# Forest Club Annual

## 1909

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## FOREST CLUB PROGRAM 1908-9.

**OCTOBER 6.**
Poplars and Their Importance........................Dr. Bessey

**OCTOBER 20.**
Influence of Windbreaks..........................C. R. Tillotson

**NOVEMBER 3.**
Forest Surveys..................................Prof. Sears

**NOVEMBER 17.**
Gypsy and Brown Tail Moths.....................Prof. Bruner

**DECEMBER 1.**
Germination of Forest Seed........................A. G. McNeel

**DECEMBER 15.**
Forest Methods in the Rockies.................H. S. Stevenson
H. H. Greenamyre

**JANUARY 6.**
Problems in Forest Ecology......................... Prof. Pool

**FEBRUARY 16.**
The Commercial Forest Nursery...............Mr. L. O. Williams

**MARCH 2.**
Lumbering in Washington........................E. G. Polleys
Microscopic Study of Woods.........................G. N. Lamb

**MARCH 16.**
Factors Affecting Stream Flow......................Dr. Condra

**MARCH 30.**
Formation of Forest Soil..........................Prof. Barker
Moisture Studies in Forest Soils...................Prof. Keyser

**APRIL 27.**
Scientific Problems in Forest Plantations............Prof. Phillips

**MAY 11.**
State Problems in Wisconsin.......................A. G. Hamel
Utilization in Wisconsin...........................J. C. Ketridge

**MAY 25.**
Forest Types in the Philippines................... G. Pagaduan
Forest Utilization in the Philippines.................... M. Lazo

## ANNOUNCEMENT

It is our intention to publish each year a Forest Club Annual. This book, issued by the Forest Club of the University of Nebraska, will contain articles on technical and practical forestry written by our student members and alumni, and is intended to be made up almost wholly of individual student articles. Other articles on local questions pertaining to forestry, by leading professional men of the state, may be included from time to time. We plan also to embody in our publication the results of a number of experiments that are being worked out by the Forestry Department.

In doing this work we are influenced strongly by the fact that many valuable and interesting observations are rendered non-available to foresters and forestry students because there is no place for their publication. By publishing an annual we intend to remedy the defect for ourselves and place our observations where they will be of use to us and to others. The fact that articles will be published ought to give a strong impulse to scientific observation among the students who have frequent chances to observe things which are quite valuable but have not been thoroughly investigated by scientists. The student making such observations often does so in a careless manner. When he knows that his work may be put in permanent form he will do it more thoroughly. Thus we hope to influence the student to do careful detailed work.

The support of a publication of this nature must be voluntary. Its very nature prevents it being self-supporting and makes such support undesirable, for a publication can only become self-supporting by being made popular which is always attended by a reduction in merit. In order to publish our book we have decided to establish patrons who will be asked to contribute to its support. All these patrons are men interested directly or indirectly in forestry, who have the interest of the publication at heart, for they believe it is useful work in a good cause. Realizing that the financial support determines the existence of our Annual we give the entire credit for its publication to our patrons.

## SEED SOWING ON NATIONAL FORESTS

G. B. McDonald

Recently, a "lumberjack" in eastern Idaho, who was inspecting some freshly extracted lodgepole pine seed, made the query, "Do you mean to tell me that each one of those little things will grow a big Bird-eye tree?" When assured that each of the good seeds would produce, in time, and under proper conditions, a mature lodgepole pine tree, he volunteered the remark: "Well, they don't grow from those things here, they just come up naturally."

It is to be regretted that not all potential timber lands secure a thrifty stand of reproduction, "naturally." If they did, the work of reforestation would be greatly simplified.

In parts of the country, notably the central and southwest, reforestation has been attempted by planting nursery stock, and has been attended with at least partial success. Heretofore, very little has been done on the National Forests to test the practicability of broadcast seed sowing as a means of reforestation, but at present plans are being prepared for conducting such experiments, on all the Forests, where there is any possibility of broadcast sowing being a successful method of reforesting denuded areas. It is the intention of the Forest Service to continue these experiments for a series of years, varying the methods from time to time as acquired experience dictates. Sowing will be done both in spring and fall, in order to determine the most suitable season for the work.

The experiments on most of the forests will be laid out in the form of strips one chain wide and ten chains long. In this way, each experimental area can be made to cover a variety of soil and moisture conditions, and later, a comparison of results can be made. The methods of sowing the different strips will be as varied as possible, in order to determine the most successful, as well as the cheapest methods for doing the work. For example, on a certain forest there may be three types of land to be reforested, viz: burned over areas at the higher elevations, burned areas at lower elevations, and open grass land in the yellow pine belt at the lower elevations. As soon as the work is fully under way each of these types of land will be represented by an experimental sowing and planting area. A typical portion of the high altitude burn will be selected, marked, and named. During the present spring, perhaps four experimental one acre strips will be laid out, two to be sown with Engelmann spruce seed, and two with limber pine seed. One acre for each species will be planted in seed spots made by digging up small patches of ground with a hoe or mattock, before the seed is sown. The other acre strip for each species will be sown by broadcasting the seed over the ground and then raking the soil. The following fall, additional experimental strips will be laid out in order to make a comparison between the results of spring and fall sowing. In a similar manner, a typical area will be selected on one of the burned areas at the lower elevation, where the original stand of timber was yellow pine and Douglas fir. Since this latter type would be more important for timber production than the former, due to the more valuable species that can be grown, and also on account of its being more accessible for lumbering, more extensive experiments would no doubt be advisable. On this area, probably six one-acre strips for both the important species would be sown and planted this spring. As for example, one acre broadcast with seed, with no treatment of the soil; the second acre strip planted in prepared seed spots one foot in diameter, which are spaced about 4x4 feet apart; the third strip broadcasted, and the soil harrowed; the fourth strip broadcasted with the soil harrowed both before and after sowing; the fifth acre planted with an old fashioned hand corn planter in seed spots, and the sixth strip planted with young trees from the nursery. The experiments will be repeated in the fall, with perhaps other variations in the method of sowing.

The third type of land, grass covered areas, will probably need more preparation than the other types, before sowing or planting can be done successfully. The heavy sod, which in many cases is the result of recurring fires, makes the prospects for successful seed sowing very poor, unless the sod is broken and killed. Where experiments are conducted on this type of land, the soil, in most cases, will be prepared by plowing and harrowing before sowing or planting is attempted.

Although good results from broadcast sowing may be expected on some of the more favorable locations needing reforesting, yet it is probable that the bulk of the land will have to be planted with nursery stock before a stand of timber can be obtained. Large areas of treeless land on some of the National Forests will probably never be afforested, on account of the conditions, adverse to forest growth, necessitating too great an outlay of money in getting the land stocked even to inferior species of timber.

The results of planting for city watershed protection as well as for the conservation of water for irrigation purposes cannot be figured in board-foot returns only. The value received in the conservation of the water supply, in many cases, will far outrank the returns from the disposal of the timber products. In view of this fact, planting on important watersheds need not be restricted to such lands that will show in a given number of years, a profit from timber produced, over and above the initial expense, figured at compound interest. Likewise, in regions where the timber supply is limited and inadequate for the future development of the locality, the Forest Service will be justified in going to greater expense in the work of reforestation than in other parts where timber production is of less importance.

The planting of nursery stock is both slow and expensive, in most cases. Broadcast seed sowing, although generally conceded to be a cheaper mode of reforestation on suitable areas, is oftentimes more expensive than when plant material is used. This is due in most cases to the high cost of the seed used, as well as to the cost of preparing the ground, and to a lesser extent, to the topography and inaccessibility of the country. Since seed collecting methods are being perfected to a marked degree, due to the extensive collecting which is being done, the cost of seed is being constantly reduced, and as soon as experience has shown the most economical methods of sowing, it is very probable that large areas in the more favorable locations can be stocked by broadcasting, at a cost far below the expense that would be incurred if nursery stock was planted. This method of using a maximum amount of seed with a minimum of labor in broadcasting, as against the use of a minimum amount of seed, and a maximum amount of labor, when nursery stock is planted, will only be more economical when the cost of the seed is kept at a low figure.

The seed collecting operations of the Forest Service, which in 1908 assumed proportions of considerable magnitude, were very successful in most cases. On account of the lack of other men, forest supervisors were asked to collect quantities of coniferous seed on their forests. In many cases, neither the supervisors nor the rangers detailed for the work had had any previous experience in seed collecting, and although the best methods were not always used, as a whole, the results were very satisfactory. It is quite frequently the case that collecting operations are not commenced early enough in the season and the work is made more difficult on account of the fact that part of the cones have opened and released the seed.

The method of collecting cones which has proven most effective in reducing the cost of seed is that of gathering from squirrel stores. To most any woodsman, the squirrels' store of pine cones is a commonplace thing, but a person with little experience in the woods might ride for days and never know that a squirrel hoard existed. In regions where the pine squirrels are numerous, the seed collectors generally secure all the seed from these "caches," and it is not an uncommon sight, at present, on most any of the National Forests to see a big 200 pound ranger skulking on the trail of an emaciated pine squirrel. The hoards are found in unique hiding places, as well as along decaying logs and in clumps of brush. In western Idaho, in the fall of 1908, numerous caches of yellow pine cones were located in ponds and creeks, from one to three feet below the surface of the water. One of these hoards, besides furnishing a plunge bath for the collectors, produced nine bushels of cones. Hoards are sometimes found in deserted cabins where the ingenious squirrels have made use of buckets, pots, pans and kettles in storing away their supply of food.

The criticism brought upon the Forest Service for its "inhumanity" in taking the squirrels' supply of cones, is generally traceable to some effervescent lawmaker, or to members of some "Woman's Society for the Protection of Dumb Beasts." The former should concentrate their efforts on "Tariff Revision," and the latter should be at home caring for their children, instead of providing "ways and means" for the emancipation of the red pine squirrel.

In regions where large lumbering operations are in progress, it is sometimes possible to collect a limited amount of seed at a very reasonable cost, from felled trees. It is not frequently the case, however, that the cutting is being done at the time the seed is ripening, or that the cutting area coincides with the areas where the seed crop is best.

A large part of the cost of seed is incurred in the extracting process. As long as the weather remains clear, most cones can be opened in from three to eight days, on canvass sheets, in sunshine; however, it is generally the case that after the cones have been collected in the fall, bad weather prevents the extraction of the seed out of doors, and a drying room must be equipped with shelves, and stoves for the completion of the work. In good collecting regions, where a supply of cones will be available every year, seed-extracting stations will be established. The equipment of these stations will be such that the seed extracting can be done quickly and cheaply, and at the same time in a manner which will insure the seed against injury.

Although afforestation is still in the experimental stage in those parts of the country where soil and climatic conditions are adverse to tree growth, still there are large areas on important watersheds and in good timber producing regions, that at present are producing nothing more than brush and grass, upon which there is no doubt but that the work of reforestation could be carried on with entire success as soon as opportunity is afforded. The greatest difficulties are first, the lack of funds for carrying on the planting on a scale which the immensity of the proposition of national reforestation demands, and second, the lack of men, who through technical training and experience are able to carry out the details of the planting work in a thoroughly intelligent manner.

## NOTES ON OSAGE ORANGE

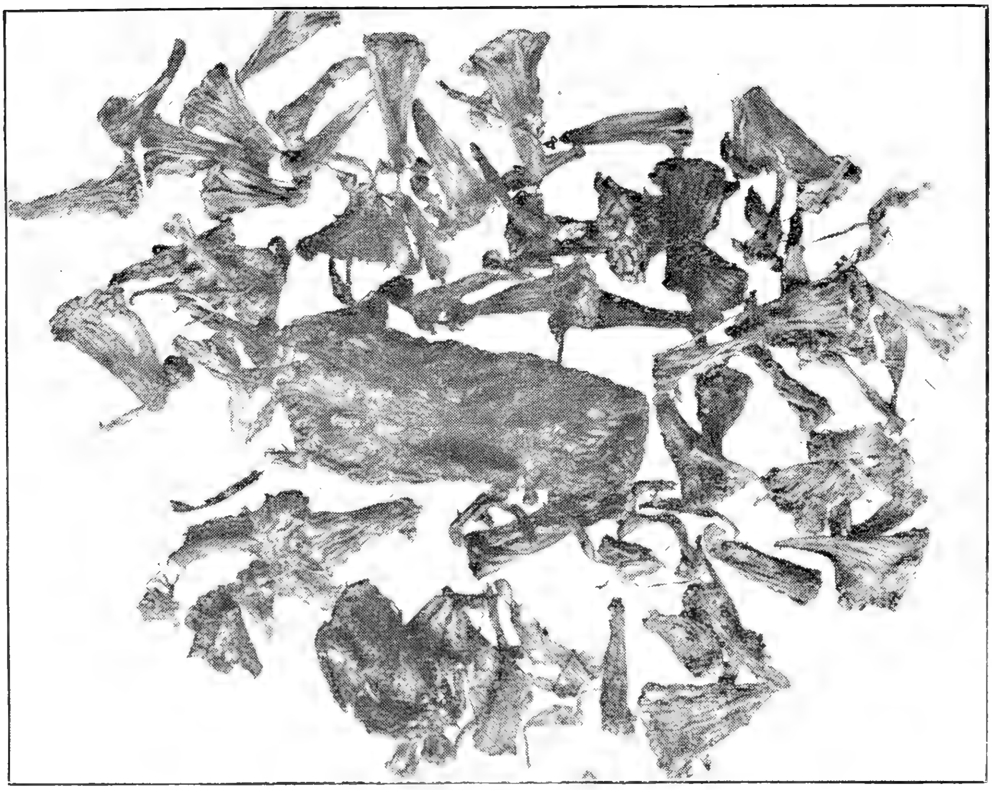
T. E. Miller

The Osage orange, *Toxylon pomiferum*, occurs naturally on rich soils in Arkansas, Texas and Oklahoma. It is essentially a con-comitant tree frequenting bottom lands which border stream courses. So far as prevalence is concerned, it is a minor species. Its silvicultural range, however, is much broader and more important than its botanical range and extends from the southern part of the United States to the northern parts of Nebraska, Iowa, and Illinois and to the southern part of the New England states. It may be planted westward to the eastern parts of Colorado and Arizona, and may be successfully grown on favorable sites in the extreme southwest. It was early prized by the Indians as being best suited for the construction of bows and arrows. This fact has earned for it the common name "bow wood."

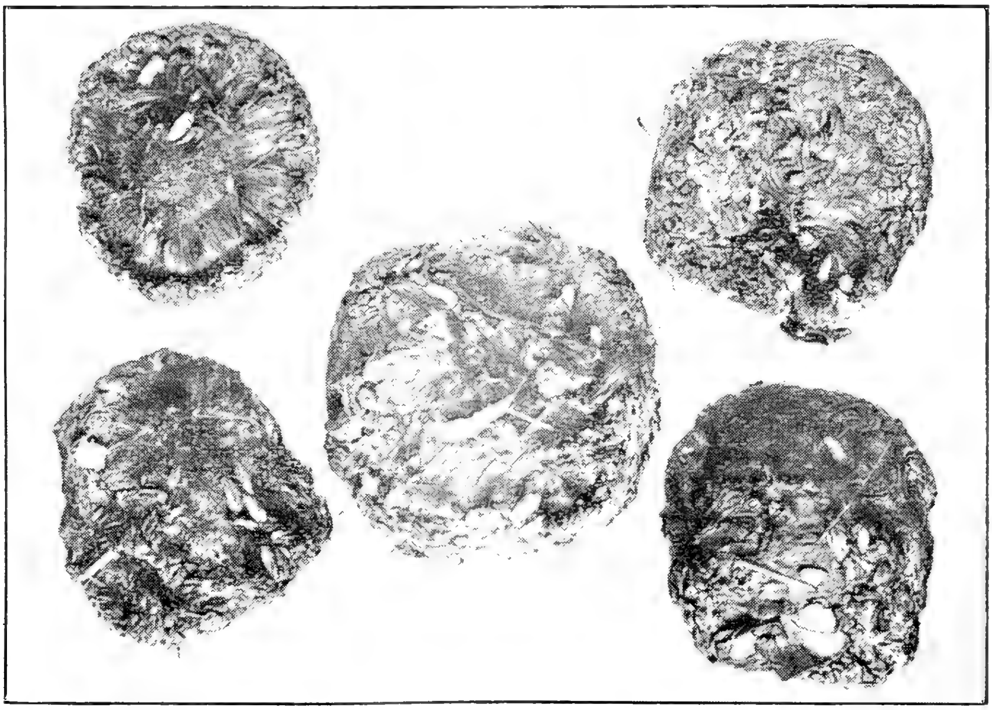
Osage orange is a tree which sometimes attains a height of sixty or seventy feet and occasionally a diameter of two or three feet. This size, however, is rarely attained outside of its natural range, although planted trees have been reported over 18 inches in diameter and 35 feet in height. Many of the principal lateral branches are characterized by broadly convex outward curves some of which occur in series. From the upper side of these curves there arise an exceptionally large proportion of vertical vigorous growing branchlets. This gives the tree a distinctive erect crown which is often scraggly. The bark on the trunk is ridged and stringy and varies from one-half to one inch in thickness. The branchlets, when they first appear are light green, often tinged with red and coated with soft pale pubescence, which soon disappears. During their first winter, they are light brown, slightly tinged with orange color, later becoming paler. The root system is distinctly fibrous or lateral. The roots are long, slender and covered by a tough, scaly orange yellow bark.

The fruit of the Osage is fleshy and varies from 3 to 4 inches in diameter. A count as to the number of seeds per fruit showed the wide variation of from 195 to 611 with an average of 357. The number of seed per pound was likewise extremely variable, and frequently the smallest seeds are about one-half the size of the largest seeds. A single count of average seed showed 11,324 to the pound.

When the white race settled the Middle West and introduced the wire fence, this tree was found to produce posts, both exceedingly strong and durable. It was also found to



I. Pieces of Osage Orange Disseminated by Red Squirrels



II. Fruits of Osage Orange which have been Partially Destroyed by Red Squirrels

make a beautiful and effective live fence and because of this it was more widely planted than any other species in the prairie region. At present, however, the planting of Osage orange for hedge fences has practically ceased and in many cases the hedges are being cut down for the posts that may be secured. Taking everything into consideration it has been found that a wire fence can be placed and maintained for a less cost and give better service than a hedge fence. The planting of this species is now largely confined to plantations on favorable sites, for the purpose of producing fence posts.

In nature or in plantations it does not reproduce well, hence planting becomes of more than ordinary significance. It does, however, reproduce well from root sprouts or from coppice growth. It is comparatively light demanding but will stand crowding better than most species. It adapts itself readily to a great variety of soil and climatic conditions and is rarely injured severely by drought. The hardiness of this tree depends largely on the site upon which it is planted. In the northern portion of its silvicultural range, it frequently winter kills and if cultivation has been practiced to conserve the moisture supply, it should cease during early August. This will allow the ground to dry out sufficiently to cause the wood to ripen up in good shape. When this is done, the Osage orange may be successfully grown as far northwest in Nebraska as Lewellen, at an altitude of 3300 feet.

The average life of a seasoned Osage fence post is said to be approximately thirty years, but there are numerous examples of much greater durability. It is usually classed with red cedar as to durability but has the advantage of much greater strength. The Sante Fe Railway system has given preference to this species for post material and is using it along the right of way as far west as New Mexico. A disadvantage in using this species for fence posts is the difficulty with which the seasoned wood takes the staple; also a green post in drying will check and the staples will drop out. This is frequently overcome by tying the wire to the posts by means of other wire.

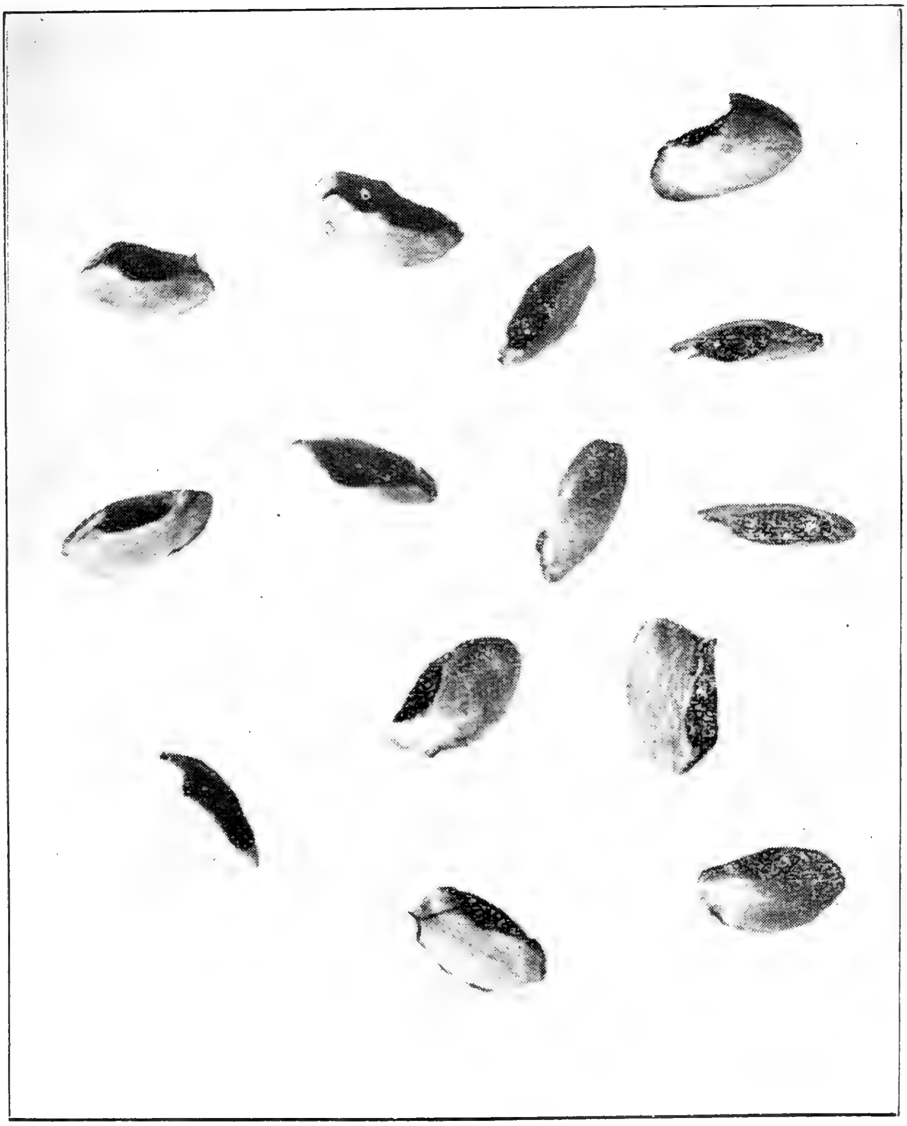
Few if any other native woods have the rich lustre of this species. The wood is very heavy, weighing 48 pounds per cubic foot. The heartwood is of a bright orange color, which turns brown on exposure; but the sap wood is a light yellow. Annual rings are clearly marked and the wood is close grained. Its adaptability for the highest class of furniture or inside decoration is limited only by the lack of production.

The methods of seed dissemination of this species have long been in doubt. For a considerable length of time the fruit with its milky juice was thought to be very distasteful to all animals if not actually injurious. During three years of investigation, Professor F. J. Phillips of the Forestry Department of the University of Nebraska found that occasionally during a dry fall, the fruit would dry up sufficiently to be floated by water. He found that on rolling land, the fruits would roll down the slopes a distance of from five to forty feet, when they fell from the parent tree. They would undoubtedly be transported a much greater distance by this method if the slope was long and fairly steep.

Dr. Sargent in his "Sylva of North America" states that the fruit falls to the ground and either disintegrates or is eaten by horses and cattle. Dr. Trelease of Missouri Botanical Garden substantiates the eating of the fruit by cattle. There is no doubt but that the fruits will decompose, but thus far, the writer from his own observation and the observations of the experiment station botanists located in the region where Osage orange is grown, has been unable to substantiate the eating of the fruit by horses and cattle. Apparently, the prevailing theory regarding the dissemination of this species is that running water and gravity are the most active agents. After the fruits are decomposed, the seeds are exposed and unless eaten by birds and rodents may be transported a considerable distance by running water.

For several years the writer has noticed red squirrels, *Sciurus rufiventer*, feeding on the seeds of this fruit, during the late fall and winter. As far as has been determined, they begin feeding on this fruit when other food, such as corn and walnuts, becomes scarce. As the accompanying cuts will show, the fruit is torn up into small bits; the seeds are then picked out and eaten. A count was made to determine the percent of seeds per fruit which the squirrels had eaten. In no case did this run less than ninety percent of the total number and frequently as high as ninety-six or ninety-eight percent. They apparently do this only when the fruits are frozen, thus enabling them to secure the seeds without getting much of the distasteful fleshy portion.

Frequently the squirrels tear up all but a small portion of the fruit and then attempt to carry this portion away. This is well illustrated by the large piece of fruit shown in Plate I. Occasionally they drop this after having carried it a distance varying from one hundred feet to a quarter of a mile. By this means Osage orange may be widely distributed.



Seeds of Osage Orange Eaten by Red Squirrels

## THE ADVANTAGES OF CLEAR CUTTING LODGEPOLE

H. S. Stevenson

In Central Colorado all lodgepole on the National Forests is cut to a diameter limit. In fact in the region examined which is quite representative for the Holy Cross National Forest lodgepole has never been treated otherwise. Even the old timber cutters who worked there before the National Forest was created used a selection system comparable to the present method except that they did not cut the defective trees. From a study of these old slashings which have not been burnt over the effect of the selection method upon reproduction may be seen and from the burnt areas results similar to those following clear cutting may be obtained.

The lodgepole on the Holy Cross National Forest occurs always in nearly pure even-aged stands and without doubt occupied the ground after a fire. The stands are dense and the trees have clear, symmetrical boles. There is almost no ground cover. The soil is shallow, moist, and rich in leaf mould, supporting a stand of trees that run from 12,000 to 15,000 board feet to the acre. The occurrence of this tree in pure even aged stands reduces the methods of silvicultural treatment that could be most readily applied to it to the two considered here, clear cutting and cutting to a diameter limit.

Near Thomasville, Colorado a tract of timber has been cut over leaving one-third of the stand to seed up the tract. Lodgepole pine was cut to a diameter limit of eleven inches and diseased trees to nine inches. Engleman spruce was cut to thirteen inches and balsam fir to eight inches. The forest was composed of 85% pine, 8% spruce and 7% balsam and this method of cutting removed all the balsam and nearly all the spruce. In the area cut over, about 150 acres, not a single pine seedling was discovered which had germinated either before or after the time of cutting showing that reproduction was not secured by this method of cutting. As the cutting was rather recent the evidence was not conclusive, but an old cutting nearby served to substantiate these results.

Within a quarter mile of this tract there was an area of about sixty acres that had been cut over twelve years before. About half the trees were removed and later many were blown down so that there remained approximately one-third of the original stand. A careful examination of the whole tract showed a fair reproduction of balsam, a few scattered spruce and just one pine. The balsam certainly represented 98% of the reproduction. Many exponents of the selection system declare that over 90% of the lodgepole cones open in three years. Since this tract had been entirely free from fire there could be only one of two reasons for the lack of lodgepole reproduction. Either the cones did not open or else the seed could not germinate. The presence of spruce seedlings which require better conditions for the germination of the seed than lodgepole disproved the latter, proving that in most cases the cones do not open naturally.

Between these two areas there was a strip of burnt over land that was an excellent example of the results following clear cutting and burning. Fire had traversed this strip eight years before and destroyed the timber completely. Counts of the reproduction here showed an average of 7500 lodgepole seedlings per acre and an occasional balsam. A careful determination of the age of these seedlings showed that all were six or seven years old, which would indicate that the tract was not seeded in from the sides but that the reproduction was due to the seed that was on the tract when the fire occurred.

From these studies it is evident that, so far as reproduction is concerned, a system of clear cutting and burning gives the best results. Opening up the forest results only in making ideal conditions for balsam reproduction. Not only is the balsam an undersirable tree, a forest weed, but it occupies the ground and keeps out the spruce which might otherwise come in sparsely. No pine seedlings germinate in the thinned stand. All natural thinnings show conclusively that balsam takes the ground to the exclusion of other species. On the other hand all burned over areas which were left almost bare by the fire are almost invariably covered with a dense stand of pine seedlings. The arguments against clear cutting and burning are that it opens up the forest too much and that the danger from fire is too great. A careful study of conditions show that these are valueless.

The only object in not opening up the forest extensively is to give protection to seedlings and induce natural regeneration. Natural conditions show that thinning or cutting to a diameter limit does not induce reproduction of pine at all. If then cutting to a diameter limit does not aid reproduction of the desired species, some other method should be used.

Danger from fire when the stand is almost completely cut out is slight and the damage in case of fire is much reduced. Under a system of cutting to a diameter limit the brush is piled with the intention of burning it. Certainly the danger is just as great or greater than in a clear cut forest. The burning of all slash removes the possibility of later fires which always are a menace to a selection forest. Certainly the danger from fire after clear cutting is less than it is for the method now employed.

The advantages of clear cutting and burning are as follows:

1. Good lodgepole reproduction results.
2. Danger from future fires is removed.
3. More material is utilized.
4. Management is simplified.

Reproduction on burnt areas throughout the Holy Cross Forest is pure lodgepole. Frothingham in his circular on Douglas fir has shown that the seed of balsam fir, Engleman spruce and Douglas fir is destroyed by fire but the seed of lodgepole is protected by the heavy resistant cone from the fire which serves to open the cone that would not open otherwise. The loss of the foregoing species in this particular region is not undesirable for they form a very small, unimportant part of the mature stands. Without a single exception every burnt area in this region is covered with a dense, uniform stand of lodgepole seedlings. It is not uncommon to find extensive stands of young trees so dense that it is almost impossible for a man to push his way through on foot. These burned areas have been entirely denuded by fire but the seedlings spring up quickly and prevent erosion that would otherwise occur on the slopes from which the forest had been wholly removed.

The complete protection from future fires afforded by burning the area before the reproduction starts is very important. One of the greatest menaces to partially cleared stands is fire. The debris from the trees cut remains as a fire trap. Furthermore part of the mature stand remains exposed for a long period, whereas if it is all removed at once there is no risk whatever.

It is also certain that more material is utilized when an area is clear cut that when any other method is used. In the district under consideration the cost of logging is so high that no operator can afford to take out the timber left in a depleted stand. As the young trees will not reach sawlog size in less than one hundred years it is doubtful if the timber left will ever be utilized. A large percent of the trees will be blown down. It has been observed that, in a stand from which 60% of the trees had been removed, the loss by windfall in from ten to twenty days after cutting was often 10% of the remaining trees. Furthermore the balsam fir will take the ground forming a temporary type that will persist for many years keeping out the more valuable pine. The balsam in this region commonly dies from some unknown cause before it reaches a diameter of 14 inches and is of little commercial value. If a clear cutting system was used about 85% of the stand would be utilized as against perhaps 60% in cutting to a diameter limit. Then by burning the slash good reproduction would be ensured at once, saving a period of many years when the land would otherwise be given over to the production of reduced stands of inferior species. If a second cutting could be made on a partially cleared area the result might be different but under present conditions that is financially impossible.

The management of the forest under a clear cutting system would be greatly simplified. Marking of trees to be cut could be entirely done away with as could brush piling. Thus the two things that cause most dissatisfaction among operators would be eliminated. If the rangers were instructed carefully they could oversee all work satisfactorily. Probably a maximum diameter limit, depending upon the use of the timber and the cost of exploitation, for all trees left on the area would be adopted.

It would not be necessary to clear cut in strips for enough seed would be left on the ground and in the slash, if the whole area was cut, to ensure natural regeneration. The lodgepole does not need shelter in the seedling stage and the dense reproduction effectually prevents any soil erosion. The burning of debris could be done on small areas at a time. The operators would willingly furnish men to aid in making fire lanes and in burning off the ground under the direction of the rangers if they were relieved from the tedious work of piling brush. With proper care the danger of fire spreading would be very slight.

The disadvantages of clear cutting and burning lodgepole have been over-estimated; the advantages which are summarized here have not been clearly understood. A greater percent of the stand is utilized and the loss by windfall eliminated by clear cutting. Furthermore management is simplified and the cost of both management and lumbering reduced. By burning the danger from fire is removed and the inferior balsam, which is liable to occupy the ground, eliminated. The fire makes a good seed bed and opens up the lodgepole cones which frequently never open under natural conditions. In short, clear cutting and burning gives a larger yield of timber, at a lower cost of production under a simpler management, and ensures a better, quicker reproduction than any other method.

## EXPERIMENTS IN FOREST TREE SEED GERMINATION

L. L. Bishop

Detailed scientific experiments in forest tree seed germination have been started at the University of Nebraska by the Department of Forestry. This work has been organized on a broad basis and will include investigations of both native and foreign seed. A greenhouse has been provided for winter and summer work while outdoor work will be conducted to serve as a comparison with the work done under glass. It is planned to use at least one acre of experimental seed beds but as the work progresses, it may become advisable to increase the area.

The work is being done by the students in the forestry courses under the direction of the head of the forestry department. It is planned to start the work on a limited scale but to have it continue over a period of years. The experiments will include tests with as large a number of species as are available. Tests will be made with the seed of the same species gathered from different localities; from different sites in the same locality; from different aged trees; from different shaped trees; from trees grown in the open and those grown in the forest; and with seeds grown on different parts of the same tree, on low branches, on high branches, and on different sides of the tree. Seed will also be tested from different parts of the same cone or pod, from different sized cones or pods, and of different weights and sizes. Green seed will be compared with well ripened seed. Several of these experiments have already been started and while very interesting results have been secured, it is desired to substantiate them fully before they are published. The effect of different degrees of light, kind of light, degrees of humidity and the various methods of seed treatment will be carefully tested. Included in this investigation will be the effect of several kinds of storage, although this work will be chiefly concerned with the species with which the United States Forest Service has not done work and will be only limitedly concerned with the species which the Forest Service is testing in regard to storing.

Naturally, the greatest importance will be attached to the species of the greatest silvicultural value. In carrying out the work, it has been planned to have a student take charge of a single phase and continue it until the course is completed when it will be taken up by other students still in the course. Definite records will be kept by each student and the work will be constantly under the supervision of the professor of forestry. Students will be given opportunity to work out any special problems which may suggest themselves or which may be suggested by the development of the work.

Another part of this work will be the keeping of careful observations as to the growth of the seedlings obtained from different classes of seed, to show for example, whether or not the sample of seed which gave the highest quality of germination will produce seedlings of the greatest growth. A number of the seedlings of the species suited to the Nebraska conditions will be used in experimental plantations established in various parts of the state, where the subsequent growth may be observed. This line of work will be conducted along lines of investigation which have been started at the Experiment Station in determining the effect of spacing, site, adaptability of species and similar questions affecting forest plantations.

There has long been a need for better scientific data along these lines and the aim of the present investigation is to supply this in part. The work must progress slowly because of the large number of experiments which may be solved and the lack of funds to establish the work on a larger basis. The advantages of continuous work throughout the year followed by the planting of many of the seedlings in plantations are readily apparent and should give excellent results.

## SUMMER BOTANY FOR FORESTRY STUDENTS IN THE MOUNTAINS OF COLORADO

Raymond J. Pool

For a number of years it has been the custom of the forestry students in the University of Nebraska to spend their summer vacation in one of the National Forests. This custom is becoming stabalized, and in fact now the students begin early in their course to plan to get out for a few weeks in order that they may come in direct contact with the varied activities of a great national forest. As a consequence of the desire to gain this practical experience students of all grades from freshmen to seniors may be found in such places throughout the west during the summer months. Many of our students find employment in the Rocky Mountain forests, especially in Colorado. Certainly this is a fortunate selection for in no other region in the United States will they meet with such varied forestal conditions or such a wealth of information to be gained by constant association through a few weeks with all these multifarious problems.

Students are not employed as forest assistants in such work, but they hire out as ordinary day laborers with the result that they are found engaged in a wide range of work such as building roads, constructing camps, carrying supplies, fighting fires, planting trees, cutting timber, etc., etc. Some few are fortunate enough to secure the somewhat more dignified position of forest guard. Regardless of the kind of work done the men are kept very busy during the daily routine, and unless they are constantly on the alert many most interesting observations may be lost which, if made, might be of inestimable value in their future career as scientific foresters. To be sure none such men have time to carry on carefully planned research; indeed I have already indicated that many of them are not sufficiently advanced in their chosen field to make this possible. And yet I believe that they can derive much benefit not only from the practical point of view, but also from the scientific standpoint, during the course of such a summer's work, especially if they have been provided with some general statements as to what they may see, or directions to guide them in making scientific observations.

The ability to do research depends first upon the investigator's ability to work up accurate data from the field or laboratory and then to deduce rational conclusions from these data. He must be able to construct logical hypotheses and then to demonstrate the truth or falsity of such hypotheses by careful investigation. The collection of accurate data toward the solution of any unknown problem of the sort with which we are dealing depends in great measure upon one's power of observation and discernment. Right here then is where busy students may, very early in their career, lay the foundation for most successful post-college service.

In this narrow space I have not attempted to give a detailed outline for one particular problem, but rather have tried to call attention in brief untechnical words to several of the most prominent points which will be readily accessible to the student and upon which he may work during his few spare moments in the mountains. As a consequence the following suggestions may be of more service to the student who is in the mountains for the first time and who is young in the work rather than to the advanced student or one perfectly familiar with mountain vegetation and with the problems of modern forestry. If by a familiarity with these pages the student's attention is called to some phase of mountain botany which otherwise would have passed unnoticed, I shall feel well paid for putting such notes into his hands.

This paper may be divided into two parts in reference to the nature of each part. The first part deals with the general systematic botany of the forest, and the second with problems which are essentially ecological. Since in my mind ecology should be preceded by all the other phases of the study of plants, especially systematic botany, I shall first direct attention to the most obvious aspects of the systematic forest botany of the region under consideration, and will close this part of the paper with a key to the genera and species of Rocky Mountain conifers, trees in which the forester is especially interested.

Since many clues to the development of arborescent vegetation are to be found in herbaceous forms it is essential that one be familiar with the species of a given region. This in itself properly constitutes a separate study sometimes known as floristics. Plant societies or forest types are made up of species and hence before a rational study can be made of the types of a given area it is obvious that the student become familiar with the species with which he is to deal. Species constitute the materials entering into the composition of an oftimes apparently heterogenous vegetation. The investigator must know the component parts and their relations before he can assemble the whole. It would require the whole of the students time for several summers to gain a complete knowledge of a flora so varied as that of the Rocky Mountains, with probably more than three thousand species of flowering plants alone. In this time he could do little with arranging these species into formations or societies, or types, except in a most general and tentative sense. It is well that with the limited time at his disposal the forestry student during his first summer in the mountains should concentrate upon obtaining a knowledge of the woody species, especially the trees. Perhaps at the same time he may note something of the requirements and of the interrelations of the various tree species as is suggested in a very fragmentary manner in the following pages.

It is a rather easy task to master the mere taxonomic characters which separate the few genera and species of trees of the region, but a much more difficult problem to undertake to determine something of their biological or their ecological relations. If in addition to the specific character of the trees of the forest he can derive some knowledge of herbaceous vegetation such as the grasses and the sedges, the composites, mat plants, chaparral, etc., his summer will prove even more enlightening, because these and many others have rather clearly defined relations to the life history of the forest cover. So other phases of forest botany such as forest fungi, the polypores, leaf-spots, the rusts of conifers, and such parasitic flowering plants as mistletoe so common on the conifers may well come in for a short consideration during his busy summer. If possible, the student should make a collection of such materials as here suggested to take back to the University with him, for he shall have therein the nucleus about which some of his future investigations may shape themselves. The tendency for the ambitious student will be to "load-up" with more material than he can carry out of the mountains. Nevertheless my advice is to get everything possible, because the more he observes and collects the more will he be at home in the region when he goes again.

While the following keys deal only with the conifers it must not be supposed that the arboreal vegetation of the mountains is exclusively coniferous. However, the broadleaf trees are few in number, and the fact remains that the forest of the Rocky Mountains is essentially coniferous. The most important broadleaf tree from the biological standpoint is probably the aspen, *Populus tremuloides*. This tree may be easily recognized by its white mealy bark and its restless orbicular leaves with long slender petioles. The trees occur in rather close groves on moist slopes and in gulches. The aspen is the most widely distributed and the most conspicuous broadleaf tree. Besides this species other poplars such as *Populus acuminata* and *Populus angustifolia* with narrow leaves are common along the lower courses of many mountain streams. In addition to the poplars the following small trees are quite common along streams: alder, birch, willow, maple, etc. On dry rocky slopes in the foothills a species of oak, *Quercus novomexicana,* often forms rather dense brush. The list of low bush-forming plants is rather large.

### CONIFERAE–THE PINE FAMILY

Trees or shrubs with resinous juice; leaves needle-shaped, awl-shaped or scale-shaped, single or in bundles of 2-5, generally persistent for a number of years; flowers appearing near the tips of the branches in early spring, surrounded at the base by a fringe of more or less papery scales; the stamens and pistils occur in different flowers; pistillate flowers composed of a central axis surrounded by scales bearing on their inner face two or more naked ovules; the axis with the scales becomes at maturity a woody cone or rarely a berry; each seed when ripe may or may not be provided with a membranous wing; staminate flowers of papery scales, soon disappearing after the escape of the pollen.

### KEY TO THE GENERA OF CONIFERAE

#### Based upon Leaf and Cone Characters

I. Leaves needle-shaped, in tufts or bundles of 2-5, usually exceeding 1 inch in length, enclosed at the base by a short sheath of papery scales; fruit a cone, scales of the mature cone thick and woody; cone scales persistent on the axis of the cone; seed with or without a wing.
*Pinus*

II. Leaves needle-shaped, single, usually less than 1 inch long, leaf sheath absent; fruit a cone, scales of the mature cone thin, papery or leathery; seed small, with wing.

1 Leaves 4-angled, with short hard bases which persist on the twigs when the leaves fall leaving a very rough surface; cones pendulous, scales papery and persistent on the axis.
*Picea*

2 Leaves usually flat, without hard persistent bases, leaving rounded or oval scars when they fall and hence quite smooth twigs.

1) Leaves with a narrow stalk-like base, scars small, usually elliptical, mature cones pendulous with a projecting 3-pointed bract beneath each scale.
*Pseudotsuga*

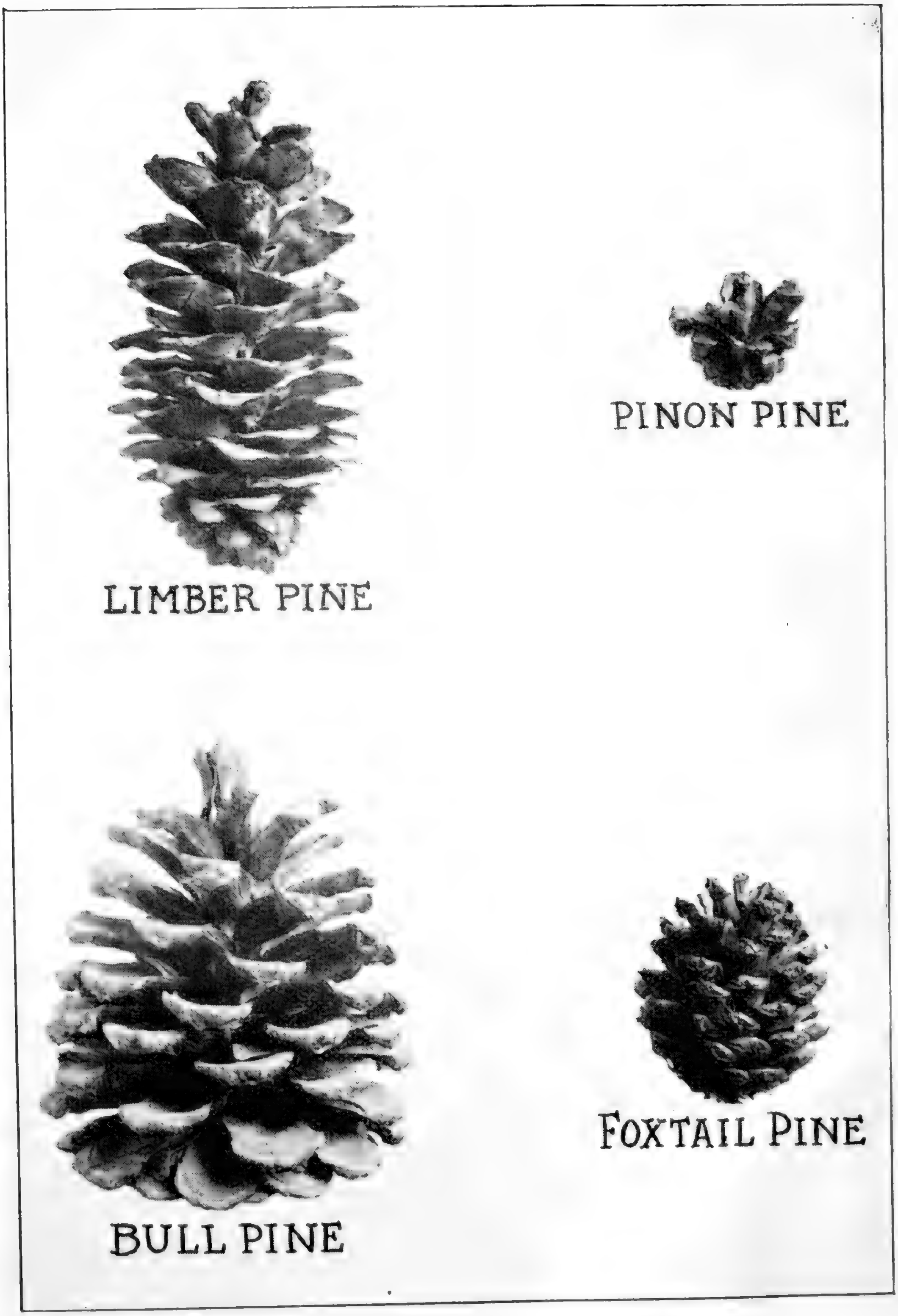
2) Leaves not much narrowed at the base, scars large, round, somewhat depressed; cones erect, purple or blackish, their scales at maturity falling separately from the axis with the seeds, axis persistent.
*Abies*

III. Leaves scale-like or awl-shaped and sharp pointed, opposite in pairs or in whorls of three; fruit berry-like, bluish black with white bloom; seeds few, bony, wingless, imbedded in the pulpy substance of the fruit.

