KIRKWOOD

CONIFERS

DEPARTMENT OF THE INTERIOR
BUREAU OF EDUCATION

BULLETIN, 1917, No. 53

THE CONIFERS OF THE NORTHERN ROCKIES

By J. E. KIRKWOOD
PROFESSOR OF BOTANY IN THE UNIVERSITY OF MONTANA

WASHINGTON
GOVERNMENT PRINTING OFFICE
1918

BULLETIN OF THE BUREAU OF EDUCATION FOR 1917.

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[Continued on page 3 of cover.]

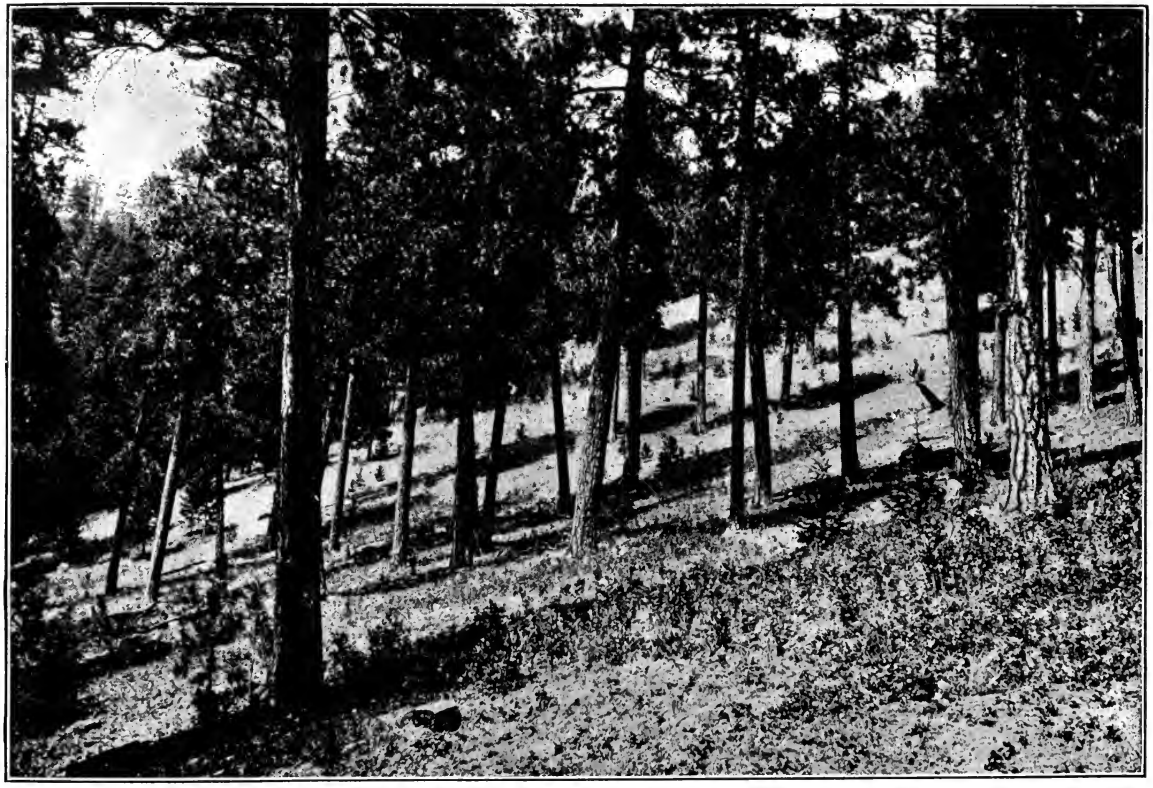

FIG. 1.—Typical stand of Yellow Pine in western Montana. Scene in the Lolo Valley in August. A southern slope.

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ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
BUREAU OF EDUCATION,
Washington, December 8, 1917.

SIR: Forest trees of all kinds have interest for all people. Familiar and affectionate knowledge of them has culture value of a very fine kind. For the people of some sections of the country a scientific study of the trees of the forest has much practical and commercial value as well. This is particularly true of the forested region of the Rocky Mountains. I therefore recommend that the accompanying manuscript on the conifers of the northern Rockies, by J. E. Kirkwood, professor of botany in the University of Montana, be published as a bulletin of the Bureau of Education for distribution among the teachers in the schools of this section and for sale in quantities by the Superintendent of Documents for the use of pupils in the schools. There is great need for such a guide for teachers and students in this subject, which, with the help of such a manual as this, will add much to the richness of the school work. It is, I am sure, quite within the province of this bureau to assist in this way the people of the country as a whole, or any part of it, to improve their schools.

Respectfully submitted.

P. P. CLAXTON,
Commissioner.

The SECRETARY OF THE INTERIOR.

LETTER TO TEACHERS.

To the teachers of the northern Rockies:

This bulletin of the Bureau of Education has been prepared by one who knows well the cone-bearing trees of the forests of the section in which you live, and the needs of teachers and children who would study these trees. The text of this bulletin is not intended to be conned and recited as textbooks too often are; it is intended to be used as a suggestive guide in the out-of-door study of the trees themselves. Should pupils in the schools or other people want copies of the bulletin, they can be had from the Superintendent of Documents, Washington, D. C., for 15 cents.

P. P. Claxton, *Commissioner.*

NOTE.

The purpose of this bulletin is to enable persons not technically trained in botany to identify the coniferous species of the northern Rocky Mountain region lying within the United States.

Nothing is published at present, so far as can be ascertained, which presents with adequate illustrations and in nontechnical language descriptions of the trees of the northern Rocky Mountain region. That some such publication is desirable is indicated by the frequent inquiries for literature on this subject in definite, concise, and popular form. This need is felt by teachers of nature study in the public schools scattered throughout the northern Rocky Mountain country, as well as by foresters, farmers, and others whose work or pleasure takes them out of doors.

Acknowledgments are due to Prof. M. J. Elrod, of the University of Montana, for some of the photographs used herein, and to Mr. E. E. Hubert, of the Bureau of Plant Industry, who has made most of the drawings.

THE CONIFERS OF THE NORTHERN ROCKIES.

I. THE FORESTS.

The forest appeals strongly to the human mind and heart. It has a deeper hold in our sentiment than all other forms of the earth's vegetation. In song and story, in the pages of romance, in the literature of history, of religion, and of science, thoughts of the forest have quickened the facile pens of many writers. The genesis of mankind was in the forest, and in the forest man lived and fought and grew; the trees he venerated and in the groves worshipped. The influence of the forest in the distribution of the human race can never be reckoned. From the first venturing upon a clumsy raft bound with roots and vines to the hulls of sturdy oak that breasted unknown seas, the history of settlement and conquest, of occupation and development, is inseparable from the story of the forest use.

The economic value of the forest can hardly be told, for when we have reckoned in terms of board feet and dollars and cents, there remains the less obvious but not the less real influence, far reaching into all manner of conditions and impossible of calculation. When the forest goes, there go with it the forest animal life, the game and the fish, the fur-bearing denizens of the woods, the clear streams, the storage of waters for power and irrigation, and last but not least the influence of the forest itself upon the soil whereon it grows, tending ever to greater richness and depth. We are told that the forests of Montana alone, if converted into lumber at the present prices, would exceed in value all the precious metals mined in the State since the discovery of gold over 50 years ago. But this vast wealth is far surpassed by the value of the great streams to manufacturing and agriculture. It is stated upon authority that more power can be developed in seven miles of the Missouri at Great Falls than is possible at several other populous cities whose wealth and influence are largely dependent upon their power sites.

The Rocky Mountain forest is one of the distinct vegetation regions in North America at the present day. It is conspicuously coniferous, evergreen; everywhere the somber influence of the fir and pine. But while the conifers or softwoods are in the ascendency as to numbers, as species the hardwoods far exceed them. The latter, of course, are more abundant along streams and in other situations where soil moisture is adequate the year round.

The forests of the northern Rocky Mountain region contain 5 or 6 species of pine, 1 of spruce, 2 of larch, 2 hemlocks, 1 Douglas spruce,

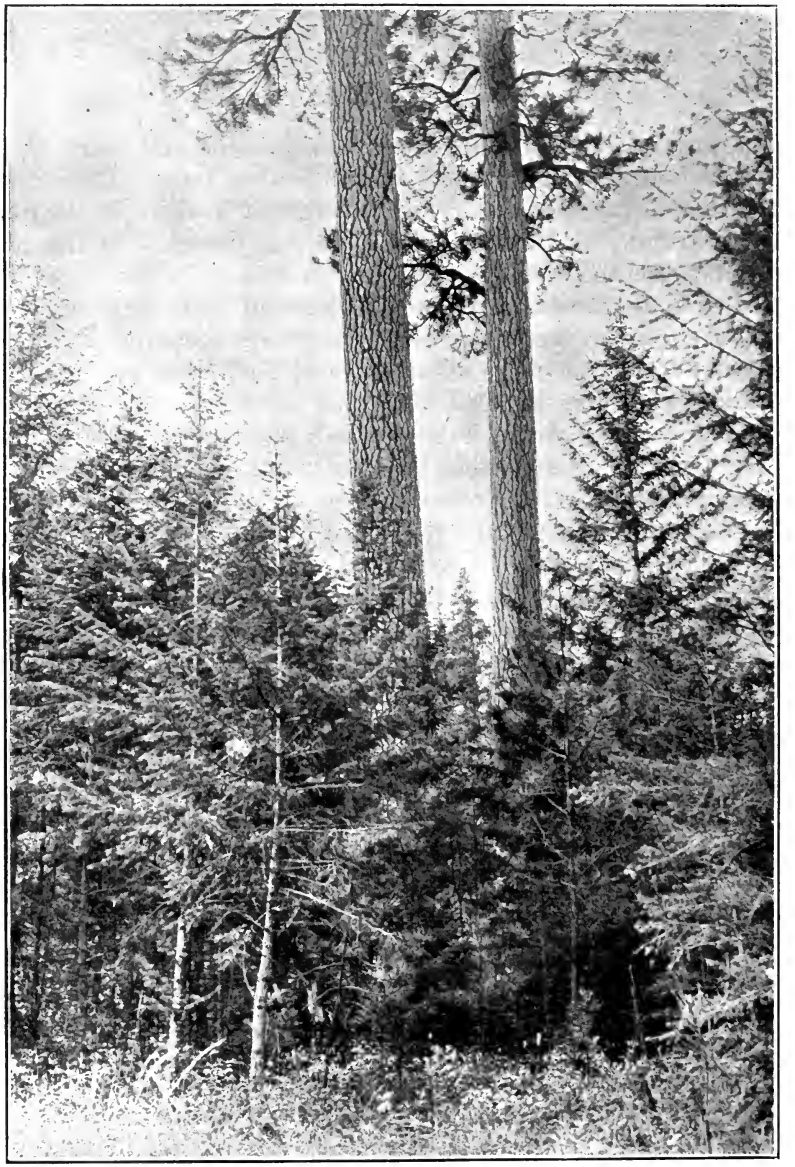

FIG. 2.—Mature Western Yellow Pine, with undergrowth mainly of Douglas Spruce. Bottom lands of Lolo Valley, Montana.

2 firs, 1 arbor vitæ, 4 junipers, and 1 yew. Among the hardwoods are 5 cottonwoods or poplars, 30 willows (of which only 7 or 8 are

found in tree form), 3 species of alder, 4 of birch, 3 of cherry, 1 of plum, 4 of hawthorns, 1 of mountain mahogany, 1 of maple, 1 of mountain ash, 1 of dogwood in tree form, and 1 of cascara. The Rocky Mountain forests, however, are more noted for things which they lack than for things which they have. Genera which are conspicuous east or west are either wholly lacking or at least very sparingly represented here. There is no native oak, hickory, elm, walnut, chestnut, sycamore, or locust. Of the many and vigorous kinds of birch, alder, maple, plum, cherry, and hawthorn of the eastern and western forests, there are only the few and inferior species mentioned.

The northern Rockies have a composite flora, not only with reference to forests but also in the lesser vegetation. That is, few species of trees seem really to be indigenous, and these are mingled with the majority which have migrated in from other sources during long periods of time. To get a better idea of what this means, it is necessary to review some of the earlier conditions.

All vegetation of the earth has been subject to periodic change and influence in relation to geology. Long ages ago,[1] in the early Cretaceous period, a continuous forest of conifers and cycads covered the North American Continent. In the late Cretaceous the land became divided by an arm of the sea which extended north from the Gulf to the Arctic through what is now Texas and Montana. During this period was the beginning of the marked differentiation of the eastern flora from that of the West. In the East are the elm, hickory, chestnut, persimmon, sassafras, tulip, Osage orange, and magnolia, which are not found on the Pacific coast; in the West are the Sequoias, cypress, and giant cactus, which do not occur east of the Rocky Mountains. Oaks are on both coasts, but not the same species of oaks; the same to a large extent is true of maples, alders, pines, firs, and many others. Toward the close of the Cretaceous there entered many hardwood types of modern form. The eastern slope of the Rockies was more humid in the Cretaceous and Tertiary than now, as one may judge by the petrified forests scattered from the Yellowstone Park to Arizona, and the remains of holly, oaks, elms, chestnuts, Sequoias, and other trees in the Florissant shales of Colorado.

In the Tertiary age the East and West were again united by land. But this was a period of successive uplifts and depressions. Areas became submerged and their forests destroyed. Other areas were subjected to severe changes locally. Erosion and other disturbances must have greatly modified the character, proportion, and distribution of the species.

With the advent of the glacial period great fields of ice pushed southward, carrying destruction to the forests before them. Smaller

[1] Harshberger, John W. Phytogeographic Survey of North America. Leipzig, 1911.

intermountain glaciers worked destruction in forests not touched by the main sheet. Evidence of such glaciers is abundant through-

FIG. 3.—Near view of the trunk of the Western Yellow Pine. Tree about 3 feet in diameter; young Yellow Pine in the foreground.

out the whole region. It is probable that some survived in advance of the ice, but modifications of climate during this period must have

been so profound as to affect severely all the forest growth within a considerable radius. Arctic vegetation preceded the glaciers and retired with them, but the descendants of some of the species are still found upon mountain peaks.

With the final recession of the ice, vegetation reoccupied the area in successive waves. First the circumboreal plants, driven by the rising temperatures, followed close upon the retreating feet of the glaciers. In the hollows were lakes and ponds which were soon occupied by a swamp flora. Following these came the conifers, to rehabilitate the land with a forest covering.

About six regions of North America are now regarded as ancient centers of plant migration. From these the northward movement began at the close of the glacial age, and some of them furnished the material for replanting the land denuded by the ice. Two of these are important in the present discussion. The Arctic flora has already been mentioned as having left its traces on the tops of the highest mountains, but it is hardly represented by any woody species except a few dwarf willows and heaths.

Two centers of distribution remain to be considered. One of these occupied a strip of the Pacific coast from northern California to Washington west of the Cascades. From it species moved southward, northward, and eastward. Some have now reached the Bitter Root Mountains and the Flathead Valley, others have passed on as far as the Black Hills. Those trees which have arrived from the Pacific center are the grand fir, the Douglas spruce, the western larch, the white pine, the hemlocks, the arbor vitæ, the yew, the mountain ash, the black cottonwood, the cascara, the flowering dogwood, several willows, and many lesser plants.

