tissue. This is the growth of the summer or autumn, when the leaves are furnishing an abundance of food, and the cell walls are very thick. The contrast is very much stronger in some woods than in others.

In the tropical forests, the trees either do not show these rings at all, or, when present, they do not represent years of growth. There the growth is continuous throughout the year, except when interrupted by drought; there is no cold weather to bring about a rest period. Consequently rings, when present, represent periods of drought instead of years, and the age of the trees cannot be ascertained definitely in this way. If the trunk examined is an oak, there will be evident streaks of white wood radiating from the central pith, like the spokes of a wheel, only in broken lines. These are called the pith rays or medullary rays.

They are lines of living tissue running at right angles to the other fibers and furnish a storehouse for the surplus food saved over from one season to another. It is the splitting of these rays that makes the silver grain in quarter-sawed oak; they are also important as the starting point for checks in seasoned lumber. They are present in all woods but are so small in many species that they cannot be perceived without the use of a microscope. A further variation may be noted in the appearance of the cross-section. The outer portion, varying with the species, from three to fifty rings in width, is of a lighter color than the inner portion. This is called the sapwood. It is through this porton of the stem that most of the water, or sap, passes. Girdle this and the food supply of the tree is cut off.

When the tree is young, all the wood is sapwood. At varying ages in the different species, by some process as yet not thoroughly understood, this sapwood undergoes a change. It ceases to conduct the sap, and is strengthened by certain injections that harden and mature it and darken the color. The change is both chemical and physical. It is then known as heartwood, and practically ceases to play any active part in the life of the tree, save as a mechanical support for the crown. The change from sapwood to heartwood does not take place at any particular age. The sapwood may extend through twenty rings on one side of the tree and only half a dozen on the other; the line separating the two is very irregular.

Surrounding the stem is a layer of bark. It varies in thickness from a sixteenth of an inch in the paper birch to six inches in the big trees of California, but is always present. Its purpose is to protect the growing tissue. There is always a soft, pulpy inner bark and a woody or corky outer bark. The various forms that it may take are as numerous as the species of trees, and in many cases as distinctive. A close examination shows that the bark is divided into annual rings, and were it not for the fact that the hard outer bark cracks and scales off from time to time, the age could be told from the bark as well as from the wood. This bark covers the entire tree, stem, roots and branches.

As yet we have not discovered the source of growth, and unless we know what to look for, may not find it at all. It is most easily seen in the spring. Between the bark and the wood is a very thin layer of mucilaginous living tissue. During the growing season this tissue grows in two directions, outward to form the bark and inward to form wood. It is by means of this tissue that all diameter growth takes place. This is called the cambium and like the bark envelops the whole tree. Where this layer is taken off, diameter growth ceases.

The buds are arranged on the branches in regular order at the base of the leaf stems. They are formed in the autumn, when the tree is maturing its season's growth, for the winter protection of the tender growing points. The buds at the ends of the branches are called "terminal" buds, those along the branches, "lateral" buds. These buds are of two kinds: flower buds, which will produce the flowers in the spring; and leaf buds. The flower buds are often to be distinguished by their larger size. They are more easily damaged by frost than the leaf buds.

The flower is that part of the plant which produces the fruit. Many persons do not know that trees produce flowers and fruits. They confine the term flower to the ornamental blossoms of certain garden plants, and the term fruit to such things as apples and oranges. Nevertheless, every plant of the higher orders puts forth flowers. In the trees, most of the flowers are very inconspicuous. There are three different arrangements for the tree flowers. In some species, such as the cherry and the mountain ash, the flowers are perfect, that is both sexes are represented in the same flower. The second class, the elm, oaks and pines among them, have the different sexes in different flowers on the same tree. The third class have the different sexes on different trees, the cottonwoods and willows being of this class. This is the reason why some cottonwoods spread the objectionable cotton over everything and others do not; why some holly has red berries, others none.

Fruit. — Every tree which produces pistillate flowers bears fruit. We use the term carelessly and frequently confuse the fruit and the seed. The fruit is the seed, — one or more in number, — together with the seed covering, whether it be a hairy catkin, a fleshy drupe or a dry samara. The flower is the generative organ that produces the fruit, and this fruit contains the seed that produces the small tree.

The fruit is important in this discussion only because it produces the seed. These seeds are of almost innumerable shapes and sizes; the important ones will be described later on. The means by which the seeds are distributed is the only point that must be taken up here. Among the species with which we are interested at present, there are only two means of distribution: the wind and the birds. The fleshy fruits, such as cherries, hackberries, red cedar berries, and the like, are eaten by the birds and dropped, often far from the tree on which they grew. The heavy nuts can only roll or be carried short distances by squirrels. All the others are supplied with some means to facilitate wind transportation, as tufts of hair, wings, leaf attachments, and the like.

LIFE HISTORY OF A TREE

With the above description of the tree and its parts in mind, it will be easy to follow out a brief sketch of its life history. When the seed is first placed in the ground, it begins to absorb moisture. This softens the outer coating of the seed and causes the fleshy portion within to swell. Moisture and warmth start the growth in the embryo of the seed, — the real germ of life. The covering splits, the primary leaves or cotyledons appear above the ground and the root grows downward. The plant at this stage feeds on the fleshy part of the seed, the endosperm. At this stage it is almost impossible for any one but an expert to distinguish the different species, since the cotyledons do not, in many species, in the least resemble the mature leaves. The arborvitæ and the pine, for example, are hardly distinguishable the first season.

The plant is established on an independent growing basis if the root strikes readily into mineral soil, but if, through any difficulty the endosperm is exhausted before the root takes hold, the seedling shrivels and dies. The different species vary greatly in their habits of growth in the early seedling stage. Some, like the nut trees, devote most of their energies to establish their root systems. The tap-root of a one-year-old hickory is often as long as, or longer than, the stem. Others, like the cottonwoods and willows, make a rapid height growth with a comparatively small root system. The hardwoods, as a rule, make much more rapid growth for the first few years than the softwoods. Most of them put forth mature leaves and grow a foot or more in height the first year. Most of the softwoods or conifers retain their cotyledons through the first season and do not put forth any real leaves. They rarely attain a height of over three inches the first year, and many of them not more than two. They are so small that they are usually overlooked in the woods unless one is familiar with their appearance. All this growth of the first season comes from the central pith. The cambium is formed as the diameter growth continues. As autumn approaches, growth ceases, the wood is matured and the buds are formed to protect the growing points, — arranged in regular order along the stem of the hardwoods, in a whorl at the top of the coniferous stem. The leaves of the hardwoods fall and the little trees are ready for the winter.

In the winter season, the hardwoods, as far as we know, take an absolute rest, although there may be more or less movement of fluids. Everything is prepared for the cold weather and the leaves are gone. The evergreens are as well prepared as the hardwoods, save that they do not drop their leaves. This is sometimes detrimental and even fatal in some open winters on the open prairies. The sweep of a south wind forces evaporation from the leaves when the ground is still frozen hard. In this way, the tree is robbed of its normal amount of moisture, and the leaves and twigs become shriveled, sometimes so severely that they cannot recover. The warmth of spring starts growth in the plant once more. The sap rises in the trees, the buds open, the leaves and flowers come out, and the live tissue, that completely covers the tree, stem and branches in an unbroken layer, begins growth. During this period, the tree feeds on the surplus food stored away the year before. The growth from the growing points in the buds produces length of branch or height of stem. The cambium produces diameter growth. Neither stem nor branch ever grows in length except at the end. There is a common belief that the fence wire nailed on the trunk of a tree will rise as the tree grows. This is not true. The trunk grows only in diameter. This spring growth is producing the thin-walled layer of cells found in the inner part of the ring in the cross-section. When the leaves come out and the work of manufacturing food begins, the thick-walled cells of the outer part are formed. Through the summer, more food is produced than can be used for growth, and this surplus is stored away in the pith rays for the growth of the following spring. This completes the yearly round of life in the tree. The following years of growth are the same as this second one.

At ages varying with the species, flower buds are formed and fruit produced. This occurs in some species, like the jack pine, at the age of seven or eight years. Such early fruiting, however, is premature and the seed, if any is produced, rarely possesses any vitality. This is more or less true of the first seed produced by any plant.

By repeating this annual program, the tree continues to grow for an indefinite period. Some species are naturally shorter-lived than others. The gray birch, for example, rarely lives more than thirty or forty years, while the big trees of the Pacific Coast are some of them three or four thousand years old. There does not appear to be any definite limit to the age of trees, but when growth becomes slow and their vitality low they become subject to the attacks of insects and fungi that cause death and destroy the wood after they die.

The thrifty tree may be picked out by its general appearance and the shape of its crown. So long as growth is rapid and healthy, the crown retains a conical shape. This is true of both conifers and hardwoods. When the tree has attained its height and the growth is less strong, the crown broadens and flattens out. This flat-topped appearance shows that the tree has practically finished its height growth and is growing only in diameter and this only to a slight extent. Extremely old trees sometimes lack enough food for growth throughout the cambium and lay on increment only in the upper portions. This condition is usually followed very shortly by death, — a death, however, that requires many years for its fulfillment.

CHAPTER IV

DENDROLOGY

The study of the kinds of trees, and of their botanical characteristics, is dendrology. The study of the cultivation or growing of trees in forest plantations is sylviculture.

A completer distinction between the two terms may be made, in order that the reader may never be confused. Sylviculture means forest-culture. It is derived from *sylva*, meaning forest, plus the word culture. It deals with forest crops as agriculture deals with farm crops. As used in forestry, sylviculture means the producing of forest trees for forestry purposes. It includes the growing of forest trees by sowing and planting, or what is known as "artificial regeneration," and the growing of forest trees by caring for established forests so that the best and most useful trees are produced and new trees spring up naturally, or what is known as "natural regeneration." In either case, nature is aided to produce the best results in the shortest possible time. In its broadest sense, sylviculture includes everything that is connected with the life history of a forest. Nature alone is oftentimes slow and uncertain, and since the forester must attend to the economic side, it becomes necessary to render aid, such as supplying seed and plants and by furnishing the most desirable trees, which nature does not always do, and by aiding in the production of the best trees in a minimum amount of time.

Sylviculture is primarily an art and as such it is based on a science. This science is *Sylvics*. Sylvics is the knowledge of the sylvicultural characteristics of forest trees. It treats of the life history of forest trees as individual species, or of a tree, while sylviculture deals with a collection of trees or with a forest. Before sylviculture can be practiced with any intelligence, a knowledge of the requirements of each species of tree, such as soil, moisture, climate, and the like, must be secured, and upon this sylviculture must be based. Sylvics begins with a knowledge of the number and kinds of our forest trees and their ready identification as to genus and species wherever found. This has to do with the simple botany of trees, their botanical characteristics, similarities and differences, and is called *Dendrology*, from *dendron*, meaning tree. Sylviculture should then, properly, begin with a study of the tree flora (as in Chapter IV) and be followed (as in Chapter V) with a discussion of sylviculture.

The scope of dendrology is large and includes much that must be omitted here. The present treatment, however, will include a study of sufficient distinguishing characteristics of our common trees to enable any student to identify such as come to his attention.

Our trees fall very naturally into two great groups: —

Conifers, — meaning cone-bearing trees, such as the pines and spruces. (Nearly all our conifers have needle-shaped leaves, and with the exception of the larches all our northern conifers are evergreen.)

Broadleaf trees, — meaning trees with broad leaves, such as the elms and oaks. (All our northern broadleaf trees have deciduous foliage, *i.e.* the leaves fall from the trees every autumn and new leaves appear in the following spring. The term hardwoods is often used instead of broadleaf trees.)

THE CONIFERS

The cone-bearing trees are of first importance in any scheme or practice of forestry. Pine, hemlock, fir, spruce, redwood and cypress timber provide the greater part of framework and finishing material in wood construction.

Key to the Common Conifers

I. Fruit a woody cone made up of overlapping cone-scales: seeds winged, two from each fertile scale.

A. Leaves needle-shaped, single or in clusters.

1. Arrangement of leaves from 2 to 5 in a cluster, usually over 2 inches long, evergreen (or persistent). *The pines.*

2. Arrangement of leaves, in brush-like clusters, many not evergreen (deciduous). *The larches.*

3. Arrangement of leaves single, short, scattered over the twigs.

a. The leaves standing on short stalks and spreading out in all directions from the twig: twigs rough after leaves fall. *The spruces.*

b. The leaves not stalked, and appear to be arranged in two ranks: resin blisters in bark of trunk: cones large, upright, scales falling with the seed. *The firs.*

c. The leaves on short stalks, and appear to be in two ranks: no resin blisters in bark: cones small, pendant or pointing outward. *The hemlock.*

B. Leaves scale-like, very small and closely pressed to the twig; Branches flattened: cones very small with scales opposite and in pairs.

The white cedar.

II. Fruit a small, fleshy, blue berry: leaves scale-like, also awl-shaped: branches not flattened.

The red cedar.

The pines. Figs. 3, 4

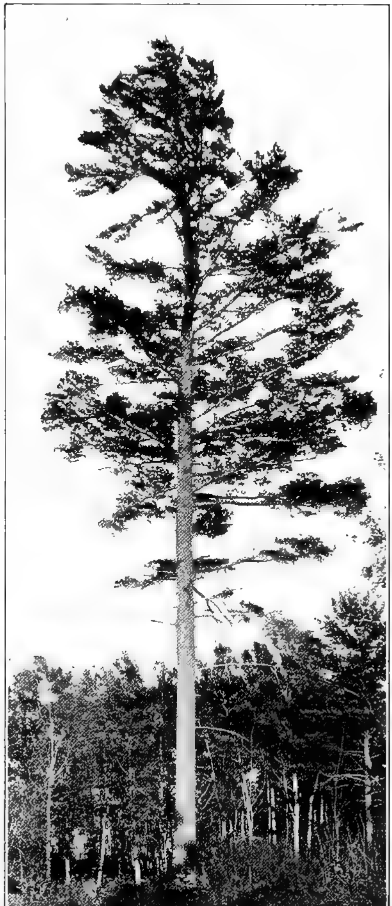

Fig. 3. — Mature white pine. — A good seed tree.

The pines are very ancient trees, having evergreen needle-shaped leaves and bearing their seed in cones. They are amongst the foremost lumber trees in this country. They produce hard and soft wood marked by light and dark bands of wood in which there is much resin. Great pine forests once oc-

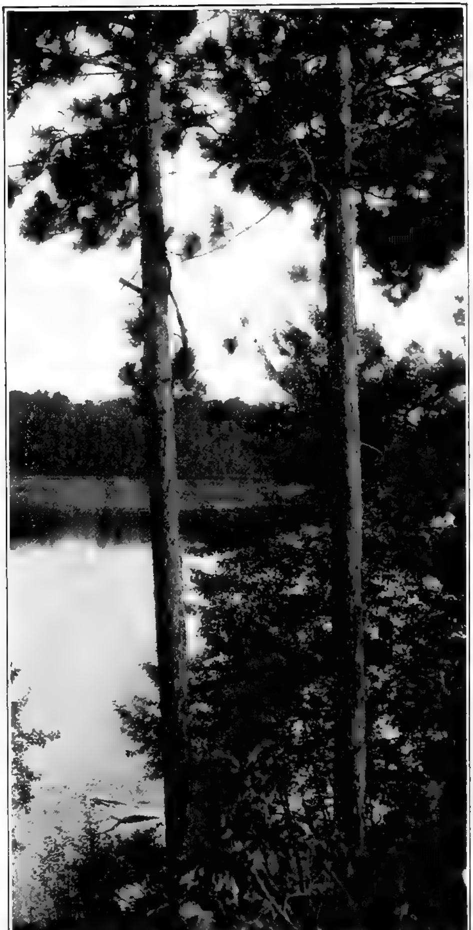

FIG. 4. — Mature Norway pine. — Pinus resinosa.

curred in the Lake States and in the East and South, but the lumberman has destroyed practically all of them. The great pine areas have been so completely cut over and burned that most of our pine land does not now produce pine, but instead worthless brush and small unimportant trees. The pines do not sprout as do hardwoods. Trees under twenty years of age rarely bear good seed and when all others are cut, there is no chance for new pine trees to grow.

THE KINDS OF PINES

NAME	LEAVES	CONES	BARK	SIZE
Pinus Strobus White pine	5 in a cluster, blue-green and soft, 3–5 in. long	4–8 in. long, scales thin and without spines	Gray, deeply furrowed and thick, smooth on young trees	80–125 ft. high, 2–4 ft. in diameter
Pinus resinosa Red pine	2 in a cluster, 5–6 in. long and dark green	2–3 in. long, egg-shaped, with small spines	Light red brown or cinnamon red, in broad plates	50–90 ft. high 1–3 ft. diameter
Pinus rigida Pitch pine	3 in a cluster, yellow-green, 3–5 in. long, stiff	1–3 in. long, egg-shaped, with small sharp spines on scales	Reddish brown scaly, or broken by irregular furrows	30–70 ft. high, 1–2 ft. diameter
Pinus divaricata Jack pine	2 in a cluster, 1–2 in. long, thick, twisted, sharp pointed	2–4 in. long, smooth, strongly curved, persistent for years	Dark gray, scaly, rough and rather thin	40–90 ft. high, 1–2 ft. diameter
Pinus ponderosa Bull pine	2 and 3 in a cluster, 3–15 in. long, yellow-green, shiny	3–6 in. long, hard, with sharp curved points on end of scales	Cinnamon red to black, divided into large plates	60–200 ft. high, 3–8 ft. diameter
Pinus sylvestris Scotch pine	2 in a cluster, 1 to 2 in. long, twisted and sharp pointed, blue-green	1 to 2½ in. long, small deciduous spine, single and clustered	Reddish gray and scaly	20 to 50 ft. high, 10 to 15 in. diameter

Our pines are known by such names as "hard pines," "soft pines," "yellow pines," "white pines," "pitch pines," all of which are given them by the lumberman and the carpenter, depending on the amount of pitch any piece may contain or whether it is hard or soft and whether the color is white or yellowish. These names are confusing and uncertain. A standard common name should always be used in speaking of any of these trees so that others may know what kind of pine is meant.

The Scotch pine and Austrian pine are not native to this country, but have been introduced from Europe. They are valuable trees for planting in certain places and are used particularly in farm plantations.

The larches

The larches are distinguished from the pines chiefly by their leaves. In summer the foliage is very different, and in the winter the larches are without leaves as are the oaks and elms. Of the three larches occurring naturally in the United States but one is found in the eastern half. This one is the common tamarack of the north woods and chiefly of the swamps. The European larch is a species introduced from Europe and is a better and larger tree than our native tamarack. It is used for ornamental planting and, to considerable extent, for farm planting. It is a valuable tree for the farm woodlot as it is a rapid grower and produces very excellent wood.

The wood of the larch is hard, durable in the soil and is resinous. Our native larch is distinctly a swamp tree of the northern states and Canada, and in most of the tamarack swamps it does not attain very large size, usually forming excellent pole and post wood.

The larches do not sprout, and new trees must always be grown from seed.

The Kinds of Larches

Name	Leaves	Cones	Bark	Size
Larix laricina Tamarack	In brush-like tufts, about 1 in. long, bright green, turning yellow in autumn when they fall	Small, light brown, $\frac{3}{4}$ in. long, globular	Thin, reddish and in small scales	50 to 60 ft. high, 18 to 20 in. in diameter
Larix europæa European larch	In brush-like tufts $\frac{3}{4}$ to 1 and $\frac{1}{4}$ in. long, bright green, falling each autumn	From $\frac{3}{4}$ to $1\frac{1}{2}$ in. long, much larger than the above	Dark grayish brown and in small scales	About 100 ft. high, and from 1 to 2 ft. in diameter

The spruces. Fig. 5

There are seven native spruces in the United States, three of which occur in the East. Of these three, the red spruce is the most important. White spruce is next in value and the black spruce of least value. The Norway spruce is a native of Europe and has been introduced into this country largely as an ornamental tree. It is a rapid-growing and comparatively short-lived tree. The conical crown with its beautiful drooping branches becomes open and ragged after about thirty years. The spruces are important timber trees. The soft, light-colored straight-grained wood has many very important uses. The red spruce furnishes the best wood for sounding-boards used for all kinds of musical instruments, and the white spruce supplies the best material for wood pulp from which paper is made. The spruces are readily distinguished from the other cone-bearing trees, chiefly by their leaves.

Fig. 5. — Three spruces. White spruce twig (*Picea canadensis*). Norway spruce cone on left. Cone of white spruce on right.

The leaves are single and are arranged on all sides of the branch. They are short, stiff, and usually sharp pointed.

THE KINDS OF SPRUCES

NAME	LEAVES	CONES	BARK	SIZE
Picea canadensis White spruce	Blue-green or pale blue, $\frac{1}{3}$ to $\frac{3}{4}$ in. long	On short stems 2 in. long, slender and pale green	Gray-brown, breaking into thin scales	60 to 100 ft. high, 1 ft. to 20 in. in diameter
Picea rubens Red spruce	Dark yellow-green, very glossy, about $\frac{1}{2}$ in. long	Stalked, $1\frac{1}{4}$ to 2 in. long, greenish purple	Thin, red-brown, scaly	50 to 80 ft. high, 1 to 3 ft. diameter
Picea mariana Black spruce	Blue-green not glossy, $\frac{1}{2}$ in. long, stiff	$\frac{1}{2}$ to 1 in. long, ovate, gray-brown, persistent for many years	Gray-brown, scaly, thin	20 to 60 ft. high, 6 to 18 in. diameter
Picea excelsa Norway spruce	Dark-green, usually shining, $\frac{1}{3}$ to 1 in. long, pointed	4 to 7 in. long, light brown	Thin, reddish brown	50 to 100 ft. high, 1 to 2 ft. in diameter

The firs

Of the nine firs in the United States, two occur in the eastern part; one of these, the balsam fir or more commonly known as the balsam, is northern. This tree is readily recognized from the nature of its cones and the resin blisters in the bark. The firs do not have resin in the wood as do the pines and spruces. This resin or balsam that occurs in the bark is collected, and furnishes the Canada balsam of commerce. The cones stand upright, and when mature they fall to pieces, leaving nothing on the tree except the slender axis to which the cone scales were attached. The wood is light, soft, not strong, coarse-grained, brownish yellow in color and is very perishable in the soil. It furnishes poor lumber and is largely used for fuel; also for poor-grade lumber used largely for making packing boxes. The firs are used to some extent for ornamental planting about farmhouses, and the average northern woodlot usually has some balsam firs scattered among the other trees.

THE COMMON FIR

NAME	LEAVES	CONES	BARK	SIZE
Abies balsamea Balsam fir	1 to 1½ in. long, dark green above, white underneath	Upright on branch, dark rich purple, 2 to 4 in. long	½ in. thick, rich brown, scaly, with numerous resin blisters	40 to 60 ft. high, 12 to 20 in. diameter

The hemlock

Of the four hemlocks in the United States, two are eastern and two are western. Of the eastern species, *Tsuga canadensis* is found usually among the trees of the woodlot or farm forest throughout the northern states from Minnesota eastward. The hemlocks are large trees with many limbs and a rough, reddish bark. The leaves are arranged on opposite sides of the branches and are short and shiny above and light colored beneath. The cones are very small for such a large tree and occur on the ends of the branches. The wood is brittle, coarse-grained, stiff and splintery and hard to work. It decays very quickly when used in moist places. The bark is very rich in tannin and is usually more valuable than the wood.

THE COMMON HEMLOCK

NAME	LEAVES	CONES	BARK	SIZE
Tsuga canadensis Hemlock	Green above, white underneath, about ½ in. long	¾ in. long, light brown, on ends of branches	Cinnamon red or dark gray, deeply furrowed and rough	40 to 70 ft. high, 2 to 4 ft. diameter

The white cedar

The white cedar is frequently called arborvitæ. There are only two species in the United States, one eastern and the other western. The eastern species is a tree of the northern swamp regions, and along streams. The white cedar is often cultivated and is very valuable for decorative planting. It forms an excellent hedge. Almost every northern farm forest has white cedar scattered in the wet places. The wood is light, soft, rather brittle and coarse-grained, pale yellow-brown and very aromatic. It is very durable in the soil and is an excellent wood for fence posts, telephone poles, shingles, and so on.

THE COMMON WHITE CEDAR

NAME	LEAVES	CONES	BARK	SIZE
Thuya occidentalis White cedar	Scale-like, ¼ in. long with resin gland	⅓ to ½ in. long, brownish yellow when mature	Thin, light red brown, shedding in vertical strips	40 to 60 ft. high, 1 to 3 ft. diameter

The red cedar

The red cedar is often called the red juniper. There are about eleven species of junipers in the United States, but only one that grows to tree size in northeastern America. The red cedar is a tree of dry and gravelly places and is found mostly along fences and in old abandoned fields. It grows abundantly on the steep dry ridges along rivers and small streams. The red cedar is readily separated from the other conifers by its fruit, which is a cone changed to a small blue berry. These berries are usually found on the trees at all times of the year. The wood is light, fine-grained, weak, easily worked and very durable in the soil. Cedar oil is distilled from the wood, and the shavings of the wood are used to preserve woolens against moths. The fragrant wood is used for many special purposes, as in making pencils and pen holders. As a post material about the farm, the red cedar is of great value.

THE COMMON RED CEDAR

NAME	LEAVES	CONES	BARK	SIZE
Juniperus virginiana Red cedar	Scale-like and awl-shaped, dark blue-green	¼ in. in diameter, appearing as a blue-green berry	Thin, light brown tinged with red, sheds in strips	20 to 50 ft. high, 8 to 18 in. diameter

THE BROADLEAF TREES

The trees with broad leaves are widely different in kind and the number of species is very large. They comprise the common hardwoods and softwoods.

Key to the Genera of the Common Broadleaf Trees[1]

I. Branches, leaves and buds opposite.

A. Leaves simple with large lobes: seeds in pairs and winged: buds mostly round and red. *The maples.*

B. Leaves compound, without lobes but toothed: seeds single and winged: buds pointed and dark brown or black. *The ashes.*

II. Branches, leaves and buds alternate.

A. The leaves simple.

1. Leaves with large lobes: fruit an acorn: buds scaly and clustered on ends of twigs. *The oaks.*

2. Leaves not lobed but toothed on edges.

a. Seeds in a burr.

1. Burr large and very spiny: nut dark brown and edible: bark furrowed vertically. *The chestnut.*

2. Burr small with short blunt spines: nut three-sided, light brown and edible: bark gray and smooth. *The beech.*

b. Seeds not in a burr.

1. The seeds disc-shaped and papery, ripening as new leaves appear: branches very fine and often zig-zag: tree vase-shaped. *The elms.*

2. The seeds very small, attached to tufts of cotton.

a. Buds usually large, covered with many scales: bark usually smooth and light colored. *The poplars.*

[1] This key includes only the common and useful trees of the farm woodlot.

b. Buds small, covered with one hood-like scale: silky underneath scale: bark dark colored. *The willows.*

3. The seeds in a small woody cone: buds with many scales: bark smooth, with horizontal markings, rolling back horizontally in thick or thin layers. *The birches.*

4. The seeds in a growth resembling a hop with many seeds each in a papery sac: bark ashy gray and scaly: branches very fine with small scaly buds. *The hornbeam.*

B. The leaves compound.

1. Fruit a large nut with a rough shell and an entire husk: pith in twigs honeycombed and brown: buds gray and silky. *The walnuts.*

2. Fruit a medium-sized nut with a smooth shell and a divided husk: pith in twigs solid (not honeycombed): buds gray or yellow. *The hickories.*

3. Fruit a bean-like pod: branches with small brown spines: leaves doubly compound: buds sunken into the bark of the twigs each between a pair of spines. *The locust.*

The maples. Figs. 6, 7, 8

The maples are fast-growing trees and are found in almost any woodlot. They furnish high-grade and valu-

Fig. 6.—Silver or soft maple (*Acer saccharinum*).

able wood and have a dense-foliaged crown, making most of them valuable for decorative planting. The maples may be recognized by their opposite, broad, coarsely lobed

Fig. 7. — Sugar maple (*Acer saccharum*).

leaves, their winged seed growing in pairs, and their opposite buds usually rounded and dark red in color. The red and silver maples produce their red blossoms before the leaves are out and their seed is ripe in early summer. The sugar maple and box elder bloom after the leaves

Fig. 8. — Box elder (*Acer Negundo*).

are out and ripen their seed in the fall. The sugar maple is the most valuable species for wood as well as for its good qualities as a shade tree. It is an excellent fuel wood. The red and silver maples are very commonly known as soft maples. They are faster growers than the sugar maple but do not furnish wood as hard and valuable. They prefer moist soil and will produce good fuel wood in a comparatively short time. The box elder is not generally considered a maple. It is the poorest of the four. It has compound leaves resembling the ash, and for this reason

The Kinds of Maples

Name	Leaves	Buds	Bark	Fruit
Acer rubrum Red maple	3 to 5 lobes, doubly toothed, whitish underneath, simple	Opposite, rounded and red, clustered flower buds	Brownish red on twigs, gray on trunk and limbs	Seed winged in pairs, ripe in early summer
Acer sacchari-num Silver maple	Lobes usually 5, long and narrow, toothed, silvery white underneath	Very similar to above but less red, slightly green or yellowish	Greenish or yellowish brown on twigs, dark gray on trunk	Seed winged and larger than above, ripe in early summer
Acer saccharum Sugar maple	5- and 3-lobed, not toothed, pale green underneath, Simple	Opposite, dark brown or black, sharply pointed	Grayish brown on twigs, gray and turning black on trunk	Seed winged and in pairs, ripe in the fall
Acer Negundo Box elder	Compound, 3- to 5-pinnate, resembling the leaves of the ash	Opposite, small, rounded and silky white	Smooth and purplish green on twigs, grayish brown on trunk	Seed winged in pairs, ripe in fall, remain on tree all winter

is sometimes called ash-leaved maple. It has been used very extensively as a tree for farm planting, as windbreaks

Fig. 9. — White ash (*Fraxinus americana*).

and for shade. It is fairly rapid in its growth and when young is quite a beautiful tree. It soon becomes unsightly and irregular in shapes, inclined to be crooked and defective unless given special care. All the maples sprout from the stump and roots.

The ashes. Figs. 9, 10

THE KINDS OF ASHES

NAME	LEAVES	BUDS	BARK	FRUIT
Fraxinus americana White ash	Compound, 7–9-stalked, leaflets occasionally toothed	Opposite, brown, terminal large pointed, lateral rounded	Grayish green and smooth on twigs, dark gray and brown, finely furrowed on trunk	Seed winged, ripe in late fall, hangs on tree until winter
Fraxinus nigra Black ash	Compound, 7–11 leaflets, not stalked except terminal one	Opposite, black, terminal large pointed, lateral rounded	Olive-green on twigs, ashy gray on trunk, furrowed and scaly	Similar to white ash
Fraxinus pennsylvanica Red ash	Compound, 7–9 leaflets, stalked	Opposite, brown, terminal large pointed, lateral rounded	Greenish gray on twigs, downy, dark gray or brown on trunk	Similar to white ash
Fraxinus lanceolata Green ash	Compound, 5–9 leaflets, stalked	Opposite, rusty brown, blunt, terminal pointed, lateral rounded	Greenish gray on twigs, smooth, dark grayish brown on trunk, furrowed	Similar to white ash

Fig. 10. — A well-developed white ash.

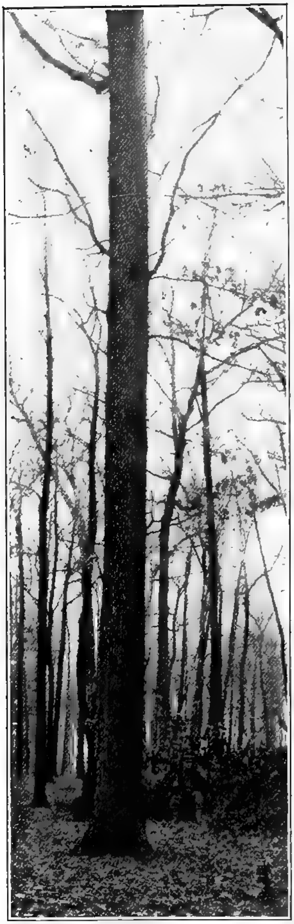

FIG. 11.—Forest-grown white oak.

The ashes are among the valuable trees of the woodlot because of the hard, strong and useful wood. The white ash produces the best wood of all the species and is the most valuable. It is also the most abundant. The various species of the ash are not easily distinguished, since in their general characters they are quite similar. All the ashes have opposite buds and have the twigs flattened where the buds occur. The green ash is probably a variety of the red ash, but is a better tree. It is largely planted in the prairie states and is a very valuable tree for this purpose. The wood of the ashes is mostly hard, strong, heavy and tough, and is used largely in the manufacture of farm tools and implements. It is also used for making baskets, for interior finish and in furniture making. The ashes are not related to the common mountain ash, which belongs in the genus Sorbus of the rose family.

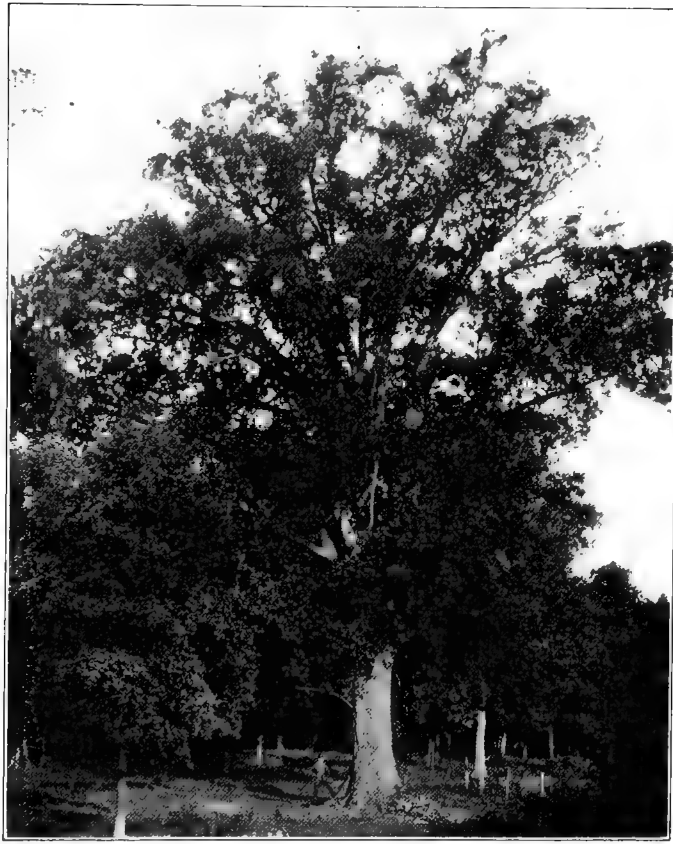

FIG. 12. — Open-grown white oak.

The oaks. Figs. 11, 12, 13, 14, 15, 16, 17

The oaks are among the most common of the woodland trees. They very naturally fall into two distinct groups,

Fig. 13. — White oak (*Quercus alba*).

the white oaks and the black oaks. As a rule, the white oaks have finer grained, tougher and stronger wood than the black oaks. For farm purposes, the white oaks are preferable. Both groups furnish good fuel wood. The

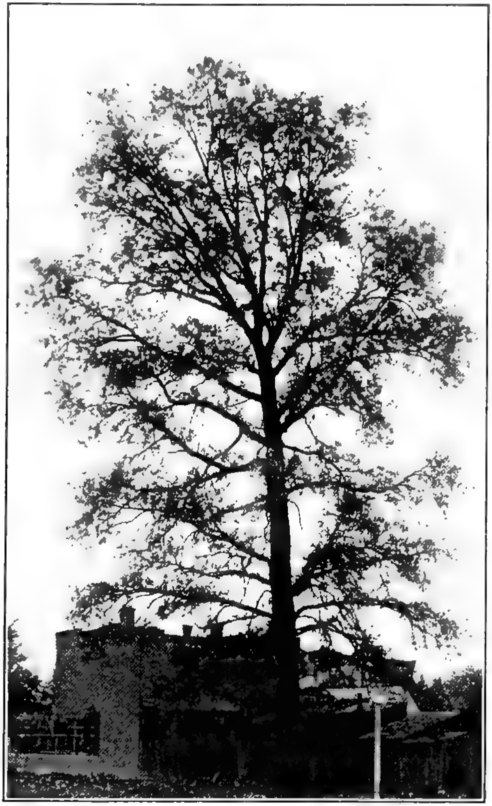

Fig. 14.—Burr oak on a city lot.

white oak, burr oak, and so on belong to the white oak group and mature their fruit in one summer; the red

FIG. 15.—Burr oak (*Quercus macrocarpa*).

oak, scarlet oak and the like to the black oaks, and mature their fruit in two summers. The oaks produce large quantities of seed. The acorns may be gathered in the fall and planted at once or kept moist and cold over winter and planted in the spring. The oaks also form excellent stump sprouts, and a good crop of fuel may be grown in this way. All the oaks are slow growers. The white oaks are particularly slow and it requires almost a lifetime to develop a good tree. The red oak is about the fastest grower of the oaks and is an excellent tree for planting. It furnishes good fuel and supplies many demands about the farm. It would be difficult to find a natural woodlot without some species of oak, and frequently several kinds are present in the same lot.

FIG. 16. — Red oak (*Quercus rubra*).

Fig. 17. — Scarlet oak (*Quercus coccinea*).

The different kinds of oaks found in the average woodlot may readily be distinguished by consulting the following contrast: —

1. Acorns maturing in one season: bark ashy gray: lobes of leaves rounded: buds rounded. *White oaks.*
2. Acorns maturing in two seasons: bark almost black: lobes of leaves bristle-tipped: buds pointed. *Black oaks.*

THE WHITE OAKS

NAME	LEAVES	BUDS	BARK	FRUIT
Quercus alba White oak	Evenly lobed, usually seven-lobed, bright green above, whitish underneath	Rounded, scaly, grayish brown and scurfy	Broken into soft irregular flakes, ashy gray, smooth on branches	Light brown, elongated, about ¾ in. long, in cup about ¼ its length
Quercus platanoides Swamp White oak	Scalloped and lobed, broad, narrowing toward petiole	Rounded, scaly, short and thick, inconspicuous, scurfy, greenish or dark gray brown	Divided into broad flat ridges, grayish brown on trunk, dark gray and scaly on branches	About 1 in broad and thick, grayish brown, in cup about ½ its length
Quercus Prinus Chestnut oak	Not lobed but coarsely scalloped, oblong, yellowish green	Usually pointed, scaly and smooth, brown	Very rough and hard, deeply furrowed, dark gray	Light brown, elongated, an inch or more in length, in a thin cup about ½ its length
Quercus macrocarpa Burr oak	Upper portion scalloped, lower portion deeply lobed, dark green, shiny above, pale underneath	Small, blunt, and rough gray, usually pubescent	Gray brown, scaly very corky on twigs, with prominent corky ridges on twigs	Variable in size ½–2 in. long with very large fringed cup almost covering acorn

THE BLACK OAKS

NAME	LEAVES	BUDS	BARK	FRUIT
Quercus rubra Red oak	Short lobes, bristle-tipped, broad, dark green above and yellowish green below, red in autumn	Scaly, pointed, short and broad, smooth and reddish brown	Dark gray or black, rough and deeply and broadly ridged, smooth on twigs, no dead stubs on trunk	Large, reddish brown, 1 in. or more in length, cup very shallow and flat, about ⅛ of acorn in cup, one-year-old acorns present in winter
Quercus coccinea Scarlet oak	Long lobed and lacy in appearance, bristle-tipped, bright green above, scarlet in autumn	Similar to above, but usually with tips hairy	Very similar to above, usually slightly rougher, trunk usually with many small stubs, on twigs smooth	Smaller than above, broad and short, less than 1 in. held in a heavy cup for about ½ its length, one-year-old acorns present in winter
Quercus velutina Black or Yellow oak	Resembling red oak in shape but glossy above, with yellowish petioles	Long, sharply pointed, 5-sided and covered with gray hairs	Almost black, rough and furrowed on trunk, smooth on branches, inner bark orange colored	Very similar to scarlet oak except cup is rougher and has fringed margin, one-year-old acorns present in winter

THE BLACK OAKS — *Continued*

NAME	LEAVES	BUDS	BARK	FRUIT
Quercus palustris Pin oak	Resembling scarlet oak except smaller	Very small, pointed, smooth, dark brown, scaly	Very dark, finely furrowed and hard, numerous little dead branches on trunk	Very small, dark brown, with vertical black stripes radiating from tip, flesh yellow, one-year-old acorns present in winter

The chestnut

There are two species of chestnut in eastern America, but only one is of importance as a timber tree, and this is the common American chestnut. Everyone within the natural range of the chestnut knows the tree and its fruit. The tree is very generally distributed throughout the hardwood forest of the United States, and almost every farm woodlot will have chestnut amongst the other species. Chestnut is particularly valuable about the farm as a post timber and for all kinds of fencing and for any purpose for which wood durable in the soil is needed. It is not particularly strong and supplies a different kind of farm wood from most other common species. It is also a desirable tree for its fruit, which is a rather large and very spiny burr containing from one to three rich brown nuts, very delicious to the taste. These ripen in the fall about the time frost appears. Chestnut grows very readily from the seed but makes better and more rapid growth from stump sprouts. A tree grown from the seed will, when cut down, send up a number of shoots from the stump that in 25 or 30 years will grow into good sized poles and produce three or four on the same stump which produced one tree before. This sprout system is the most profitable way to grow chestnut on the farm.

THE AMERICAN CHESTNUT

NAME	LEAVES	BUDS	BARK	FRUIT
Castanea dentata American chestnut	Simple, oblong, coarsely toothed, alternate, dark yellow green in color	Scaly, smooth, rounded, and yellowish brown in color	Very dark gray and deeply furrowed on trunk, smooth and brown on twigs, often with a yellowish tinge	A globose and very spiny burr containing one or more shiny dark brown, thin-shelled, sweet and edible nuts

The beech.

The American beech is a very characteristic tree and when once known is not confused with other trees, since there is but one species in this country. There are several other beeches in America, but they have been brought from Europe and are found planted for decorative purposes in parks and on lawns. They may usually be known by their deep purple leaves or green deeply cut leaves. Our native beech is a beautiful tree with smooth, tight-fitting steel- or light-gray bark and simple, alternate, oval leaves with coarse serrations. The fruit is a small prickly burr, very different from that of the chestnut, inclosing one or two small light brown triangular or three-sided, sweet and edible nuts. The wood is fine-grained, hard and strong, but not durable when in contact with the soil or when used in a moist situation. The wood makes a good interior finish and flooring, and is used for handles. About the farm, it is especially valuable for fuel and for purposes for which a strong wood is needed and where it will remain dry. The beech will grow excellently in a woodlot under the other and taller trees. It forms an excellent understory in forestry. The American beech must not be confounded with the so-called blue beech. The latter is a small tree and is entirely distinct from the former. In winter, the American beech may readily be recognized by its long, sharply pointed light brown and scaly buds and its smooth gray bark. No other tree in our northern forests has a bud like the beech.