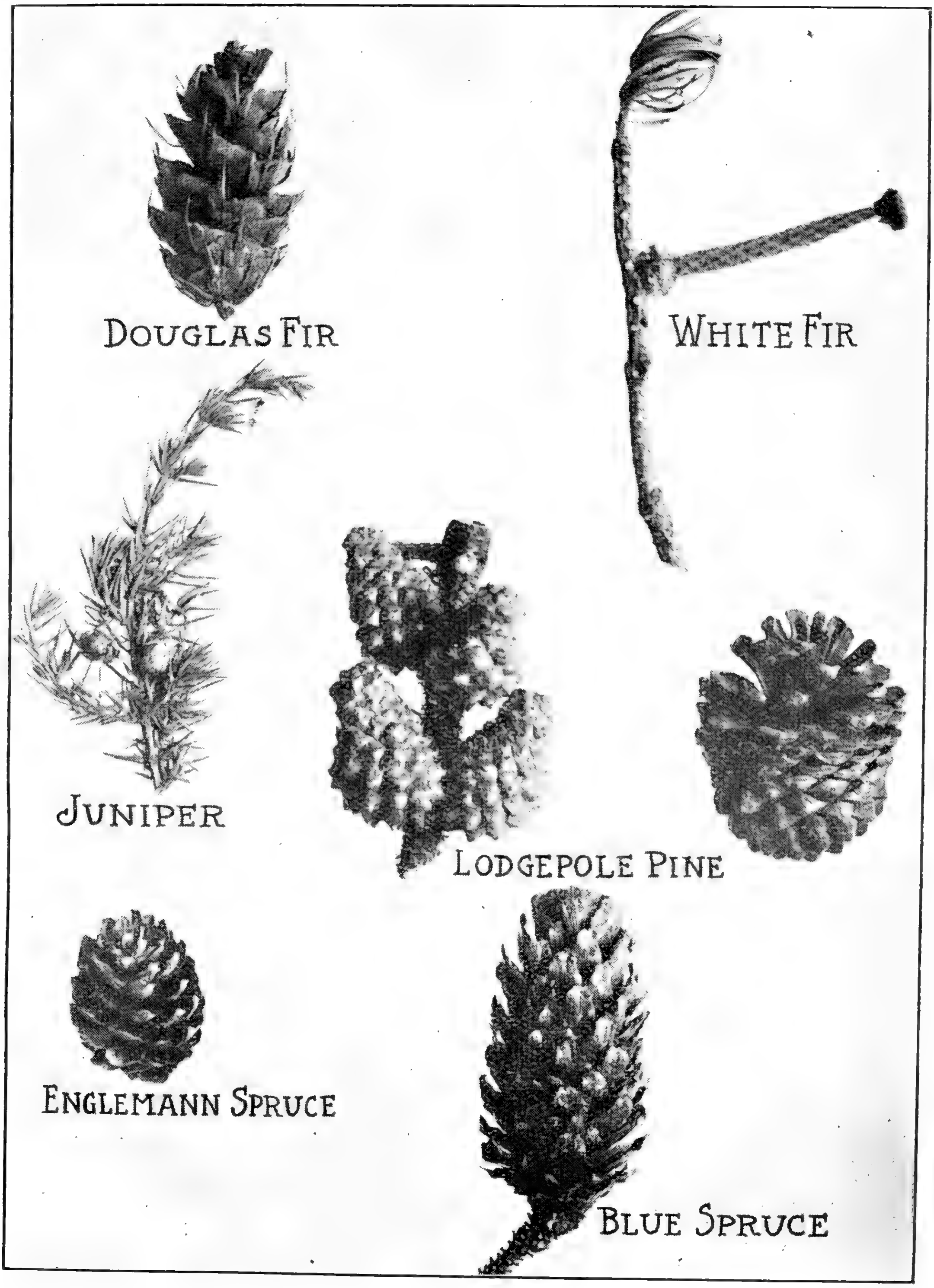
1 Leaves awl-shaped and sharp pointed, about 0.5 inch long, in whorls of three.
*Juniperus*

2 Leaves scale-like, very short, opposite in pairs.
*Sabina*

PLATE I




Colorado Conifers (Reduced ½)




Colorado Conifers (Reduced ½)

PINUS—THE PINES

## Key to the Species

1. Leaves 5 in each sheath.
   1) Cones 2.0–2.5 in. long, tips of scales blunt, each with central prickle.
   Foxtail Pine–*P. aristata*
   2) Cones 3.0–5.5 in. long, tips of scales rounded, without prickles.
   Limber Pine–*P. flexilis*
2. Leaves 2–3 in. each sheath.
   1) Leaves 3–6 in long, cones large with many scales.
   Bull Pine–*P. ponderosa*
   2) Leaves not more than 3 in. long.
   1 Cones very hard, with many scales, remaining long closed, seeds small.
   Lodgepole Pine–*P. murrayana*
   2 Cones resinous, with few scales, soon opening exposing the very large wingless seeds.
   Pinon Pine–*P. edulis*

PICEA—THE SPRUCES

1. Leaves very stiff and sharp pointed; surface of twigs between the leaves smooth, i. e. not hairy; cones 2–4 in. long.
   Blue Spruce–*P. parryana*
2. Leaves not so stiff and not sharp pointed; surface of twigs between the leaves covered with fine hairs; cones 1–2 in. long.
   Englemann Spruce–*P. engelmanni*

PSEUDOTSUGA—DOUGLAS FIR

One species, P. taxifolia, with the characters indicated in the generic key above.

ABIES—THE FIRS OR BALSAMS

1. Leaves on vigorous shoots 1–2 in. long, the two resin passages near the center of the leaf; cones 1–2 in. long, at maturity purple or almost black.
   Sub-alpine Fir–*A. lasiocarpa*
2. Leaves on vigorous shoots 2–3 in. long, the two resin passages near the lower surface; cones 2–4 in. long at maturity yellow or purple.
   White Fir–*A. concolor*

JUNIPERUS—THE JUNIPER

Leaves in 3's, awl-shaped, rigid, free and jointed at the base, spreading; fruit sub-globose, bright blue, covered with a glaucous bloom.
Low Juniper–*J. communis*

SABINA—THE SAVINS OR "RED CEDARS"

1. Leaves minutely notched at the apex; berry 0.12–0.25 in. long, usually with a single seed.
   One-seeded Sabina–*S. monosperma*
2. Leaves entire at the apex; berry somewhat larger, usually with more than one seed.
   Western Sabina–*S. scopulorum*

The above keys do not include all the species of conifers which may be found in Colorado, for instance, I have omitted the unimportant tree, *Sabina utahensis.* With some workers there is a tendency to "split up" certain of the species as above treated making a greater number of species of the remnants. Some botanists attempt to make *Juniperus siberica* from a form of *Juniperus communis,* but such an attempt defeats the purpose of classification for the beginner, because *J. siberica* is not distinct from *J. communis* At any rate for the present purpose it is best to recognize a single species. So *Pinus edulis* has been called *Caryopitys edulis,* and *Pinus flexilis* has been called *Apinus flexilis.* I prefer to use the older nomenclature.

It must not be expected that all of the above species are found in all parts of the state. The pinon pine is essentially southern and southwestern, while the lodgepole pine is essentially central and northern. Considerable variation in the altitudinal range of the species will be noticed by the student. Some of the more prominent characteristics of this altitudinal range will be considered in the following pages.

The extremely wide range of habitat variation, or variation in the site, to be found in the Rocky Mountains cannot be equalled in any other part of the United States. The fact is due primarily to the rugged topography of this particular mountain system. Nowhere else within our borders is vegetation subjected to such extreme and such varied conditions. Starting from an altitude of about 6,000 feet in the desert plains we pass very rapidly up through the foothill region, into the subalpine and finally into the Alpine grasslands and bleak Alpine summits at altitudes varying from 13,000 feet to above 14,000 feet. And all this may occur within a very few miles. Indeed by ascending from the plains to 14,000 feet one may travel not more than fifteen miles in many instances, but nevertheless he may in that distance experience the same climatic conditions, the same types of vegetation, and in fact meet many of the identical species which he would meet in traveling many days and many hundreds of miles from the same starting place to within the Arctic Circle. Certainly in the shorter distance the changes in vegetation are much more striking because they have been brought within such a few miles. We shall presently inquire with more detail into some of these changes.

The factors which are potent in the initiation of and in the development of the forest or of vegetation in general may be classified under three heads according to their nature as follows: 1. Climatic, 2. Edaphic, and 3. Biotic.

Climatic factors might also be called atmospheric factors since they are light, humidity, temperature, wind, pressure and precipitation. Great differences in these factors are imposed upon vegetation at various altitudes and upon various exposures.

Edaphic factors are in other words soil factors. The water content of the soil is by far the most important of these because of its bearing upon root activities. Other soil factors such as chemical composition may also be of importance, but soil temperature, slope, exposure, and surface character are of more importance to the development of the forest. Such soil characters as texture and cover are very important when we are considering the reproduction of stands. Vegetation is constantly under the influence of biotic factors, and while the animal life of the forest is usually of little importance, nevertheless it becomes of extreme importance in the grazing industry in its relation to the forest cover. In this form the biotic relations demand the most careful study. The relation of other plants to the forest are also many, but I shall not here enter into a discussion of these principles.

Climatic and edaphic factors are not always easy of separation. Indeed at present it seems in some cases impossible to distinguish clearly between the effects of climate and soil. In the mountains we find all gradations from precipitous canon sides to jumbled talus slopes. The talus slope when new is free from timber. Later on in life it may become so covered with trees that its early history is sealed for the young investigator. In such places we have great variation in run-off and in the amount of precipitation retained. Many most interesting observations on the results of post glacial weathering may be made in canons where such masses of talus are piled along the bases of the cliffs. At the lower end of such canons may often be found a series of terminal moraines with morainal lakes, and for some distance along the sides lateral moraines occur. The floor of such canons especially near the upper course may oftimes be nearly bare, or here and there morainic material may be seen in the form of scattered bowlders. On the smooth sometimes polished surface of such places the usual scratches and striae are prominent. Lower down in the valley large areas have a fine-textured soil, while other soil areas are characterized by large particles. This difference is most often a matter of the age of the soil.

I have already called attention to the telescoped nature of mountain vegetation and to the great differences in the plant cover at various elevations. This arrangement of vegetation superimposed in bands or belts is very commonly called zonation, and the belts are plant zones. There are various sorts of zonation, for instance we know of the great transcontinental life zones parallel with the equator. Climatic factors are most important in the production of such zones. In other words differences in latitude with the consequent changes in climate are mostly responsible for this phenomenon. When we come to mountain zones although the individual zones are much narrower than the above yet we find that essentially the same factors, i. e., climatic factors, have been powerful in their production. But here the climatic differences are initiated by changes in altitude as against latitude in the former case. The various edaphic factors are probably of much more importance in the production of mountain zones than of continental zones, since these factors are much less stable on steep mountain sides than over wide stretches of relatively level country. But still the result is practically the same except for the mere difference in width.

It was early in the eighteenth century that Tournefort in his studies of mountain vegetation first recognized zonation. He noted that on Mt. Ararat many Armenian species were found at the base of the mountain, while on the slopes above there were many species of southern Europe. Still higher plants similar to those of Sweden were found, and still above these the vegetation was very similar to that of Lapland.

So in the Rocky Mountains we find vegetation at successively higher altitudes very similar to that met as one travels from the United States to the polar seas. Writers on the subject have made various classifications of mountain plant zones, and while these differ in details, they are in the broad outline very similar. For the present I shall use a rather simple and general classification and hence one that can be rather widely applied to the region under discussion. Throughout the Rocky Mountains the following zones can be quite clearly delimited:

1. The Plains Grass Zone.
2. The Foothill Forest Zone.
3. The Mid-Forest Zone.
4. The Subalpine Forest Zone.
5. The Alpine Desert Zone.

It is seen from the names of the zones that in reality here we have a single wide belt, which is essentially forest, bound above and below by desert zones. The large forest zone is divided in turn into the three secondary zones as indicated above. It must not be supposed that these regions are perfectly distinct at all places. On the contrary, they intergrade almost insensibly in many places. However, the upper and lower limits of the broad forest belt are usually much more clearly marked than the boundary lines between the three forest zones. These five zones are characterized about as follows as they are found in Colorado.

### 1. The Plains Grass Zone.

There are no true lowlands near the mountains, but on the contrary one passes from a grass or chaparral formation at an altitude of from 5000 feet to 6000 feet directly to the foothill forest zone. The plains grass zone is essentially a grass formation surrounding the bases of the mountains and extending for many miles out on the plains. Many grasses occur in the zone the principal ones being *Bouteloua*, *Bulbilis*, *Aristida*, *Stipa*, *Sporobolus*, etc., etc. In some localities the grasses are interspersed with woody composites and in some places such woody plants as *Artemisia* and *Bigelovia* constitute the bulk of the vegetation. Many shrubs and small trees are found along the stream courses. On the higher stretches of the zone, i. e., nearer the mountains, on the low rock ridges just before we enter the foothills proper pinon pine, *Pinus edulis*, is very commonly found. The most common associate of the pine is the one-seeded Sabina, *Sabina monosperma*. These two trees appear to enjoy the driest of dry situations, where they form characteristic open stands of low trees. Some of the small trees are of great age. The rocky soil of the ridges is usually very coarse with scattered surface bowlders. The water content is extremely low especially on south exposures. Besides the conifers the soil supports a widely scattered stand of grasses and coarse herbs. Most of the ridges are covered with either granitic or sandstone soils.

It is in this zone where most interesting problems in forest encroachment may be investigated. The pinon and the sabina seldom leave their home on the ridges to wander out over the more level areas with finer soil. More often does the bull pine, *Pinus ponderosa*, migrate to lower levels and out among the grasses; even the occurrence of this species on the plains is not very common. The pinon and the sabina possess large, bony, wingless seeds so perhaps we may account in part for their absence farther out by the poorly developed devices for dissemination. But the seeds of bull pine are provided with a large membranous wing and hence they may be carried for considerable distances by the wind. It is certainly true that many more seeds of this species find their way out on the plains than is indicated by the trees found there. The reasons for this are not clear at all. I have said that the zone on the whole is grassy. In many places it is well sodded, and the water content, especially near the surface, is extremely low. The temperature of the surface of the soil is very high commonly being as high as 140 degrees F. in summer. These then are the climatic and the edaphic factors which the seedlings must overcome if the species is to encroach upon the plains. It is well known that such seedlings grow best if somewhat shaded. In the above places they are exposed to the direct glare of the drying sun. The result is that the grasses win over the pine seedlings in the competition upon the fine soil and consequently the trees are kept out by the developing sod. It is the relation of all these factors to germination and the development of the seedling rather than to the mature trees which must be studied. This reasoning may not be entirely conclusive, but it may be suggestive to the student. I might suggest that some experiments be planned in reference to this problem, because it is one which would lend itself nicely to experimentation. Here is where the forest ecologist or the worker in silvics might solve some very interesting practical problems.

**2. The Foothill Forest Zone.**

In relation to altitude, this, the first distinctly forest zone, begins at about 6,000 feet and extends upward to about 8,000 feet. Within this belt occurs most of the bull pine. As I have already indicated it may migrate to lower levels, and it may also go somewhat higher though the bulk of the species is to be found within the above limits. Bull Pine forms a very open forest. The widely scattered individuals give a park-like effect to the landscape. Grasses, woody herbs, and bushes of various species are found in the open areas. On the hillsides *Sabina scopulorum* occurs in mixture with the pine. The bull pine is found on dry and on moist slopes, on tops of ridges and in canon bottoms. The tree is not exacting as to soil requirements, growing in soils from glacial drift and volcanic ash to deep loose sands and rather tenacious clays. It is most chacteristic however on dry, well drained rocky or gravelly soils. It may live and thrive in a soil with very low water content, its deep roots enabling it to grow in nearly as dry soils as those occupied by the Pinon. The tree is a frequent and an abundant seeder after the age of twenty-five years has been reached. Seedlings meet with many of the same difficulties here that they do lower down in the plains grass zone. For efficient germination and seeding fresh, well-drained soils are required along with a moderate daily range of temperature and not too strong light. The older trees demand much light, but the seedlings must be shaded for a number of months. Seedlings commonly occur beneath the parent trees, near logs, rocks or in the shade of brush. In many places a nurse crop of aspen furnishes the necessary shade for the protection of the young trees.

On moist north exposures and sheltered slopes in canons and on benches Bull Pine occurs in mixture with Douglas Fir, *Pseudotsuga taxifolia.* In such places may also be found scattered individuals or groups of white Fir, *Abies concolor,* and Blue Spruce, *Picea parryana.* The White Fir is a very tolerant tree, small individuals may often be found beneath a rather heavy cover of the associated species.

### 3. The Mid-Forest Zone.

The altitude of this zone is from 8,000 feet to about 10,000 feet. In most places the zone is characterized by a closer forest cover since most of the bull pine has been left behind and the ground has been occupied by more tolerant species. From the central portion of the state northward lodgepole pine, *Pinus murrayana,* is the most conspicuous tree. It frequently forms very dense pure stands. The species is very tolerant of shade when young; it may persist for many years in very dense stands, but it thrives best in full light. In all close stands the diameter increment is extremely low and the trees soon become tall and slender with slight taper. The species produces each year an abundance of seed of high rate of germination. The cones may remain on the branches for many years and are only opened in some cases by fire. Natural regeneration is very slow, but with the aid of a light fire which is not of sufficient severity to destroy the cones, but to open them and allow the seeds to fall, seeding may be exceedingly thick and even. Even aged stands with full top light may often be found over areas which have previously been swept by fire. Full light and a mineral soil free from litter are the chief requirements of good reproduction.

Bull pine also occurs in this zone, as does the limber pine, *Pinus flexilis,* which because of its rather plastic nature is found in a variety of habitats. Limber pine is found on exposed, extremely dry rocky south and east exposures, on summits of ridges and sometimes in moister canons and on the banks of mountain streams. The species is usually found in dry, rocky, very shallow soil with little or no humus. It sometimes occurs on almost bare granite. The species requires much light and it never forms continuous, dense stands. The foxtail pine, *Pinus aristata,* is also found at this altitude, but it is almost always confined to dry ridges and rocky ledges of south slopes. In soil and light requirements this species is similar to the limber pine although it seems to endure even drier soils. The aspen, *Populus tremuloides*, is a very conspicuous tree in this zone, forming groves of small trees over wide areas. Englemann spruce, *Picea engelmanni*, also makes it first appearance in the upper stretches of this zone, but becomes of more importance in the zone above.

Throughout the mid-forest zone much of the forest has been burned, and the problems of fire and of seeding after the fire are many. Interesting and important studies can be made of the relation of fire to the destruction of merchantable timber, to the preparation of the seedbed, and to the opening of the cones of the lodgepole pine. Very commonly burned-over areas are stocked with a full stand of other species before the conifers come in. These species are often of great value in the early history of the coniferous forest.

**4. The Subalpine Forest Zone.**

This zone ranging from an altitude of 10,000 feet to 11,500 feet is characterized most generally by forests of Engelmann spruce, *Picea engelmanni.* Limber pine and subalpine fir, *Abies las ocarpa*, are important secondary species in many localities although neither of these species forms as close stands as is the case with the spruce. Engelmann spruce often forms large pure stands. The species demands a rather moist soil, reaching its best development on the rich retentive loams of north exposures in gulches and canons. The shallow root system enables it to grow in shallow soils. The species is very tolerant of shade, far exceeding its two common associates in this respect. It is a prolific seeder after about the twenty-fifth year. Heavy seed years occur at intervals of 3–4 years and the seed is of high rate of germination. Notwithstanding its great seed production seedlings are not so abundant as would be expected. They usually occur in small protected openings in the older forest. In such places the small trees are sometimes so thick that it is impossible to penetrate to the center of the thicket without cutting the trees.

As has been said limber pine never forms close stands, but on the other hand occurs singly or in groups under a wide range of soil conditions. At timber-line this species is often found on the exposed ridges alternating with Engelmann spruce in the canons. At this altitude, about 11,500 feet, the limber pine, ordinarily an irregular tree as to form, assumes the most fantastic shapes. The trees may be eight inches in diameter and only six feet tall with live branches only on the side away from the wind. Toward the windward portions of the trunk are in

PLAT III

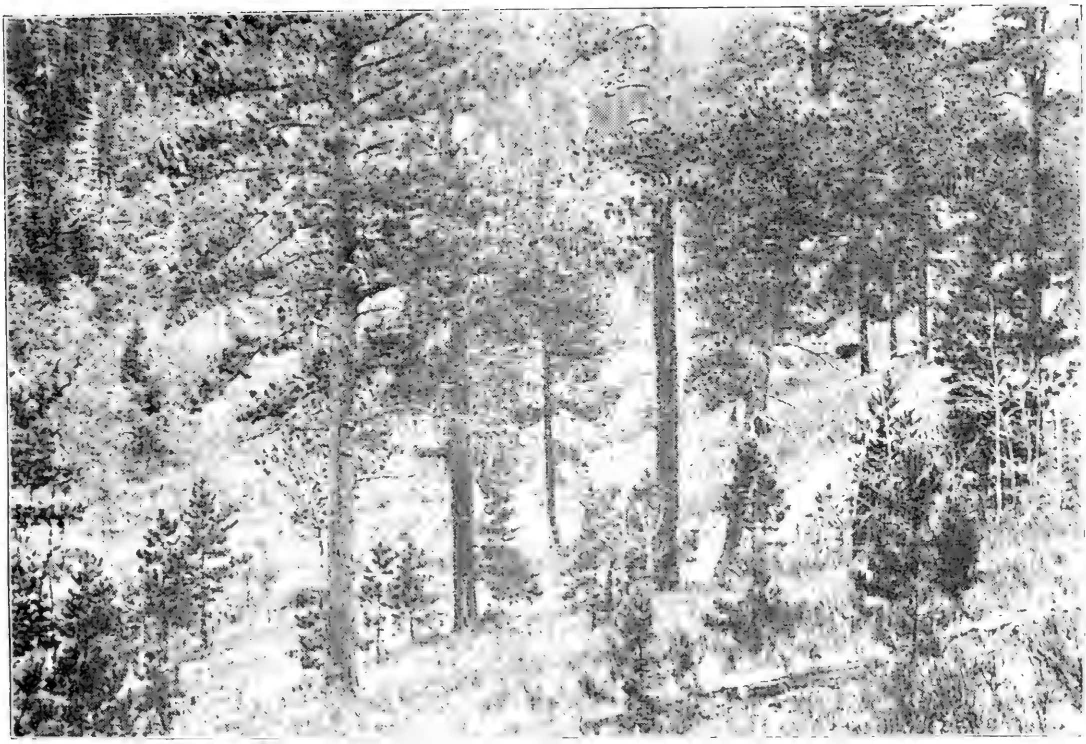


FIG. 1. Reproduction of Bull Pine at 9000 ft. in the Pike's Peak Region.

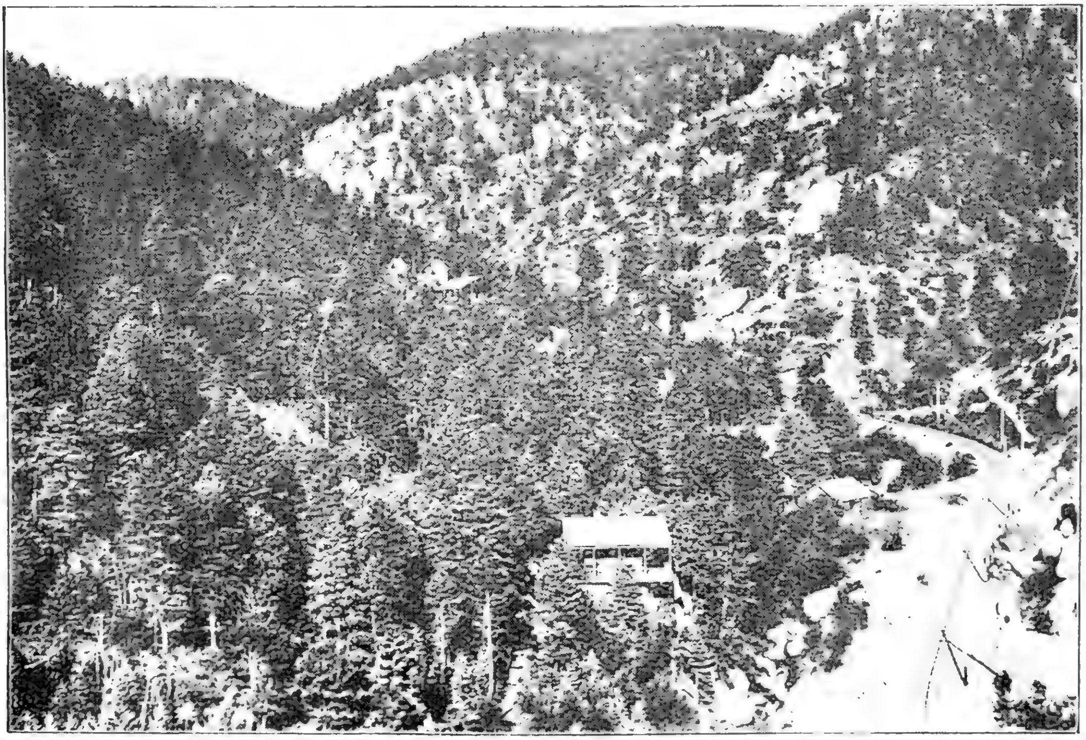


FIG. 2. Douglas Fir on North Slope at 8500 ft. in Pike's Peak Region.

many cases devoid of bark—a condition produced in all probability by blowing sand and ice particles during winter gales. The Engelmann spruce is also a common tree at timber-line in the canons. Here this species also forms low brush-like vegetation and straggling trees are found here and there with prostrate trunks and spreading branches which form a huge woody mat often several feet in diameter.

One who has never been in the mountains is inclined to think that "timber-line" is at all places a perfectly regular and clearly defined line of demarcation between the forest and the alpine heights. But this is rarely true. Local conditions modify the altitude to which trees ascend, and in fact "wind-timber" runs up in widely isolated tongues to various altitudes. Above such areas there are oftimes smaller areas of dwarfed and gnarled trees isolated from the main body below. Timber-line is usually much "higher" in canons and on north slopes than on ridges and south slopes.

Besides the conifers at timber-line there may be found dwarf birches and willows forming rather extensive areas of brush about two or three feet in height. This brush may pass well up into the Alpine Desert Zone. Bearberry, *Arctostaphylos uva-ursi,* is a very common prostrate creeping woody plant forming extensive carpets of thick glossy leaves on the open hill-sides in the lower stretches of Subalpine Forest Zone. With it are many other species of thick-leaved xerophytes.

Ponds and boggy places are quite common on flats along stream courses. Such places are always characterized by a brush formation composed of birch, aspen, and various species of willow. The zonation about the ponds or lakes is in many places well defined. Usually the first zone or the zone nearest the water is composed of species of sedges extending all the way around the lake; back of this occurs a shrub zone composed mostly of birch and willow which may give way at once to the coniferous forest or to a zone of aspen which is in turn surrounded by the conifers. The great controlling factor in such radial zonation is of course water content. The percentage of water in the soil differs considerably for the various zones, in general diminishing outward from the edge of the lake.

### 5. The Alpine Desert Zone.

I have called this a desert zone because in all its essential features it is a desert and the plants found in the zone are almost without exception extreme xerophytes. The zone is of little economic importance, but nevertheless it is of great scientific interest. Great areas of bowlder field and rock heaps covered only with lichens stretch out before one as he comes out from the timber and the brush lands below into this zone.

The altitude of the zone ranges from 11,500 to the mountain tops usually about 14,000 feet or occasionally nearly to 15,000 feet. However in many places there is considerable vegetation, but it is always low. Species of willow grow only to a height of one or two inches and in this height we may find stem, crown, flowers, and fruit. Such species often form extensive mats or carpets of glossy or hairy leaves—a live forest in extreme miniature. Many species of woody mat-forming plants and deep-rooted perennials are common. It must be remembered that the growing season in such alpine summits is a scant eight weeks and so vegetation is forced to crowd foliation, flowering, and fructification all within this brief period. We see in these demands something of the significance and the efficiency of the enormous root system richly stored with reserve materials. Grasses and sedges are numerous as to species and in some places they form extensive areas of close sod. Frequently the grasses and sedges are accompanied by other species whose flowers are oftimes large and gorgeous. In such places the rock fragments have been well disintegrated and they form with decayed organic matter considerable soil covered with the low but luxuriant vegetation which conceals all save the larger disintegrating fragments of rock. Many of the plants have very thick, hairy leaves and gaily colored flowers. At 14,000 feet the vegetation is very scant. Here disintegration has not proceeded far and practically all plants except lichens are confined to the crevices in the rock and to narrow areas with little soil between the bowlders of the jumbled alpine rock pile.

PLATE IV

FIG. 1. Virgin Engelmann Spruce at 10900 ft. in Pike's Peak Region. (After Clements)

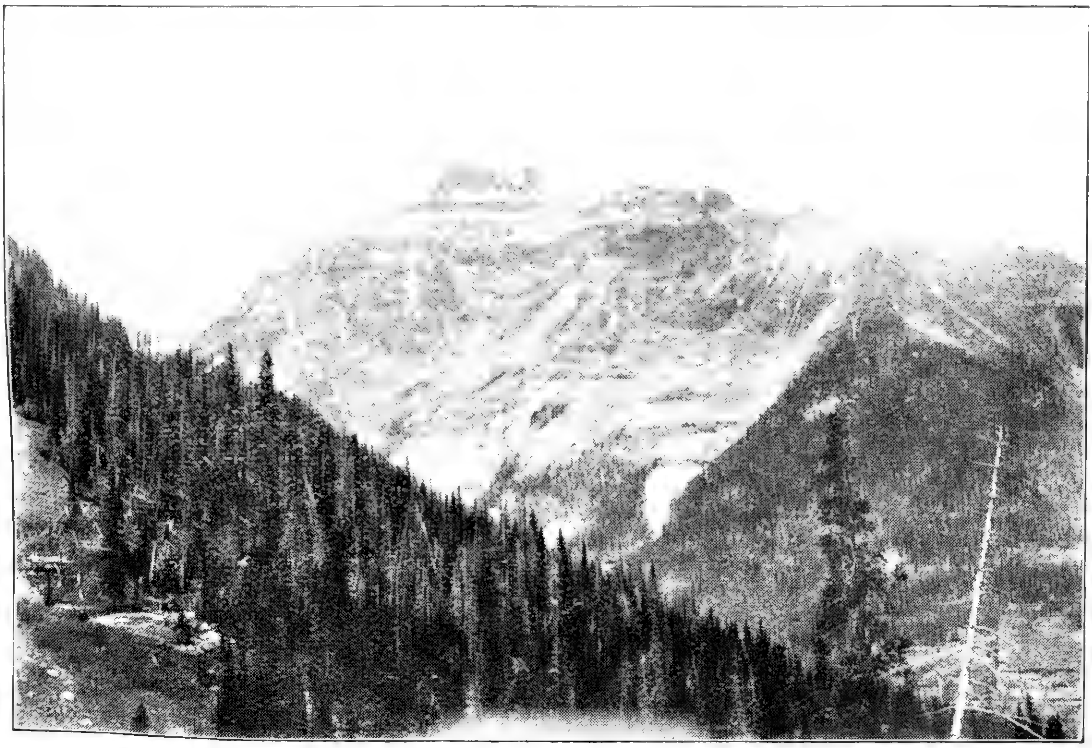


FIG. 2. Engelmann Spruce in dense stand at 10000 ft. showing destruction by rock slide. Near Ouray, Colo.

## LUMBERING COTTONWOOD IN NEBRASKA

W. E. S. Hallett

The most important commercial tree in Nebraska is the cottonwood. It is planted extensively and occurs naturally along the streams. Many good stands are found in the lower Platte valley. One of the best natural stands in the state, now being cut, is on an island in the Platte River three miles southwest of Fremont. The island contains about one thousand acres, one-fourth of which is covered with a scattered growth of trees. Mr. J. J. Hawthorne owns about five hundred acres on the island and it is upon his land that the best stand of timber is found, occupying an area of fifty to sixty acres on the south side of the island.

Besides the cottonwood which composed about 90% of this stand, there is a scattered growth of red, white and cork elm, hackberry, red mulberry, green ash, willow, burr oak and red cedar. All the latter are small non-merchantable trees. The crowns of the trees shade the ground completely, eliminating all ground cover except a few bushes. It has been estimated that the stand will cut 15,000 B. M. or better to the acre. An area of a little more than two acres that has been cut yielded 31,500 B. M. The trees have an average height of ninety feet with a log length of about thirty-five to forty feet. The average diameter is about eighteen inches. The soil is a loamy sand and very loose in texture. It is from two to four feet deep over a subsoil of sand. For the most part the ground is covered with a thick layer of leaves which decay very rapidly because of soil moisture and form a good, rich layer of humus.

As the island is only eight to ten feet above the low water mark of the Platte the roots do not need to penetrate very deep to get a good supply of water. Nearly every year when the snow begins to melt and during the spring rains the island is covered with water. Every time the river overflows it deposits a layer of sand on the ground and at the same time washes away a great deal of the litter that has formed beneath the trees.

In the past year, Mr. Hawthorne has grazed four hundred head of sheep on this area. They graze over the five hundred acres, but generally keep to the more open part of the island where there is a very good growth of grass. There was no coppice growth on the small area that was cut over years ago, and this is probably due to the cattle grazing on the land eating the sprouts.

This stand of trees has been cut over a number of times. In 1857 there was a fairly good growth which the settlers cut for building material and firewood. A few trees were left and these reseeded the area. In 1874 the stand had reached the size of hop poles, and was cut over again. It was at this time that the present growth started. The older trees left for seed trees are easily distinguished by their size, and deeply furrowed bark. One of these trees measuring 38 inches in diameter was found to be seventy-three years old. This tree showed very plainly that its rate of growth both in diameter and height decreased rapidly after it had reached the age of about forty years. The marked decrease indicates that it is advisable to manage cottonwood on a rotation of thirty to forty years. In two rotations of forty years each more wood would be produced than in a single rotation of eighty years. Furthermore the logs from the younger trees are much less liable to check than those from older trees and the trees themselves are not so much affected by butt rot.

In removing the timber from this tract a distinct system of management is used. The owner gets two-fifths of the lumber cut. He has turned over the entire supervision of the work to a manager, who takes one-fifth of the lumber besides three-fifths of the slabs, all the sawdust, and all the cord-wood for his pay. He has to pay for the cutting of the trees. The manager sub-lets the sawing to the sawyer who owns the mill. He saws up the logs and furnishes a man and team to do the skidding. He receives as his share two-fifths of the lumber cut and two-fifths of the slabs as fuel for his engine. As the logs are brought to the mill they are scaled. The first two thousand feet sawed goes to the sawyer who cuts the log into any sizes of lumber he wishes. The next three thousand is cut for the owner and the manager. In this case the latter marks on the end of each log what he wants it cut into. He markets the three thousand and settles with the owner in cash.

The logs are cut into all lengths from three to sixteen feet. No tree is cut unless it will square eight inches at the stump. If the cutters strike a tree that is defective at the stump they are required to cut higher up in the tree until they strike a place where the wood is all sound. They cut up as high into the tree as they are able to get a log that will square eight inches. If in felling the cutters split a tree they are held accountable for the wood lost because of the split. Two different parties have done the cutting, one used the saw and the other the axe for felling the trees.

This cutting was done during the warm weather the first two weeks of February. The latter part of the month there was a very severe cold spell which caused some of the logs to check very badly at the center. Second and third grade lumber is obtained from the logs that are checked.

The skidding was done by one man with a team and two wheeled cart. The cart was nothing more than the front wheels of a common farm wagon. An iron chain was attached around one end of the log and then fastened to the axle of the cart and and the log dragged to the mill. At the present time they only have to skid the logs about two hundred yards. The man and the team skid from 5,000 to 6,000 B. M. per day. Much more than this could be skidded in, but 6,000 B. M. is about as much as the mill can cut in a day.

The sawing is done by means of a portable sawmill. A twenty horse-power Rumley traction engine furnishes the power. For cutting the logs two circular saws are used, one forty inch and one sixty inch. At present the sawyer is using the forty inch saw and sawing up the smaller size logs. Besides the main saw there is a small cut-off saw with which the engineer cuts slabs for use in the engine. Coal is used with the slabs to run the engine as enough steam cannot be kept up with wood alone.

The mill crew is composed of five men and two boys. There is a sawyer; rachet setter; an off bearer; an engineer; a skidder, who at leisure times removes the sawdust from the pit; and the boys who pile and haul lumber. The wages paid these men could not be ascertained because all but the engineer had an interest in the sawmill and each received a percent of the returns on the sawyer's share of the lumber.

The lumber is graded into three classes. The first grade is clear lumber, cut any length, width or thickness that the buyer wishes. This grade sells at $25.00 per M. At the present time an order for blocks 6 inches by 6 inches, three and four feet long, used for cribbing, is being filled. Some of the first grade lumber was used by bridge contractors for flooring. One contractor used both cottonwood and western hemlock but prefered the cottonwood. The second grade lumber is mostly sound wood cut in all sizes and lengths. The lumber is sorted into widths and thicknesses but not into lengths. The buyer designates what width and thickness he wishes but he has to take the lengths as they come. This grade sells at $20.00 per M. Most of the lumber is used for rough work in building houses and barns, and for box boards. The third grade is composed of culls and boards that are badly checked. The price paid for this is from $10.00 to $15.00 per M. Some of this wood is used for box and crating material, most of it for miscellaneous purposes.

The Fremont Ice Company has contracted to take all the sawdust for use in their plant. They pay six cents an inch for it, an inch being a layer one inch thick on a standard wagon box, and haul it themselves. If they wish it delivered at the plant they have to pay eight cents an inch.

The tops of the trees and some of the slabs are used for cordwood. A person can come to the mill and get a load of limbs and branches thirty-two inches high on the trucks of a standard wagon for $1.00. For a load of slabs 26 inches high they pay $1.50. A cord of wood cut in any lengths and delivered costs $4.50. If the buyer comes after the wood he gets it for $2.50 a cord. The engineer charges $1.20 to saw up a cord of wood into 6, 8, or 12 inch lengths. Some of the slabs and culls are cut up into kindling and sold at fifty cents a barrel. As this operation has only been carried on about a month it was impossible to get any results regarding the cost per M. of the finished product, or the profit they were making on the cutting.

The owner values his entire five hundred acres at $65 per acre. Although he has turned over the management of it to another man he still retains an active interest in the work. Under his direction the trees are cut and used according to improved forestry methods. He insists that a system of cutting to a diameter limit with low stumps be used. The stumps left after the first cutting were 28 inches high, those cut 12 years ago averaged 22 inches, while the trees cut during the past winter had a maximum stump height of 16 inches. All dead and down timber is cut up as soon as possible. Every bit of the bole and top that can reasonably be considered merchantable is converted into firewood while the smaller branches are piled and burned. The complete and perfect utilization resulting from these measures makes the logging operations easier and makes the yield considerably larger than it would be otherwise.

## THE DESTRUCTIVE DISTILLATION OF HARDWOODS

C. R. Tillotson

Statistics gathered by the Forest Service show that the amount of wood used for distillation in the year 1906 was nearly 1,200,000 cords of which 50,000 cords were pine and the remainder hardwoods of an average value of $3.25 per cord. Some of the wood used for distillation consists of the waste incident to logging and lumbering operations while in other cases the wood is cut especially for distillation. The quality of the material necessary in this industry need not be high class. Although a large amount of material, consisting in the hardwood distillation almost exclusively of maple, beech, and birch, is used each year, the industry may, if conducted properly, serve as a means of utilization of crooked, small, defective, and cull body or limb wood, or better still, of the waste always incident to logging and milling operations. Forest Service statistics show that all the hardwood slabs, edgings, and trimmings annually wasted could be made to yield 16,900,000 gallons of wood alcohol and 145,000 tons of acetate of lime or just double the amount now used each year.

Wood carbonization or the production of charcoal by means of pits and kilns is by no means a new industry, but the process of destructive distillation of hardwoods by means of which the secondary products, wood alcohol and acetate of lime, are saved has reached its present state of efficiency in the United States only in the last few years. It is to these secondary products that the hardwoods owe their supremacy over the conifers both in the amount of raw material used and in the finished products resulting therefrom. The principle of this kind of distillation is simply an air-tight retort in which the wood is run on steel cars and heated indirectly. This causes it to carbonize and the volatile substances in part composing it to pass off in the form of gaseous vapor which is later condensed and which gives us the wood alcohol and acetate of lime of commerce. During the winter of 1908–9, it was the writer's privilege to investigate one of these chemical plants situated in Wisconsin and to secure the data contained in the following pages.

### Plant and Equipment

The plant consisting of four large wooden buildings and considerable yard room and covering approximately ten acres of ground is valued at $100,000.00. It has six retorts in operation continuously day and night, uses 48 cords of wood daily, and employs twenty-four men who work in two shifts of twelve hours each, twelve men to a shift. The steel cars on which the wood is run into the retorts and which have a capacity of two cords of four foot sticks are of the narrow gauge type, 4 feet wide and 10 feet 6 inches long, without a roof, and with the sides and ends built of a lattice work of steel 6 feet 10 inches high. For switching in their own yards, the company employs a small narrow gauge engine which weighs seven tons on its drivers and burns about two bushels of coal per day. Two artesian wells 10 inches in diameter and 80 feet deep furnish the water supply for the plant. A supply of approximately 6,000 cords of wood is kept in the yards at all times. Maple is used most extensively, and beech, birch, ironwood and elm to some extent. Maple yields the most alcohol, about 12 gallons per cord of wood while beech yields the most acetate, about 250 pounds per cord. By using these two woods, a good run of both alcohol and acetate is obtained. The sticks are 4 feet long and from 2 inches to 8 inches in diameter. In loading the steel cars, the larger pieces are placed on top because the heat in the retort is greatest at the top, and, consequently, the carbonization of the whole load is more uniform if the larger pieces are placed above. Before the wood is brought to the company's yard, it is left for six months in the woods to season which makes it easier to handle and also makes carbonization possible with less expenditure of heat.

**Products**

The products of this destructive distillation are charcoal, wood alcohol, acetate of lime, and tarry and gaseous compounds. Of these, the first three are of commercial importance while the last two are of such little importance that they are burned as fuel. A comparison of the closed retort method and the kiln method of carbonizing wood gives us some interesting figures on the amounts of finished products obtained by the two methods.

| | Closed Retort Method | Kiln Method |
|---|---|---|
| Charcoal per cord wood.......... | 50 bushels | 40 bushels |
| Acetate of Lime per cord wood... | 180 pounds | 65–75 pounds |
| Alcohol per cord wood........... | 12 gallons | 3– 4 gallons |

**Process of Distillation**

Four of the loaded steel cars are pushed into the retort and four carloads of the carbonized wood are pushed out at the same time. These retorts are 47 feet long and just wide enough and high enough to admit a loaded car. The retort is air tight and consists of brick walls 16 inches thick lined on the inside by steel plates 3 inches in thickness which unite to form a large steel box. This box is supported by five U bolts 1¼ inches in diameter which are fastened to eyebeams. These eyebeams together with lap tiling 4 inches thick form the cover of the retort. Between the steel and the brick walls, a space of 4 inches is allowed for expansion. The average life of one of these retorts is about ten years. Heat is applied from beneath by means of a firebox which is constructed of brick surrounded by steel bands ⅜ inches thick and 18 inches apart and which extends four feet outside of the retort, the purpose being to heat uniformly the whole retort. The firebox is roofed by an arch of fire-clay which approaches to within 32 inches of the base of the retort and whose object is to prevent the direct application of the flame to the base of the retort and thus cause it to warp. Slits about 1 inch wide by 12 inches long are cut through the side of the arch to allow the heat to come in contact with the retort. The draught is regulated by a flue with dampers. As fuel, about six cords of waste material from a sawmill is used each day. After the wood in the retort has been subjected to heat for about twelve hours, gas begins to come off. The portion of this which does not condense is fed into the furnace and burned. The tar which is formed in the process of distillation is also burned.

**Chief Product**

The chief product obtained from this wood distillation is charcoal. To char the wood thoroughly, it is left in the retort for 24 hours at a temperature of about 750 degrees F. At the expiration of this time, the cars of charcoal are run into galvanized iron coolers which are just slightly larger than the cars themselves. In these, the cars are left for two days and are then run into the yards for one day. From here, they are switched to a shed whose floor is 22 feet above a railroad track on which standard cars are set. The charcoal is screened and by means of a chute run into these cars whose capacity is about 13 to 15 of the charcoal cars.

**Secondary Products**

Alcohol

As the wood is charred, the volatile substances in part composing it are driven off in the form of a gas which passes through condensors of which there are two to each retort. These condensors are hollow cylinders 4 feet in diameter by 8 feet tall with a steel jacket ¼ inch thick, and contain 70 copper flues. Water comes into these condensors from below and is discharged through an overflow pipe above. The gas from the retort comes in at the top and passes into the flues where part of it, the so-called pyroligneous acid composed of wood alcohol and many other complex compounds, condenses and drops into a six inch vapor pan at the bottom of the flues. The gas which does not condense is drawn off at this stage in the process and fed into the furnace by means of a steam jet. From a cord of dry wood about 400 gallons of acid is obtained and more if green wood is used.

From the condensors, the acid is led to tanks, nine in number, 9 feet in diameter by 10 feet high constructed of 2 inch red fir planks. Here the tar is allowed to settle and is then drawn off through a 1½ inch pipe to the furnace and burned. Tar composes about 1-5 part of the pyroligneous acid. From these tanks, the acid is pumped to a copper still 54 feet high by 4 feet in diameter in which at equal distances apart, there are arranged one above the other 21 perforated partitions or plates pierced by holes ½ inch in diameter and 1½ inches apart. The acid is pumped in at the top of the still through a 2½ inch pipe while steam is turned in at the bottom. The acid separates and comes out at the bottom of the still while the alcohol vaporizes and comes out at the top to a series of three wooden oil traps. In these the oil which vaporized with the alcohol settles at the bottom while the alcohol which at this stage is about 15% pure is drawn off from the top and led to two alcohol tanks sunk in the floor. These are 6 feet high by 9 feet in diameter and are constructed of ⅜ inch boiler iron. Here the alcohol is neutralized by adding to it one bushel of lime to the amount of crude alcohol obtained from one cord of wood. It is now allowed to stand for six hours and is then pumped to a second copper still 50 feet high by 2½ feet in diameter. This still is composed of eleven sections with three perforated plates to each section. The alcohol comes in the top about 15% pure, is vaporized by steam coming in from the bottom, and goes out about 82% pure. The oil from the bottom of this still is waste. To each 2400 gallons of alcohol put in here, only 500 gallons of the purer alcohol is obtained, the difference of 1900 gallons being waste.