The other source of the Rocky Mountain flora lies in the far-off Appalachians of the Carolinas and southward, where the flora is one of great antiquity. Some of its species have stayed at home, but others have wandered far afield. Those which have gone farthest are those most easily aided by the wind in the distribution of their seeds. From the Appalachian country some plants moved into Texas and Kansas, others followed the Atlantic coast northward and occupied the country of the St. Lawrence and the region east of Hudson Bay. Still others wandered far to the Northwest, following the streams across the plains or north into Canada and thence across the continent, reaching the Pacific shores at Cook Inlet. In the Rocky Mountains some of these moved southward, as the white spruce, said to occur in a few places in Montana, but common throughout Canada and the northeast. Among other trees from this source might be mentioned two species of dwarf juniper, the common cottonwood of the Missouri Valley, the balsam cottonwood and the

aspen, the box elder and the paper birch, besides a number of willows and lesser shrubs.

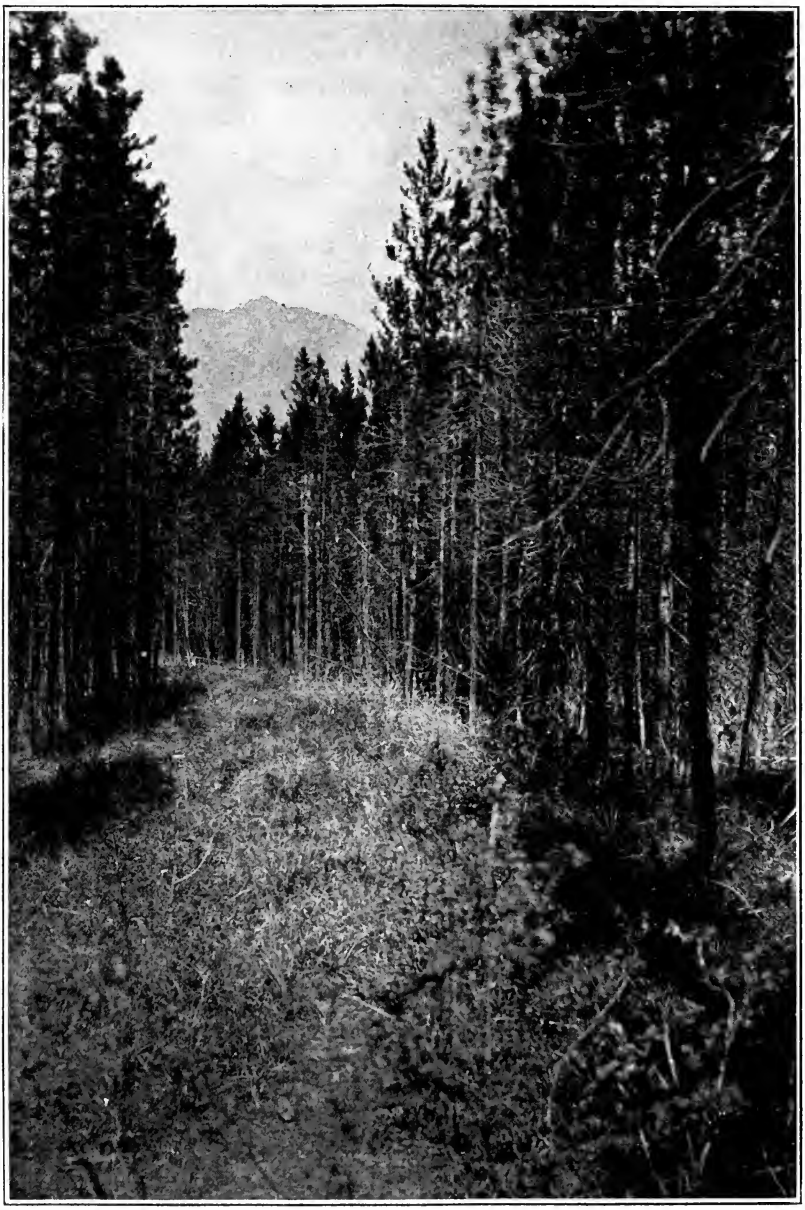

FIG. 4.—A forest of Lodgepole Pine in the Glacier National Park. August.

With these two centers in mind as the contributors to our flora in the most liberal way, there remain to consider some which are

indigenous, supposed to be relicts of a previous age when, owing to a more humid climate, they were more widely distributed than now. Among such are the Engelmann spruce, alpine fir, yellow and lodgepole pines, all very common and widely distributed species.

Thus it will be seen that in the northern Rocky Mountain country, the eastern and western floras overlap, and there, mingled with both, are the remnants of an ancient indigenous flora and the traces of an Arctic migration.

Among the several climatic factors which influence vegetation undoubtedly the most important are rainfall and evaporation. Temperature is likewise important, but within the area under discussion its influence is seen more in the distribution of species within certain limits of altitude than of latitude. Important as the annual rainfall is in determining the character and extent of the forest, more important still is the seasonal distribution of rain. The forests of the Ohio Valley are deciduous, broad-leaved woods of oak, hickory, maple, and other species demanding ample supplies of water, which are provided in an annual precipitation of 40 to 50 inches, much of which falls in the summer. Here also is a relatively low rate of evaporation. On the other hand, the forests of western Oregon are mainly coniferous and evergreen; the total rainfall is 50 to 100 inches, but it occurs mostly outside the growing season. The summers are usually too dry for anything but hard-leaved trees, except where soil waters are near the surface. The Rocky Mountain region is, in these respects, similar to the west coast, especially in its most heavily timbered sections.

Contrary to a somewhat prevalent theory, the forest follows the rain; not the rain the forest. There is no evidence at present that the forests have any influence on precipitation. The relation of forest crops to climate has long been an object of thorough research in Germany, and many facts are now well established.

The southeastern States of the Union have a rainfall of 50 to 70 inches a year. East of an irregular line from eastern Texas to Maine is a region having 40 to 50 inches a year. Westward the annual rainfall decreases to 10 to 20 inches, including the plains country, roughly from Canada to Mexico and from the eastern line of the Dakotas to the Cascade Mountains. The higher altitudes of the Rockies are favored with somewhat more, and are marked by the heavier forest formations. Fifteen inches a year is about as little as will allow forest growth, except by the mitigation of certain factors, as lower temperatures, less wind, higher relative humidity, and lower rate of evaporation. The areas of lowest precipitation are either prairie or desert.

Throughout the mountain country there is more or less definite relation between topography and local forest distribution. The

forested and the unforested slopes do not always stand in the same relation to the points of the compass. The conditions which occur

FIG. 5.—White Pine, in the Flathead Valley, Montana. July.

about Missoula may be cited as an illustration. Here it is noticeable that all the highest points are forested and most of the lower slopes

are grassland; and somewhere between, the forest and the grassland merge; also that the northern and eastern slopes are wooded to the base, while the others are bare. These features are purely a response to the distribution and storage of soil waters. Southern and western slopes exposed to sun and wind are too dry for the growth of trees; the northern and eastern exposures are more favorable, for there the snow lies later in the spring, the heat is less intense in summer, and at all times evaporation proceeds more slowly. The drier slopes, if wooded at all, are usually clothed sparsely with yellow pine and Douglas spruce; the other slopes with larch and Douglas spruce and lodgepole pine. Thus it appears that not only the features of local forest distribution are under topographic control, but also the composition of the forests and the proportions of the various species.

One is impressed by the fact that the forest species themselves differ much in their requirements. Some are like the meek; they are modest in their demands and they inherit the earth; others maintain a sort of aloofness, circumscribed by rigid demands of their own organization to a particular set of conditions. As an example of the latter is the western white pine; limited by requirements of moisture in soil and air, by a scant production of seed and by peculiar habits of growth from the seed, by a relatively narrow range of favorable temperatures, by a marked susceptibility to disease and to injury by fire, its distribution is restricted to the Cascade Mountains and especially favorable situations in the northern Rockies. On the other hand its relative, the yellow pine, easily satisfied with soil and moisture conditions, enduring a temperature range of 160 degrees or more, early and prolific in bearing seeds of good vitality and germinative power, resistant to fire and disease, is found from the British Possessions to Mexico and from the Black Hills to the shores of the Pacific.

Thus might be summarized the nature and habits of any forest species, and it would be found that such facts bear an intimate relation to its geographic distribution; and conversely the distribution of a species indicates the range of its requirements and adaptability.

Among the most significant and interesting facts of forest distribution are what are known as vegetation cycles or succession of types. A given forest may not be the permanent or final type of forest which is to occupy the area. An example may be found in the transition from grassland to heavy forest evident in various places in the intermountain region. The prairie is gradually invaded by the forest and ultimately yields to it fully. The pioneer in this invasion is the common yellow pine, closely followed by the Douglas spruce. Through centuries the forest increases, and the soil, enriched by the deposits of vegetable matter, becomes more capable of retain-

ing moisture. When this condition has been reached other trees are able to maintain a foothold, and being more tolerant of shade than

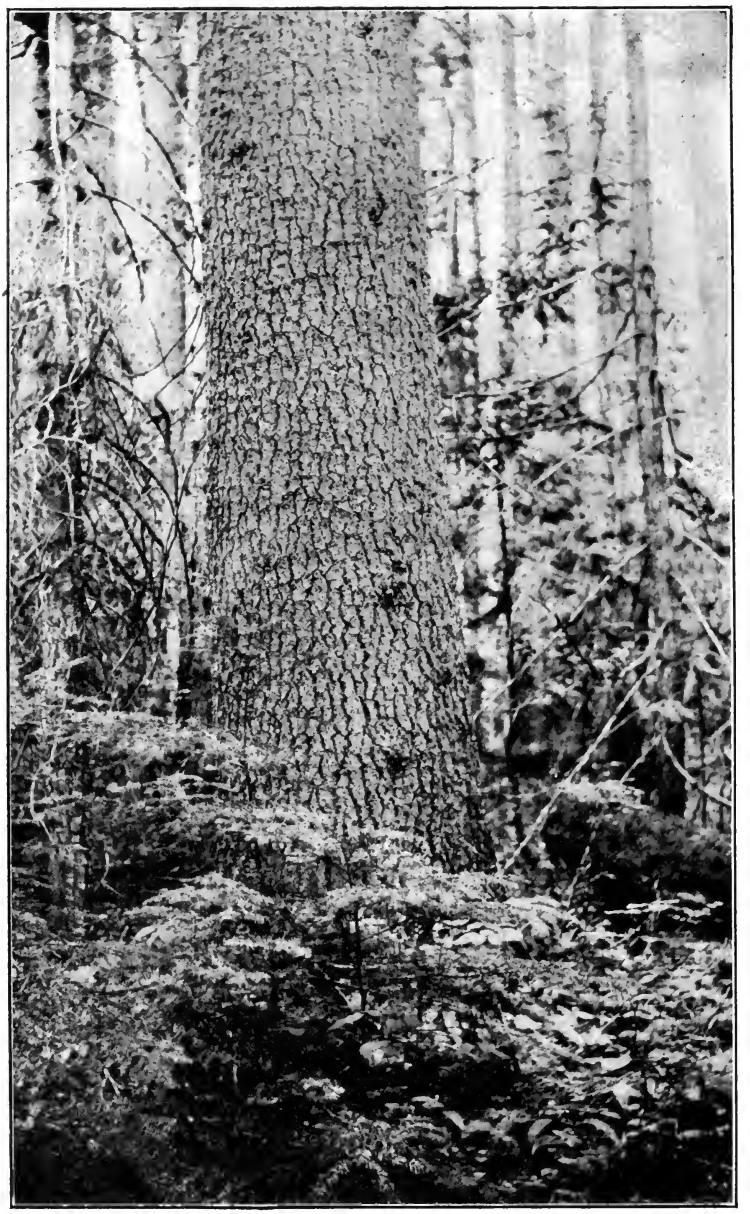

FIG. 6.—White Pine, on Priest River, northern Idaho. Tree over 3 feet in diameter; young Western Hemlocks in the foreground. July.

the pines, grow up among them and gradually crowd them out. The grass and the first growth of shrubs entirely disappear, and a

forest of entirely different aspect achieves dominance over the whole area. Along the shores of Flathead Lake are forests of fir, larch, and spruce, mixed with some hardwoods, which can be traced back to the beginnings of pines and grassland.

Slide-rock areas are common everywhere in this region. They vary from the clear gray of freshly broken rock fragments of the talus to forested slopes in all stages of development. Thus the rocks support a lichen crust which is gradually replaced by mosses. Under disintegrating influences affecting the surface layers of the rock and the accumulation of vegetable matter a foothold is given for small herbs, and then for bushes, and at last for the forest.

Similarly, changes are slowly transforming ponds into bogs and bogs into solid ground, with corresponding changes in the plant covering. River deltas and bars first occupied by the sand-bar willow increase in height and area by the augmenting influence of the willow itself, giving place to cottonwood, alder, and birch, and finally to spruce and other species.

Examples might be cited indefinitely, illustrating the march of forest development through changes by insensible degrees which pass unnoticed from generation to generation. The tendency is toward a climax type, which, so long as the climate does not change, will maintain a balance among its constituent species, among which some will be dominant and others dependent. In the climax forest they will always be shade-enduring species, for so long as the stand is open, as it must be with species intolerant of shade, just so long may other and more tolerant ones enter. Traits of a species which give dominance in a forest society may be rapid growth in height, tolerance of shade, simplicity of soil requirements—either of these or all of them taken collectively. But even in a climax forest there is no truce to the warfare; there is merely balance of the contending forces. Disturb this balance by the removal of a part, and battle is again joined, with the advantage to one side or the other.

Looking, then, into the distant future, we might expect changes to come which, if left untouched by human agency, would end in complete forest covering of the land and growth in density as well as in area. Such changes, however, are in their nature and progress like geological changes of erosion and deposition, of elevation and subsidence, always toward a more or less certain and definite conclusion. But with the forests the hand of man can affect the result and is most sure to do so.

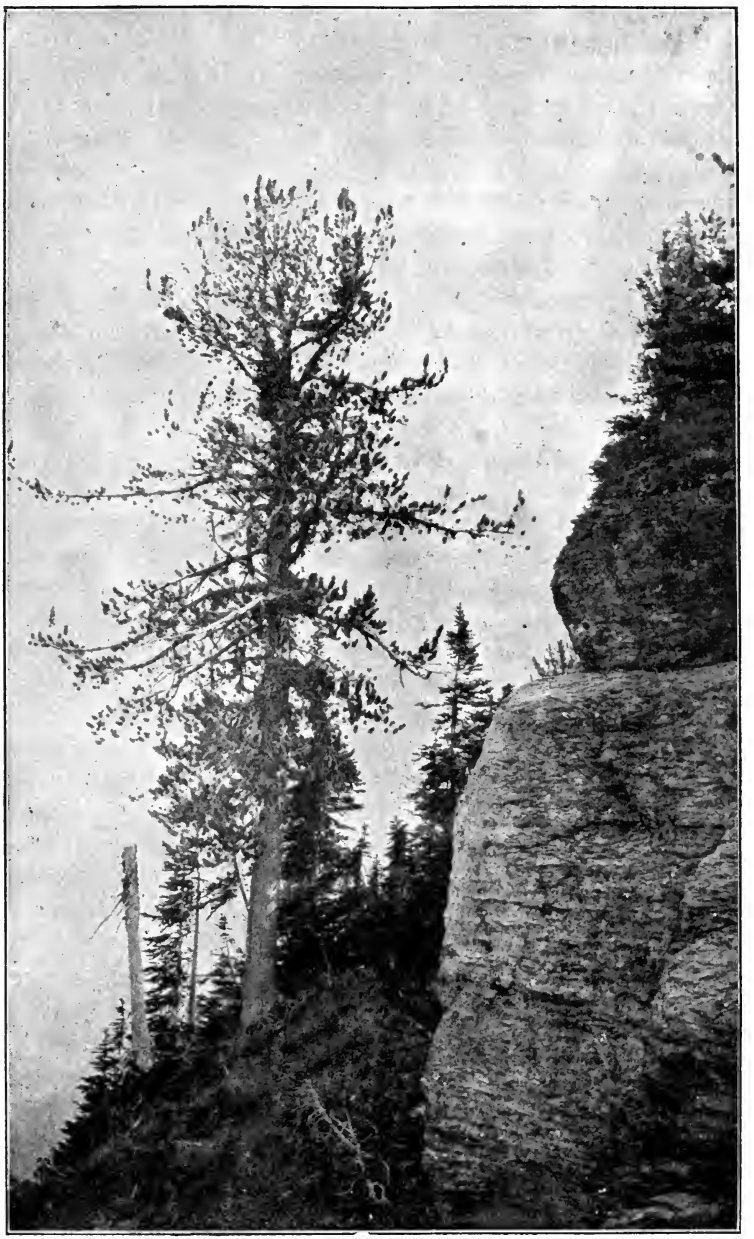

FIG. 7.—Whitebark Pine in Glacier National Park. About 16 inches diameter; altitude about 6,500 feet.