THE AMERICAN BEECH

NAME	LEAVES	BUDS	BARK	FRUIT
Fagus americana American beech	Simple, alternate, toothed, green on both sides	About 1 in. long, slender and sharply pointed, scaly and shining brown	Smooth, close-fitting and bluish gray or steel blue	A small prickly burr with one or two thin-shelled three-sided light brown nuts, kernel sweet and edible

The elms. Fig. 18

The elms are valuable trees both for their strong, hard and tough wood and for decorative planting. The elm tree assumes a fountain-like or vase form and with its drooping outer branches is one of our most beautiful shade trees. The elms are early blooming trees. The blossoms appear long before the leaves, and the seeds are ripe about the time the leaves are fully developed. The disc-like green seeds fall to the ground as soon as ripe and when the soil is favorable, they grow in a few days. Elm seeds must be planted as soon as collected. The most common species is the American or white elm. The cork or rock elm may easily be distinguished by the corky ridges on the bark of the twigs. The slippery elm has very hairy buds and the

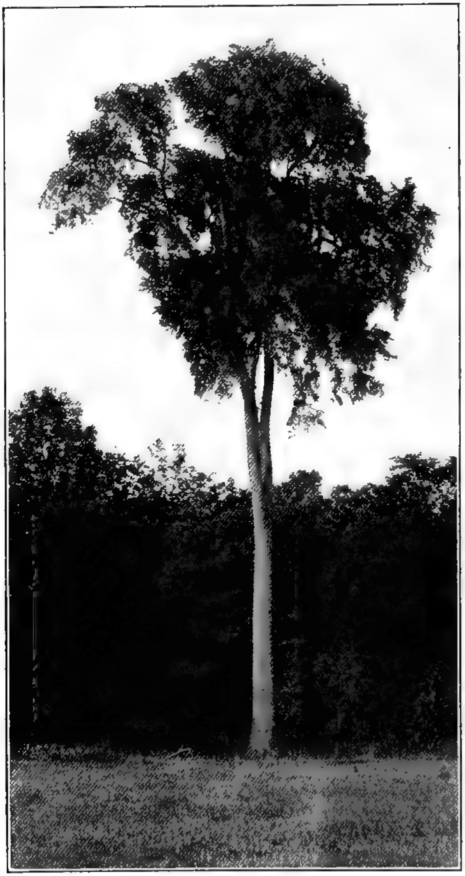

Fig. 18. — American elm. Typical form.

inner bark is mucilaginous and sweet to the taste. Elm wood has many uses and is a valuable wood about the farm and home, whenever strong and tough wood is desired. For a shade tree in the yard and on home grounds, the elm is valued next to the maple for the beauty of its crown and the deep cool shade it produces. A fine lawn specimen if far more valuable for its beauty and shade than for its wood.

The Kinds of Elms

Name	Leaves	Buds	Bark	Fruit
Ulmus americana White or American elm	Alternate, simple toothed, and rough above, smooth underneath	Scaly, smooth, brown, leaf buds small, flower buds large and flat	Dark brown, smooth on twigs, ashy gray, furrowed on trunk	A papery wafer, winged, ripe in spring before leaves are full grown
Ulmus racemosa Rock or Cork elm	Alternate, simple toothed, and similar to above	Very similar to above	Dark brown with ridges of cork on twigs, ashy gray and furrowed on trunk	Similar to above
Ulmus pubescens Slippery or Red elm	Alternate, simple toothed, rough and harsh on both sides	Rounded, dark brown, hairy, large flat flower buds, very hairy	Dark brown and rough, hairy on twigs, gray and furrowed on trunk, inner bark mucilaginous	Similar to above

The poplars. Figs. 19, 20, 21

The genus Populus, or the poplars, is a group of trees not very well understood by the layman. They are commonly

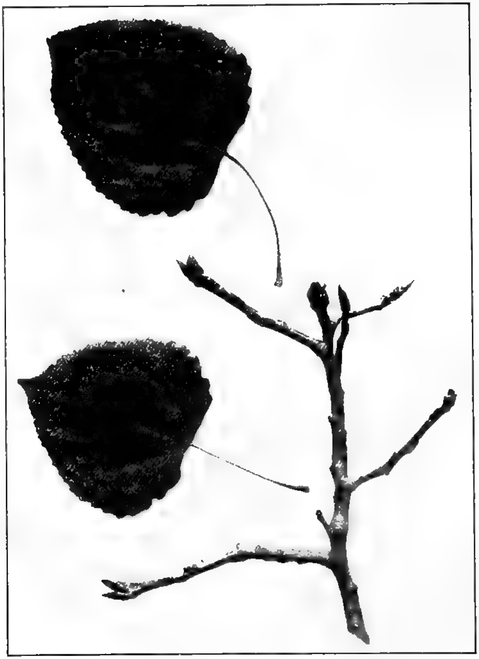

Fig. 19. — Trembling aspen or popple (*Populus tremuloides*).

known as the cottonwoods or the aspens. To this group belong such trees as the Norway poplar and the North Carolina poplar. These are varieties of the common cottonwood or *Populus deltoides*. The poplars must not be confused with the yellow poplar or tulip tree. This latter is a very different tree and is closely related to the

Fig. 20. — Big-tooth aspen (*Populus grandidentata*).

magnolias. The poplars are very widely distributed over the United States and are particularly conspicuous

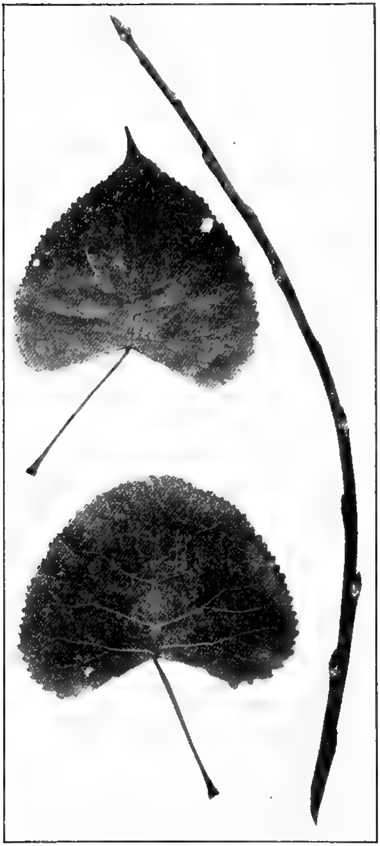

Fig. 21. — Cottonwood (*Populus deltoides*).

in the northern part, particularly on cut-over and burned-over forest land. The trees of this group always may be distinguished by the leaves and fruit. The leaves have their petioles flattened at right angles to the blade of the leaf and this causes them to flutter in the slightest breeze. They always bloom in early spring before the leaves are out, and the seed is ripe and ready for dissemination by the time the leaves are about fully developed. The seed is widely scattered by the little cotton tuft to which it is attached. This cotton is borne only on the pistillate tree, hence the nuisance about the farm and home may be entirely avoided by planting the staminate form. Although the poplars grow well from seed, all of them grow from cuttings, and it is in this way that they are propagated.

The wood of all the species is soft, fine-grained, weak and very perishable in the earth. Most of the species are rapid growers, especially the forms known as Norway

THE KINDS OF POPLAR

NAME	LEAVES	BUDS	BARK	FRUIT
Populus tremuloides Quaking aspen, or popple	Broad and rounded, shining above, flattened petiole, finely toothed	Alternate, sharply pointed and almost black, shiny and sometimes slightly sticky	Greenish gray and almost smooth, with black scars, inner bark bitter	A catkin with many capsules, each with many small seeds attached to a cottony tuft which serves to float it in the air, mature at time the leaves are developed
Populus grandidentata Large-tooth aspen	Broad and oval with very coarse serrations, or coarsely scalloped, upper surface dull	Alternate, blunt pointed, light gray and hairy, not sticky	Greenish gray, turning black, smooth except on old trunk, inner bark not bitter	Very similar to above except developing a little later
Populus deltoides Cotton-wood	Triangular with finely toothed margin, smooth above	Alternate, long pointed, sticky with a resinous balsam	Light gray on young trees, blackish gray and very rough on old trunks	Similar to above

poplar and the North Carolina poplar. These two trees are very extensively used in plantations, particularly in the prairie and northern states. The wood is valuable for fuel and gives good-sized timber in a short time. For fence posts, the wood is very suitable and lasting when properly treated with creosote or some other wood preservative. Cottonwood lumber has many uses and is becoming more prominent as other woods are becoming more rare and consequently more expensive. The wood now finds its way into finishing material for buildings and finds a large use for packing boxes and wood pulp.

There are a number of poplars that have been introduced from Europe and most of these can easily be distinguished from our native species. The Lombardy poplar is one of these and is very commonly planted. It may readily be recognized by its tall spire-like form, having all the limbs vertically arranged, forming a spire. Another common species is the white poplar, sometimes wrongly called the "silver maple." This species forms a large wide-spreading crown and has light colored bark; the upper side of the leaf is green while the under is white and cottony.

The willows. Fig. 22

There are so many species of the willows that it is a difficult matter to present any kind of classification that is of value. The willows may be found in almost every piece of wood land, particularly if there is considerable moisture in the soil or if there is a swampy area. The willows belong to the same family as the poplars and the two genera have many characters in common. A willow may always be distinguished from a poplar by examining the bud scale. The poplars have scaly buds, while the willows have but one bud scale, which covers the bud like a hood. The blossoms are very similar, being borne in separate aments and on separate trees. The blossoms appear very early in the spring, and the seeds are in some species scattered early in the spring and in others in midsummer. The willows have their buds covered, under the hoodlike scale, with a whitish silky pubescence which becomes very showy as soon as growth begins and the bud scale is pushed off. These silky buds give the name of "pussy willow" to practically any of the species with buds large enough to become showy. Some species have very large buds and when fully developed produce a very beautiful appearance on lawn trees or wherever decorative effects are appreciated.

Fig. 22. — Willow (*Salix*).

The wood of the willows is about the same as that of the poplars so far as farm forestry is concerned. They are fast growers, producing soft, light, weak and perishable wood which is put to about the same uses about the farm as poplar.

Many of our willows are introduced

from Europe and this makes it more difficult to know all the native species. Willows are good trees for windbreak purposes, particularly where snow traps are necessary about plantations. Willows produce great quantities of seed almost every year but it is not desirable to propagate them from seed, since they grow very well from cuttings, which method of propagation is the one used by all planters.

The birches

Every farm woodlot has some species of birch and frequently there are a number of species. The black and yellow birches are the most common trees in the deep woods and are usually found along streams and in moist places. The former is the larger tree, as a rule, and does not favor moist places quite so much as the latter. By consulting the following key, the common birches may be readily distinguished. As a rule, after a little observation they may be distinguished easily by their bark. The black and yellow birches have a pronounced odor and flavor of wintergreen in the inner bark. In the black birch this flavor is very strong, while in the yellow it is milder and modified by a slightly bitter taste. From the branches and bark of the black birch is distilled the extract of wintergreen. Both these trees are valuable for their wood, which has very general use for flooring and interior finish as well as for furniture and many other purposes. About the farm the birches are very useful for the excellent fuel which they produce. The wood has good heating qualities and burns without sparking. The gray and paper birches are less important except for fuel. They usually occur after a forest fire or after lumbering, and are charac-

The Kinds of Birch

Name	Leaves	Buds	Bark	Fruit
Betula lenta Sweet or Black birch	Alternate, oval, simple, finely toothed	Scaly, green and brown, staminate aments present in winter	Dark brown, shiny on twigs, very dark on trunk, resembling cherry, inner bark very aromatic	Resembling a cone, remaining on tree and shedding seed in late fall and winter
Betula lutea Yellow birch	Alternate, oval, simple, finely toothed, dull green on upper side	Very similar to above	Light brown and shiny on twigs, silvery gray or straw colored on trunk, coming off in curls, less aromatic than above	Very similar to above
Betula papyrifera Paper birch	Alternate, short pointed, doubly toothed, not shiny above	Small, scaly, sharply pointed, sometimes waxy, staminate aments present in winter	Brownish red on twigs, glossy, chalky white on outside of trunk, brown underneath separating into thin papery layers, not aromatic	Very similar to above
Betula populifolia White or Gray birch	Alternate, long pointed, triangular, shiny above and doubly toothed	Small, pointed, waxy and scaly, staminate aments present in winter	Blackish on twigs, chalky white with black blotches on trunk, not papery, not aromatic	Very similar to above

teristic of such areas as well as of abandoned fields. The birches seed abundantly and the seed is scattered widely by the wind. They also sprout from the stump and in this way are prolific fuel producers.

The hornbeam

The hornbeam, or ironwood, is not a tree that is found in the farm plantation. It is very common and is found in practically every natural woodlot in which trees have had an equal opportunity to establish themselves. The hornbeam is sometimes called ironwood and is confused with the small tree called blue beech or ironwood. The two trees are small, but the hornbeam is by far the more valuable. The two trees may readily be distinguished from each other by the nature and color of the bark. The blue beech has a close-fitting dark gray bark and fluted trunk.

THE COMMON HORNBEAM

NAME	LEAVES	BUDS	BARK	FRUIT
Ostrya virginiana Hop Hornbeam or ironwood	Simple, alternate, oval and finely toothed, resembling the elm	Very small, scaly and rich brown in color, staminate aments present in winter with the buds	Light gray, soft and scaly, resembling the bark of a young white oak	Hop-like, consisting of a number of papery sacs each containing one seed

The hornbeam is a valuable little tree for its tough and very hard and fine-grained wood. It does not grow to large size, but can be depended on to furnish a pole of exceptional strength and toughness. It is also good for handles and finds many uses about the farm. It produces considerable quantities of seed and may readily be grown from seed. It will grow in any average woods soil, and in any woodlot in which it does not occur, it is well worth while to encourage its introduction.

The walnuts. Fig. 23

The walnuts are very desirable trees to have about the farm and woodlot. Of the walnuts native to the United States, there are but two species in the East and these are easily distinguished from each other. In some sections of the country the hickories are locally called walnuts. This is not correct and leads to confusion. The English walnut also is found frequently planted about homes, but it has been introduced from Europe and does not belong to our trees. The black walnut and the butternut are quite different in their development as trees. The former is by far the better tree as well as the more valuable for its wood. The heart wood of this walnut is very dark colored and has a very fine grain, making it a very desirable and costly wood for furniture of all kinds. The roots of large trees are also very valuable, particularly for gun stocks. Good well-developed black walnut can

Fig. 23. — Branch of butternut (*Juglans cinerea*), showing chambered pith.

be used, tree and stump. The butternut is in some places called the white walnut. It is usually a very much poorer tree in its development, forming a low, wide-spreading tree or frequently having a number of stems from the same root. The fruit of both species is valuable for food, and every farm boy knows walnuts and butternuts. For farm planting the walnuts are not the most desirable trees, since they require such good soil that the land is worth more for agriculture or horticulture than for tree growing. To be sure they will grow in poor soil, but so slowly that other trees are more valuable. For the farm the walnuts are better as individual trees planted about the farm or home grounds where such trees are desired. As individual trees, the walnuts bear large quantities of fruit and they

THE KINDS OF WALNUT

NAME	LEAVES	BUDS	BARK	FRUIT
Juglans nigra Black walnut	Compound, 15–23 leaflets, alternate	Few scales, covered with silky gray hairs, lateral buds superposed, pith chambered and brown	Light gray on twigs, very dark or blackish, rough and deeply furrowed on trunk	Hard-shelled, globose with a green, smooth husk, not sticky
Juglans cinerea Butternut	Compound, 11–17 leaflets, alternate	Few scales, covered with silky gray hairs not so large as above, pith chambered, and brown	Greenish gray on twigs, gray and furrowed on trunk	An elongated, hard-shelled rough nut covered by a yellowish sticky husk

are more desirable for this purpose than for wood and timber for the farm. Walnuts are easily grown from seed. They have the habit of sending straight down a very long and persistent tap-root very early in life, so that they are difficult trees to handle successfully in planting. It is always advisable to plant the seed in the place where the trees are desired, and if there is danger of squirrels digging out the nuts and eating them, it is well to coat them with tar or anything that will keep squirrels away. If safe from mice and squirrels, the nuts may be planted in the fall. Otherwise they will need to be kept in moist sand in a cold place all winter and planted in the spring as soon as the ground is free from frost.

The hickories

The hickories are very widely distributed in North America. Most of the species are very valuable for their wood and some are valuable also for their fruit. Almost every native farm woodlot will have some species of hickory. If not, trees of a desirable species can easily be grown by planting seed where the trees are desired. Not all the hickories produce edible fruit. Some are very bitter to the taste, while some others have a very heavy and much chambered shell, so that the kernel is small and difficult to extract. As a rule, hickories in the northern states with a heavy divided husk inclosing the nut have edible fruit. The husk usually separates from the nut naturally at the time the nuts come from the trees. Of all the hickories, the pecan hickory is the most valuable for the fruit. Second-growth hickory is a common name for young hickory that has grown rapidly from the seed

The Kinds of Hickory

Name	Leaves	Buds	Bark	Fruit
Hicoria alba Mocker Nut	Compound, 7–9 alternate, strong scented	Scaly, large, egg-shaped and sharply pointed, gray and silky	Brownish gray and hairy on twigs, very dark gray on trunk, hard and grooved	A thick-shelled nut with a thick, strong-odored woody husk separating in thirds or quarters, kernel sweet
Hicoria glabra Pignut	Compound, 3–5–7 leaflets, alternate	Similar to above but very much smaller	Brownish gray and smooth on twigs, dark gray, furrowed but smooth on trunk	A thin-shelled smooth nut with thin leathery husk partially separating, kernel bitter
Hicoria ovata Shagbark	Compound, 5–7 leaflets, large, alternate	Short, rounded, scaly and pointed, outer scales dark brown, inner scales silky gray	Brownish, smooth or hairy on twigs, light gray and shedding in long hard strips or plates	A moderately thick-shelled smooth nut in a heavy grooved husk separating into thirds or quarters, kernel sweet
Hicoria minima Bitter Nut	Compound, small leaflets 7–11, alternate	Long, with few scales, brassy yellow	Smooth and gray on twigs, brownish gray and rather smooth with many fine furrows	A small smooth nut with a thin leathery husk and very bitter kernel

or from stump sprouts and consists almost entirely of sap wood that is creamy white and very tough. This wood is very valuable for all sorts of handles and for repairing parts of farm implements and machinery, and for any purpose requiring a piece of exceptionally strong and tough wood.

The locusts

The term "locust" applies to several kinds of trees, two in particular, which are very different. In the northern states the name applies equally to the black locust, also called the yellow locust, and to the honey locust. These two trees, however, are very different, but are both known as locust. The black or yellow locust is a very valuable farm tree and grows abundantly in many parts of the country. The honey locust is less valuable and is not so abundant. Both trees are ornamental and produce very fragrant clusters of flowers coming in early summer after the leaves are all fully developed. The black locust may always be distinguished from the honey locust by the nature of the thorns, which are in pairs, and very short, one on each side of the bud in case of the black locust, and very long and three-pronged in case of the honey locust. The latter frequently has thorns on the trunk of the tree three and four inches long. The black locust grows well from the seed and develops so rapidly, producing such hard and durable wood, that few trees excel it for farm purposes. The one great drawback to the extensive growing of this tree is the fact that the locust borer burrows in the wood of the trunk and large limbs, destroying the tree and rendering the wood worthless. No satisfactory remedy has yet been found for preventing the attacks of this borer.

THE KINDS OF LOCUST

NAME	LEAVES	BUDS	BARK	FRUIT
Robinia pseudacacia Black or Yellow locust	Compound with many small leaflets, dark green on upper side, pale underneath	Small, gray, silky and sunken into the stem between two small thorns	Rough, dark gray, deeply furrowed, smooth and light brown on twigs	A light thin dark brown pod with small black and very hard seeds, usually on after the leaves have fallen
Gleditsia triacanthos Honey locust	Compound with many small leaflets, dark above and pale underneath	Small, clustered and partially sunken in the stem, situated below large and long three-pointed thorns	Rough and dark, furrowed and scaly with many long thorns on the trunk, bark on twigs brown and smooth	A long and wide reddish brown pod, fleshy and usually twisted, remains on the trees after the leaves fall

CHAPTER V

PRACTICAL SYLVICULTURE, OR REGENERATION OF WOODLOTS

FOREST regeneration is the renewing or restoring of forests. It is conducted in two ways, — separately, or in combination. The two methods are called "natural regeneration," when the new wood crop is started naturally by selfsown seed or by stump shoots, and "artificial regeneration," when the wood crop is started by sowing seeds or by planting seedlings or cuttings.

NATURAL REGENERATION. Figs. 24–28

A forest already established is implied in natural regeneration. The operations consist in so treating the woods that a new crop of trees becomes established as the old crop is cut and utilized. There are several systems of handling woodlands, depending on the nature of the soil and climate and the kind of trees. Some trees reproduce naturally from seed and stump shoots, others from seed only. For this reason, a forest or woodlot must be treated according to the kinds of trees that are present.

The systems or methods used may be called

1. Selection system.
2. Strip system.
3. Group system.
4. Coppice or sprout system.

Selection system

This is nature's method of regeneration where different kinds of trees are in mixture and where the trees are of all ages. As old over-mature trees die and fall to the ground,

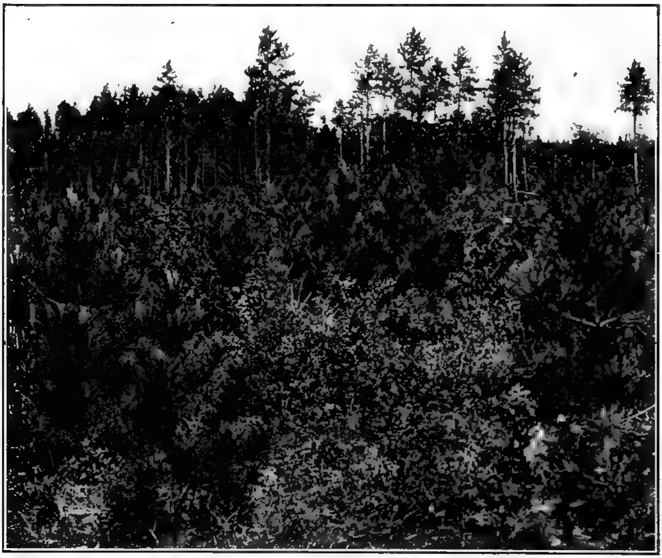

FIG. 24.—Natural reproduction of Norway pine on cut-over lands.

new and young trees soon spring up and fill in the openings. In practicing this system, only the ripe trees are taken and the open spaces left by them are readily filled in by young trees growing from seeds or sprouts. In this way trees may be selected, cut and taken out at any time, yet the forest is continuously maintained.

Fig. 25. — Dense natural reproduction of Norway pine, showing vigorous shoots.

Strip system

This system can be used only when there are trees that bear winged seeds, usually small and sufficiently light to

FIG. 26. — Natural reproduction of white oak at the edge of the woodlot.

be carried some distance by the wind, such as seed of any of the pines, spruces, maples, and the like. The

Fig. 27. — Reproduction by groups. Three age-classes are evident.

operations consist of cutting clear strips through the forest two or three times as wide as the trees are high and in no case any wider than the wind will scatter the seeds. The strips should run at right angles to the direction of the prevailing wind. The seed from the trees on one or both sides will then be scattered by the wind over the strip and a new growth of little trees will result. As soon as a strip is well stocked with new trees, usually in a few years, another strip may be cut, and so on until the entire forest has been harvested.

Group system

This system is the cutting and removal of ripe trees in groups throughout the forest and allowing the seed from the neighboring trees to supply the new trees. The groups may be scattered and occur wherever the ripe trees may be. (Fig. 27.)

Coppice system

This system can be used only with such trees as the chestnut and some oaks that grow very abundantly from the stumps of felled trees and soon restock the cut-over area with new growth in the form of sprouts. (Fig. 28.)

In the choice of any system for the farm-forest or woodlot, the one that meets the best needs of the owner and is best suited to the kind of trees and existing conditions should be practiced. The usual farm forest consists of a mixture of species varying in size from small seedlings to ripe trees. For such, the selection system is the most natural and the best to practice, since it allows the removal of trees of any size and at any time without reducing the total forest area.

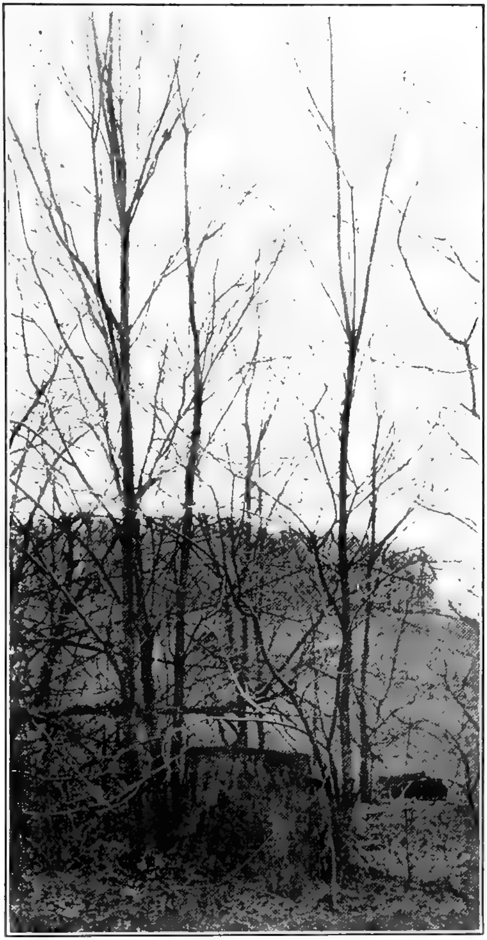

FIG. 28. — Reproduction by stump sprouts.

ARTIFICIAL REGENERATION

The artificial formation of woods is accomplished by direct seeding, by planting of seedlings or cuttings and by a combination of both. The methods of seed-sowing and of planting may now be considered.

Direct seeding, or sowing of seed

The success of direct seeding depends on the nature of the sowing, whether broadcast or in specially prepared spots called seed-spots, and the character of the soil-cover on the area to be sown. Direct seeding has many serious drawbacks. The high cost of seed and the uncertainty of good results in broadcast seeding have made the method an expensive one when practiced in the United States. Seeding in seed-spots is very much more economical and has given better results, for reasons to be pointed out farther on. The sowing of seed is advisable only when conditions are most favorable to the species of trees. Among these conditions may be mentioned the natural range, the soil and moisture, selection of seed and preparation of the soil.

Natural range. — Every species has a different range or territory, in which it is growing naturally. It is confined to this territory because the climate and soil conditions are there best suited to its growth, while the conditions elsewhere are either directly unfavorable or so much better suited to some other species that it is crowded out. Naturally the best growing trees are the most desirable for a plantation. To know that a locality is in the range of a desired species is not sufficient to determine the adaptability of that locality to sowing seed of that species. There are other limitations that largely govern the suitability of localities for growing certain trees, the chief of which are soil and moisture.

Soil and moisture. — The amount of moisture and the quality of the soil, both chemical and physical, frequently determine very largely the local tree growth. For example, the white pine is excluded from many areas well within its range on account of excessive moisture or the total lack of clay in the soil, while the tamarack, which has much the same range, is found in pure stands in the low swampy places, and even in mixture with the pine. A white pine planted in a swamp, or a tamarack on a dry hillside, would not do well even in the center of their range. Only when the climate and soil moisture are favorable, as indicated by the conditions of natural growth, can the success of any forest growth be assured. The exceptions to this rule in the case of individual trees will be considered under ornamental planting.

Selection of seed. — All seed for sowing should be cared for and tested as described in the "farm nursery" (page 112). The quality of the seed for broadcast sowing is even more important than for seed-bed sowing, because it is likely to lie on the ground a much longer time before germination takes place. Moreover, the seed sown broadcast lies on the surface of a poorly prepared soil which the roots have to penetrate to obtain a footing. Only the vigorous-growing seeds can overcome this obstacle, and even many of them exhaust their vitality and die before they can establish a root system.

Soil cover. — Practically every location in which seeding is under consideration will have a soil cover that more or less interferes with the establishing of a stand of trees from sown seed. Chief among these soil covers are (1) grass sod, (2) brush, and (3) leaf litter.

(1) Grass sod. — When grass has grown for any considerable length of time, the roots have become matted together, forming a tough sod. It is useless to sow seed on such ground. The stubble holds the seed suspended so that, if it germinates at all, the rootlet has to extend a distance through the air to reach the ground. Even then it is unable to compete with the roots of the grass. Such land should be thoroughly plowed before seeding, and if the sod is very heavy, the seeding should not be done until the next year. This gives a chance for the roots to rot and the soil to mellow. From the above, it is evident that sowing is not practicable anywhere on the prairies outside of the natural range of forest trees. The grasses are predominant in this region. and it is impossible for the tiny seedlings to compete with them successfully. Other conditions of moisture, sunlight, wind, and so on, are so different from those of the forest that the young trees die before they can adapt themselves to their new situation. This is often hard even for thrifty seedlings, and success cannot be expected of the smaller seedlings that are struggling for their lives.

(2) Brush. — Whether the brush is too dense to permit sowing is a question that must be left largely to the judgment of the farmer. If the brush is dense enough to shade out or choke the young seedlings, of course there is no use in sowing seed. This is more likely to be the case with brush that has very thick, heavy foliage. Thin-leaved, light-foliaged brush is not likely to be too dense, and in

many cases rather protects than hinders the seedlings. Destroying this brush when necessary is often a difficult operation. Unfortunately, most of the brush plants sprout luxuriantly from the root when cut or burned over, and consequently an attempt to cut or burn the brush off a certain tract often results in a second crop more dense than the first. Probably the best method is to cut the brush in early fall. The sprouts starting at this late date are caught by the early frosts before they have matured and are killed back. After such treatment, the stumps do not sprout very vigorously the next spring. Sheep are an effective means of cleaning up brush land. Enough sheep should be driven on the area in spring to crowd it, and they should be herded closely. Under these conditions they will browse the tender sprouts and injure them beyond recovery. In addition to browsing the sprouts, their sharp feet cut the leaf mold, especially in the early spring when the ground is soft, and expose the mineral soil, thus putting the ground in good shape for seeding. The first summer's grazing will kill most of the brush, while a short period of close grazing the next spring will catch the surviving sprouts and prepare the ground for immediate seeding.

(3) Leaf litter. — In most wooded or brush lands, where fires have been absent for a long time, there will be a heavy soil-covering of fallen and partially decayed leaves. These leaves form a layer sometimes several inches thick, and so poorly decomposed that a germinating seed cannot reach the mineral soil. Leaf litter may contain enough moisture to cause seeds to germinate, but before the rootlet can force itself down into the soil it

has exhausted its vitality or become dry and consequently has been killed. Leaf litter when thoroughly decomposed and mixed with the soil is a perfect fertilizer, but in any other form it is merely a soil cover. When the leaf litter is not too thick, it may be sufficiently broken with a drag to enable the seeds to reach the soil. Cattle or sheep may trample it sufficiently to accomplish the same purpose. In cases in which fire will not harm any tree growth, this litter may be burned when thoroughly dry. Great precaution must be maintained to confine the fire to a small area at a time and never allow it to run beyond control.

Preparation of land. — In practically every case, natural forest land will need some preparation before seeding is done. The method of treating the soil is a matter for the farmer or owner to decide. It should always be done in the most economical manner, yet with thoroughness. A spring- or peg-tooth harrow is an effective implement when it can be used. A drag of any sort that will tear up the soil will be sufficient. Even a tree top with some heavy, strong limbs will serve as a rather effective drag. Whatever sort of implement is used, the operation should be continued until the soil is in proper condition to receive the seed. The trampling of cattle at certain times of the year, especially in early spring, may break up the surface layer of soil sufficiently. In small special areas, the plow may be used and the ground prepared as for grain crops. In every case the seedling must fasten its roots very early in life in the mineral soil in order that growth may continue.

There is no special secret in the preparation of land for tree growth. After examining a woodlot, any person acquainted with the conditions necessary for the growth of the seed of almost any field crop can readily see what may be done to enable the seed to get down into the mineral soil. It is largely a matter of good judgment.

Seeding and planting

Seeding and planting are methods for artificial regeneration of forests. The term seeding refers to the actual scattering of seed directly in the woods, either broadcast or on small specially prepared areas. By planting is meant the actual setting-out of small trees known as seedlings that have been grown from seed in the farm nursery, or obtained elsewhere. At present, planting of seedlings is the method mostly used, and on small areas, such as the woodlot owner possesses, it seems to be the most advisable method. In some parts of the country, experiments in broadcast direct seeding show fairly good results. At all events, under the proper conditions, some of our tree species can be successfully regenerated by this method, except for large seeds like those of the hickories, the walnuts and the oaks. For these it would possibly be better for the woodlot owner to practice planting of seedlings.

Choice of method. — About the first question that arises when the regeneration of the woodlot is considered is what method to use, whether seeding or planting, or a combination of the two. This can be determined only by carefully considering the situation and the conditions. Even when conditions are favorable for seeding, it is so difficult to secure seed of good quality at reasonable cost, that it might be more economical to resort to planting. Three or four years might be gained by planting instead of seeding, and where time is considered, planting would again be advisable. Small treeless areas that are to be given over to tree growing had better be planted rather than seeded. If the woodlot has a crop of mature trees ready for removing, and a new crop of trees of the same kind is desirable, then it is a matter of replacing the old crop.

Since, however, it is very seldom that a piece of woodland has all its trees fit for cutting at the same time, and consequently removed at the same time, it becomes a problem of filling in open places in which trees have been taken out rather than to produce an entire new crop. Where the entire crop is removed, it would be better to plant seedlings at once in order to prevent a crop of brush and weeds from choking out seedlings planted later. On the other hand, if a cut-over area is practically clean, the soil might be prepared by dragging or harrowing and small seeds be sown broadcast. Large seed, such as the oaks and hickories, should be planted in furrows or in holes made by a stick, without preparing the soil. In either case the crop of brush and weeds that quickly springs up after a piece of woodland is cut over must be considered in producing a new crop of trees. The nature of this brush and weed crop must be understood before either seeding or planting can be determined intelligently.

Direct seeding may be either broadcast or partial. Broadcast seeding implies a sowing of any area in much the same way as wheat or oats is sown by hand in the field. Partial seeding implies the seeding of small areas or spots within the woodland, wherever trees have been removed and open places occur. The advantages and disadvantages of these methods will be taken up separately.

Broadcast seeding. — This method, up to the present time, is expensive and not altogether certain. It is best practiced with small seeds — as the conifers, — and is best employed directly after the forest is cut over while the soil is still broken and the ground-cover in good condition for the seed. The best time for broadcast seeding in the woodlot is late winter or early spring. Early spring seeding, either on top of the snow or as the snow is melting, seems to give best results. Fall seeding has the disadvantage of exposing the seed during the winter to birds and rodents, particularly to squirrels, which will destroy most or all of it.

Broadcast seeding may also be employed directly after a forest fire and before brush and weeds spring up. The quantity of seed to be used under this method is best determined after studying the conditions. Also the quality of the seed must be taken into consideration, as well as such hazards as erosion, washing away of seed and the destruction of seed by rodents and birds, as well as the amount of money to be expended. Consider white pine as an example. This tree has about 28,000 seeds to the pound; sown broadcast on one acre would equal about two seeds to each three square feet, if evenly distributed. Three pounds to the acre would then equal about two seeds to the square foot, which ought to be sufficient with seed of average quality sown on well-prepared forest soil, especially since seedlings three years old should not stand closer than six by six feet.

Seed-spots. — Seeding in spots is usually more satisfactory than broadcast seeding. The method is applicable to a variety of conditions and has a number of distinct advantages. The operation of establishing a seed-spot consists of clearing with a mattock or hoe a small area, about a foot square, of all sod or leaf litter, digging up the soil to a depth of a few inches, smoothing the spot, and planting the seed in this prepared ground. Small seeds like those of the pines, birches and elms are very successfully handled in this way. It is customary to put many more seeds in each spot than can grow to tree size. For example, in seeding white pine by this method, about twenty or thirty seeds to each spot result in averaging about three seedlings to each when three years old. Some of the spots will result in total failure, while others will have too many seedlings. By transplanting from the overcrowded spots to the vacant ones, an even stand can be secured. Seed-spots are usually placed close enough to one another to allow but one tree to the spot when grown to pole size. Seed-spots spaced six by six feet will eventually produce the same results as if seedlings had been planted with the same spacing. This method has distinct advantages over broadcast seeding. First, there is a marked saving of seed, since only about one-eighth or one-tenth as much seed is required. Second, the seed is placed in carefully prepared soil. Third, the spots can be selected so that no seed is wasted on barren locations. Seed-spots are particularly applicable in brushy areas; also where there is a heavy sod, and for planting underneath other trees.

Collecting and storing seeds

In every woodlot such trees as the oaks, ashes, maples are always desirable, and these trees, particularly, are the ones that it is wise to renew as fast as the old ones are removed. In renewing the woodlot under such conditions, it seems best to secure seed from the trees themselves, for seed-bearing trees may be found in any woodlot. Conditions may be such that the seed falling from the trees will spring up and produce sufficient natural reproduction so as not to necessitate any artificial aid. However, just the opposite is usually the case. Consequently, it is a wise precaution to collect seed from such species as it is desired to perpetuate and to plant them directly, either in the woodlot or in the farm nursery.

Time of collecting. — Among the hardwood trees, the time of ripening of seed varies from spring until fall; consequently it is necessary to know at what time the trees fruit in order to collect good, fresh, vital seed. The following table (page 108) states briefly the time of ripening, the time for collecting, the time for planting, of the chief seeds produced in the farm woodlot.

It will be noticed that seeds which ripen in the spring and early summer grow the same season. This must be taken into account when planting seeds of this kind. The elms are a good example of this. Seeds that mature in the fall pass the winter on the ground and grow the following spring. The oaks are a good example of this kind. It is, consequently, a comparatively easy matter to grow seedlings from spring and early summer seeds, since they ripen at a time when the soil and growing conditions are

TIME FOR COLLECTING AMD PLANTING TREE SEEDS

SPECIES	WHEN RIPE	TIME FOR COLLECTING	TIME FOR PLANTING	WHERE COLLECTED	CARE OF SEED BEFORE PLANTING	TREATMENT BEFORE STORING
Elms	Early summer	Early summer — as soon as ripe	Very soon after collecting	From tree and off ground	Keep fresh until planted	
Maples	Silver and red maple, midsummer: sugar maple, in fall	As soon as ripe	Silver and red maple, soon after collecting; sugar maple, following spring	From ground	Silver and red maple, keep fresh until planted: sugar maple, stratify in moist sand over winter	
Poplars[1] and Willows	Early summer	As soon as ripe	Immediately after collecting	From trees		
Oaks and Chestnut	Fall	As soon as they fall to the ground	Following spring after collecting	From ground	Stratify in moist sand	
Ashes	Fall	As soon as ripe	Following spring after collecting	From trees and ground	Keep dry in cool place or stratify in moist sand	
Basswood	Fall	As soon as ripe	Following spring after collecting	From trees	Same as above	
Walnuts and Hickories	Fall	As soon as they fall to the ground	Following spring after collecting	From ground	Stratify in moist sand	Remove all husk from nuts
Birches	Fall	Early winter	Following spring after collecting	From trees	Keep in cool place or stratify in moist sand	
Conifers	Fall	Early and late fall	Following spring after collecting	Pick cones from trees	Store in bags and hang in cool, dry place	Extract seed from cones by sun or artificial heat

[1] Poplars and willows are propagated from cuttings rather than from seed.

right for immediate growing. They need no special care and preparation before planting, but must be planted very soon after coming from the trees. It will also be noticed that the willows and poplars are grown from cuttings rather than from seed. However, they may be grown from seed by scattering branches containing the seed capsules on moist soil just as the capsules are opening. This is rarely practiced, since they are so readily grown from cuttings.

Occasionally during a long wet fall some autumn-ripening seeds may germinate before spring. In the woodlot, providing mice and squirrels are not numerous, seeds of this kind may be left on the ground until spring. Seeds ripening in the fall that are collected for spring planting must be kept under conditions as nearly approaching the natural conditions under the tree as is possible. It is a safe rule that all such seeds as acorns, chestnuts and walnuts must be kept moist until planting time, while such seeds as the pines and spruces may be kept air dry.

Seeds from coniferous trees are always collected in the cones. Seed trees should be located during midsummer by the presence of full-grown cones and then frequently examined as to the ripeness of the seed. This may be done by obtaining a green cone and cutting it longitudinally so as to expose the seed for examination. As a rule, the seed in the cones is ripe, while on the outside the cones still appear green. As soon as the seeds are plump and fleshy and brown on the outside, the cones must be collected. They may be picked off the branches and placed in bags. They are then thoroughly dried by spreading out on screens in the sunshine, or by artificial heat. This drying causes the cone-scales to separate and the seeds may then readily be shaken out. After all the seed has been obtained from the cones, the wings should be rubbed off and the seed separated by fanning. This seed is then best kept over winter in its natural dry state. On the farm it is very well kept by placing in a bag and suspending from a rafter or a joist in some out-building safe from mice, and where the inside temperature is the same as outside. Seeds kept this way are ready for planting the following spring, either in the seed-bed or in the woodlot.

Storing seeds over winter. — Seeds of the conifers are kept over winter as described above. Also seeds of the birches, the sugar maple and the basswood may be kept in the same way, but they are likely to lose a considerable percentage of their vitality. Heavy seeds like acorns and chestnuts must be kept moist, and this is accomplished best by stratifying in moist sand. For the woodlot owner, the process of stratifying is very simple, since the variety and the amount of seed is usually small.

Stratifying consists of alternating thin layers of seed with layers of moist sand in a box or pit so that all the seeds may remain moist. For small quantities this is best done in a box. Place a layer of wet sand a few inches thick in the bottom of the box, then a similar layer of seed, followed by another of sand and a layer of seed, and so on until all are stratified. Small seeds that may become badly mixed with wet sand are better tied into loose packages made of cheesecloth, or any thin cloth, and these packages then packed in sand. This keeps the small seeds clean and prevents the sand from becoming mixed with them. In this way any small seeds like the birch may be kept perfectly fresh and clean. The box containing the seed must then be buried one or two feet in the ground in a well-drained, moist place. In stratifying seeds, it is best to imitate natural conditions as nearly as possible. Large quantities may be stratified in a pit instead of in a box.

Planting seed in the nursery and in the woodlot. — Seeds ripening in the spring and early summer may be sown in the nursery at once, or may be sown directly in the woodlot. It is well to keep in mind at all times the fact that trees that produce very tender and delicate seedlings, until they become three or four years old, had better be grown in the nursery for a few years, while sturdy, stocky seedlings with deep roots had best be planted in the woodlot at once. Seeds of trees that early in life form a long tap-root should be planted in the woodlot directly, since the difficulty and the expense of planting seedlings of this kind becomes too great and the loss of seedlings is likely to result.

It follows then that seeds of the pines, spruces, and the like, and in some cases the elm, the silver and the red maple should be sown in the nursery and when large enough planted in the woodlot. Seeds of the oak, walnut, beech, chestnut and hickory, producing a sturdy seedling, may be placed directly in the woodlot by planting stratified seeds. Planting must be done in the early spring as soon as the ground is clear of frost.

The woodlot owner can readily decide whether it is advisable to collect the seed in his own woodlot, or in a neighboring one, and grow his own planting stock, or buy directly from a reputable nurseryman. There is a considerable saving of time by purchasing planting stock. From one to four years can be gained in the growth of the trees by doing this. It also may not be necessary or advantageous for the woodlot owner to grow his own planting stock. When nursery stock is purchased, the woodlot owner should engage from a reliable nurseryman the right kind of stock the fall previous to the time of planting so as to be sure to have the material on hand at the proper time. When it is desirable to establish a small farm nursery and to grow planting stock, the woodlot owner will find it very instructive and highly satisfactory to do so. The following instructions will serve as a guide in establishing and caring for a small nursery to supply planting material for the average woodlot.

THE FARM NURSERY

Most woodlots have coniferous and broadleaf trees. The trees in these two groups differ considerably in their hardiness and in their rate of growth during the first two or three years. This difference calls for varied methods in nursery practice. Pines, spruces, and the like, require partial shade during the first and sometimes the second season. Oaks, elms, maples, and so on, will grow without shade from the start. Each of these groups will be treated separately.