The 82% pure alcohol is now run into a third still which is heated at the bottom by a coil of pipes. From this, the alcohol comes out about 90% pure and is led first into a separator 30 inches in diameter by 5 feet tall and then to a cooler 30 inches in diameter by 7 feet tall. From the cooler, it goes to a series of three bleaching stills which have one perforaed plate to each section. To bleach the alcohol, it is treated in the first of these stills with six quarts of sulphuric acid to each 2400 gallons of alcohol, in the second still with twenty-six quarts of sodium hydrate to each 2600 gallons of alcohol, and in the third still with twenty-six quarts of chloride of lime to each 2600 gallons of alcohol. From this last still, the alcohol is run to the shipping tank.

**Gray Acetate of Lime**

The acid coming from the bottom of the first still is conveyed to a wooden still where the oil which in part composes it is taken out. The acid is then run to wooden tanks 12 feet in diameter by 4 feet high called neutralizing tanks in which it is neutralized by adding one bushel of lime to the amount of the liquid coming from one cord of wood. The lime causes the acid to turn a deep wine color. From these tanks, this mixture is pumped to vats 16 feet long, 8 feet wide, and 16 inches deep, constructed of $\frac{3}{8}$ inch steel, covered by a hood, and having a double bottom separated by $\frac{3}{8}$ inch of space. Live steam is turned into this space and the mixture boiled 4 to 5 hours. It is then shoveled out on the floor and dried three to four hours. The resulting substance is our gray acetate of lime.

## LUMBERING IN COLORADO

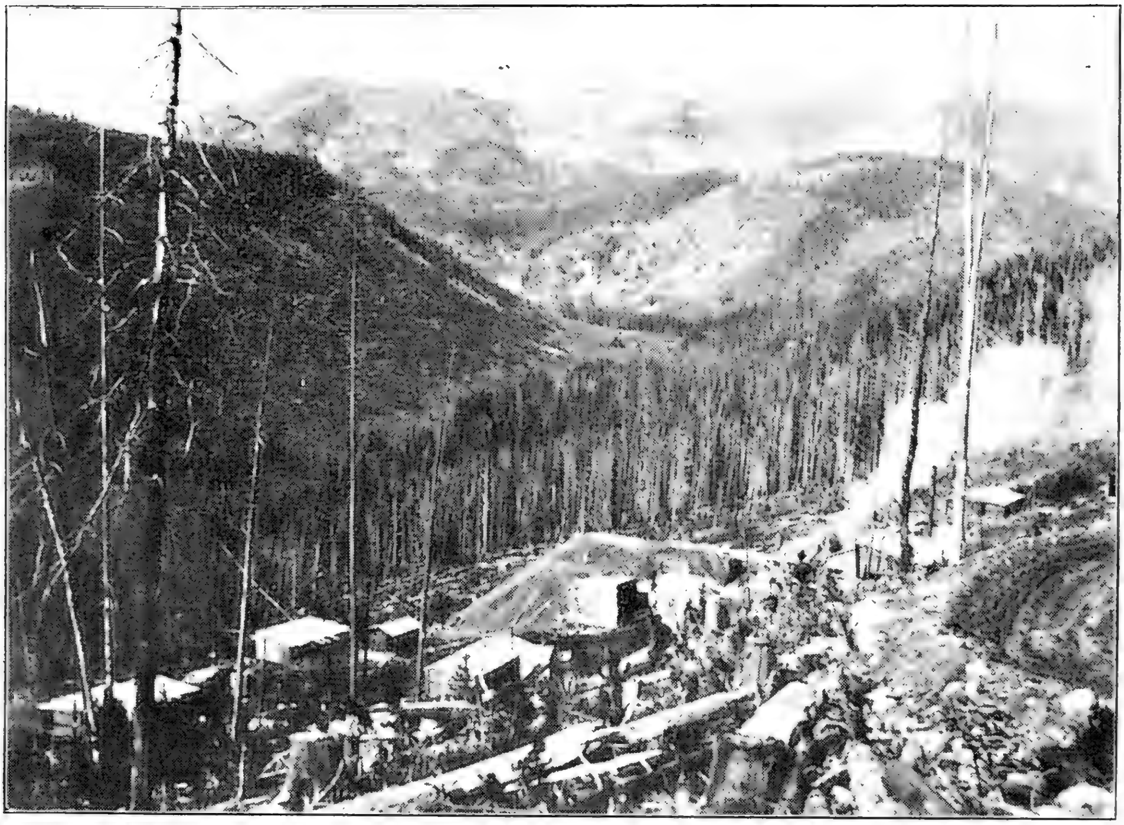
H. H. Greenamyre

The characteristic species of the forests of western Colorado are lodgepole pine and Engelmann spruce. On the Holy Cross National Forest in the west central part of the state the two are of almost equal importance. To be sure, many other species are found but they are of almost no commercial importance. The most important of these are balsam fir, blue spruce and Douglas fir. The first comes in under lodgepole pine and Engelmann spruce as a temporary type; the second, blue spruce, is confined entirely to wet valleys and along stream courses, while Douglas fir is occasionally found in mixture with the leading species, but in this locality it is at best a scrubby tree.

Lodgepole pine is found throughout the region from the lowest elevation up to timber line and may be said to constitute one of the two types. It occupies the steeper slopes, very rarely the flats, and occurs in pure stands. As this particular region marks almost the southern limit of the range of lodgepole it does not develop into as valuable a timber tree as in Idaho or Montana. In Colorado the tree reaches its best development at an elevation of 10,000 feet and often attains a height of 90 feet and a diameter of 26 inches. More commonly it is not over 70 feet tall with a diameter of 16 to 18 inches. The bole tapers considerably and is seldom free from branches for more than 30 feet above the ground. Stands of pure lodgepole vary in density from 5,000 to 20,000 B. M. per acre. However, the average stand is about 8,000 feet.

Engelman spruce constitutes another type and usually forms pure stands on the gradual slopes and on moist flats. It marks the true timber line and at the head waters of streams may be found as high as 12,500 feet. This tree reaches its best development on wet flats and attains a maximum height of 120 feet and a diameter of 36 inches. The average size is probably 80 feet tall and 18 to 20 inches in diameter. The bole is straight but tapers a great deal, and in all but the thickest stands is covered with branches almost to the ground. Stands of Engelmann spruce vary in density from 4,000 B. M. on the poorest sites to as high as 50,000 B. M. on the best sites, where the soil is good and moisture is plentiful.

On account of the topography of the region lumbering is confined almost entirely to portable mills which, of necessity, are small. The best timber throughout the mountains, espe-



A Typical Colorado Sawmill.

cially that at the lower elevations has been taken out. All that remains is relatively poor and far distant from the railroad. The building of roads, the most expensive part of the whole lumbering operation, must be carried on further and further up into the hills. The lumber haul has been lengthened in many cases doubling the cost of transportation from the mill. The present management in allowing only one-half to one-third the merchantable timber to be cut is another factor which tends to increase the cost of production and to eventually drive out the operator. The lumberman cannot afford to lay out a system of roads and establish a camp for a small amount of timber. The expense in this case more than overbalances the profits, so, in a comparatively short time all of the timber that can be profitably taken out will be cut and unless the times change materially no operations will be going on in the less important districts.

After the lumberman has bought the stumpage on a tract of land, often on a single hillside, he makes a preliminary cruise of the timber and decides upon a location for the camps. This is usually done the summer before cutting is to begin. The mill must be located so that the largest possible amount of timber can be gotten to it in the easiest way. But at the same time a large supply of water must be at hand which must be continuous throughout the summer. However, the timber is the more important for water can be "flumed" or "ditched" for a considerable distance. The logs must always be hauled down grade and it is of little consequence how steep this grade is, up to approximately 45%. Springs are common and sufficient water may be obtained from them in case a mill is not close to a stream. It is best to have the camp site as level as possible, but generally when the other conditions are satisfied little attention is given to this. The camp is invariably located at the lower central edge of the tract.

As soon as the location of the camp is decided upon a road is laid out to the railroad. In many cases, there is already a road from the railway for a considerable distance towards the camp. Often, however, the lumber road must be quite long and frequently costs a large amount of money, varying directly with the roughness of the topography. In this road down grades are essential, but many roads laid out without a preliminary survey often have level stretches and even slight up hill grades. These are to be avoided, even at a large increase in the expense of building.

The length of haul in this region is seldom over ten miles and is often not more than six. Sawmill men find that the lumber cannot be gotten out with profit when it is over ten miles. When the haul is from five to seven miles long "a trip and a half" can be made each day. When the distance exceeds eight miles, however, only a single round trip can be made each day.

Usually the summer or fall before the operations are to begin the camp is built. The mill is the central figure and all the other buildings are laid out with reference to it. A spot is selected with plenty of available room for lumber piles, sawdust, skidways, etc. Excavations are made for the engine and boiler which are hauled up from the previous setting on sleds as soon as enough snow has fallen. Generally the mill is set up and enough rough lumber is sawed out to build the mill-shed and the floors and roofs of the other buildings. The side walls are usually built of dry logs and chinked in with mud. Most of the portable mills of Colorado consist of an upright boiler, and a stationary horizontal engine of twenty-five to thirty horse power. Wood is always used as fuel. In most cases this is dry, but often a few green slabs are mixed in. Only circular saws are used which vary from forty-eight to sixty inches in diameter and which may have either permanent or detachable teeth. Both kinds are found in every district. These saws have a $\frac{3}{16}$ to $\frac{1}{4}$ inch kerf. The carriage is from twenty to thirty feet long and may have either two or three blocks. The amount of carriage track varies with the length of logs that are to be sawed, but is usually from eighty to one hundred feet. A pit is dug directly underneath the saw, and the sawdust is taken out by means of a large wheelbarrow, a sled and a horse, or in a few cases with a sawdust blower. The sawdust pile is several yards away from the mill and after a year's operation constitutes the biggest part of the camp. The slabs are disposed of in one of two ways. Where the lumber is piled directly beside the mill a track (usually elevated) is erected, running to one side of the mill, and the slabs are thrown on a car which is run out to the end of the track where the slabs are dumped on a fire. In this way there is very little danger of fire spreading through the camp and surrounding timber. When the lumber is piled on cars and taken to the yard the slabs are ricked up below the mill, several yards distant, and burned at night. One or sometimes two piles are made. These piles are burned at night when there is a breeze blowing down the gulch, which insures the safety of the mill.

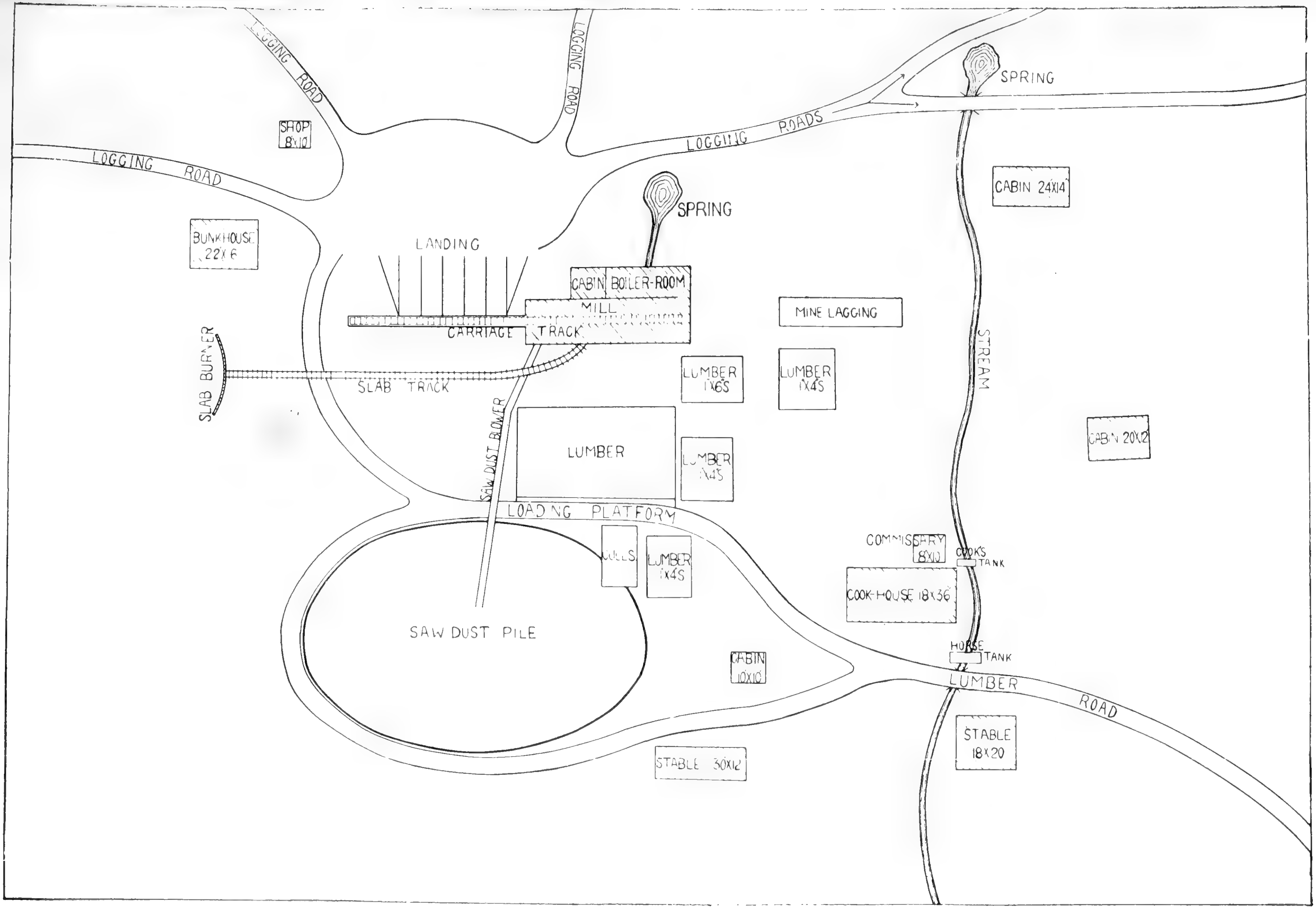
The lumber, likewise, is disposed of in one of two ways; either piled directly below the mill or taken to a place where more room is available by the aid of cars and a track. The latter system is used when there is considerable lumber held in the yard, and is to be preferred because the lumber can be sorted out and piled to better advantage. Two cars are utilized, necessitating the use of a switch. While the second car is being loaded by the "off bearer," the first is being unloaded by the lumber piler. The capacity of the Colorado sawmill is variable. The daily cut runs from 5,000 to 12,000 feet B. M., with an average of not over 7,000 feet. This differs widely with the size of the logs and the kind of material sawed.

The second building put up is the cook house. This is built either of lumber entirely or of dry logs with a floor and roof of lumber. The roof is either of the common gable type or more often the "car roof" type. In the latter case three-fourths inch boards are bent over the gable and nailed at each side. After the first layer is put on tar paper is used, then another layer is laid like the first, making the roof durable and water tight. The size of the building depends upon the size of the crew. Usually two feet of table space is allowed to each man. A room is generally partitioned off at one end, or in some cases, built at the side for the cook. A cook house accommodating twenty to twenty-five men should be about 18 x 36 feet in size. The furnishings vary with the camp. The stove, which is the most important item, is the best that can be obtained and is usually a six or eight hole range with a hot water reservoir and a heating closet. The cook's table and the mess table are made in camp of rough boards and covered with oil cloth. Rough benches or boxes are used as seats. The dishes and cooking utensils are plain porcelain ware. The grub or "chuck" at the average mill is the best to be obtained. Fresh meat is served the year round. There is usually a variety and even luxuries, such as cake, pies, canned fruit, etc., are served regularly.

Bunk houses are built in much the same manner as the cook house. They vary with the size of the crew. For the average sized crew, consisting of about twenty men, a bunk house 22 x 16 feet is erected. This gives room for a double row of three bunks on each side, accommodating twenty-four men in all. However, this is seldom full. Plenty of room is left in the middle for a stove, table, wash stand, etc. The only criticism against the average bunk house is poor ventilation. A single or double window is put at one end and a door at the other. The vileness of the air in some of these camps can hardly be imagined. This is especially true in the evening when most of the men are smoking and drying their clothes by the fire

There are always several minor buildings in camp. In addition to the one common bunk-house, there are usually two or three smaller cabins, each occupied by two or three men. These are generally built by the men themselves and not furnished by the company. The boss and the sawyer usually occupy a cabin by themselves which is known as the "Office." The stable or stables, as the case may be, are built as well or even better than the other buildings of the camp. They are always floored and the best possible care is taken of the horses. A commissary or storage house is also necessary. This is small and built entirely of lumber, generally close to the cook house. In some cases it is partially covered by the sawdust pile to keep it as cool as possible. It is seldom more than ten feet square. A blacksmith shop is not found in all camps, but usually in those from which the lumber is hauled to a side track or a "spur" instead of a town. This is little more than a shed, and does not need to be large. Only articles of absolute necessity are provided such as a forge, an anvil, a drill, and the common tools necessary for rough work. Usually no special blacksmith is employed, but there are always one or more men in camp who can do ordinary repair work and horseshoeing. A complete camp store is rarely found in the lumber camps of Colorado. However, a few necessities are often kept by the boss at his cabin. The most important of these articles is tobacco. Generally such things as gloves, socks, overalls, etc., can be obtained. The men are usually charged for such items and the price is taken out of their wages at the end of the month.

The working crew at such a camp varies from sixteen to thirty men. This depends upon the capacity of the mill, the kind of timber, and whether or not extra logs are being cut and piled for winter sawing. Men in this region are especially unreliable, and the boss often says that he has three different crews; one working, one going, and one coming. The men are hired by the month, except in the case of the sawyer who is paid by the day. Twenty-six working days are considered to constitute a month, time being taken out in case of bad weather. A working day is ten hours long and this is strictly adhered to except in the case of teamsters who are paid under a different scale of wages. Some mills run on Sundays part of the time, but this rests entirely with the men. If they care to work they may do so, but usually they receive no higher wages. The wages vary from $40.00 to $60.00 per month, according to the times, the kind of work done, and the locality. The sawyer is the highest paid man in the crew, receiving from $4.00 to $5.00 per day, and does his own filing. The timber boss ranks second, and receives from $60.00 to $75.00 per month. The teamsters and the cook each receive $60.00 per month. The engineer and the ratchet setter get from $45.00 to $55.00 per month as a rule, but often are paid no more than $40.00 to $45.00. The rest of the crew,




Ground Plan of a Colorado Sawmill.

such as log cutters, swampers, brush pilers, road builders, etc., receive the minimum wage of $40.00 to $45.00. All wages include the keep or board of the men. In a few cases board is charged for at the rate of $5.00 per week, but correspondingly higher wages are paid.

As a rule the ordinary Colorado lumber jack is an all around good fellow and conducts himself as a gentleman in camp. As long as he is treated right he is friendly and will do anything asked of him. He is usually uneducated, rough in his ways, and direct in his dealings, but certainly a congenial fellow. Frequently he uses rough language. He always chews tobacco and smokes a pipe. He drinks nothing stronger than water while in camp but when he strikes town, nothing but the best of whiskey and plenty of it is good enough for him. He drinks to excess and the saloon keeper often gets the major part of the season's earnings. But as soon as these little sprees are over, he goes back to work again always happy and contented even though he has spent a hundred or two hundred dollars. While at camp there is generally very little trouble among the men. Any little differences of opinion are always settled outside. There are no hard and fast rules of camp etiquette. Talking too much is the worst offense, and if this is not stopped in due time the offender speedily leaves camp and never returns.

The number of horses kept at each camp varies with the size of the operations, the distance from the railroad and the distance of the timber from camp. If logs are being skidded for winter's cutting, two or three extra horses are necessary. When the mill is running steadily and it is a one trip haul to the railroad, three four horse teams can take care of the lumber. When it is a trip and a half or a two trip haul, two teams are sufficient. In a few cases single teams are used, but when the difference in elevation between the camp and the shipping point is great, four horses are necessary on each wagon. The extra team is seldom needed in pulling the load down, but in hauling the empty wagon up again. The grades are often very steep, and the ascent is severe on the horses. An average mill requires three logging teams. This depends to some extent upon the distance the logs are to be hauled. During the first season's cut often two teams can do the work, but as the timber is cut further back from the mill another is necessary. Logs are hauled either on sleds or on two wheeled carts, but in either case four horses are used. Skidding for the mill requires two horses, used singly. When extra logs are to be skidded, two or three more horses are required. Occasionally the lumber companies do not own all their own horses. In this case horses are hired at the rate of $1.00 per day each, or more commonly the work is let by contract to men who furnish their own teams.

The horses are of good quality, and weigh from 1200 to 1500 pounds each. The price is variable but ranges from $200.00 to $300.00 per head for the most desirable kinds. They are given excellent care, but at best their lives are short. It is seldom that during a season's run one or two horses are not disabled or even killed outright. Skidding is frequently disastrous often resulting in a broken leg. In logging or in lumber hauling, the whole outfit sometimes runs off a grade or an embankment.

The logging roads are seldom started until the spring before the first summer's work, and are built only as they are needed. These roads often cost as much as the lumber roads. In addition to the initial building, they must be looked after constantly and in extreme cases the location must be changed after one year's use. This is necessitated by the washing of the spring freshets caused by the melting snow. Road building varies extremely and is made difficult or easy by the physical characteristics of the region. Such factors as gradient, amount of rock and composition of the rock affect the cost and maintenance of roads. In some cases, plows and even road graders can be utilized, but more commonly only the shovel and pick can be used. The width of the road depends indirectly upon the topography and varies from 4½ to 6 feet. If the slope is steep, sleds are always used, but if the grades are slight, carts are used. In the case of sleds, the roads may be slightly narrower and will admit of many irregularities to which the cart is not adapted.

The amount of excavating for side hill roads depends likewise upon the degree of slope. The road must at least be level, and usually the inner side is slightly lower to insure safety in hauling. After the preliminary cruise of the tract has been made, the course of the road is marked by blazed trees, usually by the timber boss, who himself directs the work of the men. A cut is made on the upper side and the dirt from this is used to fill in the lower side. Rocks, brush and logs are used to bank up the lower side, and keep the earth from rolling down hill. Large bowlders and trees are avoided as much as possible, but often must be removed. This is done most commonly by the use of dynamite. A hole large enough for a stick of powder is drilled into the rock, which is easily broken into small pieces. These are removed by hand or by the help of a crowbar. Stumps are often dug out but more commonly blown out with powder. On very steep slopes the road bed on the uphill side is cut down as much as three feet.

Only the main roads are built in so durable a manner. Temporary roadways are often no more than a clearing, except on steep slopes where some leveling must be done. Often rock slides are encountered, which must be gotten around or "corduroyed." Occasionally the logs are skidded a long distance to the road. Skidding, however, does not pay when the distance exceeds two hundred yards. When logging is carried on in winter to any extent, very little care need be given the roads. By January first the snow lies on the ground to a depth of four to five feet, especially at the higher elevations. It can be readily seen that stumps and small rocks make very little difference in such a roadbed. Often stream beds are followed and when this is done, almost no preparation is necessary.

Cutting in the woods begins in spring as soon as enough snow has melted to make it practical. This is seldom before June first, and usually from one to three weeks later, for where the stand is dense, the melting is very slow. At present the saw is always used in cutting, formerly the axe was used entirely. Cutting is either done by day labor or by contract. Some lumbermen always have it done by contract labor and insist that this is the cheapest, while others invariably hire their "choppers" by the month and think it better. Each method has it advantages. In the case of contract work, the equipment such as axes, saws, etc., is never furnished by the lumberman. When the men are reliable he need not worry about this end of the work. Occasionally these men even board themselves, and the responsibility of the mill owner is further lessened. Even brush piling is included in some contracts.

There are several disadvantages in having this work done by contract. One which frequently causes trouble is the trimming and lopping of the brush. It is to the contractor's interest to get as much done as possible, and in his haste he often neglects to trim the logs and lop the brush properly. He is not paid unless his work is satisfactory, but this requires continual watching. Another factor, often enters into the loss to the lumberman. The work is paid for according to the government scale and the contractor tries to beat this whenever possible.

The Scribner log scale used by the government gives practically the same scale for logs, ten, twelve, and fourteen feet in length up to a diameter of twelve inches. It is to the contractor's interest to avoid cutting trees under one foot in diameter into twelve or fourteen foot logs. By doing this he actually saves ten and sometimes twenty board feet per log, which he would otherwise have lost. This is only a small difference, but in a summer's cutting, it amounts to several thousand board feet. The stumpage is paid for according to this scale as are also the contractors and in some cases even the brush piling. It can be readily seen that through this variance in the scale rule and by the foresight of the cutters, the cost may be materially increased and a hardship worked upon the lumberman.

When the cutting is done by month's labor this loss is largely if not wholly done away with, and the price paid for the stumpage is what it should be. The boss may not be mean enough to caution the men about this particularly, and if he does not it is fair to both parties concerned. When labor is hired by the month all the tools are furnished to the men by the company, and usually the minimum wages are paid, except in the case of a very good woodsman. The rest of the crew, however, seldom know that he is receiving higher wages. If the men are conscientious workers hiring by the month generally proves to be the cheaper method. Contractors are paid by the thousand feet board measure, all logs being scaled by a forest officer, who is disinterested. The price paid varies with the locality, the timber, the density of stand, and the lay of the land. Any of these factors may change the price perceptibly. In different districts the price seems to vary even when other things are equal. Where the timber is large, and the clear length relatively great, the price paid to the cutters is lower than if the opposite conditions prevail. The topography of the tract is an important factor. When the ground is level, or even moderately steep, the work can be done faster and much easier than if the land is very steep and rough. The work is especially disagreeable when the underbrush is thick, and there are numerous rocks. In the latter case it is almost impossible to keep the tools sharp.

The contractors receive from one to two dollars per thousand, and from fifty to seventy-five cents more where the brush is to be piled. They usually make very good wages, often 25% to 50% more than is paid under monthly hire. The cutting crew consists of two men, rarely of one or three. One man sometimes cuts alone, using a single saw, but he works at a disadvantage and cannot accomplish half as much as two men working together. The outfit for a crew consists of a saw, several wedges, axes, a measuring stick and a bottle of oil. The make of the tools used varies with the camp. Although there are many arguments on the relative merits of each kind, there is really very little difference. Generally speaking Disston saws and Lippincott axes are used most extensively throughout the region but in certain camps the Atkins saw and the Kelly axe are preferred. The saws are either "M" toothed or "Lance" toothed. Both single and double cross-cut saws are used, but generally in a two-man crew nothing but the double saw is used. The one-man saw is from three to four feet long, generally three and a half foot length being preferred. Sometimes it is "swaybacked," and the thickness of the blade decreases toward the back, both factors tending to decrease the amount of "pinching."

Double saws are invariably six feet in length, since the small size of the timber makes this sufficient. The handles are always detachable, which is important when the tree or log pinches back. In this case a handle is removed and the saw pulled out endwise, no time is lost and no damage is done to the saw. The thin-bellied saws are used exclusively, on account of the small size of the timber. It can be readily seen that if a broad saw were used, a wedge could not be used in small logs.

The axes may be either single or double bitted. However, most cutters use single bitted axes of necessity, for with the other kind, wedges cannot be driven. The weight of the axe varies with the man and is usually not less than three pounds or more than four. Several extra axes and handles are kept on hand. One or two grindstones are always found in every camp. The saws are placed in a cut in a stump about four feet high where they are filed with six to eight inch cant or flat files. There are many different ways of setting and filing saws, but in most cases it amounts to no more than a matter of opinion. Each sawyer has his own method and no amount of arguing will convince him that another way is as good.

Wedges are indispensable and are usually made in camp. An old worn out horse rasp cut up into pieces and sharpened makes very good wedges. The length need not be over three or four inches and the wedge must not be too sharp or else it will cut into the wood and be of little use. It is best to have the steel in these wedges of the same temper or slightly softer than the axe head to prevent battering the axe in driving.

Kerosene is almost as necessary to the cutter as wedges. This is usually carried in a small bottle in the hip pocket and has a special cork, so that the oil can be sprinkled on the sides of the saw when it becomes covered with pitch. Kerosene immediately "cuts" the pitch and the saw can be pulled easily again. Not more than two or three applications are necessary in an hour's time, but it would be almost impossible to get along without it. A quart of oil lasts a week. This is always furnished by the company, whether the cutter be hired by the month or by contract.

When cutting is begun the men work down hill often going to the top of the ridge to begin. The trees are invariably felled up hill, in the direction they commonly lean. There would be nothing to gain by felling the tree sideways or down the hill, and in the latter case they would be badly broken. Cutting is done in strips from 50 to 100 yards wide. Only those trees are felled which are marked by the forest officer. Usually where there are two men in the crew enough trees are felled to last the entire day before they are trimmed and sawed into logs. This is not done where there is danger of piling them up. Axes alone are used in notching. The size of the notch varies with the size of the tree, but is seldom deeper than four or five inches. Its purpose is to prevent splitting when the tree is nearly cut and to aid in felling it in the desired direction. The stump height allowable varies with the species. For lodgepole pine it is seldom over fourteen inches, often only twelve inches. For Engelmann spruce the height is sixteen inches, because it is generally swell butted.

In thick stands, there is much danger of lodging the trees unless the cutters are experts, and can throw a tree exactly as desired. A slight gust of wind will often turn the tree and lodge it in spite of the best skill. There is nothing more exasperating to deal with than a tree which has lodged securely in the top of another. The quickest and most effective way is to cut the other tree. The men's lives are often endangered in this operation because the lodged tree will slip at the slightest move. Even after the trees are safely down, the men often have trouble in trimming and sawing them up, because they are so close together, or because one is directly on top of the other.

After several trees are felled the saw is laid aside and trimming is begun with the axes. Unless the trees occur in a thick stand, there are many branches, and the trimming is the largest part of the job. The limbs are generally small, and the work is not especially difficult. The greatest trouble is in keeping the axes sharp. Unless the cutting is done under contract, the tops are usually left entire until the brush is piled; but under contract, the tops must be lopped into lengths of six feet as the trees are being trimmed. The side brush is seldom longer than four feet and need not be cut up into shorter lengths.

When the trimming is finished, the trees are ready to be cut up into logs. The lengths of logs vary by two foot units from ten to twenty feet. Rarely logs are cut over twenty feet long except in the case of special orders. The trees are measured into log lengths as they are sawed, always beginning at the butt end and sawing into the tops to a diameter of six inches. From two to three inches in addition to the actual length is allowed on each log. This is necessary because the cut is not always made exactly perpendicular and after sawing the boards would not "square-up" the full length.

The only serious trouble encountered in sawing up the tree is pinching, and this is often very aggravating. If the ends of the felled trees are higher than the centers there will be pinching. Except in extreme cases this can be overcome by means of the wedge. But when the wedge will not open up the cut sufficiently for the saw to be pulled back and forth a lever must be used. A stick of sufficient strength is cut and the log is pried up until the saw is freed and cutting can continue. Sometimes under-cutting is done with the axe, or often with the saw when it can be loosened. As the logs are cut, their respective lengths are marked on the small end with lumber crayon. If there are several contractors working upon the same tract, an end mark is also put on so that the logs will not be mixed in scaling.

The size of the log varies with the species. In spruce, twenty logs per thousand feet is considered a good average, but in pine this often runs to thirty with an average of twenty-six or twenty-seven. The number of cutters necessary depends upon the timber and the amount sawed at the mill. Usually four or five are sufficient, unless logs are being cut for winter sawing.

When enough logs are cut skidding is commenced. If logs are piled on the skids to remain until winter, the skidways are built with some care and are usually fairly large. They are located with reference to the lay of the land and to the number of logs that are to be piled on them. The logs must be pulled down hill, hence the skidway is always below the majority of them. A single log is rolled down upon the skidway and securely blocked for the security of all the rest depends upon this "key-log." In some cases this gives way and the logs roll down the hill. Logs are piled up on these skidways as high and as far back as need be. For convenience in scaling the small ends are kept flush, but usually not all on one side, for this would make the pile lop-sided. As many as three or four hundred logs can be piled on a single skidway.

When the logs are hauled away as they are skidded, not much work is necessary in preparing the skid-way. The only requirement is a clear space about twenty feet wide with not too steep a slope. Logs are pulled onto this and the first one is blocked with a rock or stick to keep it from rolling down hill. Usually there are not over fifteen logs on it at a time, often only a single load. The skidding crew consists of one or two men and a single horse or rarely a team. The second man is called a "swamper" and it is his duty to clear trails and help in hitching onto the log. He generally aids the logger in loading. However, it sometimes happens that the skidder must do his own swamping. The skid horse, which must be a powerful animal, is often cruelly mistreated, and it is seldom that he lasts more than two years at this kind of work. As the ground is often exceedingly rough and rocky, the horse must be willing to go anywhere. His legs are continually being scratched up by sticks and snags and it often happens that he loses his footing and a broken leg is the result. Such qualities as gentleness, sure-footedness, willingness and strength are necessary in a good skid horse. He is taught to pull in short jerks because the logs are often in tight places and this is the most effective way to loosen them. The harness consists of a collar, hames, and traces, the latter always chains. Sometimes there is a back band to support the heavy traces. A bridle and lines are never used. The rest of the outfit consists of a heavy single-tree to which is attached a long chain with a hook at either end. The length of this chain varies from ten to fifteen feet. In hooking onto a log the chain is simply placed around the log at one end, and hooked. The only difficulty is in getting the chain underneath the log when it is lying flat on the ground. A cant hook and an axe are necessary in the outfit. If the logs are not too big several are hauled at a single load. This depends largely upon the degree of the slope. Very large logs cannot be hauled by one horse, but these are uncommon and are usually snaked in with the logger's lead team.

The horse is seldom led. In most cases he is guided by a flood of unprintable language from the skidder. Main trails are cut out and soon worn down and he soon learns to follow these. The number of logs skidded in a day varies greatly. It depends upon the size, length of haul, the condition of the ground, etc. Two skidders are almost always necessary to keep the mill running. One good man, however, can skid 6,000 feet per day.

Brush piling follows the skidding. Where labor is scarce this is often put off for a while, but the contract usually specifies that it is to be kept up with the skidding. These operations are directed by the Forest Ranger in charge and are frequently the cause of much trouble. Brush piling is at best a disagreeable job and even when men can be obtained to do the work, they seldom do it properly. In a few cases experts are hired by day or contract and receive very good wages. At present it is the practice of the Forest Service to have brush piled as far away as possible from reproduction and in conical shaped piles six to eight feet high and four to six feet in diameter at the base. Pieces longer than four or five feet are cut in two. The larger tops are trimmed but often left lying on the ground. The biggest limbs are put at the bottom and at the center of the pile to insure complete burning. The brush is packed and the smaller tops leaned up around the sides of the pile so it will not blow over. Where brush is piled by contract, the price ranges from fifty to seventy-five cents per thousand.

Log hauling is started as soon as sawing can begin. In the Rockies there are two common methods of logging, by sleds and by carts. This depends entirely upon the steepness of the slopes. If they are comparatively steep, sleds are always used, but when the tract slopes slightly or is level, carts are used. Sleds would pull too hard on level ground without snow and carts could scarcely be held back on steep pitches. Four horses are necessary and it is seldom that only two are used. The second team is always hitched ahead. It is necessary that the logger be an exceptionally good teamster and know how to handle his horses in tight places. The roads are often poor and he must be continually on the look-out or he will upset or run into a tree. On steep grades the load actually pushes the horses ahead of it, and unless they are trained they are likely to be run over and killed. In some cases, a chain is tied around the runner to aid in holding back the load. This is called a "rough-lock."

The sleds are single. They have a "bunk" about four feet long, extending out over the runner six inches on each side. The runners are heavy, three to four inches wide and shod with steel their entire length. The bunk is seldom over two feet above the ground, and is merely a heavy timber upon which the logs are loaded. The sleds are always equipped with a regular tongue and a heavy pair of whiffle trees. The lead team is hitched by means of a chain or iron rod attached directly to the sled and running up underneath the tongue. At the center of the bunk is fastened two long heavy chains which are used in "binding" the logs. An extra chain much longer is provided to throw around the entire load. Short standards which can be removed are set in at the ends of the bunk to hold the first layer of logs. It is quite necessary that the logs be bound very tight for the roads are rough and the slopes steep.

The logging cart differs only in having wheels. It is about the regulation width and height and instead of the common bolster there is a heavy timber, the "bunk" running the full length between the wheels. It is usually higher than common, almost level with the tops of the wheels.

At the skidway the logs are rolled onto sleds or carts by means of a short stick called a "skid." The loading is easy because the skidway is made so the lower edge will be slightly higher than the bunk of the sled or cart. In the case of the largest logs, the butt ends are placed on the bunk so the load will pull easier. The front ends overlap the bunk three or four feet. The other ends of the logs drag on the ground. The off side of the bunk is loaded first and before anything else is done these logs are bound with one of the chains fastened at the center of the bunk. The other side is then loaded and bound with the remaining chain. The extra chain is thrown around the whole load to be used in case of an emergency.

The unloading at the mill landing is very simple. The chains are loosened and the sled or cart is pulled out from underneath the logs which roll down upon the log-way. There are seldom more than a few loads of logs kept on this landing, for where there are many logs an extra man is required to roll them down as they are sawed up.

The cutting, skidding, and hauling are generally stopped by snow on or before January first. In this locality, snow that stays on seldom comes before November and a small amount is no hindrance. However if cutting were continued the snow would have to be dug out around each tree in order to get down to the required stump height. This is seldom practiced under the new regime of the Forest Service. Winter cutting, however, was formerly carried on to a great extent throughout the region as the stumps from six to eight feet in height show. Hauling is carried on through the winter with difficulty. It is kept up often as late as March, when sufficient logs were piled up the preceding summer. An extra man and team are necessary to break roads when the snow is on.

The amount of lumber sawed depends upon the mill, the timber, and the size of the pieces cut. The maximum cut for a Colorado portable sawmill is 12,000 B. M. per day but the average is not over 7,000 B. M. A large number of six inch logs decrease the output for a great deal of time is required in cutting them and only a few feet of lumber is obtained. If the bulk of the lumber is in the form of inch boards the amount cut per day is considerably less than if it were in plank or larger timbers. The amount of lumber cut from a given log and the quality of that lumber depends largely upon the skill of the sawyer. This is practically the only skilled labor necessary in the entire operation. The sawyer must be able to size up a log at sight and know at once just how it should be cut to get the greatest amount and the best lumber from it. Very little depends upon the ratchet-setter for directions are given him by the sawyer who is always boss of the mill crew.

The mill crew is composed of from five to eight men. The essential men are the sawyer, the ratchet-setter, the engineer, he off-bearer and the lumber piler. The ratchet-setter must be exceptionally quick and handy is turning logs on the carriage. The fireman need know only enough about engineering to keep up sufficient steam. He must cut his own wood. When the mill is equipped with a cut off saw he uses this, but if not he must use a hand saw. The off-bearer handles the lumber and slabs as they come from the saw. Usually one man is sufficient to sort and pile the lumber. When the mill is not equipped with a sawdust blower, an extra man is necessary. In addition to this work he dumps the slabs if they are disposed of by means of a car and track.

In a very few cases there is an edger and planing mill in connection with the portable saw mill. The slabs are sometimes utilized for mine-logging. Only the largest and best are used, however. They are cut up into four foot lengths, ricked up, and hauled to the railroad during the winter, usually after other operations stop. There is only a small profit in them and in most cases no use is made of the slabs except for fuel.

All sizes of boards and plank are sawed, depending to a large extent upon the demand at the market point. There is always an exceptionally large output of small stuff such as 1 x 4's and 1 x 6's because of the great number of small logs. There is very little sale for this material and when this is the case it remains piled in the mill yard. The amount of cull lumber is large because of the poor and defective nature of the timber. The best of this is sold for sheeting but a great deal is never hauled out of the mill yard.

The lumber seldom remains in the yard long after it is sawed. Enough men and teams are employed to haul the daily cut. Hauling is done on wagons in the summer and on sleds in the winter. In either case four horses are used. Because of the fact that the snow fall increases with the elevation, and as it stays on much longer at the higher altitudes, a transfer from sled to wagon is necessary in the fall or spring at a point somewhere between the mill and the shipping point. The size of the load depends upon the condition of the road. The load is never reckoned in board feet but always in the number of inches high. The maximum load for this district is seventy-two inches. Computed in board feet it amounts to nearly five thousand feet. For the average mill, three teams are necessary to haul the lumber. In some cases the lumber hauling is contracted usually at so much per M feet. The price varies with the distance to the railway and the condition of the road. On a trip and a half haul the price ranges from $2.00 to $3.00 per M feet. At the railroad the lumber is loaded directly into cars when they can be obtained. Flat cars are most commonly used. Twenty-two thousand feet is considered an average load.

The lumber sawed in Colorado is nearly all used locally. High freight rates and the heavy weight of the green lumber makes it cost more than the stuff shipped in. The wholesale price for the clearest lumber is $25.00 per M with an average price of $20.00 per M.

## A PAPER PULP OPERATION IN WISCONSIN

J. C. Ketridge

The manufacture of paper from wood has been rapidly growing in importance for the past twenty years. From one of the infant industries it has grown to be one of the greatest. Because of the immense bodies of spruce and the capability of site, the center of this industry will undoubtedly remain in the northeast, yet some of the best mills are to be seen in the Great Lakes region and a study of one of them may be considered a typical example.

While the mills of the North Woods depend upon nearly pure stands of red spruce, in which balsam occurs as a minor species, the mills of the Lake States are compelled to obtain their supply from comparatively small, isolated, widely scattered stands of white and black spruce. Hemlock, which is an inferior species in the Lake States but well adapted for making pulp, largely takes the place of the balsam in the northeast. From the forest utilization standpoint, this use of hemlock is a most important one, for if it is combined with the tannin industry there may be obtained an almost complete usage of both the bark and the wood resulting in a high type utilization of what is generally considered a poor species. Balsam and popple are somewhat used in Wisconsin but since they are very limited in their distribution do not play an important part. It will readily be noted that the concomitant stands of spruce and hemlock occurring as minor species involve a distinctive form of utilization and necessitate a much larger area for each mill than is needed in New England.

The plant at Rhinelander, valued at $1,000,000, is owned by the General Paper Company of America and is operated by the Rhinelander Paper Company. Its location at Rhinelander is an excellent one since the Wisconsin river, Chicago and Northwestern Railroad and Minneapolis, St. Paul and Sault Saint Marie Railroad offer easy communication with an immense area of timber. The plant was built during the year 1903 and operations were started in 1904.

All the buildings are constructed of brick and are fireproof throughout. They consist of an office; sulphur oven building; a building containing the digestor room, rossing rooms, and acid tank tower; and the main building, in which is located the grinders, press room, beater room and main paper machine room. Most of these buildings are connected and they occupy an area of about five acres. The remaining fifteen acres is taken up by log yards where the Company holds in reserve about forty thousand cords of wood which is drawn upon when the supply from the forests is irregular. Nearly all this wood is shipped in by rail in lengths varying from four to eighteen feet with an average of twelve feet. The smallest diameter is specified at three inches but occasionally material is accepted which contains pieces smaller than this and for which a reduction in price is made. The wood is shipped in in gondolas or box cars with an average of ten to twelve cords per car. It requires 75 cords of wood for each twenty-four hours run, resulting in fifty to sixty tons of pulp.

Operating the plant requires two twelve hour shifts of 125 men each who are paid an average wage of 17½ cents an hour. The laborers are mostly skilled in a particular line of work and are for the most part reliable, steady men. Power is furnished by a dam and turbines located five miles up stream which supply 100 H. P., and by three dynamos which supply 300 H. P. each. Power for the machine room is furnished by two engines of 250 H. P. capacity each.

The logs are usually unloaded into a pond from the cars, by two men, and floated to the wood room. Here they are cut into two foot lengths and the large pieces split to make rossing easier. The rossing consists of removing the bark and knots by means of rotary knives. In round pieces of small diameters the loss of bark and wood frequently amounts to forty percent while in large pieces it may amount to twenty percent. The wood loss alone varies from ten percent in good pieces to a maximum of thirty percent in small pieces. The machine which does the work consists of a circular plate five feet in diameter on which are riveted four knives.

At this mill two general processes of making pulp are employed, the sulphite process and the mechanical process: 20% of the output is made by the first, 80% by the second.

**Mechanical Process**

From the rossing machine the wood is thrown into a chute which leads to the grinder room. This room contains ten machines, eight of which are run by water power and two by electricity. Electrical power gives the better satisfaction because of the smooth and uniform motion while in operation. Each machine consists of a circular grindstone, 27 inches thick and 52 inches in diameter, mounted on a shaft. Leading to the base of the stone is a slightly inclined chute in which the wood is placed lengthwise and when once in the chute, the wood is forced against the revolving stone by hydraulic pressure. This grinds the wood into a pulp which has the appearance and consistency of butter and in this condition is called "stock." While the machine is in operation a spray of water plays constantly on the wood to wash the pulp away and prevent damage by burning due to friction.

From the grinder room, the stock is conveyed to the press room where it is first washed thoroughly and then run over the couch rolls which dries it and presses the water out. These rolls consist of hollow cylinders 7 feet long and 20 inches in diameter. The outer part is made of hardwood covered with a layer of felt about $\frac{1}{4}$ inch thick. There are seven of these rolls, three being used for the stock from the sulphite process and four for the ground wood stock. When taken off the roll by a "skinner" (a pointed stick 30 inches long), the pulp looks like thin pasteboard. It is folded and taken to the beater room where it is mixed with the sulphite stock.

**Sulphite Process**

The species used in this process are hemlock and a small amount of balsam. After the log has been cut into 2 foot lengths and rossed, it is conveyed to the "hog" where it is chiseled into small chips $\frac{1}{2}$ inch to 2 inches square. The chips are elevated to bins from which they are taken to the digestor where they are cooked with a compound of sulphurous acid which is manufactured at the plant.

The chemicals used to manufacture the acid are sulphur, limestone and water. The sulphur in the solid form is shipped from Louisiana costing $27.00 per long ton delivered at the mill. In order for it to unite with the lime water, it must be in the gaseous form, hence it is volatilized by burning. There are four ovens each 10 feet long, 6 feet wide and 2 feet deep that are used for this purpose. Sulphur in the powdered form is fed from above into each oven once every hour, a strong draft being maintained to secure complete combustion. The fumes are conveyed through lead pipes to the acid tanks. The limestone is shipped in from Mebashtock, Mich. Four acid tanks each 150 feet high, and 8 feet in diameter are required for the manufacture of the acid. The tanks are made of 4 x 6 Norway pine and creosoted. One roof covers the four tanks, one being built in each corner of the tower which is divided into four compartments. The tanks are charged once every week in the following manner. An elevator carries limestone to each floor where it is dumped in at the man hole. One compartment is filled at a time. In order to keep the tanks full all the time, it requires two men working 6 hours per day. When full water is turned on from above. The sulphur fumes come in from the bottom and are drawn up through the limestone and water by means of a draft created by steam run in at the top. This combination of sulphur, limestone and water results in the formation of an acid whose formula has not been determined but is similar to sulphurous acid. This is drawn off and stored in the main tank.