II. THE SPECIES.

The conifers are members of the pine family. Those of this region are, with one exception, evergreens. The majority are needle-leaf trees which bear cones and seeds provided with thin, wing-like appendages, which facilitate their distribution by the wind. The seeds are produced on the upper surface of a flat, scale-like structure, though in some cases not obviously so. The exposed position of the seeds is a mark of one of the primary divisions of the seed-bearing plants, viz, the gymnosperms; the other one of the primary divisions, the angiosperms, is characterized by the production of seeds inclosed in a pod, capsule, or other structure. The flowers of the pine family are simple, inconspicuous structures, which open early in the season. They are always of two kinds; one kind, which are relatively few in number, ultimately matures the seeds; the other kind is produced in far greater numbers and bears the pollen. Members of the pine family are all woody plants; most of them, the largest of our forest trees, have straight central shaft and symmetrical growth; others are more or less irregular in form and of low and spreading habit.

The flowers, and later the cones, consist of a central axis upon which are closely arranged scale-like structures in spiral or circular order. The male or pollen flowers vary from an eighth of 1 inch to 2 inches in length, and on the lower surface of each scale are two or more minute sacs, in which the pollen in produced. This pollen is usually discharged in May or June, and the flowers then usually drop off, though often they may be found dry and withered, clinging to the branch. The pollen of many species is produced in such quantities that it issues from the crowns of the trees, when stirred by the slightest breeze, in clearly visible clouds, dustlike, and settles on the surrounding vegetation as a yellow powder, or washed by rivulets into golden windrows. Some of this pollen falls, perchance, upon the female or seed-producing flowers, where it effects fertilization. Pollination of the flowers is thus left solely to chance through the agency of wind, and the fact of so much waste necessitates the production of a vastly greater quantity of the pollen than is actually used. The male germ cell in the pollen grain must unite with a female germ cell in another flower, in order that a seed may be produced, and one such union is necessary for each seed. The female

flowers, so called, also possess a central axis, though in this case there are two series of lateral members instead of one. One series is called the scales; these bear the potential seeds upon their upper surfaces, and later form the principal material of the cone. The other series

FIG. 8.—Limber Pine. On an exposed ridge east of the Divide.

is known as the bracts, one of which is situated below each scale. In the earlier condition of the cone the bracts are usually conspicuous and surpass the scales, but later the scales outgrow the bracts and in the majority of cases conceal them.

The cone fruit is matured in one or two years. Some species then spread apart the scales of the cone upon drying and allow the seeds to fall out; they are carried away by the wind. Seeds thus distributed are usually provided with an ample and thin membranous wing and a kernel of oily material that is somewhat lighter in weight than starch, a common reserve material in seeds distributed by other means. Seeds of this group of plants have usually a hard outer shell inclosing a mass of rich oily food material, in the center of which is embedded the germ or embryo. The latter is the young tree, consisting of a cylindrical stem terminated at one end by the initial root structure, and at the other by seed leaves or cotyledons to the number of two or more. The food material serves the young plant until it becomes established in the soil; the seed leaves then spread apart and remain throughout the first season as leaf-like structures.

The seeds of most conifers under proper conditions germinate in one to two weeks. With some exceptions they are of transient viability. Conifers as a class have leaves of hard or leathery texture, which lessens the amount of moisture they impart to the air; consequently they are often found in situations too dry for broad-leaved trees. They are trees of hardy nature, are widely and abundantly distributed over the earth, and are plants of ancient origin, whose ancestors were a dominant type of vegetation in earlier periods of the earth's history.

The members of the pine family are classified mainly upon the basis of the form and structure of the leaves and cones, though other features, such as the arrangement of the leaves, qualities of the wood, and the characters of the bark, are likewise important. Beyond these characters each species has its own peculiar limitations as to light, temperature, moisture, and other factors which influence, or determine, its local and general distribution.

THE PINES.

The pines are easily recognized by the form and arrangement of their leaves, which are usually from 2 to 6 inches in length, needle-like and clustered in twos, threes, or fives. They are borne thus on short lateral branches, accompanied by a scale or bract inserted on the main branch just below the position of the short lateral. Some species shed these bracts early; others retain them for several years. Species also differ in the length of time during which they retain their foliage leaves. All are bound to fall at some time, but new leaves come out every spring while the leaves of other years are still upon the branch, so that the tree is never without leaves. On some pines the leaves remain for 2 years, in others for 3, 4, 5, or even 12 years. When they fall they take with them the small twig on which

they grew, so that the pine leaves on the forest floor are in clusters, as they were upon the tree. Small, round scars remain upon the branch from which the clusters have broken away.

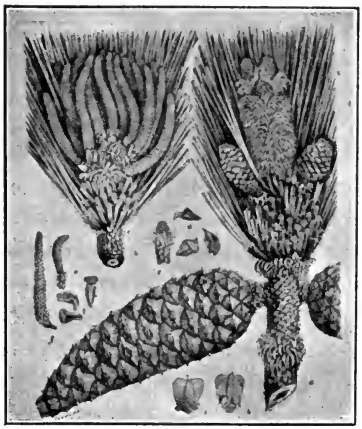

FIG. 9.—Southern Longleaf Pine. Illustrating position of staminate and ovulate flowers. Upper left, a branch with staminate cones; right, a branch with cones of three ages; at the top are two small cones at time of pollination; midway two cones a year older; below, cones approaching maturity.
After Mohr. By permission of U. S. Department of Agriculture.

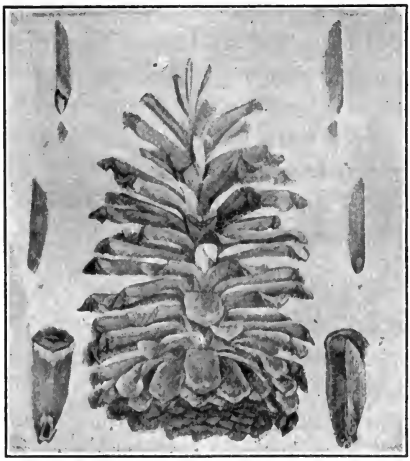

FIG. 10.—Pine cone, open. Below, to the left, lower side of seed-bearing scale showing bract; to the right, the upper side showing seeds; above to right and left, seeds with wings.
After Mohr. By permission of U. S. Department of Agriculture.

The buds produced at the ends of branches appear to consist of narrow overlapping scales, covered with gum or resin. Beneath each scale is a small green body which is the rudiment of a leaf cluster for the following season. The growth in length of the branch in any season is but the elongation and enlargement of the structures pre-

viously seen in the bud, and the bracts that accompany each lateral twig are the erstwhile bud scales.

The cones of the pines are produced at the outer ends of the branch growth for each season. They appear there in an inconspicuous form at first, but as their maturity requires two seasons, they appear when ripe at the end of the growth of the season next preceding. The pollen flowers, on the other hand, appear at the base of the shoot of the season. The mature cones of the pine are oval or oblong in form, hard, woody, and vary greatly in size among the native species.

There are two series of pines, commonly known as white and yellow. The former, among the species of the northern Rockies, is recognized by leaves borne in clusters of five and by the smoother points of the cone scale; the wood of the white pine is usually softer, lighter in weight and color, and less resinous than that of the yellow pine. The leaves of the yellow pines are in twos or threes; the cone scales are prickly, and the wood darker and more resinous.

The western yellow pine.—The most common and widespread of the pines of the northern Rockies is the one known as the Western Yellow Pine (*Pinus ponderosa*). It is found, in fact, all over the western half of North America, from the Black Hills to the coast and from British Columbia to Mexico, in some places forming splendid forests, in others reduced to scattered and impoverished specimens along the rim rock of the Missouri and the Yellowstone. It is the most drouth resisting of our forest trees. It gradually invades the grasslands and covers them with forests. It is a tree that demands a great deal of light, hence it never forms dense forests, but more or less open stands with grass and some shrubs beneath. Its seeds are scattered far and in great numbers.

This tree is recognized by its leaves, cones, and bark. The leaves are about 6 inches in length, the longest of any of the Montana pines. They are usually found in clusters of three. The cones are oval, about 4 inches in length, firm, dark brown or purplish, and each scale is armed at the end with a sharp recurved barb or pickle, which later falls off. As in all pines, there are two seeds on the upper surface of each scale, and below the scale a very small and inconspicuous bract. The cones open in August or September to discharge their seeds. Squirrels are very fond of the seeds and cut off and store great quantities of the cones; several bushels may sometimes be thus stored away beneath a pile of logs or brush, where tell-tale piles of scales reveal the secret, and may lead to the loss of the store if some seed-hunting forester happens by.

But some seeds escape the squirrels, and perchance also the birds and mice, and, if they fall on good ground and are favored with moisture and warmth, in time bring forth young trees. At first there

appears a short stem topped by a circle of small seed leaves whose tips are still bound within the coat of the seed, whence they are drawing food for the young tree until it becomes firmly rooted in the soil. After a few days the seed drops off, the seed leaves spread wide apart, and out of the center of the circle arises a tender stem with delicate pale green leaves, much like the seed leaves, but shorter. As the stem grows longer, its leaves are single, are not arranged in a circle, but are alternate. The small stem with its tender leaves is the beginning of the huge trunk of later years. The first summer it grows only an

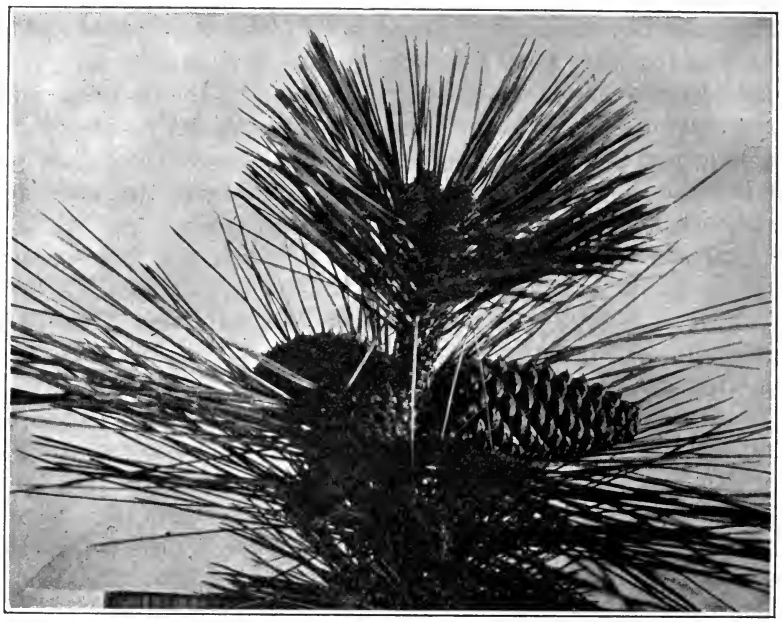

FIG. 11.—Western Yellow Pine. A branch taken in July. The small cones in the center above were pollinated in May preceding; the larger cones below are a year older, and would have ripened in late August. About one-third natural size.

inch or two above the seed leaves, and closes the season with a straight stem and no branches, but its root has gone deep into the soil, where the earth seldom dries out. At this stage the small top above ground needs little water, but the young tree is getting ready its roots to feed the larger top which is soon to come. No buds are formed the first season. The next season the stem renews its growth, and the roots are extended farther into the soil. The stem lengthens in early summer, if conditions are favorable, to several times the growth it made in the first season, and ends with the formation of a terminal bud and several lateral buds close under the terminal one. These lateral buds are the forerunners of the first of the circles of branches which are formed at intervals and characterize the growth of this and other species.

The trunk of the tree may reach a diameter of 5 or 6 feet and a height of 150 feet. Its bark is yellowish in color, divided by deep grooves into oblong areas of fairly uniform size.

The wood of this tree is of large importance commercially, and lumber from it is the principal product of many mills throughout the timbered portion of the State of Montana. It is strong and durable, and is much used in buildings and in various forms of heavier construction.

The rock pine (*Pinus scopulorum*) closely resembles the western yellow pine, and there is considerable doubt as to whether it should stand as a separate species. Some authors regard it as merely a variety of *Pinus ponderosa*, while others consider it merely the mountain form of this species. It is found from the Yellowstone Park southward and mainly on the eastern side of the Divide.

This tree may reach a height of 150 feet and a diameter of 5 or 6 feet. The bark is deeply furrowed. The leaves occur in clusters of 2 or 3, usually 3, are 4 to 6 inches long, and are bunched near the ends of the branches. The cones may reach as much as 5 inches in length, with scales thickened at the ends and armed with a sharp recurved prickle.

The lodgepole pine.—Next among the pines from the standpoint of distribution is the lodgepole (*Pinus contorta*). It occurs from Alaska and the British possessions southward into Colorado and California. It is found in all parts of the State of Montana west of the Divide; in the central and eastern part more sparingly, scattered in diminishing numbers along the river banks and the higher elevations of land in the plains region. Its demands upon soil moisture are somewhat greater than those of the yellow pine; hence it flourishes upon northern slopes, on high ridges where winter's snows lie deep, and far to the northward it forms dense thickets around the mountain lakes. One of the characteristics of the lodgepole forest is its density. It grows while young in almost impenetrable thickets, but thins gradually with age to a stand of clean and slender poles, and attains sometimes a foot or two in diameter and a height of 50 to 100 feet.