Growing coniferous seedlings

Nursery site.—A convenient location should be selected in which the soil is a moderately fertile, sandy loam, free from weeds and stones and well drained. A nursery location in which the soil is poor may readily be made suitable by improving the soil and preparing as for a garden. The average sized farm-woodlot does not call for a great many seedlings at any one time, so that when only a few thousand seedlings are required, a part of the vegetable garden may oftentimes be set aside for this purpose. When this is not practicable, the site should be chosen in which there is no danger of disturbance from the farm stock, from rabbits and mice, and as far from bird attractions as possible. Usually water is necessary at some time of the growing season, so that the water supply should be near at hand in case of severe and prolonged dry weather.

Preparing the seed-beds. — There need be no difference whatever in the preparation of the soil for growing seedlings from that of an onion or a lettuce bed. When it is not practicable to plow the ground, it may be spaded and thoroughly raked and the soil pulverized and reduced to a smooth surface. The most satisfactory width for seed-beds is four feet. This enables one to reach readily all parts of the bed for weeding and transplanting purposes and also to use ordinary building lath for shade screens. The seed-beds may be any length. When several beds are made up side by side, there should be a path two feet wide between them, and if the ground is sloping, the beds should run at right angles to the slope. If the soil is rich and inclined to be moist, the beds should be raised about four or more inches above this path. On dry or sandy soil, the beds should be on the same level as the path. The laying-out of the seed-beds may be such as to suit any special requirement on any location in which it is desirable and practicable to grow seedlings.

Planting the seed. — Coniferous seed may be sown either broadcast or in drills. Each method has its advantages. In case the seeds are sown in drills, these drills should run across the beds and about four inches apart. Double

FIG. 29. — Sowing evergreen seed-beds. Note supports for shade frames.

drills are sometimes advised, *i.e.* two rows about an inch apart with a six-inch space between the double drills. Sowing in this manner facilitates weeding, since an ordinary hand-weeder can be used. Broadcast seeding makes it necessary to pick the weeds with the fingers, but in a short time the seedlings will fairly well crowd out the weeds. Sowing seed in drills may be carried on as follows: A wide board four feet long, having fastened on one side small, three-sided strips the required distance apart, is a convenient implement for marking the drills by pressing this board, strips down, on the top of the bed. Handles fastened to the top of the board facilitate its use, since it may be handled easier. The seeds are sown in the marks of these three-cornered strips, after which they are lightly covered. In sowing seed broadcast, it is best, after the required amount is decided upon, to mark off the bed in small areas about a foot square, either by stretching strings, or by marking it lightly with a stick and sowing one square at a time. For example, if a certain amount of seed is to be sown on twenty-four such squares, then one-twenty-fourth of the seed should be taken and sown in one square and so on until all are sown. This is merely an aid to an even distribution of the seed. The depth to which a seed should be planted depends somewhat on the size. As a general rule, they should not be covered any deeper than twice their own thickness. It is a very easy matter to plant the seeds too deep, which will cause them to germinate unevenly. After the seed is sown, it is best covered by sifting fine earth upon it with a hand sieve until all is covered, then pressed down or lightly rolled so as to firm the seed in the soil. If the ground is dry, it may then be lightly sprinkled. (Fig. 30.)

How much seed to use. — The quantity of seed required depends on the kind and the amount that will grow. It is always best to test the seed by cutting a certain number and examining them. In this way a certain percentage of good and bad can be established. One ounce of good white-pine seed will be sufficient for about thirty linear feet of drills, while smaller seed like the Norway spruce will sow about seventy feet of drill. In broadcast seeding, about two and a half or three seeds, on the average, to the square inch should be sown. For white pine, this would require one pound for 60 to 80 square feet, or a bed 4 feet wide and from 15 to 20 feet long.

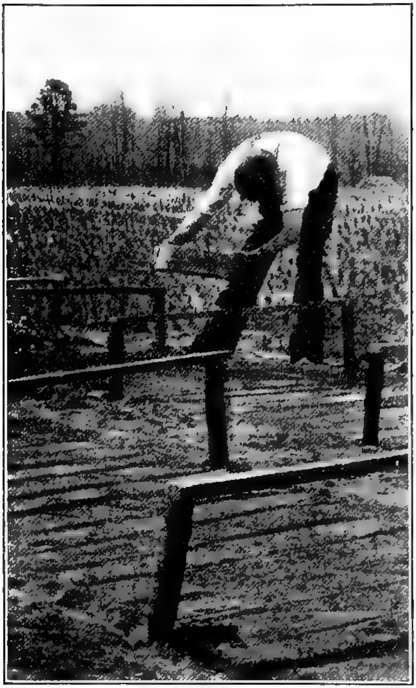

Fig. 30. — Sprinkling sand on a newly sown seed-bed.

Protecting the seed in the seed-bed. — In locations in which mice, squirrels and birds are very numerous, it is necessary carefully to protect seed in the beds. Squirrels that burrow in the ground are particularly troublesome and it is necessary, in order to keep them out, to inclose the beds with wire netting not larger than a half-inch mesh, allowing the netting to extend downward eight or ten inches below the surface of the ground. It is also necessary to cover the beds over the top with the same style of netting. The top netting may be removed as soon as the seedlings are a few weeks old. Squirrels and mice do very little damage after the seeds have come up, but birds, particularly the seed-eating sparrows, such as the field and song sparrow, will eat the seeds and will also destroy the tender seedlings, while they still retain the seed coat on the cotyledons. It is customary to coat seeds of this kind with red lead mixed in water. This does not injure the seed, but destroys their attractiveness for birds and squirrels. As soon as the seed is sown, the bed should be sprinkled lightly and then covered with a light mulch. This is best done by spreading burlap, or a strip of muslin, on the seed-bed and upon this placing a mulch of leaves, or any material that will keep the bed from drying out. Just as soon as the seedlings appear above the surface, this mulch must be removed so as to give them light and air.

Protecting the seedlings. — During the first three or four weeks, coniferous seedlings are very subject during damp weather to a disease known as "damping off," which in a very short time will cause them to wilt and die. This usually can be prevented by regulating the moisture and by thoroughly ventilating the beds after heavy rains and during humid weather. Partial shade must be provided. This is best and most economically done by making shade screens four feet square from ordinary building lath. These screens are so made as to produce half shade. Two strips of lath are used as cross-pieces and upon them the lath are nailed with spaces equal to their own width between them. These lath screens are then placed on a frame by driving stakes at intervals around the edge of the bed and about 18 inches out of the ground, joined by board strips upon which these lath screens are supported.

The screens must be kept on during the greater part of the first season, particularly during warm days, but may be removed for a short time morning and evening and on cloudy days. In the second year these shade screens usually are not required. Weeds must be carefully picked out and the beds kept clean. In dry weather the seedlings must be sprinkled, preferably in the evening.

Preparation for winter. — Late in the fall, usually after the ground is frozen and several inches of snow have fallen, the seedlings should be mulched. The beds containing the seedlings should be covered with a layer of leaves, straw or hay, upon which the lath should be placed to prevent the wind from removing the mulch. This mulch should remain until the following spring when all danger from frost is past, and should be removed just before growth begins. A good mulch will prevent alternate freezing and thawing and heaving out of the seedlings.

Transplanting. — Seedlings of the eastern conifers are small and rather delicate, as a rule, in the first and sometimes in the second year. In the woodlot in which conditions are trying, very young and tender seedlings involve a risk in planting, so that better results are secured by using transplanted seedlings. One-year-old seedlings may be taken out of the seed-bed, planted in another bed in rows about four inches apart and about two inches apart in the row. Transplanting has the advantage of improving the root system, making it more compact and fibrous. In case one transplanting is insufficient, the seedlings may be twice transplanted, or in exceptional cases three times. Seedlings may be transplanted at the beginning of the second season when they are one year old, or at the beginning of the third season when they are two years old. In case one-year-old seedlings are transplanted, it usually is necessary to provide them with partial shade for at least part of the summer. Two-year-old seedlings will not require shade. Transplanting adds to the cost of the seedlings, and for average conditions two-year-old seedlings untransplanted furnish the most desirable planting stock. Transplanting must be done in the early spring before growth begins. The woodlot owner may use transplant-beds made up similar to seed-beds, and the seedlings planted as noted above. Planting may be done in rows at such distances apart as is most convenient for cultivation, depending on whether cultivation is by hand or with a cultivator. For a small number of seedlings, a regular four-foot bed with close planting is most economical. In transplanting operations, it is most imperative that the roots of the seedlings are kept moist at all times, since a small amount of drying will prove fatal. Transplanting operations are best practiced in cloudy days and even in misty or rainy days, providing the soil is not too wet. In sunny or windy weather, the roots must be covered with wet moss or burlap as soon as taken from the ground. Any other material that will protect them from the air and sunshine and keep them moist may be used. They must be kept in this condition until they are placed in the transplant beds.

Growing broadleaf seedlings in the farm nursery

Since the seedlings of the broadleaf trees are very hardy and rapid growing, as a rule, the seeds may be planted directly in nursery rows in well-prepared ground.

These rows may be as far apart as is desirable, depending on the method of weeding and cultivation which it is expected to use. No shade-frames are necessary, but it may be advisable to locate the nursery in the protection of large trees or farm buildings.

Broadleaf tree seeds. — Most broadleaf tree seeds, if stratified during the winter, will be in excellent condition for germination the following spring, and they should be planted as soon as the ground is free from frost and dry enough for working. Very hard-shell seeds, such as the black and honey locust, frequently remain in the ground until the beginning of the second season before they grow. This tardiness in growing can be remedied by soaking the seeds in hot water. Immerse the seeds in a quantity of water heated to 180° F. and allow them to cool and remain for a day or two. If the seeds still seem very hard and show little benefit, they should receive a second treatment. The water must not be too hot, and a safe rule to follow is to heat it to the point at which it is too hot for the naked hand. Seed thus treated must be planted immediately in order that the seed may remain moist, since drying out would very readily kill it. Seeds that have been stratified over winter must be planted as soon as removed from the moist sand. Seeds maturing in early summer, like the elms, must be planted as soon as collected.

Planting the seeds. — As mentioned above, it is best to plant the seeds of broadleaf trees in long rows. When only a few hundred are grown, it is better to place the rows about a foot apart and depend on hand cultivation; however, they may be grown along with a field crop and cultivated with a horse cultivator. As a rule, however, the tree seeds must be planted earlier than the agricultural crops, so that it is better to use a separate location. The seeds should be planted in much the same manner as peas or beans, placing the seed in the ground to a depth of about twice its own thickness. If all the seeds are good, seeds like those of the oaks should be placed about one or two inches apart in a row. Elm, maple, basswood, and so on, should be sown three or four deep, since a considerable number of such seeds will not grow. Water must be available in case of dry seasons. Germination may be hastened and result more evenly if a straw or leaf mulch is applied as soon as the seeds are planted. Careful cultivation and the keeping out of all weeds is necessary.

Transplanting. — As a rule, hardwood seedlings are large enough to plant into the permanent site when one year old, but when it is desirable to keep them for another year or two in the nursery, they should be transplanted in rows wide enough to admit of horse cultivation. Transplanting operations depend to some extent on the nature of the root system. Many broadleaf trees produce heavy tap-roots, even during the first year. When these trees are left in the nursery without transplanting, this root becomes so large that the transplanting operation becomes a difficult as well as an expensive one. Seedlings of this kind, when transplanted in the nursery, should have the roots well pruned, since this will congest the root system and make it more fibrous. While these seedlings are very young, alternate freezing and thawing during the fall and winter may heave them out of the earth, so that for the first year or two it is advisable to use a winter mulch, consisting of straw or leaves applied as soon as the ground is frozen, and preferably on top of a few inches of snow. This mulch prevents alternate thawing and freezing and should be removed in the spring as soon as freezing conditions are over.

Expenses. — The cost of seedlings grown in the farm nursery usually can be made very insignificant, since the work can be done at odd times in the evening or morning, at no time occupying more than a few hours, so that along with the regular farm work the care for a small nursery would scarcely be noticed. On the average farm there is usually spare time and labor that can be used for such purposes. The equipment, in case wire netting is necessary, together with lath, stakes, and so on, need cost but very little. Seed, whether collected or purchased, in the case of conifers will range from 75¢ to $3 a pound; in case of hardwoods or broadleaf trees from 10¢ to $1 a pound. In case planting stock is purchased, one-year-old coniferous seedlings may be obtained for about $1 a thousand. Transplanting always increases the cost, and, as a rule, transplants cost about twice as much as seedlings. The cost of broadleaf seedlings will vary with the species and the size from about 50¢ to $2 a hundred. From the standpoint of economy, it is far more economical to establish a small nursery and to grow planting material, except when labor must be hired to carry on the work. In the latter case, it would be better to purchase planting stock from a reliable nursery.

SPRING OPERATIONS IN THE FARM NURSERY

When the seedlings in the farm nursery are old enough to be planted into the permanent site, they must be taken from the seed-beds, or nursery rows, in the early spring as soon as the frost is out of the ground and before the growth

Fig. 31.— Lifting and counting seedlings in nursery.

is started. Pine or any small spruce seedlings are best lifted from the beds with a spade, since the spade can be forced into the ground well below the roots, lifting them out entire. They must then be carefully separated from the soil, leaving the roots clean. They are sorted into sizes — usually two — tied in bundles of fifty or a hundred and packed into a basket or box containing wet sand, moss, burlap or some similar substance. (Fig. 31.)

In case the planting is done sometime after the seedlings are taken from the seed-beds, these bundles of seed-

Fig. 32. — Seedlings heeled-in awaiting planting or shipment.

lings should be carefully heeled-in. The process of heeling-in consists of planting the bundles of seedlings in a solid row in a trench deep enough to receive the bundles up to where the leaves begin, packing the bundles in very firmly and tramping the soil around them with the heel so as to close up all air spaces. (Figs. 32–33.) Heeling-in should be done preferably in a shaded and protected place. During an early spring when seedlings start to grow before it is convenient to plant them, their growth may be retarded by lifting and heeling them in. When planting follows immediately after the lifting of the seedlings, they should be taken from the nursery to the planting site, packed in boxes or pails so as to remain always moist. When the planting takes place after the seedlings have been heeled-in, they should be removed from the trench as fast as needed, packed and transferred to the planting site as before. Great caution should be exercised to keep the roots wet at all times.

Fig. 33. – Heeling-in evergreen seedlings.

Broadleaf seedlings are not so delicate, and although it is necessary to use care in exposing the roots, a small amount of drying usually does not seriously injure them. They may be taken to the planting site in bundles with the roots wrapped in burlap, or anything that will keep them moist. When planting stock purchased from a nursery arrives at a time inconvenient for immediate planting, then the seedlings should be removed from the package in which they were shipped and carefully heeled-in until planting time.

Field planting of farm nursery stock. Fig. 34

Planting in the field demands a variety of methods, the simplest being the planting of a clear area or field. Usually there are only parts of the woodlot, small open areas and spaces between the trees, in which it is desirable to plant. When this is the case, no regular system can or need be followed out. The seedlings may be set at random, so long as they are spaced about six feet from one another and placed where they are certain to have an opportunity to grow. In an open area, lines of stakes should be set, three or four in a row, to serve as a guide for a planting crew. In most cases, it is sufficient to have two men in a crew, one man to carry the seedlings in a pail or basket with some wet material covered over the roots, and to plant the seedlings; the other man to be provided with a mattock or grub hoe with which to dig a suitable hole. Two men working together can carry on the work very rapidly and efficiently. As soon as the hole is dug, the planting man takes a seedling from the pail or basket, plants it immediately in the fresh earth, setting the seedling a little deeper than it stood in the seed-bed, spreading the roots as much as possible, sprinkling over them soft, clean earth, pressing it down firmly with the hand, filling up the entire opening and then firming thoroughly with the heel. With a little practice this operation need require less than a minute's time. When the soil is

Fig. 34. — Planting evergreen seedlings under shade of birches.

clear from stones and roots, one stroke of the mattock will open a large enough hole to receive a two-year-old seedling. By pulling slightly on the handle of the mattock, the opening will be made large enough to receive the roots of a seedling before the mattock is removed. When the mattock is taken away, the seedling is in its place and a little thorough tamping with the heel will firm the earth sufficiently.

The most desirable spacing for all woodlot purposes is about 6 × 6 feet. As soon as one seedling has been planted, the man with the mattock advances in the line of the stakes two full paces, or what to him would be six feet, planting another seedling and progressing in this manner until the end of the line is reached. When more than one planting crew, for instance five or six, are working at the same time, the crew following the staked-out line should always be one space ahead of the crew on the next line. The crew on the second line should be one space ahead of the crew on the third line, so that the front presented by the planting crew's progress is across the field in a diagonal line, or diagonally abreast. Only one line of stakes is necessary for the first crew to follow. The other crews take their distance six feet ahead in line and six feet at right angles from the seedling planted immediately ahead of them in the opposite row. It is desirable, when convenient, to do planting of this kind during cloudy weather, since not so much care is necessary in protecting the seedlings. A good supply of wet moss or burlap, or whatever is most convenient to use, should be on hand at the planting site so that at no time may the seedlings in the pail or basket become dry.

Broadleaf seedlings may be planted in the same manner, but as a rule, since they are larger and have longer roots, it requires more care in setting them. When it is practicable, furrows six feet apart may be thrown and the seedlings planted in the bottom of the furrow, using the earth turned out by the plow for covering the roots. Two men, after some practice, should plant from 1200–1600 coniferous seedlings in a day, and, in the case of the hardwood seedlings, from half to three-quarters as many, since more time is required for digging and setting the plants. Spacing 6 × 6 feet requires 1210 trees to the acre, so that two men working together should plant from three-quarters of an acre to one acre of broadleaf seedlings and from one to approximately one and one-half acres of conifers. The cost of planting depends on the skill of the planters, and on local wages. When workmen can be obtained for $2 a day, coniferous planting should not cost more than $3 or $4 to the acre, while broadleaf planting will cost proportionately more.

Treatment after planting in the farm nursery

It is always advisable to care for a plantation until the trees have grown to such a size that they may take care of themselves. Small seedlings may be choked by a rank growth of grass, weeds and brush. Farm stock, particularly cattle, must be kept out, since they will nip off the tops of the seedlings as well as destroy many of them by trampling. It is always advisable to exclude all stock from the permanent woodlot and particularly from plantations. In a short time a few cattle may destroy an entire plantation, thus losing several years of work and effort. It may be advisable, when possible, to cultivate the plantation with a horse cultivator for a few years to keep down weeds and grasses, and as soon as the trees become large enough to crowd each other and interfere with their growth, thinnings should be carried on. Instructions for thinning and improvement work will be given under a separate chapter.

WOODLOT PLANTATIONS IN MIXTURE

When it becomes necessary to establish a new woodlot by planting, then it may be desirable to plant two or more species in mixture. A clear distinction must be made between woodlot plantations and windbreak plantations. The former are made primarily for the production of fuel and farm timber rather than for protection, and species are selected that meet these requirements. For windbreak plantations, the prime object is to afford an effective barrier against the force of the wind, and trees are selected with reference to their vigor, size, density of crown and immunity from climatic injuries rather than to the quantity and quality of wood produced. It sometimes is convenient to have the woodlot serve as a windbreak for the farmstead, but as a rule profitable woodlot species are poor windbreak trees.

Mixtures suitable for general prairie planting where conditions vary from sub-arid to river-bottom lands

For planting a woodlot the following mixtures are suggested as useful ones:

I. Green ash and hackberry 4 × 4 feet, the species alternating in rows. Hackberry will crowd the ash, causing it to produce good height growth. At the same time it will furnish some fuel from the thinnings. The hackberry should be removed as soon as it begins to interfere and cause any injury to the ash, leaving the ash spaced regularly 8 × 8 feet.

II. Green ash and white elm 6 × 6 feet in equal mixture alternating in rows. The elm forces the ash into well-formed trees and should be removed as soon as the stand becomes too dense, yielding considerable fuel. This mixture is suitable to soil slightly better than No. I.

III. Burr oak and hackberry 4 × 4 feet. These species are very hardy, but of slow growth. Close planting is advised, to shade the ground as soon as possible. When crowding begins, thinning should commence with the hackberry, leaving the oak for the final crop. This mixture is suitable for very poor, comparatively dry soil.

IV. White elm and black locust 6 × 6 feet. The locust grows more rapidly than the elm and can be expected to furnish posts and fuel in a comparatively short time. The elm will shade the ground, keep out grasses and maintain fairly good conditions. Thinning may be made in both the elm and the locust.

V. Boxelder and cottonwood in equal mixture 4 × 4 feet. The boxelder is slower in growth than the cottonwood and forms an understory and shade for the ground. The cottonwood grows rapidly in height and produces timber. Thinning should be made in the boxelder until it is all removed, since in itself it is of little value, but is used merely to aid the cottonwood. This mixture is adapted to general prairie planting where soil moisture may be reached readily by the roots. The trees in this mixture are very hardy and can be counted on to endure the severe colds in the northern prairies.

The following mixtures are suitable for general planting in the Lake States, or anywhere in the general range of the white pine.

I. Norway pine and jack pine in equal mixture 4 × 4 feet. Close spacing is required in order that the ground may be covered and the soil protected as early as possible. In thinning, the jack pine should be removed first, since it is shorter lived and of poorer quality than the Norway pine. Further thinning must be made in the Norway pine itself. This mixture is a good one for sandy ground in the Lake States.

II. White pine and Norway spruce in equal proportion 6 × 6 feet. The spruce will endure more shade than the pine and will serve as an understory forcing the pine upward, thus producing tall trees. Thinnings should begin with the spruce and later run into the pine. This mixture is well adapted in the general range of the white pine.

III. Sugar maple and white pine in equal proportions 6 × 6 feet. This mixture of conifer and broadleaf is one that has been very widely used with very good success and can be used anywhere the maple and the pine occur naturally. The maple is slow in growth, forms a dense shade and serves as an understory, shading the ground and maintaining good forest conditions. The pine is forced into good height growth. Thinnings may take place both in the pine and the maple and when the pine is finally removed, a second crop of maple may be cut in a comparatively short time.

IV. Norway spruce and European larch in equal mixtures 6 × 6 feet. The larch growing more rapidly than the spruce will form the overstory while the spruce forms the understory and shades the ground. This mixture is very suitable for poor, sandy soil in the Northeast.

V. Chestnut and white pine 6 × 6 feet in equal proportions. The chestnut must be removed first, since it grows more rapidly than the pine and will produce pole and post material, while the pine is left for the final crop. This mixture is a valuable one in the general range of the chestnut.

VI. White ash and red oak 6 × 6 feet in equal mixtures. These two species are very nearly equal in their rate of growth and thinning may include both species. A well-kept woodlot of this mixture can be depended on to furnish saw timber from both oak and ash. This mixture is adapted to moderately fertile bottom lands.

VII. Sugar maple and chestnut in equal mixture 6 × 6 feet. The chestnut growing more rapidly than the maple forms the overstory, while the maple shades the ground and forms the understory. Thinnings are made in both the chestnut and the maple. The chestnut is removed first, leaving the maple for the final crop. This mixture can be used in the northeastern states.

CHAPTER VI

PRACTICAL SYLVICULTURE — WORK IN THE WOODLOT

When the woodlot is a piece of native woodland or a planted grove, it should have the same careful attention, after its kind, as is given a crop of grain. To be sure, neither the same amount nor the same intensity of attention is required, but the farm woodlot ought to be an object of sufficient interest and pride to receive such attention and treatment as it needs. It is a mistaken notion that a tree once started will take care of itself and under any circumstances produce the best it is capable of. It would be just as fair to expect a stalk of corn uncared for to grow to successful maturity. The farmer takes it for granted that, in order to grow a crop of potatoes or corn, he must carry on a process of intelligent cultivation. He knows definitely that his crop of potatoes or corn will be very largely in proportion to the amount of labor he has expended in caring for it. While there is no question as to the necessity and value of cultivation and care in the growing of a field crop, it is usually considered unnecessary to aid the growing trees in the woodlot. It is generally assumed that nature's methods are the best and that labor expended in improving the woodlot is time wasted. This is no more true than that nature's methods are the best for the orchard or the garden. No orchardist would

FIG. 35. — Poorly stocked stand of hardwoods.

plant his trees and then have his attention end there. The woodlot, in order that it may be of its utmost value, requires a certain amount of attention and intelligent

Fig. 36.—A poorly kept woodlot. The trees are over-mature and deteriorating. Reproduction and ground cover are wanting.

treatment. Just as a field of corn needs weeding, so the woodlot needs weeding. To be sure, the weeds in a woodlot are not like those in the field of corn, but instead are small, worthless trees occupying valuable space, utilizing the soil and interfering with the growth and development of good trees. Work carried on in the woodlot in caring for the crop of trees is known by the general term of thinning. Thinning may mean actual removal of good trees when the stand is too thick, the removal of defective, poor and worthless trees or the removal of anything that tends to improve the tree growth. The practice of intelligent thinning very quickly shows a marked effect on the development of the trees in a stand. In Europe during a period of 74 years, the forests have yielded an increase in wood of 300 per cent, or from an annual growth of 20 cubic feet to the acre a year

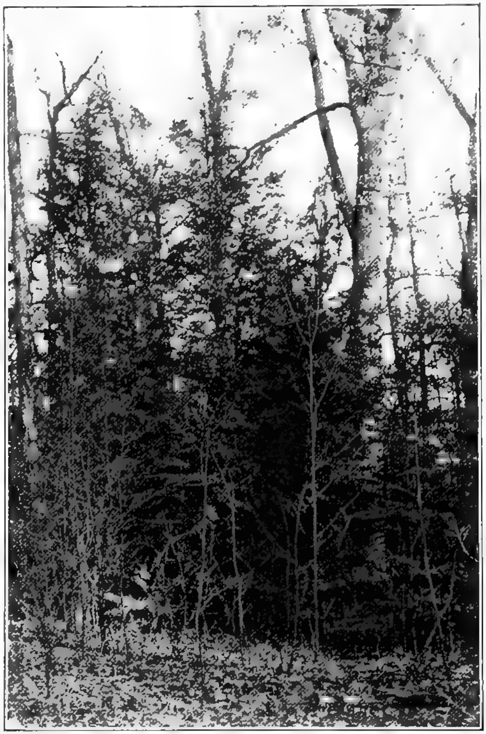

Fig. 37.—A good example of woodlot of the selection type. Trees are of all ages, both conifers and hardwoods.

to that of 65 cubic feet to the acre a year. This increase in yield has been brought about almost entirely by a systematic and intelligent process of thinning.

The theory of thinning lies in the fact that a tree as a growing organism is governed in its rate of growth and perfection of development by the amount of light, moisture and soil fertility it secures. Light is the first and most important factor. A tree responds to light through its leaves just as an animal responds to air through its lungs. Leaves are the lungs of plants and it is through the leaves that most of the wood of a tree is formed. Wood is made up largely of carbon obtained from the air by the leaves in the presence of sunlight. It follows then that increased light produces more leaves, consequently a greater leaf surface, which results in a greater production of wood. A tree growing in dense shade cannot develop as fast as when given a large amount of light. It should be the purpose of every woodlot owner to produce wood as rapidly as possible. As soon as a stand of trees becomes crowded and the trees interfere with one another, some should be removed and a greater amount of light admitted to the remaining ones. The amount of light to admit at any one time is a matter for careful judgment, since height growth is best obtained in a close stand, and a crop of grass must not be allowed to come in and occupy the forest floor.

To illustrate how largely wood is made up of carbon taken from the air by leaves in the presence of sunlight, let us take as an example a cigar and a piece of wood the same size; burn the two and compare the amount of ash. The cigar is a product of the leaves of a plant, while the wood is a part of the woody stem. The large amount of ash from the cigar shows the amount of fertility drawn from the soil. The comparatively small amount of ash

FIG. 38. — Greatly in need of thinning.

from the piece of wood indicates what the tree obtained from the soil and stored in the wood. Tree leaves contain about as much ash as tobacco leaves, but the tree returns its leaves to the soil, while the tobacco leaves are harvested. The agricultural crop utilizes the seed and leaves, while the forest crop utilizes the wood made largely of carbon from the air. It follows from this that crowding or shading, which deprives the tree of its necessary amount of sunlight and space in which to grow, reduces its leaf surface and consequently interferes with and checks the amount of wood produced. Thus thinnings tend to give the good trees more light and more available soil and moisture; consequently there is an accelerated growth and development of better and larger trees.

As an example, take a woodlot containing about 1200 trees to the acre. This number of trees, if equally distributed, would be spaced about 6 × 6 feet. Each tree then would have about 36 square feet in which to spread its branches. In a few years, side branches from the different trees will begin to interfere with and finally crowd one another. As this interference and crowding continue, the stronger trees outgrow and overtop the weaker ones, producing a crop of trees, some of which are poor and worthless, others fairly well developed.

Trees differ in rate of growth even in the same species and some are certain to outgrow others and overtop them. When this condition begins to show its effect on the trees, nature should be aided by removing the poor trees to make more room for the good ones. This should continue as long as the trees interfere with each other. When finally the trees are fifty or sixty years old, instead of 1200 there probably would be only about 200 or 250 trees. Nature, if not interfered with, would eventually produce practically the same number of trees, many of poor quality and small dimensions, and would require a great deal of time. During the early life of the trees in the woodlot, it is quite important that they crowd one another to some extent, since this tends to increase their height growth by forcing them upward, producing tall, straight trunks. As soon as a good height growth has been attained, then the ax should be used in opening the woodlot, letting in more light, giving the trees more room and encouraging greater growth in diameter.

Carrying out thinning operations in a woodlot in which only one or two species of trees occur is quite a simple matter as compared to the average woodlot which contains a mixture of trees of different species and trees that differ in their soil, moisture and light requirements. In the average farm woodlot, thinning usually takes place only when some fuel or timber is needed about the farm. This usually is beneficial to a certain extent, but it is not sufficiently systematic to enable the trees to produce their maximum growth. The same system of thinning that is adaptable to the native woodlot may not be adaptable to the planted grove, since the native woodlot contains a greater variety of trees and of various sizes, while the planted grove may contain but two or three kinds and usually of the same age and size. When a woodlot has been cut over, most of the hardwood species will sprout from the stump, producing great quantities of shoots, which if properly cared for will develop into valuable trees. The fact that these sprouts grow in great numbers calls for a still different system of thinning. It follows from this that the farmer must consider the kind of trees, the manner in which they were established, the number of species and the soil and moisture, before he decides how, and to what extent, he is going to carry on his thinning operations. The wood that is removed during the thinning process may always be of use around the farm, particularly for fuel. It is very seldom that early thin-

Fig. 39. — Evergreen plantation. Some of trees dying from crowding.

nings yield any revenue directly, since it may be necessary, particularly in sprout growth, to thin before the sprouts are large enough to be utilized. The value of early thinnings shows itself in the improvement and the additional growth of the trees that are left in the woodlot. When the material removed is large enough for fuel, or for any other purpose, then the operation may pay for itself and may yield some revenue, but in forestry the profit from thinnings is looked forward to in the final crop rather than in the wood that is removed during thinning operations.

TIME OF THINNING

It will be understood in this discussion that the term thinning is applied to any operation that tends to remove from the woodlot any undesirable material, either living or dead, at any time, or any desirable and valuable trees in overcrowded stands at such times as seem best for the woodlot. This definition of thinning is not the one adhered to strictly by the forester, but is used here in a broad and general sense.

As to the time of thinning the woodlot, it is a difficult matter in a treatise of this kind to give anything other than general advice, since conditions are so variable. It is a good rule to commence thinning early in the life of trees, and this time is best indicated when there is a beginning of active crowding between individual trees. In the vigorous-growing natural stands or in the planted grove, this crowding usually begins at about twelve to eighteen years. At this time only such trees should be removed as interfere with one another or with other and better trees that will eventually be suppressed and stunted. Such a thinning should be light and the operator should look to the crown of each tree rather than to the number of trees on any particular area. The prime object is to give each tree crown space and yet to maintain a thinned but even canopy over the entire woodlot area.

The woodlot owner doubtless will object to this kind of an operation, since the material removed cannot be expected to defray the incurred expense or to net any revenue. It is often the case that a farmer is able to spend some of his own time or the time of some of his farm hands in this kind of work to very good advantage without any particular sacrifice of the regular farm routine work. The operations may be carried on in the winter time or when there is a scarcity, for a short period of time, of the ordinary farm work. Under such circumstances, thinning operations cannot be considered expensive and the value of a future crop of timber should be considered rather than re-

Fig. 40. — Hardwood grove properly thinned.

turns from the immediate thinning. In woodlots of considerable area, such as are attached to some farms, there may be a local market for cordwood, and under such conditions later thinnings may prove financially profitable,

Fig. 41.—Thinning in hardwood stand.

as well as beneficial to the trees left in the woodlot. It is a good rule to thin lightly and often, so as at no time to expose the forest floor to a large amount of sunlight, which would encourage a growth of grass.

Later thinnings, following possibly ten or fifteen years later, usually pay for themselves and in some cases are profitable even when the woodlot owner can use the wood on his own farm. Thinnings made in a stand thirty or forty years old of the average species of our forest trees are made with a different object in view from that of the early thinnings. At this time most of the trees will have attained their principal height growth, and if allowed to remain unthinned will become tall and lanky. The chopper again must look to the crowns of the trees rather than to the number standing on the ground so as to give each tree an equal and sufficient amount of crown space. This admitting of more light enables each tree to develop more leaf surface, consequently to grow very rapidly in diameter, thus laying on large quantities of wood. It is rare that a farmer with a small woodlot will care to grow trees for a particular use, but he can always use to best advantage tall, well-developed trees of various sizes. It seems best then to encourage height growth first by a close stand and then by thinning at the proper time, to provide for the rapid increase in diameter. This has in every case a tendency to produce well-developed trees.

KIND OF THINNINGS

In a general way thinnings may be considered as of two kinds, first, improvement thinnings, and second, reproduction thinnings. Each of these may be given a paragraph.

Improvement thinnings

Improvement thinnings have as their purpose merely the improvement of the present stand. This may consist

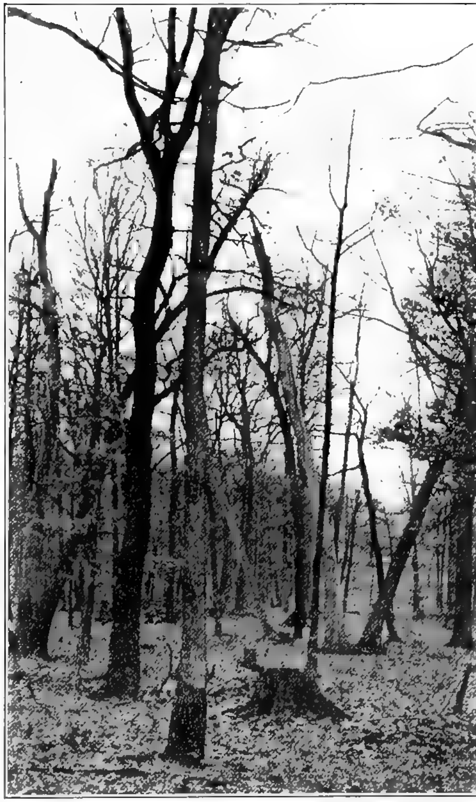

Fig. 42.—Woodlot in need of an improvement cutting.

in clearing woodlots of dead material, either on the ground or on the stump, of removing brush, small worthless trees, or removing a part of the regular stand so as to improve the development and the quality of the remaining trees. An improvement thinning must never be very heavy, since the purpose is to benefit the trees that are to make the final crop, and at all times there should be sufficient density to the canopy to shade out any grasses that would be sure to come in if the crowns were grouped or unevenly distributed.

Reproduction thinnings

Thinnings of this nature have for their purpose the encouragement of reproduction so as to have a crop of new trees well started by the time the mature crop is removed. Reproduction thinnings must necessarily be heavier than improvement thinnings and must be carried on at such times as the trees are producing seed and the soil is in favorable condition to receive the seed, in order that the new trees may start evenly throughout the woodlot. There always must be enough light admitted to the ground to enable these young trees to grow. As soon as they are thoroughly established and grown to a considerable size, say ten years old, the old trees may be rapidly or gradually removed. The woodlot owner must be very careful of this new growth during the process of removing the old trees. With the right kind of species properly handled, it may be unnecessary to add any planting, except possibly to a small extent where the growth is uneven. In case seeding cannot be depended on, from the native trees, to supply the reproduction, and sprout growth is not advisable, a regular reproduction thinning may be made, followed by the planting of seed or seedlings. This is certain to produce a more uniform stand and to establish a new growth of trees in very much less time than when natural reproduction is depended on. In the woodlot, improvement thinnings usually develop into reproduction thinnings as the trees approach commercial maturity. In the selection system of handling woodlands, reproduction thinnings are made whenever the selected or mature trees are cut and removed.

RESULTS OF THINNINGS

The practical results of thinning the woodlot are usually not appreciated at the time they are made, nor is

Fig. 43.—Cordwood taken out in thinning. Note evenness of remaining stand.

there a record kept that will show what are the actual results in increased growth. The increase in wood volume is through increased diameter rather than through increased height. An average white pine tree 10 inches in diameter at $4\frac{1}{2}$ feet from the ground and 60 feet high contains 95 board feet of unedged lumber. By providing

FIG. 44. — Fifty-year-old plantation of white pine. Note the density of shade.

more space in a stand for such a tree by thinning, its diameter may be increased to 15 inches with practically no increase in height, thus increasing the volume from 95 to 195 board feet. This is a gain in diameter of 100 per cent, aside from the better quality of wood produced. An averaged developed chestnut tree 10 inches in diameter will produce two railroad ties and about one-third cord of wood. The same tree with a five-inch increase in diameter will yield five ties and one-half cord of wood. This means an increase in tie value alone of 150 per cent. This may also be applied, but with slightly less increase, to oak. Hardwood sprout growths in the woodlot by judicious thinning may be converted from a cord wood to a log proposition. This increase in value is the result of rapid growth of individual trees through careful thinning, often bringing them to commercial maturity ten or twenty years earlier than if left unthinned. The quality of the timber is largely increased through clear, straight, tall and even-grained trees. In addition, the woodlot is kept clear of diseased and insect infested trees, danger from fire is reduced to a minimum, all parts are made more readily accessible and the general appearance and æsthetic value are greatly improved.

In a woodlot of white pine in New England in which thinning operations were carried on, there were trees ranging in diameter from five to twenty-two inches, in height from sixty to seventy feet and spaced approximately on an average twelve by twelve feet, or about three hundred trees to the acre. Thinnings were made as shown in the following table: —

	Diameter Breast High (Inches)																	
	5	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Trees removed	6	17	31	30	38	40	17	18	12	10	3	—	2	1	—	—	—	—
Trees left	1	1	3	10	16	32	19	36	36	32	29	24	24	10	4	4	4	1

Out of 511 trees 225 were removed, representing about 27,050 board feet out of a total of 77,190 board feet. All together, during the thinning process, about two-fifths of the trees were removed, representing about one-third of the volume. The cost of this thinning varied from 83 cents a thousand board feet to $1.50 a thousand board feet for day labor.

CHAPTER VII

FOREST PROTECTION

PROTECTION of the woodlot is an extremely important and very simple matter. Most of the difficulties and complications in connection with forest protection occur in the management of extensive forests. Here large sums of money must be spent in making different parts of the forest accessible, in cutting expensive fire breaks and in maintaining patrols in the danger season. These are the things that require money and technical knowledge.

Few woodlots involve any of these questions. They are usually small and surrounded by open country or well traversed by roads, making them accessible all around. These roads and the open country are very efficient fire breaks, which, together with location of the woodlots in a comparatively thickly settled country, make any patrol unnecessary. The woodlot is, however, liable to a certain degree to the following dangers: fire, grazing, mismanagement, trespass, windfall, sunscald, insect and fungi attacks. The remedies in most cases are very simple.

FIRE

Only two types of fires are likely to occur in the woodlot, the ground fire and the surface fire. The ground fire burns below the surface fed by the humus, leaf mold and peat in the soil. These fires occur commonly only in those regions in which there is a great amount of peat in the soil, this usually being the case in swampy country only. Such land is too wet to burn except in very dry seasons, when it becomes very inflammable. A fire started on the surface eats rapidly into the ground, sometimes to considerable depths according to the thickness of the peat formation. The fierce heat from such a fire enables it, when it has once secured a good start, to dry out the ground ahead of it sufficiently to burn through a quite wet swamp. Fire often smolders across a swamp in this way unnoticed and breaks out in a violent conflagration on the other side. The Hinckley fire and several other disastrous fires started in just this way. The usual cause of such a ground fire is a poorly located and neglected camp fire; sometimes it is a discarded match or cigar stump or a surface fire. Such a fire destroys not only the fertility of the soil, but the soil itself, and burns off the roots of the trees so that they fall of their own weight or are blown over by the first wind. This makes a tangled mass of dead trees and brush in which the next fire would be wholly beyond control. There is only one way to fight such a fire: by ditching all around it to the depth of the mineral soil and keeping a careful watch to see that it does not cross the ditch. If, by any chance, the fire gets a start unnoticed and kills the trees, the burned area should be gone over as soon as possible and all the material that can be used in any form removed. This should not be neglected, for the shallow-rooted species that grow in such situations are seldom durable and rot very rapidly. When the useful material has been removed, the remaining brush should be burned carefully to lessen the chances of another fire.

A surface fire burns in the moss, leaves and underbrush. In fact, in many regions it is such a common occurrence for the forests to burn over in this way every spring and fall that no one pays any attention to them. Some owners even set these fires in their woodlots with the idea of improving the grazing. It is the impression generally that these surface fires do no damage because they do not very obviously injure the mature trees. This impression is altogether wrong. The surface fire does an enormous amount of damage in any forest; and more especially is this so in the woodlot. The obvious injury to the mature timber is, indeed, slight, but damage has been done. The litter which should naturally increase the fertility of the soil is destroyed, and land that is burned over every year deteriorates steadily. The surface roots are injured or killed by the heat and the trees rendered liable to windfall. The trees are burned at the base so that considerable loss is experienced in logging through the cutting of high stumps and the butting of the bottom log — the very best timber in the whole tree. This is more especially true of conifers.

The greatest loss is in the young growth, which is very susceptible to injury from fire in all species. A surface fire every three or four years is sufficient to destroy most of the young growth and the annual burning makes all reproduction impossible. It also fosters the growth of herbaceous weeds and sprouting shrubs to such an extent that tree seedlings are crowded out completely. In the virgin forest in which most of the timber is mature and very little young growth is present, this does not matter so much to the owner, for he counts on moving to another tract for his next cut and has no idea of raising another crop on the same ground. In the woodlot in which the location is necessarily permanent, the very existence of the forest depends absolutely upon this young growth. A certain amount of timber must be ready for the harvest each year or the woodlot fails of its purpose. To furnish this mature timber regularly and continuously, young growth of all ages must always be present. Fire of any kind breaks up this series and impairs the producing capacity of the forest.

These fires occur at different times of the year in different sections of the country but there are two seasons when they are most prevalent. In the spring after the snow has melted and before the vegetation has leafed out, the sun's rays fall directly on the leaf mold and make it as dry as tinder. Practically the same conditions exist in the early autumn after the leaves have fallen and before the snows or fall rains begin. The least spark will then cause a fire which soon gets beyond control unless discovered in the very inception. These are the times when fires are most likely to occur, but a severe drought may bring about these conditions at any time of the year.

The railroads are responsible for a very large percentage of the forest fires. Sparks from the smoke stack and live coals from the fire box are almost certain to start forest fires in dry seasons. In fact, it was found necessary in a particularly dry season in the Adirondacks to patrol the forests after every train, and the patrol was seldom in vain. Spark arresters on the smoke stacks and regulations restricting the dumping of the ashes to suitable places do away with most of this danger. The clearing and burning over of a strip on either side of the right of way is also a very good protective measure. If it is not desirable to have this space idle, keep good, healthy trees growing to the very edge of the right of way and keep them very carefully freed from all dead limbs and dry litter on the ground. Highways should be treated in much the same manner as railroads on account of the danger from matches and cigar butts carelessly thrown aside by the passers-by.