The digestors are 30 feet long and 8 feet in diameter. They are cylindrical in shape but taper at both top and bottom and hold ten tons of chips. Oxidation of the sides must be guarded against as the acid is very strong, hence there are three layers, the outside being made of brick, the next of steel and the inside of lead. After the chips are dumped in, the acid is poured on, the door is closed and the chips allowed to cook for 10 hours after heat is applied. This is a delicate process and must be supervised by an expert. The temperature and pressures are indicated by means of automatic registers and at the same time are recorded by automatic tracing charts. At the end of ten hours, the material is cooked sufficiently and is called "sulphite." It is washed and run over the couch rolls as described under the mechanical process.

The sulphite is now mixed with the "stock" from the mechanical process. After being weighed the pulp is taken to the beater room where it is run through a series of "beaters" which consist of rectangular tanks rounded at the corners, 10 feet long, 5 feet wide and 4 feet high. In one end is a paddle wheel, which is revolved rapidly after the stock has been put in and water added. The beating process reduces the pulp to a finer consistency. During this stage, various chemicals are added, namely, alum which is used as a bleacher, a glue which holds the fibers together, a sizer which "sets" the paper, and rosin which fills up all the pores. The stock is next run through a series of secondary beaters during which the process of the primary beaters is continued. The operation requires six to eight hours.

The stock is now ready for the paper machine. The paper room contains two large machines each 108 feet long and 12 feet wide, requiring a force of 250 H. P. for operation. From the secondary beaters the stock is conveyed to large rectangular tanks. It now has the appearance of water and from the tanks it is run onto an endless wire screen 70 meshes to the square inch. This screen has both a horizontal and a lateral motion. This has the effect of "setting" the paper and making it homogeneous. While in motion a spray of water is played upon the stock to regulate its consistency.

From the screen the stock is run onto a series of 26 iron rollers, which are placed horizontally and diagonally. Each roller is 4 feet in diameter and 10 feet long. They are heated by electricity and press and dry out the stock until it comes out as the finished product. Before the paper is ready for market it is run over nine colander rolls which are placed vertically one above another. As the paper is very thin, the operation is a delicate one, and if a tear does occur, sometimes half a day is lost before the machine is running properly again. All waste paper is taken to the beater room where it is mixed with the stock.

The paper is now wound off from the colander rolls at the rate of 550 feet per minute. When a thickness of 67 inches has been reached the core is taken off. Such a roll of paper weighs 1300 pounds. The roll is then rewound and at the same time it is cut into widths of 33½ inches. One of these rolls weighs 600 lbs. It is in this form that paper is shipped to newspapers to whom it is sold at the rate of $40.00 per short ton, or $2.00 per hundred weight.

## LOGGING IN WISCONSIN

A. G. Hamel

The Lake States region is noted for its advanced methods of exploitation and utilization. It is here that most of our present methods for level areas have been devised and perfected, while many methods now in use over mountain areas likewise owe their origin to the Lake States.

When logging was first started in this region only the choicest white pine bordering the stream courses was cut and it was considered doubtful if timber ten miles or more from a drivable stream could ever be utilized. Later snow and ice roads were developed and, with the increased demand for timber, cutting gradually began to include the average stands of white pine and the best trees of other coniferous species. Finally the demand for all species and the desirability of using even the poorest trees has become so great that railroad logging is at present the most extensive method in use. Its advantages are numerous. All species and sizes can be hauled by rail while driving by stream is adapted to light woods only. Logging by rail can be made continuous throughout the year while stream logging is periodic and uncertain. No logs are lost in transport while stream logging often causes a loss of ten percent in many of the light woods. Special orders can be filled rapidly by rail logging while stream logging does not allow freedom in this respect.

A typical example will illustrate costs and methods to a limited extent. Variations from this are to be found in every lumber camp but the operations of Mr. C. D. Robbins are considered to be as representative as could be selected in northern Wisconsin. The operation is only moderate in size but serves the purpose better than an exceptionally large one would or a very small one.

Two camps are established as nearly as possible in the centers of the timber which is to be cut. Camp No. 2 comprises a barn, blacksmith shop, granary, machine shed, cook house, store house, bunk house, root cellar, office (wanagin) and water tank. The cook house, store room and bunk house are located in one building 123 feet long by 24 feet broad. The kitchen is 14 feet long, dining room 39 feet long and store room 10 feet long. The remaining space is used for a bunk house. The side walls of the building are of hemlock, birch and white pine logs and are seven feet high. Logs for this purpose must be of uniform size, straight, sound and of moderate taper. These logs are peeled on the inner walls to keep the interior neat as possible, and in some camps are whitewashed. The roof is made of cull lumber and covered with prepared roofing. This is the best constructed building in the camp and special care is taken to secure good ventilation and light. The remaining buildings are much smaller and less care is used in their construction.

A camp of this kind is completed in a short time by experienced men. For one man it would take the following length of time to cut the timber, skid the logs to camp and construct the buildings: 80 days for a barn 100 feet by 30 feet; 14 days for a blacksmith shop 20 feet by 18 feet; 12 days for a granary 20 feet by 16 feet; 75 days for the building which contained the cook house, bunk house and store house; 11 days for an office 24 feet by 17 feet; 21 days for a root cellar 16 feet by 12 feet. The costs of these buildings varies with their size and their height. Generally a camp of this size is estimated to cost $1500 to $2000.

The crew in Camp No. 2 is composed of the following men:

| | Title | Salary per month |
|---|---|---|
| 1 | camp boss | $100 |
| 1 | time keeper | 35 |
| 1 | blacksmith | 75 |
| 1 | wood butcher | 40 |
| 1 | cook | 75 |
| 1 | cookee | 35 |
| 1 | assistant cookee | 30 |
| 1 | barn boss | 35 |
| 1 | chore boy | 30 |
| 1 | filer | 40 |
| 26 | sawyers | 30 |
| 13 | swampers | 25 |
| 13 | teamsters | 30 |
| 2 | loading crews | |
| | 2 top loaders | 35 |
| | 4 send up men | 30 |
| | 2 tailer down men | 25 |
| | 2 teamsters | 30 |

In addition to this crew there is a general woods-foreman who superintends all work in both camps and lays out all ice roads, logging roads, etc. The train crew consists of one engineer who receives $75.00 per month, fireman, $35.00 per month, brakeman, $35.00 and two section men who receive $30.00 per month. When no repairs are necessary on the railroad the section men are compelled to work in the woods. The board furnished to the men is very good and much better than it has been in the past. At present it is difficult to hold experienced men unless they are paid well and given the best of grub. The average meal in the woods consists of bread or biscuits, butterine, syrup, tea, coffee, potatoes, fresh meat, rice, pie, doughnuts and cake. Breakfast is served at 5:30 A. M., dinner at 11:45, and supper at 5:30 P. M. A variety of food and all that the men can eat is required and furnished. At this camp the cost per man per day is 29.7 cents. The average cost is between 25 and 35 cents.

In this operation each saw crew cuts on an average 10,000 B. M. per day and one swamper follows each crew of sawyers. Sawyers are instructed to cut a six inch top diameter limit with a stump height not to exceed 18 inches. The sawyers are very conscientious in the matter of stump heights, so much so, that it was usual to find the stumps cut to a much lower height than is specified. As a rule great care is exercised in the felling of the trees so as to prevent as much damage as possible. The butt logs are usually cut into 14 foot lengths while logs above this are cut into 10 to 16 foot lengths. It is the duty of the swamper to trim all trees of side branches and to clear a way for the skidders. Some lumbermen use two swampers instead of one and find that it facilitates the work for the skidders.

The amount that is skidded per day depends upon the character of the timber, topography and the distance to be hauled. An average day's work for a short haul is 10,000 B. M. per day. For very short hauls skidding tongs are used while for hauls from one-sixteenth to one quarter of a mile go-devils are used. When tongs are used, only one or two logs can be skidded at a time while if go-devils are used, five to six good sized logs may be hauled. An average go-devil load scaled by the Doyle rule showed 542 board feet. Both horses and oxen are used for skidding. Where only a short haul is necessary and skidding is difficult, oxen are preferred. The horses weigh from 1400 to 1800 pounds each and cost $500 to $700 per team. Oxen cost $200 to $300 per team. Since horses are difficult to keep during the summer, some operators prefer the oxen because they can be turned out to pasture at any time and will do well on rough feed.

Skidways are placed on level land bordering the railroad where the haul will be the shortest. Each skid should hold a carload of logs and they are usually filled twice a day. Where timber is being cut faster than it can be hauled away by the log train special skidways are built which often hold 50,000 board feet. Occasionally a certain skid is reserved for a special kind of timber, as for large sizes, for different species, for piling, etc.

There are two loading crews in Camp No. 2, each composed of five men. Empty logging cars are "spotted" at loaded skidways by the train crew. These cars will hold from 2,000 to 2,800 B. M. but at the Robbins camps the average load is about 2,000 feet. Each loading crew is supposed to load 50,000 B. M. per day but occasionally falls below this where the timber is poor or accidents happen.

At camp No. 1 all log cars were unloaded and the loads transferred to a standard guage car by a steam loader or by a horse loader which is known as a horse-jammer. The steam loader averaged 100,000 feet per day while the horse-jammer averaged 25,000 feet per day. The steam loader is to be greatly preferred for this class of work and if worked to the best advantage should save from 40 to 60 percent of the cost that would be necessary to handle the logs by the horse-jammers. Horse-jammers may be built for approximately $100 and are an advantage because of their slight cost, ease of moving and adaptability for small operations. The horse-jammer is a derrick which is built upon a sled and can be set close to the car. It is held in place by the use of cables and chains which are fastened to trees and the rails. A cable is run through the top and bottom of the derrick, one end of which is used to load the logs while the other is fastened to the team. The team end of the cable is so arranged that the team can haul both ways, thus saving the time which would be necessary to return to the derrick at the end of each haul, if such an arrangement could not be made.

The topography of the Lake States is well suited to railroad logging yet the laying out of the logging road is often a difficult proposition. It should be located so as to tap the best bodies of timber, to follow the easiest gradients, and have as few curves and bridges as possible. It is usually laid out by the woods superintendent but occasionally by a cruiser. It is invariably a narrow gauge road because of the smaller cost to build, equip and operate than would be necessary for a broad gauge. In this operation the road was 36 inch gauge, made of 30 pound steel costing $28.00 per ton. The cost per mile for grading and laying rails was $500.00, for ties was $150.00. In making fills and cuts it is customary to make the grade extend two feet beyond the end of the ties. Where there is a large fill a foundation is made by criss-crossing timbers which may or may not be supported by an earth filling. Logging engines have a variable cost and whereever possible second hand engines are used for the purpose. A new logging engine costs $5,000 but a second hand one can be obtained much cheaper. The one used by the Robbins Lumber Company cost $800.

The present methods of lumbering are very destructive. The operator works only for immediate results with no thought of the future yield. For the sake of a few dollars gain the possibility of a much larger future gain is totally disregarded. As time advances methods will change more and more, the utilization will become much more intensified and instead of present gain alone both present and future gain will be carefully considered.

# The Forest Club Annual

## Volume II 1910

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# THE NOMENCLATURE OF FOREST TREES.

Charles E. Bessey

Since forest trees are plants and since they are subject to the same changes of names as other plants, it follows that their nomenclature must be in every way identical with the general nomenclature of plants. From the earliest times it has been necessary to have rules of some sort in regard to the naming of plants. The earliest definite formulation of such rules was made by the great Swedish botanist, Linne, about the middle of the eighteenth century. His rules were written in Latin, which was then the prevailing language of learning, Botany included. These rules have been revised and amended since Linne's time, and are now well known to all working botanists, and should be equally well known to all foresters.

In 1867 a notable revision of these rules occurred in the International Botanical Congress which was held in Paris in that year. An English edition of these rules was published under the title "Laws of Botanical Nomenclature Adopted by the International Botanical Congress Held at Paris in August, 1867". This body of rules is known as the "Paris Code," and it has been the basis of all recent regulations as to nomenclature. About fifteen years ago many American botanists feeling that the laws of nomenclature were not sufficiently definite in regard to certain points, made some modifications of the "Paris Code," and these were printed and issued under the name of the "Rochester Code", by the Botanical Club of the American Association for the Advancement of Science. Certain American botanists, however, from the first, objected to these Rochester rules and refused to abide by them. Further modification of these rules were made subsequently at a meeting in Philadelphia, and these later rules have been known as the "Philadelphia Code". All these changes however, were based upon the "Paris Code" which had been adopted by an International body of botanists.

In 1905, after several years of agitation, another International Botanical Congress was held in Vienna, and the result was a considerable revision of the "Paris Code." The rules issued by this Congress are known as "The International Rules for Botanical Nomenclature, Adopted by the International Botanical Congress of Vienna, 1905". This latest statement is now accepted very generally throughout the world. Some of the American botanists who had taken part in the formulation of the Rochester and the Philadelphia codes have not yet accepted the "Vienna Code", but since the latter includes much of what was originally in controversy between many American and the foreign botanists, it is desirable that the Vienna rules should be accepted, even though they do not fully express the ideas of some of the more progressive American botanists.

I have gone over this "Vienna Code" and selected from it those rules which are of most importance to foresters, and have given them with some little modification of the language, and with some comments which I have added. These rules as here given then are *based upon* the "Vienna Code", but are not identical in language with that code.

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## STATEMENT of such RULES for BOTANICAL NOMENCLATURE as are of INTEREST to FORESTERS.

(Based upon the "Vienna Code" of 1905.)

1. Natural history can make no progress without a regular system of nomenclature which is recognized and used by the great majority of naturalists in all countries.

2. The rules of nomenclature must not be arbitrary nor imposed upon scientific men by mere authority, but they must be founded upon considerations which are clear and forcible enough to be comprehended and accepted by scientific men in general.

3. The essential things to be reached by the Botanical Code of rules as to nomenclature are: (a) Fixity of names, (b) The avoidance of confusion by the creation of useless names, (c) Means for rejecting names which may lead to error or ambiguity.

4. No custom or practice which is contrary to rule can be upheld if it leads to confusion or error.

5. It is very desirable that the principles and rules of

nomenclature should be as similar as possible in Botany and Zoology.

6. Scientific names of all kinds that are used in classification must be in Latin. When taken from or based upon a word or words in another language they must be Latinized and so modified that they are essentially Latin names. (It is only by following this rule strictly that we can secure uniformity in names; otherwise we should have names in English, in French, in German, in Russian, Chinese, Japanese, etc. As an illustration of the advantage of Latin names for plants I may refer to the "Botanical Magazine" published in Tōkyo, Japan. One portion of this magazine is printed in the Japanese language, and yet all botanical names in this part are printed in Latin and have exactly the same form that they have in European languages.)

7. It is a rule in Botany which has been maintained for many years that every plant belongs to a "species", every species to a "genus", every genus to a "family", and every family to an "order", and every order to a "class", etc. (It is essential that the sequence given here should be followed, and not varied fromin any particular. This preserves uniformity in the general arrangement of all kinds of plants in lists of systematic works.

8. Below species we may destinguish "varieties" which are more marked, and "forms" which are less well marked variations from the specific type. (Here again it is essential that these words be used in this sense alone; to use the word "variety" when we mean "species" is a common, but inexcusable error.)

9. Although the definitions of species, genera, families, etc. will vary with different botanists, yet there always has been a pretty general agreement, and the differences of opinion in regard to the limits of these groups are of minor importance. (This paragraph is of importance inasmuch as there is a widespread impression outside of botanical circles that botanists are entirely at loggerheads in regard to these matters. The fact is that there is vastly more of agreement than of disagreement in regard to the limits of these groups.

10. When one species is fertilized by another the result is a "hybrid", when one variety is fertilized by another the result is a "halfbreed", sometimes called a "cross" or "mixture".

11. Every natural group of plants (species, genus, family, etc.) can have only one valid name, and this must be the oldest name applied unless such name has been previously used for some other group.

12. No one should change a name without the best of reasons based on a more profound knowledge of the facts than previously existed.

13. Botanical nomenclature dates back to Linne's book, the "Species Plantarum", which was published in 1753.

14. In order that certain old names which had been in general use for a long time should not be changed, the Vienna Congress prepared a list of names to be preserved in spite of the law which requires that the oldest name should in all cases be used. (This rule which provides for the preservation of names which otherwise would be changed (see Appendix) has been objected to very strenuously by many American botanists. They hold that the law of priority should be followed regardless of the fact that under its strict application certain names will disappear; but a majority of the Congress having voted for this list of retained names, this is at present a valid rule under this Code.)

15. In the making of names of the larger groups, ordinal names are to have the ending "-ales" and family names to have the ending "-aceae".

16. It is recommended that botanists in making generic names should use judgment and taste by (a) not making names very long, or difficult to pronounce, (b) not using a name that has already been used and that has become a synonym, (c) not naming genera for persons who are not botanists or who are generally quite unknown, (4) not taking names from barbarous tongues, (e) not making a name by the combination of words from two different languages.

17. The botanical name of a plant is always the genus name immediately followed by the species name. The *two*

*words* constitute parts of *one name.* The names of ~~genera~~ must begin with a small letter excepting those that are taken from the names of persons or from generic names. (This rule, which is one of the minor ones called "Recommendations" is not followed by all of the botanists. There is a growing feeling in favor of the decapitalization of all specific names, and in my opinion this is the better way).

18. In forming specific names for plants botanists are recommended to (a) avoid very long names and those which are difficult to pronounce, (b) avoid names taken from little known localities, (c) avoid names which express a character which is common to other species of the same genus, (d) avoid names which are similar to others used in the same genus, (e) avoid names which have been previously used in a genus and which have become synonyms, (f) avoid naming a species after a person who has neither discovered, nor described nor in any way studied it, (g) avoid making specific names of two words (unless they are fused into one word), (h), avoid names which have the same meaning as the genus name.

19. Two species of the same genus cannot bear the same specific name. (This rule is exactly in accord with the rule among people. We do not give different children in the same family the same name).

20. Hybrids between species are to be indicated by the sign x; thus when a hybrid has been made between two species of willow the designation is, as follows: *Salix aurita* x *caprea.* If the hybrid is between species of different genera both names must be written out in full with the x sign between, thus; *Ammophila arenaria* x *Calamagrostis epigeios.*

21. When a name is given to a plant, in order to be effective it must be described sufficiently to be identified, and this name and description must be printed and distributed to the public, especially the botanical public.

22. On and after January 1, 1908 the publication of names of new groups will be valid only when accompanied by a Latin diagnosis. (This rule, which at first seems to be arbitrary, is very desirable. Latin is the only universal language, and if all original descriptions are put in Latin they can be

read by people of all nationalities. Think of what the condition would be if Russians, Japanese, Chinese, and other botanists wrote their descriptions in their own languages ! A botanist would have to be a veritable polyglot in order to consult the original descriptions.)

23. A name alone, unaccompanied by the description, although published properly, is not accepted by botanists. (The reason for this is obvious. A name alone gives no clue to the plant itself, but must be accompanied by a description.)

24. The date of the name is that of the proper publication, as indicated above. This is important where the same plant has been described by different people. In such cases the earliest description properly published is the one which is retained.

25. In order that dates and descriptions may be verified the name of the author who first published the name must follow it. (Some people object to appending the author's name to the botanical name, but in the careful work necessary in scientific botany it is desirable that a reference to the original publication should be easily made.)

26. When a genus is divided into two or more genera the original name must be kept, and given to one of the new genera, and the rule provides that the old name should go with the more important new genus.

27. When two genera are united into one, the older of the two names is to be retained.

28. Names cannot be rejected or changed or modified merely because they are badly chosen or disagreeable or because a particular botanist prefers another. A name should be changed however;

(a) When the plant has an earlier name which is valid.

(b) When the name is based upon a monstrosity.

(c) When the specific name merely repeats the generic name.

(The third of these (c) is not in accordance with the practice of many botanists, who write *Catalpa catalpa, Liniaria linaria,* etc.)

29. When the species is moved from one genus to another

its name must not be changed unless it is found that the same name has previously been used in that genus.

30. The original spelling of the name must be retained except in case of a typographical or orthographical error, and it is recommended that this liberty of making corrections should be very judiciously used.

Under the minor rules the following recommendations are made.

31. Botanists should use the scientific names of plants, preferably to names of any other kind, unless the so-called "common names" are clear and actually in use.

32. Every friend of science should oppose the introduction into modern language of the names of plants which are not already there, unless such names are derived from the Latin botanical names. (This rule, if followed, would provide for Anglicized names rather than the so-called common names.)

33. The metric system is recommended for use in Botany for reckoning weights, measures, etc., and it is especially recommended that such measures as foot, inch, line, etc., should be rigorously excluded from scientific language.

34. Very minute dimensions are to be reckoned in micromillimeters (microns, or thousandths of a millimeter.)

35. Temperatures are to be expressed in degrees of the Centigrade thermometer.

## APPENDIX

List of names of interest to the Forester to be retained in spite of the Law of Priority, as recommended by the "Vienna Code."

| Family | Retain these names | Instead of these |
|---|---|---|
| Cycadaceae | Zamia L., 1763, | Palmafilix Adans. 1763 |
| Taxaceae | Podocarpus L'Her, 1807 | Nageia Gaertn. 1788 |
| Taxaceae | Phyllocladus L. C. Rich., 1826 | Podocarpus Labill 1806 |
| Pinaceae | Agathis Salisb. 1807 | Dammara Rumph, 1786-8 |
| Pinaceae | Cunninghamia R. Br. 1826, | Belis Salisb. 1807 |
| Pinaceae | Sequoia Endl. 1847 | Steinhauera Presl 1838 |
| Palmaceae | Arenga Labill 1803, | Saguerus Rumph. 1763 |
| Palmaceae | Chamaedorea Willd, 1806 | Nunnezharia Ruiz et Pav. 1794 |
| Palmaceae | Desmoncus Mart. 1823-50 | Atitara Marcgr. 1741 |
| Juglandaceae | Carya Nutt. 1818, | Scoria Raf. 1808<br>Hicorius Raf. 1817<br>Hicoria Raf. 1838 |
| Ulmaceae | Zelkova Spach. 1841 | Abelicea Reichb. 1828 |

Appendix Continued on next page.

| | | |
|---|---|---|
| Moraceae | Maclura Nutt. 1818 | Toxylon Raf. 1817 |
| Loranthaceae | Arceuthobium Marsch-Bieb. 1819 | Razoumowskia Hoffm. 1808 |
| Menispermaceae | Cocculus DC. 1818 | Cebatha Forsk. 1775 |
| Calycanthaceae | Calycanthus L. 1759 | Beurreria Ehret 1755<br>Butneria Duhamel 1755 |
| Myristicaceae | Myristica L. 1742 | Comacum Adans. 1763<br>Aruana Burm. 1769 |
| Rosaceae | Physocarpus Maxim. 1879 | Opulaster Medik. 1799 |
| Rosaceae | Holodiscus Maxim. 1879 | Schizonotus Raf. 1836 |
| Leguminosae | Wistaria Nutt. 1818 | Kraunhia Raf. 1808 |
| Simarubaceae | Ailanthus Desf. 1786 | Pongelion Adans. 1763 |
| Aquifoliaceae | Nemopanthus Raf. 1819 | Ilicioides Dumont. 1802 |
| Theaceae | Gordonia Ellis. 1770 | Lasianthus Adans. 1763 |
| Canellaceae | Canella, P. Br. 1756 | Winterana L. 1759 |
| Elaeagnaceae | Shepherdia Nutt. 1818 | Lepargyrea Raf. 1818 |
| Ericaceae | Gaylussacia H. B. K. 1818 | Adnaria Raf. 1817 |
| Verbenaceae | Tectona L. 1781 | Theka Adans. 1763 |

Although under the action of the Vienna Congress the names incated above are to be retained, I cannot think the action a wise one. If we are to follow the suggestions made in paragraph 28 above, we ought not to reject the earlier names in the foregoing list. It is illogical to make a rule ("the law of priority") and then to provide for a disregard of it in certain favored cases. We may hope for the ultimate abolition of this list of names to be retained contrary to the law of priority.

# MARKING YELLOW PINE FOR CUTTING IN THE SOUTHWEST.

G. A. Pearson.

In marking any tract of timber there are always a number of factors that determine which trees should be removed and which should be left. The first consideration should always be that of providing for a future stand. Whether natural or artificial regeneration is aimed at, it is always important to leave the stand in such a condition that the establishment and development of young growth will be favored. Present financial returns, while of less vital importance, must usually be considered. It is desirable, for instance, that the cutting on a sale be so regulated that the timber will command the highest obtainable price. Other factors, varying with local conditions, usually present themselves, but the two above mentioned are paramount, and when they conflict with one another a compromise is generally necessary. In localities where natural regeneration takes place readily, and where the expense of logging and marketing timber is high, it may sometimes be advisable to sacrifice the best conditions for reproduction in favor of financial returns, but where conditions are unfavorable for reproduction this consideration should take precedence over all others.

In the yellow pine forests of the Southwest reproduction is usually obtained with great difficulty. The question of perpetuating the forest is therefore of most vital concern to the forest officers, and it must always be placed before that of immediate financial returns.

In order to understand the problem of marking timber for cutting in the Southwest a knowledge of the natural conditions of the region is necessary. The climatic conditions of the average year are decidedly unfavorable to the establishment of seedlings. When we add to this the fact that in the past a great amount of damage has been done by fire and grazing, it is not difficult to account for the scanty young growth on large parts of the western yellow pine forests. Under the control of the Forest Service, the two last factors will be largely eliminated in the future, and therefore, the real factors to be considered are those imposed by nature.

Undoubtedly the most important physical factor is moisture. This manifests itself in a deficiency of precipitation and severe dry winds during the spring and fall seasons, especially the former. As a rule, practically no rain falls from May 1 to July 1, and frequently the period of drought is considerably longer. During this period the soil becomes completely desiccated to a depth of six inches or more, with the result that any seedling which has not succeeded in establishing its root system in the lower soil strata must necessarily succumb. Owing to the extreme dryness of the spring and early summer months, pine seeds do not germinate until the coming of the rainy season in July and August. Consequently a seedling has but little time in which to establish a root system which will enable it to live through the dry period of the following spring. Even though the soil may contain a comparatively high per cent of moisture, the existence of a tender young plant becomes precarious on account of the high wind and terrific evaporation which prevail during the months of May and June.

Another serious enemy to the young seedling is frost. A seedling which starts in August frequently fails to become sufficiently lignified to withstand the severe frosts which usually come early in October. It is estimated that fully 75 per cent of the western yellow pine seedlings which started on the Coconino National Forest in the summer of 1908 were killed by frost during the following October. The loss from this cause in 1909, though much less than in 1908, was considerable.

Naturally the seed supply is of very great importance. Good seed crops occur on most areas once every four or five years, while usually some seed is produced every year. Owing to the long period during which seeds must lie in the ground before conditions become favorable for germination, large quantities are annually destroyed by rodents, birds and other animals, and in the poor seed years it is probable that only a few of the seeds which fall are ever given an opportunity to germinate. On the whole, however, the scarcity of reproduction should be attributed to unfavorable climatic conditions rather than to a deficiency in the seed supply.

The typical western yellow pine forest is naturally very open; yet virgin stands have been found to exercise a profound ameliorating influence upon the rigorous climatic conditions of the Southwest. Instrumental observations in a large open "park" and in an adjoining body of virgin timber near Flagstaff, Arizona, show that the air movement in the park on windy days is almost twice as great as that in the forest, while the evaporation is about one-third greater. The influence of the forest upon temperature makes itself felt mainly in greatly raising the nightly minimum by reducing radiation. These conditions immediately suggest the adaptability of a shelter-woods system of management; for, while western yellow pine is very intolerant, even the lightest cuttings leave abundant openings in which seedlings may spring up.

The system of cutting now being practiced in the western yellow pine forests of Arizona and New Mexico is the selection system. Under this system the first cutting should be moderate, with the object of opening up the stand sufficiently to stimulate reproduction without destroying the protective influence of the forest. Then, as soon as the young growth has become well established, the remaining stand of mature timber should be removed. From a silvicultural standpoint the second cutting should take place in from 20 to 30 years after the first cutting; but owing to the fact that there are large amounts of over-mature timber on many of our forests, together with the fact that cut-over areas cannot, as a rule, be profitably logged a second time until the merchantable stand has been considerably increased, it will probably be at least 50 years before extensive second cuttings are made. While such a practice is not ideal, it is believed to be the best that can be generally applied at present. On certain forests, however, where the supply of virgin timber is limited, and where a steady supply is needed for local use the period between cuttings can be materially reduced.

Owing to great variability of western yellow pine stands, it is impossible to lay down any hard and fast rules as to the amount of timber to be left after the first cutting. Every area which is marked for cutting should be made the subject of a careful study both from the silvicultural and the lumberman's point of view. The first object to be aimed at is to leave a sufficient number of suitable trees to insure a sufficient amount of seed and protection; this, however, should be obtained at the least possible loss of merchantable timber, for it must be borne in mind that if mature trees are left many of them will be lost through windfall or decay before it is possible to return for a second cutting.

A matter of first importance is the distribution of the trees left after cutting. The aim should be not to simply leave a certain number of trees or a certain volume of timber per acre, as has sometimes been done in the past, but to leave trees where they are needed. Where large natural openings occur a number of seed-bearing trees should be left in the borders, especially on the windward side. In places where there is a good stand of poles beyond danger from fire no mature trees should be left. If, however, the young growth is still in danger from fire a sufficient number of old trees should remain to insure reproduction in case of fire.

The kind of trees to leave should receive very careful consideration. No sound "black jack" should be cut unless thinning is desirable. Where it is necessary to leave "yellow pine", a thrifty full crowned tree should always be selected if possible. Decadent trees usually bear only a small amount of seed, and they are sure to die before a second cutting can be made. Slender, thin crowned trees produce but little seed and afford practically no wind protection. A study of the comparative vitality of seeds from "black jack" and over-mature "yellow pine" has shown a decided difference in favor of the former. Trees standing in somewhat isolated positions have the best crowns and are most windfirm; when such trees are not available it is well to leave several trees in a group. When several members of a group are left, those on the borders, especially those on the south or west sides should be selected in preference to those in the interior of the group. Very large, clear-boled, mature "yellow pines" should as a rule be cut even though a large opening is made, because such trees are very liable to be wind thrown, entailing a great financial loss with little benefit to reproduction. Defective, insect or fungus infected trees should as a rule be cut; frequently, however, it may be advisable to leave defective trees when they are needed to close large openings, providing that they are not a menace to the remaining stand. In such cases the marker must exercise his own judgment as to whether the probable influence of such a tree upon reproduction will justify the sacrifice of its merchantable value.

In marking timber for cutting two general conditions ordinarily present themselves, namely: stands containing a large amount of young growth, and stands consisting almost entirely of mature trees.

In stands containing many large "black jacks" and poles, marking is comparatively simple. Where the immature growth is sufficient to furnish ample protection and seed all the mature timber should be cut. Enough large trees should be left to insure an ample seed supply, however, even though they are not needed for protection. Where the number of seed bearing "black jacks" above sixteen inches in diameter is less than five per acre, enough "yellow pines" should be left to provide this number of seed bearing trees.

Stands made up almost entirely of mature or over-mature timber require very careful judgment on the part of the marker. Ordinarily to leave a sufficient number of trees to secure favorable conditions for reproduction on such areas will result in a great loss from decay and windfall. The danger from this source can be decreased by selecting the smaller and more thrifty trees in groups. In order to shorten the period of reproduction, the first logging should be made, if possible, within two or three years after a crop of seedlings has sprung up beneath the old trees, and in order to save the mature timber an effort should be made to return for a second cut within twenty years; ordinarily, however, such a close supervision of cutting would not be practicable at present.

On sparsely timbered areas, where to leave a sufficient stand to insure the necessary protection and seed supply would render the cost of logging excessive, cutting should be deferred from 15 to 20 years under good protection from fire and sheep, with the hope of securing reproduction before the timber is cut.

From the foregoing observation it becomes apparent that no set of "marking rules" can serve as more than a general guide in determining which trees in a stand should be removed and which should be left. The marking should be done by men who have both a theoretical and a practical knowledge of silviculture and lumbering. Every tree or group of trees should be considered individually and in its relation to the remaining stand. The marker should have constantly in mind a picture of the stand as it will appear after cutting. This requires a considerable amount of experience which, as a rule, can only be acquired by marking stands and then examining them after they have been cut. One fact which should be clearly understood is that marking is a study in the field, and that good results cannot be obtained by blindly following a set of instructions, no matter how well these instructions may have been prepared.

# TREES AND SHRUBS AT ARBOR LODGE.

Wade R. Martin and John S. Boyce.

It is the purpose of the Forestry Department at the University of Nebraska to make a list of the important trees and shrubs in Nebraska, both native and exotic, and to study not only their dendrological characteristics but also their silvical habits. With such an object in view a recent study was made of the trees and shrubs at Arbor Lodge, Nebraska City. This is the famous estate of the late Hon. J. Sterling Morton, where there is now growing a greater variety of trees and shrubs than on any other estate in the middle west.

Soil and climatic conditions at Nebraska City are very favorable to plant life as is shown by the luxuriant growth of more than two hundred species from various parts of the world. The average annual temperature is 50 degrees Fahrenheit, with a maximum of 108 degrees Fahrenheit in July and a minimum of 29 degrees Fahrenheit in February. The average date of the earliest killing frost in autumn is October 7 and the latest in the spring is April 21, which gives a growing season of one hundred and sixty-nine days. The annual precipitation is thirty-one inches and seventy per cent of this falls between April and August. June is the month of heaviest rainfall, averaging about five inches. Since Nebraska City is situated in the low valley of the Missouri River, the wind velocity is low and averages only nine miles per hour. The soil is very deep and rich and is mostly loess, although some glacial deposits may be observed in cuts near the city.

## WHITE PINE PLANTATION.

The white pine plantation is the most interesting and important silvicultural study at Arbor Lodge since it is the only plantation of its kind in the state. It now consists of about six hundred trees which occupy nearly two acres. The trees were planted in 1890 as transplants, two or three years old, and were originally spaced 4x4, but some have died and some have been cut. The plantation is situated near the top of a gentle slope which has a southerly exposure. The crown density varies from four-tenths to a complete cover, making an average of about eight-tenths. The trees are mostly dominant or intermediate, and only a few are suppressed. The boles are well cleaned since it is the practice to remove dead and dying branches by knocking them off with an axe. There is scarcely any ground cover except in open spots where there is a good growth of grass and a few Rhododendrons. The latter have been set out under the protection of the white pines and are making a splendid growth. The forest floor is in excellent condition. The litter is two to three inches deep and a well decayed humus is one inch deep. The soil beneath is very rich and moist. The trees have been producing a small amount of seed for the past six or seven years, although no regular crop has yet been produced. In order to ascertain the average height, the average clear length, and average diameter, the trees in two rows, one extending north and south, the other east and west, were calipered and their heights and clear lengths estimated. By averaging the figures in the following tables the average height is found to be twenty-one feet, the average clear length twelve feet and the average diameter five and four-tenths inches.

Diameter and Height Measurements—White Pine.

| DBH in Inches | Height in Feet | Clear length in Ft. | DBH in inches | Height in Feet | Clear length in Ft. |
|---|---|---|---|---|---|
| 4.70 | 18 | 10 | 5.70 | 21 | 3 |
| 6.30 | 24 | 11 | 3.65 | 18 | 13 |
| 6.42 | 22 | 9 | 3.20 | 18 | 13 |
| 5.65 | 24 | 11 | 6.65 | 21 | 10 |
| 4.98 | 25 | 12 | 7.30 | 23 | 6 |
| 3.82 | 24 | 13 | 7.00 | 23 | 8 |
| 7.15 | 22 | 10 | 4.40 | 20 | 9 |
| 4.52 | 21 | 14 | 6.30 | 19 | 7 |
| 3.15 | 20 | 14 | 3.90 | 16 | 8 |
| 6.10 | 21 | 12 | 3.15 | 20 | 13 |
| 6.50 | 21 | 11 | 4.97 | 22 | 14 |

Table continued on following page

| | | | | | |
|---|---|---|---|---|---|
| 3.80 | 18 | 13 | 6.90 | 24 | 8 |
| 4.62 | 19 | 13 | 6.60 | 22 | 14 |
| 3.60 | 17 | 12 | 7.30 | 23 | 9 |
| 6.25 | 21 | 13 | 5.12 | 20 | 6 |
| 6.48 | 22 | 15 | 5.15 | 22 | 6 |
| 4.23 | 22 | 13 | 4.89 | 23 | 15 |
| 5.82 | 20 | 12 | 6.20 | 22 | 10 |
| 7.00 | 18 | 4 | 4.20 | 22 | 13 |
| 2.70 | 16 | 2 | | | |

The following list comprises two hundred and four species and varieties which were found growing at Arbor Lodge. It is possible some were missed. One hundred and fifty-nine of these are considered as trees and forty-five as shrubs. Of the one hundred and fifty-nine trees, fifty-five are foreign species and one hundred and four native to the United States, and of this one hundred and four, thirty are native to Nebraska.

*Abies balsamea* Mill. Balsam Fir.

Height 30 feet. Clear length 10 feet. Diameter 13.8 inches. Situated alone on level ground. Crown regular and pyramidal. Grass is growing beneath the tree. Very hardy. Native to the United States.

*Abies cephalonica* Loud. Cephalonian Fir.

Height 3 feet. Diameter 1 inch. Situated alone on level ground. Grass is growing closely around the tree. Age 4 years. Native to United States.

*Abies cilicica* Carriere. Cilician Fir.

Height 4 feet. Diameter 1 inch. Rather tender. Planted under *Pinus strobus* for protection. Age 4 years. Native to Asia Minor.

*Abies concolor* Lindl. & Gord. White Fir.

Height 6 feet. Diameter 1 1-2 inches. Situated in a draw. In good condition and hardy. Native to United States.

*Abies nobilis* Lindl. Red Fir.

Height 6 feet. Diameter 2 inches. Situated alone on level ground. Hardy. Native to the United States.

*Abies nordmanniana* Spach. Nordmann's Fir.

Height 8 feet. Diameter 2 inches. Exposure southwest. Soil cultivated. Crown spreading and regular.

Leaves heavy and flat, with a bluish green tinge. Age 5 years. Browns slightly in winter, otherwise hardy. Native to Asia.

*Abies picea* Lindl. Silver Fir.

Height 3 feet. Diameter 1 inch. Age 4 years. Hardy. Native to Europe.

*Abies pinsapo* Boiss. Spanish Fir.

Height 3 feet. Diameter 1 inch. Exposure southwest. Leaves grow backward on the stem and are very sharp. Age 4 years. Native to Europe.

*Abies veitchii* Lindl. Veitch's Fir.

Height 4 feet. Diameter 1 inch. Exposure southwest. No grass beneath the tree. Branches shorter on the north side. Very hardy. Native to Japan.

*Acer negundo* Linn. Box elder.

Height 18 feet. Clear length 6 feet. Diameter 3 inches. Soil cultivated. Situated in rows in a draw. It is very hardy. Native of Nebraska.

*Acer palmatum* Thunb. Japanese Maple.

Height 3 feet. Small tree of dense habit. Stood the winter well under the protection of pine boughs. Age 5 years. Native of Japan.

*Acer pennsylvanicum* Linn. Moosewood or Striped Maple.

Height 7 feet. Dense, upright habit. Situated on level ground. Bark striped with broad pale stripes. Age 4 years. Hardy. Native to the United States.

*Acer platanoides* Linn. Norway Maple.

Height 12 feet. Diameter 4 inches. Spreading branches with a large, regular crown. Hardy up to 1905 when it sun scalded and is now attacked by fungi. Native to northern Europe.

*Acer polymorphum* Sieb. & Zucc. Japan Maple.

Small tree. Growth slow and very shrubby. Native of Japan.

*Acer saccharinum* Linn. Silver Maple.

Height 40 feet. Clear length 10 feet. Diameter 24 inches. West exposure. Crown wide-spreading and irregular. Grass at foot of tree. Native to Nebraska.

*Acer saccharinum* Linn. Var. *wieri* Schwer. Wier's Cutleaf

Maple.

Height 15 feet. Diameter 3 inches. Branches pendulous. Hardy though branches easily broken by wind. Native to United States.

*Acer rubrum* Linn. Red or Scarlet Maple.

Height 12 feet. Clear length 4 feet. Diameter 4 inches. Situated in nursery on cultivated soil. West exposure. Slope gentle. Age 6 years. Hardy. Native to United States.

*Acer Tataricum* var. ginnala Max. Siberian Maple.

Height 2 feet. Small, spreading, and bushy. Age 6 years. Hardy but not a good grower. Native to Europe and Asia.

*Aesculus hippocastanum* Linn| Horse Chestnut.

Height 11 feet. Diameter 2 1-2 inches. East exposure. Should have protection as it sun scalds and is attacked by fungi. Six were killed the first winter that they were set out. Age 6 years. Native to the United States.

*Ailanthus glandulosa* Desf. Tree of Heaven.

Height 25 feet. Diameter 9 inches. Southwest exposure. Crown irregular. Tree leans toward the north. Soil cultivated. Numerous sprouts and root suckers. Hardy. Native to China.

*Alnus glutinosa* Gaertn. European or Black Alder.

Height 25 feet. Diameter 5 inches. Situated in a draw. Crown large and regular. Vigorous and rapid growing tree. Age 4 years. Native of Europe and Africa.

*Aralia spinosa* Linn. Hercules' Club.

Height 7 feet. Has no branches. Situated on level ground. Several plants are growing together. Has stout prickly stems. Age 5 years. Native to the United States.

*Araucaria excelsa* Robt. Brown. Norfolk Island Pine.

Height 3 feet. Tree is tropical and grows only in the greenhouse. Native to Norfolk Islands.

*Baccharis halimifolia* Linn. Groundsel Tree.

Height 7 feet. Northeast exposure. Spreading, bushy habit. Large range of adaptability, especially near salt water. Age 4 years. Native to United States.

*Betula alba* Linn var. *pendula laciniata Linn.* Cutleaf Birch.
Height 15 feet. Diameter 3 inches. Northeast exposure. Not hardy. Killed by attack of fungus appearing as black spores on the bark. Age 6 years. Native to the United States.

*Betula lenta* Linn. Cherry, Black, or Sweet Birch.
Height 30 feet. No clear length. West exposure. No grass beneath tree. Hardy and healthy. Age 6 years. Native to the United States.

*Betula nigra* Linn. Red or River Birch.
Row of trees in the nursery. Height 12 feet. Soil cultivated. Southwest exposure. Age 6 years. Hardy. Native to Nebraska.

*Betula papyrifera* Marsh. Canoe Birch.
Height 28 feet. Clear length 6 feet. Diameter 4 inches. Grass growing beneath the tree. Age 6 and 9 years. Hardy. Native to Nebraska.

*Catalpa catalpa* Karst. Catalpa or Indian bean.
Height 25 feet. Clear length 9 feet. Crooked bole. Grass growing beneath tree. Hardy. Native to United States.

*Catalpa kaemferi* Sieb. & Zucc.
Height 12 feet. No clear length. Northeast exposure. Slope gentle. No grass beneath tree. Age 5 years. Hardy. Native to China.

*Catalpa speciosa.* Warder. Hardy. Western catalpa.
Height 40 feet. Clear length 7 feet. Diameter 12 inches. Cultivated at base of tree. Crown regular. Northeast exposure. Gentle slope. Three rows were situated in the nursery. Planted 3 x 3 feet. Southwest exposure. Height 18 feet. Clear length 6 feet. Soil cultivated. Native to United States.

*Castanea dentata* Borkh. Chestnut.
Height 30 feet. Clear length 12 feet. Diameter 11 inches. Northeast exposure. Produces a large crop of seed each year. Borers, fungi, and sun scald affect this tree. Young trees on south and southwest slopes are likely to be injured, if not protected from sun and wind. Native to United States.

*Cercis canadensis* Linn. Redbud or Judas Tree.

Height 18 feet. Clear length 5 feet. Situated on level ground. Grass growing beneath tree. Seed crop abundant. Seed pods are entered by some kind of insect which eats the seed. Hardy. Native to eastern Nebraska.

*Celtis occidentalis* Linn. Hackberry.

Height 40 feet. Clear length 10 feet. Diameter 12 inches. Northeast exposure. Very hardy. Native to Nebraska.

*Cephalanthus occidentalis* Linn. Button Bush.

Height 4 feet. Hardy and vigorous. Age 4 years. Native to Nebraska.

*Chamaecyparis pisifera* Sieb. & Zucc. var. *filfera* Hort.

Exotic.

*Chamaecyparis pisifera* Sieb. & Zucc. var. *squarrosa* B. & H.

Exotic.

*Cladrastis tinctoria* Raf. Yellow Wood.

Height 8 feet. Age 5 years. Thrives in most any soil. Native to United States.

*Cornus alba* Linn. Siberian Red Osier.

Reaches height of 6 tot 10 feet. Native of China.

*Cornus amomum* Mill. Silky Dogwood.

Height of 6 to 10 feet. Spreading. Native to United States.

*Cornus florida* Linn. Flowering dogwood.

Height 6 feet. Northeast exposure. Bushy tree with spreading branches. Age 5 years. Hardy, growing in thicket. Native to the United States.

*Cornus stolonifera* Mich. Wild Red Osier.

Age 6 years. Hardy. Native to the United States.

*Crataegus coccinea* Linn. Scarlet Thorn.

Height 6 feet. Northeast exposure. Protected on the south by arborvitae. Hardy. Native to United States.

*Euonymus alatus* Maxim. Winged burning Bush.

Height 5 feet. Corky, winged branches. Native to Japan and China.

*Euonymus atropurpureus* Jacq. Burning Bush.

Height 7 feet. Upright branches. Situated in draw. Native to Nebraska.

*Eleagnus angustifolia* Linn. Russian Olive.

Height 14 feet. West exposure. Very scrubby. Native to Europe and Asia.

*Fagara clara-herculis* Small. Prickly Ash.

Native to United States.

*Fagus ferrugina* Act. American Beech. . .

Height 9 feet . East exposure. Branches forked. Fairly hardy. Native to the United States.

*Fagus sylvatica* Linn. European Beech.

Height 7 feet. Age 6 years. Has been much thriftier than native beech. Native to Europe.

*Fraxinus americana* Linn. White Ash.

Height 18 feet. Exposure southwest. Crown regular. Age 6 years. Native to Nebraska.

*Fraxinus lanceolata* Borkh. Green Ash.

Height 35 feet. Clear length 11 feet. East exposure. Crown regular. Branches larger on the north side. Soil cultivated. Native to Nebraska.

*Fraxinus nigra* Marsh. Black Ash.

Height 35 feet. Clear length 18 feet. Diameter 12 inches. Northeast exposure. Soil cultivated at the base. Native to the United States.

*Ginkgo biloba* Linn. Maidenhair Tree.