The leaves of the lodgepole pine are 2 to 3 inches long and are borne in pairs. The cones are usually less than 2 inches in length, rather sharply tapering and one-sided, the scales prickly. The cones hang with persistency to the branches and open very slowly. Branches may be found with the cones of 10 or more years still in position and unopened. The reason appears to be that these cones do not always dry sufficiently on the branch. Sometimes a fire singes the tops of the trees. The heat, or the drying which follows the killing of the tree, opens the cones and allows the seeds, which are small and light, to be carried far and wide by the wind. The seeds of the lodgepole

are thus sown sometimes within two days of the passing of the fire, and being early on the ground and in great numbers are enabled often to preoccupy the ground to the exclusion of everything else. The

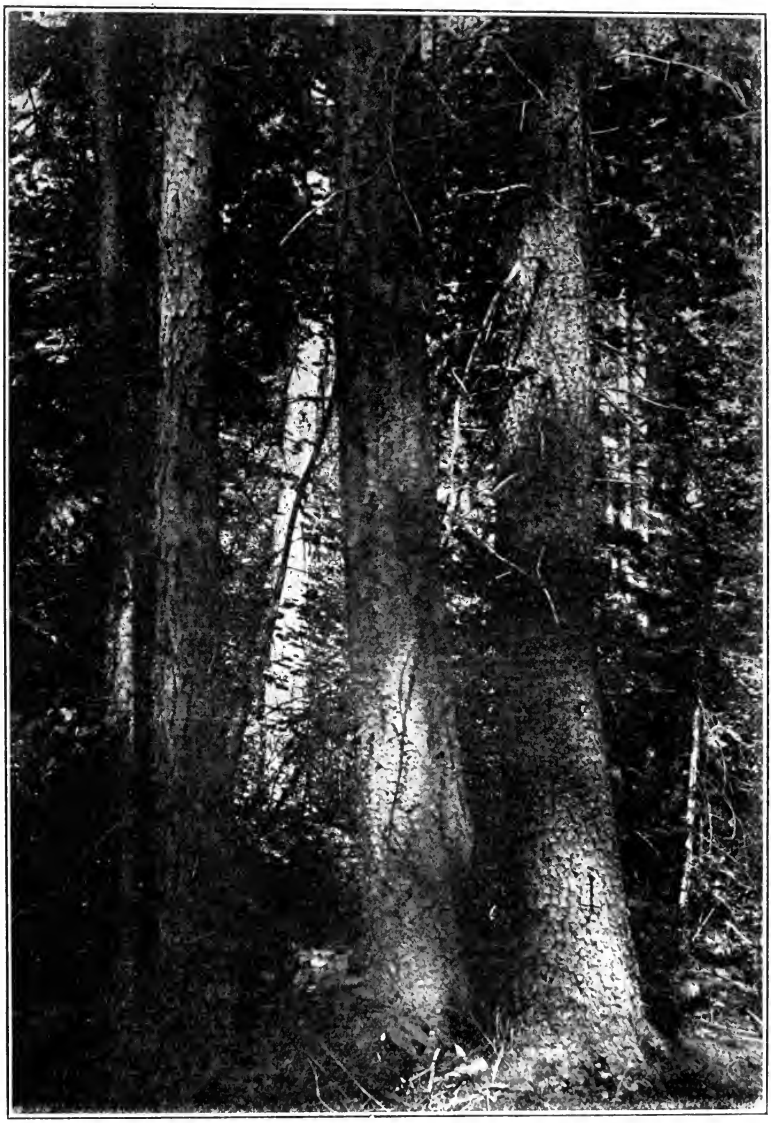

FIG. 12.—Three western Montana trees near Flathead Lake. Left, Western Larch; center, Douglas Spruce; right, Lodgepole Pine. The Lodgepole is about a foot in diameter. July.

seeds thus released are not one crop merely, but the combined fruitage of several years. The uniform density of lodgepole reproduction over wide areas is a natural result of wind sowing.

The bark of the lodgepole is thin and scaly, except sometimes at the base of older trees where it breaks up into rectangular blocks. The wood is highly resinous, but not very durable. It is used to some extent for railroad ties, mine timbers, and telephone poles, and where treated with wood-preserving agencies serves these purposes well. It is not as a rule manufactured into lumber.

The western white pine (*Pinus monticola*) is found only in the somewhat narrow range from the British possessions south on the west slope of the Rocky Mountains into Montana and Idaho and in the Cascade Mountains into California. Its range in Montana is confined to the western end of the State, where it seeks the better watered localities, either along stream bottoms, where it reaches its best development, or on the windward sides of the mountains where the precipitation is abundant. A tree less sensitive to shade than the others, it contends well with other species in its earlier years, grows rapidly in height, and overtops its rivals. Its seeds are provided with ample wings and are scattered far, though in rate of reproduction it is much behind the lodgepole and yellow species. It is much subject to disease and pests, and is easily injured by fire. These characteristics combine with other factors to limit its distribution.

This species may be recognized by its leaves alone. These are five in each cluster, 3 or 4 inches long, very slender, and of a pale green color. The twigs are smooth, and the bracts are shed early. The cones are nearly cylindrical, 8 to 10 inches long, and about 1½ inches in thickness. The scales of the cone are large, rather thin, and light brown in color. In its earlier years the tree has a smooth, light-colored bark, but with age this changes to a darker gray, broken up into small rectangular areas.

This is the most valuable of the forest trees of Montana and Idaho. White pine lumber, owing to its soft, even grain, clear color, strength, and desirability for many purposes, has a high commercial value. The best forests of this species are found in northern Idaho.

The whitebark pine (*Pinus albicaulis*) in its general range extends from Canada southward to Wyoming in the Rocky Mountains and to southern California through the Cascade Range and the Sierras. It is a tree of the higher altitudes, being found in Montana usually above 5,000 feet, and from there up to the timber line, where it becomes reduced in the bleaker situations to straggling and decrepit forms. In the more sheltered places where sufficient soil moisture is available it grows to a diameter of 4 or 5 feet, though usually much smaller, and may reach a height of about 60 feet. In places it forms pure forests, but often occurs in mixture with fir and spruce.

The form of the tree is characteristic. Its branches have a strong upward curvature, which gives the crown of the tree a candelabrum-

like effect by which the older ones can be recognized almost as far as they can be seen. One of the features of the tree is its frequent habit of growing in groups, sometimes five or six stems appearing to come from the same root. This is evidently due to the fact that the cones

FIG. 13.—Western Larch, in the Flathead Valley.

of this species do not open naturally to discharge the seeds from the tree top, but fall to the ground and disintegrate from the center. The result of this behavior is that a number of seeds are liberated on one spot and may give rise to a cluster of several trees. In time the

competition between the members of a group results in an advantage to some and the suppression of others, so that they vary greatly in size, and would seem to be of different ages. Examination of the stem, however, will usually show them to be of the same age.

The botanical characteristics of the species are rigid leaves about 2 inches in length, in clusters of five, and rather densely crowded toward the ends of the twigs. The cones are about 3 inches long, purple, with thick heavy scales. The seeds are relatively large, and, owing to the habit of the cones above mentioned, are almost devoid of wings. The squirrels frequently extract the seeds from these cones while they are still on the tree. The bark of the tree is thin, scaly, and light gray. The wood is often much twisted in the grain, and is soft, of even texture, and light colored. The small size and the inferior form of the trunk, and the usual inaccessibility of its habitat render the tree of little commercial value.

The limber pine.—Another species which is characteristic of the higher altitudes is the limber pine (*Pinus flexilis*), the general range of which is from Alberta to Arizona and southern California. In Montana this tree is confined to the eastern slope of the Continental Divide and to some of the outlying ranges. Ordinarily it reaches a diameter of 2 feet, more or less, and a height of about 50 feet, though in sheltered canyons it sometimes assumes much better form. When it descends among the dry and grassy foothills, it may be stunted and dwarfed.

Botanically it is similar to the preceding species, and its leaves and twigs are scarcely distinguishable from it. The cones, however, are somewhat longer and narrower, tan colored, and have thinner scales. The cones, when dry, spread apart to liberate the seeds. The wood is light in color, though fine grained, owing to the slowness of its growth. It is of no commercial importance.

THE LARCHES.

The larches are deciduous conifers. In the fall the leaves turn yellow, and in the winter the trees are devoid of foliage. Leaves to the number of 10 to 40 are borne in brushlike clusters. On the youngest shoots the leaves are always singly arranged and equally distributed along the branch, but at the close of the first season lateral buds appear here and there in the axils of these single leaves, and these buds give rise in the next season to clusters of leaves. The clusters are thus borne upon short, lateral branches, as in the pine, with this difference that in the larch the number of leaves is indefinite, such lateral branches are fewer in number, and they continue to grow slowly during the period in which they bear leaves. There comes a time, of course, when, owing to the elongation of the branch, they are left in the shade and perish.

In the early spring erect bright red flowers here and there may be found on the growth of the second season preceding; these are the seed-bearing flowers. In somewhat greater numbers on the same

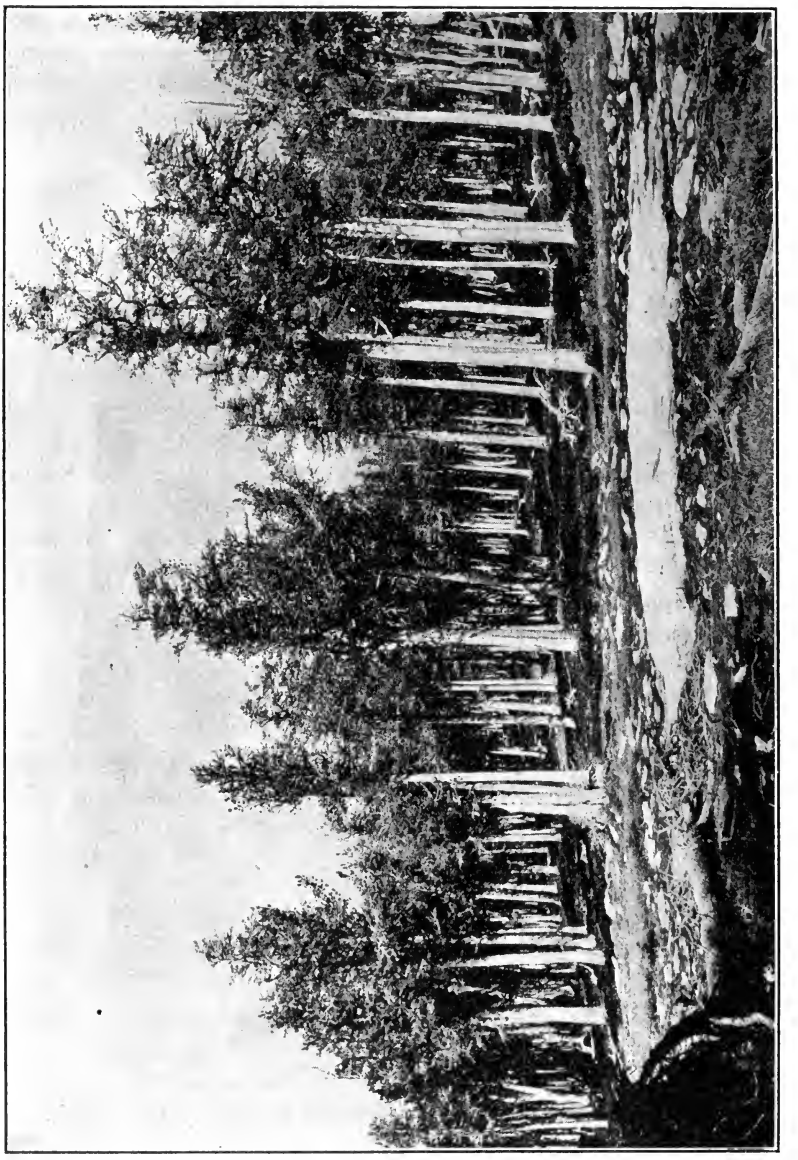

FIG. 14.—Lyall's Larch, on Mount Lolo. Trees a foot or less in diameter; about 8,000 feet altitude. August.

year's growth are smaller yellow flowers, which bear the pollen. Upon fertilization the red flowers turn downward; the pollen flowers wither and fall. The fruit of the larch is matured in one season. The cone is small, an inch and a half or less in length and

less than an inch in thickness. The scales are thin and the bracts protrude slightly. The seeds are less than an eighth of an inch in length, with wings three or four times the length of the seed, that provide for their wide distribution on even moderate winds.

The early growth of the larch is much like that of the pine. It grows rapidly under normal conditions, rising 1 to 3 feet a year. It needs considerable light and water. The form of the larch is narrowly conical in outline, with a thin open crown and numerous slender twigs. The species of the larch are few. There are but four in North America, and two of them occur in Montana. The larches are partial to cold regions.

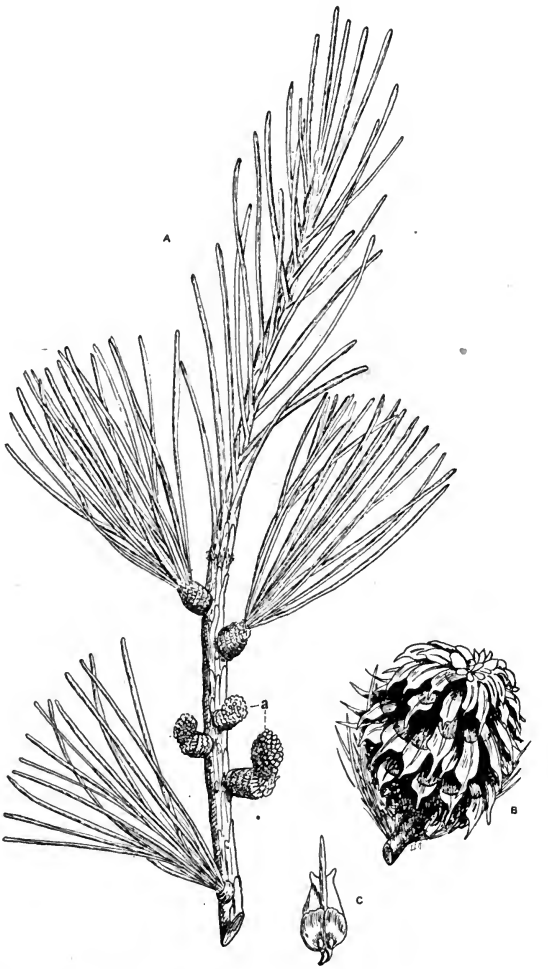

FIG. 15.—Western Larch. *A*, Branch two years old; the older portion bearing pollen flowers at *a*, and clusters of leaves on short spurs. Last year's growth with leaves arranged singly. *B*, A cone; C, a young seed-bearing scale and bract. About two-thirds natural size.

The western larch (*Larix occidentalis*) is found only in northwestern North America. It is also known as Tamarack, and occurs in the Rocky Mountains south to northern Idaho and northwestern Montana, and in the Cascades to Oregon; its northern extension lies within British Columbia. In Montana it is found west of the Continental Divide in the Flathead, Blackfoot, Clark's Fork, and Bitter Root Valleys and reaches its best development in Flathead and Lincoln Counties. In the drier portions of its range it is found on north slopes, which provide lower temperature and greater soil moisture.

The western larch sometimes reaches a diameter of 5 to 6 feet and a height of nearly 200 feet. Its thick bark below is a protection against small fires that would provel fatal to species less favored.