Next to the railroads, the burning of fallows is the most frequent cause of fire. The farmers fire their meadows and marshes in the spring to burn out the dead grass and to improve the pasture. In spite of the laws making a closed season for fallow burning in many states, fires are started at dry seasons and quickly get beyond control. In fact, many farmers take no further interest in a fire after they have started it, and let it run wherever it will. The property of others is often destroyed in this way and the fires frequently run into the forests from the meadows. More care in choosing a suitable time for firing the meadow would eliminate most of this danger. Such a fire should never be started during a drought or when there is a heavy wind. About five o'clock in the afternoon on a clear day shortly after a rain is a good time to set such a fire. The open field then will be sufficiently dry to burn well, while the moisture in the woods and the falling of the dew in the evening will prevent the fire from getting beyond control. Where meadow land adjoins forest, a strip a rod wide should be plowed and kept clear.

The setting of fires in the woods itself should never be permitted — for the returns in grass will never repay the damage done to the forest. This practice of firing the woods is most prevalent in the South, where it is done regularly every year. In some places the people are beginning to learn from experience that the burning is not a good practice even from an agricultural standpoint. The fertility of the soil decreases steadily and the better grasses are replaced by coarser and inferior species.

In some sections many fires are started by tramps who camp in the woodlots for the night, cook their dinners, and are careless with their camp fires. They take no care in locating the fires and then leave them to be spread by the wind. They should be watched closely and care should be taken in handling them, or they may maliciously or thoughtlessly fire the woods.

There are a few precautionary measures that should be observed in every woodlot no matter how remote the danger from fire may appear to be. All slashings from lumbering, all windfalls and all dead brush should be piled and carefully burned. This is an inexpensive process and prevents the occurrence of a violent fire. A fire running in a clean woods is easily controlled, but in the dry slashings or windfall it is impossible to do anything with it.

If the tract is large, there should be several roads through it to make all parts of it easily accessible and to serve as bases from which to fight the fire. These should be kept well cleaned out and the mineral soil exposed wherever possible. There is no better fire break than a well-maintained road. Unassisted it will stop any surface fire in a clean forest and prevent it from spreading over the whole tract. These are both good sylvicultural measures and cause no inconvenience.

The most effective implements in fighting fire are the shovel and the plow. A well-turned furrow will stop a light ground fire and a shovel-full of mineral soil spread over the advancing line will put out the blaze wherever it touches. In digging a ditch to head off the fire, the dirt should be thrown in toward the blaze so that the fire will be too much weakened to jump the ditch. Often, when a ditch cannot be placed effectually across the whole front of the fire, it can be flanked obliquely and the front so reduced that it can be controlled, or it can be run into a swamp or stream. Every swamp, stream, road or hill top is a point of vantage from which to fight. There is such a drought from a valley that little can be done with a fire on a slope, but a very small fire break will stop it on a ridge.

The time to fight fire is at night. In the day time when the sun has dried up the dew, warmed up everything and raised a wind, the flames cannot well be handled and the fire will usually travel faster than a small crew of men can work. A small fire may be attacked in the day time and handled before it has gained great headway, but if it is under full headway a great amount of labor is saved by waiting till night to make a fight against it. The day should be spent in studying the fire and the topography, picking out good vantage points and making preparations for the night's work. The wind usually goes down somewhat with the sun, the dew dampens everything and the fire is reduced to a fraction of its daytime fury.

When the tract abuts on another forest property, it is well to place a road on the boundary or at least clear the brush from a strip two rods wide, plow a few furrows on either side and burn in between. This strip should be burned over every year — preferably in the spring — and kept clean.

GRAZING Figs. 45–48

Grazing is one of the evils that is doing the most damage in the farm woodlots to-day. On a large number of the

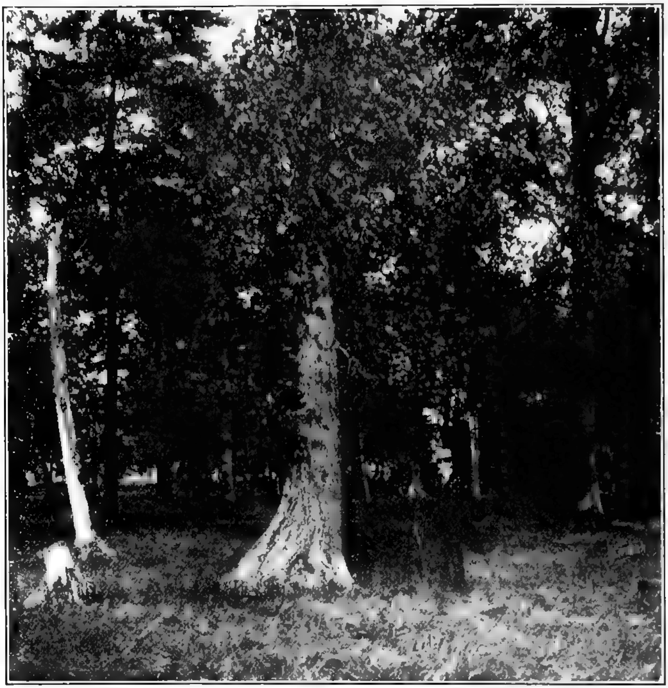

FIG. 45.—No reproduction at present. Due to grazing.

farms, the woodlot is regarded as a shaded pasture and grazed continuously, little thought being given to the effect on the wood-producing capacity. This has gone on year after year till the tract has, in fact, become a shaded pasture; the forest conditions have completely disappeared and the woodlot has the appearance of a city park with a few mature trees scattered over an open grass plot.

The amount of damage done depends on many factors. Of these, the most important are: the condition of the forest when the stock is admitted; the species of animal admitted; the species of trees; the condition of the soil and the slope of the land.

The injury to the forest consists of: the browsing of the young seedlings, and of the succulent leaves and shoots of everything within reach; the gnawing and stripping of the bark, especially from the young trees; the trampling and breaking down of seedlings; the bruising of the surface roots, especially by the heavily shod horses; and the hard packing of the forest floor.

The greatest damage is likely to result when regeneration is in its early stages — for it is the browsing and tramping of the young seedlings that does the most damage to the forest. Each seedling nipped off means from two to four years wasted in the growth of that tree, and the same thing is likely to occur again when the growth is renewed. This means that there is very little chance for the young growth to grow above the reach of the animals, where it would be comparatively safe. The correctness of this theory is proven by the appearance of tracts that have been heavily grazed for a series of years. Young growth is absolutely lacking and only the mature trees remain.

In a large forest which is managed on the compartment system, it is easily possible to allow grazing in the forest generally but prohibit it on the areas undergoing reproduction. In the woodlot this cannot be done. Nearly all the woodlots are managed on the selection system, individual trees cut here and there throughout the woods, which means that reproduction is going on all over the

Fig. 46. — Effect of grazing on hardwood reproduction.

woods at the same time. This makes it impossible to protect young growth from the grazing animals.

Cattle are most frequently pastured in the woodlot and they do less damage than any other grazing stock. They prefer grass to trees, and will not browse so long as the grass holds out. Care should be taken not to turn in more stock than the grass in the woods can carry; nor to turn them in before the grass has started; nor to keep them there when the grass is old and tough. If these rules are not followed carefully, the cattle will be forced by hunger to browse, and on account of their height and weight can

FIG. 47. — Damage done by cattle to oak sprouts.

do a great deal of damage. Cattle browse only on the broad-leaved species, but may damage coniferous seedlings by trampling them.

Goats do not need the incentive of hunger to make them browse. They prefer the shoots of the trees to grass, and eat conifers as well as deciduous trees. By standing on their hind legs and walking up the small saplings with their front feet, they are able to bend down trees six or eight feet high and browse off the tops. They eat with a jerking, pulling motion which frequently strips the bark

Fig. 48. — Effect of grazing. Note reproduction to the left of fence where stock has been kept out.

from the trunks along with the small twigs. They should be kept out of the woodlot at all times.

Sheep have somewhat the same characteristics as goats, but are not so apt to browse unless the ground feed runs out. Neither do they take kindly to the coniferous seedlings. However, the numbers must be very carefully limited — for, if the range becomes at all crowded, the sheep will browse very heavily on the young hardwood growth. The fact that sheep are frequently used to clean up brush land shows what they will do in the way of destroying broadleaf growth. Greater care is necessary in limiting the number of the sheep than cattle, for when crowded they are like a flock of locusts. Horses, especially young horses, do much damage by browsing the leaves and small twigs as high as they can reach, and gnawing the bark off the saplings. They also trample down a great many seedlings with their heavy tread and tear the bark from the surface roots of the shallow-rooted species with their iron shoes. They will not browse conifers, but break down many of them in running around for exercise. Fürst, in his book on forest protection, classifies the domestic animals, according to the amount of damage that they do, as follows: goats, horses, sheep and cows.

When the soil is light and has a tendency to drift with the wind, grazing animals do much to stir it up and start it moving. When there is heavy clay, they pack it down so that germinating seeds cannot get a foothold. When the slope is steep, they are very apt to pry loose the earth and start erosion.

Do not use the woodlot for a pasture unless it is necessary, and then graze it as lightly as possible. That is a rule which can be followed safely everywhere and at all times, except when the object is the clearing out of the underbrush.

MISMANAGEMENT

Probably the greatest danger to which the woodlot is subjected is mismanagement by the owner. No attention is given to the maintenance of production, either in quantity or quality. The amount of wood needed on the farm is the standard for cutting, without any regard to the amount produced. The rate of growth, which is the only true gauge of the producing capacity, is not considered. When the woodlot is large, sufficient timber is not removed and the excess growth rots away. When the woodlot is too small, all the annual product and some of the producing stock are taken, thus decreasing the output yearly. Nearly every woodlot is deteriorating in quality under the present system of management. The most desirable species are cut until they are all gone and the undesirable species are left to seed up the vacant places. A few years of such treatment leaves a tangle of tree weeds, worthless for almost any purposes except firewood. A little care in the selection of trees for cutting would make it possible to utilize most of this poor timber for firewood before the good species are cut and thus insure the seeding of the ground by the better species. In this way the value of the woodlot may be improved from year to year instead of lowered. This properly belongs to sylviculture and will be taken up in detail under the head of "The Care of the Woodlot."

TRESPASS

There is no form of property that is so liable to trespass as forests. There is a very general idea that the forest is common property and open to the public for hunting, picnics and wood supplies of all kinds. The small woodlot is not exposed so much to theft as to hunters and tramps who are likely to set fires. However, when the woodlot borders on the property of another, especially forest land, the line should be carefully surveyed and clearly defined. Both parties should be witness to the accuracy of the survey and testify the same on the map or survey notes. If the woodlot lies at some distance from the house and remote from a well-traveled road, it should be visited occasionally to see that no one is trespassing. Not only is the wood lost by the theft, but the whole scheme of management is upset by the promiscuous cutting.

WINDFALL

Windfall is likely to occur only when the woodlot is made up of shallow-rooted species, such as the spruce, beech, birch, balsam and tamarack. It is usually caused by winds that blow fairly consistently from some one direction. Damage is prevented by leaving a row or two of deep-rooted species along the windward boundary for a windbreak and never exposing the shallow-rooted trees to the full force of the winds by cutting the wind-firm trees around them. This is quite easily done because the shallow-rooted trees are usually shorter and located on lower ground where the wind is not so likely to strike them. In case the woodlot is made up entirely of shallow-rooted species, it is necessary to accustom them to the wind and thus strengthen their roots by thinning them gradually and not making any heavy cuttings where the remaining trees will be exposed to the wind. Should windfall occur, the same measures that are described under "ground fires" should be taken at once. In a small woodlot, little loss need result.

SUNSCALD

Sunscald is more likely to occur in the case of lawn or park trees than in the woodlot. It is caused by the direct rays of the sun scorching the bark and cambium layer of the trunk. Only the smooth, thin-barked trees are exposed to this danger. Maples and basswoods are particularly susceptible. It almost invariably occurs on the southwest side where the sun strikes hottest. The burning kills the growing tissue just under the bark and causes the bark to peel off in patches. The result is an ugly wound, an easy mark for fungi, that weakens the trees and sometimes causes their death. If left exposed, such a wound can never heal over. In the lawn or park, the trunks of these thin-barked trees should be wrapped with burlap or straw until the crowns have grown sufficiently to shade them. In the woodlot, they can be shaded by other trees or underbrush. Sprouts from the roots, that do not look well on ornamental trees, can here be allowed to grow to protect the trunk. Care should be taken not to leave such trees exposed on the south or west side of the tract. When the scalding has taken place, the injured tree should be cut out before it becomes a breeding place for insects and fungi. The lawn tree, if wrapped before the scalding has spread too far, will heal the wound in time, but such a healed-over wound is especially susceptible and should never be exposed again.

INSECTS

When the supply of timber in the United States seemed unlimited, the comparatively insignificant ravages of the insects were unnoticed, but as the supply of standing timber has decreased, the work of the insects has come more to our notice and they have apparently become more numerous. When the growth of our forests becomes more concentrated under proper management, we may expect the insects to play a more important part as they do in the forests of Europe to-day. Up to the present time, comparatively few insects are known to have done extensive damage in this country. The gipsy and brown-tailed moths have worked havoc over rather limited areas in New England. The larch saw fly at one time destroyed much of the tamarack in the Northeast. The white pine weevil frequently does considerable damage in the same district. The spruce-destroying beetle killed all the spruce on large tracts in the forests of West Virginia and the pine-destroying beetle has done much the same damage in the Black Hills. The hickory borer is fairly well distributed throughout the range of that species and the locust boreres are found nearly everywhere that the black locust or mesquite grows. These are the most important of the insects which attack the trees in the forest and the ones to be fought against and destroyed. There are several others that do considerable damage among lawn and park trees, but have never yet become numerous enough to do much damage in the forest. The most important of these are the elm beetle and the forest tent caterpillar. These insects may be divided into two classes: the leaf-eaters, which work mostly on street and lawn trees, and the bark borers, which work wherever their favorite species are found.

The gipsy moth

Of all the insects which have infested the trees of the United States, the gipsy moth has done the most damage and most stubbornly resisted all attempts at control. It was brought to this country from Europe in 1868 in connection with some silk-producing experiments. It escaped from captivity in Massachusetts and gradually increased in numbers till the state was obliged to attempt its extermination in 1890. It spread over a large portion of Massachusetts and invaded New Hampshire, Maine, Connecticut and Rhode Island. These states have spent several million dollars in combating it, but have not yet been able to exterminate it.

The moth has a wing spread of $2\frac{1}{2}$ inches, and is a dusky white with blackish blotches and streaks. The eggs, four or five hundred of them, are laid in July and August directly on the bark of trees or on fences, walls, and the like. They form an irregular oval mass, $\frac{3}{4}$ by $1\frac{1}{2}$ inches, of a yellow or dark creamy color from the hairs or scales from the body of the female. This color is distinctive. The eggs hatch about May 1, and the swarm of young caterpillars usually become full grown by midsummer. The mature larva has a dusky or sooty colored body. Along the back, counting from the head, which is marked with yellow, is a double row of six pairs of red spots. It frequently attains a length of 3 inches. They become full grown during July, usually about the first. Injury occurs in May and June, increasing as the caterpillars grow. When fully grown, usually in July, the caterpillar spins a few silken threads for support, casts its skin and changes into a pupa which is dark reddish or chocolate in color and very thinly sprinkled with dark reddish hairs. The pupa stage lasts from ten days to two weeks, while the caterpillar is changing to a moth.

The female moth does not fly and dies soon after depositing the egg mass, which remains over winter on the tree. All the damage is caused by the caterpillars. The moth spreads in the caterpillar stage or by the transportation of the egg clusters.

The caterpillar feeds on any species of tree found in Massachusetts and completely defoliates them. Two or three defoliations will kill the hardwoods, one only will kill the softwoods.

The insect has many natural enemies, but they are not sufficient to keep it in check without human aid. The most effective method is the soaking of the egg masses with a creosote mixture applied with a small swab or brush. The trees must be climbed and a careful search made for the clusters. Arsenate of lead, 10 pounds to 100 gallons of water, may also be used effectively as a spraying solution when the caterpillars are small. Since the caterpillars crawl up the trees in search of a crevice in which to lie during the day, a loose band of burlap will form an inviting retreat in which many will collect. This must be examined daily and the caterpillars destroyed. Bands of paper covered with printers' ink or "tanglefoot" catch many and prevent them from going up the trees.

The brown-tail moth

The brown-tail moth (*Euproctis abrysorrhora*) was introduced from Europe on some nursery stock in 1890.

Owing to the flying abilities of the female, the spread has been very rapid. It now infests about the same territory as the gipsy moth.

The winter webs, three or four inches long, may be found on the tips of the twigs of fruit and shade trees. They are composed of silk and leaves woven into a tough net which is bound to the twig by silk and leaf stems. This is filled with a mass of small, brown, hairy caterpillars $\frac{1}{8}$ inch long. The little caterpillars emerge late in April and early May and attack the opening buds. These nests contain 400 to 900 caterpillars. These are of a blackish color, covered with warm brown or reddish brown hairs. The head is jet black, while the body is marked with yellow. Projecting from the back of the fourth and fifth segments is a large tuft of reddish brown hairs looking like a brush, and two-thirds the height of the body. On the middle line of both the ninth and tenth segments is an orange or coral red retractile tubercle. By the second week in June the caterpillar has attained its full growth, 1 to $1\frac{1}{4}$ inches in length, and has molted three or four times. Its head is then a pale brown, mottled with darker brown. The body is a dark brown or black, well marked with patches of orange and covered with some cross tubercles bearing long barbed hairs. The white dashes along the sides of the abdomen are more prominent and enable the immediate identification of the caterpillar. During the second week in June they pupate, spinning their cocoons of white silk among the leaves. This stage lasts about twenty days. Most of the moths emerge during the second week of July. They usually emerge late in the afternoon and are ready to fly that night. Both sexes are pure white, except the abdomen, which is dark brown. The wing spread is from $1\frac{1}{3}$ to $1\frac{1}{2}$ inches. The tip of the abdomen of the female forms a large tuft or brush of golden or dark brown hairs, to which is due the name of the insect. They are strong fliers and readily attracted by lights. Egg-laying commences at once. The egg mass, dark brown in color from the hairs from the tip of the female's abdomen, is laid on the under side of a leaf near the outside of the tree. It is about $\frac{1}{3}$ by $\frac{1}{4}$ inch and contains from two to four hundred eggs. It is decidedly convex and ridged. The eggs hatch in about three weeks, about the first of August. The young caterpillars feed upon the surfaces of leaves, skeletonizing them, and when abundant causing the leaves to turn brown. They grow rapidly and spread over the tree. In September they weave the web for their winter home.

The brown-tail moth prefers fruit trees, but when very numerous attacks all kinds of shade and forest trees. The damage is caused by defoliations, as in the case of the gipsy moth. In addition to the danger to the trees, the fine hairs from the tubercles on the caterpillars are blown about by the wind at the time of molting and cause a painful skin irritation wherever they light.

The best known remedy is the collection of the winter webs between October 1 and April 1. They should be clipped off with long pruning shears and burned in a stove, since they do not burn readily in the open.

Spraying of the caterpillars in early August is also effective. The caterpillars are much more susceptible than those of the gipsy moth. This, however, is more expensive. The banding of the trees with tanglefoot is also successful in the case of isolated trees, but the bands must be constantly watched to see that they do not become covered with dust, webs or dead caterpillars. Destruction of the pupæ in June and early July is usually accompanied by severe poisoning.

The pine-destroying beetle of the Black Hills

This pine beetle (*Dendroctinus ponderosa*), is one of the most active and destructive insects in the West and has already ruined large areas of timber in the Black Hills. It is not, however, of very great importance from one point of view, because the bull pine, the species most subject to its attacks, is not very well adapted to woodlot growth.

Hopkins describes the adult as "a stout, dark brown to black beetle, individuals of which vary in length from about $\frac{1}{6}$ to $\frac{1}{4}$ inch."

The presence of the insect may be discovered by the fine, powdered dust sifting down the trunk of the tree. It first appears in August, when the adult beetles settle on the trees in swarms, and start their galleries, the resin and sawdust being pushed out of the opening where they form pitch tubes around the holes. These galleries are usually almost straight cut in the soft inner bark, often grooving the wood, and the eggs are laid in the notches along the sides. When the larvæ hatch they start side galleries, at right angles to the primary gallery, that increase in size as the larvæ grow. At the end of this gallery the full-grown larvæ dig a widened cavity in which pupation takes place. The adult digs from this cavity through the bark and passes on to another tree. A great number of these galleries will girdle the tree and interfere seriously with the movement of sap.

If the insects are in sufficient numbers, the tree is killed. The needles turn red the first year, a number of secondary enemies attack the weakened tree, fungi enter the wounds and in three or four years the tree is worthless.

The beetle is best kept in check by cutting the infected trees, for it is in these weakened and dying trees that they multiply. The trees felled should be peeled or placed in a pond to kill the larvæ. When the cutting can be carefully regulated, the insects can be controlled easily in this way, — for they must be present in great numbers to successfully attack living trees.

The spruce-destroying beetle

The spruce of the northwestern part of the United States finds its most formidable enemy in the *Dendroctinus piceaperda*, the spruce-destroying beetle. It has destroyed vast quantities of spruce timber in Maine, New Hampshire and West Virginia and is still active in those regions.

According to Hopkins "The adult varies from $\frac{3}{16}$ to $\frac{5}{16}$ inch in length and from $\frac{1}{16}$ to $\frac{2}{16}$ inch in width. It also varies in color from light yellowish brown in the younger specimens to reddish brown or nearly black in mature stages. The egg is small and pearly white like that of most bark beetles."

The larva hatches out a minute, white legless grub and feeds on the inner bark till it increases to a size slightly larger than the adult. It may be distinguished by a dark yellowish brown space on the upper surface of each of the last two abdominal segments. The pupa is nearly white, of the same size and somewhat the same form as the adult, but without free legs and wings, and is found in oblong cavities in the bark where the broods develop.

The insects hibernate in the bark in the form of adults and larvæ, — the eggs and pupæ cannot stand the cold — from October to the first week in June. Activity then commences; the mature larvæ change to pupæ and the adults lay their eggs in about twenty days, ten more and the larvæ hatch, thirty more and the larvæ are mature. In eighty days from the time activity commences, the first adults develop. They continue to develop till the last of September, but continue in the bark till activity ceases. Thus the insect spends eleven of the twelve months in the bark and is dormant seven and a half out of that eleven.

The evidences of work are much the same as those in the case of *Dendroctinus ponderosa.* Pitch tubes are formed on the bark, fine sawdust is thrown out from the galleries of the larvæ, the leaves turn a light gray-green and soon fall off. The twigs turn reddish. One season's work is usually enough to kill the tree, unless the attack is confined wholly to one side, for the galleries of the adults and larvæ in the inner bark completely girdle the tree.

All practical remedies lie along the line of carefully directed cutting. The beetles are dependent on the presence of large numbers for their ability to attack living trees. Since most of the beetles are located in the merchantable part of the tree, the logging, provided the logs are placed in a pond or peeled, kills large numbers of them and may reduce the number below the point at which they can attack living trees. The weakened condition of the trees girdled for trap trees attracts many and the logging of these trap trees destroys them. Other methods are too expensive to be practical.

Elm-leaf beetle

The elm-leaf beetle (*Galerucella luteola*) is one of the most familiar enemies of the elm tree throughout its range. It has destroyed thousands of shade and lawn trees, and, when numerous, frequently spreads to the woodlot and forest. It is evidenced by the skeletonized brown leaves in midsummer and the falling caterpillars.

The beetle is $\frac{1}{4}$ inch long, orange and black when young and a dull bronze-green when he has wintered over. The caterpillar is $\frac{1}{20}$ inch long when young, hairy and almost black, but grows to $\frac{1}{2}$ inch in length and changes to yellow and black. The pupa is a bright orange-yellow and $\frac{1}{5}$ inch long. The eggs are an orange-yellow, 3–26 of them being in irregular rows on the underside of the leaves.

The elm-leaf beetles winter over in attics, sheds and other protected places. They fly to the trees with the coming of the leaves, eating irregular holes in the foliage and feeding for some time before they begin to lay. They lay a few eggs daily for a month or six weeks and sometimes total as many as 650. The eggs hatch in less than a week and the grubs appear about the middle of June. These larvæ feed on the under surfaces of the leaves and skeletonize them. They are full grown in 15–20 days, and wander down the trunk to pupate in some crack or other slight shelter. This is accomplished in about seven days.

These busy little fellows sometimes start a second brood in July and even a third one in October. If the leaves are stripped off a tree two or three times for a couple of seasons, it dies.

To destroy these beetles, spray the underside of the leaves with arsenical poison early in spring, or spray kerosene emulsion on the pupæ on the ground or lower trunk of tree. There is no effective remedy in the forest.

Bronze birch borer

The adult of this beetle (*Agrilus anxius*) is a beetle from $\frac{3}{10}$ to $\frac{1}{2}$ inch in length and olive-brown in color. The pupa is white, slender in form and about $\frac{1}{2}$ inch in length. The larva is a grub $\frac{3}{4}$ inch long, and a creamy white with black mouth parts.

This insect is very common throughout the North, especially where the cut-leaf birch is plentiful. It has played havoc with thousands of birch trees in our parks and lawns and has, in a few instances, attacked the white birch in the forest. Unless a careful lookout is kept, the damage is accomplished before the cause is located. The surest sign of its presence is the dying of the top branches.

The beetles appear in the early summer, the eggs are laid and the larvæ enter the tree in the fall and winter under the bark in the upper branches of the tree. With the warm weather in the spring, they begin burrowing in the soft cambium. Their presence may be traced by lightly reddish welts or streaks on the bark. Their galleries are sinuous, irregular and much interlaced. They pupate in May.

In a woodlot the only practical remedy is to cut down the infested tree in winter or early spring and carefully burn all parts of it. In the case of valuable lawn trees, it may be possible to cut away only the infested branches, if they can all be discovered. It may be a help to band the trunks of the trees in May with raw cotton or sticky paper and kill the beetles so caught. Usually, however, the tree is injured beyond help before the insects are discovered, and it should be destroyed to prevent the injury of other trees.

Forest tent-caterpillar

This insect (*Malacosoma disstria*) is found practically all over the United States and has been known from time to time to destroy large tracts of forest in different parts of the country. They have several times become so numerous as to stop railroad trains.

The moth is small, light buff-colored and very active. The caterpillars are almost black, with a row of whitish diamonds down the back. The pupæ are found in white or yellowish cocoons in any convenient place.

The moths appear in June or July and deposit their eggs in July, usually on the lower twigs. The larvæ remain in the eggs over winter and hatch out with the warm weather in the spring. They immediately begin stripping the leaves, on which they feed till about the first of June. They then begin to wander about to find a place to pupate. This requires about two weeks. They seem to prefer the sugar maple in the North and the oaks in the South, but when they become very numerous, they will attack anything.

There are several remedies that may be used in the case of valuable shade trees, but nothing for the woodlot, except the cutting out of the infested trees. The lower twigs may be trimmed and burned in winter, thus destroying the eggs; the caterpillars may be jarred from the trees with a padded mallet and crushed; the egg clusters may be sprayed with kerosene emulsion or whale oil soap; the cocoons may be destroyed. These methods will be very effective if they are undertaken before the insects become too numerous.

Fall web-worm

This widespread insect (*Hypantria textor*) is one of our most destructive leaf eaters. It is found all over the United States east of the Rockies and feeds on a large number of species, including white elm, willows, poplars and all fruit trees. It can be identified readily by the conspicuous web tents on the tips of the branches and including the leaves, which are soon skeletonized and turn brown. The webs are never in the crotches.

The moth varies from pure white to much spotted with black. The caterpillar is hairy, yellowish brown and black, the hairs springing in clusters from black and orange tubercles. The cocoon is thin and mixed with larval hairs, and is found at or near the surface of the ground. The eggs are in yellow clusters on the underside of the leaves.

Moths are seen flying from early in June to the middle of August. The eggs hatch in seven to ten days and the caterpillars begin to appear in the latter part of June, but are thickest in August. They spin their web at once, and feed on the upper surfaces of the leaves within. They enlarge their webs from time to time to include more food. When a month old, they descend trees to pupate on or in the ground.

To destroy these insects, burn the web carefully, and see that none escape. Spray with arsenical poisons about the time the caterpillars appear. Hogs turned into a plantation will root up and eat thousands of the cocoons.

The locust borer

This insect (*Cyllene robiniæ*) has done an enormous amount of damage not only by destroying trees, but also in many parts of the country by forcing the abandonment of an attempt to plant the black locust, which would otherwise be a very valuable plantation tree.

The beetle is $\frac{1}{2}$ to $\frac{3}{4}$ inch long, brightly marked with golden yellow, with the antennæ and legs dull yellowish. The pupa is $\frac{3}{4}$ inch long, flattened and yellowish. The larva is $\frac{6}{10}$ to $\frac{7}{10}$ inch long, flattened and club-shaped.

Beetles appear on the trees in great numbers in September. The eggs are laid in crevices of the bark. They soon hatch and the larvæ immediately bore into the cambium, where they spend the winter. With the warm spring days, they start activities again, only this time they bore into the heartwood. The gallery is about a quarter of an inch in diameter and usually curves upward. The larvæ pupate about the middle of July and the beetles come out in September.

The presence of the insects is evidenced by holes in the bark from which the sap runs, a deadening of the cambium and consequent loosening of the bark, and sawdust around the base of the tree. As a rule, they do not attack trees under four or five inches in diameter, so that they will usually reach fence-post size before the borer attacks them. This, however, does not always hold true, and occasionally trees of one or two inches are badly riddled.

Little can be done to destroy these borers except to cut down and burn the infected trees in winter or early spring. The insects seem to attack more readily the trunks that are in full sunlight and hence dense planting may be a preventive. They can be kept from lawn trees by spraying or painting the trunks with something offensive to the insects. This is somewhat objectionable, and too expensive to apply in plantations.

CHAPTER VIII

FOREST MENSURATION

Forest mensuration is the measurement of the crop. It is generally conceded to be the proof of all forestry work. Without measurement, one can know nothing of the contents, value or growth of his forest. The most complicated parts of the science arise in the handling of extensive forests and concern only the professional forester; the operations necessary in the management of a woodlot are very simple and should be familiar to every farmer. Many a farmer loses fully half of what is really his due because he does not know what is in his woodlot, how to measure the quantity of its products or how to estimate its real value.

The unit in the measurement of all kinds of lumber, whether boards or dimension stuff, is the board foot, — a board one inch thick, one foot wide and one foot long. For example: an inch board one foot wide and sixteen feet long contains sixteen board feet; written 16 ft. B.M. (measuring 16 ft. board measure). A two-inch plank of the same dimensions contains 32 ft. B.M. A "2×4" twelve feet long is equivalent to an inch board eight inches, or two-thirds of a foot, wide and contains eight board feet; 8 ft. B.M. A half-inch board six inches wide and 12 ft. long actually contains 3 ft. but usually is counted as inch material, on account of the increased labor and increased waste in sawing, and would be considered 6 ft. B.M. The two-inch plank would not really make two inch boards if sawn, because an eighth or sometimes a quarter of an inch, — according to whether a band saw or a circular saw is used, — is lost in sawdust. But this is not taken into account in measuring the thicker pieces. And so it is evident that there is more waste in sawing inch boards than in thicker material. The prices of lumber are usually quoted at so much a thousand feet board measure; written 1 M.B.M.

Lumber (which is an Americanism for boards) is measured by means of a lumber rule on which there are six or eight scales, one for each common length, on which the contents of one-inch boards are calculated for all widths. The scaler must estimate or measure the thickness of each board and throw away all fractions. Thus, the scaler comes to a sixteen and a half foot plank. He turns to the sixteen-foot scale and measures the width. If it is twelve and a half inches wide, he looks opposite the twelve-inch mark in the sixteen-foot scale and finds the figure 16 — the contents in board feet of a one-inch board twelve inches wide and sixteen feet long. He finds that the plank is two inches thick. He doubles the figure given on the scale and writes down 32 ft. B.M. as the contents of the plank. He disregards the extra half inch in width and the extra six inches in length. Hence the cutting of odd widths and lengths is always a loss to the owner. The most convenient time for scaling lumber is just as it comes from the saw and before it is piled.

Fence posts are sold by the piece and are graded, according to the length and the diameter at the small end, into standard grades. These grades vary in different parts of the country and for different species. A chestnut post in the East must be seven feet long and six inches at the small end; for a locust post, three inches at the small end is standard. As a rule, the standards are of a little smaller size in the West, or wherever the posts have to be shipped by rail.

Piling is sold by the lineal foot and graded according to length and diameter. Railroad ties are sold by the piece. They must be cut according to the specifications of the railroad to which they are to be sold. As these specifications vary from time to time and for the different roads, a copy of them should always be secured just before the ties are cut. A different grading of the ties according to width of face and depth may make a great difference in the total returns. It must be remembered that a tie contains about thirty board feet and it should be carefully considered whether a tree can be most economically used for ties, posts, piling, poles or saw logs. It is rarely advisable to cut all the trees into the same product, and each part of the tree should be devoted to the product that will bring the best returns. It seldom is profitable to split a large tree into posts or ties unless it is a species especially suited to that form of product.

Telephone poles are graded according to length and diameter at small end. Logs usually are measured by the same standard unit as lumber, — the board foot. For example, a log is said to contain 200 ft. B.M., when the lumber sawed from it will scale 200 ft. B.M. For the purpose of measuring logs, the contents of logs of all lengths, diameters and species have been worked out and tabulated. Such a table is called a log rule. There are forty or fifty of these rules in common use in the United States. Some are based on diagrams, some on mathematical formulæ and still others on the actual results measured at the tail of the saw. All of them are more or less inaccurate. One that is accurate in one region will not be at all accurate in another in which the character of the timber is different. For this reason, the rule that is considered the best suited to the timber of a certain region usually is selected as the legal standard of that state. Other rules may be used in private contracts, but in all state business and all law suits in which the scale is not mentioned, the state standard must prevail. The Scribner and Doyle rules are those most widely used in the country.

Logs are measured by means of a scale stick. This somewhat resembles a lumber scale. It usually is made of hickory and finished on one end with a convenient handle, on the other with a metal ferrule. On it are printed six or eight rows of figures representing the different standard log lengths: twelve, fourteen, sixteen, eighteen, twenty, twenty-two and twenty-four feet. In each row, opposite the inch marks on one edge, are the figures representing the number of board feet in a log of that length and diameter. Thus, for example, a scaler approaches a log, seventeen feet long and fifteen inches in diameter at the small end, with the Doyle rule. He disregards the odd foot in length and turns to the sixteen-foot column on his rule. All logs are scaled down to the nearest even length represented on the rule. The scaler lays the rule across the small end of the log,—for all logs are scaled on the small end,—and measures the diameter inside the bark, being careful to get the average diameter if the log is not round. Opposite the fifteen-inch mark and in the sixteen-foot row he finds 121 ft. This he records as the contents of the log.

Any one can scale sound and straight logs when the contents may be read directly from the scale, but much experience is needed to scale crooked or defective logs with any degree of accuracy. The number of board feet that the defect will spoil must be estimated and deducted from the amount given by the scale. It is wholly a matter of experience and judgment.

ALLOWANCE FOR DEFECTS IN SCALING

The only difficult thing about scaling logs is the determination of the allowance to be made for defects. Since this is learned by the scaler only through long years of experience and actual observations of the sawing out of defective logs at the mill, it cannot very well be picked up by the farmer in the comparatively little practice that he receives in scaling. Allowance for defect must be largely a matter of guess work with him.

Some attempts have been made to systematize this discounting for defects and reduce the results to tables showing the number of board feet to be deducted for a certain size and form of defect. For the aid of the inexperienced farmer some tables worked up by H. D. Tieman of the Yale Forest School are inserted here, quoted from H. S. Graves' book on "Forest Mensuration."

A cull table for center defects. — "This table is applicable to all center defects, such as holes, cup shake, rot, etc., which are four inches or more from the bark. To apply the table, measure the longest diameter of the defect, find the loss in board feet from the cull table, and deduct from the gross scale of the log. If the defect runs through the log, or if it appears only at the large end, measure the defect at the large end, otherwise at the small end. The table should be used only with short logs."

CULL TABLE A

Loss by Defects of Different Diameter near the Center of Logs. (Good for Defects more than 4 Inches from the Bark)

Diameter of Defect	Length of Logs in Feet						
	10	12	13	14	16	18	20
Inches	Board Feet						
2	5	6	6.5	7	8	9	10
3	9	11	12	13	15	16.5	18
4	14	17	18	20	23	25.5	28
5	20	24	26	28	32	36	40
6	27.5	33	36	38.5	42	49.5	55
7	36	43	47	50	57	65	72
8	45	54	58.5	63	72	81	90
9	56	67	74	78	89	100	112
10	67	81	87	93	107	120	133
11	80	96	104	112	128	144	160
12	94	113	122	132	151	169.5	188
13	109	131	142	153	175	196.5	218
14	125	150	162.5	175	200	225	250
15	142	171	184	218	226	255	283

Discounts for defects near the edge of logs.—"Under this head may be included rot, splits due to careless felling, superficial shake due to fire scars, sunscald, frosts, or any other defects which require the removal of a wide slab. The scaler measures the width of the slab which would obviously have to be cut off, finds in the table the loss in board feet, and deducts this from the gross scale of the log. If the defect runs through the log, following the grain, and does not extend deeper at the large than at the small end, the measurement is taken at the top. If the defect appears only at the large end, or extends relatively nearer the center than at the small end, the scaler must estimate the width of the slab, at the small end, which would have to be taken off."

CULL TABLE B

Loss by Cutting Slabs from One Side of 10-Foot Logs

Width of Slab in Inches	Diameter of Log in Inches										
	6	8	10	12	14	16	18	20	22	24	26
	Board Feet										
1	0	0	1	1	2	3	3	3	3	4	4
2	3	4	5	5	6	7	8	8	8	10	10
3	7	8	9	10	11	13	14	15	15	16	17
4		14	15	17	19	20	22	23	25	26	28
5			22	24	26	28	30	33	35	37	39
6				33	35	38	41	43	46	49	52
7					45	49	52	55	59	62	65
8						60	65	68	73	76	80
9							77	82	86	91	96
10								97	102	107	112
11									119	124	129
12										141	148
13											167

CULL TABLE B

Loss by Cutting Slabs from One Side of 12-Foot Logs

Width of Slab in Inches	Diameter of Logs in Inches										
	6	8	10	12	14	16	18	20	22	24	26
	Board Feet										
1	0	1	1	2	2	3	3	4	4	5	5
2	4	5	6	7	7	8	9	10	11	11	12
3	9	10	11	13	14	15	16	18	19	20	21
4		17	19	21	23	24	26	28	30	31	33
5			27	29	32	34	37	39	42	44	47
6				39	43	46	49	52	56	59	62
7					55	59	63	67	71	75	79
8						73	78	82	87	92	97
9							93	98	104	110	115
10								117	123	129	135
11									142	149	155
12										170	178
13											200

CULL TABLE B

Loss by Cutting Slabs from One Side of 14-Foot Logs

Width of Slab in Inches	Diameter of Logs in Inches										
	6	8	10	12	14	16	18	20	22	24	26
1	0	1	1	2	2	3	4	4	5	6	6
2	4	5	6	7	8	9	10	11	12	13	14
3	10	12	13	15	16	18	19	20	22	23	25
4		19	22	24	26	28	30	32	34	36	39
5			31	34	37	40	43	46	48	51	54
6				46	50	53	57	61	65	68	72
7					64	68	73	78	82	87	92
8						85	91	96	102	107	113
9							108	114	121	128	134
10								136	143	150	157
11									166	173	181
12										197	207
13											234

CULL TABLE B

LOSS BY CUTTING SLABS FROM ONE SIDE OF 16-FOOT LOGS

Width of Slab in Inches	Diameter of Log in Inches										
	6	8	10	12	14	16	18	20	22	24	26
1	0	1	1	2	3	3	4	5	5	6	7
2	5	6	7	9	10	11	12	13	14	15	16
3	11	13	15	17	18	20	21	23	25	26	28
4		22	25	27	30	32	35	37	39	41	44
5			35	39	42	45	49	52	55	59	62
6				52	57	61	65	69	74	78	83
7					73	78	83	89	94	99	105
8						97	103	109	116	122	128
9							123	131	138	146	153
10								155	163	171	179
11									189	198	207
12										226	237
13											268

Every farmer who sells any timber from his woodlot should understand this process thoroughly, for sharp practice often imposes on the ignorance of the owner and he loses much of his profits through an unfair scale.

In some parts of the country, notably eastern New York, the standard is used as the unit of log measure. This standard is a log thirteen feet long and nineteen inches in diameter at the small end. Five standards are considered the equivalent of a thousand board feet. This rule is not very widely used.

All logs for export are sold by the cubic foot, the most accurate unit of measurement. This measure is not used in the United States except in a few special cases.

The cubic contents of a log is found accurately enough for all practical purposes in the following manner: Measure the diameter of the log inside the bark at each end, being careful to get the average diameter if the log is not round. Turn to the table in the appendix of this book giving the area of circles. Add the two areas thus obtained. Divide the sum by two to get the average, and multiply the result by the length of the log in feet. This gives the number of cubic feet in the log. This method is sometimes used when the logs are sold for pulpwood.

CORDWOOD

One important unit of measurement that is used a great deal in connection with woodlot practice is the cord. The standard cord is a pile of 4-foot wood, 4 feet high and 8 feet long, and contains 128 cubic feet of stacked wood. A cord foot is one-eighth of a cord and contains 16 cubic feet of stacked wood. It is used as a measure of firewood, pulpwood, stave and heading bolts, short handle stock, shingle bolts, tan bark and nearly all other material that is cut into short lengths.

The cord, however, though used as an absolute unit of measurement, does not always represent the same volume of wood, by any means. Some of the volume is occupied by the spaces between the sticks. The amount of this space will vary with the size, length and form of the sticks in the pile and the method of piling. The straighter the sticks, the more closely they will lie together in the pile and the higher will be the solid wood content. Thus cords of pine, fir, spruce and tamarack will yield much higher results than the more crooked and irregular hardwoods.

Large sticks yield a higher solid content than small sticks, because there is less chance for spaces between them. And for the same reason round wood stacks smaller than the same wood split up. It is a common saying among wood choppers that wood swells when it is split. It follows from the preceding reasons that there is less solid content in a pile of long sticks than in a pile of short ones, for there is more chance for crooks and bends. It follows that in a pile of sixteen-inch kindling wood four feet high and eight feet long, there is considerably more wood than in a third of a cord of standard-length sticks.

The solid wood content of a cord varies so much, — from fifty to one hundred ten cubic feet, — that no definite statement can be made in regard to it, but it is well to have the preceding points in mind when buying cordwood.

The term "cord" does not always mean a standard cord. Its meaning varies in different localities. The length of the sticks varies from one foot to five feet, and yet a pile four feet high and eight feet long is known as a cord. Sometimes the distinction between short cords and long cords is made. They all sell as cords, but the proper allowance for the length of the sticks is made in the price.

Another case in which anything like a general statement is only a guess that is rarely realized, is in the conversion of cords to board measure. Yet in some cases, — when large sized material is cut into short lengths, — both units of measurement are used, and it is convenient to have some factor by which to convert one into terms of the other. Since this ratio varies from 250 feet to the cord in some localities to 1000 feet in others, it is absolutely necessary that each locality have a factor of its own for no general factor will do. This conversion factor is obtained by scaling many logs before they are cut up and corded, and taking the average. The pulp companies of New England in buying spruce usually consider a cord equal to 560 board feet. Two cords to the thousand is as nearly a general statement as can be made, and that, in many cases, is very far from the truth.