Height 15 feet. Northeast exposure. Good grower. Very hardy. Native to China.

*Gleditsia triacanthos* Linn. Honey Locust.

Height 30 feet. Clear length 8 feet. Diameter 12 inches. Southeast exposure. Very gentle slope. Grass growing beneath tree. Hardy. Native to Nebraska.

*Gymnocladus dioicus* Koch. Kentucky Coffee Tree.

Height 35 feet. Clear length 18 feet. Diameter 10 inches. Standing among other trees. Grass growing at the base of the tree. Native to Nebraska.

*Hamamelis virginiana* Linn. Witch Hazel.

Height 8 feet. Still in bloom as late as Nov. 25, after oak leaves had been killed. Grows well either in full sun or partial shade. Native to Nebraska.

*Hicoria glabra* Britt. Pignut.

Height 35 feet. Diameter 13 inches. Tall tree with a narrow, round topped crown. Grows in woodlot with other species. Native to Nebraska.

*Hicoria minima* Britt. Bitternut.

Height 35 feet. Diameter 12 inches. Tall, straight, clear bole with a large crown. Requires a moist soil. Native to Nebraska.

*Hicoria ovata* Britt. Shagbark Hickory.

Height 30 feet. Diameter 10 inches. Growing with the other two species of Hicoria. Is rather tolerant. Native to Nebraska.

*Ilex opaca* Art. American Holly.

Height 7 feet. Northeast exposure. Regular crown. Well protected by other trees. Berries and leaves unhurt by frosts as late as Nov. 25. Native to the United States.

*Juglans cinerea* Linn. Butternut.

Height 18 feet. Diameter 4 inches. Northeast exposure. No grass growing beneath tree. Age 6 years. Hardy. Native to Nebraska.

*Juglans nigra* Linn. Black Walnut.

Height 35 feet. Clear length 11 feet. Diameter 11 inches. Little grass beneath tree. Crown regular and small. Native to Nebraska.

*Juniperus communis* Linn. var. *hibernica* God.

Height 2 feet. Very shrubby. Well protected. Native of Europe.

*Juniperus communis* Linn. var. *suecica Loud.*

Height 6 feet. Densely branched. Soil cultivated. Well protected. Native of Europe.

*Juniperus sabina* Linn.

Height 3 feet. Northeast exposure. Native to Europe and Asia.

*Juniperus virginiana* Linn. Red Cedar.

Height 35 feet. Clear length 3 feet. Diameter 19 inches. Crown large and conical. Branches thick and hanging low. Pronounced taper to the bole. Situated on the crest of a small hill. Grass growing beneath tree. Native to Nebraska.

*Kalmia latifolia* Linn.

Height 18 inches. Tender to sunshine. Native to United States.

*Larix europaea* D. C. European Larch.

Height 12 feet. East exposure. Fairly hardy. Situated in a draw. Native of Europe.

*Ligustrum ibota* Sub. Japanese Privet.

Height 6-7 feet. Age 6 years. Important as a hedge. Considered the best ornamental hedge known. Native to Japan.

*Liquidambar styraciflua* Linn. Sweet Gum.

Height 15 feet. Diameter 2 inches. Northeast exposure. Cultivated at the base of the tree. Hardy. Native to United States.

*Liriodendron tulipifera* Linn. Tulip Tree.

Height 28 feet. Diameter 5.5 inches. Exposure northeast. Slope gentle. Has numerous sprouts. Age 6 years. Hardy. Native to the United States.

*Magnolia acuminata* Linn. Cucumber Tree.

Height 8 feet. Northeast exposure. No grass at base of tree. Large terminal buds. Age 4 years. Native to the United States.

*Magnolia glauca* Linn. Sweet, Swamp or White Bay.

Native to United States.

*Magnolia stellata* Maxim. Starry Magnolia.

Height 3 feet. Northeast exposure. No ground cover. Many branches. Scrubby. Native to Japan.

*Magnolia soulangeana* Soul. Soulange's Magnolia.

Exotic.

*Magnolia soulangeana* var. *Lennei*. Lenne's Magnolia.

Exotic.

*Magnolia tripetala* Linn. Umbrella Tree.

Height 20 feet. Clear length 4 feet. Diameter 2.7 inches. Leans due to crowding by hemlock on southwest. Grass growing sparsely beneath tree. Age 4 years. Hardy. Native to the United States.

*Malus floribunda* Nichols. Flowering Crab.

Native to Japan.

*Malus ioensis* (Wood) Button. Western Crab.

Native to Nebraska.

*Malus malus* Linn. Apple.

Native to United States.

*Morus alba* var. *tartarica* Linn. Russian mulberry.

Native to Europe.

*Morus rubra* Linn. Red Mulberry.

Native to pastures in Nebraska.

*Ostrya virginiana* Willd. Hop Hornbeam.

Native in pastures and along streams. Native to Nebraska.

*Picea alcockiana* Sir Alcock's Fir.

Native of Japan.

*Picea canadensis* Butt. White Spruce.

Height 10 feet. Exposure northeast. One of the most satisfactory spruces. In mixture with other trees. Native to the United States.

*Picea excelsa* Link. Norway Spruce.

Height 35 feet. Clear length 14 feet. Diameter 14.5 inches. Regular crown. Well pruned. Pronounced taper. Twigs drooping. Native to Europe.

*Picea excelsa* var pendula. Loud.

Native to Europe.

*Picea engelmanni* Engelm. Engelman Spruce.

Native to the United States.

*Picea mariana* Butt. Black Spruce.

Native to the United States.

*Picea orientalis* Carr. Oriental Spruce.

Native to Asia.

*Picea polita* Carr. Tiger's Tail Spruce.

Height 5 feet. Exposure southwest. Gentle slope. Crown conical. Foliage rigid and spiny. Age 3 years. Native to Japan.

*Picea parryana* Sarg. Colorado Blue Spruce.

Height 25 feet. Clear length 6 feet. Diameter 10 inches. Killed the grass beneath the tree. Regular, round, tapering crown. Native to the United States.

*Picea pungens* Engelm. Colorado Spruce.

Native to the United States.

*Pinus austriaca* Austrian Pine.

Height 45 feet. Diameter 15 inches. Clear length 10 feet. Abundant seed crop. Very hardy. Native to Europe.

*Pinus cembra.* Linn. Swiss Stone Pine.

Height 10 feet. Diameter 2 inches. Leaves mostly one in a sheath. Native to Europe.

*Pinus divaricata* Dum. Cours. Jack Pine.

Height 6 feet. No clear length. Planted as nursery stock in rows. West exposure. Native to United States.

*Pinus laricio* Poir var. *Austriaca* Endl. Corsican Pine.

Native to Asia.

*Pinus massoniana* Lam.

Height 12 feet. Diameter 2 inches. Regular crown. Northeast exposure. Gentle slope. No grass beneath tree. Cultivated soil. Native to Japan.

*Pinus ponderosa* Laws. Bull Pine.

Height 9 feet. No clear length. Regular crown. Age 7 years. Quite drouth resistant. Is being planted in the sandhills region of Nebraska. Native to the United States.

*Pinus montana* Mill. Mughus.

Height 18 inches to 2 feet. Very scrubby. Spreads out over the ground like a bush. Age 6 years. Native to United States.

*Pinus resinosa* Art. Norway Pine.

Height 8 feet. Situated on level ground near white pine. Grass grows beneath the tree. Hardy. Native to the United States.

*Pinus rigida* Mill. Pitch Pine.

Native to United States.

*Pinus sylvestris* Linn. Scotch Pine.

Height 30 feet. Cear length 8 feet. Diameter 17 inches. Level ground. Crown regular. Hardy. Native to Europe.

*Pinus strobus* Linn. White Pine.

Height 35 feet. Clear length 9 feet. Diameter 22 inches. Broad, wide branching crown. Situated on level ground. Has killed the grass slightly. Hardy. Native to the United States.

***Philadelphus coronarius*** Linn. Mock Orange.

Age 6 years. Hardy. Native to Europe.

***Platanus orientalis*** Linn. Oriental Plane.

Height 25 feet. Diameter 5 inches. Northeast exposure. Gentle slope. Grass growing clear around base Hardy and rapid growing. Native to India.

***Populus alba*** Linn. Silver Poplar.

Consists of three large sprouts which are covered with adventitious growth. Height 45 feet. Diameter 16, 19 and 17 inches for each sprout. Cultivated around base. Hardy, but suckers a nuisance. Native to Asia and Europe.

***Populus angulata*** Aiton, Carolina Poplar.

Height 50 feet. Clear length 7 feet. Diameter 9 inches. Soil cultivated around base of tree. Native to the United States.

***Populus deltoides*** Marsh. Cottonwood.

Height 45 feet. Clear length 25 feet. Diameter 18 inches. Crown injured by wind. Soil cultivated around base. East exposure. Hardy. Native to Nebraska.

***Populus deltoides*** var. *van geertii.* Van Geert's Golden Poplar.

Grown in nursery. Have a yellow foliage. Age 5 years. Hardy. Native to the United States.

***Populus nigra*** Linn. var. *Italica.* Lombardy Poplar.

Height 35 feet. Diameter 8 inches. Many adventitious shoots. Northeast exposure. Cultivated around base of tree. No attack by borers. Hardy. Native to Europe.

***Prunus avium*** Linn. Sweet Cherry.

Fairly hardy, but not thrifty. Native to Europe.

***Prunus americana*** Marsh. Wild Plum.

Native to United States.

***Prunus armeniaca.*** Apricot.

Hardy, but flower buds are killed. Fruit poor. Native to Asia and Europe.

***Prunus cerasifera*** Fissardi. Purple leaved Plum.

Age 6 years. Tips killed in 1903 and 1904. Top killed in 1905. Native to Asia.

*Prunus cerasus* Linn. Early Richmond Sour Cherry.
Hardy. Native to Japan.

*Prunus serotina* Ehrk. Wild Black Cherry.
Height 10 feet. Scrubby. Grows native in pastures. Native to Nebraska.

*Pseudotsuga taxifolia,* Britton. Douglas Fir.
Height 30 feet. Clear length 8 feet. Diameter 8 inches. Crown regular. Exposure northeast. Slight taper to the bole. Stands transplanting well. Native to the United States.

*Ptelia trifoliata* Linn. Hop tree.
Age 6 years. Hardy. Native to the United States.

*Quercus bicolor* Willd. Swamp White Oak.
Height 9 feet. Diameter 2 inches. Exposure northeast. Slope moderate. Not very hardy. Age 4 years. Native to the United States.

*Quercus coccinea* Moench. Scarlet Oak.
Height 15 feet. No clear length. Diameter 4 inches. Northeast exposure. Hardy and a good grower. Age 6 years. Native to Nebraska.

*Quercus macrocarpa* Mich. Burr Oak.
Height 35 feet. Clear length 20 feet. Diameter 10 inches. Northeast exposure. Grass growing beneath tree. Park-like formations of burr oak associated with ash, elm, bull pine and cedar, occur at Arbor Lodge. Trees average 6-15 inches in diameter and 30 feet in height. Practically no litter. Trees cleaned about 18-20 feet. Native to Nebraska.

*Quercus palustris* Muench. Pin Oak.
Height 15 feet. Northeast exposure. Crown regular Grass growing around base of tree. Age 4 years. Hardy. Native to the United States.

*Quercus phellos* Linn. Willow Oak.
Height 11 feet. Northeast exposure. Age 4 years. Was transplanted and is now dying. Native to the United States.

*Quercus prinus* Linn. Post Oak.
Height 9 feet. Diameter 2 inches. Fairly hardy. Native to the United States.

*Quercus robur* Linn. English Oak.

Height 10 feet. Northeast exposure. Bole very crooked. Native to Europe.

*Quercus rubra* Linn. Red Oak.

Height 25 feet. Diameter 3 inches. Crown reguar. Occurs in mixture with white pine. Soil cultivated. Northeast exposure. Native to Nebraska.

*Rhus cotinus* Linn. Smoke Tree.

Height 8 feet. Hardy. Much branched. Age 5 years. Native to Europe and Asia.

*Rhus glabra* Linn. Smooth Sumac.

Native to Nebraska.

*Rhus typhina* Linn. var. *larciniata*. Cutleaved Staghorn Sumac.

Age 4 years. Native to United States.

*Rhododendron catawbiense* Rush. Catawba Rhododendron.

Height 2 feet. Growing well under protection of white pine. The statement has been made that Rhododendrons will not grow in Nebraska. The three species at Arbor Lodge are growing well and seem hardy. Native to the United States.

*Rhododendron maximum* Linn. Great Laurel.

Height 4 feet. Age 4 years. Growing well under white pine. Native to the United States.

*Rhododendron hybrida.*

Height 2 feet. Was planted in 1908 and is doing well. The two parents of this hybrid are not known. Native to the United States.

*Robinia pseudocacia* Linn. Black Locust.

Height 45 feet. Clear length 8 feet. Diameter 13 inches. North exposure. Crown irregular. Hardy. Good grower. Native to the United States.

*Salix babylonica* var. *dolorosa* Rowen. Wisconsin Weeping Willow.

Height 25 feet. Branches pendulous. Situated in a draw. Very hardy. Native to the United States.

*Salix pentranda* Linn. var. *laurifolia*. Laurel-leaved willow.

Height 40 feet. Diameter 5 inches. Bole straight, making a fine ornamental tree. Situated in a draw. Native to Europe and Asia.

*Salix vitellina* Linn. Golden Willow.

Height 30 feet. Branched at a height of 3 feet. Butt 3 feet in diameter. Crown very regular. Tree in poor condition. Native to the United States.

*Sassafras sassafras* Karst. Sassafras Tree.

Height 40 feet. Clear length 10 feet. Diameter 13 inches. Northeast exposure. Demands shade. Hardy. Native to the United States.

*Sciadopitys verticellata* Sieb. & Zucc. Jap Umbrella Tree.

Height 4 feet. Shrubby. Regular, conical crown. Soil cultivated. Native to Japan.

*Sorbus americana* Marsh. Mountain Ash.

Height 20 feet. Diameter 4 inches. Situated in a draw. Crown regular. Hardy. Native to the United States.

*Tamarix amurensis* Hort.

Native to Russia and Asia.

*Tamarix gallica* Linn.

Native to Europe.

*Taxodium distichum* Rich. Bald Cypress.

Height 7 feet. No clear length. Southeast exposure. Age 4 years. Native to the United States.

*Taxus canadensis* Marsh. American Yew.

Height 3-4 feet. Protected by white pine. Age 4 years. Native to the United States.

*Thuya occidentalis* Linn. var. *compacta.*

Age 4 years. Hardy. Native to the United Sttates.

*Thuya occidentalis* Linn. var. *aurea.* Douglas. Golden abroritae.

Height 6 feet. Age 5 years. Soil cultivated. Native to the United States.

*Thuya occidentalis* Linn. var. *ericoides* B & H.

Native to the United States.

*Thuya occidentalis* Linn. var. *pyramidalis.* Pyramidal arborvitae.

Narrow, compact, pyramidal crown. Native to the United States.

*Thuya orientalis* Linn. Oriental arborvitae.

Very peculiar since it is a type form of arborvitae but has also the Juniper leaf. Native to Asia and Japan.

*Tilia americana* Linn. Linden.

Height 15 feet. Clear length 4 feet. Diameter 4 inches. Regular much branched crown. Sun scalded. Northeast exposure. Age 6 years. Native to Nebraska.

*Tilia platyphellos* Scop. European Linden.

Height 11 feet. Much forked. Northeast exposure. Age 6 years. Trunk liable to sun scald and cracking. Native to Europe.

*Toxylon pomiferum* Raf. Osage Orange.

Height 28 feet. Clear length 8 feet. Diameter 9 inches. North exposure. Branches irregular due to pruning. Liable to winter killing. Native to United States.

*Tsuga canadensis* Carr. var. *pendula.* Sargent's Hemlock.

Height 2-3 feet. Shrubby. Age 5 years. Hardy. Native to United States.

*Tsuga canadensis* Carr. Hemlock.

Height 28 feet. Clear length 8 feet. Diameter 7 inches. Crown regular. Grass killed beneath tree. Crowded by Scotch Pine on West. Native to the United States.

*Ulmus scabra* Mill. Camperdown Elm.

Height 12 feet. Clear length 7 feet. Grafted on Ulmus americana. Branches pendulous. South exposure. Hardy. Native to Europe.

*Ulmus campestris* Smith. English Elm.

Height 10 feet. Northeast exposure. Mixed with other species. Soil cultivated. Age 6 years. Native to Europe and Asia.

*Ulmus americana* Linn. White Elm.

Height 50 feet. Clear length 9 feet. Diameter 24 inches. Crown irregular. Grass growing at the base of tree. Situated on level ground. Native to Nebraska.

*Ulmus fulva* Michx. Slippery Elm.

Height 40 feet. Clear length 6 feet. Poorly cleaned. Diameter 18 inches. Crown large and regular. Situated on level ground. Native to Nebraska.

SHRUBS.

*Azalia mollis* Blume.
*Berberris thornbergii* D. C. Dwarf Barberry.
*Berberris vulgaris* Linn. Common Barberry.
*Berberris vulgaris* Linn. var. *atropurpurus* Rgl. Purple Leaved Barberry.
*Bocconia cordata* Willd. Plume Poppy.
*Caragana aborescens* Lamb. Siberian Pea Tree.
*Cedrus atlantica* Monetti. Cedar.
*Celastris scandens* Linn. Bitter Sweet.
*Cercediphyllum japonicum* Sieb. & Zucc.
*Clethra alnfolia* Linn. Sweet Pepperbush.
*Corylus americana* Walt. Hazelnut.
*Corylus avellana* Linn. European Filbert.
*Cydonia japonicum* Pers. Japanese Quince.
*Daphne mizereum* Linn.
*Deutzia scabra* Thunb. var. *crenata* Voss.
*Diervilla florida* Sieb & Zucc.
*Forsythia suspensa* Vahl.
*Forsythia viridissima* Lindl.
*Funkia cordata* Hort.
*Hibiscus moscheutos* Linn. Chinese Hibiscus.
*Hibiscus rosa-sinensis* Linn. Chinese Hibiscus.
*Hibiscus syriacus* Linn. Rose of Sharon.
*Halesia tetraptera* Linn. Snowdrop Tree.
*Incarvillea delavayi* Bur and Franch.
*Koelreuteria paniculata* Laxm. Varnish Tree.
*Lonicera japonica* Thunb. var. *halliana* Arb. Kew.
*Lonicera percylmenius* L.
*Paeonia moutana* Linn. Tree Peony.
*Paulownia imperialis* Sieb. & Zucc.
*Ribes floridum* L'Her. Black Currant.
*Rosa chinensis* Jacq. Chinese Rose.
*Rosa multiflora,* Thunb. Rambler.
*Rosa rugosa* Thunb. Single Rose.
*Rosa rubiginosa* Linn. Sweet Brier.
*Rosa wichuraiana* Crepn. Memorial Rose.
*Rhamnus lanceolata* Pursh. Common Buckthorn.
*Rhodotypes kerriodes* Sieb & Zucc.

*Sambucus canadensis* Linn. var. laciniata.
*Sophora japonica* Linn. Japanese Pagoda Tree.
*Spirea sorbifolia* Linn.
*Spirea tomentosa* Linn. Hardhack.
*Spirea* van houttei. Zabel.
*Syringa persica* Linn. Persian Lilac.
*Viburnum opulus* Linn.
*Yucca filamentosa* Linn. Bear grass.

# BOUNDARY SURVEY IN KOOTENAI NATIONAL FOREST.

L. L. Bishop.

Proper forest management of the United States National Forests demands that there be a complete and accurate survey covering each Forest. The survey should determine the relative values of all National Forest lands in order that the soil types may be put to their best use. It is also necessary to determine the extent, amount and value of all stands of timber and the extent of grazing areas. A map is essential to show graphically all the more important features of the forest such as topography, settlements, means of communication, and other factors which may affect the protection or commercial value of the land and its products. During the past summer the writer was engaged in performing such survey work as a Forest Guard on the Kootenai National Forest, where the conditions are typical of those to be found throughout extensive portions of Montana and Idaho.

To secure the information necessary for the basis of a working plan five crews were organized. Each crew consisted of one forest ranger, who was well acquainted with local conditions, and of two forest guards who were in most cases students from Forest Schools, serving temporary appointments during the three months or more of summer vacation. A portion of the boundary of the Forest and a strip four to six miles on each side of it, was assigned to each crew. At the end of the season approximately one-half the total area of the Kootenai National Forest had been surveyed and mapped.

Each crew was assigned the following camp outfit:

2 6 x 9 foot tents
5 tin plates
4 tin cups.
4. knives
4 forks
4 spoons.
2 frying pans

1 tin baking oven
1 baking pan for oven
1 small bread-pan
1 wash basin.
1 10-quart water pail
1 2-quart granite pail
1 4-quart granite pail
1 6-quart granite pail
1 coffee pot
1 tea pot
1 1-quart dipper
2 first aid packs
3 canteens
1 4-pound axe
1 shovel
1 grub hoe

The grub hoe and shovel were carried during the fire season only. The ranger supplied ropes, hobbles and a bell. Oats were occasionally packed if the grazing was especially poor.

The office supplies of each crew consisted of stationery, pencils, pens, ink, note books, colored pencils, ruling pens, small drawing board, celluloid triangle, architects seale thumb tacks and drawing ink. The field instruments comprised a good pocket compass, tally register, good camera, supply of photographic films, maps of region and surveyor's chart. Each member of the crew carried personal effects such as one pair of good blankets, one quilt, extra clothing, stationery, stamps, shaving outfit, fire arms, ammunition, fishing tackle, towels, soap, etc. The provisions carried were:

20 cans milk
50 pounds flour
50 pounds potatoes
20 pounds sugar
20 pounds bacon
10 pounds kidney beans
10 pounds rice
10 pounds oatmeal
10 pounds prunes
5 pounds apricots

5 pounds lard
5 pounds salt
5 pounds coffee
3 pounds tea
2 pounds cocoa
2 pounds raisins
2 pounds corn starch
2 pounds chocolate
One-fourth pound pepper
2 pounds baking powder
1 package yeast
1 bottle vanilla extract
9 pounds butter in tins
1 bottle "Mapline" extract.

This supply of provisions, together with the rest of the outfit, was packed on two pack horses. Fresh supplies were obtained whenever necessary. For packing, one cross-tree packing saddle and one riding saddle were used, and by carefully arranging the pack nearly as much could be put on the latter as on the pack saddle. After camp had been established the riding saddle was useful for such work as making a reconnaissance of the locality, securing mail, or making other trips which covered any considerable distance.

The difficulties in reaching that portion of the boundary assigned to any crew varied according to the distance from the office and the character of the country which must be crossed to reach it. In some cases it would take a crew three or four days to reach their work. Often there were no trails or roads leading in that that direction and so a great many extra miles would have to be travelled. Fifteen to twenty miles a day was all that could be covered by a crew with two pack horses. By the time breakfast was over and the camp outfit tied up and put upon the saddles, it was between eight and nine o'clock. At noon, if the packs were heavy, the horses were allowed to rest an hour or more, then the packs were replaced and the trip continued. Since comfortable camps had to be made at night the crew did not travel later than six o'clock.

When the place was reached from which the boundary survey was to be started, all hands set about establishing camp. In making camp each member had a certain part to do; for example, one man would put up the tents and put the supplies in them; another would untie the supplies, build a fireplace, cut wood and get boughs for the beds; the other member of the crew would tend to the horses and possibly catch fish for the next meal if there were time and if not, start preparing the meal. This routine was followed throughout the season.

In choosing a camp site there were always several things to be considered, among which the most important were: first, location relative to the boundary to be worked from that camp; second, water supply for camp purposes and for horses; third, feed for horses; fourth, ease in getting to and from postoffice or source of supplies; fifth, lay of ground as regards erection of tents, location of beds, and liability of flooding; sixth, fire wood, tent poles, boughs for beds, etc.

After the camp was established, the crew would set out to locate itself; that is, find out in what section and quarter-section the camp was located. If this could not be done by aid of maps with which the crew was supplied, each man would start from camp in a different direction looking carefully for survey lines. When a blazed line was found it was followed to the first section corner or quarter-section corner, and from the descriptions on the bearing trees the location of the camp was obtained. On such trips careful notes were kept so that the same ground would not have to be covered again. When the corners were located, the official monument nearest the camp would form the basis for work.

In the morning a certain portion of the township was assigned each member of the party for investigation. It was his duty to determine the location of all streams, base and top of each ridge, meadows, lakes, benches, houses, roads, trails, fences, ditches, improvements of all kinds, amount and kind of timber, burned areas, windfalls, and at least a relative idea of the elevations of the locality. To obtain this knowledge one could not at all times follow the section lines.

It was frequently necessary to go back and forth through the section in straight lines to determine the location of the prominent features. In order to keep a straight course a pocket compass was used. A tally register was supplied to record the number of paces taken between known points. In this connection it will be seen that it was necessary for each person to know the number of paces he took to a mile, and the variance caused by such features as slope, underbrush, time of day, physical condition, etc. Each man carried a pocket note book containing cross-section paper, upon which a map of the locality was sketched as it was passed over. In another place in the same note-book records were made of the exact number of paces that were taken from one ridge to the next, from the top of the ridge to a creek, road, or trail; the number of paces across one type to the next, across a burned area, etc. Notes were also made as to homesteads, improvements, and reproduction. Maps and reports which were to be sent to the office were compiled from these field notes and field sketches. These maps and reports were made in camp by the man most skilled in this class of work. When the field work was received at the supervisor's office the reports were typewritten and approved by the supervisor and then were sent to the District office.

To show the information a map is expected to contain, a sample township map has been reproduced in colors, using the legend of the United States Forest Service Atlas. The green portion of the map indicates that while the area is forested, it has no present commercial value. Those areas are shaded green, upon which the stand of merchantable timber has been estimated to be less than 2000 board feet per acre. For example, tracts of lodgepole reproduction with perhaps a few scattering tamaracks or yellow pines of commercial size are indicated by this color.

The light shade of blue is used to indicate areas upon which the merchantable timber has been estimated to run from 3,000 to 5,000 board feet per acre, as for example, a very open stand of yellow pine which may be due to poor site conditions, past cutting, or fire. Tamarack and fir may form a part of such stands, but usually yellow pine constitutes the whole stand. The darker shade of blue, shown on the map as a solid color, indicates those areas upon which a stand of from 5,000 to 10,000 board feet per acre is found. As above, this is pure yellow pine or often yellow pine mixed with fir and tamarack. Most of the timber throughout northwestern Montana has the density shown by the dark blue. In many townships stands of timber were found which would run far above 10,000 board feet per acre. In such cases other colors were used, as for example, a stand of from 10,000 to 25,000 board feet was shown by a brownish yellow, while a still greater density was shown by a darker shade of the same color.

The yellow colored areas shown on the map are meadows or park lands. In the township in which the map was made, these grass covered areas had been caused largely by the natural drainage of marsh land upon which the forest had not as yet encroached. The red lines, which in all cases are found over one of the other colors, indicate, that in the mind of the examiner, the land had all the essentials necessary for agriculture. These essentials consisted of a level surface, good soil and fair, natural drainage. Emphasis was placed upon the absence of rocks, since large areas would be agricultural if the rocks could be profitably removed. There was often a difference of opinion between the examiners and the inhabitants of a National Forest. The latter frequently tried to have the poorest sites declared agricultural. The solid red areas are those which at the present time or within the last few years have been under cultivation. Such tracts are usually small and are found only near the stream courses.

Burns are indicated by vertical black lines. An absence of other colorings shows that the tract is void of standing trees or of any considerable amount of reproduction. Blotched green in connection with the black lines indicates a burn upon which there are a number of scattered trees standing. A solid green over black lines indicates that the forest cover has been re-established upon the burn.

The composition of the stand as to species and amount of each, is shown by the heavy black figures and the letters. The species represented on the map by letters, are as follows: Dl—Douglas fir—*Pseudotsuga taxifolia;* PO—lodgepole pine—*Pinus contorta;* P4—western yellow pine—*Pinus ponderosa;* L7—larch—*Larix occidentalis.* The number of thousand board feet per acre is shown by the figure used in connection with the legend for the species. For example, between two ridges on the map are found the following: P43, which means western yellow pine, 3,000 board feet per acre; L72, which means larch (*Larix occidentalis*), 2,000 board feet per acre; and D11, which means Douglas fir, 1,000 board feet to the acre. Where the legend of a species is given and no number following, it indicates that the timber is not of merchantable size; that is, "PO" would mean lodgepole reproduction.

The small figures found at section corners, tops of ridges, and where a stream crosses a section line indicate elevation above sea level. These elevations are taken largely from surveyor's charts, railroad maps, or any other reliable source. Aneroid barometers should be used where such data is lacking or inefficient.

As explained by the legend, the heavy dark lines indicate the boundary of the National Forest. The accompanying map furnishes a good example of the Forest Service policy in excluding agricultural lands from the National Forests as far as possible. Usually the boundary of the forest will be found to be at least one-half mile up the slope of the mountains and sometimes farther. It is impossible to conform to this general rule in all cases, but wherever there is agricultural land within the National Forests, it is subject to entry under the act of June 11, 1906.

A written description of the township was attached to each map and sent to the office with it. In preparing this description the following outline was used:

1. Location and area.
2. Description of topography.

   Description should be brief and include the main streams, their direction, the altitude of the highest points, and the general trend of the drainage.
3. Climate.

   Precipitation, length of snow season, approximate depth of snowfall, frosts, etc.
4. The forest.

(a) A brief description of the various species and silvicultural types of forest cover.

(b) A rough estimate of the amount of merchantable timber according to watersheds or logging units, its accessibility, and prospective markets. A short, clean-cut statement of each logging chance—amount—quality—method of logging—cost of logging—possible mill sites, etc.

5. Relation of forest to water supply.
   The forest as a protective cover; present use of water for irrigation and power, and possible acreage and value of irrigated and irrigable lands dependent on streams described for water supply. Possible reservoir sites and other irrigation and power works.
6. Industries.
   Nature and relative importance, dependence on the resources of the area described, extent and value of the most important industries in each township.
7. Settlements.
   Location, size, importance, and industries. Careful discussion of each settlement with abandoned or sold homestead entries. Use general outline of agricultural settlement report but make brief and to the point; enlarge on the agricultural success, failures, or chance for success and give history of claim.
8. Roads, trails, and railroads.
   Roads and trails built by Forest Service should be noted separately.
9. Lumbering.
   Extent of lumbering in the past and at present. Its effect upon the forest. Conditions of cutover lands. Effect which inclusion in Forest has had upon lumbering. Need for timber. Means of supplying it from elsewhere. Price of different species in the local market nearest to the tract described.
10. Grazing.
    Extent of industry in locality and to what extent the stock is dependent on the use of the range described. How much stock now using area. Where owned. Where stockmen reside. Relation of range on Forest to range outside. Describe character of range, whether brush, grass, etc. Extent of open parks and pas-

ture in timber. The effect of range control inside of National Forest compared to unrestricted area outside.

11. Fire.

    Damage from fire. Cause.

12. Situation.

    Attitude of forest users toward the National Forest policy. State any illegal settlements or operations on area. Give, if possible, briefly each settler's attitude.

13. Conclusions and recommendations.

    State whether any changes in the present boundary in eliminations or additions should be made. Give full reasons.

The importance of photographs to illustrate particular points in the report cannot be overestimated. Cameras will be furnished to each examiner and a number of photographs should be taken to show not only every settlement or abandoned settlement, but also considerable areas in relation to the boundary and particularly the actual character of the land contiguous to boundary itself.

The examination of homesteads was considered one of the most important features of the work. The clearings were small, usually five to ten acres, and these areas were always located with reference to ease of clearings. Large trees were left standing and the farmer usually cultivated around these and many stumps which were not removed. The cost of clearing timbered land runs from $50 to $150 per acre and is a factor in limiting the cleared area. Cleared land is mostly used for timothy hay and garden truck, both of which do very well; fruit is produced in sheltered spots. The cabins and outbuildings are poor.

Most of these claims have valuable stands of timber and many have been sold to some lumber company as soon as final proof has been made. The prices for claims range from $3,000 to $10,000.

The examiner is also asked to learn the attitude of the residents towards the Forest Service and its policies. On the whole the sympathy of the settlers is with the Service, but they occasionally disagree as regards methods of administration.

Nearly every homesteader interviewed agreed that the final working out of the Forest Service policy would be a good thing for the development of the country. Special points of difference are in the Forest Service enforcements of the laws prohibiting cutting of the timber from homesteads except for the purpose of clearing the land, enforcement of the homestead laws requiring residence and improvements on homesteads before proof, and refusal to open for homestead entry lands bearing heavy stands of timber.

The cost of labor for carrying on the work was distributed as follows: The ranger was paid $1,000.00 per annum and the guards $900 per annum. One horse was furnished by the ranger; fifty cents per day was allowed for the use of the other. The average cost of living was about $12.00 per month per man, but this expense was paid by the men. The total cost to the Kootenai National Forest was $2.00 per square mile. This does not include the cost of tools and equipment.

An important feature of the work, which should not be overlooked in figuring the cost, was the fire protection afforded by the distribution throughout the forest of the several crews.

# EFFECTS OF AN ICE STORM ON FOREST TREES

R. R. Hill.

On November 27, 1909, a storm area extended over most of that part of the United States between the Rocky Mountains and the Mississippi River. One unusual feature of the storm was that the isothermal lines extended nearly north and south and that an area of low pressure about fifty miles wide and six hundred miles long occurred in the central part, extending from Amerillo, Texas, north and east to Minnesota. In this region the temperature ranged from 20 degrees Fahrenheit to 30 degrees Fahrenheit and precipitation was general, falling in the north as snow, farther south as sleet, and in southern Nebraska and south into Texas as rain. The precipitation at Lincoln, Nebraska, approximately two inches, was the heaviest recorded. Here, after two days of cloudy weather, the wind which had blown from the south changed to the north early in the afternoon of the 27th and the temperature fell from 66 degrees at one o'clock to 43 degrees at 3 o'clock and to 35 degrees at seven o'clock, when a rain commenced. At nine o'clock the temperature was 31 degrees and it continued below freezing during the rain which lasted until seven o'clock the next morning.

The moisture was precipitated from a warm stratum of air above to a cold stratum below, where it was reduced nearly to the freezing point and immediately formed ice when it struck a cold surface. On the branches of trees the covering thus formed varied from one-fourth to one-half inch in thickness, depending upon the size of the branch and the exposure. It was usually thicker on the under surface than on the upper surface. The ice formed a comparatively heavy load at a considerable distance from the fork and so caused an extra strain on the limb. Dr. E. M. Wilcox, Professor of Agricultural Botany, University of Nebraska, estimated the amount of ice upon a red cedar (*Juniperus virginiana*) twenty-five feet tall. He weighed a branch five feet long and one and three-fourths inches in diameter which had been broken off about five feet from the stem. He found that with the load of ice the branch weighed eighty pounds and that after melting the ice the branch weighed only eight pounds. Judging from this, Dr. Wilcox estimated the total amount of ice upon the whole tree to be about two tons. This closely adhering mass not only added an unusual burden to the stems, but it held them more rigid and correspondingly less able to bend under the weight. To these factors largely is due the breaking of limbs. Most of the broken limbs were small, a few were large. Healthy small branches broke usually at two to three feet from the stem; branches affected by insects or fungi broke where the injury was greatest; long branches extending beyond the usual crown line broke, with few exceptions, at the crotch.

The following observations were made on trees grown in the open. The hardwoods suffered more than the conifers. Of the hardwoods growing commonly in this region, the soft maple (*Acer saccharinum*), the cottonwood (*Populus deltoides*), the box elder (*Acer negundo*) and the black willow (*Salix nigra*) were most severely injured. The green ash (*Fraxinus pennsylvanica* var. *lanceolata*) and the American elm (*Ulmus americana*) suffered less, while the black walnut (*Juglans nigra*), and the hardy catalpa (*Catalpa speciosa*) had only a few small branches broken. Several branches were broken from the maple and cottonwood which measured from six to eight inches in diameter. This indicates to some extent the comparative strength of the wood of these trees, since only the healthy branches were considered in this comparison. Probably eighty-five per cent of the injuries of box elder were due to the weakening of the wood by the fungus, *Pleurotus ulmarius.* The damage to the ash was due largely to the weakening of the branches by borers. The black willow sustained more injury than any other forest tree, probably on account of its brittle wood. Nearly every black willow out in the open lost one or more of its larger branches.

At the Nebraska Experiment Station, where many of the above mentioned species occur in woodlot formation, only one tree was injured, a maple, and it had been weakened by a fungus. In the cottonwood grove no important damage was noted except along the north edge. In the woodlot the dense stand has resulted in self pruning and a smaller crown area, which, together with the protection from the wind explains the decreased effect of the storm.

Slight damage was noted among the conifers. A few red cedars from eight to twelve feet tall were bent beneath the load of ice until their tops rested on the ground. One was broken about three feet from the ground where a branch had left a scar. At the Experiment Station where the Scotch Pine (*Pinus sylvestris*) is grown both on exposed sites for a windbreak and in clumps, only one instance of injury was observed. This was a broken stem two inches in diameter. Though the extensive leaf surface of the conifers caused relatively much more ice to cling than on the barren branches of the deciduous trees, yet the former resisted the extra strain.

It was interesting to note that the unpruned trees were injured more than those which were carefully trimmed. In the case of many shade trees the branches broken should have been sawed off many years before. Several crotches observed had been split open previous to this ice storm and although able to sustain the weight of the branch alone, readily broke when the unusual strain came. The largest branch observed was eight inches in diameter and was broken from an elm. It occurred at the crotch and showed an old split extending through one-third of its diameter. Careful pruning would not have permitted this branch or the infected branches of box elder and ash to be broken off by storms.

Since sapwood is weaker than heartwood, it might be supposed that young growth would suffer more than old trees. But this was not conspicuously true, probably because in the case of old trees there is a relatively much larger area of twigs and small branches at a relatively greater distance from the point of support, making the weight of ice on the larger, older stems out of proportion to their strength.

It was noticeable that most of the large broken branches extended, when in their normal position, almost horizontally. The support of an upright branch is more dependent on its ability to resist end pressure than on its flexibility. The support of a horizontal branch depends almost wholly on its flexibility which distributes the strain throughout its entire length.

A coating of ice makes all the branches rigid. The horizontal branch then becomes less flexible and the load is concentrated at a few points instead of being distributed throughout its entire length. A coating of ice on a vertical branch increases the resistance to end pressure. This is a possible explanation for the fact that more horizontal than upright branches were broken.

The permanent injury of the storm is chiefly indirect and lies in the exposure of the wounded surfaces to attacks of insects and fungi. The crowns of the shade trees will remain more or less irregular because of the loss of branches. To avoid the damage done by such storms it is advisable to plant cottonwood, maple, and willow, particularly, in groves with a windbreak of conifers on the north side.

Fortunately, the wind was not strong during this storm. Its velocity ranged from three to nine miles above the normal. Had it blown thirty or forty miles an hour—not an unusual thing in Nebraska—the damage would have been enormous. As it was, the injuries were confined almost entirely to exposed hardwoods and to those hardwood species which have naturally weak, soft wood or those in which the wood had been weakened by disease or insects.

# SAMPLE PLOTS FOR FOREST STUDIES.

C. G. Bates.

There is probably nothing so much needed at the present stage of American forestry as very careful investigations of the problems of silviculture. The principal ideas of forestry have been furnished us gratuitously from European experience, although, of course, there is still room for invention. But it is in the application of these ideas to local conditions, that we are certain to run aground, and it is only by continued experiment that we may hope to work out a silvicultural code applicable to the forest tree species with which we have to deal.

It is in the hope of aiding experimenters that I wish to suggest a system of sample plot methods, applicable, I believe, to almost any form of forest study. While originality in investigation work is highly desirable, I feel that the scheme hereinafter outlined, if followed generally, will furnish results in every case easily interpreted, and, consequently, of greatest value to the person unfamiliar with the local conditions of the experiment. It leaves very little to the imagination of the student, and still less to the vague and indefinite style of descriptive dissertations which have formed the basis of many of our conclusions with regard to forest problems.

The methods described in this paper are by no means new. They are for the most part well known to ecologists and to botanists whose researches have much less immediate importance than those of the forester. For fear that the inexperienced person may think of ecology as something vague and impracticable, I wish to demonstrate the usefulness of these methods in the every-day work of forestry.

The person who wishes to obtain convincing results in forest investigations, must, so far as possible, eliminate from the experiment every factor except the one which he wishes to bring into prominence. Explanations of the effect of this factor or that factor, upon the results obtained, are never quite satisfactory.

Take for example, an experiment to determine the relative value of several species for planting in a given situation. We must in such a case eliminate every difference in quality of stock, age, nursery treatment, etc., and be certain that the factors of the situation, such as slope, soil, soil moisture, and the general quality of the situations in which the several species are planted, are the same. Otherwise, no definite conclusions can be drawn from the results of the experiment.

### LOCATION OF PLOTS.

Sample plots in order to be of value for forest studies in any particular region or on any single Forest must be on areas which represent typical conditions, or still better, there may be duplicate plots in situations which represent extreme conditions. If we wish to obtain a contrast of the behaviors of different species, we must eliminate differences in physical factors, that is to say, the various species must be treated under the same physical conditions. On the other hand, if we wish to obtain a knowledge of the effects of different situations upon trees, it will be best to use a single species, in the same number, on the several situations. Exceptions to this rule may, of course, occur where the investigator proceeds with a fair assumption that one method or another, or one species or another, is not applicable to the particular case. However, in any such case, the experiment will have added value if the negative is as carefully proven as the positive.

### PLOTTING SYSTEM.

The basis of any series of sample plot for forest studies should be the Block, which is made up of several Plots, in each of which a species or a method is to be tried out. The size of the Block and the number of Plots which it contains is determ ined by the number of points which must be proven, and is necessarily limited by the area upon which uniform physical conditions may be obtained. When comparisons of methods, species, etc., are desired, all the Plots must be on the same kind of ground. If slopes are chosen it must be borne in mind that the result will be applicable only to the same slopes. If level ground is chosen, the results may be made to some extent generally applicable by inductive methods. For such studies the Plots should be square and of equal size. In comparing the behavior of a tree in various situations, the Block may have the form of a strip composed of a single row of Plots, which may be either square or rectangular. The most convincing results are are to be obtained by extending this strip continuously over the entire range of situations, and measuring the results in all parts of the strip. (See Plate 9.) Each Plot in the strip will thereby represent a particular situation.

The Plots may be square and contiguous, and thereby utilize all the space, and furnish results for every slope and degree of slope, or, to reduce the work, they may be made non-contiguous and located on typical portions of the slopes, bottoms, or ridges, and give only typical results, which may be filled out by induction; or lastly, they may be rectangular, their length being approximately equal to the length of the slope which they characterize, or the width of the ridge or bottom of which they form a transverse section. As the length of such Plots in mountainous regions may be very great, the width may be only a small part of the length, or the Plots become too cumbersome.

In Plots of any size or shape the decimal system should be followed throughout. The square Plot should always be of such a size that it may be readily divided into 100 equal sections. The rectangular Plot should be of such form that it will comprise an even number (preferably a multiple of 10), of square sections. Such a method will greatly facilitate the worl of temporarily determining the sectional subdivisions for the purpose of an examination. Such subdivisions have no particuular value in themselves, but simply make possible greater accuracy within the Plot.

## METHODS OF SUBDIVISION.

The square Plot should consist of 100 equal subdivisions, called "Sections". In the Plot, which is, for example, 200 x 200 feet, the subdivisions are obtained by marking the 10 equal divisions on both the east and west boundaries with more or less permanent stakes. Beginning at the north side of the Plot a strip 20 feet wide is laid off by stretching two 200-foot tapes between the corresponding stakes on the opposite sides. The subdivisions of this strip, each a section 20 feet square, are then found by laying straight poles between the corresponding points on the parallel tapes. If frequent examinations are to be made, the corners of the sections should be marked at the outset by means of stakes. If examinations are to be made at long intervals, such marking will be only a waste of time, since in a carefully measured Plot the Sections may be at any time accurately located by the method of tapes. This leads me to the subject of very careful surveys in the original laying out of Plots. The transit is absolutely essential to accuracy in such work, since even an error of three or four inches in a Plot 200 feet square may lead to important variances in the laying out of Sections and the tabulating of results. In such a study, for example, as one which involves the counting of lodgepole pine seedlings, results may be badly confused by shifting a Section three or four inches in one direction or another, and thus including seedlings which belong in another section.

In the square Plot the Sections are numbered serially, beginning at the northeast corner, running west in the first row, from west to east in the second row, etc., thus bringing Section 100 in the southeast corner. This is the system of numbering Sections in the ordinary land surveys, and is particularly applicable in sample Plot work, because in working through the Plot it obviates the necessity of traveling back and forth over the same ground. In the rectangular Plot the single row of Sections should be numbered from east to west or from north to south according to the direction of the strip. Similarly in the Block the numbering of the Plots is begun at the northeast corner, but these numbers may not be continuous, since after the establishment of two or more Blocks, new Plots may be added to any of these. In mentioning a Plot, the Block letter should always be given, thus "A 2" or "B17".

### MARKING PLOTS.

The marking of sample Plots, especially if their conditions are to be followed for a long period, is a most important feature, and permanent as well as conspicuous marking is needed. In a region where stones are available, but not so abundant as to cause confusion, a fairly regular stone should be used at the corner of each Plot and the necessary marks made upon it with some durable paint. In a distinctly rocky country, posts of a durable wood, well-seasoned before setting, should be used, since they will be more conspicuous than a rock. Each corner of a Plot should be marked with a post squared to a size of not less than three inches and projecting two or three feet above the ground. The body of the post should be painted white. A cap or band of black on the top adds to its conspicuity. The post should be so set that each face of it is towards the center of the Plot or Plots which it marks. In case the post is in the middle of a Block the Plot numbers should be marked on each face. One post, in the most conspicuous position available, should be marked as follows: On the side opposite the Plots, for example, "Cheyenne—SS Plots"; on the opposite side "Plot 7"; on one of the other sides "Block A". The fourth side should show the location of this post with respect to the Block as a whole, for example, "NE Corner", so that this will serve as a guide to the entire Block. All such markings should be in black, in contrast to the red paint used in the location of all measurements within the Plot.

Within the Plot the points on large trees where caliper measurements are taken, should be marked with red paint, as also the number of the tree, in case the trees are numbered serially. The use of brass-headed tacks for such marking has not been sufficiently investigated to determine the value of such a practice. The single argument against the use of paint is its non-durability, and this difficulty can only be overcome by repainting possibly every five years. Such an operation can usually be done most conveniently at the time of the re-examination and remeasurement of the trees. Points at which soil samples are taken, points at which light, evaporation, or any other physical factors are measured, should be marked by small white stakes with red letters and a red cap to add to the conspicuity. The size of the stakes will, of course, depend upon the quality of the ground, and the difficulty of finding them.