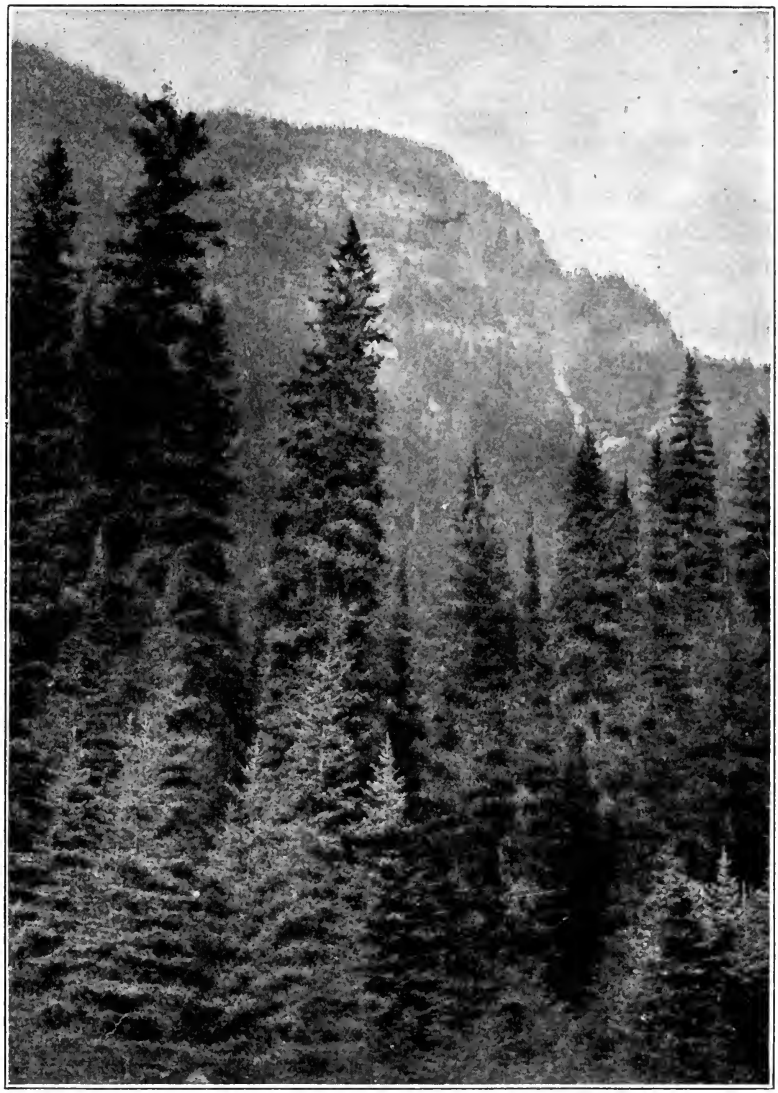

FIG. 16.—Engelmann Spruce, in Glacier National Park. Scene on creek bottom in August.

The leaves of this species, which are usually less than 2 inches in length, are triangular in form. The number in a cluster varies greatly. The cones are oval, an inch to an inch and a half in length, and of a brown color. The scales are the conspicuous parts, the tips

of the bracts projecting beyond their ends. The scales of the cones spread apart when ripe, to allow the seeds, which are borne on the upper surface of each scale, to disperse. The tops of older trees are scraggy and unsymmetrical. The bark is flaky, gray, or sometimes resembling that of the yellow pine in its oblong yellowish blocks. The wood is firm, light in color, but turns darker upon exposure to light. It is much used for construction and interior finish. It has considerable commercial importance and forms the chief output of a number of mills in the northwestern part of Montana.

Lyall's larch (*Larix Lyallii*) is also called Alpine Larch. Its range geographically is about the same as that of the other species, but it is restricted to higher altitudes, a fact which greatly circumscribes the area that it covers. It is found at altitudes of 7,000 feet or more, sometimes in pure uniform stands. It may attain a diameter of 2 feet and a height of 50 feet, but such dimensions are exceptional.

The marks by which Lyall's larch is recognized are the woolly coating on the growth of the last year or two, and the purple color of the cones, which are somewhat larger than those of the other species and have more prominent bracts. The bark of the tree is a light gray, thin and scaly. The wood is hard and of very fine grain, a feature, however, which is common to many species of the high mountains where growth is slow. The tree is of no value commercially.

SPRUCE.

A spruce tree is readily recognized by a few conspicuous marks. As a rule, it is a tree of rather dense foliage, with short, rigid, single leaves alternating in position. The points of the leaves are sharp; this causes the branch to present a prickly sensation to the touch. The leaves, moreover, are usually four-angled in transverse section. When the leaves fall from the branch they leave a prominent peg-like elevation, by which a spruce branch may be identified even in the absence of the leaves. The cones of spruces vary in size with the different species, but they agree in the suppression of the bracts and the drooping attitude which they assume upon the branch. Two seeds are borne on the upper surface of each scale, and these, when liberated, are provided with ample wings. The spruces are partial to moist soils and cooler climates. Some of the species are much used for paper pulp and produce lumber of fine quality. The Norway spruce, an introduced species, is commonly cultivated in many parts of the United States.

Engelmann spruce (*Picea Engelmannii*) is the only native species in Montana. Opinions of botanists differ somewhat in this matter, some holding that another species, *Picea Columbiana*, also occurs.

Observation, however, has borne the conviction that there are no real or constant marks distinguishing the two species. This tree has an extensive range. It is found from the Yukon to Arizona and

FIG. 17.—Engelmann Spruce, in the upper Bitter Root Valley, Montana.

New Mexico, over the higher elevations of the Rocky Mountains, and in the Cascades to northern California. In Montana it occurs at altitudes from 3,000 feet to timber line, where it often forms dwarfed

and stunted specimens. It seeks wet soil, is abundant around lakes, where it sometimes forms pure forests, and along stream bottoms, and again on high slopes where the moisture from melting snows is perennial. Owing to its moderate demand for light, it often forms dense forests, excluding every other form of plant life. It grows also at higher elevations, mixed with fir and pine, and on lower ground may reach a diameter of 4 and a height of over 100 feet.

The botanical characters of Engelmann spruce are seen in its various parts. Its leaves are about 1 inch long, and often covered with a whitish bloom, especially in younger specimens. They are sharp pointed and stand out in all directions from the twig. The cones are produced in numbers near the ends of the branches. They are about 2 inches in length and three-fourths of an inch in diameter, with thin scales, and bracts only minutely visible at the base of the scale. When ripe the scales of the cone spread apart, and the seeds from the tree tops are carried great distances. The bark of the tree is thin, scaly, and gray. The wood is light in weight and color. At present lumber is not extensively manufactured from spruce in Montana.

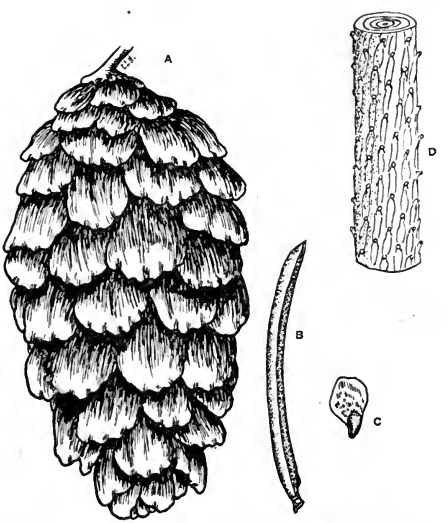

FIG. 18.—Engelmann Spruce. *A*, Mature cone; *B*, leaf; *C*, seed; *D*, portion of twig; about natural size.

The white spruce is reported as extending southward along the Rocky Mountains into northern Montana. This species extends across the continent from the Atlantic coast northward to Alaska. It is probable that the white spruce is very sparingly distributed in the Rocky Mountains within the United States, and is, of course, unimportant. It is described as a tree ordinarily less than 75 feet in height, with a diameter of 1 foot, more or less. The foliage has a light green color, with a whitish tinge, and the young shoots have a fetid odor when crushed. The leaves are somewhat shorter than those of Engelmann spruce, and the cones, usually less than 2 inches in length, are soft to the touch. The bark of the tree is brownish in color and broken into thin scales. This is botanically known as *Picea Canadensis*.

The blue spruce (*Picea pungens*) is found chiefly in the central Rocky Mountain region, but occurs as far north as the Yellowstone

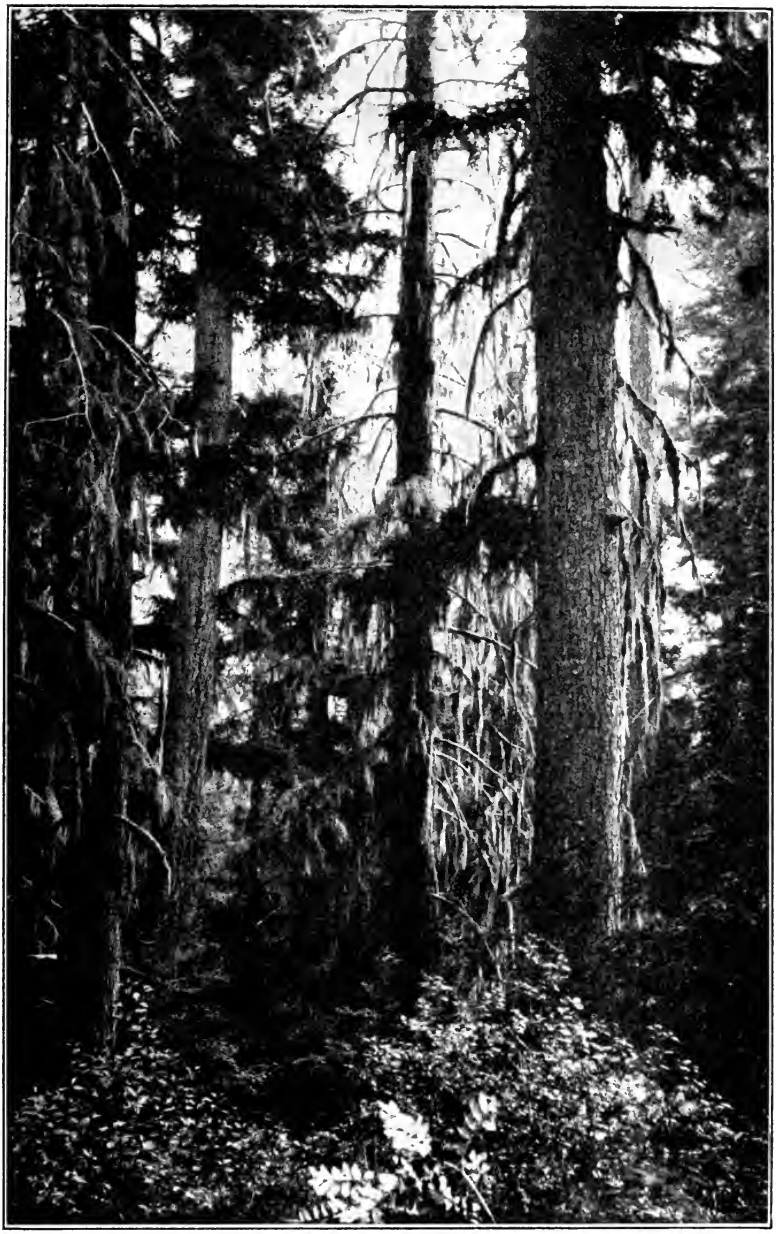

FIG. 19.—Western Hemlock, in Glacier National Park. The moist conditions are indicated by the lichen, *Alectoria*, hanging from the branches.

Park. It is called "blue spruce," because of the blue-green cast of its foliage, and is of some interest as being the "State tree" of Colorado. It is also known as *Picea Parryana*.

The blue spruce is a small tree and differs from Engelmann spruce in having smooth instead of pubescent twigs. In its growth it usually preserves a conical form, but often spreads its branches wide, and may be reduced to a shrubby form at high altitudes. The bark is gray, usually smooth and firm, in older trees becoming hard and thick. The twigs are shiny and smooth and the leaves about 1 inch in length and sharp pointed. Cones are usually plentiful, borne singly or in clusters, and 3 or 4 inches long.

The wood of this tree is of little importance commercially, but the trees are exploited much by horticulturists for ornamental planting and are widely grown throughout the country.

HEMLOCKS.

Four species of hemlock are native to North America. Two of these occur on the Atlantic coast and two on the Pacific. The hemlocks, like the spruces, prefer a cool climate and moist soil; they are also partial to regions of relatively high atmospheric moisture. They are trees that endure much shade and often grow in great numbers under other trees in a forest; veritable thickets of young trees sometimes occur in such situations. In form the hemlocks have some features that are distinctive. The leading shoot of the tree has a more or less horizontal or nodding habit for a foot or two of its length; the branches, at least the secondary ones, usually droop, and there are many small twigs which, though originating on several sides of the branch, come to be distributed in a more or less flat spray.

FIG. 20.—Western Hemlock. *A*, Twig and cone; *B*, seed-bearing scale; slightly enlarged.

In its botanical aspects the tree may be described as follows: Its leaves are usually much flattened and at the base narrowed into a stalk that becomes twisted in order to bring the upper surface of the leaf into the plane occupied by the spray of branches. The leaves are short and usually lighter colored beneath; they fall from the branch rapidly upon drying and leave a

small protuberance, similar to that found in the spruces, but not so prominent. The fruit of the hemlocks is a small cone with thin scales

FIG. 21.—Mountain, or Black Hemlock, in the St. Joe Mountains of northern Idaho; on the extreme left an Alpine Fir; altitude about 6,000 feet.

and very inconspicuous bracts. The seeds mature in one year, are small, light, and well winged. The bark of hemlocks is dark colored, hard, and rough, and less than 2 inches in thickness. The bark,

moreover, contains a large amount of tannin and is much used in tanning. The wood is usually hard, brittle, and not very durable upon exposure to the weather. The flowers of both kinds occur on the smaller twigs in great numbers, opening early in the spring.

The western hemlock (*Tsuga heterophylla*) is found from Alaska southward to northern California, and in the Rocky Mountains to western Montana and northern Idaho. Its range in Montana is confined to a few places in the northwestern portion of the State, in the Flathead Valley, the Glacier National Park, and in the better-watered situations westward. The roots of this tree spread thickly interwoven in the surface layer of the soil, so that the slightest ground fire is fatal to it. The seeds germinate readily upon old rotten logs and stumps and on whatever surface sufficient moisture is retained, and the roots ultimately reach the soil. In regions especially favorable to the growth of this species it is not uncommon to find trees 2 feet or more in diameter, with their roots astride some fallen log, or perched upon a stump 12 or 15 feet high; occasionally the destruction of its early support leaves the tree resting upon stilt-like roots. The young trees spring up in enormous numbers in the deeper forests, and their tops extend characteristically in a more or less horizontal spray.

The western hemlock does not reach its best development in the Rocky Mountains, but in western Washington and British Columbia, where it reaches a diameter of 5 feet or more and a height sometimes of 200 feet. The wood is useful for many purposes. Large quantities are used in the manufacture of paper. It has, however, no importance in Montana mills.

The leaves of this species vary a great deal in size, some a fourth, others 1 inch in length, with a median groove on the upper side; they are thickly produced in alternate arrangement along the slender twigs. The cones are less than 1 inch long and one-fourth to three-eighths of 1 inch in thickness, pendent from the ends of the twigs. The bark is hard and rough, and exceedingly rich in tannin.

The mountain hemlock (*Tsuga Mertensiana*), also called Black Hemlock, is sometimes regarded by botanists as belonging to a different genus. It bears, however, sufficient resemblance to the hemlocks to be discussed here. It is a native of the higher altitudes and is found from Alaska through the Cascade range to California, and in the Rocky Mountains to northern Idaho and western Montana. It is found in Montana only in the extreme western portions of the State. It is found at timber line and also at lower altitudes, where it is mixed in larger forests with pine and other species. The tree may attain a diameter of 4 feet, and a height of 60 feet, and bears a dense and narrowly pyramidal crown, the branches of which are sometimes heavily loaded with cones.