The nineteen-inch standard in the Adirondacks is roughly considered equivalent to one-third of a cord. A double cord is a pile of eight-foot sticks four feet high and eight feet long. It is a very common unit in handling pulpwood.

THE HEIGHT OF A TREE

The total height of a tree is of little importance to the farmer, but he should be able to measure the clear length and merchantable length of a standing tree. There are several finely adjusted and expensive instruments that give very accurate results, but these are not necessary for ordinary woodlot work. A cheap, homemade instrument will give sufficiently accurate results.

Take two strips of wood about a quarter of an inch thick and an inch wide, — the top of a grape basket will be good enough material, — one four and a half and one six inches long. Tack these together so as to form a right angle. Connect the two loose ends with a third strip. Beginning at the right angle, measure off a half inch on the short strip. Drive a small wire nail into the edge of the strip at this point and at points one and a half, two and a half, three and a half, and four and a half inches from the right angle. Drive a similar nail at the opposite end of the six-inch strip. Mark the quarter and half inch divisions on the short strip with small notches. Now drive a nail through the center of the six-inch strip and nail the triangle to the end of a pole five feet three inches long, the opposite end of which has been sharpened. The instrument is now complete. To measure the clear length of a standing tree, pace off a distance of fifty feet from the base of the tree, taking care to keep on the same level. Stick up the staff in the ground so that the graduated arm is parallel to the trunk of the tree, which must be in sight along the line AB. Since the staff is five feet long, the line AB will strike the tree five feet from the ground. The observer, with his eyes at A, looks at the point to which he wishes to measure and notes, by means of the nails and notches, where his line of sight crosses the graduated arm. The reading on the graduated arm in inches gives the height of the observed point above the ground in feet, each inch representing ten feet. By using the sight at D instead of A, the distance from the tree to the instrument may be reduced to twenty-five feet. This is convenient in the case of thick brush preventing a longer sight, but is more liable to error and harder on the neck of the observer. Should it be desirable to measure something over fifty feet high, place the instrument one hundred feet from the tree and double the readings. Such an instrument should be used by the estimator to measure the number of logs in a tree, till he trains his eye to make an accurate estimate without it. Usually an accurate enough estimate can be made by standing a ten- or sixteen-foot pole up against the tree.

VALUATION SURVEY

An accurate record of the amount of timber on a given tract may be secured by the following method. One man may do it but three can work more economically. A number of tally sheets such as that in the table on page 198 should be prepared and placed in a convenient holder. Starting at one corner of the tract, the party moves parallel to one of the adjacent boundaries, two of the men measuring with calipers all the trees on a strip 66 feet, or one chain, or 4 rods, wide, and the third man recording the results on the tally sheet. These measurements should always be taken $4\frac{1}{2}$ feet from the ground. The trees on the inside of the strip are scratched with a bark marker or marked with chalk to avoid measuring them twice. The tally man may measure the length of the strip by means of a chain 66 feet long, attached to his belt. An experienced man can pace the distance accurately enough. Such a strip ten chains long contains one acre. For convenience in figuring out the result, the acres should be kept on separate sheets. When the end of the tract is reached, the party turns and runs another strip contiguous to the first. In this way the whole tract is covered. Not only are all the trees on the tract recorded according to diameter and species, but, by noting on the back of each sheet the nature of the country traversed, data may also be secured for a fairly accurate map and the area of the tract is measured. If such an accurate survey is not desired, the strips may be run by compass at any interval desired. Strips every ten chains give 10 per cent, twenty chains 5 per cent, and forty chains $2\frac{1}{2}$ per cent of the tract. Ten per-cent measurements give results accurate enough for most purposes, if the tract is large; on small tracts — 100 acres and less — all the trees should be measured. If the owner wishes to do the work alone and desires only a rough estimate, he may pace the distances and estimate the diameters of the trees in the strip. He should, however, first measure a number of trees to accustom his eye to accurate estimating. It is best to train the eye in this way every morning before starting the work.

There are dozens of such so-called "cruising" methods, and any one of them is fairly accurate for all practical purposes. The one described is, in the author's opinion, the most easily applied to small tracts by the untrained cruiser. The estimator should at the same time note, as nearly as possible, the percentage of loss from crooked and defective trees; also the average height of the various trees of different diameters. The field work of the valuation survey is then complete. It remains to figure out the result from the collected data.

These records from the different tally sheets are then collected on a single sheet. The totals thus obtained are divided by the number of acres surveyed and the result is an average acre of the whole tract, giving the number of trees of each diameter and species.

The data secured from the valuation surveys are worked up in the form of a table giving the number of trees of different diameters in each species on the average acre. This is called a stand table. By means of it the number of trees of different diameters and species on any number of acres on the tract may be calculated.

STAND TABLE MADE UP FROM MANY TALLY SHEETS OF THE SAME FORM

LOCATION______ DATE______

TYPE ______. No. ______.

SPECIES	WHITE OAK	RED OAK	WHITE ELM	CHEST-NUT	HARD MAPLE	WHITE ASH	HICK-ORY	BLACK CHERRY
D. B. H. in inches								
1	11	2	6	16	2			
2	17	5	7	9	1			
3	16	3		5				
4	7		2	2	3			
5	3	1						
6	1		1					
7		2		1	1			1
8	2	1						
9				1		1		
10		1	1					
11	1				1			
12	1							2
13		1						
14	2						1	
15			1	1		1		
16					1		2	
17	1							
18				1			2	
19		1					1	1
20			1			1		
21	2						1	
22	1		1	1				
23		1						
24	1							
25		1		2				
26	1				1			

STEM ANALYSES

The next step is to find the volume in board feet and cords of all the trees represented in the stand table. This is most easily found by means of a volume table. In most cases, it would be possible for the farmers to secure the desired volume tables from the Forest Service, Washington, D. C., which distributes them free of charge to all applicants. These volume tables — there should be one for each species — give the number of board feet contained in trees of certain diameters four and one half feet from the ground, and of a certain average height.

VOLUME TABLE

RED OAK — NO. OF TREES

	Height of Tree in Feet						
D. B. H.	60	65	70	75	80	85	90
Inches	Merchantable Feet B.M.						
6	33	35	37				
7	43	46	50	53	55		
8	57	60	64	67	72		
9	70	75	79	84	89		
10	88	92	99	104	109	116	
11	108	115	121	127	133	139	144
12	114	140	149	156	163	169	175
13	164	173	182	190	198	206	212

In the stand table we have recorded the diameter of the trees four and one half feet from the ground (D. B. H.) together with the number per acre and the species. Thus by referring all the trees in the stand table to the proper volume tables, we are able to obtain the total volume of all the trees on the average acre. This is called a yield table and from it the farmer is able to tell the exact amount of lumber that his tract will cut, how much the yield will be if he takes out only the trees above a certain diameter, and what will be left for future cuts.

CRUISING METHODS

There are almost numberless methods of estimating timber by ocular estimate, or "cruising," as it is commonly called; but only two or three that are applicable to the woodlot will be taken up here. The results of the estimating is worked out in board feet, but the unit measure in the field is the log. The number of logs of different species, lengths and diameters are recorded on a tally sheet and the results worked out in the office. The diameter should always be estimated at the small end and inside the bark, since that is where the scale is applied. The diameter at the large end does not make any difference.

In order to do this work accurately, the eye must be trained to two things, the estimating of diameters at a distance, and the estimating of heights. The first may be secured by the use of tree calipers, which the beginner should always carry with him. He should estimate the diameter of every tree and then check it up by the use of the calipers. By doing his estimating at different distances from the tree, he can learn what the different diameters will look like at varying heights on the tree. The eye quickly becomes trained to this work, and in a short time the estimator will find that he rarely has to change his guess when the calipers have been applied. Till the estimator has become very expert, it is best to use the caliper check each day when beginning work, for the eye is apt to lose its cunning over night and needs tuning up.

The eye can best be trained to measure heights by the use of a ten- or better, a sixteen-foot pole,—the length of an ordinary log. Stand the pole against the base of a tree. Retreat a few paces and note how high it comes on the tree and how many times it could be contained in the height of the tree, or to the top of the top log. Together with this practice, estimate the diameters at the various log lengths. In this way a very fair idea of the number of logs a tree contains can be reached. When cutting timber, this process should be checked by first estimating the timber carefully and then measuring the log lengths and diameters on the felled tree.

The next thing that must be learned is the thickness of the bark of the different species at different heights. It varies considerably in thickness from the ground to the top of the first log, but above that it is fairly uniform. This can best be learned from the observation and measurement of felled trees. The testing of the bark of standing trees at breast height is not a good test. In estimating the diameter of logs inside the bark, do not forget to double the thickness of the bark before subtracting it.

When the eye has been trained in this way, the actual work of estimating may be started. The method used will vary somewhat with the size of the tract and the purpose of the owner. The smaller the tract the more accurately the work can be done.

In a small woodlot, all the logs of merchantable size should be estimated and recorded on the tally sheet. This may easily be accomplished by one man. He needs no other equipment than a tally board and something with which he can mark the trees he has estimated to prevent taking them twice. This may be a hatchet for light blazing; a scratcher for scratching the bark or a piece of chalk, — probably the last would be the easiest to handle.

Starting at one corner of the woodlot, he runs a strip along one of the boundaries, estimating the number, length and diameter of the logs in each tree and recording them under the proper species on his tally sheet. He must remember to allow for a reasonable stump and avoid the bad crooks. He marks each tree, as he estimates it, where the mark will be most conspicuous on his return trip. When the end of the woodlot is reached, he faces about and runs another similar strip next to the first. In this way, he estimates the logs in every tree in the woodlot and his tally sheet contains the data needed to calculate his total crop of merchantable logs.

Few woodlots are too large to permit of this method, but when they are, one of the following methods may be used. The problem is to estimate a certain definite percentage of the trees. This may be done in a number of ways. If the area of the tract is known, the number of acres necessary to make up the required percentage can be calculated and estimated. The acres estimated should be scattered evenly over the tract, so that a good average is secured and not bunched up in any one place. There are dozens of mathematical methods for distributing these acres evenly, but it is just as well for each man to make up one to suit himself.

If the area of the tract is not definitely known, and it is not desirable to go to the trouble of a survey, a fairly accurate percentage may be secured by the proper spacing of the four-rod strips. If the strips are four rods apart, they will contain 50 per cent, twelve rods apart 25 per cent, sixteen rods apart 20 per cent, 36 rods apart 10 per cent, 76 rods apart 5 per cent and 156 rods apart $2\frac{1}{2}$ per cent. The larger the percentage taken, the more accurate the estimate will be, and less than 25 per cent should never be taken on any woodlot.

When this data has been obtained, the field work is completed and the remainder of the work must be done in the office. This work consists of converting the logs into board measure by means of a log scale. The most widely used log scales are printed in the appendix. The process is as follows: first, look up the log scale used in that district in which the logs are to be sold. Turning to the column of the log scale representing the logs of the length in the first column of the tally sheet, look up the first diameter appearing on the tally sheet and write down opposite to it the number of board feet given in the scale for that diameter. This represents the number of board feet that may be cut from a log of this length and diameter. Multiply this by the number of logs of this class and write it down in the next column to the right. This must be done for every diameter of the different lengths appearing on the tally sheet. The sum of each column will represent the total number of board feet in the logs of certain length and species. The sum of the totals of all the columns will give the total number of board feet contained in all the logs recorded on the tally sheet, if this represents only a percentage of the whole area correct for 100 per cent.

One more thing is necessary. Not all these logs will be sound. The percentage of rot will vary with the locality and the species. This percentage of waste for each species can most easily and most accurately be secured by careful inquiries at the nearest saw mill. This percentage of "cull," as it is called, must then be subtracted from the total of each species.

The farmer is then in a position to sell his timber and drive an equitable bargain. He knows just how much sound timber of each species he has for sale, and the proportion of long lengths. He must, however, remember that his figures are only an estimate and be prepared for a reasonable difference between his figures and those of the buyer, which are also based on an estimate.

It may be well to describe a common method used by cruisers on large tracts of low value. It is, like most of the cruising methods, based on the estimation of sample areas. The unit sample area is usually the acre. These samples must be located according to some system, for if the cruiser relies wholly upon his judgment, he is apt to place the average too high. For example: the cruiser starts from the southeast corner of the forty, the common unit in all large tracts, and paces west 20 rods, then north 20 rods. With this point as a center, he estimates all the trees in a radius of 118 feet, thus covering one acre. He then paces 40 rods west and 40 north and repeats the operation. Twenty rods north and 20 west brings him to the northwest corner of the forty where he can check up his pacing. This estimate of 2 acres in every 40 is 5 per cent of the whole and the estimates obtained on these two sample acres should be multiplied by 20 to get the estimate of the 40. Some judgment is necessary to see that these samples do not fall in timber too far above or below the average. It is this element of uncertainty that makes the partial estimates unsatisfactory, especially with the beginner whose judgment is not sufficiently trained.

CHAPTER IX

FOREST UTILIZATION

THE farmer may get comparatively little use from the timber on the woodlot and render the future crop almost worthless by poor judgment and careless handling. It is a common practice for the farmer to cut his timber without any thought to its usefulness or value. He goes to his woodlot for his winter supply of firewood. Oak, hickory and maple make the best fire; and the largest and straightest trees make the most wood for the least work. It follows naturally that the best trees are first put in the cordwood pile. The result, which does not enter into his calculations at the time, is disastrous. Not only could these trees have been put to a much more valuable use, but their removal means a depletion of the better species and ideal conditions for the reproduction of the poorer species which are left. We must remember that it is the kind of seed trees which we leave that determines the composition of the future stand. If nothing but weed trees are left, they will be quick to take advantage of the situation, and the next crop will be nearly all weeds.

The owner should consider carefully this selection in his cuttings. He should have an eye to the market for different wood products in his locality and cater to the most profitable. Of course this is possible only when the woodlot is of considerable size and more than sufficient for the family supply. But even when firewood is the only product, the same care should be taken in cutting to keep the stand in good condition.

In the older hardwood districts in which there are furniture factories, there are several species which are exceedingly valuable, especially the older trees. These are the white oak, black walnut, black cherry and yellow poplar. Such trees should be valued very carefully before they are sold, and they should be sold as individual trees, never by the acre or thousand feet. The buyer should be brought to the grounds and asked to place a value on the tree after a careful inspection. If possible, several buyers should be made to bid for the trees. The tree should then be cut according to the buyer's direction. If the tree is cut without this precaution, and the logs hauled to the factory to be sold, the special value of the tree may have been destroyed. In the black walnut, for example, the particularly valuable parts are the stump and the curly grain near the branches. Unless special directions are obtained for the cutting, these parts are likely to be lost. Some of these trees, worth more than a hundred dollars, are ignorantly cut up into firewood. However, it must not be thought that all trees of this species are so valuable; it is only the large, old trees, and even some of those have no special value beyond being good lumber.

FOR CONSTRUCTION TIMBERS

Different requirements are necessary for timbers to be used in outside, or exposed, and inside construction. When the wood is exposed to the weather or more particularly to contact with the ground, durability in these situations must be added to its other qualifications. For building purposes timber should be fairly strong, especially for dimension stuff, hold a nail well, work fairly well with tools, and hold its shape, when once seasoned. According to these specifications, pine makes the best construction timber that we have, spruce next, and hemlock and tamarack are good substitutes for dimension sizes. Among the hardwoods, red oak, maple, white elm, basswood, ash and cottonwood are good for inside work, white oak, red elm, mulberry, catalpa and black walnut for outside. Of course any timber that can be used outside can also be used inside. Trees of a size and form to produce such timbers should be kept for this purpose, for even though they may not be needed on the farm, they will bring a good price as saw logs at any mill.

FENCE POSTS AND RAILS

The matter of the selection of fence posts is dealt with under the chapter on Wood Preservation and it is necessary to add here only a few details on the sizes and methods of manufacture.

The standard length for a post in most sections is seven feet. They may be a few inches longer, but never shorter. If they are cut in the autumn or winter, they dry more slowly and check less than when cut in the spring or summer; consequently they are stronger. They should be peeled as soon as cut and carefully piled so that they are not in contact with the ground and are exposed to a free circulation of air. If the post is to be driven in, the top should be cut off square; otherwise it should be cut at an angle. In either case, the cut should be smooth, preferably made with an ax, in order that the water may run off readily and not soak into the top of the post. If the top of the post is painted when green, the checking of the end will be largely prevented.

Posts can often be split to advantage. If a considerable portion is heartwood, a six-inch post can be halved, a seven and a half inch post quartered. These are light posts and can be used only as fillers in a fence between stronger ones. Chestnut and ash can readily be split with an ax, other species are better sawn. If the posts are to be sold, they will find a more ready market if bright in color and trimmed to a uniform length. Posts for sale should always be sorted into size classes, — three, four, five, six inch, and so on, and the round and split posts separated.

The wire fence has almost entirely displaced the old post and rail, but there are still a few districts in which they are used, — mostly in the chestnut country. Chestnut is by far the best wood for this purpose, because it is so readily split and is so durable. White oak is also used, and occasionally locust.

RAILROAD TIES

Railroad ties are best made of the same kind of wood as fence posts, durability and the holding power of the spikes being the principal requirements. Cedar is about the only fence post wood which should not be used for this purpose; it is too soft and has not the necessary strength. Nevertheless many are sold, especially to branch roads.

Before cutting any railroad ties, the specifications of the buyer should be carefully studied. They may be secured from any agent. Most companies classify their ties into "firsts" and "seconds." If the specifications are not secured and carefully considered, many seconds will be cut that could just as well have been made firsts. In hewing ties in a woodlot, it is better to do all the hewing in one place so that the chips may easily be piled and burned. Most roads also classify ties into hewed and sawed and make a difference in the price.

IMPLEMENT PARTS

For farm implement repairs wood is needed that is strong, hard, tough and elastic. The best woods for this purpose are hickory, ironwood, oak and elm in the order in which they are mentioned. Pieces for this purpose should be cut, peeled and stored under cover where there will be a free circulation of air so that they may become thoroughly seasoned. Large pieces should be split into quarters; this prevents season (Fig. 49) checks and hurries the process. This adds very greatly to their strength. Care should be taken in selecting the pieces to see that the grain is straight and free from knots. Proper seasoning requires from three months to a year, according to the thickness of the piece. Every farmer should keep a supply of such pieces on hand so that he will have seasoned wood when he needs it, and not be obliged to use green pieces of inferior quality. The second growth of these species, of small size, especially sprout growth, is superior to the older timber for these purposes. It is tougher, less brittle and more elastic, will bend more to a strain without breaking and stand harder jars.

Stock for handles should have the same qualities as the wood used for agricultural implements. When this stock is cut for sale, it is important to know the specifications of the factory, that the proper lengths and sizes may be obtained. It is very easy to spoil a large quantity

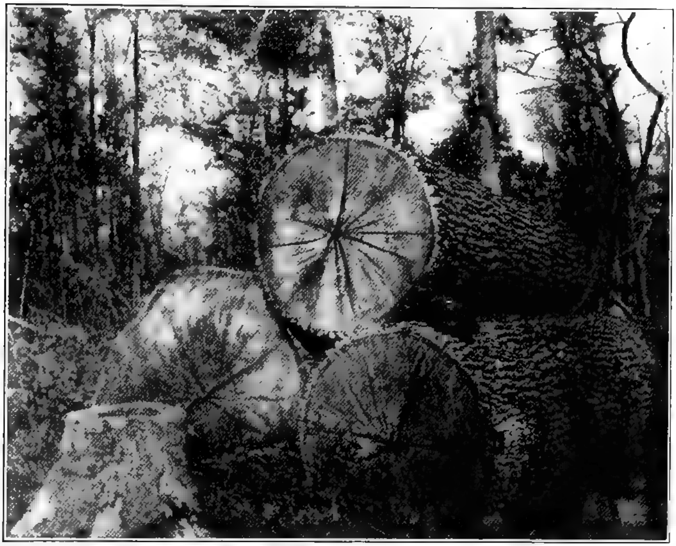

FIG. 49. — Season checks in hardwood logs.

of such stock by cutting it even a fraction of an inch too short. This makes a good market for the products of a plantation because such small sizes can be utilized.

FIREWOOD

Some species make better firewood than others. Generally speaking, the heavier a wood is, the more heat it will produce to the cubic foot burned. Some woods burn more readily than others. As a rule, the coniferous woods ignite more easily and burn more readily than the hardwoods, but the hardwoods produce hot coals that are ideal for cooking. This divides the woods into the natural classes of coniferous kindlings and hardwoods for a steady fire.

Unfortunately the woods which make the most valuable timbers also make the best firewood, and many a valuable saw log is cut up into cordwood. The straight trunks of these species should be set aside for saw logs. At least a third of the tree would still be left for firewood and those parts, too crooked or too small for lumber, make excellent cordwood, especially for home use, when more or less odd lengths make very little difference.

The process of selecting trees for firewood should roughly follow this general outline:

Decide how much cordwood is to be cut.

Select first the old trees that show signs of rot or have suffered some injury. Take first from these trees saw logs, ties, fence posts or any other valuable pieces for which there is a market. Cut the rest into cordwood. Of course, if there is no market for any of these products, it is senseless to save them and the whole tree should be put into cordwood.

Select next the weed trees of the forest, the trees that have no special value. They may not make particularly good firewood, but they will burn well enough when mixed with some better wood. They should be removed, to keep them from seeding up the ground and to give the better species a chance to reproduce themselves.

If any more trees are needed, they should be taken from the most crowded stands. The directions for this are given under "thinnings."

Do not cut too much. There are other winters coming.

LOGGING

Winter is the best time to log, especially for the farmer who is busy with his crops during the other parts of the year. The snow and ice in the North, which make sleigh hauling possible anywhere in the woods, and the freedom from insects in all regions, make the winter months preferable. The woodlots vary so greatly in size and in the character of the timber that no definite scheme of logging can be laid down. Only a few hints of general application can be given.

Felling

A tree can be felled in almost any direction except directly opposite to the way it is leaning, and even this can often be accomplished by means of wedges if the tree does not lean too much. First the direction of felling should be chosen, so that there is no danger of its lodging, being propped up by another tree, — or damaging any thrifty young growth. Care should also be taken that the trunk does not fall across a rock or large log. This will often break or shatter the trunk. It is, however, well when possible to have the middle of the trunk supported in some way so that the saw may not bind in cutting the trunk into logs. On a steep hillside, the trees should be thrown across the hill, not down it. The trunk is then more easily "broken up," and is less likely to be broken.

When the direction has been decided upon, cut with an ax a notch on that side of the tree. In conifers it need not exceed more than two or three inches in depth; in hardwoods, it should extend to the center of the tree, and "cut the pig tail." This prevents the tree from splitting up the trunk and "kicking back," an accident quite common in hardwoods. It is always dangerous to stand directly back of the saw in cutting hardwoods. Conifers occasionally do the same thing. This notch should be as nearly as possible horizontal and clean cut. It should be made as close as practicable to the root collar, for the wood in the stump is the best part of the tree. It also aids in reproduction when sprout growth is depended upon.

The outer bark should then be chipped off around the trunk a few inches above the notch because this bark greatly retards the saw. The saw should be started two or three inches above and opposite the notch. Care must be taken to keep the cut straight, or the saw will bind. Do not press too hard on the saw, and do not jerk it. The motion should be regular, smooth and with just enough pressure to keep the saw constantly in contact with the wood. If it is desired to have the tree fall exactly in the direction of the notch, the cut should be kept parallel to it; if it is to be swerved to the right, the left corner should be cut through first, and *vice versa*. If the saw binds in a large tree, wedges, either iron or hardwood, can be driven in the kerf back of it, care being taken that the wedge does not touch the saw. In a small tree, the pressure can usually be relieved by pushing with the hand against the trunk above the saw. Never try to wrench a saw loose. When the tree starts to fall, remove the saw, and step back from the tree. Keep an eye aloft for falling limbs either from the falling tree or its neighbors. If the tree shows a tendency to lean back on the wedges, stop the saw when within a couple of inches of the notch, take off one handle, remove the saw and force the tree over with the wedges. Keep a sharp look-out in this case, for there is always danger that the wood may give way and the tree fall backwards. When a tree starts to fall, stand comparatively near the trunk, it is the safest place, then move back to avoid any jumping of the butt.

Dividing the log

The tree once felled, it is necessary to mark off the log lengths. The purpose for which the logs are to be used must be kept carefully in mind. As a general rule, long lengths are more valuable than short ones. However, two straight short logs are more valuable than one long crooked one. Unless for some special purpose, logs are usually cut either 8, 10, 12, 14, 16 or 18 feet long, except in the Adirondacks where odd lengths are the rule. Short lengths are cut more in the hardwoods; conifers are seldom cut less than 12 feet.

First measure the total length of the stem that can be used for logs and so divide it that the whole stem is utilized. In doing this it must be remembered that a log must be cut at least three inches longer than the required length. Cut the butt log 18 feet if it is straight; if not, it is better to make it shorter. A considerable crook can be avoided by cutting right at the middle of the bend.

Too large a bend must be "butted" out. When the logs are marked, clean away the bark at that point and saw off the logs. In sawing a horizontal stick the weight of the saw is sufficient; do not bear down on it. If the saw binds, wedge as before. It is also necessary sometimes to prop up the under side of the trunk. The limbs can be trimmed off either before or after the logs are cut. This will depend on how the logs open up. They should be cut smoothly, close to the trunk, not left to catch in the ground when the log is snaked out.

Skidding

This is dragging the logs to the place where they are to be loaded. The method of skidding must be adapted to the conditions, and there are about as many methods as there are different conditions. Here the methods can be only briefly sketched.

Two general divisions may be made: (1) when small skidways are made in the woods in any convenient place; (2) when larger skidways are made on the road.

The first method is used when the logging is done in the summer time on hard open ground so that a wagon can be taken anywhere in the woods, or when there is not enough snow in the winter to prevent the sleighs from leaving the road. One or two, rarely three or four, loads are put in each skidway. This means that the logs need be skidded only a short distance. Under these circumstances, the logs are usually "snaked" to the skidway. In snaking, a pair of skidding tongs are attached to a whiffle-tree, one horse for small logs, two for large, and the logs are dragged along the ground. A collar chain is sometimes used in place of the tongs, and a farmer would be more likely to have the chain. It is looped around the large end of the log, and the loose ends put over the hook on the whiffle-tree. It is not quite so quickly or easily handled as the tongs. In placing these small skidways, they should be located where a load of logs can be most easily collected and at the same time be accessible for the wagon or sleigh. It is cheaper and more easily handled than the large skidway when the ground is in the proper condition, but it never pays to go off the road for a load and get stuck. This is frequently done when the nature of the ground has not been sufficiently considered.

When there is deep snow, or the ground is soft, sleighs or wagons should not leave the road, and it becomes necessary to skid the logs to the road-side. This means a longer distance to skid than when small skidways are scattered through the woods, and the process of snaking logs, one by one, is too slow. A single sled or "go-devil" is used. The large ends of several logs are rolled onto the sled by means of cant hooks, and chained fast. The other ends drag. This method pays up to a quarter of a mile. If there is very much timber to come out, it pays to extend the logging road when the distance becomes greater than that. Sometimes, usually in summer logging, a heavy, forked branch, or "lizard," is substituted for the sled and used in the same way.

These skidways should be located on the main road and, if possible, so located that the bank at that point is on a level with, or slightly above, the sleigh or wagon bunks. This facilitates loading. All brush should be removed. A couple of long poles, possibly three, should then be laid at right angles to the road, and near enough together to catch the ends of the shortest logs. If there are a great many logs, the hauling will be made much easier by putting the long and short logs in separate skidways. As the logs are rolled from the sleds, they are rolled out onto these poles. When the first tier is completed, slender poles are laid on top of them, so that the logs of the second tier can easily be rolled over on top of them. These poles are pulled back after each log is rolled out to keep them from becoming tied down. When the skidway becomes so high that it is difficult to get logs on it and would be difficult to load from the top of, it is better to make another skidway. Never waste your time by building up a skidway that it will be difficult to tear down.

Hauling

If there are only a few logs and the distance is not over half a mile, it will probably pay to haul them on the skidding sled, or on two skidding sleds chained together. It would not pay with a lizard. If there are many logs, it pays to load them on a regular log sleigh or wagon. The condition of the road will govern the size of the load.

If the skidway is above the bunks, the logs can be rolled down without any apparatus; if not, the cross haul is used. Skids, made of stout poles about six feet long, and fitted with an iron hook in the end, and the other end beveled, are hooked into the iron bands on the ends of the bunks so as to form a rollway for the logs. One end of the loading chain is hooked to the reach, the other end passed under the log and back across the sleigh or wagon.

The team, the leaders usually being used for this work, is backed up to the opposite side of the wagon. The free end of the chain is hooked to the whiffle-tree, preferably with a grab hook that can be released by a lever. This avoids the danger of upsetting the load if the horses cannot be stopped. When the team is driven out at right angles to the road, the log is rolled up the skids onto the bunks. Two horses in this way can handle almost any logs that are cut in the Northeast. One horse can handle small logs. When the log is in place, the chain is unhooked and put around another log while the team is being brought back into position. A little faster work is possible if the chain unhooks in the middle instead of at the whiffle-tree. The horses soon learn the system and one man alone can put on a load with a well-trained team. When the load is in place, it is bound fast with the loading chain. Sometimes a binder pole is used.

From four to eight thousand feet make a good load on an iced road on which there are no heavy grades. On a heavy down grade, straw put in the ruts will act as a brake. In wagon hauling, or on snow roads, from one thousand to fifteen hundred feet is about the limit.

When the logs have been removed, the other marketable products should be taken from the remaining portion of the tree: ties, posts or firewood.

THE CHIEF USES OF OUR COMMON WOODS

Yellow poplar. — Panels; flooring; molding; clapboarding; sheathing; shingles; siding on railroad cars; interior finish of Pullman cars; coffins; bodies of automobiles; carriages and sleighs; sides of farm wagon beds;

woodenware; bungs; slack barrels and tobacco hogsheads; backing, tops and sides for pianos; veneers; boxes, especially biscuit boxes and cigar boxes; scroll saw work; wood carving; wood burning; matches; excelsior; paper pulp; porch columns; hat forms; cores for veneer furniture and for interior finish.

Basswood. — Mirror and picture backs; drawers and backs of furniture; molding; woodenware; panels and bodies of carriages; ceiling; wooden boxes; inner soles of shoes; cooperage heading; slack barrel staves; butter churns; fine carving; papier-mâché; paper pulp. The flowers are used for tea; the inner bark of some species for coarse cordage and matting and glue brushes.

Buckeye. — Artificial limbs; woodenware; paper pulp; wooden hats; fine wood carving; pyrography.

Maple. — Furniture; flooring; sugar barrels; mantels; runners of sleighs; peavy handles; ox yokes; ax handles; sides, backs and bridges of violins; bicycle rims; woodenware; wooden shovels; shoe pegs and lasts; gun stocks; saddle trees; teeth of wooden gear wheels; piano keys and hammers; wood split pulleys; framework of machinery; ship building; paddles; maple sugar; surveyors' implements; plane stocks; wooden types; faucets; clothespins; charcoal; acetate of lime; wood alcohol.

Sumach. — Tanning; dyeing and dressing skins; Japanese lacquer work.

Black locust. — Police clubs; fence posts; insulator pins; construction work (bridges); turnery; wheelwright work; tree nails (pins); ship building (ribs); hubs of wheels (automobiles); house foundation.

Black cherry. — Fine furniture; cabinet work; interior finish; tool handles; surveyors' instruments.

Dogwood. — Tool handles; spools, bobbins; shuttles; mauls; wheel hubs; machinery bearings; engraving blocks.

Black gum. — Heavy hubs; rollers in glass factories; mangles; ox yokes; stock of sledge hammers in steam forges; veneers for berry baskets and butter dishes; slack barrels; in cheap furniture for backing and drawers; barn flooring; excelsior.

White ash. — Wagons and carriages (poles, shafts, frames); interior woodwork; inner parts of furniture; mantelpieces; sporting goods (bats, etc.), oars and gymnastic bars; lances; agricultural implements; tennis racquets; snowshoes; skis; wooden pulleys; barrel hoops; pork barrel staves; baskets; dairy packings (firkins, tubs, etc.); tool handles.

Sassafras. — Light skiffs; fence posts; rails; cooperage; insect proof boxes; ox yokes. Roots yield oil of sassafras.

Elms. — Wheel stock, especially hubs; buckboard beds; neck yokes; fence posts; ribs of small boats; top spans in covered railroad cars; railroad ties; tongues for sleigh runners; saddle trees; flooring; exported for inner lining of boats; butcher blocks and churns (butter); cheese boxes; furniture; sugar and flour barrel staves; patent coiled hoops for slack cooperage; agricultural implements; bicycle rims; basket making; gun stocks; frame timber, of piano cases; wheelbarrows; hockey sticks; construction of battle ships.

Sycamore. — Furniture (lining of drawers); plug tobacco boxes; butchers' blocks; interior finish; beehives (hollow log sections); butter and lard trays; wooden bowls.

Walnut. — Interior finish; furniture; gun stocks; tool handles; cabinet work; boat building.

Hickory. — Axe handles; wagon stock (especially whiffle-trees; neck yokes; spokes, tongues, felloes, axles); buckboards; rustic furniture; barrel hoops; screws; mallets; parts of textile machinery; farm implements; wooden rails (top); baskets; bows of ox yokes; boat building; hickory bark for flavoring sugar (to imitate maple sirup).

Oaks (white and burr). — Furniture; wagon and carriage stock; especially spokes, felloes, hubs, tongues, bolsters; sandboards; reaches; brake bars; axletrees; whiffle-trees; railroad ties; freight cars (framework); ship building; house building and interior finish; shingles; agricultural implements; bridge building; mining timber; wine, beer, and whisky barrels; parquet flooring; staircases; splint wood baskets; hogshead and barrel hoops; bark used for dyeing.

Chestnut oak. — Bark used for tanning; fencing; bridges; railroad ties; substitute for white oak, but objectionable in tight cooperage.

Red oak. — Shingles; furniture; interior finish; tight and slack cooperage; railroad ties.

Chestnut. — Tanning extract; coffins; furniture (cores of veneer furniture and doors); interior finish; shingles; fencing railroad ties; sheathing; Jacob staff for compasses; bridge building (trestles); telephone poles; backing of piano veneers; slack barrel hoops; staves.

Beech. — Wood alcohol; wood ashes; charcoal; shoe lasts; plane blocks; clothespins; handles; wooden bowls; horse collars (hames); parquet strips; flooring; street paving; railroad ties; sugar barrels; furniture made from veneers, or bent after steaming; chairs.

Hop hornbeam. — Posts; levers; tool handles; wagon brakes; shoes; wedges.

White birch. — Toothpicks; shoe pegs and lasts; wood pulp; spools; clothespins; screws; flooring; veneers; furniture; bobbins and spindles; wooden skewers; home-made barrel hoops.

Yellow birch. — Furniture (usually mahogany finish); match boxes; wheel hubs; tool handles; buttons; brush backs; shoe pegs; clothespins; sugar barrels; dry distillation for wood vinegar, wood alcohol, charcoal.

Black birch. — Imitation cherry and mahogany furniture; ship building; bark distilled for oil of wintergreen.

Cottonwood. — Boxes; wood pulp and fiber; slack barrels; woodenware; flooring; excelsior; cores for veneers in organs and pianos; matches; building lumber; furniture; wagon beds; turnery; fence boards.

White cedar. — Posts; fencing; telegraph poles; railroad ties; tanks and buckets; shingles; street paving; boats.

Red cedar. — Tanks; posts; buckets; telephone poles; chests; pencils; interior finish.

White pine. — House building and finishing; boxes and crates; sash, doors, blinds; shingles; backing of fine veneers; excelsior; matches; laths; woodenware; slack barrels; framing of machinery; furniture; patterns for casting metals; ship masts; baled shavings for filtering gas, bedding for horses, packing for crockery.

Jack pine. — Ties and piling; cheap lumber; boxes; laths; wood pulp.

Norway pine. — Lumber generally; ship building; construction; flooring; masts; piles of wharves; covering, lining, siding, flooring and sills of railroad cars; railroad ties.

Spruce. — Chemical fiber and paper pulp (down to five inches in diameter); matches; construction; posts; railroad ties; fresh-water ship building; clapboards; flooring; ceiling; step-ladders; sounding boards (from butt logs); oars; paddles; spars; wharf piles; telegraph poles; toys; wood type; butter buckets; slack cooperage; wooden thread (for mattings); chewing gum; vanillin. In Europe spruce bark is used for tanning.

Hemlock. — Lumber; dimension stuff; construction timbers; shingles; railroad ties; fencing; paper pulp and fiber; bark for tanning.

Tamarack. — Fence posts; telegraph poles; soda fiber; ships' knees; railroad ties.

CHAPTER X

BY-PRODUCTS OF THE NORTHERN WOODLOT

By-products of timber-cropping are very many. They are the products other than timber and wood. The turpentine and rosin industry of the South, the making of many medicinal extracts and the securing of dyes are good examples. In some cases, as with the turpentine industry, the by-product may be actually the most important product commercially. The secondary or by-products of the farm woodlot are not many. The most important ones in the North may be mentioned, however.

MAPLE SIRUP AND SUGAR

Practically every woodlot, whether natural or planted, contains some maple trees that may be used in the production of maple sirup and sugar for the home. The early settlers obtained all of their sugar from this source, and the Indians made sugar from the maples long before this country was inhabited by the white man. To-day maple sirup and sugar are delicacies and command such a high price that substitutes with an artificial maple flavor have come into use. Comparatively small amounts of maple sirup and sugar are now produced for the market, but it is not unusual to find many rural families producing sufficient of this delicacy for home consumption from the maple of their own woodlot, or even from the shade maples in the yard. A few weeks of work in the woodlot in early spring during sap time afford a pleasant diversion from the ordinary farm routine and may yield considerable revenue as well as add a choice product to the home table. In 1910 the output of maple products was over 4,000,000 gallons of sirup and over 14,000,000 pounds of sugar. The total value of these products was over $5,100,000. Vermont and New York produced over 70 per cent of this product. These two states, together with Pennsylvania, Ohio, New Hampshire, Maryland, and Michigan, have produced over 90 per cent of the total production of maple sugar since 1880.

THE SUGAR MAPLE

All of the native maple trees produce a sweet sap that may be used in making sirup and sugar. The quality of sap, or the degree of its sweetness, differs with the various species. There are at least three species that may be used in the production of sirup and sugar. Of these the sugar maple (*Acer saccharum*) is the best and is the tree that produces the sweetest sap and consequently the bulk of the maple products that go on the market. This species is very widely distributed and may be found in every native woodlot, as well as among the trees planted for shade and decorative purposes. A variety of this maple known as the black maple (*Acer saccharum* var. *nigrum*), occurring largely throughout the range of the sugar maple, is said to be the best sap-producer. This maple is very hardy and occurs extensively in the western range of the species. The red maple (*Acer rubrum*) is very widely distributed and is an abundant sap-producer. It produces more sap than the sugar maple, but yields less sirup and sugar. The silver maple (*Acer saccharinum*) yields an abundance of sweet sap that in quality or sugar content is about the same as that of the red maple. The red and silver maples are considered sugar-producing trees mostly in those regions in which the sugar maple does not occur. It is very common to find these three species being used for making sirup and sugar, when they occur in mixture. It is not necessary to have a large number of trees to make an operation worth while. A dozen good trees will yield sufficient sap during a good season to warrant tapping them. It is not uncommon to find farmers tapping three or four trees, and even one tree, when it happens to be a large tree and is a real sugar maple. When properly tapped and cared for, a shade maple in the yard may yield a large amount of rich sap without any injury to the tree.

SEASON

The period of "sugar weather" varies with the locality and season. Usually the sap begins moving in the trees earlier than is generally realized. It is a wise policy to get an early start so as to be prepared for the season should it come in a rush, as it sometimes does. Sap begins to flow as soon as the temperature fluctuates above and below the freezing point, or 32° F. Frosty nights and warm days indicate good sugar weather. Generally the season begins about March 1 in southern sections and later to the northward. It may begin two weeks earlier and continue for a week or a month, depending on weather conditions.

EQUIPMENT

When a large sugar bush is operated, it is necessary to have considerable sirup and sugar making equipment. Ordinarily the farmer has sufficient equipment on hand that he can use for this purpose, so that, together with what he can readily make, there need be little or no outlay. A sharp, clean-cutting auger is necessary. A brace with a half inch or three-fourths inch bit is very convenient. Spouts or spiles can be home-made from any convenient wood and will answer the purpose very well. When only a few trees are tapped, the spouts may be made from the common elder by removing the pith. The sap pails can usually be secured about the farm house for the short time necessary and may consist of tin,

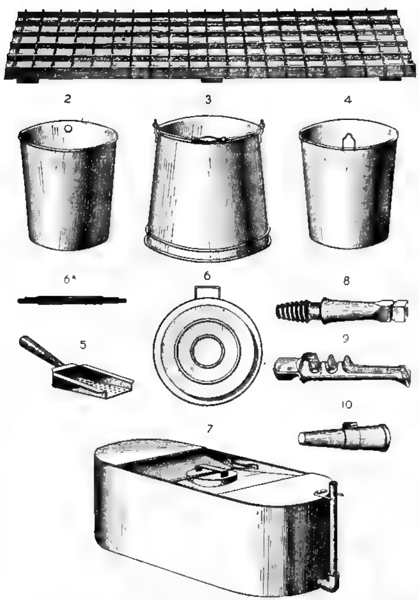

FIG. 50. — Sugar-making utensils: *1*, sugar mold; *2*, *4*, sap buckets; *3*, gathering pail; *5*, skimmer; *6*, cover for sap bucket; *6 a*, cross section of same; *7*, gathering tank; *8*, *9*, *10*, sap spouts.

wooden, and earthenware. They should be provided with some kind of a cover. Metal spouts with hooks attached for hanging buckets can be purchased, but this is not necessary, since light home-made spouts can be used and the buckets may stand on the ground or blocked in a firm position.

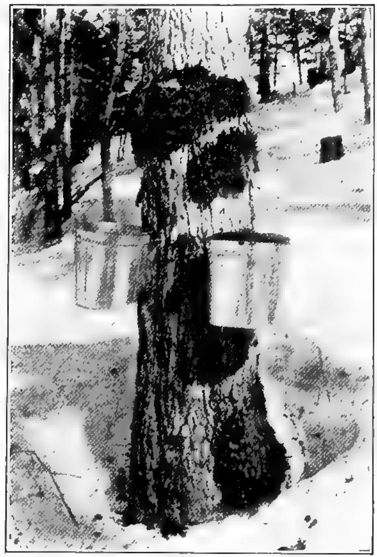

Fig. 51. — A tapped tree with pails in place.

TAPPING THE TREES

If the sap containers are to stand on the ground, the trees must be tapped just a little higher than the rim of the bucket. If metal spouts with hooks attached are used, the tapping may be done two or three feet from the ground, or at any convenient height. As a rule, trees should be tapped on the sunny side. Holes on the north side are said to flow longer than holes on the south side. Before tapping, all loose bark should be brushed from the tree where the hole is to be bored. The hole should slant upward enough to drain well and not over two inches deep. All auger chips must be removed. For the sake of the trees, it is best to tap only one place in a tree. Two or three spouts are frequently placed in one tree so close together that the sap will flow into one bucket. This is not advisable, since it may injure the tree. Only the very largest trees should have more than one spout. Small trees should not be tapped.

COLLECTING SAP

When a few trees only are tapped, the sap may be collected in buckets and carried to the farm house. When a large number of trees are tapped, a tank holding two or more barrels and hauled on a stoneboat can be used. One or more clean, wooden barrels will serve the same purpose. The sap should be gathered each day. The sooner and faster the sap is boiled after it leaves the tree, the better is the sirup.