## MEASUREMENTS OF PHYSICAL FACTORS AND THEIR NOTATION.

As already stated, for most forest studies comparisons should only be made between Plots which represent the same physical conditions, and in selecting such Plots it is not sufficient to make an ocular estimate of the physical factors. The conditions of soil are particularly deceiving, since radical differences may occur in a very short distance. We must demonstrate the similarity of the Plots by taking soil samples and determining their moisture content, which is always to be expressed as a percentage of the dry weight of the soil. Surface, as well as deeper samples should be taken. Samples about four inches deep, and weighing from 30 to 60 grams, are most satisfactory. The depth of the soil sample is expressed by the distance to the lower extremity. Thus a sample representing the first four inches of soil is called a "four-inch" sample, while a 12-inch sample represents conditions between points 8 and 12 inches below the surface. In a Plot of less than one acre area about five soil sample points should suffice to prove the quality of the soil as regards moisture. The five samples are taken at the inside corner of the second section from each corner of the Plot, and at the center of the Plot. Thus in a 200 foot Plot, soil sample point one would be 40 feet south and 40 feet west of the northeast corner of the Plot, point two south and east of the northwest corner, point three in the center, point four north and east of the southwest corner, and point five north and west of the southeast corner. Should further soil samples be required for a moisture survey of any Plot the numbers should be in the same order as the numbers of the Sections in which they are taken. Forms have been prepared for use in soil-sampling, which provide space for the number of the Plot, the number of the point at which samples are taken and the depth to which they are taken, as well as the number of the soil-can used, wet weight, dry weight, difference and percentage of moisture. The points where soil-samples are taken are to be marked with white stakes with red lettering. The designation "S 1", "S 2", etc., should be given each stake, according to its location. When several sets of soil samples are to be taken in a given Plot, at certain intervals, all samples should be taken, at any one examination, on the same sides of the stakes. The holes which result should be filled in and the next samples should be taken on a different side of the stake, several inches from the first point.

Soil samples for chemical analysis will seldom be needed, but when taken, should be composite samples taken from all parts of the Plot and aggregating a volume of about one quart.

Such samples should never be dried in an oven, but in the sun, and should be analyzed as soon as possible after taking, since chemical changes are likely to occur in them when bottled.

The amount of direct sunlight in the forest, which usually has an important influence on reproduction, may be estimated with a fair degree of occuracy and is usually expressed as a complement in the scale of ten. Thus a "density" of "9", means that about .1 or 10 per cent of normal sunlight reaches the ground. For more careful studies the use of the photometer (light-measurer) is advocated. The simplest instrument of this sort measures only the direct light which is expressed as a percentage of the full sunlight for the hour. In sample plot work the average amount of light in the Plot may be obtained by two methods. First, by measuring the light at a single point for all hours of the day; secondly, by measuring the light in all parts of the Plot, for a single, typical hour. In the latter scheme the amount of light will be obtained by exposing the photometer while the carrier is in motion between two points. This will give the average amount of light in a certain strip. Five parallel strips through the Plot should give a fair average. They should be located as follows: (1) Between Sections 1 and 10; (2) Between Sections 21 and 30; (3) Between Sections 41 and 50; (4) Between Sections 61 and 70; (5) Between Sections 81 and 90. At the ends of each strip stakes should be set marked "L 1", "L 2", etc. When stationary exposures are made, a single stake marks the exact point. In duplicating light measurements, to demonstrate, let us say, the progress of crown development, the same season and hour should be chosen, as in the first measurement.

The soil temperature may to a certain extent be taken as as an index of the effect of insolation on a given slope or part thereof. Radiation from the surface soil is very rapid, but at a depth of a foot or more the variations in temperature at different times of the day are not more than 1 or 2 degrees. The insolation of the surface soil is largely controlled by the cover, as well as by the slope and aspect. In the Nebraska sandhills temperatures of 140 degrees Fahrenheit have been noted on south slopes, while at the same time less exposed slopes were 30 degrees to 40 degrees cooler. This was found to be a very important factor in the fatality among seedlings. Soil temperatures should be frequently measured in sample plots, especially when the behavior of trees on different situations is to be studied. Whenever possible, such measurements should be taken at the center of each Plot, and the points marked with a stake, and the letters "ST". The depths at which soil temperatures are taken must, of course, appear in the notes.

Other factors which it may be necessary to measure, in order to thoroughly comprehend differences in situations are, with the symbols which should appear on stakes,—air temperatures "T"; maximum air temperatures "Max T"; minimum air temperatures "Min T"; wind movement "W"; and atmospheric humidity "H". Most of these will be measured at the center of the Plot and one stake will suffice for all.

APPLICATION OF THE SYSTEM.

The applicability of these methods to forest studies may best be seen by the following examples:

Example (1)—Planting Experiment.

Experimenting in planting in the sandhills of Nebraska, we wish to determine the relative advantages of the various situations for planting yellow pine; we wish to contrast especially north slope, south slope, bottom and ridge conditions which are, in this locality, regularly repeated at short intervals; at the same time we wish to determine the relative vitalities of yellow pine, jack pine, and Scotch pine when planted under the most adverse and most favorable conditions; it is, therefore, necessary to have a strip extending across aridge, to the south slope, bottom, and north slope, and to divide this strip into Plots, in each of which results will be obtained which are typical of certain exposures. Let us say that two adjacent ridges with other situations occurring between them are 400 feet apart, it will, therefore, be necessary to have a strip of sample Plots 400 feet long, and this may best be divided into ten Plots, each 40 feet square. In each Plot 100 trees will be planted by the same methods and with the same kind and quality of stock. The number of trees in each Plot which survive from the shock of transplanting and the climatic difficulties of the first year or two, will serve as an index of the qualities of the several localities. Thus on the south slope we may have 72 per cent living at the end of the first year, in the bottom 50 per cent, on the north slope 100 per cent, and on the ridge 95 per cent. These percentages when plotted form a curve which follows more or less closely the changes in topography.

In order to demonstrate our second point, namely, the properties of yellow pine, jack pine, and Scotch pine, we have simply to add two plots on both north slope and south slope, which represent the opposite extremes of situation (See Plate 9). Scotch pine and jack pine respectively will be planted on either side of the Plot in the main strip which contains the yellow pine. We are thus assured of the three species being affected in the same way by physical factors. The accompanying sketch with its crude topographic features will show this a little more clearly.

To fully explain the results of the first experiment, we must make sufficient measurements of physical factors to determine in what respects the conditions vary in the different situations. We know that the moisture conditions will differ, but the relations between the Plots may vary between spring and late summer. We know also that the various situations receive different amounts of sunshine. It is not in the hope of expressing these differences quantitatively but simply to make comparisons that we would take soil samples in each Plot, measure soil temperatures, wind velocities, and other factors which might affect the tender seedlings. In this study, the results of each examination of a Plot are tabulated on a map sheet (see Plate10) which is simply a square, with 100 subdivisions. In each subdivision an initial letter is placed showing the condition of the tree which has been planted in that position. By this method, the status of the Plot at any time is shown graphically and an individual record is kept of the behavior of each tree.

Example (2)—Reproduction Study.

In a cutting operation where it is desired to obtain reproduction by natural means, the distribution of seed trees is probably the most important silvicultural consideration. It is not only necessary to distribute these so that the entire area will be seeded, but also so that the seed trees will not be thrown before they have accomplished their work and before a possible second cutting will make them merchantable. In such a study as this, without any previous knowledge, we must simply experiment on a small scale with the different methods of distributing the seed trees. For this purpose Plots not less than an acre nor more than 10 acres should be used. In case of the use of a strip system of cutting, reproduction studies need not cover the entire strip, but simply a typical section of the strip in the form of a square. Immediately after the cutting, existing reproduction, if not too numerous, should be located in each Plot by the system of Sections previously described. In order that this reproduction may not be confused with later growth, the existing seedlings should be marked either by means of a small florist stake set at the base of each tree or by means of a small spot of paint on the stem of the tree near the base. Such stakes wherever used in forest studies should be about 6 inches long and one-half inch wide, and before using they should be completely dipped in white paint and dried. The paint will add to their conspicuity, durability, and to their usefulness, in case it is desired to place marks upon them. Should reproduction be present in large numbers in the Plots at the outset, such a study as here described is, of course, unnecessary, but simply for the purpose of an experiment, the results of which will be applicable to large areas, existing reproduction may be entirely removed.

Supposing that we are beginning with only seed trees upon the area, the first examination will involve only the definite location of these trees by the sectional system. Having the boundaries of a Section temporarily marked, it is very easy to locate the trees within it simply by ocular estimate of the distance from each corner of the Section. Such a system will not apply where the size of the Section exceeds 50 feet, and in case larger Plots are used further subdivision will be necessary. However, for large areas having only a few trees upon them, the most accurate results will be obtained by setting up the transit at the corners of the Plots, obtaining bearings on each tree from at least two points, or bearing and distance from one point. At the time of the first examination, it is always desirable to obtain a knowledge of the soil conditions throughout the several Plots, since if any radical difference exist, the Plots cannot be considered comparable, and a new location must be chosen, or the differences must be followed through all seasons and climatic changes in order to explain differences in reproduction. The possible effect of factors other than soil moisture may usually be seen at a glance, and supposing that these have been given equal weight in choosing the several Plots, they need not be measured at the outset. For instance, dealing with a fairly even slope, it may be supposed that insolation and radiation, wind exposure, etc., will be the same throughout.

Since the period required for reproduction as well as amount obtained, is an important factor in forest management, the first examination of the Plots to determine the relative value of the several methods of seed tree distribution, should be made as soon as there is any possibility of the appearance of reproduction, and the examinations should be repeated with sufficient frequency to determine the progress of reproduction under each system. In order that we may have a clear understanding of the reason for failure in any particular case, we must know not only how many trees survive for several years but also how many germinate and fail for one reason or another. To determine this frequent counts must be made during the first season, after a good seed year, and such factors as may be involved in the death of seedlings must be measured. It is not sufficient to count the seedlings (by the sectional method) at the beginning and end of the season, since late germinating seedlings may replace those which germinated early and perished. At the time of each counting, if not in the entire Plot at least in typical Sections of the Plot, existing seedlings should be marked with florists stakes, and the date of their first appearance noted on the stake. The results of each count should be tabulated on the Silvical map sheet, stating the number of seedlings found in each Section, or in the case of a second or later examination, the number of old, new, and dead seedlings.

Example (3)—Experiment with Cutting System:

A cutting system applicable to a given species must be determined not only by the success of the reproduction obtained but by the increased diameter growth and volume increment in the trees left on the ground. In a forest study of this phase of silviculture, it is absolutely essential that sample Plots should be on ground of uniform soil quality and soil moisture. The stand must be carefully measured before any cutting is done. The diameter of trees should be taken in two directions and each tree placed in a height class. Sample trees should then be taken for each height class, in order to determine the volume of the entire stand. This work must, of course, be preceded by numbering and locating exactly each tree in the Plot. The marking of trees to be cut must not, of course, be done on a theoretical basis,but should follow the lines practiced in timber sales or at least follow such lines as will be applicable when the results of the experiment are fully determined. There is, of course, not only the purpose of obtaining a uniform distribution of the stand in the case of selection cutting, but also the removal of defective and dying trees, even though their presence in the stand is desired. Overmature trees are sometimes more useful for seeding purposes than for their timber. During cutting operations the timber workers should be closely followed and the exact product of each tree cut should be determined at the mill in the case of trees cut for lumber, or on the ground in the case of trees cut for ties, props, etc. As far as possible, these measurements should be preceded by exact volume and taper measurements of typical trees of each height class.

After the cutting operations have been completed, all remaining trees should be described and if they represent extremes of quality as regards suppression, the reasons for leaving them should be noted. It will then be extremely simple to interpret the maps, which show the location of the trees in the original stand, as well as the condition of the stand upon the completion of the experiment.

A remeasurement of the trees at the end of a five or ten year period and at similar intervals thereafter, and the measurement of sample trees of each class for volume and taper should furnish a growth history of each tree. Such definite results can not be obtained by diffuse measurements in the forest where the tree is recognized in later examinations only by its relative size.

The operations which characterize each Plot should be extended somewhat beyond the boundaries of the Plot. In other words, each Plot should simply be a sample of the larger area treated. Otherwise, the figures obtained near the edges of the Plot will have no value.

### CONCLUSION.

The *code described* above is recommended solely for the sake of obtaining definite results in forest studies of such uniform character that any student may easily interpret them. The results of any study may be shown most clearly and convincingly by graphic methods. But graphic illustrations mean that one must have definite quantities, with definite locations, and these cannot be obtained by ill defined methods of study. If we have, in the forest, performed certain systematic operations, it is quite simple to express these on paper, in such a way that they are at once understood, without recourse to volumes of text.

## WASTE IN LOGGING AND MILLING IN COLORADO

A. T. Upson.

The locality in which this study was made lies slightly west of the central part of Colorado in the Sopris National Forest. The topography is very rough and rugged, consisting of alternating ridges and valleys which range from 6,000 to 12,000 feet in elevation. Low rocky ledges and broad shallow basins often occur. The slopes of these flat ridges or narrow plateaus are sometimes precipitous rocky walls, and sometimes long and gentle.

The soil on these ridges and plateaus is a shallow, moist, light-brown, sandy or gravelly loam. In steep places, formations of yellowish or reddish sandstone are often covered with only a thin layer of soil while others are entirely exposed. In the valleys, the soil is much better and consists of a deep, moist, rich, sandy loam.

The tree species of commercial importance in this region are conifers. Lodgepole pine is found extending from the valleys to timber line, especially on the steeper slopes, and constitutes about 80 per cent of the stand. Engelmann spruce is found in the valleys, on the more gentle slopes and on the plateaus, where it often marks the true timber line. It constitutes about 10 per cent of the stand. Balsam fir is found beneath or mixed with pine and spruce and forms 7 per cent of the stand. Douglas fir and blue spruce are found in mixture with the other species and form 2 per cent of the stand. However, a blue spruce log is never seen at the mill and a Douglas fir log only occasionally.

The forest is managed under a modified selection system of cutting to a diameter limit. Lodgepole pine is cut to a minimum diameter limit of eleven inches breast high, Engelmann spruce to thirteen inches and balsam fir to eight inches. This prevents cutting more than one-half of the commercial stand. On account of this fact and also on account of the topography of the region, lumbering is confined to small portable mills. The best timbered areas have been logged and only the poorer stands remain.

The camp and mill in which this study was made were located at an altitude of about 10,000 feet. The surrounding timber ranged from 5,000 to 20,000 board feet per acre, with an average of about 8,000 feet. The mill used was a small portable one which sawed on an average about 7,000 board feet per day of ten hours. An old-fashioned circular saw was used which cut a kerf of one-fourth inch. The mill was working on about 100,000 board feet of logs which had been cut in February, 1909, and which had lain in the woods until the following July, when this study was made.

The waste in logging and milling was determined by a series of field and mill studies. The stump height was considered as being equal to the breast-high diameter of the tree. This would cause a slight error if cubical contents were being accurately determined, but was considered satisfactory for the present investigation since the method is much faster and the error is very slight. In obtaining the entire volume of the tree the volume of the stump was not considered.

Merchantable log length was considered to extend to a point in the top where the log measured six inches. Cordwood material consisted of that remaining portion of the main stem and all branchwood which had a diameter of more than three inches. At the mill measurements were taken of the actual sawed product—lumber, sawdust and slabs from logs of various diameters and lengths. From this data, tables of volume and per cent of loss were obtained.

The merchantable length of the tree was first measured to a top diameter of six inches and rounded to two foot classes. A fifty foot tape graduated to tenths of feet was used. The diameter of the tree, breast-high inside bark was found by calipering twice at right angles outside bark and then deducting the thickness of the bark. These D. B. H. measurements were made to tenths of inches and rounded into inch classes. The average merchantable length of each diameter class was then determined. Whenever an abnormal swelling occurred at breast-height, measurements were taken just above and just below the abnormality and the average recorded. The form used in recording these measurements is shown below:

Table No. 1—Log Table.

| D. B. H. in inches | Length of Merchantable Portion of Log in Feet. | | | | | |
|---|---|---|---|---|---|---|
| | 24 | 26 | 28 | 30 | 32 | etc. |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |
| etc. | | | | | | |

After the average merchantable length of each diameter class had been found, the number of pieces and length and diameter of each piece of cordwood was determined. From these figures the total amount of cordwood was calculated. The form of the table used in recording these measurements was as follows:

Table No. 2—Cordwood Table.

| Ave. Diam. in inches | Length of Piece in Feet. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | etc. |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| etc. | | | | | | | | | |

The diameter of the merchantable log was determined by averaging the top diameter with the diameter breast-high which was considered to be equal to the basal diameter. The cubical contents were then determined by the formula for a cylinder. Other formulas were tried, such as Smalian's, but did not check up with the sawed product and so were thrown out.

The sum of the volume of cordwood in cubic feet and the volume of merchantable log length in cubic feet was considered the merchantable volume of the tree. From this total volume the per cent of cordwood for each diameter class was determined by dividing the volume of cordwood by the total merchantable volume. In order to accurately determine the board feet in logs of various sizes each log was marked and the amount of lumber was determined as it came from the saw. From this preliminary study it was found that the squared piece which might be sawed from any given log could be accurately foretold by using the Two-Thirds Log Rule. However, this did not allow for the amount of sawdust wasted in sawing the squared piece into lumber. To determine this sawdust waste the following formula was used:

$$V = \frac{\frac{\frac{2}{3}(D + d)}{2} \times S \times N \times L}{12 \times 12}$$

in which

V = volume of sawdust in cubic feet
D = large diameter in inches
d = small diameter in inches
S = Sawkerf, ¼ inch.
L = average length in feet for that diameter class.
N = number of times sawed which was determined for each diameter class.

Since there has been a good permanent market for two inch plank it was the custom to saw as many planks as possible from each squared piece, but when there was an odd width it was necessary to saw a varying amount of one inch boards. The following table will show the average number of times that each squared timber was sawed through. In the 13 inch log class and larger log classes it was the custom to saw as many inch boards as possible from the material outside any squared timber that otherwise might be wasted in slabs. This table also allows for all such extra cuts.

Table No. 3.

| D.B.H. | Number Times Sawed |
|---|---|
| 8 | 2 |
| 9 | 2 |
| 10 | 3 |
| 11 | 3 |
| 12 | 3 |
| 13 | 4 |
| 14 | 4 |
| 15 | 4 |
| 16 | 5 |
| 17 | 5 |
| 18 | 5 |
| 19 | 6 |
| 20 | 6 |

Up to the 13 inch diameter class all waste from kerf was determined from the squared lumber which could be sawed from such a log. In and above the 13 inch class, edging boards were cut and so it became necessary to allow for such an increased cut. The extra sawdust lost in cutting the edging boards should be determined by allowing one-fourth the volume of all lumber cut outside the squared timber. It was assumed that from a log having the diameter D, the face of the slab would have a breadth of ½ D and so the total amount of edging boards could be computed from the following formula:

$$V = \frac{\frac{\frac{1}{2}\,(D + d) \times N}{2}}{12 \times 12}$$

D = large diameter of log in inches.
d = small diameter of log in inches.
V = volume of boards in cubic feet.
N = number of inch edging boards determined by mill studies

The following table shows the number of inch boards which may be sawed from the slabs of logs of each diameter class:

Table No. 4.

| D.B.H. of Tree | Number of Inch Boards from Slabs | D.B.H. of Tree | Number of Inch Boards from Slabs |
|---|---|---|---|
| 8 | None | 15 | 1 |
| 9 | " | 16 | 2 |
| 10 | " | 17 | 2 |
| 11 | " | 18 | 2 |
| 12 | " | 19 | 3 |
| 13 | 1 | 20 | 3 |
| 14 | 1 | | |

To determine the amount of sawdust lost in cutting slabs from logs below the 13 inch class the following formula was used:

$$V = \frac{\frac{\frac{2}{3}\,(D + d)\ L \times S \times N}{2}}{12 \times 12} = \frac{\frac{\frac{2}{3}\,(D + d)\ L}{2}}{144}$$

in which
D = diameter of log in inches at large end.
d = diameter of log in inches at small end.

L = length of log.
S = width of saw kerf, ¼ inch.
N = number of slabs which is 4.

The reduced formula shows that each log below the 13 inch class loses an amount of sawdust equal to a board one inch thick having the breadth and length of the slab. The method of determining the amount of sawdust lost in sawing the squared timber and in sawing edging boards in and above the 13 inch diameter class has been previously described.

The per cent of waste of sawdust was obtained by dividing the amount in cubic feet by the total merchantable content of the tree, as shown in the final table. If the per cent is wanted for merchantable log length it can easily be determined by using merchantable log material in place of the total merchantable content.

The volume of slabs for logs under the 13 inch class was determined by taking the volume of the round log and subtracting the volume of the squared timber and then subtracting the volume of sawdust lost in removing the four slabs. In and above the 13 inch class the lumber and sawdust made in cutting edging boards should also be subtracted from the volume of the logs. The total amount of slabs was divided by the total merchantable volume of the tree to determine the per cent of slab waste.

Table No. 5.

| D. B. H. In Inches | Total Volume of Tree to 3-inch Diam. in Cu. Ft. | Merchantable Portion to Three-Inch Top | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Cordwood | | Lumber | | Slab | | Sawdust | |
| | | Cubic Feet | Per Cent | Cubic Feet | Per Cent | Cubic Feet | Per Cent | Cubic Feet | Per Cent |
| 8 | 7.06 | 0.65 | 9.2 | 3.22 | 45.6 | 2.05 | 29.0 | 1.14 | 16.2 |
| 9 | 8.75 | 0.78 | 8.9 | 4.05 | 46.2 | 2.57 | 29.4 | 1.35 | 15.5 |
| 10 | 10.62 | 0.85 | 8.0 | 4.80 | 45.2 | 3.27 | 30.8 | 1.70 | 16.0 |
| 11 | 12.71 | 0.85 | 6.6 | 5.82 | 45.8 | 3.98 | 31.3 | 2.06 | 16.1 |
| 12 | 15.94 | 0.92 | 5.7 | 7.44 | 46.7 | 5.11 | 32.1 | 2.47 | 15.5 |
| 13 | 17.65 | 0.92 | 5.2 | 9.10 | 51.6 | 4.65 | 26.3 | 2.98 | 16.9 |
| 14 | 20.69 | 1.05 | 5.0 | 10.70 | 51.7 | 5.64 | 27.3 | 3.30 | 16.0 |
| 15 | 25.15 | 1.10 | 4.3 | 13.14 | 52.2 | 7.03 | 28.0 | 3.88 | 15.5 |
| 16 | 27.50 | 1.10 | 4.0 | 15.43 | 56.1 | 6.41 | 23.3 | 4.56 | 16.6 |
| 17 | 32.94 | 1.20 | 3.7 | 18.73 | 56.8 | 7.72 | 23.4 | 5.29 | 16.1 |
| 18 | 37.43 | 1.30 | 3.5 | 21.13 | 56.4 | 9.25 | 24.7 | 5.75 | 15.4 |
| 19 | 44.01 | 1.40 | 3.2 | 26.16 | 59.5 | 9.26 | 21.0 | 7.19 | 16.3 |
| 20 | 53.12 | 1.50 | 2.8 | 31.71 | 59.7 | 11.46 | 21.6 | 8.45 | 15.9 |

There is a slight inaccuracy in the lumber figures in the 8 and 9 inch classes. This is probably due to the small number of trees measured in these two classes.

The combined volume of the slabs and sawdust as given in the above table is very accurate. However, considering the two separately there is a very slight inaccuracy in apportionment due to the fact that the sawdust lost in cutting the wane edges from such boards as come from slabs was not calculated. Theoretically this should be considered and the volume of sawdust lost should be deducted from the amount of slabs.

A factor to be considered in using the table is the amount of slab used for different purposes. Slabs are often cut into 4-foot lengths to serve as mine lagging. However, only the largest and best slabs can be utilized for this purpose. The demand for mine lagging at this particular mill was not great, so the amount sawed was limited. Another use for slabs was fuel. Only the driest and best seasoned slabs could be used. This would exclude all slabs from logs of balsam fir as the wood of this species was very wet and soggy.

Below is given a table showing per cent of slabs used for mine lagging and fuel for each diameter class:

Table No. 6.

| D.B.H. in Inches | Per Cent of Slabs Used for | |
|---|---|---|
| | Mine Lagg'g | Fuel |
| 8 | .... | .... |
| 9 | .... | .... |
| 10 | .... | .... |
| 11 | .... | .... |
| 12 | 1.00 | 1.00 |
| 13 | 1.50 | 1.25 |
| 14 | 2.50 | 1.75 |
| 15 | 3.00 | 2.00 |
| 16 | 4.00 | 2.00 |
| 17 | 4.00 | 1.75 |
| 18 | 4.50 | 1.50 |
| 19 | 4.75 | 1.50 |
| 20 | 5.00 | 1.00 |

In Table No. 5 each species is closely confined to certain diameter classes. Balsam fir comprised nearly all the material in 8, 9, 10 and 11 inch classes. Lodgepole pine and balsam fir furnished most of the logs in the 12, 13 and 14 inch classes, with the lodgepole greatly predominating. Lodgepole pine and Engelmann spruce or white spruce, as it is called in this region, made up the 16, 17, 18, 19 and 20 inch classes with a much larger per cent of spruce logs in the larger classes. However, occasionally balsam fir and Douglas fir were found in these larger classes.

MISCELLANEOUS FACTORS.

There are a large number of factors which affect the volume and worth of finished product in any forest region. Some of these conditions which are important on the Sopris National Forest are as follows: Cordwood is never used commercially in this region and so could be disregarded altogether, in which case there would be a large increase in the per cent of waste shown in Table No. 5. However, if ideal intensive forest conditions existed now in this region, as will of necessity exist some day, cordwood should not be disregarded and so it was taken into account in this study. However, stumps and branchwood smaller than three inches were disregarded. The volume of the lumber in cubic feet which may be sawed from trees of any special diameter class, as given in table No. 5, may be relied upon as being approximately correct. As has been stated before, these studies were made at the mill while it was in operation. They were also compared to reliable formulas which furnishes a good check on the results obtained.

However, there are other factors which affect the amount of lumber that may be sawed from a log in any milling operation in this region. The thickness of the saw is a very important factor. As a rule, a rotary saw is thicker than a band saw, the former causing a greater waste in sawdust than the latter. If a band saw could have been used in this operation the volume of finished product would have been materially increased. The second factor is the width of the smallest board which may be used. The narrower the board that can be utilized, the greater will be the total finished product of a specified log. In this region, the narrowest board was 4 inches; therefore, the amount of lumber sawed was larger than if the narrowest board had been 6 inches. Another factor is the thickness of the boards. A log sawed into 2 inch plank will yield a greater cut in board feet than if it is sawed into inch boards, because there are fewer cuts and hence less waste in sawdust. At this sawmill as many two inch plank were cut as was possible and this caused the waste to be less than it would have been had inch boards been sawed as is customary in some Rocky Mountain mills. Great skill is required to cut timber in such a way as not to waste material other than that absolutely necessary in slab and saw-kerf. The sawyer must decide almost instantly how a given log should be sawed and this demands a clear head and great experience. At this mill the sawyer was well trained in his art.

The efficiency of the machinery directly affects the per cent of waste. A saw which is poorly set and filed will waste more material in sawing than one that is properly handled. Cheap machinery often produces boards thicker at one end than at the other. This means the total product from a given lot of logs will be less than could be obtained with better machinery. This factor is quite important in the small mills of the Rockies, since the machinery used is not of the highest class. The amount of log taper also becomes a factor in the lumber output of a mill. Logs having considerable taper will over-run the log scale more than those with little or no taper since some short boards may be cut from the wider portion of the logs. Shrinkage and checking are also important since the lumber is affected by these factors. These items are of considerable importance in the various Colorado species which are sold for commercial purposes. There are several other natural factors which cause a large amount of waste in this region that are not shown in Table No. 5, and which should be considered briefly.

1. A fungus, *Fomes pinicola,* occurs on Englemann spruce. This is a dry rot which affects the heartwood and causes it to become red. Spruce is attacked to a greater extent at and near timber line than at lower elevations. Affected logs which are brought to the mill are generally sawed up and used for fuel. When the saw strikes a log infected with this disease the wood crumbles and a dry dust is formed in large quantities.

Loss due to this rot runs as high as 10 per cent of the logs brought to the mill with an average of about 7 per cent.

2. Lodgepole is infected by a parasite, (*Razoumofskya americana,*) commonly known as false mistletoe. Its attack is not very injurious commercially as only the bark and the outer sapwood are infected and the infected portion is confined to the slab waste. The infection for this region is more widespread in pines on site class III than on site class I.

3. Another natural defect is shake. This occurs in the form of heart shake or cup shake in Englemann spruce and balsam fir in open stands and on exposed sites. Two per cent of all material brought to the mill should cover this loss.

4. In open stands there is more limbwood and consequently a greater per cent of cordwood and a smaller per cent of lumber. This loss is especially marked in spruce even in the densest stands since the Englemann spruce is tolerant and persistent in retaining its lower limbs even in old age. It is well known that spruce exhibits this same low limbed development during early growth. The presence of a large amount of limbwood means a greater number of knots, greater loss in lumber and a cheaper grade of lumber. Greater butt swell also occurs in open stands but this does not materially affect the figures in the table since butt swell has been disregarded in board feet. No estimate was made on this factor but an estimate should be made if one is dealing with open stands and with cubical measure.

5. The losses due to careless felling are greatest in balsam fir and Englemann spruce as these species often show great brittleness. The loss rarely goes over one per cent because, when it does occur, only a part of the log timber is impaired.

6. Ten per cent of all sawed lumber is broken more or less in handling. Much of this is due to inferior species. Balsam fir furnishes the poorest lumber. It is heavy, coarse-grained, sappy wood, and checks badly in seasoning. Englemann spruce lumber also splits easily in handling. Yarding is very poorly done and is the cause for a large proportion of this loss.

## CONCLUSION.

Large portions of the Rocky Mountain stands are of comparatively inferior class and will furnish lumber of poor grades only. There has been much needless waste in the past because of poor methods, poor machinery and careless work. There is a good field for improving the present methods and especially in developing a local market which will in the near future need every class of lumber that may be produced.

# NEBRASKA FOREST FUNGI I.

Raymond J. Pool.

## INTRODUCTION.

The rapid progress of plant pathology in the last twenty-five years followed by the special development of particular phases of the subject has been one of the most noteworthy facts in the history of botany. Indeed, the rise of this important subject may be considered one of the most prominent advances in the science of botany during the last quarter of a century. This is especially true when we consider the late researches on parasitic fungi and on the bacterial diseases of plants. The progress of this phase of botany has been so phenomenal that already it has become necessary to subdivide pathology into various provinces each with its corps of trained investigators. Certain specialists spend their whole time in the study of the diseases of field and forage plants, of garden crops, of orchards and vineyards, of greenhouse and ornamental plants, and of forest and shade trees. The subdivisions have been made even more numerous and specialized than here indicated.

The study of forest pathology, that is the study of those factors operative in the production of disease in forest trees, and of methods of treatment, eradication and prevention of the disease, is one of the most important phases of plant pathology. This fact has lately been recognized by the United States government and a special corps of investigators has been appointed in the U. S. Department of Agriculture for the organization and study of this particular espect of the problem on a national scope.

There are a number of more or less permanent abnormalities of function and structure developed in plants which cannot be traced to any casual organism. Yet it can be truthfully said that the study of plant pathology has, in the main, centered about diseases caused by fungi. Every forester could render much valuable service in the study of forest fungi and the diseases caused by such organisms, if he were a well trained plant pathologist. However, it is impossible in most cases for him to take sufficient time from the study of the other important and essential technical branches which are to fit him for service in forestry to master the methods of plant pathology. He is forced by the immensity of knowledge and the scarcity of time to leave this important economic phase of his study practically undeveloped. He must, therefore, turn to well-trained specialists for advice in the matter of the diseases of the trees under his care. During the forestry course the student may, however, find time to learn something in detail concerning the organisms which produce disease in trees, even if he cannot prepare himself for making the exhaustive study necessary for the complete understanding of the pathogenics of such organisms. In other words he may become more intimately acquainted with forest fungi, and forest insects as well, by enlarging upon that particular side of his general courses. Such an understanding of fungi might be gained from a course in mycology, or better still from a course in forest mycology. It seems to me that a course in forest mycology should be established in every school of forestry. Such a course should include among other things a review of the general morphology, physiology and classification of the fungi followed by a more detailed study of the nature and development of the fungi which attack the various parts of forest trees. The role of fungi in the decay of timber should be treated, and field trips should be made for the purpose of observing and collecting material for class work and to become familiar with the general field relations of forest fungi. With such training the young forester would be enabled to make intelligent observations and to take adequate and accurate notes in regard to certain fungi. He could collect specimens wisely and could send them to the proper office with all the necessary data. In a field well scattered with such foresters the practical successes of the forest pathologist would multiply very rapidly, and the summation of our knowledge of forest fungi be greatly increased. It was the appreciation of this condition of affairs which led to the establishment of a forest mycology course in the Department of Botany in this University.

A natural outcome of this spirit has been the decision to investigate more closely our own local forest fungi and to publish reports of our investigations from year to year as a part of the Forest Club Annual.

The present knowledge of Nebraska forest fungi is due almost entirely to the activity of the Botanical Seminar and the Botanical Survey of Nebraska conducted by that organization. A great work yet remains to be done in this particular field. With the co-operation of the Forest Club and the Forestry Department it is hoped that the knowledge of the forest fungi of Nebraska will be very greatly extended in the next few years and that at the end of the period this renewed activity will be substantially represented in the form of the reports here projected.

Herbarium cases have been made to hold the collections. These cases are made with the ordinary compartments for the reception of such specimens as will be mounted on species sheets, and also with drawers, instead of the ordinary compartment, for the reception of the larger woody fungi which are usually cut into thin slices and mounted on species sheets. It is impossible to gain a good idea of the large woody fungi from a thin slice of the sporophore. The complete specimens will doubtless prove greatly superior to the "slice specimens" in giving the student a proper notion of the appearance of the fungus in the forest. The collection will constitute a portion of the equipment of the Forestry Department and it will be available for study, especially for students in forest mycology.

It is planned to make this first paper the introductory chapter of a series and to begin in the next volume of the Annual a treatment of the local forest fungus flora with keys, descriptions and illustrations. Hence the present paper will contain a discussion of the general nature and development of fungi without any particular reference to forms of local importance.

## THE NATURE OF FUNGI.

**General:**

From the phylogenetic point of view fungi have come to be regarded as degenerates from certain algal ancestors which they resemble in many ways except in the matter of chlorophyll. The absence of chlorophyll is probably the most striking single feature of the fungi. As originally understood fungi included all chlorophyll-less thallophytes except the lichens. This was long before the true nature of the lichen was known, since today we know that the lichens are in no essential way different from other parasitic fungi. The great distinguishing feature of the lichens is their parasitic association with certain algae. This association is regarded as a symbiotic one, and some choose to call it mutualism. Under such a treatment it is seen that the fungi included the Myxomycetes or the Slime Moulds. There are some who still hold that these organisms are plants related to the fungi. True, many of the slime moulds in their fruiting period do resemble in a way some of the fungi, especially the Mucoracae and the Lycoperdaceae where they were first classified. The resemblances of the plasmodium or the vegetative condition of the slime moulds to that of the fungi are very slight. The vegetative phase of the slime mould resembles in many ways certain animals. On the whole the differences are so great between slime moulds and fungi that there are few botanists who still consider the slime moulds as fungi or who even place them as an ''anhang'' to the vegetable kingdom. There is much to be revealed by future research as to the nature of these peculiar organisms. Certainly it can be said that the true relationship and significance of the slime mould is still unknown.

As I have already indicated we commonly regard the fungi as greatly reduced chlorophyll-less plants, descendents of some algal stock which they resemble in a number of structural characteristics. Fungi then cannot in any way be singled out as typical plants, since the typical plant is provided with chlorophyll and by the possession of such pigment is capable under the proper conditions of carbohydrate synthesis. The branching filiaments or hyphae of the fungi resemble somewhat the vegetative filiaments of certain algae except in the matter of color. In some fungi there is a tendency on the part of the vegetative hypae to be unicellular, in others multicellular hypae is the rule. Both these conditions are paralleled in the algae. In the fungi a common method of propagation is by means of conidia which are the end cells of certain filiaments that are cut off by a transverse wall and rounded up in the form of a thin-walled spore. Sometimes such cells break up into a number of nuclei or cells, thus giving rise to a sporangium. These conditions are quite common in the algae. Then, too, the sexual reproduction in many fungi closely resembles that process in certain algae. For instance, the formation of the zygospore in the Mucoraceae is quite similar to that in the Zygophyceae among the algae. This apparent similarity is taken to indicate a possible close relationship between the two groups. Again a similar parallel is seen in the formation of the oospore in the Peronosporaceae as in Albugo and in such algae as the Siphonophyceae. And this again may possibly represent another line of descent. In this same way it might be shown that parallels and homologies exist between the Ascomycetes and certain other algal groups. Following such purely hypothetical reasoning we may conclude then that the fungi are lowly, chlorophyll-less descendents from the algae, which they resemble in many ways except in matters of nutrition; and that they have not all come from a single such ancestor, but that in various groups or families of algae certain members have lost their chlorophyll, have accepted the hetrotrophic type of nutrition, and have then given rise to a line or to lines of fungi.

It cannot be supposed that the changes indicated above took place in a relatively short space of time. Such changes are usually very slow. The change from an autotrophic habit of nutrition and life is a slow one and the gradual adaptation to a dependent habit of living was doubtless accompanied by a very slow and gradual loss of chlorophyll. The development of the hetrotrophic type of nutrition is absolutely necessary for the plant which loses its chlorophyll, if it is to persist as a living organism. It cannot be conceived that such a great change in the fundamental processes of the plant could be quickly made. However, this change has become so perfect that the fungi now bear little superficial resemblance to the algae. It requires a detailed study of the structures least effected by such changes, namely the sex organs and other reproductive structures, to reveal the above relationship.

Because of the minute size and inconspicuous nature of many thousands of the species, the fungi are less generally known to the world than the size of the group or groups warrants. Some of the families such as the Agaricaceae, the mushrooms, and the Polyporaceae, the pore fungi, are known to everyone, but one who knows only mushrooms and pore fungi possesses hardly more than a single atom of the mass of knowledge possible of these most interesting plants. In number of species the fungi are outranked only by the seed plants. Up to the present time there have been described about 65,000 species of fungi, while the species of seed plants number about 150,000. In the light of recent researches on the specialization of parasitism in the fungi, when so many so-called "biologic forms" or "physiological species" have been found to exist within a certain morphological species, it seems that such species may exist in infinite numbers. One is led to wonder if such a peculiar type of nutrition may not some day creep out in visible form upon such physiological species and so increase the number of fungi many fold. The extreme would be reached should a particular species of parasite be developed for each and every individual host plant. The physiology of such "physiological species" is one of the most perplexing problems before us today.

**The cells of fungi:**

In general it can be said that the cells of fungi do not differ in any essential manner from colorless cells of other plants. There is cell wall, protoplast, nucleus, nucleolus, vacuoles, etc., much the same as in other plants. However, we know that these structures show consderable variation in the higher plants, and this is also true for the cells of the fungi. The cells of seed plants for instance present many variations in structure and composition of the cell wall. In some cases it is extremely thin and delicate while often it is greatly thickened and hardened. The physical and chemical properties of cell walls are very variable in different plants and in the same plant at different stages of its growth. Generally such variations in structure and composition result in placing the plant concerned in a more advantageous relation to its environment, whether or not we wish to regard such variations in the light of adaptation. The cell wall in the fungi is in the great majority of cases very thin and remains so especially in the vegetative portions and also in the reproductive portions of the more rapid growing forms and short-lived species, yet in many cases it becomes very thick, hardened and elastic, especially in the reproductive portions of the perennial species of the Polyporaceae. The cell walls of such forms are often woody or fibrous, and in some cases they are impregnated with a substance resembling suberin in its physical consistency, so that a sporophore made up of such cells is commonly elastic and coriaceous. Such cell walls are frequently lamellated and colored, the color or colors being confined to certain layers or evenly distributed throughout the wall.

Another type of cell wall is to be found in the fructifications of the Tremellaceae or "jelly fungi," many of which are common on decaying wood. The cell walls of these fungi are peculiar because of the great differences in imbibition water which they are capable of holding under different conditions. By the imbibition of quantities of water the walls become resolved into a collodial condition. They are then soft, pliant, gelatinous and greatly thickened and the result is an enormous increase in the volume of the sporophore concerned. They are of this general nature when young and growing, or when after maturity they are moistened by dew or rain. They become very hard, brittle or horny and contracted when dry resulting in a marked diminution of the volume of the sporophore. In such state the walls are very thin. These same general relations hold for a few other fungi as in some of the Agaricaceae where the gelatinization may go so far that the walls become completely dissolved and the resulting drops of viscid fluid cover the surface of the pileus or stem.

As to chemical composition the cell wall is in some cases cellulose as Wager has shown in certain of the oosporous Phycomycetes. However in the great majority of species the cell wall does not consist of pure cellulose since it is insoluble in an ammoniacal solution of cupric hydrate, and it does not give a blue reaction's when treated with iodine and sulphuric acid or with Schulzes solution. Because of this peculiarity DeBary proposed the name fungus-cellulose for this particular sort of cellulose. Some investigators have concluded that such cell walls are composed of ordinary cellulose with foreign materials mixed with it, and that these admixtures in some cases are albuminoid in nature. From some researches it was concluded that the cell membranes of the fungi contain also chitin, a substance very similar if not identical with that so common in the animal kingdom especially in the Crustacea and Insecta. The cell walls are frequently pitted. Through such pits the protoplasts of contiguous cells may be in connection for long distances. This continuity of protoplasm has been demonstrated for the Agaricaceae, the Lichens, some Moulds, and especially well for the Laboulbeniaceae, the beetle fungi.

The protoplasm is usually granular, and, as in other plants, usually occupies the whole lumen in the case of young cells. In older and larger cells the protoplast becomes vacuolated with the appearance of several or finally a single large cavity filled with cell fluids. The single or few large vacuoles are formed by the coalescence of smaller vacuoles. The presence of the vacuole with its membrane of protoplasm is as essential to the intake of nutritive materials by osmotic movement in the fungi as in any other plants. Moreover the osmotic pressure which may be exerted upon these delicate protoplasmic membranes of the fungi finds no parallel in other portions of the vegetable kingdom. Certain saprophytic fungi have been cultivated in a culture medium the osmotic equivalent of which was as high as one hundred thirty atmospheres or more. The protoplasm has been observed to perform certain movements one of which is a streaming from cell to cell through the pits in the walls. A circulatory movement has also been observed.

The nuclei in the fungi are very inconspicuous, except in those cells concerned with the reproductive processes. Only with difficulty can the presence of such structures be demonstrated for the cells of the ordinary vegetative mycelium. Where present the nucleus possesses a membrane, a nucleolus, and a nuclear network similar to those structures in higher plants. Mitosis here is similar in all essentials to that process for higher plants, but is of a more simple type more closely resembling such a division among the algae.

As to other cell inclusions it remains to be said that fats or oils are present in the cells during growth in the form of small granules or drops. In resting cells, such for instance as spores, in sclerotia, etc. these smaller drops sometimes collect into larger aggregates which then give a distinctive appearance to the spore or cell concerned. Carbohydrates and proteins are also very commonly present in the cells of fungi. Glycogen is probably the most abundant and wide spread carbohydrate. It is a very common reserve material in the fungi. Its role in the fungi seems to be about the same as that of starch in autotrophic plants. Glycogen is a colloidal carbohydrate, but does not differ empirically from starch although it is more readily soluble and dializable. The test for glycogen is a reddish-brown color when treated with iodine, instead of blue as in the case of starch. Glycogen is present in greatest abundance in those cells concerned with reproduction and in storage tissues. The organization of bits of protoplasm into plastids is lacking in the fungi. Structures similar to the chromatophores of higher plants have never been found in fungus cells.

**The mycelium:**

Whatever form the plant body of the fungi may assume it is usually composed of thin-walled, tubular filaments called hyphae, which collectively constitute the vegetative portion of the fungus. Such a collection of hyphae is commonly known as the mycelium. The filaments are either unicellular or multicellular. The hyphae often branch profusely to form a more or less cobwebby weft of mycelium. However, the mycelium assumes many different forms besides the loose cottony or cobwebby character, such for instance as typified in the rhizomorphic strands of *Armillaria mellea* or *Clitocybe parasitica,* the horn-like sclerotia or resting bodies of *Claviceps purpurea,* and various forms in other species which exhibit forms of resting mycelium. The long string-like strands of *Armillaria mellea* and the sclerotia of *Claviceps purpurea* are nothing but specialized portions of the mycelium and they are essentially vegetative in nature. Such structures usually possess a definite outer coat or rind which is composed of thick-walled cells and which encloses a softer tissue, the cells of which are richly supplied with reserve material of which glycogen is the chief constituent. After a period of rest this reserve nutrient material is drawn upon and the round of life of the species is continued or completed with the formation of reproductive organs or sporophores. In such sclerotia we have, then, a well developed protective envelope and an interior storage region.

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# EXPLANATION OF FIGURES.

Fig. 1. Nuclei in reproductive cells. The formation of aeciospores in Phragmidium. (after Christman.)

Fig. 2. Rhizomorphic strands in Armillaria mellea. (from the Bonn text-book.)

Fig. 3. Two forms of pseudoparenchyma.

Fig. 4. Forms of basidia.

Fig. 5. Portions of hyphae with vacuoles.

Fig. 6. Forms of asci.

Fig. 7. Various forms of spores.

Fig. 8. Latex vessels in Russula. (from Massee.)

Fig. 9. Two forms of simple conidiophore.

Fig. 10. Three forms of haustoria.

Fig. 11. Algal cells and fungal hyphae in a lichen, Xanthoria. (from the Bonn text-book.)