The leaves of this species are more pointed than those of the preceding and have a low ridge instead of the groove on their upper

FIG. 22.—Mountain Hemlock, about 4 feet in diameter.

surface. The dense foliage is dark green. The cone is about an inch and a half in length and about half an inch in thickness, cylindrical, and has thin scales. The seeds are small and possess ample wings.

by which they are carried far, as the cone opens on the tree. The bark is gray, coarse, and roughened by long ridges. The wood is firm and fine grained but of no importance.

DOUGLAS SPRUCE.

The genus to which this tree belongs is known to botany as *Pseudotsuga*, which means "false hemlock." It bears little resemblance, however, to the hemlocks, spruces, or firs, except in its general aspect. Two species are known, one of which is restricted in its distribution and of little value; the other is found throughout the Rocky Mountain region from British Columbia to Mexico and west to the coast, and is of immense importance economically. As but one species is to be considered in this discussion, the description of the genus will be included in that of the species.

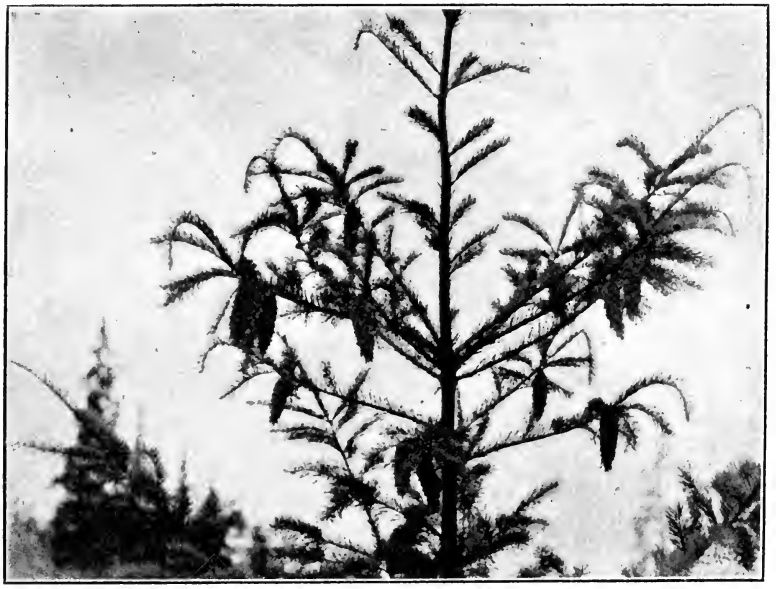

FIG. 23.—Top of a young Douglas Spruce.

The scientific name of this species is *Pseudotsuga taxifolia*. Several popular names are in common usage: Douglas spruce, Douglas fir, Oregon fir, red fir, yellow fir, Oregon pine, etc. The name Douglas spruce is here chosen, since the tree bears more resemblance to the spruce than to the fir.

This tree is found in practically all of the coniferous timbered regions of the northern Rockies. It furnishes a considerable part of the lumber manufactured in this region. It is often found growing with yellow pine in the drier situations, and it is one of the most drouth-resistant species. It grows much larger, however, where it

has abundant moisture, and on the coast where the rainfall is ample reaches great size. In that region trees of this species are some-

FIG. 24.—Grand Fir, typical form. A Pacific coast tree uncommon in the Rocky Mountains. Tree about 100 feet high in this case, but much larger ones are to be found.

times found with a diameter of 12 feet, and it is not uncommon to find trees over 200 feet in height.

The Douglas spruce is given to the formation of forests so dense in places as to shut out all direct sunlight from the soil. The abundant seeds produced by this species and the facility with which they are scattered by the wind result in the rapid reforestation of cleared land. The young trees come up in great numbers, sometimes in impenetrable thickets, in which the gradual suppression of the weaker members brings about in time a forest of tall, straight, and clear trees. The large amount of waste which naturally accumulates upon the ground and its resinous quality make fire risks imminent, and vast areas of fine timber have thus been lost. This tree is found from sea level in Oregon to altitudes of 5,000 feet or more in Montana, but

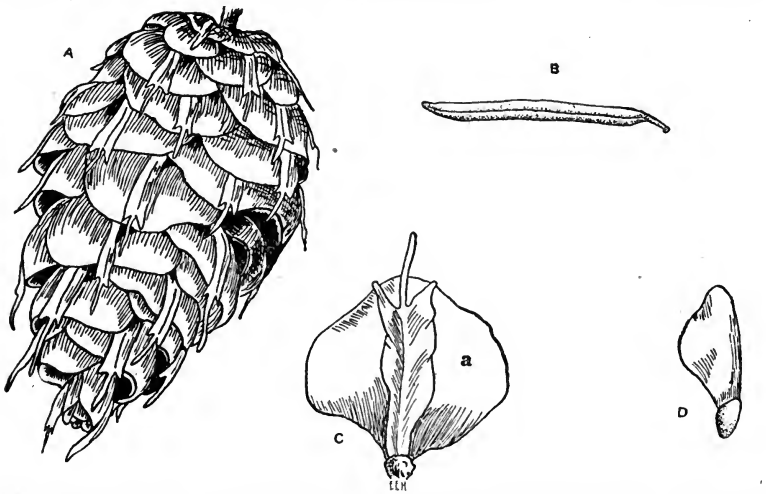

FIG. 25.—Douglas Spruce. *A*, Cone; *B*, leaf; *C*, bract and lower side of seed-bearing scale; *D*, seed.

is found only at altitudes of 8,000 or 9,000 feet in the southern limits of its range.

In habit this tree presents a straight central shaft and a crown somewhat oval in outline except for the sharp point of the conical top. The limbs droop, curving upward at the ends. The leaves are about an inch in length, flat, blunt, and paler beneath. They arise alternately on all sides of the smooth twigs. When the leaves fall they usually leave small protuberances on the branch, as in the hemlock; they fall less readily, however, in drying. The cones are 2 to 3 inches long, usually less than an inch in thickness, and have thin scales, on the upper surface of each of which two seeds are normally borne. One conspicuous and significant feature of the cones is in the bracts, which are three-pointed and project prominently beyond the end of the scale. This alone is sufficient to identify the tree in this region. The cones hang downward on the branch, and open on the tree to discharge the seeds.

The greenish, seed-bearing flowers appear erect on the young branches early in the spring, and the yellow pollen flowers appear near by in the axils of the leaves. The cones are matured in one

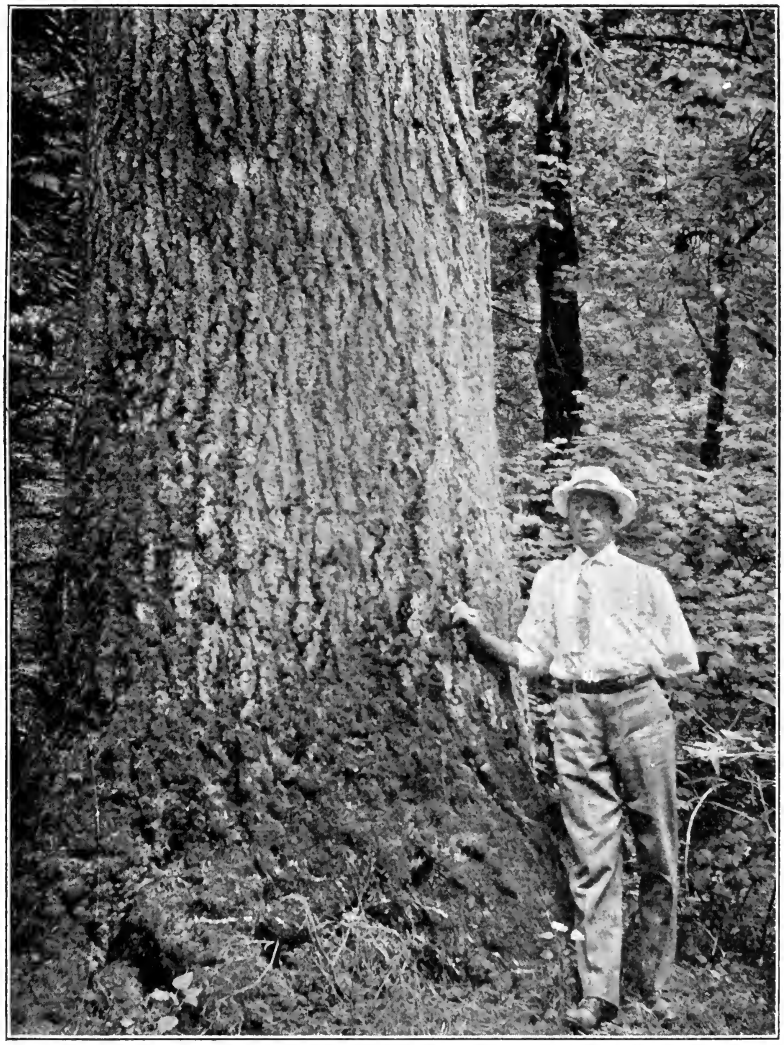

FIG. 26.—Grand Fir. In young trees the bark is smooth, but it grows rougher with age.

season. The bark of the tree becomes rougher with age, furrowed by long intersecting grooves. In its internal structure the bark reveals yellow streaks alternating with red or brownish ground tissue that may also serve as a mark of identification.

The Douglas spruce has been planted in the Eastern States and cultivated largely in Europe. Its wood is of great importance in heavy construction, for ship building, for masts and spars, for interior finish, and a great variety of uses.

FIRS.

Most of the true firs are large forest trees. They are natives of the cooler regions and are partial to moist soils. For these reasons they

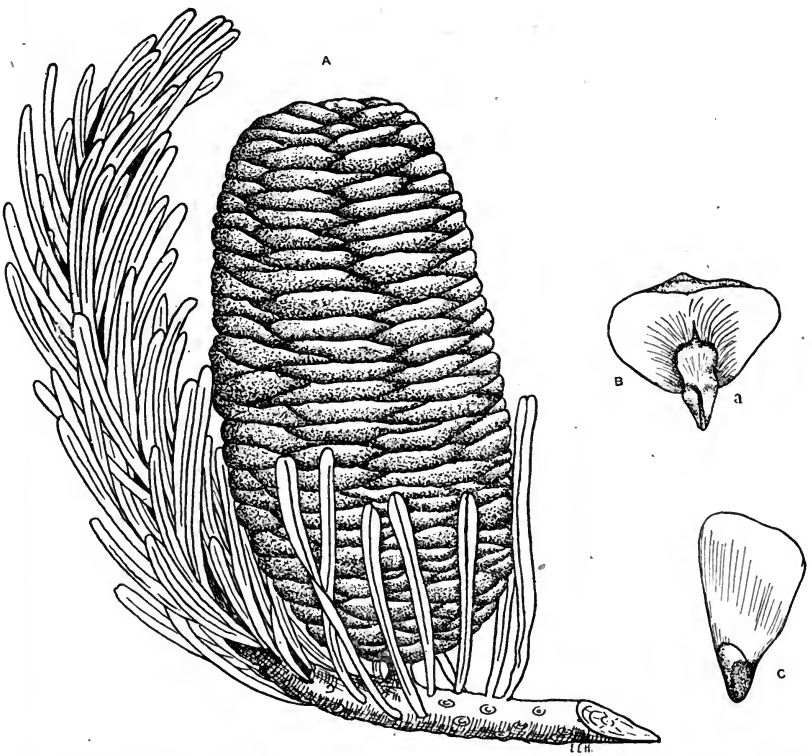

FIG. 27.—Grand Fir. *A*, Twig and cone in natural position; *B*, bract and lower side of seed-bearing scale; *C*, seed.

are found in northern latitudes and the higher elevations of mountains and reach their best development on river bottoms, in canyons, and on mountain slopes close to perennial snows. Many of them are shade-enduring species and grow for years in the shelter of thickets. Under favorable conditions they grow rapidly, reproduce plentifully, and are widely distributed, sometimes in pure, sometimes in mixed stands.

The distinctive marks of the firs are usually recognized with ease. The leaves are flat, blunt at the apex, and somewhat narrowed at the base. They arise equally from all sides of the twig in alternate

order, but by torsion come to lie nearly in the plane of the flat branching system of twigs. When detached they leave a small round or oval scar, smooth, and not elevated as in the spruce and some other

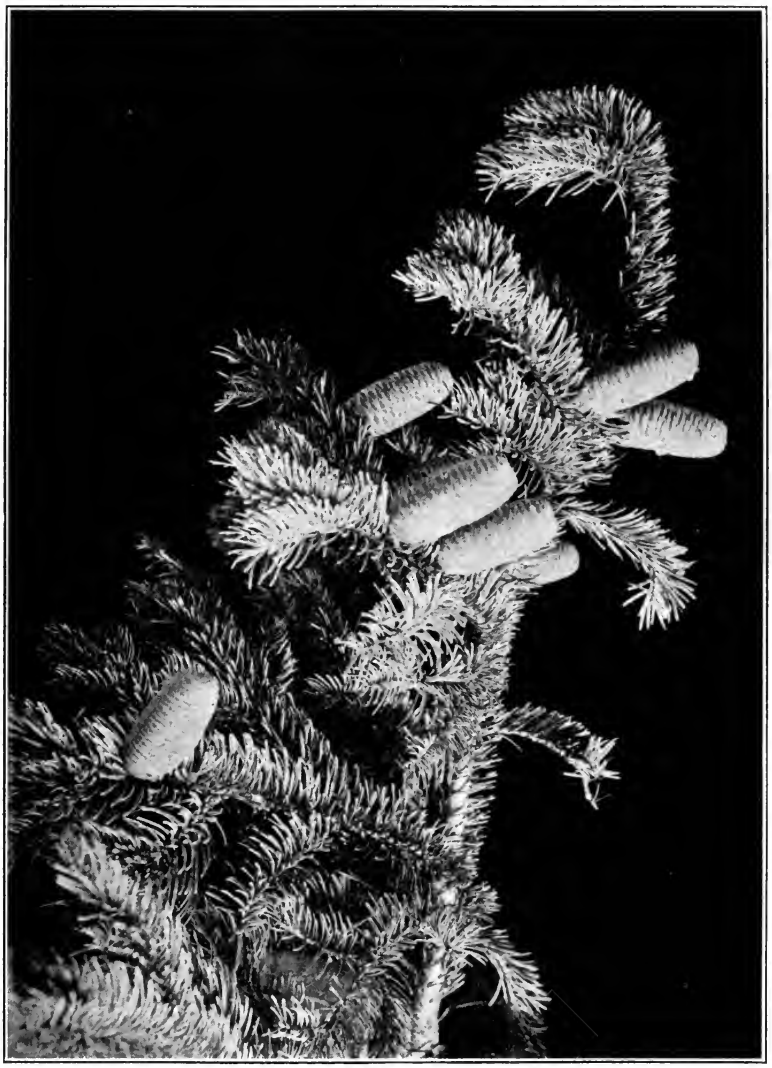

FIG. 28.—Branch of Grand Fir. Condition in July.

genera. The leaves on the topmost branches usually curl sharply and rigidly upward, and so often appear in contrast to those below. The younger stems and branches are usually smooth, with prominent gum blisters. Flowers of both kinds are borne on twigs of the previous

year, the seed-bearing rather few, the others numerous in the axils of the leaves. The pollen is scattered early, and the fruit is matured in one season. The cone always stands erect upon the branch, and its length, in different species, varies from 2 to 6 or 8 inches; it is cylindrical or oval in form. The cones of firs at maturity disintegrate upon the tree, so that seeds, scales, and bracts are liberated together, and the axis of the cone, like a spike, is left standing upon the branch. Two seeds are borne on the upper surface of each scale. The bracts in both Montana species are entirely covered by the scales in the ripe cone, though they are easily found when the cone is broken up. The cones are hard and compact, though the scales are thin. The wood of most of the firs is light in weight and color, soft, and not durable when exposed to the weather. The lumber of some species is good for certain purposes, but the species native to Montana are of no importance for lumber. There are two species of fir found in this region.