BOILING THE SAP

A large sugar bush will require a boiling house with special boiling and evaporating apparatus. The average farmer's woodlot will, as a rule, have less than one hundred trees suitable for tapping, so that the sap can easily be boiled over a stove in an outhouse, or in a covered kettle in a shed. An open shed with a roof is not necessary, but in bad weather it is a great convenience. The kettle should be kept covered so as to keep windblown ashes and dust out of the boiling sap. Boiling is frequently done in the woods by using open kettles or pans.

MAKING SIRUP

In boiling, the impurities rise to the surface in the form of a scum which should be removed with a perforated metal skimmer. As the sap becomes concentrated, a mineral substance may form and float in the sirup or be deposited on the bottom and sides of the kettle or pans. This is a lime formation, and if floating, it may be removed by straining through cheesecloth, or by allowing it to settle and later draw off the clear sirup. In sirup-making, the boiling should be completed at the proper time. This is

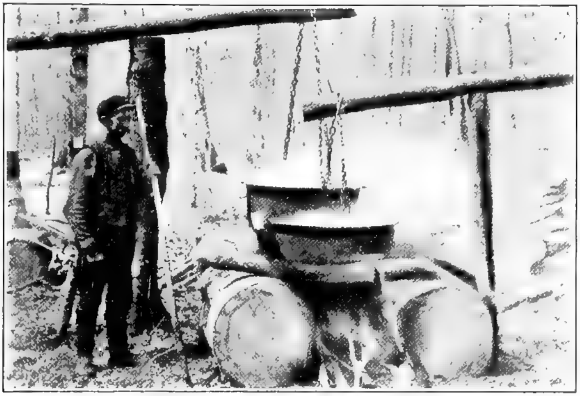

FIG. 52. — Boiling down the sap in kettles in the woods.

determined by testing in various ways. If the sirup is too thin, it has a tendency to sour; if too thick, it will crystallize and form sugar. When properly made, a gallon should weigh eleven pounds. This is the standard weight of a gallon. After a little experience, the maker can very readily judge the density by the way the bubbles break on the surface of the boiling sirup or by the way it pours from a spoon. A safer way is to test with a thermometer. Sirup that boils from 217° to 219° F. is at the correct density and will weigh about eleven pounds a gallon. A safer plan is to weigh a gallon of the cool sirup.

SUGARING-OFF

In making sugar, the sirup should be reboiled until it begins to crystallize. Formerly this point was found by pouring a little sirup on the snow or by dipping into it a twig bent into a loop. If the sirup became waxy on the snow, or formed a film within a loop, it had boiled enough and was ready to "sugar." Under more modern methods, the test is done with a thermometer, and sugar is made at different temperatures, according to the qualities wanted. During the early run of sap, 238° F. will make cake sugar, but later in the season the sap will require 242° F. If harder sugar is wanted, the thermometer can be brought up to 245° to 253° F. The pan or kettle is removed from the fire, and the sugar is slowly stirred to lower its temperature and thus avoid too rapid granulation. It is then molded into cakes of one to five pounds or put in ten pound pails.

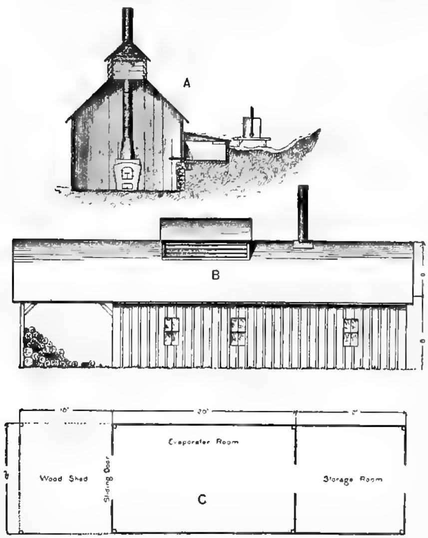

FIG. 53. — Plan of model sugarhouse: *A*, sectional view showing evaporator, storage tank, and gathering tank (on sled). *B*, elevation. *C*, ground plan.

Sugar or sirup should be stored in a cool, dry cellar or storeroom, as excessive heat tends to make the sugar mold and the sirup to ferment.

YIELD PER TREE

Different quantities of sap are yielded by the same grove in different years, depending on the condition of the weather. However, an average mature maple will produce about twelve gallons of sap or three pounds of sugar per annum. This is about the average, but much higher yields have been reported. For example, a grove was known to average 19 gallons of sap a tree during eight consecutive seasons, which included one poor year. A tree in Vermont produced $30\frac{3}{4}$ pounds of sugar in one season, its sap being so rich that seven quarts made one pound of sugar. Another maple in the same state gave 175 gallons of sap in one season.

EFFECT ON TREE

Three pounds is looked upon as a good yield. This represents about 9 per cent of the sugar contents of a small tree, and probably not more than 4 per cent in the case of a good-sized tree. This amount under ordinary circumstances can easily be spared by the tree without injury. If, however, a cloudy summer or forest caterpillar defoliation lessened the opportunity for starch storage, or if the environment, leaf area, age or size of the tree militated against it, such a drain might become a serious one. Tapping does very little injury to the tree, if properly done. Trees tapped annually for many years show little or no effect from this slight injury. Usually the holes heal over in one or two seasons.

Notes on maple sugar making

Ice found in the buckets on frosty mornings should be thrown out, if it is floating. If the whole mass is frozen, it should be collected.

One gallon (eleven pounds) of standard sirup will produce from six and one-half to eight pounds of sugar.

One hundred trees in a favorable season should yield forty gallons of sirup of three hundred pounds of sugar.

One tree will yield from one to seven pounds of sugar a season or from one pint to one gallon of sirup.

Wash the spouts or spiles with boiling water and when dry store away for next season.

Trees in the open give more and richer sap than those farther back in the bush, crowded and shaded, because of greater leaf expansion and sun exposure.

No more sugar is yielded by tapping on the "branchy" side of a tree than that relatively devoid of branches.

Without exception more sap and sugar is obtained from the outer 1.5 inches than from tissues deeper in the holes. Four-fifths of the sugar yielded from a tap-hole six inches deep came from the first or outer three inches of wood tissue. The remaining fifth would not compensate for the extra labor of boring and increased injury to the tree.

The sap obtained from the customary tapping height (four feet) was found to be greater in quantity and better in quality than that from the root (at ground level) or higher on the tree (fourteen feet).

The larger the tap-hole the more sap and sugar, for a time at least. It is undesirable, however, so to wound the tree that the hole will not soon heal over. A $\frac{3}{8}$-inch to $\frac{5}{8}$ sharp bit is recommended for tapping.

The spout should not obstruct the wood tissues of the tree, should securely hold the pail and should be easily inserted and removed.

Sixty-three per cent of the sap drops before noon. There is a slight betterment in its sugar content as the day advances. The average sugar content of maple sap is about 3 per cent. There is a decrease in solids as well as in sugar as the season advances.

If three pounds of sugar be made to the tree, from 4 per cent to 9 per cent, according to the size of the tree, is removed.

The flow of sap is diminished and the flavor of sirup and sugar altered where there has been a severe attack of leaf-eating insects the year before.

There is a difference in opinion as to the quality of the sap yielded by the soft maples (red maple and silver maple), some holding that the sirup is inferior in quality and color, while others say it compares favorably with that of hard maples. However, it is thought that the soft maples do not stand tapping as well as the hard maples and "play out" earlier in the season.

WINTERGREEN OIL FROM BLACK BIRCH

The bark of the black or cherry birch (*Betula lenta*) contains a pleasant flavored aromatic oil which is almost identical with the oil of wintergreen made from the common wintergreen (*Gaultheria procumbeus*) and is widely used as a substitute. This oil is made by distilling the bark and twigs of the birch by the usual distillation process. Considerable revenue may be secured from the bark and branches of this birch, or the brush after cutting for other purposes. This industry is confined chiefly to the northeastern United States and uses what otherwise would be waste brush fit only to pile and burn.

TANNING MATERIALS

The leaves and bark of sumac, the bark of white oak (*Quercus alba*), chestnut oak (*Quercus prinus*) and hemlock, together with the wood of the chestnut, are valuable products of the eastern forests and woodlots used for tanning hides and skins in the manufacture of leather. Sumac is used for tanning fine kid leathers. The leaves generally are used. They are collected during the summer and dried ready for market.

Owing to the comparatively slow growth of the oaks and the hemlock, about one good crop is as much as a lot will yield in a life time, but a well-managed woodlot of considerable size within reach of markets for tanning material may yield in time considerable revenue from the bark of these trees. Oak bark is peeled in the spring of the year immediately after the trees are felled (from April to June). Hemlock bark may be peeled any time during the summer until August or September. The felled trees are girdled every four feet, and the bark is removed with a chisel-like tool called a "spud." The bark comes in strips of variable width. These pieces of bark are leaned against the tree trunk with the flesh side out where there is free circulation of air for drying and seasoning. In two or three days, if the weather is dry, the bark may be collected and ranked into cords. Tan bark is sold by the cord and brings from $6 to $12, according to the kind and quality.

Chestnut wood for tanning purposes finds a ready market in many places in the eastern United States. Chestnut wood contains a higher percentage of tannin than does the bark, differing in this respect from oak and hemlock, the bark of which contains more tannin than the woods. For this reason, chestnut wood is used extensively in the manufacture of tannin extract. Practically every eastern woodlot contains chestnut and when within reach of an extract plant, chestnut cordwood may be marketed to good advantage. Wood from old and young trees may be used as well as from living and dead trees. The wood from dead trees must be sound. The wood of old trees has a higher tannin percentage than wood from young trees. Dead chestnut wood is said to yield more tannin than living wood. There is also a higher percentage in the butt of a tree than in the top.

Specifications of extract wood

Extract wood is purchased either by the standard cord ($4 \times 4 \times 8'$ or 128 cu. ft.) or the long cord ($5 \times 4 \times 8'$ or 160 cu. ft.). A cord of 128 cubic feet contains approximately 90 cubic feet of solid wood, leaving 38 cubic feet of air space. A cord of 160 cubic feet contains approximately 128 cubic feet of solid wood. Split wood from large trees is preferred, but extract plants will accept chestnut sticks that are not less than four inches in diameter at the small end. A cord of 128 cubic feet usually sells for $2.50 to $3.00 on board cars at shipping point, and $3.00 to $3.50 a cord of 160 cubic feet. Wood with the bark on is as readily accepted as wood that has been peeled. The wood is ground into small particles by special machinery, conveyed into large tanks where it is treated with hot water. The water leaches out the tannin, producing a dark colored liquid. This liquid is then evaporated in special vacuum evaporating pans until sufficiently concentrated, after which it is shipped in barrels or tank cars.

CHAPTER XI

THE DURABILITY AND PRESERVATION OF WOODS

THE term durability as applied to wood usually refers to the natural resistance of the wood to rot, and it will be so considered here.

This quality of durability is of great importance, both to the farmer who already has an established woodlot or to the one who is about to do some planting. The uses to which a larger part of the wood used on the farm is put demand durability in contact with the soil and the weather, — for on this durability depends very largely the cost of maintaining the structure. Fence posts, gate posts, poles, stakes, sills, and the like, all require durability in contact with the soil, while all the work on the exterior of the home and out-buildings must resist the ravages of the weather.

In addition to these uses for durable wood on the farm itself, there is frequently a good market for ties and poles. For these pnrposes the more durable woods bring very much better prices, especially white oak for ties and white cedar or chestnut for poles. This market is profitable enough to demand careful consideration in the management of the woodlot.

Therefore, it is to the farmer's interest to pay particular attention to the durability of the species that he is growing in his woodlot. The following is a list of woods arranged by H. von Schrenk in order of lasting power: —

Very Durable	Durable	Short Lived
Walnut	Ash	Beech
Locust	Larch	Sycamore
Sequoia	Yellow pine	Birch
Cedar	Spruce	Linden
White oak	Fir	Cottonwood
Catalpa	Yellow poplar	White pine
Sassafras	Douglas fir	
Chestnut		
Long leaf pine		

FACTORS INFLUENCING DURABILITY

Durability is affected by very many conditions. The greater the proportion of solid wood substance, the greater the durability. Hence, the higher the specific gravity, the longer a wood will last. This, however, applies only to wood of the same species. Heavy red oak is more durable than light red oak, but not nearly so durable as light cedar.

Broad-ringed hardwoods, that is, the trees that have made more rapid diameter growth, are less durable than narrow-ringed, or slow-grown hardwoods. Experiments in Europe have shown a great difference. Coniferous, or soft woods, pines, spruces, and so on, are much more durable when they have grown slowly and formed even, narrow rings. Thus, we see that in growing timber for durability, it is best to plant hardwoods in good soil, but they should be crowded into a slow and even growth by close planting and light thinnings. The timber of a sound mature tree is more durable than that of an immature or overmature specimen. There is more solid wood substance in it. If a tree is too old, the center of the heartwood is not very durable.

Intense coloration of heartwood is another indication of the durability of timber. As a rule the trees with dark heartwoods are durable. This is a rough criterion. In the same species the darker specimen is always the more durable. This coloring is due to the formation of tannin and vanillin in the heartwood. Both these are distasteful to bacteria and fungi. Colorless heartwoods lacking these substances have nearly the same properties as sapwood and are little more durable than they.

Besides this lack of protective materials in its make-up, the sapwood is at great disadvantage in resisting rot. The cell walls are not thoroughly lignified and the wood is consequently soft and of low specific gravity. There is more moisture in sapwood than in the heartwood, and the greater porosity of the sapwood makes it easier for it to alternately dry out and absorb moisture. The drying of the sap leaves a sugary residue in the cells which seems very attractive to the spores of the bacteria and fungi. It is the combination of these causes that makes the sapwood of the cedar, — whose heart is one of the most durable woods we have, — rot in a year or two; it contains more ready food and served in more attractive form for its enemies.

The season of cutting is popularly supposed to be a very important factor in the durability of timber, and there has been much discussion on the subject. This importance has probably been greatly exaggerated. Since the presence of moisture is necessary to the growth of fungi, the time when the least moisture is in the trees should naturally be chosen, the autumn or winter. This time of cutting has the further advantage of having the last season's layer of wood fully lignified and thus more resistant of decay. The chief objection is the difficulty of peeling the bark from logs cut at this time. On the other hand, logs cut in the spring or early summer peel readily and season quickly in the ensuing hot weather. The only difficulty is that some woods, especially oak, will season too rapidly and consequently check badly. These cracks are very injurious to the logs and form good openings for the attack of the fungi, which are especially numerous at this season.

Fall or winter is a good time for the cutting of all species; it is the best time for oaks and all other woods that check badly in seasoning. Other non-checking species may be cut in the spring; they are easily peeled and advantage may be taken of the rapid summer seasoning.

Naturally durable woods

Some woods are naturally more durable than others. Chestnut or cedar will last in the ground for years, while cottonwood or birch will often rot within nine months. For this reason there has, in the past, been a tremendous demand for the so-called durable woods for fence posts, railroad ties, telegraph and telephone poles, and so on. The supply of white oak, white and red cedar, chestnut, red elm, black ash, locust, coffee tree, cypress, tamarack, and the like, has rapidly decreased and, consequently the price has constantly increased.

Substitutes

The price of some of these species has now reached a prohibitive point that makes it necessary to find some substitute, cheaper and yet as effective as possible. Steel, cement, combinations of the two, and several other materials have been tried with very little success, as a general rule. The only really satisfactory substitute seems to be inferior species of wood that have been treated with some preservative to prevent decay.

There are some places in which cement posts can be used with advantage. They are so heavy that they cannot be shipped very far, but when the cement can be secured easily and the sand is found close by, the posts can be made where they are to be used and will prove very satisfactory. Their use should never be attempted where there is any considerable amount of alkali in the soil, for the alkali will eat out the cement and the post will very soon crumble.

Many such preservatives have been used in European countries for many years with admirable success. Beech, one of the least durable of woods, is treated in France and the ties guaranteed for fifteen years. Salts of zinc and copper are also successfully used. These experiments were on European species and it cannot be predicted with certainty what the results would be on American species and under American conditions. It is probable, however, that the results will be much the same. It should be even more satisfactory in this country than in Europe, for we have some cheaper speciės here, — and all species are of equal durability when treated.

CAUSE OF ROT

What is generally known as rot in wood is the result of a low form of vegetable or fungous growth. There are thousands of species of these plants, but as they are all parasitic and have practically the same development, a brief, general life history will answer for all of them.

The spore, or egg, from which this plant develops is almost, in some cases wholly, invisible to the naked eye. They are carried about by the wind in countless numbers. The vast majority of them fall in unsuitable locations and die, but some of them, finding openings in trees and logs, begin their own development to the destruction of the host on which they are growing. They usually take up their positions in a dead tree or log, but occasionally make their way into some live vigorous tree the bark of which has been broken by a wind storm, a poor job of pruning, or some other injury.

Once the spore has found lodgment in a favorable locality, it begins a very rapid development. Mycelia, long, white, threadlike filaments, penetrate the cell walls and fill up the interior of the cells. In this way the life of the cell is destroyed, and the substance of the wood becomes food for the fungus. The growth of the plant is indeterminate and so many cells of the wood are destroyed that the host itself finally gives up the struggle and dies, thus giving itself up wholly to the myriad of weaker fungi and insects that attack a dead or dying tree.

When the fungus has reached the proper stage of development, the mycelia develop fruiting bodies on the outside of the wood. These fruiting bodies are usually in the form of a mushroom, toadstool or shelf fungus, but may have many different forms. Some of these fruiting bodies are renewed annually, such as the mushrooms, but the shelf fungus renews itself by simply laying a new covering over the old growth. In this new growth thousands of spores develop and mature. From them the mature spores start out to establish another generation of pests. Without such plants there would be no rot.

Certain conditions are necessary to the growth of this fungus. Without them it cannot exist. The most important of these are air and moisture. This may readily be seen by examining a telegraph pole which has been in the ground for some years. It will be found in very good condition everywhere except where it enters the ground. Here, especially if there is any sapwood on the pole, there will be a ring of rot, because here alone we have the two requisites, air and moisture present in sufficient quantities to support fungus. In the upper portions of the pole, there is plenty of air, but the supply of moisture is not constant. Below the surface, where the soil holds the moisture continually, there is not sufficient air.

This accounts for the fact that timbers will lie, unimpaired, for years on the arid desert where the wood dries out very quickly after a rain. It explains why the piling put in by the Lake Dwellers centuries ago is yet in good condition, and why logs which have lain for centuries under the water-soaked moss and débris in the woods of Washington and Oregon show no signs of decay. The air cannot get to them.

When either air or moisture is lacking fungi cannot live; and where fungi cannot live there is no rot. Since air and moisture are both necessary to the development of fungi, it is seen plainly that by eliminating either one of these, rot can be prevented.

METHOD OF SEASONING LOGS AND TIMBER

This process should begin in the woods as soon as the timber is cut and proceed slowly and steadily till the wood is dry. To accomplish this the logs should be peeled, if they are to be left in the woods any length of time, and put upon skids. It would pay in some cases to split the more valuable hardwood logs to cause more thorough drying. This seasoning should not, however, be allowed to proceed too rapidly or the logs will check badly, and the cracks will open up the damp interior of the log to the attacks of the fungi. The checking of the ends of logs is prevented by a coat of paint that prevents too rapid seasoning, and hence checking.

Seasoning lumber

In the lumber yard, still greater care should be taken with the seasoning of the sawn lumber. The bottoms of the piles should be raised on skids, and lath strips or, better yet, narrow inch boards, — placed near the ends of the boards and always directly below each other, — put between every two layers of boards across the pile. This insures good circulation of air.

When possible, lumber should always be piled under cover for seasoning. This allows a more even temperature, protected from the direct rays of the sun; and there is good circulation of air without exposure to the heavy winds. From three months to a year and a half according to the species and thickness of the pieces is necessary for thorough seasoning. Some valuable cabinet woods require ten or twelve years to season thoroughly. It is well to paint the ends of the lumber piles to prevent too rapid drying and consequent checking.

A cheap and very effective, although rather slow method of seasoning logs is to soak them in a pond. This leaches out the sap from the cells and causes the timbers to dry very rapidly when taken from the water. It also prevents checking to a considerable degree. Many species are improved greatly by this soaking process and to many it is a necessity. Besides seasoning against fungi, this also destroys the larvæ of boring insects that may be in the sapwood.

Wood should never be painted until it is thoroughly seasoned. The moisture confined in the interior of the wood by a coat of paint is sufficient to support the growth of the dry-rot fungus. Thus we often find a post completely rotten through the center though it is painted and placed in a dry situation. For this same reason sills or joists should never be built solidly into a wall so that the air cannot circulate freely around them. Otherwise moisture collects and dry rot sets in.

THE COATING OF TIMBERS

However, when the wood has once been properly seasoned, a coating of some substance which will keep the wood from reabsorbing moisture will greatly increase its durability, — for it is the constant soaking and drying out that rots a wood most quickly. This coating should be of an oily or resinous substance which will make a smooth coating and will not peel off when dry. It should be applied to the whole exposed surface.

Coal tar

Coal tar is probably the best of these coverings. If applied hot and mixed with oil of turpentine, deeper penetration and hence better protection is secured. One part of unsalted grease to three parts of tar oil answers the same purpose as the turpentine and is cheaper. One barrel of coal tar will cover from two to three hundred posts if properly applied.

Oil paint

Oil paints may also be used to advantage on well-seasoned wood. They are made of boiled linseed oil mixed with lead, pulverized charcoal or some other substance to give it body. Soaking the dry wood in crude petroleum or creosote is also recommended.

Lime white-wash

Plain lime white-wash makes a fairly good protective covering. It is not, however, as good as an oily or resinous substance because the salts leach out of the wood rather easily. As long as the lime is present, it works perfectly, but the lime washes out. The wood must, of course, be dry and the white-wash spread evenly. If shingles are to be treated in this way, they should be dipped before being laid.

Charring

Charring is a very good method of protecting those timbers which come in contact with the ground. The carbonization of the exterior of the wood forms a coating impervious to the fungus attacks. It also serves to harden the wood. It must, however, be very carefully applied. A rather thick layer of charcoal must be formed over the entire exposed surface, but at the same time the timber must not crack. A crack either exposes the interior to rot or allows the fire to burn in so deep that the strength of the timber is seriously impaired. The process should not be applied to any timbers on whose strength dependence is placed. It is only suitable for posts and poles.

A very effective way to char posts is to dip them in tar or, better yet, crude petroleum, and burn off the coating. This chars the posts evenly and drives some of the oil into the wood. Some experiments have shown that posts treated in this way have tested very well in comparison with posts treated with creosote.

GENERAL RULES ON PRESERVING TIMBERS

All timbers should be thoroughly peeled, both outer and inner bark, before treatment. Bark prevents seasoning, prevents the preservative from sinking into the wood and itself absorbs preservative which will not increase the durability of the wood.

Sapwood is much more easily treated than heartwood, in fact the penetration of the liquid practically ceases when the heartwood is reached, unless some special provision is made for it, except in the case of elm, of which the heartwood treats more readily than the sap. The more distinct the heartwood, the harder it is to treat.

The deeper the penetration, the more efficient the treatment. It is for this reason that open and closed tank treating processes are preferred to the cheaper brush methods. The better the wood is seasoned, the easier the treatment and the deeper the penetration. An oily or resinous solution is better than a solution of mineral salts. The species without distinct heartwood treat as though they were all sap.

The process of treating the so-called inferior woods to increase their durability has been in use in Europe for many years. The results of the treatment of European woods by all the different processes under European conditions of soil and atmosphere are fairly well known. The factories which do the treating often guarantee their products for a certain number of years. For example, such companies in France guarantee their beech railroad ties for fifteen years' service. It is an established and thoroughly reliable industry. It has been put to every test and found satisfactory. In the United States the abundance of all kinds of wood prevented the use of preservatives. Only the increasing scarcity of durable woods and the higher price in consequence have made it possible. The government and the railroads have been doing most of the experimental work along this line. All the processes known in Europe and some original ones have been tried with varying results. Dozens of different methods and impregnating materials are used. Many of these require an expensive and complicated apparatus which puts them beyond the farmer's reach. Only such simple and inexpensive processes as have been found best suited for use on the farm will be considered here.

Preservative materials

The most effective, cheapest and most easily secured material according to the United States Forest Service is creosote, dead oil of coal tar, a by-product of coke ovens and gas factories. The higher the specific gravity, the better the results obtained. The price varies from 10¢ in the East to 27¢ in the Rocky Mountains, and 15¢ on the Pacific coast. Timbers treated with this material have often had their length of service increased tenfold.

Copper sulphate, zinc chloride, mercuric chloride, carbolineum and many patent solutions make more or less inferior materials on account of cost, solubility or difficulty in applying.

There are three practical methods of applying the preservative: painting it on with a brush; dipping the timbers in a tank of the preservative; or putting them through what is known as the open-tank process.

Brush method

The advantage of the brush method is that it requires no tank, and the application is consequently cheap. The creosote should be kept at a maximum temperature of 150° F. especially if the weather is cold, for it quickly solidifies at a low temperature. The hot liquid is spread evenly on the thoroughly peeled and seasoned post with a large brush. Great care should be taken to get it into all the cracks. When the first coat has dried, the second coat should be applied. The application of a third coat does no good. In cold weather this process is not very satisfactory. The creosote, coming in contact with the cold wood and the cold atmosphere, solidifies so quickly that it does not have a chance to soak into the wood. The hardened first coat forms a shell through which the second coat seldom penetrates.

Even under the best conditions, the penetration obtained under this process is very slight, seldom averaging over one-sixteenth of an inch. Provided the cracks that already existed in the wood are thoroughly filled, which is far from certain in this process, the post is entirely free from decay so long as it holds its original form; but the slightest check or crack that occurs after treatment exposes the unprotected interior, and dry rot gets into the wood, making the outer coating of preservative useless, or, perhaps, even a means of conserving moisture for the use of the fungi. This method is only good when a better cannot be applied.

Dipping

Very good results are secured by dipping the posts into hot solutions of creosote or carbolineum. The solution should be kept at a maximum of 150° as before, because creosote volatilizes very rapidly above that point. The posts are dipped into the tank and laid away in some well-ventilated place to dry. The penetration under this method is not very much greater than with the brush method, but a more even coating is obtained and the submersion in the hot liquid opens up all the incipient checks and thoroughly fills them with creosote. It requires the initial cost of a large iron tank and more fuel to keep a large body of creosote at a high temperature, but the method of application is much more rapid, and when there are any number of posts to be dipped, it is

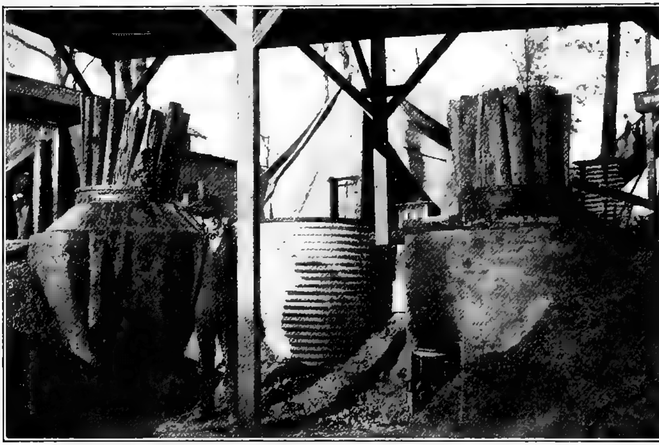

FIG. 54.—A United States Forest Service plant for the preservative treatment of fence posts.

cheaper then the brush method. It is the best method of treatment aside from the actual impregnation of the woods.

Open-tank treatment. Figs. 54, 55

The open-tank method is peculiarly adapted to the treatment of fence posts, poles, ties or other small timbers. The same apparatus is required as for the dipping process; an iron tank fitted with a fire box or steam coil for raising the temperature of the creosote. Slightly better results are secured if an even temperature can be maintained. This is better accomplished by steam, which, however, is not always to be had. The less surface the liquid has, the less oil will be lost by volatilization; hence the tank should not be of too large diameter.

The Forest Service recommends surrounding the metal tank with a plank framework inclosing a space 4 inches wide between the tank and the boards. This space should be packed with sawdust. This packing is especially beneficial in cold climates. It prevents the too rapid solidifying of the creosote. The erection of such a plant will cost from $30 to $45.

For this treatment the seasoned peeled posts are placed in the tank of creosote, either wholly submerged or only the butts under as is desired, and kept there from ½ to 6 hours. The temperature of the creosote should be kept as nearly as possible between 200° and 210°. The expansion caused by the heat forces out much of the water and air from the wood cells.

The fires are then drawn and the posts left in the cooling solution for ½–14 hours. The cooling causes a vacuum in the cells from which the water and air were driven by the heat, and the creosote is forced into these vacuums by the pressure of the atmosphere. Mr. Weiss of the Forest Service thinks that a short hot bath and a long cool bath probably will give the most economical results.

If there are a large number of posts to be treated and it is desirable to hurry the work, two tanks may be used, one for the hot bath and the other for the cool. The posts may then be transferred directly from one tank to the other and the hot tank immediately refilled. This is an

Fig. 55.—Single tank for treating posts.

especial advantage in a wet climate in which there is danger of the top of the post rotting. In this case the cool tank is made oblong, about 4×4×8 feet, so that the posts may be put in horizontally and completely submerged. This gives a deep penetration in the butt of the post where it is needed and only a dipping of the top.

The posts will float very high in the creosote and some contrivance will be necessary to force them under. This can best be done in the following way: set two posts firmly about six inches apart beside the tank. Fasten them together at a level with the top of the tank with a cross piece. Take a pole four or five inches in diameter and about ten feet long. Insert one end between the posts and under the cross piece, letting the other end protrude across the tank. Under the loose end of the pole anchor a pulley. By means of this pulley and a rope attached to the end of the pole, the pole may be drawn down and tied. Then cut a two-inch plank of a length that will fit loosely in the tank crosswise. Lay this flat. Cut another piece about two feet long. Nail one end of this to the center of the first piece so that it stands at right angles to it. Brace it securely. When the posts are placed in the tank lay this long piece on them. Then place the pole across the upright piece. Draw down the end of the pole with the rope and the posts will be submerged. This apparatus has worked very successfully.

The penetration secured by this method varies from an eighth of an inch to two inches according to the species, the degree of seasoning and the thickness of the sapwood. It usually is possible to get complete penetration of the sapwood; the heartwood is little affected. This penetration is sufficient to prevent small checks and cracks from exposing the untreated interior of the post. The life of a post is increased under normal conditions of use and atmosphere to about twenty years.

Experience in Minnesota has shown the following equipment to be best suited for use on the farm on which steam is not always available. It is inexpensive, can be transported easily from one farm to another in any wagon and is more easily heated than the ordinary tank. It consists of a single cylindrical tank, built of twenty gauge galvanized iron, three feet in diameter and three and one-half or four feet deep. The iron may be plain or corrugated. The latter makes a stiffer tank, but in either case it should be reënforced around the top and bottom with three-quarter inch angle iron. It should be perforated six inches from the botton and two feet from the bottom to receive a two-inch pipe. If the iron is plain, locknuts should be provided to make the joint tight; if it is corrugated, nipples should be soldered in. Into these openings a four-foot "U" of two-inch pipe is inserted, as shown in the figure. This apparatus works like the water-back on a stove. A fire is built under the "U" pipe, and the oil in the tank is readily heated. The temperature can easily be controlled in this way, and there is less danger from fire in case of an overflow from the tank. When the hot bath has been completed, the fire can be removed and the oil cooled as desired. When the butts of the posts have been treated in this way, the oil left in the tank can be applied to the upper portion of the posts with a brush. This utilizes the oil which otherwise would be wasted and insures the top of post from rotting while the butt is still good. Such a tank can be bought for ten or fifteen dollars. It is quite as effective as the more expensive double tank outfit and is much more easily moved about. It is necessarily much slower than the double tank process, but that would not be very important where a comparatively small number of posts is involved.

The cost of such treatment cannot be stated definitely in a general work of this kind. It will vary in different parts of the country according to the cost of labor, fuel and creosote. The creosote is of course the controlling factor. The cost of fuel and labor are almost negligible and, moreover, in many cases cost nothing but a little effort on the part of the farmer himself. This method is recommended by the United States Forest Service as the best.

Fifteen cents is probably near the maximum if we consider the cost of fuel and labor.[1] Considering the annual expense of a treated post as compared with an untreated post, we find that the increased life of the treated post, in spite of its higher initial cost, makes its annual cost lower by one to three cents. At that rate a long line of fence would pay fairly well.

	UNTREATED POSTS	TREATED
Cost of post	$.06	$.06
Treating	.00	.15
Setting	.12	.12
Cost set in fence	$.18	$.33
Length of service	6 years	20 years
Annual cost	$.03	$.0165

Saving per year per mile of fence with treated posts, $4.32.

The agents of the carbolineum companies assert that a simple dipping with carbolineum, at a cost of three cents a post, is as effective as the more expensive treatment with creosote. This has never been adequately tested.

A community, by buying one of these treating plants and coöperating in the use of it, could greatly reduce the cost of treatment and this without any inconvenience to themselves. The capacity of one plant would probably be enough for all.

[1] The average cost of treatment is less than ten cents.

The apparatus is inexpensive, the process simple, the work easy and capable of being done at a time of the year when the farmer is at leisure, and the results are worth

Fig. 56. — Cottonwoods as roadside trees.

trying for. The farmers owe it to themselves and to their children to make better use of the timbers growing on their farms.

CHAPTER XII

ARBORICULTURE AND ORNAMENTAL PLANTING

ALTHOUGH ornamental planting does not belong in a book on forestry, it has to do with trees, and popular demand requires that a few of the important points be taken up briefly. The foregoing chapters on the handling and growth of trees in groves and plantations make it easy to deal with the individual tree or small group.

Lawn trees are usually grown for one of two purposes: ornament and shade, or the hiding of some unsightly object. In either case, it is necessary to have hardy trees that can stand the cold of winter and the hot winds of summer without becoming stunted and scrawny in shape.

The trees selected for such planting need not be chosen from the list of trees that are suitable for forest plantations in that region. The more careful selection of location, the more thorough care and cultivation that may be practiced with the individual tree, make it possible to grow successfully many species that could not succeed under plantation conditions. Such species are always more or less of a risk, but the added interest in growing a tree that is a stranger to the region makes the chance worth while. If shade and ornament is the object, care should be taken to select trees which will produce this effect. Often trees of ugly form and appearance are placed where much better species could easily be grown. The only excuse for an ugly tree in such a situation is its oddness, and the growing of such trees should not be risked till the chief object of shade and protection have been secured by the use of safe species.

Fig. 57. — Roadside planting of catalpa.

In order to be desirable for a lawn, it is not enough that a tree shall grow and thrive. It must have a shapely form that will please the eye, and be long lived. If a shade tree, it must have dense enough foliage to produce a solid, cool shade and not have merely enough leaves to stop the breeze and let through the heat of the sunshine. Moreover, the branches must be long, low and widespreading enough to furnish a considerable area of shade. It must be free from the attacks of insect pests that in the form of dropping bugs or caterpillars would make its protection unpleasant. It must be "clean"; that is, it must not shed excessive quantities of cotton, leaf stems or twigs on the lawn. It must not bear soft, squashy berries or other similar fruits. The trees which fulfill all these requirements are not very numerous; there are, however, good species for every region.

Trees for roadside planting or bordering a driveway need not possess all these properties; in fact, some of them are undesirable. They must not have low, widespreading limbs, but rather limbs that rise at a sharp angle so that they are widespread only at a considerable distance above the ground. Neither soft fruit or leaf litter are objectionable, but falling limbs and cotton are as undesirable here as elsewhere. They should also be long lived. Such trees form over the drive a high arch which is very attractive. They should be rapid growers, for the effect is not appreciated until the trees are large.

In the formation of groups or clumps, the most important point is the ability of the trees to grow in close formations. For this purpose, trees are selected that are very tolerant of shade. They should always be of rather compact form, and have the habit of branching down to the ground. This adds density and solidity to the appearance of the group. Here again the trees should be "clean," but otherwise the nature of the fruit is immaterial. Rapidity of growth is not essential, for the clump presents an attractive appearance at all stages.

FIG. 58.—Windbreak of willow showing dense foliage to the ground.

In the formation of a screen, thick limbs growing down to the ground, a dense foliage, the ability to grow in a close group and rapid growth are the qualities to be desired. Such trees as the white pine or the basswood might give promise for a time, but the effect would soon be spoiled. As the trees grow older, they would lose their lower limbs, and the screen would soon be full of openings. Willows, spruce, balsam and cedars make the best screens, because they put out limbs close to the ground and retain them as they grow older (Figs. 58, 59). They grow very close together, and form an impenetrable screen. Willow is, of course, the best for quick results, but it is rather short lived and is deciduous. If this species is used, two rows should be planted, and one of them cut back every eight or ten years. This makes them sprout vigorously and keeps the lower limbs thrifty. It is well to plant a row or two of spruce or cedar at the same time. These will make a more permanent evergreen screen. When they have attained sufficient size, the willows may be cut down.

TRANSPLANTING LARGE TREES

The methods of planting small seedlings have been dealt with under Sylviculture, but in lawn planting it is often desirable to use fairly good sized trees. The transplanting of these requires much more care and skill. Deciduous trees and conifers require different methods.

The deciduous trees, or hardwoods, are best transplanted in the early spring before growth has started. They should be taken up with as much of the root system as possible. If all the roots can be kept intact, a very light pruning of the crown is all that is necessary. This, however, can very seldom be done, and when the roots are pruned it is necessary to prune the crown more heavily. A balance must be maintained between the roots and the crown, the advantage always being kept with the former. Probably the safest method is to cut off all the limbs and prune the main stem severely. This, however, is apt to injure the shape of the tree and should be avoided when possible. In transplanting, the roots should not be exposed any longer than possible and never allowed to dry out. The roots of the hardwoods are not so sensitive as those of the conifers, but they will not stand too much exposure.

In setting out such a tree, a hole should be dug that will easily accommodate the roots in their original position.

Fig. 59. — A prosperous evergreen windbreak.

They should never be crowded. The black surface earth should be put in a separate pile. The tree should be placed as nearly as possible in the same position in which it was growing, — possibly set two or three inches deeper. The black earth should then be put in first and packed tightly around the roots. The other soil may then be used to fill the hole, care being taken to firm it well. The soil should be left a little lower than the surrounding ground so that some of the surface water may be retained in the hollow. A top dressing of well-rotted manure or wood ashes will help, for trees, like anything else, grow better in good soil. No manure should be put in the hole around the roots for fear of burning them. It is possible to plant such trees in the autumn after the falling of the leaves, but they are apt to suffer from the frost the following spring if there is much clay in the soil.

The conifers need more careful handling. Their roots should never be exposed or allowed to dry out in the least. This can be prevented only by moving them with a large ball of earth. Since it is very difficult to keep such a ball of earth intact when the ground is soft in the early spring, the following method is recommended when the tree has to be moved any distance. For a short move they can be handled like the hardwoods. In the autumn, before the ground is hard frozen, dig a trench around the tree to be moved so as to include most of the roots in the central core of earth. Fill in the trench with straw to keep the ground at the bottom from freezing. Dig a hole in the place in which the tree is to be replanted large enough to accommodate the ball of earth conveniently. Also fill this with straw or manure and cover the earth taken from the hole with the same material to prevent freezing.

Nothing more need be done till some convenient time in the winter when the ground is hard frozen, and preferably when snow is on the ground, because it is easier to load the tree on a low sled than on a wagon. Remove the straw from the trench around the tree, and loosen the ball of earth at the bottom and load the tree on the sled or wagon. Skids are often more convenient than a wagon when there is no snow. The ball of earth on the roots will be hard frozen and will hold together readily. When the tree has been brought near its location, remove the covering from the hole and dirt pile. Lower the tree into the hole so that it is a little deeper than it was before. Fill in around the ball of earth with the soft earth, packing it firmly so that there is a good contact with the ball and with the sides of the hole. Leave a layer of straw over the fill to prevent injury from the freezing and thawing in the spring. If this method is carefully practiced, the tree should be affected little by its move. Care should be taken to secure all the roots, for if pruning of the top is necessary, the shape of an evergreen is likely to be spoiled.

By means of these methods, it is possible to transplant almost any tree, but there is a limit of labor and expense beyond which it is not usually advisable to go. With the increase in the size of the tree, there is an enormous increase in labor. As a general rule, it does not pay to transplant a tree that is more than three or four inches in diameter. In this connection it must be remembered that much of the pleasure derived from a lawn tree is obtained from observing its growth and development. In this respect comparatively young trees are even better than the older ones which are no longer making very apparent changes.

THE PRUNING OF TREES

The pruning of trees is an operation that very easily may be overdone. It is necessary under the following conditions: when the roots have been injured; when dead limbs occur; when rot appears; to improve the shape of the tree; to prevent damage from wind.

When the roots have been injured

This subject has already been dealt with under the head of transplanting. The same conditions may be brought about by root disease, or necessary pruning of roots, and the same remedy applies.

When dead limbs occur

The appearance of dead limbs may be due to old age, insect or fungus, snow, hail or wind breakage, or insufficient nourishment. In any case, only the dead or infected limbs should be removed. If there are indications of insects or disease, the pruned limbs should be carefully removed and burned. No trace of them should be left.

To improve the shape of the tree

Pruning for this purpose should be done very sparingly. It is not generally advisable to attempt to change very greatly the natural shape of a tree. The shape and habits of a tree should be known and considered when the tree is planted, instead of planting indiscriminately and then trying to make it conform to the fancy of the owner. Any attempt to make a tall, fan-shaped tree round-headed, or *vice versa*, will fail, and the tree so treated will always have a stilted, artificial appearance. A more bushy growth can be secured by pruning the leading shoots and this is sometimes advisable. It is also comparatively easy to accentuate the natural tendency of the tree by cutting off any stray branches which may be wandering somewhat from the usual form. This may often be done to advantage. If there is any question about pruning a tree, always let it alone.

To prevent wind breakage

Certain trees are very liable to breakage in windy places. These are always trees in which the branches form a sharp angle at the fork. The soft maple and the white elm are typical and probably the worst offenders in this respect. Their natural shape is very beautiful and should not be tampered with except when experience has shown that they cannot stand the strain. If the soft maple is planted on the prairies or in any other unusually windy location, its spreading tendency should be thwarted as much as possible by severe pruning, for the wood is weak and brittle. Close forks should be prevented as much as possible. The wood of the elm is stronger and tougher; the fork is its weak point. When it will not disfigure the tree, one of the branches should be cut off. The essential forks can be strengthened by boring a hole through both branches about two or three feet above the fork and putting in a long bolt well washered at both ends. This will often prevent breakage and preserve the natural shape of the tree. Conifers never need pruning except in the case of dead or injured limbs, with the exception of arborvitæ or red cedar when used in a hedge. The commonest reason for pruning is to clean the lower limbs from the trunk so that one can walk under the tree. This can always be safely done, but it should be remembered that this low branching is one of the chief beauties of some trees, especially such conifers as spruce, balsam and larch.

How to prune

The limb should be cut close to the main stem with a smooth, even cut. No long stubs should be left. Care should be taken not to let the limb break off when partially cut and skin the main stem. This can be prevented by cutting a little on the underside first. When the limb has been removed, the wound should be covered over with grafting wax, tar or white lead to prevent the entrance of fungi spores. Pruning is best done in the early spring before growth starts.