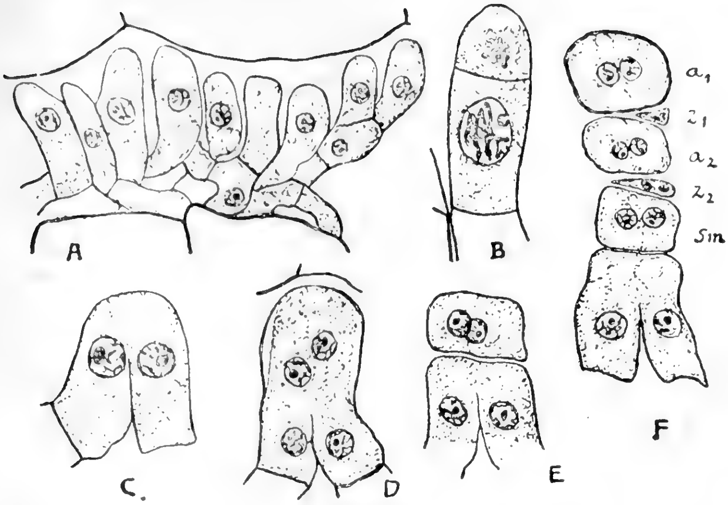



Fig. 1

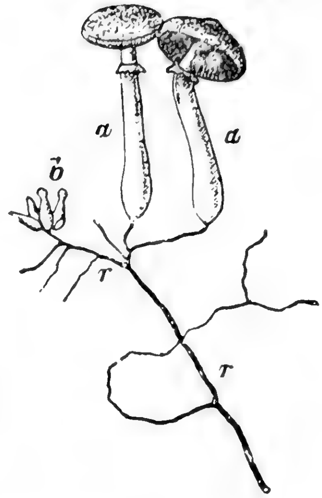



Fig. 2

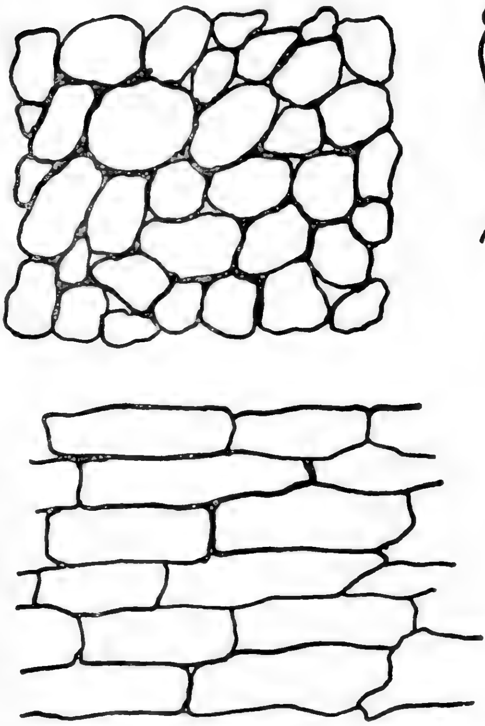


Fig. 3

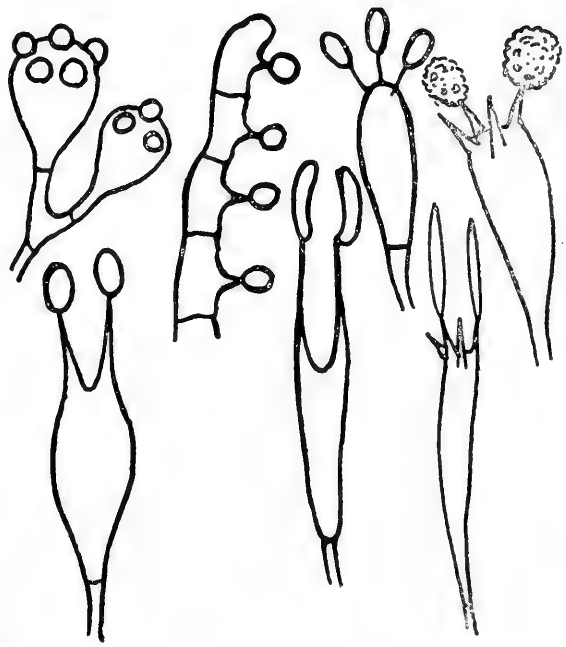


Fig. 4

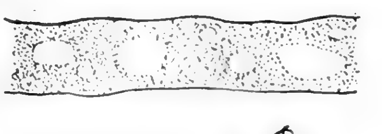


Fig. 5

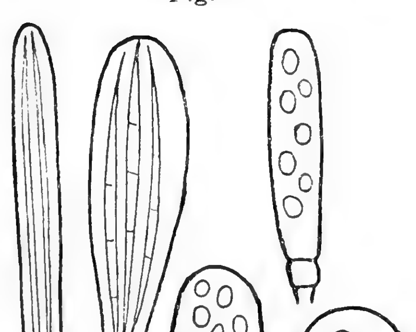


Fig. 6

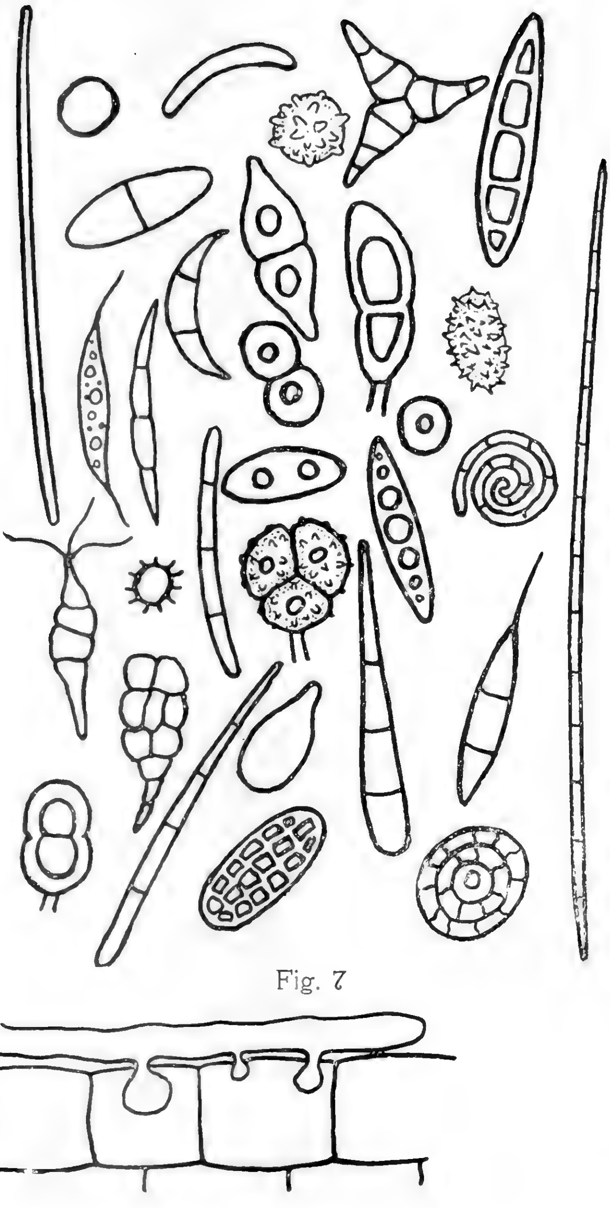


Fig. 7

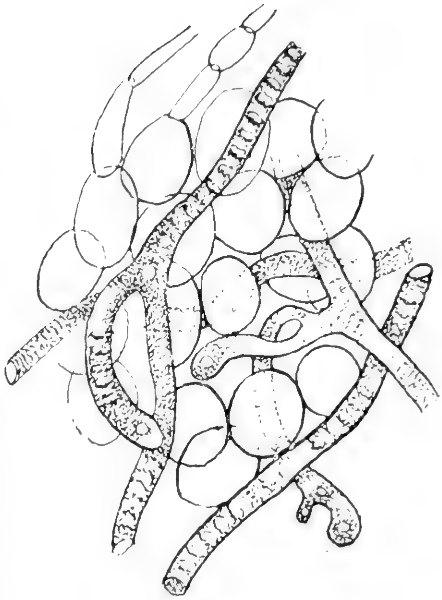


Fig. 8

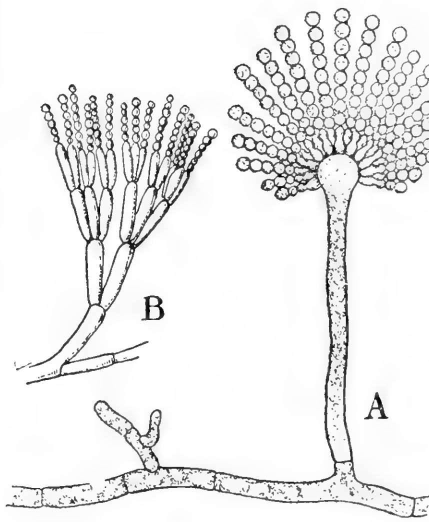



Fig. 9

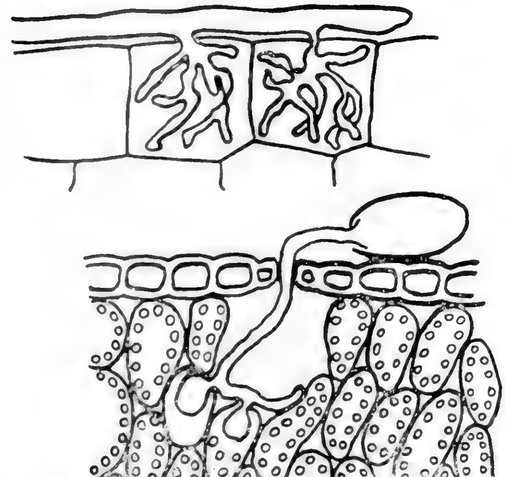


Fig. 10

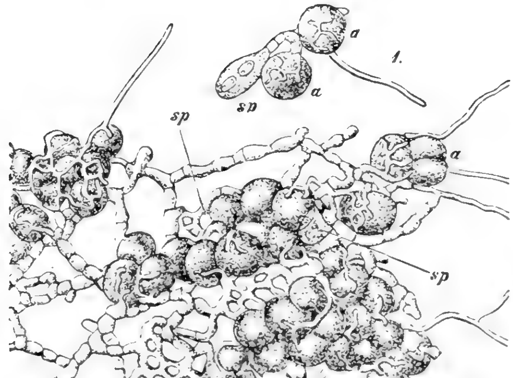



Fig. 11

Both these tissues are developed from the ordinary vegetative mycelium by an intimate mingling together of the hyphae until a coalescence results and a well developed tissue is formed in which it is difficult and, in some cases well nigh impossible, to distinguish or separate the individual component hyphae. Such an aggregation of cells because of some resemblance to parenchymatous tissue of higher plants has been called pseudoparenchyma. It must be remembered, however, that pseudoparenchyma is formed merely by the massing together and the coalescence of hyphae, a gradual process similar to the differentiation of the primordial meristem or cambium in seed plants. Such parenchyma-like tissue is found in many groups of fungi, but it is confined in the main to the resting stages or to the fructifications. Good examples occur in the Pyrenomycetes (black fungi), Discomycetes (cup fungi), the Hymenomycetes (toadstools), and Gasteromycetes (puffballs). The "tar spots" developed by species of the genus Rhytisma on the leaves of maples and willows are very similar to the structures described. In such forms the outer cells of those of the rind are coaly black. Besides these massive resting bodies made up of pseudoparenchyma, single cells or chains of cells in the mycelium may round up, become thick-walled and pass into the resting state. After a period of rest, such cells may germinate and give rise to a new mycelium.

A specialized conducting system is a rarity in the fungi, since ordinary osmotic interchanges are sufficient to supply all parts with the necessary nutritive materials and to cast forth all by-products. However, some fungi do reveal the presence of a conducting system or at any rate conducting tubes which originate as lateral outgrowths from ordinary hyphae. These tubes are at first transversely septate, but the septae eventually disappear leaving rather long continuous tubes. In the genus Lactarius, a toadstool, these tubes are variously branched and are continuous for considerable distances. In this genus the tubes carry a laticiferous material in such quantity that when a tube is broken the latex oozes out in the form of drops.

**Nutrition:**

It has been stated on a previous page that the absence of chlorophyll is the most striking feature of the fungi. Herein we see the significance of the particular type of nutrition by which they are further characterized. Because of the disappearance of this, the most important and essential pigment known, fungi have become dependent organisms, since without chlorophyll they are incapable of carbohydrate synthesis, a process so essential for the development of complex assimilatory compounds. Without it they cannot manufacture elaborate foods such as sugars and others from the crude materials supplied by the soil and air, but they must obtain them "ready made" and in this way they are peculiarly dependent upon other organisms. It may be stated that if it were not for chlorophyll there would not be the slightest trace of life upon the globe, and that, if from some accident all chlorophyll should disappear, most life would be terminated within a very few hours, and it would be a question of but a few days until all life on the globe would be extinct. The fact that fungi live upon foods already manufactured may explain in a measure their relatively simple structure, for it may be stated as a general law of biology that the more numerous and complex the processes of an organism the more highly differentiated must it become. The absence of the food-constructing apparatus must of necessity simplify the various processes of the plant and in the end result in the production of a weak, poorly developed, and dependent organism. Indeed many degrees of this phenomenon occur in plants outside the fungi.

As to the materials entering into the composition of the foods of fungi it can be said in the main they differ very little from those which go to the nourishment of autotrophic plants. Thus we might name the eight or nine elements essential to the nutrition of most chlorophyll-bearing plants and it would be difficult, even dangerous, to subtract any of them when those essential to the nutrition of fungi are considered. Possibly iron is the one element most easily removed from the list since its particular physiological role seems to be in the formation and the up-keep of the chlorophyll. But with certain fungi the presence of iron, though never arousing the production of this green pigment, does result in a much more luxuriant growth than in cases where the element is lacking. This fact led Molisch to conclude that iron is as essential to fungi as to higher plants. The elements carbon, oxygen, hydrogen, nitrogen, sulphur, potassium, calcium, magnesium and iron enter into the nutrition of fungi in the form of compounds elaborated by or resulting from the decay of other organisms, either plants or animals. About the only fairly accurate general statement that can be made in regard to these elements with reference to the fungi is that most such plants require but one of the alkaline earths, that is either calcium or magnesium. Most autrotrophic plants require both these elements.

As a consequence of their food habits it is found that the fungi may be arranged into two general groups according to the condition in which they find the food. Thus, we have many thousands of species procuring their nutriment from more or less *decayed* plant or animal remains. Such fungi are called saprophytes. Many such forms live upon dead twigs or sticks in which there is not a great amount of decayed matter. Others like many of the cup fungi and toadstools demand a much greater quantity of decayed material. Such fungi take a very important part in the process of decay, aiding very materially in the breaking down of lifeless organisms and in the return of complex organic compounds to simpler combinations. These relations are seen to no better advantage any where than in the deep moist forest where saprophytic fungi are abundant, and where such forms have a very important relation to the building up of the soil.

In the other group we have perhaps the majority of the species of fungi and these derive their nourishment from *living* plants or animals by sending hyphae into the living tissues and appropriating the food-stuffs which have been constructed for an entirely different purpose. Such fungi are called parasites, and the living organism from which they derive their food is called the *host*. Most parasitic fungi are parasitic upon other plants, although many of them occur only upon insects or higher animals.

These two apparently wide extremes, saprophytes and parasites, seem quite easily and effectively separated by the above characterizations. But as I have said after all the classification is only general, and, in reality when the fungi are viewed as a whole there is no sharp line of demarcation between the saprophytic and parasitic forms. The two conditions, if indeed they be two conditions, are merely habits, but habits which are so hidden, so deep-seated that the most careful research has failed to reveal their *true* physiological nature. The balance between saprophytism on the one hand and parasitism on the other appears to be a most delicate one. The two apparently different conditions merge into each other so gradually and so insensibly that indeed it is impossible to say with a surety in all cases that one fungus is a saprophyte and that another is a parasite. It has been found that many fungi attain their best development as saprophytes, but some of these, if the occasion demands, may live and grow as parasites, or such may be the normal round of life. Again others may be for the most part parasitic, but under certain conditions may adopt the saprophytic habit. The physiology of such processes or changes is one of the most perplexing questions in the whole field of botany. In the light of such apparently easy changes it is seen how superficial and in fact how unscientific is such a classification as that indicated above. A classification which strikes more clearly at the true nature of things must include these changeable or intermediate forms, that is, those fungi which at different times exhibit the two types of nutrition. The commonly accepted classification of this sort is as follows:

Obligate saprophytes
Facultative parasites
Obligate parasites
Facultative saprophytes.

Obligate saprophytes are those fungi which grow upon non-living substances, and at no time send their hyphae into living cells or tissues. Facultative parasites are saprophytes which may under certain conditions become parasitic. These conditions are as yet very incompletely known. Obligate parasites are those fungi which, so far as known, are at all times absolutely dependent upon other living things for their nutrient materials. Facultative saprophytes are fungi which are in the main parasitic, but under certain incompletely known conditions are capable of leading a true saprophytic existence. Of obligate saprophytes there are many examples to be found in the mould fungi and among the toadstools which grow upon humus in the forest. It must be remembered however, that not all species of these groups are of such nature. Indeed many of the Basidiomycetes, among which occur the toadstools, are facultative parasites. Many such fungi which are characteristically humus plants, or which occur upon rotten logs or decayed portions in living trees, may occasionally develop the parasitic habit effecting either the root or the stem. *Armillaria mellea* the "honey agaric" is a good example of this kind of fungus. *Mucor mucedo,* the common black mould, ordinarily a saprophyte, may cause a very serious disease of sweet potatoes, and indeed has been known to cause injury to certain seedlings. The best examples of obligate parasites are to be found in the Uredinales, the "rust fungi." Yet in this group it should be remembered that the teliospores germinate very readily under saprophytic conditions. In other parasitic fungi a yeast-like propagative process is an interesting saprophytic condition. Examples of facultative saprophytes are found among the Peronosporaceae, the so-called, "downy mildews," but in the main the species of this group are obligate parasites.

Parasitic fungi very commonly develop special nutritive structures as lateral developments of certain hyphae. These structures are called *haustoria.* They may be simple flask-shaped lateral extensions of the wall of the hyphae or these extensions may become variously divided and the divisions may be branched. The haustorium usually bores its way through the walls of certain cells of the host plant and once inside the cell it assumes the characteristic shape. The chief purpose of the haustorium is to render easier and more ready the absorption of food contained in the cells of the host.

The majority of parasitic fungi complete their round of life upon or within a single host plant. Such fungi are said to be *autoecious.* On the other hand there are many species of rust fungi which require different hosts for the development of certain stages in their life cycle. Such species are known as *heteroecious* parasites. De Bary was one of the first to work out the heteroecismal nature of the rusts. Since his day heteroecism has been demonstrated for many species of the rust fungi. A number of such forms develop one of the stages upon certain forest trees, while other stages of the same parasite occur upon distantly related shrubs or herbaceous plants. As an example I may cite the European Currant Rust, *Cron-*

*artium ribicola*, the aecial stage of which has been reported as very destructive to the White Pine, *Pinus strobus,* in Europe, while the uredinial and the telial stages occur upon various species of Ribes. This particular disease has recently broken out in Canada and north-eastern United States on nursery stock imported from Germany. The genus Coleosporium is another heteroecious rust and the aecial stage of the various species occur on species of Pinus. These aecial stages of Coleosporium are usually referred to the genus Peridermium. *Peridermium acicolum* occurs on the leaves of *Pinus rigida,* while the unredinial and the telial stages have chosen various species of Solidago (golden rod), and in this condition the rust is known as *Coleosporium solidaginis.*

The specialization of parasitism in the fungi has progressed so far that certain parasitic forms are capable of adjusting themselves to physiological differences in the host plant which is wholly indiscernable to the investigator. This adjustment is indeed so fine that no morphological change is produced in the parasite. In accordance with this ability there are developed within a given morphological species of parasite numerous specialized forms which differ from each other only in some unknown physiological manner. Thus a given fungus, for example, *Erysiphe graminis*, a powdery mildew, is parasitic on oats, barley, rye, and wheat, and also upon numerous wild grasses. Experiments have proved that there are really numerous kinds of parasitism possessed by this species, for it is found that the form of this parasitic species on oats will not grow upon barley, rye or wheat, that the form on barley will not grow upon rye, wheat or oats, and so on. And yet no structural differences can be made out which serve in any way to distinguish these various forms. It is concluded then that the differences are physiological, and the various forms are therefore called ''physiological species'' or ''biologic forms.'' This phenomenon is further characterized by other interesting phases, but this is not the place for the discussion of such details. Physiological species may not be of direct interest to the forester at this time, but when we think that such forms may possibly be developed in all species of parasitic fungi the question becomes one of intense vital intrest to the forester as well as to the mycologist and the plant pathologist.

There are many examples of saprophytic seed-plants. This is especially true in certain humus dwelling Orchidaceae and Monotropaceae. Many of these plants have adopted the strictly saprophytic mode of nutrition, and it has been found that the roots and rhizomes of such plants stand in close relation with fungal hypae. The same relation to fungal filaments also holds for many green plants which occur in bogs or other places rich in humus. Such an intimate association of a fungus with roots is known as *mycorhiza.* This relations is in no way a noticeably parasitic one although there may yet be a question in this regard with certain mycorhiza, since Nadson recently reported from Russia a wholesale destruction of oak seedlings which he attributed to "disturbed symbiosis," the fungus having become parasitic. A similar condition of affairs has been observed in the chestnut. The fungal hypae penetrated into the tissues of the root and there developed the injurious parasitic characteristics. Nadson believes that a mycorhiza fungus is in its essential nature a parasite.

There are two quite clearly defined types of mycorhiza depending upon the position of the fungus hyphae. In *ectotrophic mycorhiza* the fungus lives in the humus in close external contact with the roots, oftentimes forming a sheath of closely woven hyphae over the surface of the younger roots and root tips. But in no case does the fungus penetrate deeply into the tissues of the root. Frank has demonstrated the presence of this type of mycorhiza in many of our forest trees especially among the Oaks, Beeches, Birches, and the Conifers. In some cases the fungi concerned are members of the Agaricaceae. The fungus in such an association is supposed to have some influence upon the supply of water and mineral food materials for the plant upon whose roots it is found. It is said that the tree provided in this way with an intimate fungal associate is enabled to utilize more directly the mineral materials and organic remains in the soil. Frank supports this idea by culture experiments and by a rather long series of other experiments.

In the case of *endotrophic mycorhiza* the fungus hyphae enter the cortical tissues of the root and develop in the cells at some distance beneath the epidermis. The cells occupied by the fungus are usually in a series arranged as a concentric cylinder between the epidermis and the stele. The fungus does not cover the epidermis in the form of a sheath and so the development of root hairs goes on quite normally, while in ectotrophic mycorhiza they are suppressed in the region of the fungus. Some of the cells inhabited by the fungus are killed, while in other cases the fungus threads die in the cells and their abundant protein remains go to the nourishment of the host. In still other cases the protoplasm of the infected cells is all consumed by the hyphae which then round up in the form of an oval or spherical mass which passes into the resting condition. Upon the decay of the root tissues these resting bodies may put forth fresh hypae and infect new host plants.

Some investigators have concluded that in a few cases of mycorhiza the fungus portion is an active agent in the assimilation of atmospheric nitrogen in much the same manner as are the tubercle bacteria. If this be the case then trees with a well developed mycorhizal condition are certainly more favored than those without it. On the other hand Stahl thinks that possibly the fungus merely aids in the absorption of the ordinary mineral food materials from the environment, and that it does not in any way supply the needs of the host plant for nitrogen. Stahl claims that the chief advantage gained from ectotrophic mycorhiza is that the host more easily absorbs the usual materials from the soil, and that endotrophic mycorhiza is an aid in the transport of these substances through the cortex and hence aids in the rise of the transpiration stream.

## REPRODUCTION.

There are two distinct periods in the life history of a spore-forming fungus. In one period the most characteristic structures are the hyphae and the mycelium, initiated by the germination of the spore. The time which elapses between the germination of the spore and the development of new spores is an extremely variable one for the fungi. Depending upon the species and the conditions this vegetative period varies from a few hours to several weeks or even months. This period is a more or less inconspicuous stage in the life history of the species, and usually when the spore producing period is at hand the presence of the fungus is more clearly indicated. The vegetative period has been sufficiently discussed in the foregoing pages for our present purpose. We must now examine very briefly the question of spore formation or reproduction as the other conspicuous period in the life cycle.

The reproduction of fungi is usually and normally accomplished by means of spores. Spores are formed either sexually or asexualy. Sexual reproduction occurs chiefly among the lower fungi especially in the Phycomycetes, and it takes place by two methods already pointed out for the algal relatives namely conjugation and fertilization of a female nucleus by a male nucleus resulting in the development of a zygospore (Zygomycetes) or an oospore (Oomycetes). In either case the resultant spore is a rather thick-walled resting spore supplied with a considerable amount of reserve foodstuffs. Because of this nature the sexual spore is capable of withstanding a rather long period of unfavorable conditions and still of germinating upon the approach of favorable conditions. Such a conjugation and well defined sexuality has been demonstrated for a number of the Ascomycetes. But in this group fertilization results in the development of a spore-fruit with many spores instead of a single or, at best, a few spores as in the Phycomycetes. Such a spore-fruit is typically made up of two rather well defined parts, the ascus apparatus and the envelope apparatus. The essential portion of the ascus apparatus is the ascus or the group of asci with their spores. The asci spring from lateral processes known a ascogenous hyphae which push out from the fertilized oogone or egg cell. The envelope apparatus takes its origin from the vegetative cells close to the fertilized egg cell and develops a covering of vegetative tissue, very commonly pseudoparenchyma, about the ascus apparatus. In many Pyrenomycetes (black fungi) the envelope almost completely encloses the asci, while in many Discomycetes (cup fungi) the envelope is not continuous over the asci so that at maturity a saucer-shaped sporophore is produced. Some few Ascomycetes such as Exoascus lack the envelope apparatus and hence the fruit consists of asci alone.

In the Basidiomycetes the sexual process is in doubt. So far it has not been demonstrated for this group to the satisfaction of all botanists. Nevertheless the Basidiomycetes develop a spore-fruit characterized by a spore-producing area or basidium apparatus, and a vegetative envelope which partially or completely encloses the basidium apparatus. Curiously enough some of the Basidiomycetes, such as Exobasidium, are also lacking in the matter of a sterile envelope, and the fruit then consists of naked basidia and spores.

Spores produced by the asexual method are quite commonly called condia or condiospores. The condia are borne on the mycelium or more commonly on special hypae which arise from the mycelium. These special hypae are called condiophores. Condiophores are of a wide range of structure. Some such structures are simple, erect hyphae. Others are much branched in a variety of forms. In the latter cases the condiophores are very different from and easily distinguished from the ordinary vegetative hyphae. The spores are developed at the tips or along the sides of these structures by an aggregation of the protoplasm into more definite masses which soon become surrounded by a cell wall, after which they round up and eventually become separated from the conidiophore. Conidia are formed in immense numbers during the growing season and since they are thin-walled and capable of immediate germination they constitute the chief means of the rapid geographical extension of the species. They are very minute and are easily scattered by the wind which is their chief means of dissemination.

Many Phycomycetes and Ascomycetes usually possess both kinds of spores. In such species the conidiospores usually precede the acospores in point of time. During the actively growing period the conidiospores are produced in abundance, but later as the general tone of the plant becomes lowered the other type of spores are formed upon the same mycelium which developed the conidiospores. There is however a great group of fungi composed of numerous smaller groups, which is characterized by the production of asexual spores oply. These fungi are known as Imperfect Fungi, or Fungi Imperfecti, and probably represent conidial stages of other fungi. In fact many species have already been connected with various genera and species of Phycomycetes and Ascomycetes. This is probably the nature of all the Fungi Imperfecti of which there are many thousands of species. None of them so far as I know have ever been proved conidial forms of Basidiomycetes, although such a relationship is possible and some day may be demonstrated. At any rate we should be slow in concluding that the imperfect fungi are conidial stages of certain Ascomycetes in all cases, even if the weight of our present knowledge seems to warrant such an inference. We shall probably never know the true relationships of all the 16,000 species of "imperfects." Among the species are many which cause very destructive plant diseases. The greater number of the leaf-spot and anthracnose fungi of forest trees are characteristic members of this interesting group.

Mature fungus spores are provided with an outer and an inner wall: the episporium and the endosporium respectively. The endosporium is usually thin and inconspicuous while the episporium is relatively much thicker and it is this wall which really gives surface-character to the spore. In many thin-walled spores such as conidia the differentiation into two wall layers is not obvious from the mature resting-spore, but this character may appear at germination when the endosporium usually develops the primary germ tube. When spores are colored it is found that the bulk of the color is confined to a particular part of the episporium or is completely distributed throughout this the outer wall. In many cases the spore is smooth and colorless, but in many others the outer wall is variously modified. It may be developed in the form of low folds or undulations. Again portions of the episporium may be projected outward as wart-like processes and either blunt or fine-pointed spike-like appendages of a varying configuration. Some spores possess an outer hygroscopic layer which increases greatly in thickness with the addition of water. Spores of such a wide range of surface markings and colors are very commonly pluri-septate with or without a constriction at the cross walls. Spores usually reveal the presence of a granular content with or without oil drops, that is, when the color of the episporium is not so dense that the inner structure may be seen. The nucleus is conspicuous in many spores especially after the use of a nuclear-stain. As to form, spores may be spherical, oval, boat-shaped, fusiform, allantoid, asteroid, needle-form, thread-like or helicoid.

Other details in the matter of the reproduction and structure of specific forms will be treated in the succeeding papers of the series.

SPECIAL PHASES.

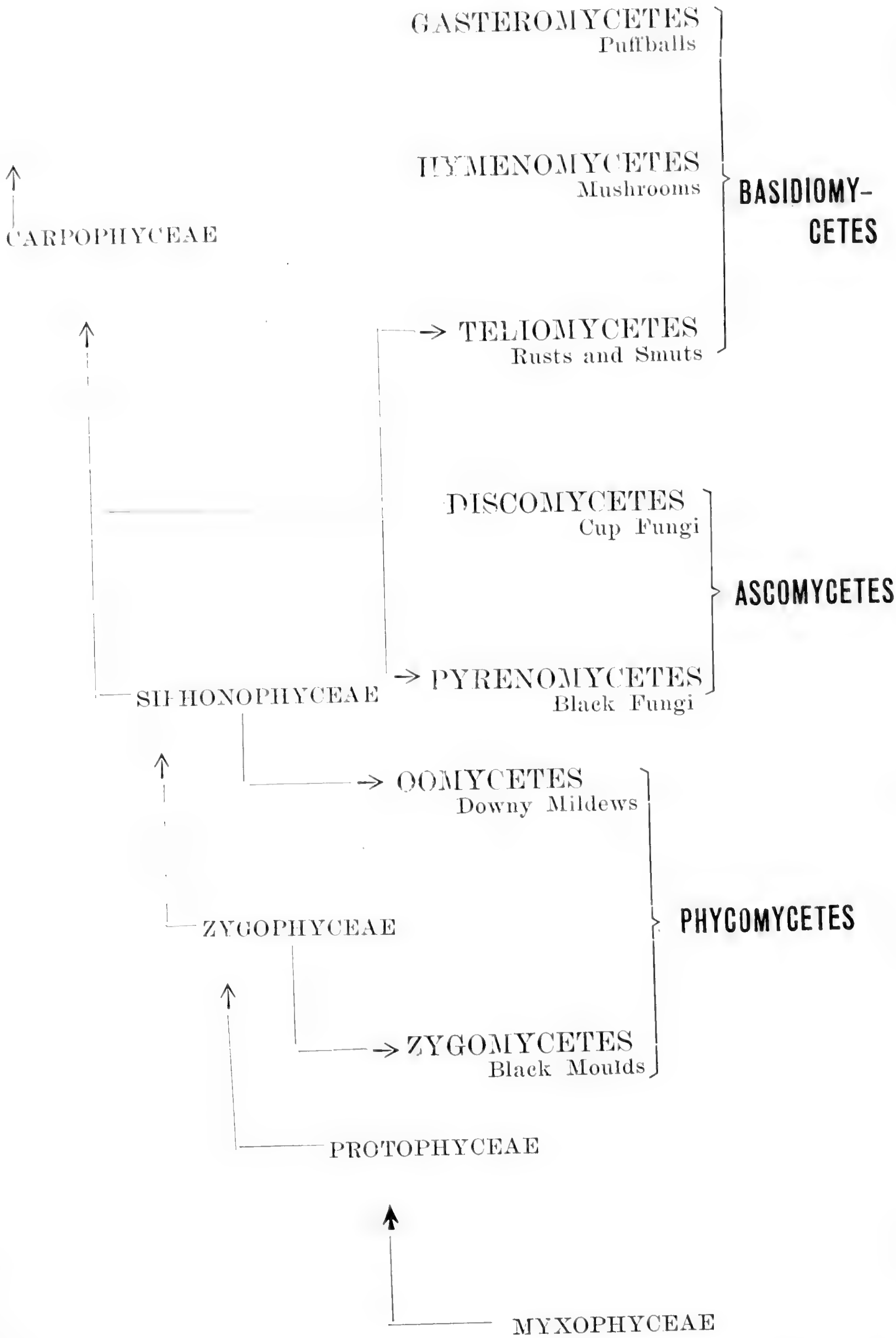
**Chromogenic Fungi—**

There are many fungi of much economic interest because of their habit of growth upon living forest trees. Still others are instrumental in the production of decay in standing timber or in lumber cut and piled in the yard. The presence of such fungi is very commonly indicated by decayed or "punky" spots in the wood. Everyone is more or less familiar with such forms as these, together with their effect upon the infested portions. However there are other species which are found in perfectly sound lumber in the yards and which do not produce a readily noticeable decay. Their presence is chiefly indicated by a particular color or stain or a combination of stains rather than by decayed areas. Such forms are known as *chromogenic fungi* or color-producing fungi. The color may be blue, brown, black, pink, yellow, or purple. The presence of such pigment or pigments forming blotches on lumber greatly reduces the sale value of that lumber because naturally the grade of the lumber is lowered. Once in the lumber piles the fungi develop rapidly and the result is the loss of thousands of dollars each year to the lumber industry.

The blue stain in pine wood has been known in Europe and in this country for many years. Hartig and Frank both refer to it in their publications on forest fungi and plant diseases. The most extensive work on chromogenic fungi in America has been done by Hedgcock. He divides such fungi into three groups according to the color produced as follows:

1. Wood-bluing fungi
2. Wood-blackening or wood -browning fungi
3. Wood-reddening fungi.

The most common fungi producing a blue color in lumber piled in the yards are species of Ceratostomella. This genus belongs to the Pyrenomycetes (black fungi) among the Ascomycetes. The mycelium of *Ceratostomella pilifera* (Fr.) Wint., a common species, penetrates the sapwood of dead and dying pine trees giving it a peculiar blue tint. This fungus has been found on the wood of almost all the species of Pinus in the United States. The cause of the color is not well known. Be-




The Origin and Relationship of the Main Groups of Fungi sides pine, the fungus is reported as occurring upon the sapwood of Abies, Quercus, and Fraxinus. Other species of Ceratostomella occur on the lumber from Fagus and Liquidambar. Various species of Graphium among the Stilbaceae are responsible for stains which range in color from dirty gray to dark brown or in some cases black. Hedgcock isolated a number of species of Graphium from the wood of Pinus, Populus, Acer, Quercus, Liriodendron, Liquidambar, Fagus and Wistaria. As in Ceratostomella the mycelium enters the wood through the medullary rays, and is usually confined to the sapwood. Hormodendrum and Hormiscium, two Dematiaceous imperfect fungi, are also responsible for similar stains in Pinus, Ulmus, Fraxinus, Quercus and Liquidambar. Species of Penicillium and Fusarium are the chief wood-reddening fungi according to Hedgcock. Reddish stains have been found on a number of trees. The wood of box-elder, (*Acer negundo*) about Lincoln, Nebraska, is very commonly stained red and I have observed both Pencillium and a Fusarium-like fungus in such colored areas. The stain is a bright red when the wood is moist and becomes dull and not so conspicuous when dry. It is present for long distances in the main stem and the branches of this tree in Nebraska. The stain is usually more abundant in the heart wood or in the center of the branches although it has also been observed in the sapwood. It was especially noticeable during the recent ice storm in Lincoln that a great majority of the branches broken off were so colored. In one case which came to my notice a branch eight inches in diameter was broken and split. In this branch the main stem and all the branches were stained in the manner described. The red stain covered the greater part of the surface of a longisection through the pith. It would seem from the presence of the stain (indicating the presence of a fungus or fungi) in so many of the trees and branches broken off during the ice storm that the fungus weakens the parts infected to a considerable degree.

As to the cause of the color in the wood stained by these various fungi Hedgcock states that the blue stain in wood harboring the mycelium of Ceratostomella is due to the color of the filaments which are, in part, blue. The blue pigment is not exuded from the hypae. In Graphium stains the color is due to the color of the hyphae also since the wood cells are not stained. The same is true for Hormodendrum and Hormiscium. In stains resulting from Penicillium however the wood itself is colored by a red or yellow pigment which is excreted by the fungal hypae and absorbed by the wood cells. Wood stained by Fusarium takes its color from both the hyphae and from pigmented excretions which the cells of the wood absorb.

THE MAIN GROUPS OF FUNGI.

I. PHYCOMYCETES— Algal Fungi
  2. Zygomycetes—Black Moulds
  2. Oomycetes—Downy Mildews

II. ASCOMYCETES—Sac Fungi
  1. Pyrenomycetes—Black Fungi
  2. Discomycetes—Cup Fungi

III. BASIDIOMYCETES—Club Fungi
  1. Teliomycetes—Rusts and Smuts
  2. Hymenomycetes—Mushrooms and Pore Fungi
  3. Gasteromycetes—Puffballs

Of all the fungi the Phycomycetes are the lowest since they most closely resemble such lower algae as the Zygophyceae and the Siphonophyceae as has been pointed out elsewhere. The hyphae are usually much branched so that a well developed mycelium characterizes most of the species. Some of the smaller families possess little or no mycelium. The filaments are usually unicellular, that is, not septate, during the vegetative period. With the approach of the spore-producing period cross walls develop in the region of spore formation. Occasionally the filaments of the vegative mycelium becomes consipcuously septate. Both sexual spores and condia are formed. Sexually formed resting-spores are developed after conjugation and fertilization. The resemblances between the two types of sexuality in the Phycomycetes and the sexuality of certain algae have been pointed out. The condia occur either singly or in chains at the tips of modified hyphae or in sporangia. In a number of species the conidium is single celled at maturity but upon germination its contents divide into a number of daughter cells each of which becomes a zoospore. In other cases the condia germinate directly without the intervention of zoospores. The condia are borne in sporangia in some forms, in which cases they are commonly called sporangiospores. Many of the Phycomycetes are responsible for serious plant diseases. Species of Phytophthora and Pythium produce a disease in seedlings known as "damping off." It should be understood that a number of fungi not Phycomycetes produce the characteristic symptoms of "damping off." There are many diseases of garden crops induced by various species of this group of fungi.

The main structure which distinguishes the Ascomycetes from other fungi is the ascus. The ascus (plural, asci) is a spherical to club-shaped to cylindrical cell in which the spores are formed. Some German mycologists regard the ascus as homologous with the sporangium of the Phycomycetes. The filaments of the mycelium are multicellular and the spore producing structure is much more complicated than in the algal fungi. The spore-fruit of the Ascomycetes resembles in a way that of some of the higher algae. This fruit or ascocarp arises as a consequence of conjugation of sex cells and in the typical forms is composed of two general parts, the ascus apparatus and the envelope apparatus. The asci, as end cells of certain hyphae which push out from the fertilized oogone, are usually developed in groups and thus constitute the ascus apparatus. The asci are surrounded by a vegetative, protective and nutritive envelope. A few forms such as those in the Exoascaceae and the Gymnoascaceae are characterized by the absence of the enveloping sterile tissues, and the asci being borne in naked groups directly upon the mycelium.

Variations in the structure and configuration of the envelope of vegetative tissue give rise to characters which are useful in separating the various orders and families of the Ascomycetes. Those with a more or less waxy or hard and carbonous envelope tissue which covers and encloses almost completely the asci are called Pyrenomycetes or Black Fungi from the fact that such a fruit is very commonly carbonous or black. The fruit of the Pyrenomycetes is called a perithecium. The perithecium may be spherical, flask-shaped or hysteroid. There are a number of families of black fungi among which are a number of species that cause destructive diseases in forest trees. Thus *Diaporthe parasitica* is quite commonly supposed to be the cause of the chestnut bark disease. Clinton has recently advanced the idea that much of the damage which has been suffered by Chestnut trees and laid upon this fungus as the cause is really a disease resulting from climatic or physical conditions especially winter killing. Ceratostomella, the "wood-bluing" fungus already discussed is another black-fungus.

Those Ascomycetes in which at maturity the envelope tissue is broken in such a way that the sporocarp assumes the shape of a cup or saucer with the asci exposed over the surface are called Discomycetes or Cup Fungi. In most cases the open part of the fruit is colored in a characteristic way, and the enclosing sterile tissue is fleshy or waxy or in a few cases carbonous. Such a fruit is called an apothecium. These facts with the more widely exposed asci are the main points of difference between Discomycetes and Pyrenomycetes.

The characteristic feature of the Basidiomycetes is the basidium, a cell from nearly spherical in shape to club-shaped or cylindrical which bears the spores on the summit of the free end or on the sides. Basidia, like asci are end cells of certain hyphae. In the greater number of Basidiomycetes the basidia are arranged in a layer over the sporophore or certain portions of the sporophore and in many cases these portions are surrounded more or less completely by vegetative tissue as in the Ascomycetes. The mycelium is very similar to that of the Ascomycetes.

There are three quite well-defined subdivisions of the Basidiomycetes. The Teliomycetes commonly known as the Rusts and Smuts are characterized by very simple basidia not arranged in a layer, and by their parasitic habit. Certain stages in the life history of the Rust fungi are developed upon forest trees and in this condition they are sometimes destructive. This is especially true for species of Coleosporium and Peridermium.

The Hymenomycetes include the Mushrooms and the Pore Fungi among others. In all cases the basidia are arranged in a definite layer over certain portions of the sporophore and these areas are usually exposed at maturity. Thus we have the gills of the mushrooms and the teeth of the tooth fungi covered with basidia, and the pores of the pore fungi lined with the same. The species are mostly saprophytes although many of them may and do become parasitic. Members of this group are exceedingly common in the humus soils of forests and upon forest trees.

The most conspicuous members of the Gasteromycetes are the Puffballs, although the group also contains the Birds' Nest Fungi and the Stink Horns. In all of the puffballs the layers of basidia with their spores are not greatly exposed at maturity. As a consequence some mechanical force is necessary in most cases to break open the envelope of vegetative tissue and to bring about a wider liberation and dissemination of the spores than would otherwise occur. The common forms are more or less spherical or globose in shape, while some of them are provided with long stalks. In the case of the Stink Horn fungi the stalk as it elongates carries the exposed area of spores with it out of the envelope and the envelope is left in the ground.

A word further should be said about lichens. As stated in an earlier page the lichens are parasitic fungi in which the parasitized plants or hosts are certain algae. Members of the blue green Algae, the Myxophyceae, and the yellow green Algae, the Protophyceae, are thus parasitized. In the main the lichens are Ascomycetes, either Pyrenomycetes or Discomycetes which have become parasitic upon algae rather than upon other plants. A few lichens are found among the Basidiomycetes. The vegetative structure of the lichens, the thallus, is commonly pseudoparenchymatic in nature, although hyphae are quite easily demonstrated for the majority of species especially in the early stages of growth from the spore. Lichens grow very commonly upon trees in the forest because the algal portion finds very favorable conditions in such places, but it should not be supposed that lichens are parasitic upon the trees because such is not the case; the fungus derives its nourishment in a parasitic way entirely from the algal associate.

(To be continued.)

# A NORTHERN IDAHO LUMBERING OPERATION

E. G. Polleys.

In this article an attempt will be made to describe in a rough way the various stages a tree goes through from the forest to manufactured lumber, and also to give some figures on the cost of each stage as well as on the whole operation. The sawmill is located on Lake Pend O'Reille while the logging operations are carried on either on the banks of the lake or along rivers and small streams tributary to the lake. The species cut include most of the timber trees common to that region: Western white pine, hemlock, spruce, red cedar, yellow pine, larch and Douglas fir. The white pine was the most important species and formed about 30 per cent of the entire cut; about 50 per cent was hemlock, cedar and larch; the remaining 20 per cent was of yellow pine, Douglas fir and spruce.

The logs were bought several years ago at a stumpage price of $1.50 which has been used as a basis throughout this article. However, at the present time the price of stumpage in this region is from $2.50 to $4.00 for bodies of timber of any considerable size and the price is bound to increase materially.

## LOGGING.

Contract logging prevails in this locality and all logging has been done by using horses. Most of the logs were cut by one contractor who logged the entire year on a large stream and its tributaries; in summer, skidding the logs to the main stream; in winter, banking the logs along the smaller streams to be taken out with the spring floods. A fairly large amount was winter logged by another contractor who delivered the logs in the water to a company that controls the river. These logs were taken out with the river company's drive. Some logs were also bought in small lots from farmers who delivered the logs in the water at so much per thousand. The cost of logging up to the point of driving was $5.00 per thousand feet board measure.

### DRIVING.

Driving the logs obtained from the larger contractor was done by crews hired by the company. A special crew was used to get out winter logs during the spring flood, while a steady crew took out the summer logs on the main river. The cost of driving including toll for improvements made by other companies amounted to 50 cents per M for logs delivered at booms on the lake. Logs from the smaller contractor were driven out and delivered in the lake at a contract price of 50 cents per thousand feet.

### TOWING.

The company maintained one tug for towing and for carrying supplies. This was usually operated by a crew of two men, a captain and an engineer. At times of very heavy work, however, a lineman was also used. The one boat would take care of all towing, except when the log rafts were extraordinarily large and the weather bad, then another boat would be hired. The engineer received $3.25 per day; the captain, $3.25, and the lineman, $2.50 per day. The cost per M for towing logs to the sorting boom at the mill was forty cents.

### SORTING.

The logs were generally delivered at the sorting boom in mixed rafts, then the white pine and spruce logs were floated down into a boom directly below the mill. When these logs had been sawed, the cedar logs would be sorted out and sawed, and then the remaining mixed lot would be cut into lumber. A sorter received $2.50 per day. The cost per M for sorting amounted to $0.06.

### MILLING.

The sawmill had a capacity of about 80 M lumber scale in a ten hour day. It was equipped with one double cut band saw and a band resaw. A force of 23 men was employed, not including power crew and lath mill men. Steam power, generated by a fuel of sawdust and shavings, operated the mill. All other waste not desired for lath manufacture or slab wood went to the "burner." The figures on expense of mill operation, labor, repairs, supplies, and power are based on figures for one month's cost and are compiled in two ways:

First, as a daily average expense and wage scale, and secondly, as cost per M by apportioning labor, supplies, repairs, etc., to an average cut of 64 M per day.