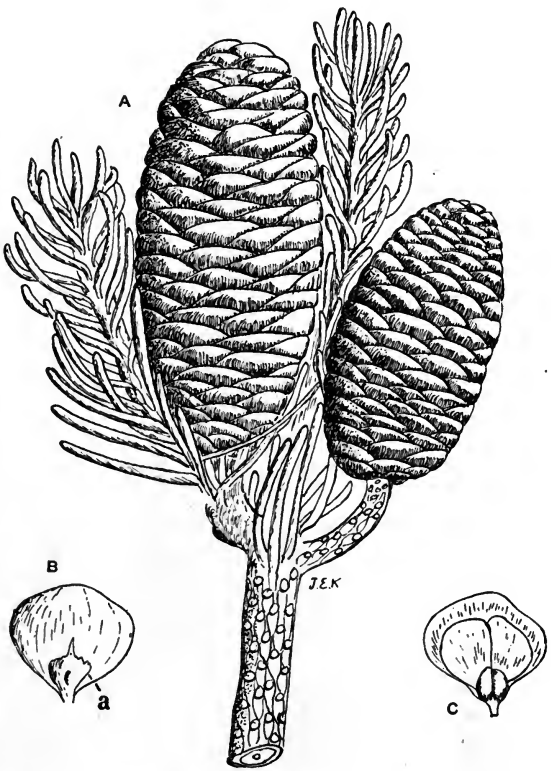

FIG. 29.—Alpine Fir. *A*, Twig and cones in natural position; *B*, bract, at *a*, and lower side of seed-bearing scale; *C*, upper side of seed-bearing scale with seeds in position.

The lowland or grand fir (*Abies grandis*) reaches its best development in Montana in the Flathead country and the moister valleys in the western end of the State and the panhandle of Idaho. Its general distribution, however, is more extensive, and reaches from British Columbia to northern Idaho and Montana west of the Divide, and in the Cascades to northern California. In western Oregon and Washington, along the river bottoms, the tree often reaches a diameter of 5 and a height of 200 feet or more, with as much as 75 or 100 feet clear of limbs.

In its younger state the grand fir has a conical form; as it approaches maturity the outlines of the tree become more cylindrical, owing to the drooping of its lower branches. A habit of the tree fre-

FIG. 30.—Alpine Fir, in Glacier National Park, at an altitude of about 6,000 feet. The spire-like form is characteristic.

quently seen is the presence of several erect stems in the tops of older crowns; these develop usually after the destruction of the original leader. The leaves are an inch, more or less, in length, with lighter color on the lower surface, and a tendency to come into a lateral flank-

ing position on the twig by the torsion of their short stems. The twigs also have a habit of spreading horizontally, and those which originate above or below bend into a horizontal position to conform with the rest. The cones of the grand fir are green at maturity, about 3 or 4 inches in length and 1 inch or more in thickness, composed of broad, closely overlapping scales. The bark of this species is smooth in youth, but gradually it becomes broken by furrows, which deepen with age; in old trees the bark is about 2 inches thick, with uniformly narrow ridges and deep grooves, grayish on the surface, but a deep brick-red within.

The alpine fir (*Abies lasiocarpa*), often called balsam fir, in Montana is more common. It is not the true balsam fir, however, as that species is a native of the northeastern part of the continent and differs from this in some very important features. The range of the Alpine fir extends from Alaska to Alberta in the north, and southward through the Cascades to California and in the Rocky Mountains to Arizona and New Mexico. In Montana it is common on all the higher altitudes, not only of the main but also of the outlying ranges. In some places it occurs as low as 2,000 feet, as in the northwestern part of the State, along the Kootenai River, but for the most part it occurs from 5,000 feet up to timber line, where it is mixed with Engelmann spruce and whitebark pine.

One of the striking features of this tree is its form, by which a normal specimen can be distinguished as far as it can be seen. Its typical shape is that of a very narrow spire. It seldom has much clear length, owing to its habit of growing in open groups. The bark is smooth, seldom rough, even in old specimens. The leaves are shorter and darker colored than those of the grand fir. The cones are oblong, dark purple, and 1½ to 3 inches in length. This tree may attain, under the best conditions, a height of 150 feet and a diameter of 3 or more feet. Owing to its usual inaccessibility and its inferior form, the alpine fir is of no importance commercially.

ARBOR VITAE.

The arbor vitæ is commonly called a cedar, although that appellation is applied to several other genera as well. Two species of this genus occur in North America, one on the Atlantic, the other on the Pacific coast. They are trees which endure shade, require a good deal of moisture, and a moderately cool climate.

In all of the preceding genera the leaf arrangement is alternate or spiral; in the arbor vitæ and juniper the arrangement is opposite or cyclic. This applies to the cone members as well as to the leaves. The stem of the arbor vitæ is a straight central shaft, extending through the crown. The branches droop conspicuously, and

the twigs are arranged in a flat spray or branching system, the ultimate divisions of which are almost contiguous laterally. The leaves would hardly be recognized as such by the uninitiated; they are very small scales, less than an eighth of an inch in length, closely applied to the surface of the slender twig which they entirely cover. The leaves stand opposite in pairs and lengthwise of the twig are arranged

FIG. 31.—Alpine Fir. The smooth bark is characteristic, even to maturity.

in four ranks. An interesting feature of the arbor vitæ is the fact that in its seedling stage the first season it produces flat, sharp-pointed, outstanding leaves, a fourth of an inch or more in length. In an axil of an upper one of these a branch appears which bears leaves that are scalelike and continue so in the subsequent growth.

On the ends of the ultimate twigs the small flowers are borne, each kind consisting of a few pairs of scales, each pair at right angles to the one above or below. The cones, which are often produced in great numbers, are half an inch or less in length, each of the fertile scales producing one or more seeds. These seeds, unlike those of the preceding species, are surrounded by the wing; they are oval in form, a quarter of an inch or less in length. The trunk of the tree is usually much folded at the base, with buttress-like roots. The bark is 1 inch, more or less, in thickness, light gray, and divided by long furrows; it is strongly fibrous, separating, upon proper manipulation, into long, ribbonlike strips.

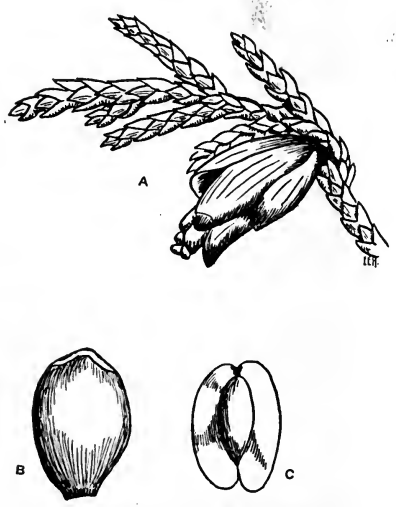

FIG. 32.—Arbor Vitæ. *A*, Twig and cone; scale-like leaves; *B*, scale; *C*, seed.

The western arbor vitæ (*Thuya plicata*) is found from southern Alaska to northern California along the coast, in the Cascades through Washington and Oregon, and in the Rocky Mountains to Montana and Idaho. It reaches its best development in the deep, moist soils of the lowlands along the coast of Washington and British Columbia, where large specimens are found 10 to 15 feet in diameter, some of them with a height of 200 feet or more. The lumber of this tree is of high value, being light, soft, easily worked, and very durable. Especially is the latter true of older trees, the growth of which has been very slow as they approached maturity, resulting in a fine and uniform grain. One may often find in the forests of the coast region prostrate trunks in sound condition which have lain so long that other forest trees to a diameter of several feet have grown on top of them, with huge roots reaching down on either side. This timber is used almost exclusively, in the Northwest, for telegraph poles and shingles; the lumber is useful also for many other purposes. The tree is capable of enduring deep shade, and grows often in mixtures with other species. In Montana the arbor vitæ is found only west of the Divide, where it attains a diameter of several feet in the river bottoms and deep canyons under conditions of perennial moisture.

This tree is recognized by its flat sprays of small twigs that form a compact system. The twigs are distinctly flat, and the leaves in pairs, forming four ranks of closely overlapping scales. The cones are three-eighths or half an inch long, borne on the ends of the

twigs, and composed of three to five pairs of scales. In form the cone is a narrow oval. The cone is matured in one season, and the seed is easily scattered to a great distance.

FIG. 33.—Arbor Vitae. Scene in St. Joe Mountains in Idaho.

JUNIPERS.

The junipers are not readily recognized as conifers by those not familiar with the more minute structure of the flower and fruit. The fruit has the appearance of a berry and is commonly so called. In reality, however, the fruit is a cone of a very few scales that have become fleshy and united, their identity being distinguishable only by small points on the surface of the fruit. These fruits are usually globular or oval and contain few seeds. The junipers are sometimes

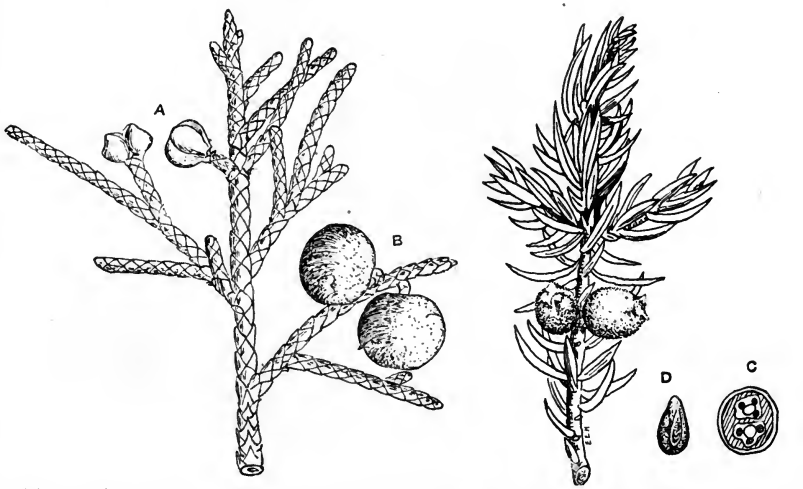

FIG. 34.—Junipers. Left, Rocky Mountain juniper with immature cones at *A* and mature ones at *B*. Leaves scalelike. Right, dwarf juniper, twig, and fruit; *D*, seed; *C*, fruit (cone) in section, showing two seeds.

dicœcious, i. e., the pollen and the seed flowers are borne on separate trees. In either case the flowers are very small and inconspicuous. Some of the junipers mature their fruit in one season, others require two. The wood is fine grained, aromatic, and durable. In its smaller forms it is used for posts, but it is useful otherwise in many ways. A species of wide distribution through the Atlantic region is much used in the manufacture of pencils.

The Rocky Mountain juniper (*Juniperus scopulorum*) is the most common of the Montana species and occurs in many parts of the State east and west of the Divide. It is found scattered with yellow pine along the rim-rock of the Yellowstone and its tributaries, on slopes and crests high up toward the summit of the main range of the Rocky Mountains, and west of the Divide appears commonly in all forested portions of the country, and attains a diameter of nearly 2 feet and a height of 30 feet or more in the better-watered parts of the Flathead Valley. Beyond this State its range extends northward in the Rocky Mountains into Alberta and southward into

Arizona; it is found in the Black Hills, and westward reaches the coast of Washington and British Columbia and to the eastern part of

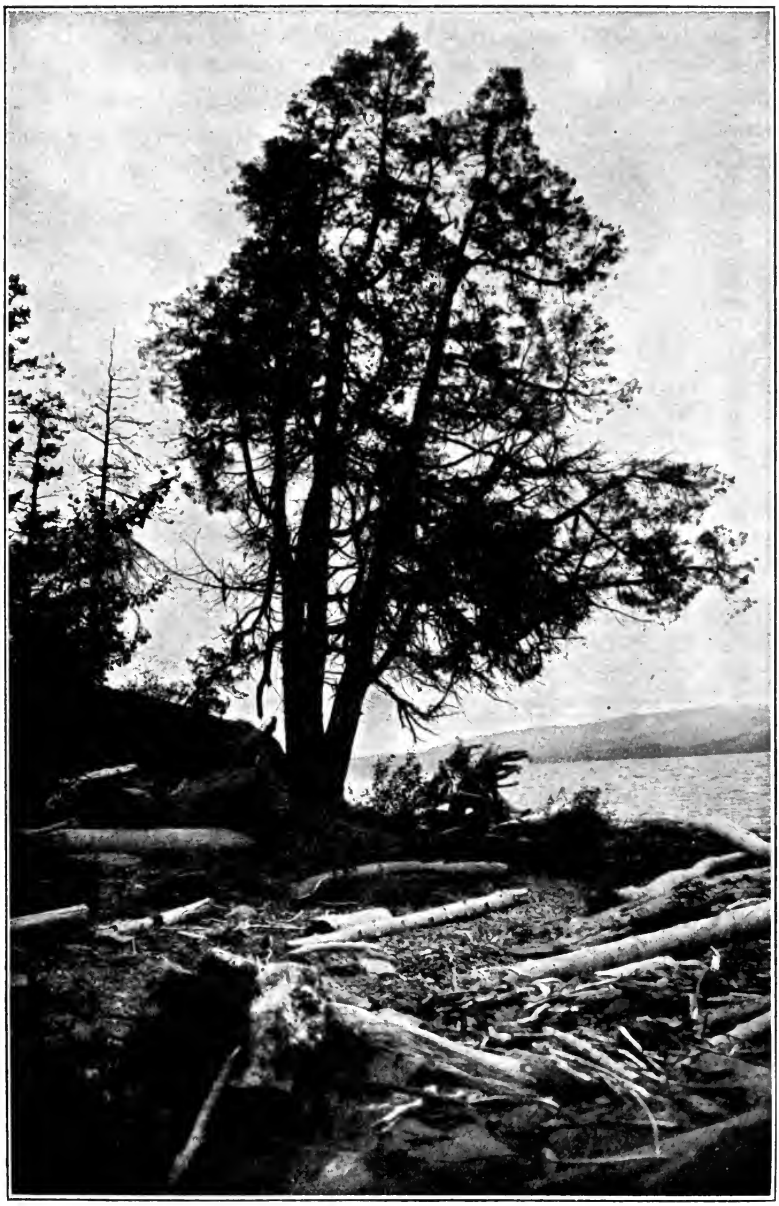

FIG. 35.—Rocky Mountain Juniper, on Flathead Lake.

Oregon and Nevada. This tree is able to grow in dry uplands, but like many other plants does much better where soil moisture is abundant.

Where it grows unhindered the form of the tree is that of a blunt cone; under other conditions the top is often open and irregular. The younger trees show a straight central shaft which becomes less conspicuous later by the development of several strong branches and the ultimate stunting of the leader in old crowns. The bark is reddish brown, thin, and separates in strips of considerable length. The wood is light in weight, compact, red or light brown, and very durable. Owing to its small size and poor form, it is useful only for minor purposes. The ultimate branches of this tree are great numbers of short cylindrical twigs, along which minute, scalelike leaves in close order are arranged in alternating pairs. The "berries" are terminal on the twigs, are oval in form and blue in color, usually containing two seeds. In this, as in other junipers, the fruits are sought by birds and animals, that scatter the seeds undigested. The junipers have no means of dissemination by the wind, but some of the species are very widely distributed.