ORNAMENTAL TREES

Entire books have been written on the arrangement of trees in ornamental planting and only the briefest mention of the most important points can be made here. In the first place it must be remembered when a tree is planted that it is going to grow, and due allowance must be made for its ultimate size. Do not plant too close to the house or porch. Never plant directly in front of a window unless for the purpose of blocking some unattractive outlook. If there is any good view or object of interest in the vicinity, bear it in mind and keep the view of it open. If there is any objectionable view, blot it out. Always keep an opening or two to the main road and the approach to the house. Too many trees are better than too few; they can easily be cut out. Some open lawn is desirable; do not scatter trees everywhere, group them or bank them around the edges. If the shape of a tree is its chief beauty, place it in the open where it may be seen to advantage.

The following tables give the characteristics and uses of our more important ornamental trees.

Common Name	Scientific Name	Hardy	Site	Form	Fruit	Density of Foliage	Use	Age	Rate of Growth	How Propagated	Good Points	Bad Points	Remarks
River Birch	Betula nigra	Entire region	Moist places	Fan-shaped	Strobile	Thin	Shade and ornament	Medium	Fair	Seed or seedling	Peculiar shaggy bark		Poor on prairies
White Willow	Salix alba	Entire region	Moist places	Spire-shaped	Capsule	Medium	Screen or windbreak	Short lived	Very rapid	Cuttings	Rapid growth, many small limbs, branches low, hardiness	Dirty	Best tree for prairies
Golden Willow	Salix alba vittellina	Entire region		"			'	"			"	Dirty	Little more ornamental
Weeping Willow	Salix babylonica	Everywhere, best in East	"	Round crown drooping	'	Thin	Ornament	'			Odd	Very dirty	Limbs continually falling
Cottonwood	Populus deltoides	Everywhere	"	Fan-shaped		Medium	Shade tree	"	"		Rapid growth	Dirty, short lived	Plant cuttings from staminate tree and avoid cotton
Carolina Poplar		'		"			"		"	"	"	'	More rapid growth
Norway Poplar		Probably over entire region	"	"		"		'	"	'	"	"	Same as Carolina

Lombardy Poplar	Populus nigra italica	Entire region	Moist places	Spire-shaped	Capsule	Medium	Ornament, border tree	Short lived	Very rapid	Cuttings	Rapid growth	Ugly	*One* or *two* look well
Tulip	Liriodendron tulipifera	North to Mass., west to Ohio	Good soil	Fan-shaped	Cone-like	Thin	Ornament	Long lived	Medium	Seed or seedling	Very pretty	Poor shade	Needs plenty of light
Flowering Magnolia	Magnolia fœtida	North to Conn., west to Ohio	'	Oval crown		Dense	"		'		Beautiful		Very tender in North
Holly	Ilex opaca	"	" Moist	Small oval crown	Hard berry	Dense	'	'	Slow	'	Evergreen, pretty red berries		"
Blue Beech	Carpinus caroliniana	Entire region	"	"	Dry, loose cone	"	Ornament				Rather pretty	Small	Only adds variety
Ironwood	Ostrya virginiana	Entire region		'	Strobile		"	"	'		'	'	'
Beech	Fagus atropunicea	Entire region	'	Round crown	Nut	Very dense	Ornament, shade	"			' Splendid shade		One of best shade trees
Bronze Beech	Fagus atropurpurea	North to Mass., west to Ohio						'		'	' Odd foliage		"
Shagbark Hickory	Hicoria ovata	Entire region	Good soil	Fan-shaped	'	Thin		'	Medium	Seed	Odd bark nuts		Protection in North
Bitternut Hickory	Hicoria minima	'	" Moist	Oval crown		'	"		'	'			Adds variety

Common Name	Scientific Name	Hardy	Site	Form	Fruit	Density of Foliage	Use	Age	Rate of Growth	How Propagated	Good Points	Bad Points	Remarks
White Oak	Quercus alba	Whole region, best east Miss.	Good soil	Wide-spreading	Acorn	Very dense	Shade	Indef-inite	Rather slow	Seed	Fine form, splendid shade	Slow growth	Poor growth on prairies
Red Oak	Quercus rubra	"	Fair soil	"					Rapid	"	Fine form, splendid shade, rapid growth	None	Fair
Post Oak	Quercus minor			Same as White, not quite so widespreading									Poor
Scarlet Oak	Quercus coccinea			Same as Red, but smaller tree									Fair
Sugar Maple	Acer saccharum	Entire region	Good soil	Round crown wide-spread	Dry samara	Extremely dense	Shade or street	Indefi-nite	Rather slow	Seed or seedling	Fine form, splendid shade, beautiful in fall		Protected, hard to grow
Norway Maple	Acer platanoides	Entire region except far North	"	"		"			Fair	"	"		"

Silver Maple	Acer saccharinum	Entire region	Best on fair soil	Tall, fan-shaped	Dry samara	Medium	Street or drive	Rather short	Rapid	Seed or seedling	Rapid growth, good form, great hardiness	Broken by wind	Easy to grow, must be pruned
Box Elder	Acer negundo	Entire region	Almost any soil	Rather scraggly	"	Dense	Shade or street	Short lived	Rapid	"	Rapid growth, hardiness	Dirty, poor form, short lived, insects	Good, produces forest conditions
Green Ash	Fraxinus lanceolata	Entire region	Good soil	Conical	"	Thin	Shade or street	Long lived	Rapid	"	Hardiness	Poor shade, not pretty, dirty	Good on prairies
Black Walnut	Juglans nigra	Except in extreme North	Good soil	High spreading, scraggly	Nut	Thin	Roadside	Long lived	Rapid	Seed	Rapid growth, nuts	Poor shade, scraggly, dirty	Protected, fair in South
Butternut	Juglans cine-[illegible]	"	"	Round crown	"	"	Lawn		"		"	"	"
Bass Wood	Tilia americana	Entire region			Non-edible nut	Medium	Shade	"	Fair	Seed or seedling	Good shade, good form		Protected, fair
European Basswood	Tilia europea					Same as American							
Paper Birch	Betula papyrifera	North of Ohio	Moist places	Conical	Strobile	Thin	Ornament	Fairly long lived	Fair	Seed or seedlings	Very pretty, bark pretty in winter		Protected, fair

Common Name	Scientific Name	Hardy	Site	Form	Fruit	Density of Foliage	Use	Age	Rate of Growth	How Propagated	Good Points	Bad Points	Remarks
European White Birch	Betula alba			Same as	Paper			Short lived	Fair	Seed or seedlings		Subject to insects	
Yellow Birch	Betula lutea	Entire, best east Miss.	Fair	Conical, tends to fan	Strobile	Thin	Ornament and shade	Long lived			Fair shade, pretty bark		No good
Sweet Birch	Betula lenta	East Miss.	Fair				"				Fair shade, pretty form		
White Pine	Pinus strobus	Entire region	Needs a little clay	Long, conical crown	Cone	Medium	Shade and ornament	Long lived	Rapid	Seed or seedlings	Pretty near		Needs protection, prairies
Norway Pine	Pinus resinosa		Anywhere	Short crown		Thin	Ornament						
Scotch Pine	Pinus excelsa										Variety	Scraggly	Good conifer for prairies
Austrian Pine	Pinus austriaca								Fair				
White Spruce	Picea canadensis		Low places	Conical		Dense	Ornament, screen				Branches to ground, many limbs		Grow close, dense screen

Norway Spruce	Pica excelsa	Entire Region	Low places	Conical	Cone	Dense	Ornament, screen	Long lived	Fair	Seed or seedlings	Branches to ground, many limbs		Little better growth than White, prettier
Blue Spruce	Pica parryana	'				'	'				Very pretty foliage		Stout, sharp needles
Engelmann Spruce	Pica Engelmanni	'	'	Same as Blue, with foliage green				'					
Hemlock	Tsuga canadensis	"		Long, conical crown	Cone	Dense	Ornament, shade		Slow	'	Handsome tree, clean		Must be protected in Minnesota
Tamarack	Larix laricina	North of Ohio		Conical		Thin	Ornament				Very pretty		Deciduous northern species
European Larch	Larix europea	'	'		"	'			Rapid				Goes little farther south
Red Cedar	Juniperus virginiana	Entire region	Any site not too wet	"	Berry	Dense	Ornament and screen		Fair	'	Dense growth		Good on prairies, seed 2 yrs. germinate
Arborvitæ	Thuja occidentalis	Entire region	Low places		Cone	'			Slow	'			Needs good protection on prairies
Golden Arborvitæ	Thuja	Entire region		"		"		'		"	Pretty, yellow tipped foliage		"
White Cedar	Chamæcyparis thyoides	Northwest Ohio and southward	'				'				Pretty, dense growth		No good

Common Name	Scientific Name	Hardy	Site	Form	Fruit	Density of Foliage	Use	Age	Rate of Growth	How Propagated	Good Points	Bad Points	Remarks
Red Fir	Pseuda-tsuga taxifolia	Entire region except North	Fairly good soil	Long, conical crown	Cone	Dense	Ornament	Long lived	Fair	Seed or seedling	Pretty, odd		Lends variety
White Elm	Ulmus americana	Entire region	Almost any	Fan-shaped	Dry samara	Fairly dense	Shade, driveway		Rapid	"	Good shade, and shape	Subject to insects	One of our best street or driveway trees
Winged Elm	Ulmus racemosa	"	"	More of an oval crown			Shade		Fair		Good shade, odd		Peculiar bark on small branches
Hackberry	Celtis occidentalis	"	"	Fan-shaped	Drupe					"	Good shade, good shape	Soft berries	Does not need as much pruning as elm on prairies

CHAPTER XIII

HISTORY OF THE FOREST

So many new problems have confronted the people of this country that we are too likely to think that all our difficulties are peculiar to our own conditions. Forestry is commonly considered as a brand new theory all our own, a theory which many think not needed or altogether impracticable. We forget that the countries of Europe were at one time as "new" and as unsettled as our own, and have since passed through the same stages of development and many more besides.

We look to our frontiers for our necessary supply of timber and do not realize with what rapidity those frontiers are becoming cut-over and settled regions or that a time will come in no very distant future when the frontiers, in the present sense of the word, will have ceased to exist. The same was true in Europe, but the frontiers have long ago disappeared and they have learned to produce their timber like their other crops in the heart of the settled region, and produce them successfully at a good profit to the owners and to the state. It has long ceased to be an experiment with them and is recognized as being absolutely necessary to the country's welfare. A brief review of that development in Germany, the most progressive of the European states in that line, will aid us in getting the proper view point for understanding our own conditions.

At the time when the Eastern tribes invaded Germany, that country was practically an unbroken forest and the tribes living there were of a wandering character. The needs of their civilization, or rather of their barbarism, were few and their demands upon the forest practically none. Their life was very much like that of our eastern Indians. Their fuel was supplied by the dead wood on the ground and they cut practically no standing timber.

When these tribes settled down to village life in a permanent location, it became necessary to build substantial houses of wood, and fields had to be cleared for agricultural purposes. That meant the cutting away of the forest. This opening thus started was necessarily steadily enlarged from year to year. The villages grew in population and needed larger areas for the raising of their food supplies. With the demand for firewood for so many persons concentrated in one place for so long a time, the dead timber no longer sufficed and the supply had to be drawn from the standing timber. Moreover, the more complicated system of village life was constantly developing new uses for wood. And we must remember that wood fulfilled many more purposes then than it does with us, for the use of the metals was very little known.

With the establishment of village life came the idea of private ownership of land. The house with the surrounding garden was private property, the pasture was the common property of the village, but the forest was not as yet considered as property at all. It was used by any one and every one as a source of wood and as a hog pasture, for when the forest was composed of beech and oak, the mast was considered of as much or even more importance than the wood.

The first idea of the forest really belonging to any one came with the conquering Romans. According to their law, all the unsettled portion of a conquered country became the property of the ruler, and so the forest became the property of the new kings. They had little use for it except as hunting grounds and managed it accordingly. They protected the game, making it a greater offense to kill a deer than a man, but they did not interfere with the use of the forest for fuel and pasturage. This privilege was the only source of the peasants' wood supply, dependent entirely upon the favor of the king.

The king granted much of this forest land to his nobles, who in turn created game preserves and cared nothing for the forest itself. The peasants continued to secure their fuel and pasturage in the same way, and the continuance of this practice finally constituted it a right, which the nobles no longer had the power to take away.

In spite of this free use of the forest that the villages enjoyed, they suffered from a shortage of wood at a very early date. The supply in the immediate neighborhood of the towns was used up and the difficulty of transporting such bulky material more than a few miles made the vast areas of forest on the frontiers almost useless to the towns, — it was out of their reach. There were no railroads nor adequate road systems of any kind; therefore the towns on the rivers were the only ones which could draw on the timber supply of distant regions. This was an important factor in the rapid growth of the river towns. With the growth of the towns the timber famine became more acute.

It is interesting to read some of the laws that were passed to remedy this evil. The size of houses and the number of houses that could be built were regulated. The use of the green bush as a tavern sign was forbidden. The use of coffins was prohibited in Austria and canvas bags used to save wood. No wood could be shipped from one district to another and the bakers of one town were even prevented from baking bread for their neighbors of another town unless the customer brought his wood with him. Of course these measures postponed the day when the present supply would be exhausted, but only postponed it. It was at this time that a few far-sighted men took warning from existing conditions, foresaw the inevitable timber famine and realized the temporary nature of the relief obtained by restrictions which were being placed on the use of wood. They knew that something must be done to increase the supply, and there was evidently but one way to do this, — to grow trees.

The conception of this idea was closely followed by laws aimed at the renewal of forests instead of the restriction of consumption. These measures were at first inadequate because so little was known of the growth of trees and the necessary measures of culture. It was a subject which had never before received any attention and there were no trained men to take charge of or direct the work. Every plan tried was in the nature of an experiment. No one even knew how long it would take to grow a tree. Some believed in the planting of seedlings grown in nurseries, while others argued for the use of the seedlings that grow naturally under the old trees in the forest.

The work was further hindered by the fact that the idea of the forest as a hunting ground rather than a source of timber still persisted. The protection of the game was still considered of paramount importance by the nobles who owned the larger part of the forests, and for more than a century the control of the forests as wood-producers was in the hands of the game wardens. Moreover, the peasants' rights of usage, which had become so firmly established that it was impossible to stop them, were now found to interfere seriously with the proper handling of the forests.

However, the proper solution of the problem had been found, and the work developed rapidly. Schools were established for the training of men to take care of the forests, and experiment stations worked out the best methods of treatment. It was recognized as an important factor in the nation's welfare and placed on an independent basis. Long before the development of transportation facilities made possible the cutting of the last of the natural forests and before the pinch of the timber famine was very seriously felt, there were mature forests that had been planted out and cared for in systematic manner.

Every stick of timber that Germany uses to-day has been grown from seed under a definite system of management and as carefully cultivated as any crop in the country. This management has been so successful that every acre of forest land in the government forests yields a net revenue to the state annually averaging about $2.50. Some forests yield as high as $12.50 an acre. Moreover, they are furnishing steady employment to hundreds of thousands of men throughout the country and thus distributing millions of dollars among the classes most in need.

Many of the cities manage their own municipal forests and manage them to such advantage that their taxes are considerably lightened, and in some cases done away with altogether. Associations and other organizations seek revenue in this manner, and many private owners realize the value of the investment though they have not as yet developed their systems to the same degree as the government.

Such is the status of the forests in many of the countries of Europe, those which are the most progressive and most prosperous. Some of the countries of southern Europe have been slow to take up the work. They are mostly the states that are backward in every form of development, and they are now suffering from their lack of foresight. All of them have their progress retarded by lack of timber and are paying out large sums for wood imports, while their own neglected forest areas, instead of yielding a revenue, are lying idle and becoming more and more worthless from year to year. In some localities, such as Greece and Spain, the country has been reduced almost to desert conditions. All of them have now realized their mistake and are spending large sums of money to place their forests on a paying basis. They are the oldest countries of Europe in civilization, and it would have meant hundreds of millions of dollars to them if they had stopped this leak centuries ago.

THE NORTH AMERICA EXPERIENCE

Now let us turn for a moment to the development of North America. When the first settlers came to this continent on the Atlantic coast, they found an endless forest extending from Canada to Florida. There was practically no open land of any considerable extent.

Clearings had to be made to secure even the little space necessary for the building of villages. The clearing of fields for crops was a tremendous undertaking. Timber was the one thing of which the early settlers had a great, and to them worthless, superfluity, — for there was no local market and the facilities for export were very insufficient. Naturally the settler came to look upon the forest as his most formidable enemy; it hindered his early move in the development of the country and fostered the wild animals and still wilder Indians. No wonder he looked on the forest as something to be destroyed and handed the feeling down to his children, completely overlooking the almost invaluable benefit that he was receiving from such an abundant supply of cheap lumber.

For a hundred years after the first settlement, no man traveled far enough west to discover a country that was not heavily wooded. The question of timber supply never entered their heads, for the supply seemed to them truly inexhaustible and under the circumstances the conception of a lack of wood was inconceivable. A very small percentage of the wood that had to be cut for other purposes could be used, and enormous quantities of it had to be burned to get rid of it. Little was cut for the value of the wood itself.

Only as the towns developed was there any call for wood from a distance, and even then the geography of the country was such as to hide from them the distance to which the forest frontiers were being driven. Lack of transportation in inland Europe had given the people early warning of what would eventually take place in the country as a whole. In America the settlements were all on the coast, and innumerable rivers of unheard-of size stretched far inland to float the timber from the interior down to the settlements on the coasts.

Unfortunately for the conservation interests, about the time that the depleting of the local supply on the coast might have become apparent, the introduction of the railroad and the improvement of inland waterways made it possible to tap the vast resources of the lake region for the benefit of the East. Thus the idea of an inexhaustible supply, — later to prove so dangerous, — was given renewed strength. And so continuous and all-sufficient has been the supply poured into the older and more thickly settled sections from more and more distant forests that people have been slow to learn how nearly the "inexhaustible forests" have been exhausted.

The once unbroken forests of the Northeast are now, with the exception of certain parts of the mountainous country, reduced to scattered remnants of culled-over woodland incapable of supplying any considerable part of the local demand. The vast forests of Michigan alone were at one time considered sufficient to supply the world forever. Yet so rapid has been our increase in population and so unprecedented our development that those forests have been practically wiped out, and Michigan is already out of the race as a timber producer. Wisconsin and Minnesota had the same fate, and now this whole great nation, larger and more timber hungry than ever, has only the West and the South to look to for her future supply. The timber of the Rocky Mountains is inconsiderable when it comes to answering the demands of the whole country and the possibilities of the South and West are definitely limited. Yet the idea of an inexhaustible timber supply, ground into the people for over a century, persists. Washington shingles are sold in Boston, and Louisiana pine is common on the Chicago market, but the status of our timber supply is not heeded.

Some twenty-five or thirty years ago, a few far-sighted men who knew the history of European countries began to realize that measures were necessary to prevent a real timber famine in the United States. Unfortunately very little was known of the amount of timber still standing. That there was danger of a timber famine was true enough, but it was very hard to make the people believe this, and some wild predictions that later proved to be very wide of the mark hurt the cause.

Moreover, these first enthusiasts adopted the wrong methods. The abundance and consequent cheapness of timber forced wasteful methods. The quality of timber cut in the early days led them to demand the higher grades and refuse any lumber inferior to what they had been using. The culling out of these higher grades caused tremendous waste. Only the largest trees could be cut and only a small part of those utilized. There was no market for the poorer stuff. The apparent worthlessness of this culled forest and the cheapness of timber generally led to the ignoring of forest fires and it became the regular thing for culled land to burn over, destroying the small growth and doing irreparable damage to the adjoining virgin forest. The fires destroyed far more than was utilized. No attempt was made to save young timber or to utilize more completely the large trees.

The promoters of forestry placed the blame for this waste on the lumbermen, who were really responsible to only a very small degree. The people demanded cheap lumber and refused everything but the very best quality. Such lumber as they demanded then can hardly be bought now at any price. The lumbermen had either to furnish what was wanted or go out of business. The result was, as we have shown, a criminal waste, but the people were responsible, and the lumbermen were only the agents, practically forced to act as they did. Under these conditions, it was only human nature that the lumbermen should resent being called robbers and vandals. Thus it was that they were turned against the movement when their support and coöperation was what was most needed to give it stamina.

As in almost every new movement, the first supporters to rally to the cause were sentimentalists, travelers who had visited Europe and been caught by the glamour of the beautiful orderly forests and the universal respect and reverence for trees. It was the sentiment of the thing that attracted them, not the usefulness. Naturally they wanted to see this order of things introduced into their own country. They knew nothing of the conditions here nor of the fitness of their schemes, but they insisted vigorously and vociferously on their adoption. This persistent clamoring, with the great truths back of it, gained them many followers. The strength of the movement forced legislation and some general laws were passed, directed toward the conservation of forests. Little more than this could be done because those back of the movement did not know definitely what they wanted to do nor how to do it. The timber interests that really could have accomplished something if they had been properly directed held aloof on account of the unreasonable attacks upon them and the impracticable nature of the measures proposed. Those measures, if put into practice at that time, would have killed the lumber industry.

FOREST SERVICE IN THE UNITED STATES

In 1881, the government appointed a forester but gave him little authority and no appropriations, because it was not known definitely what his duties were or what he ought to do. His work was confined necessarily to collecting data and making reports on forest condition.

As early as 1799, Congress passed an act for the purchase and protection of certain cedar and live oak timber for ship building for the Navy. This act was confirmed and reënacted several times up to 1831, but nothing important ever came of it. The action was rather spasmodic, but it shows that even at this early date there was some apprehension in regard to the exhaustion of certain kinds of timber for special purposes of importance. It perhaps had its origin in the action of England which had long been accustomed to reserve especially fine trees for this purpose. Nothing further was done to encourage tree planting and forest preservation till 1872 when J. Sterling Morton through the State Board of Agriculture inaugurated Arbor Day in Nebraska. Such a day has since been recognized by every state in the Union. The next year, 1873, Congress passed the Timber Culture Act, by which title could be obtained to 160 acres of prairie land if 40 acres of it were planted to trees according to certain specifications. This law was well meant, but so framed that its terms were continually avoided, and it led to a great deal of fraud. Moreover, the poorly handled plantations and excuses for plantations were largely unsuccessful and brought discredit upon prairie tree-planting generally.

In the meanwhile, the marvelous extension of the railroads after the Civil War and various acts of Congress, — such as the Homestead, Desert Land, and Timber and Stone acts, — to encourage settlement, hastened the destruction of the forest to an alarming degree.

Emerson Hough brought the matter to the attention of the American Society for the Advancement of Science and was in 1877 appointed special agent by that body to make a detailed report on forestry. The result of that report was the establishment of the Division of Forestry in the Department of Agriculture. The office thus established gave forestry official recognition, which helped, but that is about all it accomplished. The forester was left almost wholly without funds or support and could do little besides educational work by means of reports.

The Timber Culture Act was the cause of so much fraud that it was repealed in 1891 and with its repeal came the first big step in advance. The same bill that repealed the Timber Culture Act gave to the President the right to create forest reserves by proclamation. President Harrison immediately took advantage of it to set aside about 17,000,000 acres of forest reserves. They were under the charge of the Department of the Interior, but lack of funds made it impossible to do anything with them; however, they were of tremendous importance because they marked the beginning of an almost continuous advancement. These reservations were challenged at one time, were suspended for a while, but they were afterwards restored.

The Division of Forestry for some years attempted to introduce better lumbering methods and the more conservative use of our forests, but they were met on every hand with ignorance and adverse economic conditions. The abundance of timber made lumber too cheap for any one to pay much attention to the growing of forests, and the splendid transportation facilities blinded the mass of the people to the rapid disappearance of the forests. It was up-hill work, but the movement steadily gathered strength. In the meanwhile a large amount of valuable data was collected on the growth, habits and handling of our trees.

In spite of all difficulties, the government work grew rapidly in scope and volume as the people became better educated and better acquainted with existing conditions. The Division of Forestry became a Bureau, and in 1905 when the national forest reserves, then grown to over 100,000,000 acres, were transferred from the control of the Interior Department to the Agricultural Department, the Bureau grew to the Forest Service, an office of the same grade as the Reclamation Service. The work of the Service has since that time been concentrated on the development of the reserves.

There was for several years a great deal of opposition to these reserves. The name gave the impression that the forests and everything else in the boundaries were to be reserved from use; that they were to be kept as they were till some future date and for a future generation. That was the common idea of forestry, — the withholding from use of all available timber. Nor could people be expected to have any different idea when the supporters of forestry were everywhere quoting "Woodman, spare that tree" and indulging in bitter tirades against the lumbermen and the cutting of timber. Of course such a policy did not appeal to practical men.

When the forest reserves were transferred to the control of the Forest Service, they were renamed National Forests and every effort made to show that they were meant for use, the most complete use, and not to be stored away in idleness for an indefinite future. The subsequent handling of these National Forests has done much to emphasize this. The free use of the timber by the small settler has been practically unrestricted and the lumber companies have been sold stumpage at reasonable rates and allowed to cut mature trees as rapidly as provision could be made for a future crop. The restrictions put on the method of cutting have not been burdensome. The grazing regulations, at first thought to be prohibitive and a most unjust imposition, have been found to be a boon to the country and a most effective scheme for the more complete utilization of the grazing lands.

The sentimental side had played its part, and that an important one, in forcing the attention of the people. It accomplished this as no other phase of the question could have done. Now, however, when the first stage of enthusiasm was over and the work of actual development began, its memory remained as a hindrance. The scheme proposed by the first sentimentalists was so visionary that the whole system of forestry remained discredited in the eyes of business men for some years. Nevertheless, forestry is strictly a business proposition. On account of the long time element involved, it is a business that is better handled by the state or other long-lived corporations, but it may also be made a paying proposition for the individual owner. It is based on strictly business principles. Far from keeping the virgin forests untouched for the use of future generations as the sentimentalists proposed, the forester cuts his timber just as soon as it ceases to earn a reasonable percentage of profit. He cannot afford to have land that might be growing young timber occupied by old trees that have ceased to grow; this is poor forestry because it is poor business. The only difference between a forester and a lumberman is that the former never cuts till he is assured of a second crop and a consequent higher value of his cut-over land, and the latter works for the highest possible present cut regardless of the future; each is working for the highest money revenue from the land as he sees it.

The forester works for a good reproduction before he cuts his first crop, because he does not want the land to be idle for a minute. He conducts cultural methods to increase the rate of growth so that the mature timber may be secured sooner and his profits be correspondingly larger. He cuts carefully that there may be less waste; he selects poor soil that his rent may be low and the profit high. Every one of these measures is governed by the principles of profit and loss; none of them by sentiment. Whether the forest be for the production of timber, the protection of mountain slopes or for esthetic purposes, the question of profit is never forgotten. The financial outcome is always considered as the true basis and is changed only as much as the chief purpose of protection or ornament demands.

The Forest Service is planning to raise the most valuable crops possible to be grown on its true timberlands, make as much money as it can on the protected slopes and at the same time get the best protection, plant up the open spaces that do not furnish good grazing, and so regulate the stock on the grazing land that the highest possible number of stock will be accommodated and the quality of the range improved; all measures for the very best use of all the land that comes under its jurisdiction. The motto of the forester is always complete use, never useless reservation.

It is clear that forestry in this country has already reached an advanced stage on the government forests and a complicated system is being rapidly built up. Technically trained men are necessary for carrying out the work, and their training is little less thorough than that for other professions. This book, however, does not propose to take up those details that are necessary only in the handling of large tracts of forest land. Only those phases of the work that are applicable to the farm woodlot will be considered in a handbook for the farmer who wishes to handle his woodlot to the best advantage.

THE DEVELOPMENT OF THE FORESTS IN CANADA

The development of the forests in Canada has not followed exactly the same lines as in the United States. This is due partly to the character of the forests themselves, partly to the slow rate of settlement and partly to the form of government.

As in the United States, the forests in Canada are located on the Atlantic and Pacific coasts with a broad stretch of treeless prairie in between. There is one great difference. In the United States the forests extend to the northern boundary; in Canada there are millions of acres which lie within the grasp of the frozen north beyond the limit of merchantable tree growth. Moreover, this great tundra region is incapable of ever producing any merchantable forests and the same is true of a considerable portion of the northern plains.

There is also a great difference in the composition of the two forests. Owing to the northern latitude and consequently severe climate of Canada, the number of species in the forest is much smaller than in the more southern country. Spruce becomes the predominant genus in the coniferous forests instead of pine, and the hardwoods are confined to the less desirable species such as birch, poplar and elm. The magnificent hardwood forests of oak, hickory, yellow poplar, walnut and buckeye found in the southern Appalachians and the Ohio valley are entirely lacking. Nor is the development of the northern species with the single exception of white spruce as good as in the South. On the Pacific coast the forests more nearly compare with those of the northern Cascades.

As in the United States, the first settlements along the Atlantic coast were made in a country of unbroken forest, and the movement westward to the treeless prairies was much slower. Hudson Bay trappers brought in many reports of the vastness of the northern country, but failed to give any detailed account of the timber there. The natural inference was that the whole country was timbered like the Atlantic coast. The result was an almost unshakable belief in the existence of an inexhaustible timber supply which should suffice all Canada's needs forever. This impression spread to the United States, and the mass of the people there believe that they can turn to Canada for wood when their own supply is exhausted. This idea of an inexhaustible timber supply was no less fatal to the early development of forestry in Canada than it had been in the United States, and no more easily dispelled. It stands out to-day as one of the most formidable obstructions to the settlement of an efficient forest policy, though investigations have long ago proved its falsity.

Estimates of the extent of the merchantable forests in Canada, all based on fragmentary and insufficient data, vary widely. Probably the best guess is around three hundred million acres. This is only about three-fifths of the area of the merchantable forests in the United States, and although the export lumber trade has been rather heavy, it is safe to say that far the larger part of the remaining supply will be needed for the now rapidly growing population of Canada.

In the earlier days the export trade in lumber was heavier than it is to-day. The concentration of the population on the Atlantic coast, the network of desirable and navigable streams leading to the sea and the close relationship of Canada to the northern country, which was dependent upon imports for the whole wood supply, made this almost inevitable. The lack of inland transportation facilities made its later decline quite as natural. The development of the transcontinental railroads led the settlers to the open prairies of the West and opened up a new and ever growing market to consume the lumber supply at home. Up to the time when the expansion on to the prairies took place, and that movement was comparatively late in coming, the growth in population had been rather slow, and the effects of the heavy logging along the Atlantic coast had not been severely felt.

These conditions have served as a disadvantage to Canada, but her close relations with England have been distinctly to her advantage. England had, even before the settlement of Canada, long been dependent on outside sources for her timber supply. Her naval supremacy in those days of wooden ships made her especially anxious to conserve anything which might serve as ship timbers. The French had ordered reservations of such timber as early as 1683, and when the British occupied the country they enlarged the reservations. In 1763 and 1775 reservations were ordered in every township. These orders were not very strictly enforced on account of the belief of the "inexhaustible supply."

It was not until 1879 that the home government adopted the policy of reserving to the crown all the timberland not already granted. But vast tracts of timber had already passed into the hands of private individuals. Under the French, all of the land had originally belonged to the king, who granted them to others under feudal tenure. A trading company controlled the whole country in this way up to 1663, when the failure of the company terminated the relationship. This was followed by the practice of granting to individuals, through court favor, large tracts of land as gifts, on condition that they should be regranted to colonists. The result of this was to make the colonists practically the serfs of the original grantees, which condition was terminated only in 1854 by the home government freeing the colonists through the indemnification of the noblemen. The land then passed to the colonists. The English continued the practice of granting land to soldiers, to individuals and to the Church. An order to reserve every seventh section for the support of the Protestant Church was largely responsible for the Papinean rebellion in 1837. The lands withdrawn for the purpose were later sold and the proceeds turned over to the cities for educational purposes. Other large tracts, either through grant or sale, have passed into private hands, and numberless small tracts have been turned over to the settlers in the same way. Fifty million acres were granted to the railroads as an aid to their construction.

Thus in one way or another the larger part of the land in the eastern provinces passed out of the control of the government. These conditions are, however, reversed in the western provinces, and in the Dominion as a whole the larger part of the forest lands still belong to the crown, some eight million acres. Of this enormous area about sixty per cent contains scrubby timber fit only for local use.

In 1826 the government adopted the policy of allowing any one who would pay a fixed stumpage fee to cut timber from the crown land. A surveyor-general of woods and forests was appointed to collect the revenues. This was the first attempt on the part of the state to secure any revenues from its forests. This plan was defeated because the lumbermen found it cheaper to buy the land on contract, cut the timber and forfeit the land together with the first payment. This practice, the subversion of government timber contracts, led to a tangle of graft and corruption.

In 1841, as the result of an investigation of these conditions, the home government turned over the administration of the crown lands to the different provinces. A more active control followed, but the efforts were all directed toward a larger immediate revenue, and no effort was made to perpetuate the supply. Timber limits were sold on competition bids, the successful bidder securing the exclusive right to cut in a certain definite tract and paying so much additional for the timber actually cut. Many of these limits were held as a speculation. To prevent this, laws were passed insisting upon the cutting of a certain percentage of the holdings each year. A tremendous overproduction and consequent fall in the market was the inevitable result. All the laws tended to force increased cuts in order to bring in larger revenues.

Out of this chaos the present systems for the sale of timber on the crown lands have been slowly developed. They are all of the same general character, but vary in the details of their application in the different provinces. Certain definite limits are granted for a certain term of years, usually twenty-one years. During this period, definite regulations in regard to cutting and manufacture must be observed, and the holder must pay a ground rent, a fee for the exclusive use of the limit and additional fees for all timber cut. The stipulated prices and regulations can be changed from time to time as conditions demand. An attempt is made to enforce conservative methods.

As in the United States, a few far-sighted men, notable

Sir Henry Joly de Lotbiniere, had begun early to agitate the question of introducing forestry methods and establishing forestry branches in the official administration, but they could not get a hearing. The belief in the inexhaustible timber supply was against them. It was, however, their efforts which made possible the progressive movement following the meeting of the American Forestry Congress at Montreal in 1882. At this meeting the fire problem formed the chief subject of discussion, and as a result of it, various forest fire laws were passed in the different provinces. Ontario led in this movement. In 1885 their laws were strengthened by the initiation of a ranger system in which the limit holders paid one-half the cost of the rangers, thus giving the lessees a direct interest in the protection of the forest. The benefits of this system were so marked that it was soon copied in Nova Scotia, New Brunswick and Quebec. Even the Dominion government followed suit.

The influence of these protective systems were very plainly felt and a very active interest aroused in the welfare of the forests. They began to take their place among the valuable resources of the country. Ontario established a bureau of forestry in 1883, but allowed it to degenerate into an immigration office in 1907. Quebec placed its work on a more permanent basis by placing it in the hands of technically trained men, who supervised the cutting on leased lands. This work was a success. In 1898 a forestry branch was instituted in the Dominion Department of the Interior and a Superintendent of Forestry was appointed.

As in the United States, these officers at first accomplished nothing, but they gradually came to practical work. Their most important work for the first few years was to keep the needs of forestry before the people. This they did very successfully, and out of it came the policy of permanent forest reserves. The first reservations were made by the Dominion Minister of the Interior in 1895, in the Riding and Turtle Mountains, a thinly timbered district of Manitoba. Several others were added in the same way, and in 1906 they were confirmed by Act of Parliament and placed under the Superintendent of Forestry. Some ten or twelve million acres have been set aside in this way, but the Forestry Branch has never been given funds adequately to handle them.

Ontario followed suit with reservations of some twelve million acres, and Quebec has followed the same policy on a less extensive scale. British Columbia had wasted a large portion of her forest area, but in 1909 reserved the remainder and started the movement which resulted in a very active forestry branch a few years later.

It is only in the past two or three years that much attention has been paid to the management of these areas along forestry lines, but the movement is now progressing rapidly. The various provinces, especially British Columbia, are forging ahead, and the Dominion Service is developing rapidly.

In addition to this work of the Provinces and Dominion government, the Canadian Pacific Railway has inaugurated a very active forest policy and now employs more foresters than any other institution except the United States government. Several of the large paper companies are also practicing conservative lumbering and employing foresters.

The Dominion Branch has established a large experiment station on the prairies and has done a great deal, by the distribution of free nursery stock, toward the planting up of those sections. This work has been a decided success.

In 1900 the Canadian Forestry Association was formed and has done much toward backing up the government departments. It has been of great value in interesting the people and lumbermen in the work of the Forestry Branch. Since 1905 they have been publishing the Canadian Forestry Journal as a means of educating the people.

In 1907 the University of Toronto established a Faculty of Forestry with the equipment necessary for a complete course of instruction. In 1908 New Brunswick also established a department of forestry in the University. The Agricultural College at Guelph has for some years been offering a course in farm forestry.

As may be seen from the foregoing, the progress toward the application of forestry in the Canadian forests has been very slow and dotted with many setbacks, but the prospect at present is, on the whole, promising. The political interference in the management of the forests — which has been the great obstacle in the past — is gradually disappearing, and this, together with the rapidly increasing timber supply, is awakening the people and the government to the necessity of a permanent and constructive policy. Such a policy adopted and the means furnished to put it into practice, it is not too late for Canada to grow her own supply indefinitely. There is plenty of available productive land.

CHAPTER XIV

FOREST INFLUENCES

Opinion is very likely to go to extremes in everything, but more especially is this true when there is very little definite knowledge of the facts, and the imagination has full play. The influence of forests on the natural phenomena within and around them offers a splendidly vague field for all kinds of fanciful theories.

At first no one thought of any such influence. There was nothing to bring it forcibly to the attention, and what little was read of it in foreign books was taken for useless theories of the detail-loving Germans. Moreover, the conditions were not diversified enough to offer different viewpoints. Every place was covered with woods and plenty of it. There had been no experience with the open prairies, or with cut-over mountain slopes. When the development of the country pushed civilization out over the plains, and the great commercial rivers of the East became spasmodic in their flow with the clearing of the timber from the mountains, people began to read on these subjects in the histories of other countries. The newspapers took the cue with a will, the possible results of deforestation in this country were carried to the limit of the imagination, and the theory of forest influence grew apace in the public mind. Naturally, public opinion has gone to the other extreme and it now attributes to the forest many ridiculously impossible powers, but there is, nevertheless, a leaven of truth in it all, and the present beliefs, wild as they seem, are nearer the facts than no belief at all.

INFLUENCE ON PRECIPITATION

The most generally mooted question of to-day is whether the forest is the direct cause of greater rainfall, whether the precipitation is greater in the forest than in the open country; and if so, how much greater. Belief in such influence is used as an argument in favor of planting trees, and has considerable weight with many. In spite of its prominent place in the public mind, this is probably the least important of the forest influences. Competent scientific men have been studying this question in European countries for a century or more, where there are vast forests of very dense growth, but they have not as yet been able to decide definitely whether that particular influence exists or not. If, then, this influence, increase in rainfall, is so small as to be imperceptible in the case of an extensive and dense forest, it certainly need not interfere with our calculations in the consideration of a small plantation of a few acres. This factor may be wholly disregarded in all farm forestry. A forest, then, does not influence the amount of precipitation, but it does have an important influence on the disposal of the precipitation. This, in fact, is one of the most important effects of forest cover. It directly controls the permanent flow of springs and streams.

INFLUENCE ON RUN-OFF. Fig. 60

The influence of forest cover on surface run-off was noted long ago in other countries and has been forced upon the attention in this country by the cutting of the timber in the mountainous regions. The best examples of the results of deforestation are now to be found in China, but the records of the process are not to be secured. The more recent denudation of the mountains in France, though not so complete as that in China, is more to the point, because all the records of the process from the densely wooded mountain sides to the bare hills, and even the attempts at reforestation are complete.

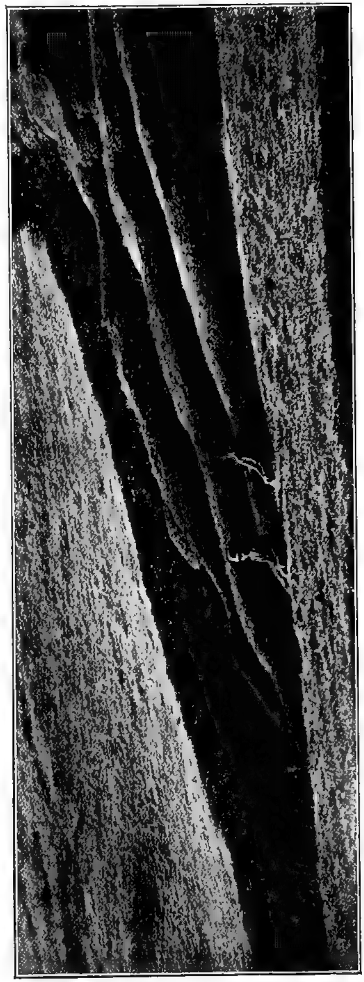

Fig. 60. — Gullies caused by erosion on deforested clay slope. This land should never have been cleared.

Rainfall is not distributed evenly throughout the year. There are seasons of heavy precipitation, and seasons of more or less severe drought.

When the surface of the earth is bare uncovered rock or impervious soil, the rainfall runs off in unobstructed streams as it falls. The result is a heavy flood, varying in strength with the character of the country and the size of the drainage basin, for a short time after the precipitation and then a dry stream bed. This is true of the conditions existing in a very large part of China and the Mediterranean countries, as well as in considerable areas of the United States.

These conditions are not at all adapted to man's wants. His business and even his life is dependent upon an even supply of water in the rivers and springs, and this even supply can best be secured by keeping the natural water-sheds under forest. History and theory agree that this will accomplish the purpose. Attempts have been made in the United States to find two water-sheds, near together, of practically the same area, one forested and one bare, — to compare the run-off of the water in the two. It was very difficult to find two water-sheds which exactly corresponded to the requirements, but sufficient data has been secured to establish the following facts:

The force of the falling raindrops is so broken by the network of limbs and branches that the ground is not beaten hard as is the case in the open. The soil remains light and permeable; the organic litter from the trees mingled with the surface soil helps to keep it so. The water dripping lightly from the branches or sliding down the trunks of the trees sinks readily into this permeable soil, instead of running quickly over the surface as is the case on rock or packed clay. Not until the soil has become wet to the point of saturation does any moisture run from it to the stream bed, which means that an unusually heavy and long-continued rain is necessary to cause a flood in a stream whose water-shed is well forested. This water that soaks into the ground gradually seeps to lower levels and finally emerges from the springs to maintain the normal stream flow. Naturally a moderate rise in the streams occurs after a prolonged period of heavy rainfall, but such a rise can do little or no damage, and, as we have seen, a sudden and destructive flood is impossible.

The snow is disposed of by the forest in the same way as the rain. The crown cover shuts out the rays of the sun and prevents the snow from coming under the heat of direct insolation. It is late in the season in the mountain regions when the temperature in the shade rises sufficiently to melt the snow for any length of time during the day. Thus the run-off from the forested mountains is practically none when the snow is melting rapidly in the early spring in the open and in the lowlands. The water supply from this region is kept stored up in the ground and in springs as a reserve that keeps the streams flowing through the dry months when other sources are exhausted. Observation of two streams in California, one with a bare water-shed and the other with water-shed well forested, has proved this almost conclusively. The streams were well located in a region in which there was a distinct rainy season followed by absolute drought. The bare water-shed sent down its waters immediately after the rain in torrential floods carrying away everything movable along the banks and making any use of the water impossible. Shortly after the close of the rainy season, the volume of the stream began to decrease rapidly and in two months the stream bed was dry. The forested watershed, on the other hand, absorbed the rainfall in the way described above, and, though there was high water in the creek during the rainy season, there was no flood to injure improvements along the banks. At the close of the rainy season, there was very little decrease in the volume of stream flow and a fair amount of water flowed in the stream bed throughout the dry season, when water is most needed and most valuable for irrigation purposes.