The shrubby red cedar (*Juniperus sabina*) occurs in the northern part of Montana. It is a prostrate shrub, forming in mats, and is seldom more than 2 feet high, but usually about 1. The appearance of its twigs is much like that of the preceding species, and so is the fruit; in both structures, however, they differ in points which are more readily appreciated by the technical botanist. This species has a very extensive distribution, being found not only in the more northerly latitudes of North America, but in those of Europe and Asia as well.

The western juniper (*Juniperus occidentalis*) occurs in the southern part of the region included within the scope of this paper, particularly in the Yellowstone Park. Mr. Sudworth[1] describes this tree as being usually from 15 to 20 feet in height, with a diameter of 16 inches, more or less. Trunks are straight, with prominent ridges and low branches. The bark is a clear, light cinnamon brown, distinctly cut by wide, shallow furrows. Leaves pale, ashy-green, and prominently marked on the back by a glandular pit, whitish with resin. The fruit is one-fourth to one-third of an inch long, mature about September of the second year, bluish black, and covered with a whitish bloom, and slightly marked at the top by projecting points, the tips of the flower scales. The flesh is scanty and dry and contains from two to three seeds, which are pitted and grooved.

This tree has closely fitting and scale-like leaves, and in its general form resembles somewhat the Rocky Mountain juniper.

The dwarf juniper (*Juniperus communis*) is easily distinguished from the other junipers by its distinct, outstanding leaves, in circles of three. The fruit matures at the end of the second season, is dark

[1] Sudworth, George B. Forest Trees of the Pacific Slope. Superintendent of Documents, Government Printing Office, Washington, D. C., 1908.

blue, about a quarter of an inch long, with three points at the apex. The leaves are one-fourth to one-half inch in length, flat, sharp-

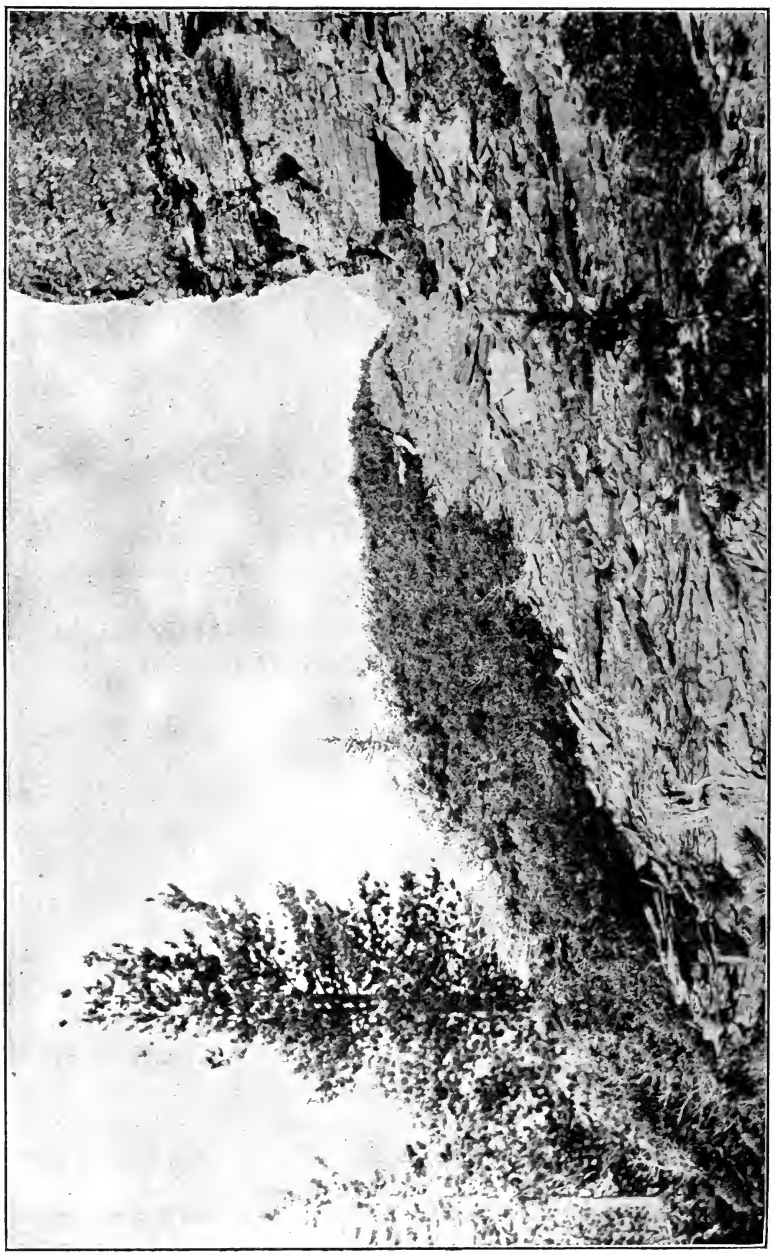

FIG. 36.—Dwarf Juniper, in Glacier National Park; forms mats covering the rocks; altitude about 6,500 feet. August.

pointed, and somewhat paler beneath. In Montana the habit of this species is that of a prostrate shrub. It often forms dense mats over several square rods, but usually in clumps several feet across. It

seldom is higher than 2 or 3 feet. In some parts of the United States the dwarf juniper attains tree form, 20 feet or more in height and a diameter of several inches.

In Montana this species occurs at altitudes from 3,000 to 6,000 feet or more, and is widely distributed through the mountainous regions of the State. It is one of the most widely distributed plants of the northern hemisphere. It is found across the continent from Greenland to Alaska, and south to Pennsylvania and Nebraska, and in the mountains to Texas and Arizona. It occurs also in Europe and Asia.

THE YEW.

The yew (*Taxus brevifolia*) is not a conifer nor a member of the pine family, but, as it is the most nearly allied to these in the Mon-

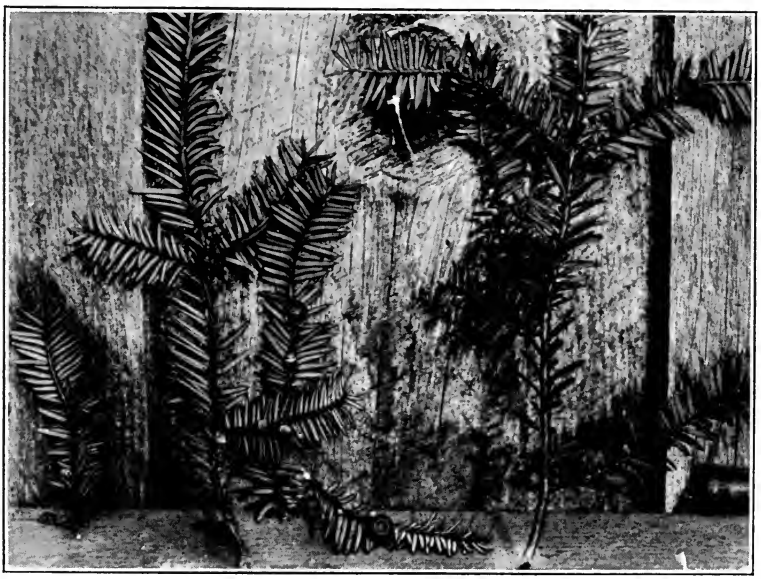

FIG. 37.—Western Yew. Branches showing fruits in various stages of development. July.

tana flora, it will be mentioned here. It possesses certain features which suggest the conifers, viz, the form of its leaves and its evergreen habit. The leaves are alternately arranged, flat, sharp-pointed, about three-fourths of an inch in length, and horizontally disposed. The branches also have a strong tendency to form in flat sprays. The fruit is distinctive. It consists of a single exposed seed, which is partly enveloped by a fleshy collar (aril) which turns red when mature. These fruits in all stages of development may be found on the same branch. When ripe the aril is about a quarter of an inch in diameter, round, and slightly flattened apically.

The yew in Montana, except in the most favorable situations, is a mere shrub, growing in thick forests in the shade of other trees. In the region about Flathead Lake it attains a height of 20 feet and a diameter near the ground of 1 foot or more, although the stem divides low into several stout branches. Farther west, in the moister places on the coast, it grows much larger and with better form. The bark of the yew is thin, red, and flakes off in large scales. The wood is moderately hard, of very fine grain, dark in color, and of great resiliency. It is much used for the manufacture of bows for archery. A relative of this species, the English yew, was long ago famous in history for the bows which were fashioned from its wood.

The western yew is found in Montana west of the continental divide and north from the head of the Bitter Root Valley to the west. Its range at large extends from southern Alaska into California and the mountains of eastern Washington and Oregon.

KEY TO THE GENERA OF MONTANA CONIFERS.

1. Leaves in clusters of two, three, or five ..... Pines.
2. Leaves in clusters of ten or more ..... Larches.
3. Leaves borne singly:
   - Leaves alternate—
     - Leaves sharp-pointed, rigid ..... Spruce.
     - Leaves softer, blunt or rounded on the end—
       - Cones erect, solid ..... Firs.
       - Cones pendent—
         - Bracts conspicuous, three-pointed ..... Douglas spruce.
         - Bracts entirely concealed ..... Hemlocks.
   - Leaves mostly scale-like, opposite or in circles—
     - Sprays flat, cones dry ..... Arbor vitæ.
     - Sprays bushy, cone berry-like ..... Junipers.

III. DIRECTIONS FOR THE STUDY OF THE CONIFERS.

Observe the tree as it stands; it is differentiated into stem, crown, and roots. Is the stem discernible as a continuous straight shaft through to the top of the crown? In most conifers of normal growth it does so appear, though in stunted specimens, and in some old ones, the main stem dissolves into a few large branches. At a convenient distance compare several trees of the same species as to the profile of the crown, as to the habit of branching, as to the attitude of the main branches and also the lesser ones. Can you recognize and define any peculiarities of outline which mark the particular species? Observe the tree nearer at hand and notice whether the branches seem to be grouped in circles at intervals. This is a common feature of the branching of certain species, and if clearly defined the circles of branches may be taken to indicate where one season's growth has ended and another begun. The distance between successive whorls may usually be considered one year's growth. Such intervals do not lengthen after the first season. Make special observations of the bark—its color and surface, whether rough or smooth; the depth and direction of the channels, and the form and size of the areas they inclose; the manner of scaling off, and its thickness. Notice the bark of trees of different ages in the same species. Follow the changes which take place as to color, surface, etc. Is the same series of changes noticeable from the younger to the older parts of the main stem of the same tree?

The branches.—Do the branches show the same characteristics as the main stem? Are the features of the bark the same? Do other branches tend to arise from the main one in circles? Look for ring-like markings on the branch. They may be found in most cases at intervals of an inch to a foot or more, and indicate the limits of the season's growth, like the whorls of branches on the main stem. Do the whorls of twigs on a branch stand in relation to such markings? Are there buds on the tips or the sides of the branches? Remove the scales from one of them. Do you find a small green elevation just above and at the base of each scale? They are present in winter buds and are the beginnings of leaves for the next season. What is the arrangement of the bud scales? Refer to the branch just below the bud and see what has become of the bud scales. Determine by a series of observations during the summer when the buds are formed and the amount of development which takes place in one season pre-

paratory for the next. Watch the unfolding of buds in the spring and the appearance of the various parts. How long does it require for the main growth in length to be accomplished?

The leaves.—Observe closely a single leaf. Is it uniform in color, rigid or flexible, sharp or rounded at the point? Cut across a leaf and notice the outline of its section. Are the leaves borne singly or in clusters? The pines have leaves in twos, threes, or fives, and the larches in bunches of from 10 to 40. In the pine observe the short spurs upon which the leaves are borne; these are short branches. Compare with those found in the larch. Determine at what age the leaves fall. To do this, count the number of years back from the end of the branch to where the leaves are about all shed from the branch. Try this method on other branches and compare. This matter stands in relation to the density of the branching, and it will be found that in some trees the leaves are shed earlier than in others. The leaves succumb and drop off when they are shaded. Can you by examining the leaves learn something as to the needs of the tree with reference to light? Another method of determining the age at which leaves are shed is to cut through the branch at the place where the leaves have fallen and count the rings in the wood, one for each year's growth. If the branch has been of slow growth, this may require the aid of a lens. Observe whether the position and attitude of the leaves are the same in all species. In what trees do the leaves occur in alternate or spiral arrangement? Are there any in which they are in circles, or opposite?

The flowers.—The flowers of the conifers appear early in the season, before the new leaves have fairly expanded on the same branch. The flowers of these trees are always of two kinds. Look for the ovulate or seed-bearing flowers on or near the ends of the branchlets. These are erect and usually red and consist ordinarily of a compact series of outstanding scales on a short central axis. The pollen flowers, in much greater numbers, are usually a little farther back from the ends of the branches and are either pendent or projecting in all directions, except in the case of arbor vitæ and most of the junipers, in which they are terminal on short branches. What do you observe as to the relative numbers of the flowers of both kinds? Compare, if possible, various members of the pine family as to the position of the flowers on the branch. Examine the parts of the flowers. Look for the young seeds at the base of the scale on the upper side. Find the source of the pollen. In many cases the flowers of pines and other members of this group are on high branches and out of reach from the ground, but old trees may sometimes be found with spreading and low-hanging branches on which cones have been produced in previous years; they will usually be found in flower at the right season.

The fruit.—Observe the position of the cones or fruit. Does the cone stand in the same position as the flower? How much growth has intervened? Are there younger and smaller cones on the tree at the same time? What do you infer as to the length of time required for the maturing of the fruit? Examine cones of different species and note differences of size, form, color, hardness, surface markings, and other features. What trees mature their cones in one year? Which in two? Take a closed ripe cone from the tree and keep it in a dry place. Observe the manner in which it opens. Examine the structure of the cone. Is there more than one series of organs? Notice in most cases the bract just below the seed-bearing scale. Compare different species as to the relative development of scale and bract.

The seed.—What is the position of the seed in the cone? How many seeds are borne on each scale? In what position on the scale? What facilities for distribution do the seeds possess? How effective as a means of distribution are the wings found on some seeds? Let fall some seeds having wings from a height of several feet. Is the rate of its fall controlled by the wing? Of what use is such retardation of fall among seeds disseminated by the wind? Estimate the average number of seeds to the cone. Remove the coat of a seed and observe the fleshy contents. In the center of the fleshy mass lies the embryo, a cylindrical or club-shaped body with a root rudiment, or radicle, at the smaller end, and at the larger a circle of small members, the seed leaves or cotyledons; the young stem is the middle portion. The fleshy material surrounding the embryo is called the endosperm, and serves as food for the seedling until it becomes established in the soil. Soak a few pine seeds in water for a day, and then sow in light soil in boxes or out of doors, keep slightly moist, and watch for the appearance of the young plants. Observe the behavior of the young plants with reference to the seed coat and endosperm. What purpose do the cotyledons serve first? Later? Compare seeds of different members of the pine family as to their form and their behavior during germination.

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BULLETIN OF THE BUREAU OF EDUCATION FOR 1917.

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No. 34. Institutions in the United States giving instruction in agriculture. A. C. Monahan and C. H. Dye.
No. 35. The township and community high-school movement in Illinois. H. A. Hollister.
No. 36. Demand for vocational education in the countries at war. Anna T. Smith.
No. 37. The conference on training for foreign service. Glen L. Swiggett.
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