Perhaps as much water comes down from the bare watershed in the course of a year as from the forested one; in fact, probably considerably more water comes from the former, for there are several factors that tend to dissipate a part of the water that falls on the forested shed. A part of the water — the lighter the rain the larger the percentage — is intercepted by the crowns of the trees and evaporates before it reaches the ground at all. It is also a well-known fact that more moisture evaporates, through the transpiration of the leaves, over an area covered with vegetation than from a bare surface. Also, in the forest the water is held in the ground so much longer than in the open that there is more opportunity for evaporation in that way. Thus, the actual amount of water in the forest-born stream in the course of a year is really less than in those coming from the bare country; but seventy-five per cent of the latter is lost in flood, is of no value for irrigation purposes or water power and does much damage to improvements along its banks, while all the former can be utilized all the year round and there is no damage to adjacent property.

Since the cutting of the forests at the headwaters of many of our rivers, disastrous spring floods have developed in these streams that do a tremendous amount of damage both to shore property and to navigation. Later in the summer the water in these same streams reaches such a low level that navigation is again impeded and water power seriously disabled. The floods, formerly unknown, that have of recent years become of annual occurrence in the southern Appalachian mountains are said to damage improved property alone to the extent of ten million dollars annually. The spring flood and consequent summer drought in the Allegheny and Monongahela rivers above Pittsburgh, besides the enormous damage done in that city and in the Ohio valley, greatly impair the navigation of the Ohio River for five months. Floods in the spring make navigation dangerous, and in the summer there is not sufficient water for the larger boats to get into the upper stream. If the water that now flows down the Ohio in a year were evenly distributed throughout the seasons, the now coveted nine-foot level would be maintained the year round at Pittsburgh and the navigation of the river would be perfectly safe for the largest boats at all times.

All these flood and drought phenomena are now proved, as far as such a thing can be proved, and generally admitted to be the result of the removal of the forests from the water-sheds. Moreover, as has been proved by many observations in all parts of the world, springs are affected in the same way as the rivers. There were very many examples of this in India. As the forests were cleared away, the flow of the springs became less and less each dry season until it was finally as dry as the remainder of the country.

EROSION. FIG. 61

We have seen how the forest cover prevents rapid surface run-off, conserves the rainfall and consequently regulates the flow of the streams. What happens when

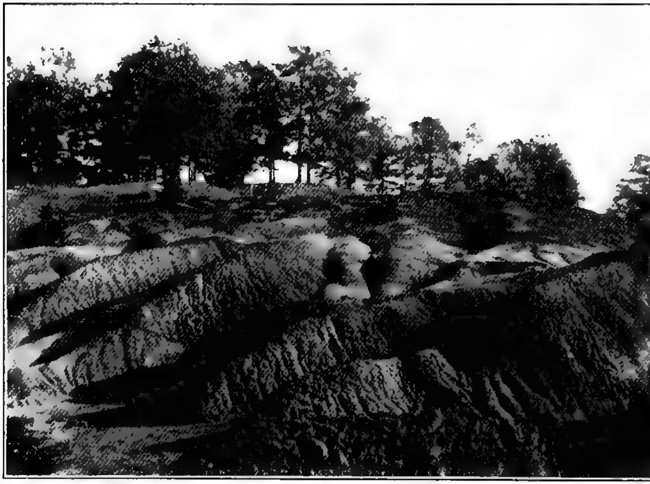

FIG. 61.—Land badly eroded as result of clearing and cultivation.

the forest is cut away? The removal of the shade opens up the ground to the direct insolation and more open circulation of the wind. The humus and leaf mold which was kept always moist in the sheltered shade of the forest is now exposed to alternate wetting and drying. Under these conditions it decays very rapidly, all its vegetable structure disappears, the leaves and twigs are reduced to fine mineral particles and the bare soil is exposed to the driving wind and rain. There is no longer any spongy blanket to absorb the water as it falls and there is an immediate surface flow toward the lower valleys. This flow gathers volume and velocity as it goes and finally joins the torrential streams in the valley in a very short time after the rain has fallen. This is the beginning of the flood which probably does great damage in the valley on the lower stretches of the river, where millions have been invested in bridges, quays and other improvements.

The exposed mineral soil, heretofore protected and mixed with the humus, is, upon the disappearance of the humus, a loose mass of mineral particles. A drop of water rolling over this surface carries the lightest of the mineral particles with it in suspension. As these individual drops join and the stream gains in volume and velocity, larger particles are carried along with it, until the great mountain torrent rolls huge bowlders down its worn bed. The first little trickle of water makes an almost imperceptible track in the soft earth; the water from the next rain naturally follows the track of the first, and the track grows deeper. The deeper the cut, the larger the stream of water collected in it; the larger the stream of water, the greater its carrying capacity; and so erosion proceeds apace.

First the humus — and with it the fertility of the soil — is carried away; then the surface soil follows, leaving the subsoil exposed in great gullies; finally nothing but rock and hard packed gravel remain. This process occurs in every hillside forest that is cut over and abandoned. There are millions of acres of cut-over land in the hilly parts of the United States now in various stages of erosion.

Some are just losing the humus from the surface soil, some are in the last stages of rock and gravel. The rapidity of the erosion depends largely on the nature of the soil. The clay soils of the Mississippi and the foothills of the southern Appalachian mountains lend themselves readily to this process and become lost to cultivation by this means in a few years. The farmer has robbed himself of millions of acres of valuable woodland in attempting to bring under cultivation mountain land not suited to that purpose; and it now lies worse than a worthless waste.

In France, when the government of the Republic ordered the cutting of the forests that had been conserved for years under the rule of the monarchy, thousands of square miles on the steep slopes of the Alps were eroded to a barren waste in just this way. The ground became so gullied and so completely robbed of all its fertility that it was impossible to establish any growth on it by ordinary means. Everything was washed out of the ground as soon as planted. Hundreds of millions of dollars have been spent, and hundreds more must yet be spent in the future in the building of dams and the digging of ditches to hold the floods till vegetation of some kind has secured a foothold.

Sections of Greece, a large part of Asia Minor, Arabia, Palestine and all northern Africa and nearly all of China have come to their present desert condition from former fertility and luxurious vegetation through just such process of erosion. It is bound to come to us if we persist in clearing the forests from the hillsides. Nor is the damage from erosion confined to the hillside districts.

The detritus washed from the lands above is deposited on the fertile lands in the valleys below. Thousands of families were driven from their homes in the most fertile valleys of France along the foothills of the Alps because two and three feet of sterile débris from the mountains were spread over their fields. In our own country the floods in the Missouri and Mississippi rivers have many times buried the overflowed lands along their banks with many feet of sand that absolutely destroys the value of the lands for several years to come. This is taking place along all our foothill streams and rivers.

When this sand and débris is not deposited on the overflow lands, it is deposited in the stream bed or along the coast near the mouth of the river. Hundreds of miles of rivers in the United States have been lost to navigation in this way, and the government has spent millions and millions of dollars in keeping others open. The government experts estimate that one billion cubic feet of débris are carried to the sea by the streams annually. It is the heaviest tax that the farmer has to pay and most of it comes from areas from which the forests should never have been cut.

This sediment carried by the streams does the greatest amount of damage in the irrigated districts. Here vast reservoirs are constructed at enormous expense, and to make the work economical these structures must last a long time. If the forests are cut away from the drainage basins of the streams that feed these reservoirs and erosion sets in, these expensive reservoirs are filled in a few years and their value destroyed. Not only is the reservoir destroyed, but the natural reservoir site — probably the only one in the region—is destroyed and irrigation in a larger part of that district is rendered impossible. While this silting up of the reservoir is going on, the fine particles not deposited in the basin are carried down the ditches and spread over the fertile fields, dulling their productive capacity.

These are the results of cutting forests as expressed in the terms of erosion. A well-placed forest prevents these results.

LESSENING OF EVAPORATION

Distribution of stream flow and the prevention of erosion are not, however, the only influences that the forests exercise over the surrounding country. They lessen evaporation, which is a very active agent in drawing the moisture from the soil. T. Russell, Jr., of the United States Signal Service, made some experiments in 1888 to learn the amount of evaporation on the western plains. During the year this evaporation amounted to 50–80 and, in some spots, even to 100 inches, while the rainfall over this area is 30–12 inches and less. "Thus in Denver, where the maximum annual precipitation may reach 20 inches, the evaporation during one year was 69 inches. This deficiency of 49 inches naturally must be supplied by waters coming from the mountains, where the precipitation is large and the evaporation low. (On Pike's Peak alone there may be 45.6 minus 26.8 or 18.8 inches to spare.)"

To understand better the application of this, we must examine the most important factors determining the amount of evaporation. The first of these factors to be considered is the soil cover. In experiments made in Germany during the months of July and August, 1883, to determine the amount of evaporation from different soils, it was found that from 1000 square centimeters of bare ground 5730 grams of water were evaporated, and that from the same area of similar soil covered with two inches of straw 575 grams were evaporated. This shows that the naked soil evaporated more than ten times as much as the covered soil. It is evident, then, that the soil covering has an important function in preventing evaporation.

The forest cover acts in the same way. If the loss by evaporation from an open field be compared with that of a forest-covered ground, as a matter of course it will be less in the latter case, for the shade not only reduces the influence of the sun upon the soil, but also keeps the air under its cover relatively moist, therefore less capable of absorbing moisture from the soil by evaporation. Moreover, the forest cover above, which intercepts the direct rays of the sun and shades the ground, also assures us that the ground will be covered with a layer of dead branches, leaves, twigs and the like.

The next point to be considered is the effect of wind velocity on evaporation. The evaporation under the influence of the wind is dependent not only on the temperature and dryness of the wind, but also on its velocity, which being impeded, the rate of evaporation is reduced. T. Russell, Jr., experimented on this subject in 1887. His experiments were made with Riche's hygrometers whirled around on an arm 28 feet in length, the results of which were compared with those from a tin dish containing 40 cubic centimeters of water exposed under shelter. The results show that, with the temperature of the air at

84° and a relative humidity of 50 per cent, evaporation at 5 miles an hour was 2.2 times greater than in a calm; at 10 miles, 3.8; at 15 miles, 4.9; at 20 miles, 5.7; at 25 miles, 6.1; and at 30 miles the wind would evaporate

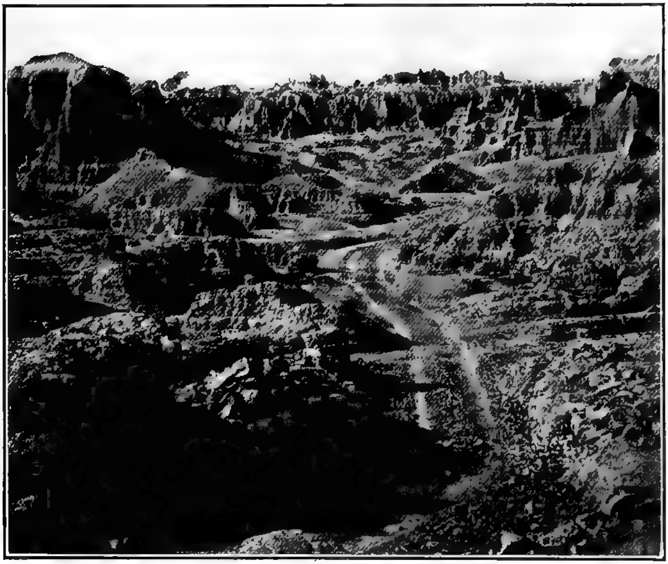

Fig. 62. — The results of wind erosion in the bad lands.

6.3 times as much water as a calm atmosphere of the same temperature and humidity.

When we consider that the average velocity of the winds that constantly sweep the western arid and subarid plains is from 10 to 15 miles, not rarely attaining a maximum of 50 and more miles, the cause of the aridity is not far to seek.

In Switzerland the change of temperature from the normal, experienced under the influence of the Foeher, or warm wind, has been noted as 28° to 31° F., and a reduction in relative humidity of 58 per cent. A Foeher of twelve hours' duration has been known to "eat up" entirely a snow cover of two and one-half feet. In Denver, a Chinook has been known to induce a rise in temperature of 57° F. in twenty-four hours (of which 36° in five minutes), while the relative humidity sank from 100 to 21 per cent.

Anything that lessens the velocity of the wind lessens evaporation: hence the influence of the forest. Any one who has been in the heart of a dense forest knows that the severest wind is not felt there. This is because the trees impede the velocity of the wind, and consequently evaporation in the forest is less. As one approaches the windward side of the forest, one feels the wind more and more. This shows that the degree of influence that the forest exerts on the wind is in direct proportion to the size and density of the forest. But even the narrow windbreaks and shelter belts exert a very appreciable influence.

King has found in experiments made in Wisconsin that the influence of even a thin stand of woodland on the rate of evaporation was considerable. In one experiment made in the month of May, the instruments were so placed as to measure the evaporation to the leeward of a scant hedgerow 6 to 8 feet high, containing a few trees 12 feet high and many open gaps. It was found that at 300 feet from the hedge the evaporation was 30.1 per cent greater than at 20 feet, and at 150 feet it was 7.2 per cent less than at 300 feet. The experiment was made during a moist north wind. It is sufficiently evident, therefore, that even a thin hedgerow exerts an influence that can readily be measured. In fact, the presence or absence of protecting belts of trees under the conditions often existing on the prairies may make a difference between a good and a poor crop. All who are acquainted with our prairie regions know that great damage is often done to wheat, corn and other crops by the hot southwest winds which are likely to occur in the growing months. In Kansas and Nebraska in the summer of 1894, immense tracts of corn, fully tasseled out, were killed by such winds. At the same time it was noticed that when corn was protected by trees or slopes of land, or when the humidity of the wind was increased by passing over bodies of water or clover fields, the injury was greatly lessened. King found that an oak grove 12 to 15 feet high exerted an appreciable effect in a gentle breeze at a distance of 300 feet.

The records show that in southwestern Minnesota in the dry years of 1910–11 many of the grain fields were completely burned up with the exception of a narrow strip north of the windbreaks. The yield from these strips was sufficient to furnish seed grain for the whole farm, and in one season the windbreaks more than paid rent on the land they had occupied throughout their existence.

At the Dominion Experiment Station in Assiniboia, Saunders found on one occasion that windbreaks exerted an appreciable influence at 50 to 80 feet to leeward for every foot in height, but this was during a very severe wind. The greater the velocity of the wind, the farther the influence of the windbreak is felt. It probably may be laid down as a general rule that windbreaks will exert an appreciable influence for at least one rod for every foot in height.

It may not be necessary to state that the damage done to crops by the cold, dry winter winds is mainly due to rapid evaporation, and that plants are liable to suffer as much by winter drought as by summer drought. This is certain, that since summer and winter drought, that is, rapid evaporation due to continuous dry winds, is the bane of the farmer on the plains, rationally disposed timber belts will do much to increase available water supply by reducing evaporation.

The exact difference in the rate of evaporation in the forest and in the open country from all causes is not known in this country, but experiments in Bavaria show the rate in the open field to be six and one half times that in a deciduous forest. In this connection we must consider the hot winds that so often cause injury to farm crops in Kansas, Nebraska and the Dakotas. These are often ascribed to the "staked" plains, whence, taking a northeasterly direction, they draw all the moisture from the vegetation with which they come in contact. The view has also been presented that they have their origin on the Pacific coast, ascend the Rocky Mountains, lose their moisture and descend on the eastern slopes. But all theories that ascribe their origin to a distant source are inadequate to explain their phenomena. For example, all who are acquainted with these winds know that they blow only during very dry weather, when the earth is heated very hot, that a good rain speedily brings them to an end, and that they blow only during the day time, commencing about 9 A.M. and continuing until sundown.

This daily movement is often constant for several weeks, showing that there is evidently some connection between them and the course of the sun. For these reasons, and others, the best authorities unite in attributing them to local origin.

George C. Curtiss describes the process of the production of a typical hot wind as follows: "The necessary conditions are those of the 'warm wave,' namely, a diminishing pressure to the northward, producing southerly winds which initially elevate the temperature above the normal. A cloudless sky favors an intense insolation, as a result of which the dry ground is soon raised to an extreme temperature, and the air is heated from it by radiation, reflection and conduction. The resulting diminution of density due to the rise of temperature furnishes impetus to previously existing horizontal currents, and by 10 o'clock in the morning the hot wind is fully developed. Hundreds of miles of hot dry earth contribute to maintain and feed the current, and gathering strength as the sun mounts higher, the hot wind sweeps over the defenceless prairie. Neither hills nor forests rise in its path to break its power or dispute its sway, and with no enemy save the tardy rain cloud, the fetid blast sucks out the life sap of the growing grain. It will be readily seen then that each of the states, Kansas, Nebraska and North and South Dakota, develops its own hot winds and cannot charge them to the account of its neighbors."

Since, then, these hot winds are of such origin, it is clear that windbreaks at frequent intervals on the prairie farms would prevent their formation. The increased humidity of the air in the immediate neighborhood of the windbreak and the physical obstacle presented would counterbalance the superheating of the intervening space. These same groves and shelter belts that prevent evaporation and drying winds also perform several other important functions. They prevent the drifting of the sand and snow. This property of shelter belts has been almost completely ignored in this country but has been recognized in Europe for many years. In France, plantations have been used to check and successfully keep in place the enormous sand dunes which were and in some places still are, traveling inland from the coast. The root systems help to hold the sand in place and the upper parts of the tree reduce the force of the wind. On the steppes of Russia, where the tremendous sweep of the wind lays bare the winter crops over large areas, and piles the snow in great drifts where it is not wanted, low windbreaks have been used very effectively to keep the snow in place. It will not be long before such simple and natural devices will take the place of the expensive snow breaks now built by the railroads.

Neither sand nor snow drifts in the forest and we should learn our lesson from nature. Moreover, the absence of strong winds in the interior of a forest makes it appear very probable that the planting of breaks and groves at short intervals would prevent the formation of tornadoes on the open prairie, — for these violent windstorms soon lose their force when they enter the forest.

Another factor of forest influence well worth noticing is the improvement of the soil on which trees grow. Large amounts of soluble mineral salts are added to the surface soil by the falling of leaves and small twigs, which decay and give up their mineral content. This mineral matter is either taken from the air by the leaves themselves or drawn up from the ground by the roots. The roots of the trees pierce to the subsoil and bring up mineral foods that the roots of smaller plants would never reach. In the same way large amounts of humus are added to the soil and keep it porous and retentive of moisture and gases. The roots by their decay also open up the subsoil and let in air and moisture. In this way the surface soil is being continually improved. It has been estimated that after a sandy soil in New England is so exhausted that it will produce no other crop, it may be renewed to its original fertility and productiveness by the growth of trees on it for thirty years. This should always be kept in mind in locating the woodlot and in calculating the benefits to be derived from it.

CHAPTER XV

TABLES AND RULES

RELATIVE HARDNESS OF WOODS

TAKING shell bark as the highest standard of our forest trees, and calling that 100, other trees will compare as follows (Scribner's Lumber and Log Book):

Shell Bark Hickory	100
Pignut Hickory	96
White Oak	84
White Ash	77
Dogwood	75
Scrub Oak	73
White Hazel	72
Apple Tree	70
Red Oak	60
White Beech	65
Black Walnut	65
Black Birch	62
Yellow Oak	60
White Elm	58
Hard Maple	56
Red Cedar	56
Wild Cherry	55
Yellow Pine	54
Chestnut	52
Yellow Poplar	51
Butternut	43
White Birch	43
White Pine	30

TABLE OF TREES ARRANGED IN ORDER OF FUEL VALUE AND WEIGHT OF DRY WOOD[1]

(Green's Forestry in Minnesota)

Names	Approximate Relative Fuel Value	Specific Gravity of Absolutely Dry Wood
Shellbark Hickory	83.11	0.8372
Hop Hornbeam	82.43	.8284
Juneberry	77.95	.7838
Bitternut Hickory	74.74	.7552
White Oak	74.39	.7470
Bur Oak	74.06	.7453
Locust	72.96	.7333
Hackberry	72.08	.7287
Blue Beech	72.26	.7286
Cork Elm	72.20	.7263
Green Ash	70.71	.7117
Scarlet Oak	70.82	.7095
Slippery Elm	68.98	.6956
Kentucky Coffee Tree	68.88	.6934
Sugar Maple	68.75	.6916
Norway Maple	——	.6800*
Honey Locust	66.86	.6740
Red Oak	66.04	.6621
Yellow Birch	65.34	.6553
White Ash	65.16	.6543
White Elm	64.54	.6506
European White Birch	——	.6400*
Black Ash	62.72	.6318
Tamarack	62.16	.6318
Red Ash	61.99	.6215
Red Maple	61.65	.6178
Black Walnut	60.91	.6115

[1] In this table the figures relating to North American species have been taken directly from or calculated from data in Sargent's "Silva of North America" and the report of the tenth census, and those relating to European species are from various European sources.

* Air dried.

TABLE OF TREES — *Continued*

Names	Approximate Relative Fuel Value	Specific Gravity of Absolutely Dry Wood
Canoe Birch	59.40	.5955
Red Mulberry	58.56	.5898
Wild Black Cherry	58.14	.5822
River Birch	57.42	.5762
Austrian Pine	——	.5700*
Silver Maple	52.52	.5269
Scotch Pine	——	.5200*
Douglas Spruce	51.53	.5157
Wild Red Cherry	50.03	.5023
Red Juniper	49.11	.4926
Red Pine	48.41	.4854
White Poplar	——	.4800*
Jack Pine	47.50	.4761
Bull Pine	46.99	.4715
Norway Spruce	——	.4700*
Largetooth Poplar	46.11	.4632
Speckled Alder	45.88	.4607
Black Spruce	45.71	.4584
Ohio Buckeye	45.03	.4542
Basswood	45.00	.4525
Chestnut	44.95	.4504
White Willow	——	.4500*
Black Poplar	——	.4500*
Boxelder	42.82	.4358
Hemlock	42.20	.4239
Hardy Catalpa	41.48	.4165
Balm of Gilead	41.42	.4161
Butternut	40.66	.4086
White Spruce	40.38	.4051
Aspen	40.10	.4032
Cottonwood	38.52	.3889
White Pine	38.47	.3854
Balsam Fir	38.02	.3819
Blue Spruce	37.26	.3740
White Fir	.36.07	.3638
Balsam Poplar	36.11	.3635
Arborvitæ	31.53	.3164

WEIGHTS OF CORDWOOD

(Scribner's Lumber and Log Book)

	Lb.	Carbon
1 Cord of Hickory	4468	100
Hard Maple	2864	58
Beech.	3234	64
Ash	3449	79
Birch	2368	49
Pitch Pine	1903	43
Canada Pine	1870	42
Yellow Oak	2920	61
White Oak	1870	81
Red Oak	3255	70
Lombardy Poplar . .	1775	41

LAND MEASURE

10 Rods by 16 Rods	1 Acre
8 Rods by 20 Rods	1 Acre
5 Rods by 32 Rods	1 Acre
4 Rods by 40 Rods	1 Acre
5 Yards by 968 Yards	1 Acre
10 Yards by 484 Yards	1 Acre
20 Yards by 242 Yards	1 Acre
20 Yards by 121 Yards	1 Acre
220 Feet by 198 Feet	1 Acre
110 Feet by 396 Feet	1 Acre
60 Feet by 726 Feet	1 Acre
120 Feet by 363 Feet	1 Acre
300 Feet by 145.2 Feet	1 Acre
400 Feet by 108.9 Feet	1 Acre

WEIGHT PER 1000 FEET OF SEASONED LUMBER

KIND	LB.	KIND	LB.
Ash	3550	Poplar	3056
Cedar	2925	Willow	2780
Cypress	3350	Locust	3800
Beech	4000	Norway Spruce	2760
Cherry	3720	Hemlock	2350
Birch	2950	Hickory	3960
Dogwood	3930	Walnut	3690
Elm	3220	Pitch Pine	4150
Butternut	1960	Red Pine	3075
Chestnut	3170	Yellow Pine	2890
Maple	4000	White Pine	2880
Oak	3675		

WELL-SEASONED FUEL

(Scribner's Lumber and Log Book)

"The best time to cut, haul and prepare wood for fuel is in the comparative leisure of the winter, and where wood is used for fuel it should be thoroughly dried, as in its green and ordinary state it contains 25 % of water; the heat to evaporate which is necessarily lost; therefore, the burning of green wood is greatly wasteful.

"A log of unseasoned wood weighing, say 100 lbs., will weigh, when dry, only 66 lbs. What now has it lost? any combustible matter? anything that will warm your house or cook your food? No! it has lost 34 lbs. of water. If about one-third the weight of green wood is water, then there are 1443 lbs. of water in a cord. This has to be made into steam before the wood can be burned. By drying the wood most of the water is expelled and there is little loss of heat in the drying as it burns. Now, it costs about $2.00 to work up a cord of wood for the stove after it is hauled to the wood pile, and it makes a difference that anyone can calculate, whether a cord of wood burned green lasts 20 days, or burned dry lasts 30 days. A solid foot of green elm wood weighs 60 to 65 lbs., of which 30 to 35 lbs. is sap or water. Beech wood loses one-eighth to one-fifth its weight in drying; oak, one-quarter to two-fifths. Therefore, get the winter's wood for fuel or kindlings and let it be seasoned as soon as possible, and not have a daily tussle with sissling firebrands and soggy wood."

CORDWOOD ON AN ACRE

(Scribner's Lumber and Log Book)

"To estimate the quantity of cordwood on an acre of woodland requires experience. A person who has been engaged in clearing land and cutting wood could give a very close estimate at a general glance, but other persons would make the wildest guesses. An inexperienced person may proceed as follows: measure out four square rods of ground; that is, 33 feet each way, and count the trees, averaging the cubic contents as nearly as possible of the trunks, and adding one-fourth of this for the limbs. Then, as 128 cubic feet make a cord, and the plot is one-fortieth of an acre, the result is easily reached.

"Fairly good timber land should yield a cord to every four square rods. A tree two feet in diameter and 30 feet high to the limbs, will make a cord of wood if it is growing in close timber, and the limbs are not heavy. If the limbs are large and spreading, such a tree will make $1\frac{1}{4}$ to $1\frac{1}{2}$ cords. A tree one foot in diameter will make one-fourth as much as one twice the diameter. In estimating it is necessary to remember this fact.

"The estimates given to the Department of Agriculture in different states are as follows, according to the 'Maine Farmer':

"Several counties in Maine, 30 to 40 cords per acre. In New Hampshire, average yield 20 to 40 cords per acre. In Vermont, the forest yields 25 to 50 cords per acre. In Rhode Island, about 30 cords per acre. In Connecticut, sprout land yields about 25 cords per acre every 25 years. In New York, 30 to 60 cords per acre. In Delaware, well-set second-growth wood lands yield 30 to 40 cords per acre. In Maryland, 30 to 40 cords. In Oregon, however, the yield of the evergreens and oaks is perfectly astounding, some counties estimated as high as 300 to 600 cords per acre."

SHAPE OF THE AXE

(Scribner's Lumber and Log Book)

"The form of the edge of a chopping-axe should be determined by the purpose for which that tool is intended. When an axe is to be employed more for scoring timber than for chopping firewood, the form of the cutting edge should be nearly straight from one corner of the bit to the other, with the very corners rounded off so that the axe will not stick badly in the timber. The object of having the axe nearly straight on the cutting edge is to enable the chopper to score fully up to the line without hacking the timber beyond the line. When the bit of the axe is what choppers term very circular, it is unfit to score timber with, as the most prominent part of the cutting edge will hack the surface of the timber a half inch or more beyond the line. But by scoring with an axe that has nearly a straight edge, but few hacks may be seen after the timber has been hewed. A good chopping-axe should be rounded on the cutting edge and weigh from 3½ to 5 pounds (some prefer lighter, others heavier), well hung on a tough, springy handle."

RED OAK

(Graves' Mensuration)

Maximum Growth Trees in a Sprout Stand. (Based on the measurement of 53 trees near New Haven, Conn.)

Age, Years	Diameter Breasthigh, outside Bark, Inches	Height, Feet
20	3.5	36
30	5.4	47
40	7.3	57
50	8.8	65
60	10.4	70
70	11.2	

PITCH PINE IN PIKE COUNTY, PENNSYLVANIA

(Graves' Mensuration)

Rate of growth in diameter

Age, Years	Diameter Breast-high, Inches	Diameter inside the Bark					
		1′ High, Inches	11′ High, Inches	21′ High, Inches	31′ High, Inches	41′ High, Inches	51′ High, Inches
10	2.7	2.1					
20	4.6	4.0	0.6				
30	6.4	5.8	2.7	0.8			
40	8.0	7.4	4.6	2.7	0.2		
50	9.4	8.8	6.2	4.3	2.0		
60	10.5	9.9	7.4	5.6	3.6	0.7	
70	11.2	10.6	8.4	6.7	4.9	2.5	
80	11.6	11.0	9.1	7.7	6.0	3.7	0.6
90	11.9	11.3	9.6	8.3	6.8	4.8	2.0
100	12.1	11.5	10.0	9.2	7.4	5.7	3.2

Rate of growth in volume

Age, Years	Fuel-Wood		Lumber		
	Whole Trees		One-log Trees, Board Feet	Two-log Trees, Board Feet	Three-log Trees, Board Feet
	Cu. Ft.	Cords			
40	6.5	0.073			
50	10.6	.119	20.0	29.7	
60	13.4	.161	24.3	36.9	47.2
70	16.3	.182	28.0	42.9	53.8
80	17.7	.198	30.5	47.1	58.4
90	18.8	.210	32.3	50.3	61.9
100	19.6	.219	33.8	52.6	64.4

RATE OF GROWTH OF CHESTNUT

(Graves' Mensuration)

(From the measurement of 68 trees in Connecticut.)

A. Dominant trees in the forest

Age, Years	Diameter on Stump inside Bark, Inches	Diameter Breast-high outside Bark, Inches	Diameter at 10 Ft. above Stump, inside Bark, Inches	Diameter at 20 Ft. above Stump, inside Bark, Inches	Diameter at 30 Ft. above Stump, inside Bark, Inches	Diameter at 35 Ft. above Stump, inside Bark, Inches
10	2.1	2.1	1.35	0.3		
20	5.4	5.1	4.3	3.4	0.9	
30	8.7	7.8	6.9	6.1	3.7	2.9
40	11.45	9.7	8.9	8.0	5.8	5.0
50	13.7	11.3	10.6	9.5	7.25	6.5
60		12.5	11.9	10.7	8.55	7.8

B. Trees in the open

10	3.0	3.0	2.2			
20	7.8	7.4	5.9	4.5	2.5	
30	13.2	11.5	9.8	8.0	6.0	
40	18.5	15.3	13.2	11.0	7.9	
50	23.4	18.5	15.9	13.4	11.2	

RATE OF GROWTH OF RED CEDAR

(Graves' Mensuration)

(Based on the measurement of 23 trees near New Haven, Conn.)

Age, Years	Diameter inside Bark on Stump, Inches	Diameter inside Bark at 6 Ft. above Stump, Inches	Diameter inside Bark at 12 Ft. above Stump, Inches	Diameter inside Bark at 18 Ft. above Stump, Inches
A. Trees in the open				
30	5.5	4.0	2.3	1.6
40	6.8	5.1	3.5	2.6
50	7.8	5.9	4.5	3.6
B. Crowded trees, but not overtopped				
30	4.8	3.7	2.3	1.3
40	5.9	5.0	3.3	2.1
50	6.8	6.0	4.1	2.6
60	7.4	6.6	4.6	2.8
C. Trees free in youth, but later on overtopped				
40	4.4	3.7	2.7	1.4
50	5.1	4.5	3.4	2.2
60	5.5	4.8	3.7	3.0

COMPARATIVE RATE OF GROWTH IN HEIGHT AND DIAMETER OF CHESTNUT FROM THE SEED AND COPPICE

(From the measurement of 1245 trees in Maryland)

Age, Years	Height		Growth each Ten Years, Height		Annual Growth each Ten Years	
	Trees from Seed, Feet	Coppice, Feet	Trees from Seed, Feet	Coppice, Feet	Trees from Seed, Feet	Coppice, Feet
10	7	23	7	23	0.7	2.3
20	17	42	10	19	1.0	1.9
30	33	57	16	15	1.6	1.5
40	52	69	19	12	1.9	1.2
50	64	77	12	8	1.2	.8
60	73	83	9	6	.9	.6
70	80	87	7	4	.7	.4
80	84	90	4	3	.4	.3
90	88	92	4	2	.4	.2
100	91	93	3	1	.3	.1
110	93	94	2	1	.2	.1
120	95	95	2	1	.2	1

COMPARATIVE RATE — *Continued*[1]

Age, Years	Diameter Breast-high: Trees from Seed, Inches	Diameter Breast-high: Coppice, Inches	Growth each Ten Years: Trees from Seed, Inches	Growth each Ten Years: Coppice, Inches	Annual Growth each Ten Years: Trees from Seed, Inches	Annual Growth each Ten Years: Coppice, Inches
10	0.8	3.8	0.8	3.8	0.1	0.4
20	3.4	6.8	2.6	3.0	.3	.3
30	6.0	9.3	2.6	2.5	.3	.3
40	8.7	11.4	2.7	2.1	.3	.2
50	11.2	13.4	2.5	2.0	.3	.2
60	13.4	15.1	2.2	1.7	.2	.2
70	15.4	16.7	2.0	1.6	.2	.2
80	17.2	18.0	1.8	1.3	.2	.1
90	18.8	19.2	1.6	1.2	.2	.1
100	20.1	19.8	1.3	.6	.1	.1
110	21.0	20.4	.9	.6	.1	.1
120	21.6	20.8	.6	.4	.1	.1

NORMAL YIELD TABLE FOR SCOTH PINE. QUALITY V

(Graves' Mensuration)

Age, Years	Number of Trees per Acre	Basal Area, Sq. Ft.	Average Height, Feet	Diameter of Average Tree, Inches	Yield per Acre, Cu. Ft.	Yield per Acre of Thinnings, Cu. Ft.	Forest Form Factor
10			2.3				
20			6.6				
30	3200	57.9	14.8	1.9	186		.225
40	2256	81.2	21.0	2.6	586	57	.349
50	1588	93.3	25.9	3.3	1058	86	.455
60	1152	100.2	30.2	4.0	1429	86	.485
70	828	104.1	34.1	4.8	1743	86	.492
80	640	106.3	38.0	5.5	1986	71	.486
90	520	107.6	41.3	6.1	2158	57	.479
100	428	108.4	44.3	6.8	2287	57	.472

[1] From "Chestnut in Southern Maryland," by R. Zon, Bull. No. 53, U. S. Forest Service.

YIELD OF FULLY STOCKED STANDS OF SECOND-GROWTH WHITE PINE [1]

Age of Stand, Years	Average Height, Feet	Total Trees per Acre	Merchantable Trees per Acre	Yield per Acre, Cords
10	5	2220		
15	9	1700		
20	14	1600		
25	22	1310	400	11
30	32	1090	510	21
35	45	885	620	30
40	54	690	540	38
45	62	510	460	45
50	68	400	380	53
55	72	300	300	65
60	76	260	260	80

NORMAL YIELD TABLE FOR SPRUCE QUALITY III

(Graves' Mensuration)

Age, Years	Number of Trees per Acre	Basal Area, Sq. Ft.	Average Height, Feet	Diameter of Average Tree, Inches	Yield per Acre, Cu. Ft.	Yield per Acre of Thinnings, Cu. Ft.	Forest Form Factor
10			3.6				
20		61.3	10.2				
30	3300	102.3	19.4	2.4	672		.331
40	1924	140.8	30.2	3.7	2115	29	.495
50	1216	162.4	42.0	4.9	3673	129	.534
60	840	178.9	52.2	6.2	5059	229	.539
70	628	189.2	61.0	7.4	6274	243	.539
80	500	200.0	68.9	8.5	7317	229	.534
90	424	209.5	73.6	9.5	8217	200	.528
100	380	217.7	78.4	10.2	8960	186	.522
110	346	224.2	82.0	10.9	9632	171	.520
120	320	229.8	84.6	11.8	10232	143	.520

[1] From "The Natural Replacement of White Pine on Old Fields in New England," by S. N. Spring, Bull. No. 63, U. S. Forest Service, 1905.

VOLUME TABLE FOR RED OAK

(Graves' Mensuration)

(Based on 130 trees measured at New Haven, Conn.)

Diameter Breasthigh, Inches	Height of Tree in Feet							
	20	25	30	35	40	45	50	55
	Merchantable Cordwood in Cubic Feet							
5	1.23	1.61	1.91	2.24	2.55	2.91	3.12	3.40
6	1.78	2.31	2.83	3.31	3.77	4.22	4.61	5.04
7			3.79	4.40	5.08	5.68	6.25	6.79
8			4.88	5.75	6.56	7.31	7.99	8.75
9					8.31	9.27	10.13	10.97
10							12.62	13.64
11							15.70	16.87

Diameter Breasthigh, Inches	Height of Tree in Feet						
	60	65	70	75	80	85	90
	Merchantable Cordwood in Cubic Feet						
5	3.66						
6	5.45	5.81	6.16				
7	7.32	7.81	8.31	8.78	9.27		
8	9.43	10.07	10.70	11.31	11.93		
9	11.76	12.62	13.31	14.04	14.75		
10	14.63	15.62	16.52	17.42	18.30	19.20	
11	18.04	19.16	20.18	21.17	22.15	23.12	24.06
12	12.33	23.62	24.90	26.04	27.15	28.16	29.14
13	27.33	28.85	30.34	31.62	32.98	34.21	35.40

VOLUME TABLE FOR SPRUCE, IN BOARD FEET[1]

Diam. breasthigh, inches	Height of Tree in Feet: 25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	Diam. breast-high, inches
	Contents in Board Feet[2]																
9	18	21	24	27	30	34	38	42	48	53	59						9
10		25	29	34	38	44	50	55	61	67	73						10
11			34	41	47	53	61	68	74	81	87	93					11
12			39	48	56	63	72	81	88	97	105	114					12
13					63	73	84	94	104	115	126	137	148				13
14					71	82	96	108	121	134	147	160	172				14
15					79	92	108	122	138	153	167	182	200				15
16						102	121	137	155	173	190	208	232	255			16
17							135	152	173	193	214	236	260	282			17
18								167	190	214	238	264	290	315	339		18
19									207	237	266	294	232	350	379		19
20										265	294	324	355	387	419	452	20
21											322	357	392	426	461	496	21
22											353	390	430	467	504	541	22
23												425	469	510	550	588	23
24													509	555	600	637	24

[1] From the Adirondack Spruce, by Gifford Pinchot.

[2] By the Scribner Rule.

VOLUME TABLE FOR WHITE PINE OVER 100 YEARS OLD[1]

(Based on 100 trees)

DIAM. BREAST-HIGH, INCHES	Height of Tree in Feet: 65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	DIAM. BREAST-HIGH, INCHES
	Contents in Board Feet[2]																			
10	26	28	30	32	34															
12	56	61	65	69	74	78	83													
14	98	105	113	120	128	135	143	150												14
16		153	164	175	185	196	207	218	229	240										16
18			227	242	256	272	287	302	317	332										18
20				323	343	363	383	403	423	443	463									20
22				418	444	470	496	522	549	575	601	627								22
24					561	595	627	660	694	726	760	793	826							24
26						720	760	800	840	880	920	960	1000	1040	1080					26
28							911	959	1007	1055	1103	1151	1199	1247	1295	1343				28
30								1138	1195	1252	1308	1365	1422	1479	1536	1593				30
32										1440	1505	1571	1636	1702	1767	1832	2018			32
34											1717	1792	1866	1941	2016	2090	2165			34
36												2033	2118	2203	2288	2372	2457	2541		36
38													2394	2490	2585	2680	2776	2871		38
40														2802	2909	3018	3125	3233	3340	40

[1] From the White Pine, by Gifford Pinchot and H. S. Graves.

[2] By the Doyle Rule.

VOLUME TABLES FOR PITCH PINE

(Graves' Mensuration)

Dominant trees 60 to 80 years old.

(Based on 75 trees measured in Milford, Pa.)

Diameter Breasthigh, Inches	Fuel-Wood		
	45′–54′ Trees	55′–64′ Trees	Tree of all Heights
	Cubic Feet		
9	9.6	15.7	9.6
10	11.9	15.7	12.3
11	14.6	17.8	15.5
12	18.0	20.5	19.2
13	22.1	23.9	23.4
14	27.0	28.1	28.3
15		33.4	34.0
16		39.8	40.1
17		47.8	47.3

LUMBER AND FUEL-WOOD

Diameter Breast-high, Inches	One-log Trees		Two-log Trees		Three-log Trees	
	Board Feet	Cords	Board Feet	Cords	Board Feet	Cords
9	19	0.045	28	0.023		
10	22	.059	33	.028	43	0.017
11	27	.075	41	.033	52	.021
12	33	.095	51	.039	63	.026
13	41	.120	64	.047	76	.031
14	52		79	.057	93	.038
15			97	.069	114	.046
16			117		141	.056
17					177	.070

VOLUME TABLE FOR CHESTNUT

(Graves' Mensuration)

Dominant trees about 50 years old.

(Based on 99 trees measured in Milford Pa.)

Diameter Breasthigh, Inches	Height in Feet				
	40	45	50	55	60
	Merchantable Cubic Feet				
6	3.4	3.8	4.1		
7	4.7	5.2	5.6	6.0	
8	6.1	6.7	7.3	7.9	
9	7.8	8.5	9.3	10.0	
10	9.6	10.5	11.4	12.3	
11	11.6	12.7	13.9	14.9	15.9
12		15.2	16.5	17.7	19.0
13		17.8	19.4	20.9	22.3
14		20.6	22.3	24.2	25.9
15			25.8	27.7	29.7

TABLE SHOWING RANGE OF DURABILITY OF FENCE POSTS IN MINNESOTA. (AIR-DRY)

(From "Forestry in Minnesota," by Green)

Red Cedar	30 years
White Cedar (quartered 6-inch face)	10–15 years
White Oak (6-inch round)	8 years
Red and Black Oak	4 years
Tamarack (Redwood)	9 years
Elm	6– 7 years
Ash, Beech, Maple	4 years
Black Walnut	7–10 years
White Willow (6″ in diameter, peeled and dried)	6–7 years

INDEX

FARM STRUCTURES

By K. J. T. EKBLAW, M.S.

Associate in Agricultural Engineering, University of Illinois; Associate Member of American Society of Agricultural Engineers

Illus., Cloth, Crown 8vo, 347 pp., $1.75 net; postpaid, $1.88

In the preparation of this book it has been purposed to provide a treatise concerning farm structures which will appeal not only to the teacher who desires to present the subject to his students in a straightforward and practical way, but to the progressive farmer who recognizes the advantages of good farm buildings. The popular literature on this subject consists mainly of compilations of plans accompanied by criticisms of more or less value, or of discussions of farmsteads too expensive or impractical to be applied to present ordinary conditions. The elimination of these faults has been among the objects of the author in the writing of this text.

The development of the subject is manifestly the most logical, beginning with a description of building materials, followed by a discussion of the basic methods employed in simple building construction, then presenting typical plans of various farm buildings in which the principles of construction and arrangement have been applied. Descriptions of the more essential requirements in the way of equipment and farm-life conveniences are appended. The illustrations have been prepared with the object of making them truly illustrative and of aid in the understanding of the subject matter which they accompany. Comparatively few building plans are included, since most buil ing problems possess so many local requirements that a general solution is impossible; however, the plans presented are typical, and are so suggestive in presenting fundamental principles that a study of them will aid in the solution of any particular individual problem.

It is not intended that the study of this text will produce an architect; but it is hoped that it will provide the student with a sufficient knowledge of building operations to enable him, with some knowledge of carpentry, to erect his own minor structures and to differentiate between good and bad construction in larger ones.

THE MACMILLAN COMPANY

Publishers 64-66 Fifth Avenue New York