DAILY WAGE SCALE OF MILL CREW.

| | |
|---|---|
| Foreman, $125, 26 days per month | $ 4.80 |
| 1 Sawyer | 7.00 |
| 2 Setters, at $3.50 | 7.00 |
| 1 Filer | 8.00 |
| 1 Filer helper | 4.00 |
| 2 Edgermen | 7.00 |
| 1 Scaler | 2.75 |
| 1 Resawyer | 3.00 |
| 1 Tailsawyer | 2.75 |
| 2 Trimmermen, at $2.50 | 5.00 |
| 1 Trimmerman | 2.25 |
| 1 Oiler | 2.50 |
| 8 Common laborers, at $2.00 | 16.00 |
| Total | $72.05 |

MILL SUPPLIES.

| | |
|---|---|
| Cost of mill supplies 1 day | $3.51 |
| Cost of repairs per day: | |
| Labor | 5.52 |
| Repair supplies | 9.05 |
| Total | $18.08 |

POWER AND LIGHTS.

| | |
|---|---|
| Cost of supplies, oils, etc., for engines, 1 day | $8.96 |
| Wages of operating crew: | |
| Engineer, 26 days at $100 per month, or per day | 3.85 |
| 1 Day fireman | 3.00 |
| 1 Night fireman | 2.75 |
| 1 Watchman | 2.50 |
| Total | $21.06 |

APPORTIONED COST PER M OF SAWED LUMBER.

| | |
|---|---|
| Foreman | $ .075 |
| Sawing | .110 |

| | |
|---|---|
| Setting | .110 |
| Filing | .190 |
| Edging | .110 |
| Scaling | .040 |
| Resawing | .050 |
| Tailsawing | .040 |
| Trimming | .110 |
| Oiling | .040 |
| Common labor | .250 |
| Mill supplies | .055 |
| Repairs | .230 |
| Power and lights | .330 |
| Total | $1.74 |

A lath mill was operated in connection with the saw mill. The lath were made by contract at $ .85 per thousand, the contractor paying for his own help.

YARDING, MANUFACTURING AND SHIPPING.

The remainder of the operation after the lumber left the mill until it was loaded on the cars was in charge of the yard foreman who had the planer boss under his orders.

Lumber was carried out of the mill on an endless chain. Each piece was graded as it passed the grader who was stationed at one end of the long sorting shed. Eight sorters were employed in taking the lumber off the chain and piling it on low wooden rolls. These men watched the grade marks and dimensions of the pieces; each man taking off certain sizes and grades, and laying them on the proper piles. The chain moved slowly enough to allow one man to take care of 4 or 5 piles at once. The object of piling over rolls was to facilitate loading on special wagons which were used in hauling out to the piles. The wagons were backed under the outer end of the roll piles; a chain was thrown over the pile and hooked and tightened. The driver by turning a crank which was attached to a set of rolls on the wagon can easily shift the whole pile on to the wagon. The teamster then hauled the load to the yards and left it for the pilers.

PILING.

All piling was done by contract at 40 cents per M; four men being required to take care of the daily cut.

SEASONING.

All lumber was seasoned by air drying. To be well seasoned the lumber should have been left in the piles four to five weeks during the dry season, but it was sometimes taken out of the pile at the end of three weeks if the supply was short on certain dimensions. When ready for manufacture the lumber was taken out of the piles by a yard grader and helper who examined it for changes in grade due to seasoning. The western yellow pine should have been kiln dried but the per cent of this species in the whole cut was too small to pay for the construction of a dry kiln.

WAGE SCALE OF YARD MEN.

| | |
|---|---|
| Foreman, $110 per month, or per day | $4.25 |
| Graders | $2.50 to 3.00 |
| Common labor | $2.00 to2.25 |
| Teamster | 2.50 |

YARD CREW.

The number of men in the yard crew was very uncertain because it was made up largely of transient labor. Vacancies in the loading and planer crews were filled from the yard crew, making the number still more uncertain. For this reason it is not possible to place a per M cost on any of the separate parts of the work under the yard boss.

PLANING MILL AND SHIPPING OPERATIONS.

The equipment of the planing mill consisted of one large surfacer for dressing two sides of boards; one sizer for surfacing sides and edges; two matchers for making flooring, ceiling, etc., one rip saw; one moulding machine and one siding saw for making bevel siding. The capacity of the planing mill averaged about 60 M per day. The crew could manage five machines and consisted of a boss and 10 men. One man from the crew occasionally helped the boss grind knives and oil the engines. Usually a feeder did this work while his partner cleaned up around the machines. Rough lumber hauled into the planing mill on trucks, was pushed up to the machines by hand, fed through and reloaded on the same kind of trucks.

WAGE SCALE IN PLANING MILL.

| | |
|---|---|
| Boss, per month $100.00; per day | $3.85 |
| Feeders, per day | 2.50 |
| Tailers, per day | 2.00 |
| Repairs and supplies, per day | 1.70 |

The grading and loading crews took the lumber from the machines either to the dry shed or directly to the cars. As a rule the common grades of lumber were loaded directly into the cars after being regraded by the tally grader. All selected lumber and siding was graded severely and was usually stacked in the dry shed to be held until needed for shipping.

The dry shed and shipping crews usually consisted of eight men who worked in pairs; each pair consisting of a grader and a helper. One of the graders with his helper worked entirely in the shed at grading, trimming select lumber, and tying up siding, moulding, etc., into bundles. Two of the grading crew took the lumber directly from the machines and loaded it on cars while the other crew was kept busy in the shed loading trucks of select lumber. The main dry shed, in which all select and common white pine lumber, siding, and moulding, and the best larch flooring was kept, was built in direct connection with the planing mill and loading platform. This arrangement made the handling convenient and fast. Select yellow pine and cedar siding were stacked in a small shed out in the yard. All other lumber went into common and dimension stock and was piled in the yard.

Besides the regular planer and shipping crews, two extra men were employed to do odd carpenter work or to fill places in shipping or planer crews when needed.

WAGE SCALE.

| | |
|---|---|
| Graders, per day | $2.50 to 3.00 |
| Common labor, per day | 2.00 |

BARN EXPENSES.

Eight work horses and a company driving team were used about the plant. One double team was used for hauling lumber from the mill to the yard, one team was used on the dump cart, one team was used for retail hauling and odd work, and two single harness horses were kept for hauling lumber into the planing mill.

Cost of feed one month ........................$240.55
Cost of feed one month per horse................ 24.05
Barn man per month............................ 30.00

The cost per M of all the work from the time the green lumber left the sawmill until it was shipped, including barn expense, amounts to $1.33.

GENERAL EXPENSE AND INTEREST.

The general expense account for one month which includes the salaries of the manager, assistant manager, bookkeeper, and stenographer, together with selling expense and office supplies amounts to $1252.21. Insurance amounts to $420 per month. Interest amounting to $1,770 was allowed as 6 per cent dividend on capital invested. An allowance of $1,250 was made for a one per cent depreciation of the plant for each month. The cost per M of general expense and interest amounts to $2.73, according to company figures. Interest rates vary from 6 to 8 per cent.

All figures on cost as given in this article, except the wage scale, are for the month of July 1909. The average is slightly higher than usual, but the estimate was made at this time because the sawing and shipping were about equal in that month. It was not possible for the writer to obtain cost figures for the entire year. The cost per M for the stumpage, logging, driving and toll is given on the log scale basis, but the mill scale overruns the log scale about 25 per cent, and thus decreases the cost as given.

A synopsis of the cost per M of each part of the operation and the total cost per M is given below:

Stumpage
Logging
Driving
Toll
$7.40 less 25 per cent for underrun..............$5.92
Boat expense towing at mill
Sorting logs at mill boom
Sawmill operating
Repairs for sawmill
Power and Lights
.......................................$1.80

| | |
|---|---|
| Piling by contract .............................. | .40 |
| Shipping Expense | |
| Planing mill operation | |
| Planing mill repairs | |
| Barn expense | |
| ........................................ | 1.33 |
| General Expense: | |
| Office salaries | |
| Selling expense | |
| Office supplies | |
| Insurance | |
| Interest on borrowed money | |
| 6 per cent dividend on capital | |
| 1 per cent depreciation of plant each month | |
| ...................... | $2.73 |
| Total cost per M.................... | $12.18 |

## COLLECTION OF FOREST TREE SEEDS AND FRUITS.

M. Lazo.

As the study of forestry is rapidly growing in this country it is essential that the equipment of the forest schools should be more complete. One weak point in equipment is the lack of material for silvical and dendrological studies. For silvical studies, collections of certain growth forms and injuries, collections of seedlings from various regions and of different ages, would be invaluable in connection with text and lecture work. In dendrology collections of leaves, seeds, cones and other fruits are, in general, much better to work with than descriptions and illustrations. A collection of wood specimens showing the bark is about the only way a definite idea can be given of bark peculiarities. Some universities already have fine collections of herbarium material; the Harvard herbarium and the Jessup wood collection are both well known. Here at the University of Nebraska the herbarium consists of over 200,000 specimens while the wood collection of many species is valued at $5,000. There is also a collection of tree seeds and fruits of over 200 species, one-third of which are conifers; and a cone collection of about fifty of the more important coniferous species.

Herbarium material alone is undoubtedly of great use in dendrological work, but unless the specimens are supplemented by a working collection the material loses considerable value to the student. A working collection should consist of many specimens showing all sizes of seeds of each species. This means then that there should be two sets of material—one a permanent set of type specimens, the other a set of many specimens which will be used and handled by the students and will necessarily have to be replenished from time to time.

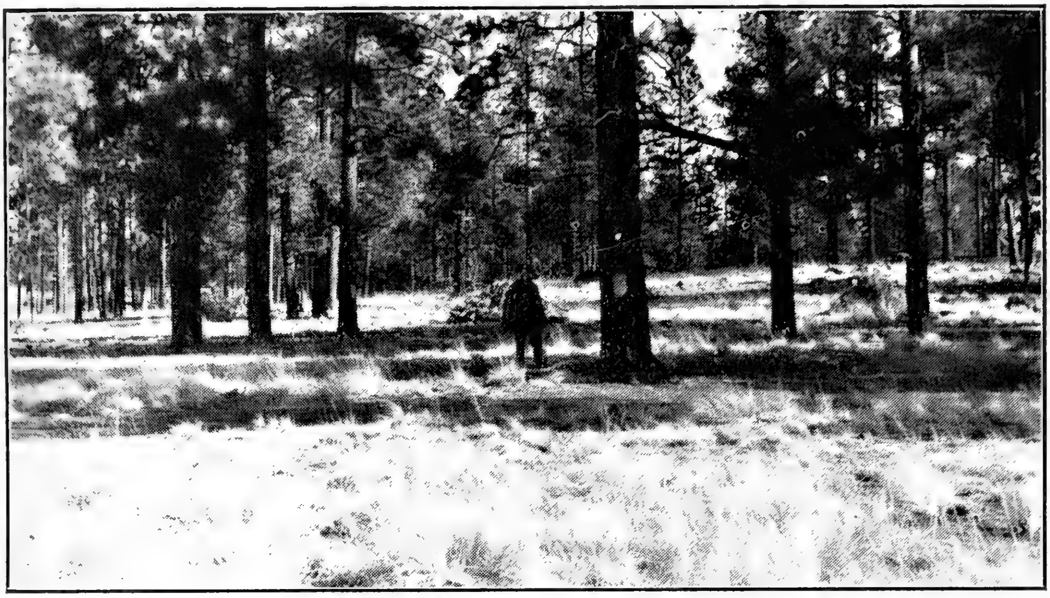
The seed collection should contain the smaller fruits such as those of elms, maples and ashes. Specimens of the same species from different regions showing marked differences in size should also be included. This difference may be brought out prominently by arranging series of various sizes on herbarium sheets. For instance, fasten across the sheet a row of *Pinus* *ponderosa* seeds from the Rocky Mountain Region and beneath that glue another row of seeds of the same species from the Pacific Coast Region. This would bring out the difference of sizes not only for the regions but it would also show a difference for the same species in the same region. A group showing the similarities and differences of the various coniferous genera fastened to one sheet would be instructive. So with the elms, birches, oaks, ashes, and many other hardwoods. These sheets then would comprise a part of the type collection of the smaller fruits and seeds. The larger fruits could be better cared for in glass covered drawers divided into small compartments; each compartment being large enough to contain several type specimens.

The working collection should consist of about a half pint of seeds of each species. The student undoubtedly gets great benefit from a mass of seeds, which he can handle over and cut to pieces as much as he desires. The mere act of handling causes him to become quite well acquainted with them; and if he is allowed to examine them with a jack knife and hand lens the image he has gained of those seeds will be retained a long time.

Most of the seeds at the University of Nebraska are kept in straight-sided screw-top glass jars which have capacities of one-half pint and pint. In general they show no tendency to mold or decay, if quite thoroughly dried before they are placed in the jars. A few seem to be normally the receptacle for certain insect eggs, which hatch out in the warm room, the larvae destroying the seeds. The seed of mesquite and honey locust seem to be especially unfortunate in this respect. This damage may be prevented to a large extent by fumigating the seeds with carbon bisulphide. A few cubic centimeters poured into the jar, and the top screwed tightly in place, will, if left for several hours, get rid of this danger. Some of the larger fruits such as acorns are especially liable to mold. Experiments are now in progress to determine whether the growth of the mold cannot be inhibited by keeping some dissicating substance in the bottom of the jar. Since none of these seeds are to be used for germination experiments, it may be possible to sterilize by dry heat and still preserve the form and structure of the seed.

The regular working collection of cones here at the University of Nebraska is kept in an herbarium case which contains drawers of various sizes. A dozen or more cones of each species are retained and whenever there are great differences apparent in cones of the same species from different regions, care is taken to preserve both types. The cones are grouped according to the alphabetical arrangement of genera and species as a matter of convenience. It has been found that open cones do not give the proper idea of size and shape, and to obviate this impression various methods are being tried to keep the cones closed without wrapping them in a clumsy mass of cord. A few specimens closed and a number open would be an ideal arrangement. The use of pins and small brads is a method that has given the best result so far, even with fir cones. Pins of various lengths were driven into the cone through the tip of the scales, short pins near the apex of the cone and the longer ones near the base. On the hard sealed yellow pine cones it is necessary to use brads, while on the softer sealed white pine cones pins answer the purpose very well. Covering the closed cone with coats of shellac was tried but did not give satisfactory results. Methods of keeping fir, hemlock, and tamarack cones closed are still to be tried.

PLATE I



A dense stand of "black jack" in which the mature "yellow pines" have been cut. No "yellow pines" needed for seed.

A comparatively open stand after cutting. A few "yellow pines" have been left for seed.

PLATE II

Partial View of Plantations at Arbor Lodge

PLATE III

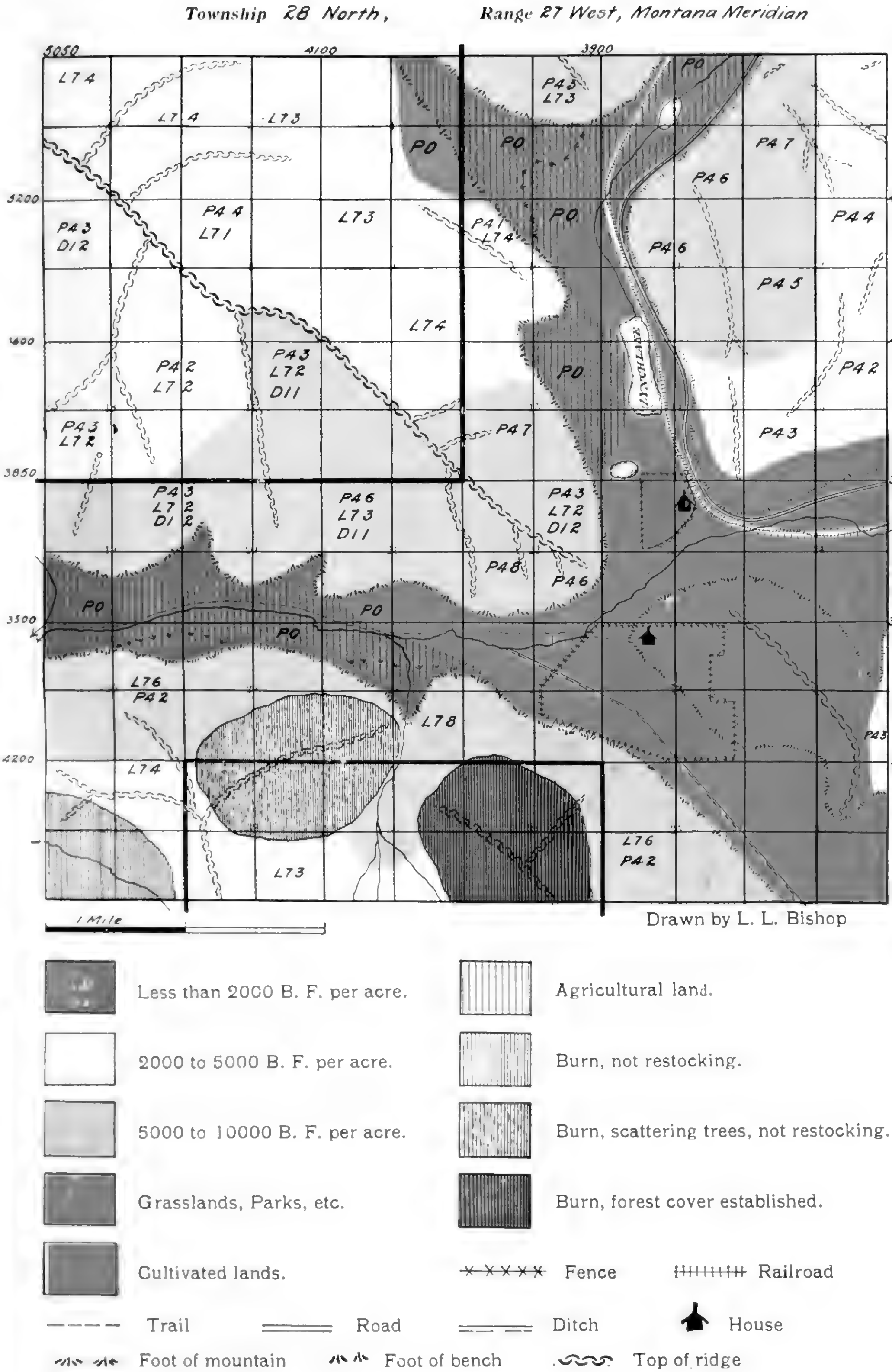
Thrifty Stand of Young Timber

High Type Forest Showing Excellent Reproduction

PLATE IV

Homestead on good Agricultural Land but Poorly Cleared.

Poorly Cleared Homestead

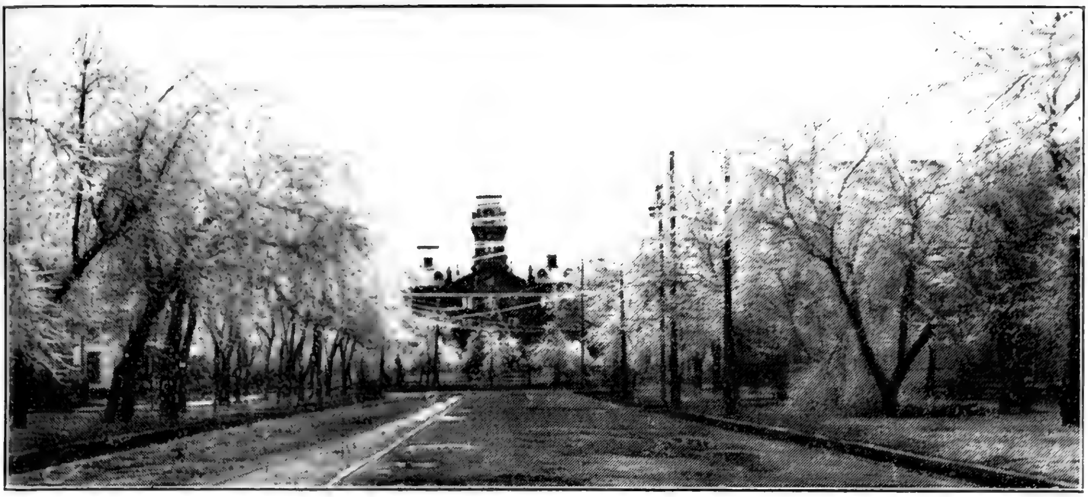



Sample township map, after method used by United States Forest Service.

PLATE VI

A new Homestead in High Class Timber

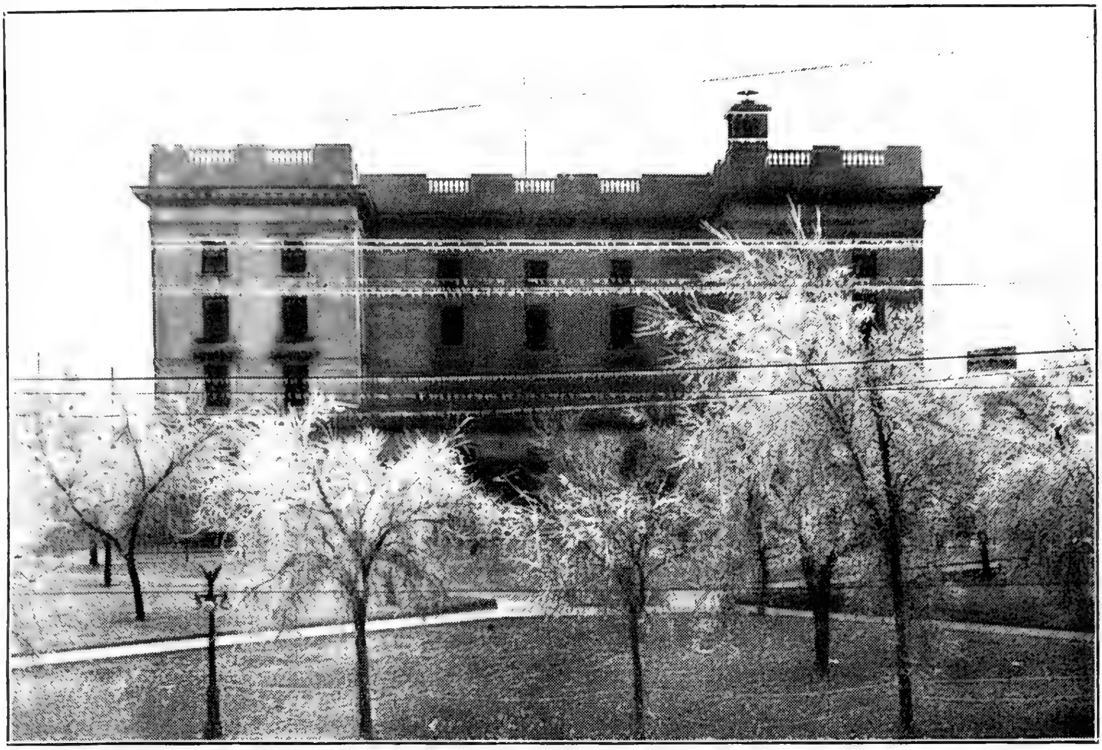
PLATE VII



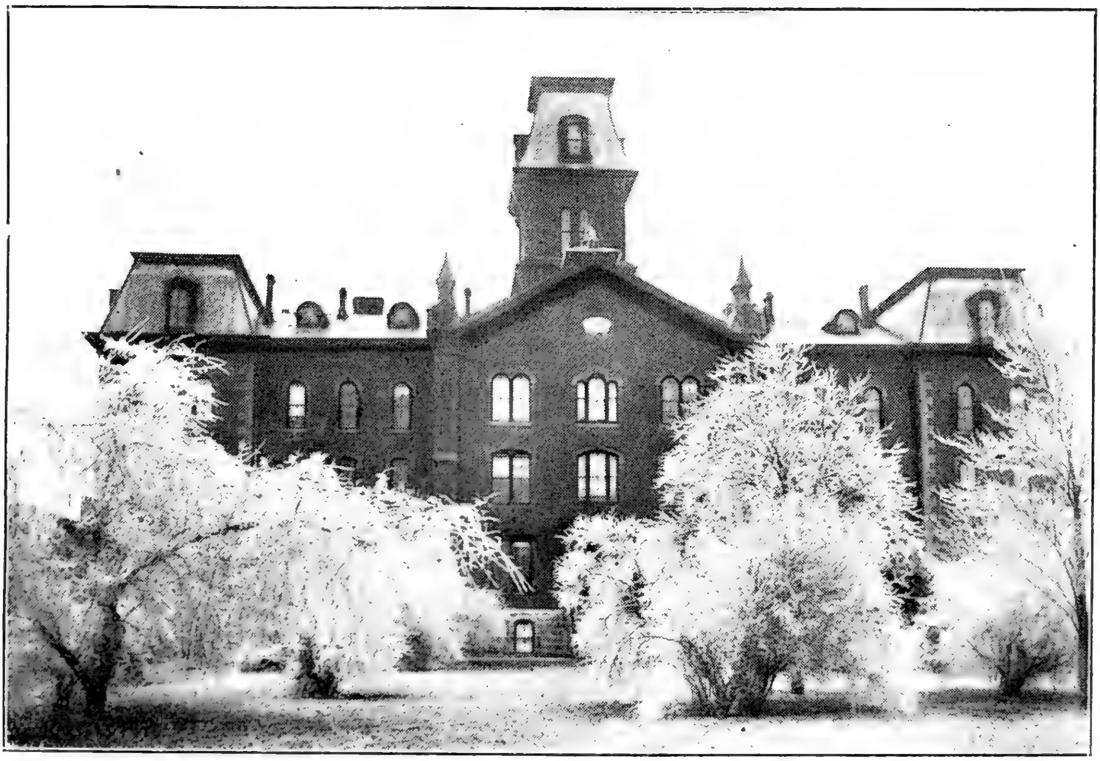
Ice Coating on Street Trees

Effect of Ice on Several Red Cedar

PLATE VIII

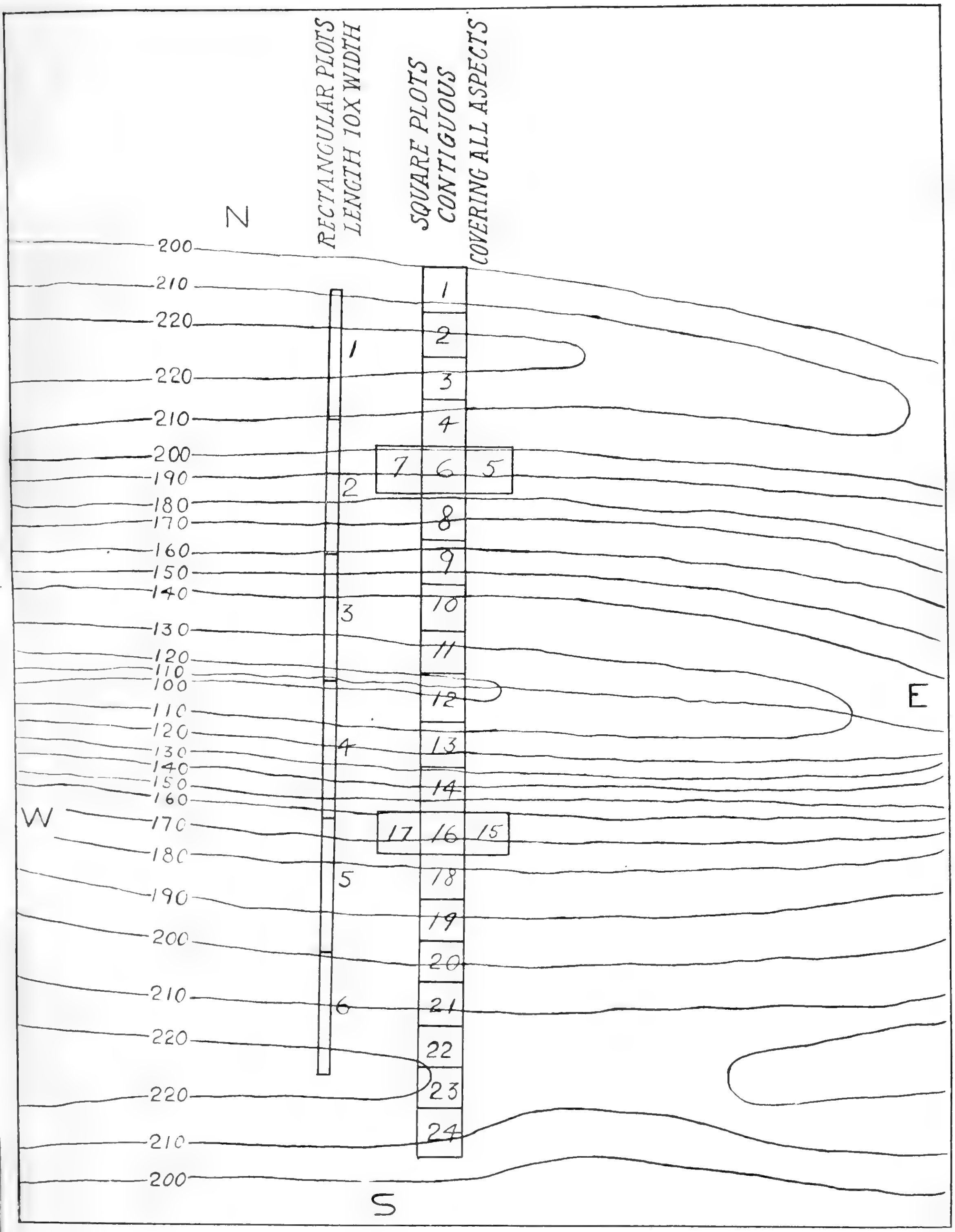


Ice Coating On Young Elms



Ice Coating on Campus Trees and Shrubs

PLATE IX


RECTANGULAR PLOTS LENGTH 10X WIDTH
SQUARE PLOTS CONTIGUOUS
COVERING ALL ASPECTS
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E
W
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210
220
220
210
200
190
180
170
160
150
140
130
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23
24

PLATE X

# SILVICAL MAP SHEET

*Plot* .............. *Block* ................. ............................................ *Forest.*

*T.* .............., *R.* ..............., ........................... *M., Section* ................., *Quarter* . .

*Character of Experiment* ..........................................................................

*Species* ..........................................................................

*Object of Examination* ..........................................................................

*Observer* .......................................... *Date* 19

*Mapped by* .......................................... *Scale:* *Inches* = *Feet.*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 |
| 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 |
| 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| 70 | 69 | 68 | 67 | 66 | 65 | 64 | 63 | 62 | 61 |
| 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
| 90 | 89 | 88 | 87 | 86 | 85 | 84 | 83 | 82 | 81 |
| 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |

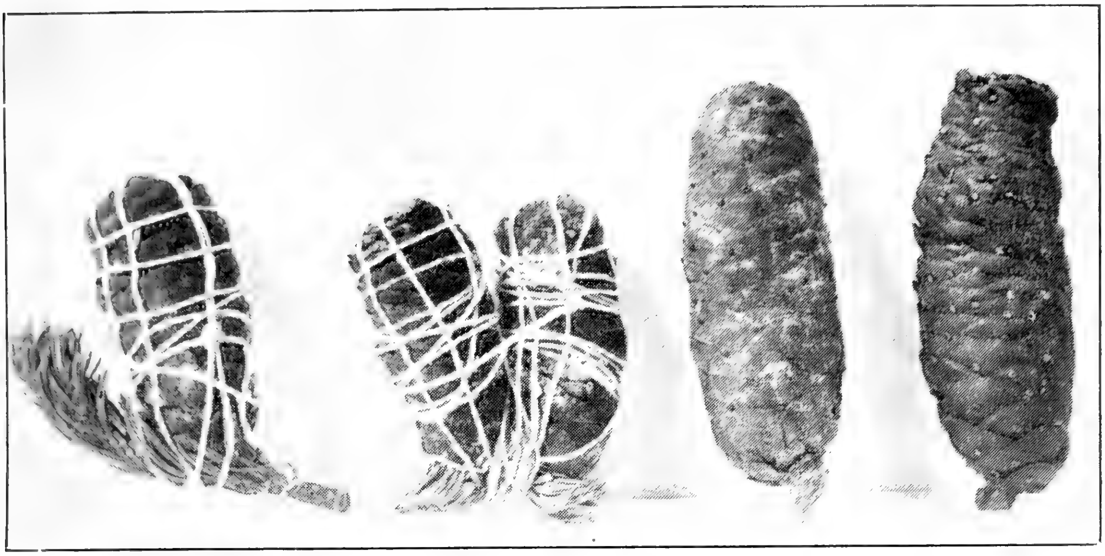
*Remarks:*

PLATE XI

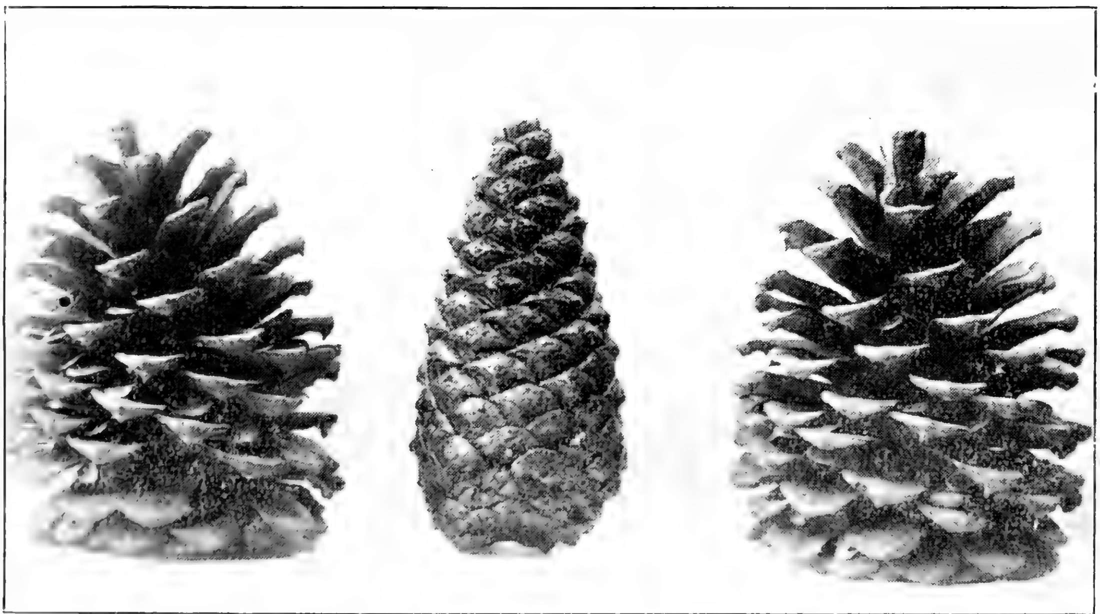

a. *Pinus palustris;* b. *Picea rubens;* c. *Pseudotsuga taxifolia;* d. *Larix laricina;* e. *Tsuga heterophylla;* f. *Abies concolor;* g. *Pinus taeda;* h. *Pinus ponderosa;* i. *Pinus flexilis;* j. *Pinus edulis;* k. *Liriodendron tulipifera;* l. *Ulmus americana;* m. *Fraxinus americana;* n. *Liquidambar styraciflua;* o. *Toxylon pomiferum;* p. *Nyssa sylvatica;* q. *Tilia americana* r. *Betula lutea.*

Natural size

PLATE XII



*Abies concolor*



*Pinus ponderosa*

# The Forest Club Annual

## Volume III 1911

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Entire credit for the publication of the Forest Club Annual is due to the patrons. The annual publishes articles on forestry and forest botany contributed by students, alumni, and others. The primary purpose of the annual is educational and it aims especially toward the development of the student.

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## FOREST CLUB PROGRAM, 1910-1911

OCTOBER 4.
Forest Nursery Work in New Mexico..............T. Krueger

OCTOBER 18.
A Year in Wisconsin Lumbering......................J. F. Buol
State Work in Ohio................................L. H. Douglas

NOVEMBER 1.
Forest Conditions in Idaho.......................Prof. Sponsler

NOVEMBER 15.
Silvical Notes on Washington Species..............C. F. Korstian

NOVEMBER 29.
Forest Insects in Nebraska..........................Prof. Bruner

DECEMBER 13.
Symposium—Forest Fires
Montana, R. Chapline
Nebraska, R. A. Phillips
New Mexico, E. T. F. Wohlenburg
Colorado, W. R. Martin

JANUARY 10.
Forest Ecology in Northern Michigan................Prof. Pool

JANUARY 24.
Symposium—Forest Reconnaissance
Colorado, S. V. Fulloway
New Mexico, O. F. Swenson
Montana, R. J. Guthrie
Washington, C. F. Korstian

FEBRUARY 7.
Basket Willow Investigations.........................G. N. Lamb

FEBRUARY 21.
Substitutes for Lumber in Nebraska................J. P. Lansing
Freight Rates on Lumber..........................B. Critchfield

MARCH 7.
Forest Conditions along the Mexican Boundary.....Prof. Phillips

MARCH 21.
Silvical Experiments in Forest Planting..............J. S. Boyce

APRIL 4.
Log Skidding and Transportation in Lake States....R. A. Phillips

APRIL 25.
The Revision of the Genus Cratægus..................Dr. Bessey

MAY 9.
Importance of Planing Mills in Forest Utilization......D. G. White

MAY 23.
Wood Pulp......................................Prof. Sponsler

# INDEX

# FACTORS INFLUENCING LOGGING AND LUMBERING COSTS IN COLORADO NATIONAL FORESTS.

By F. W. Morrell.

## INTRODUCTION.

In a discussion of the cost of lumber manufacture in any mountain region, even though it be a small area that is considered, prices will differ much, because of widely differing conditions in accessibility and labor. There is also a great variation due to the kind and quality of machinery and other equipment, and what might be termed the "personal element", or business ability of men engaged in the industry. Briefly stated, the principal factors affecting the cost, manufacture and marketing of lumber are as follows:

1. Accessibility.
   - (a) Distance of timber from railroad.
   - (b) Topography of country on which timber grows.
   - (c) Topography of country over which roads must be built to get timber to the railroad.
   - (d) Distance of loading point from market for lumber.
   - (e) Freight rates.
2. Labor.
   - (a) Cost of labor.
   - (b) Quality and supply of labor.
3. Equipment.
   - (a) Mills, wagons, sleds, etc.
   - (b) Horses.
   - (c) Supplies — cost of food and feed.
   - (d) Accessibility to base of supplies.
4. The personal element; the ability of operators to conduct a lumber business differs very widely, and the profits of different men operating under the same conditions are found to vary greatly.
5. The climate conditions; especially the amount of snow fall, upon which depends the possibility of operating throughout the winter months.

## FACTORS GOVERNING STUMPAGE PRICES.

The usual steps in the process of manufacture, upon the basis of which stumpage prices are in part regulated on the National Forests are as follows:

1. Cutting.
2. Skidding.
3. Logging.
4. Roads; logging and lumber roads.
5. Sawing.
6. Planing and seasoning.
7. Hauling.
8. Loading.
9. Brush piling.
10. Freight.

In this discussion these items of cost will be considered as being affected by other varying factors.

GENERAL CONDITIONS.

Cost of operating in different localities is affected principally by the remoteness of the tract from settlement, by climatic conditions and by cost of labor.

If the timber is situated far from settlement, the cost of operating is increased by the greater cost of food-stuffs, feed and equipment that is occasioned by the long haul. The cost is also increased on account of the difficulty in securing men, because as a general rule they prefer to work nearer towns, and so increased wages must often be paid to hold them. If the timber is at high elevations where the snow fall is heavy, the cost is increased on account of the necessity of operating in deep snow or closing operations for several months until the snow has melted. Both of these hardships increase cost greatly, since deep snow necessitates digging around the trees in order to cut the stumps low and adds cost in the trimming and the sectioning of trees. Cost of brush piling, skidding, logging and hauling are also increased on account of snow.

If the lumberman takes the alternative of stopping operations during winter months, which is usually done in the more snowy regions from about February 1 to June 15, he usually loses because the money invested in equipment is bringing no returns, and the horses must be fed during an idle season. If the necessary labor is available and the operator has the capital he can prevent this loss by banking logs during the summer and fall for winter sawing.

In Forest Service contracts no distinction in cost is made for the various factors affecting the manufacture of different species. Engelmann Spruce and Lodgepole Pine are more easily cut, sawn and hauled than are Douglas Fir and Western Yellow Pine, but there is more brush to be trimmed and the trees are smaller, so the cost is about equalized. The lowest prices for

PLATE I.

Felling Crew on the Colorado National Forest.
Engelmann Spruce Tree Scaling 2,200 Feet.

Good Brush Piling in a Dense Stand, except some Piles are too Close to Living Timber.

labor are paid on the eastern slope of the Continental Divide, and in the southern part of the State, where climatic conditions are best and the timber is located nearer to the labor supply. The highest prices are as a rule paid in the northern part of the State on the Routt and the Medicine Bow National Forests, where winters are long and severe, transportation facilities are poor, and it is a long distance from towns of any size.

CUTTING.

As a usual thing Western Yellow Pine can be cut somewhat cheaper than the other species. The general factors influencing cost favor it on account of its growing at low altitudes and being more favorably situated climatically. The logs are larger and other things being equal trees can be sectioned more cheaply on this account. Another factor in favor of this species is the small amount of rot, but this advantage is offset by the fact that the wood is harder and saws somewhat more slowly. The previous advantages make the contract prices for cutting Western Yellow Pine about 25 cents per thousand board feet cheaper than Lodgepole Pine or Engelmann Spruce. Even though it saws as readily, it costs a little more to cut Lodgepole Pine than it does to cut Engelmann Spruce because the trees have a smaller diameter and are not so tall. This usually makes the cost of sawing Engelmann Spruce about ten to twenty-five cents lower than that of Lodgepole Pine, but no difference is made in contract prices.

The cost of cutting varies from $1.00 per thousand for Western Yellow Pine, to $2.00 for Lodgepole Pine and Engelmann Spruce in deep snow. The average cost for Western Yellow Pine is about $1.25 per thousand and for other species about $1.50.

SKIDDING.

The cost of skidding will depend, like that of cutting, upon the accessibility to labor and food supplies, and upon the climatic conditions. Other items affecting it are the topography of the area being logged, the cost of horses and of horse feed, the density of the stand, and the amount of fallen timber and undergrowth.

The difference due to accessibility of labor and of food supply are apparent from the discussion of the cost of cutting.

Deep snow adds greatly to the cost of skidding as a general rule. When snow becomes more than three feet deep it usually becomes necessary to dig out skid trails and the increased cost in doing this is evident. In the snowy regions, timber cut and not skidded may be entirely covered by the snow fall of a single day and it is then difficult or impossible to find the logs. The cost may easily be doubled on account of the snow in the high altitudes. If the logs are cut during summer they can be skidded before snowfall, and thus eliminate this item of increased cost.

In rough country with many boulders and rock slides, skidding is difficult and expensive. Where the ground is very rough it is sometimes impossible to skid until it is covered with snow, and the cost may be easily tripled, considering the increased expense of cutting and skidding in snow.

The denser the stand the smaller the cost of skidding, other things being equal. A dense stand makes it possible to haul out more logs over the same skid-trail and shortens the distance the logs must be hauled in order to fill a skid-way. Considering this factor alone the cost of skidding Engelmann Spruce and Lodgepole Pine is less than that for Western Yellow Pine or for the usual stand of Douglas Fir, because the stands are denser.

The cost of skidding increases with the amount of fallen timber and undergrowth, due to increased cost of swamping skid-trails and skid-ways.

### LOGGING.

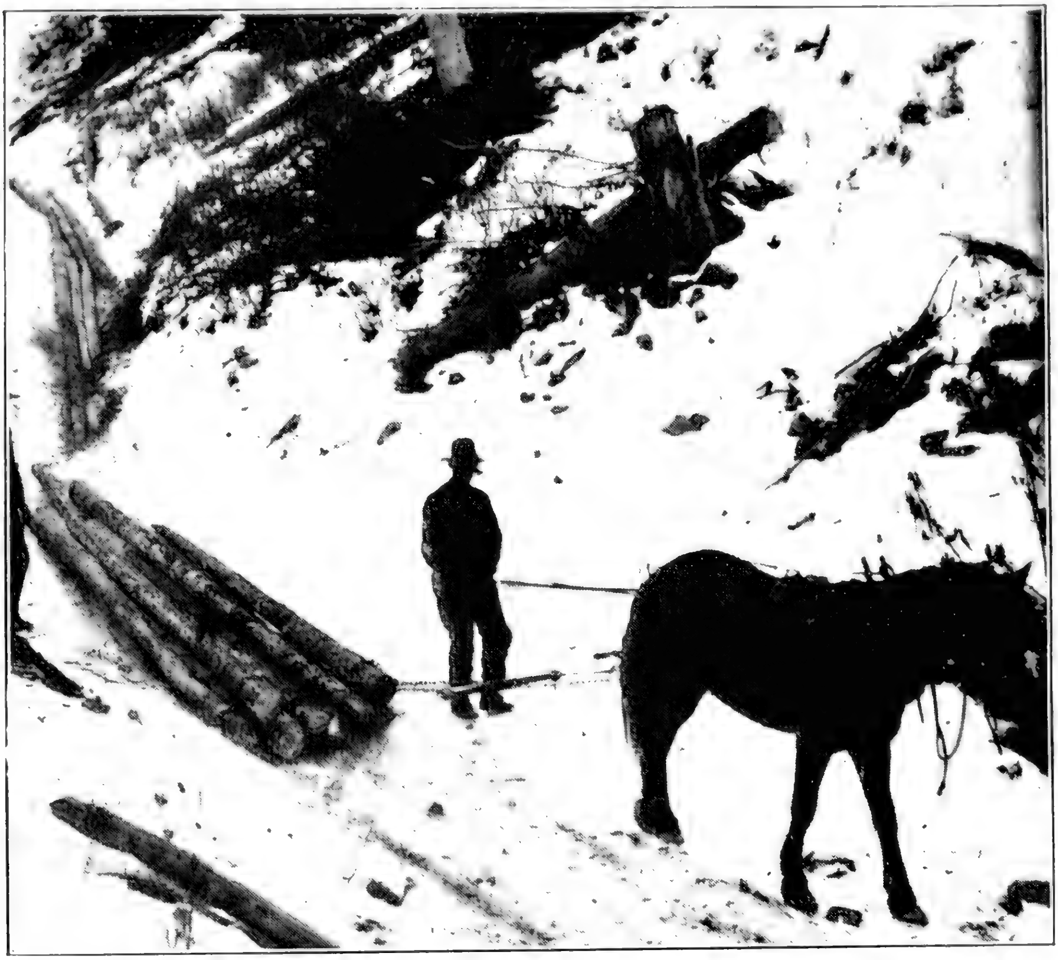
Like skidding, the cost of logging depends largely on the topography of the country and the climatic conditions. It also varies greatly with the distance from the timber to the mill. Where a good road can be constructed the expense of logging is very materially lessened. A moderately steep grade of 8 to 14 per cent. is often desirable, because large loads can be taken down it, and the climb is not so steep as to be too heavy a burden for the team. Roads which wash, are too rocky, or are boggy, or lie so that they become icy, materially increase cost. On an average road where the lumber is not more than 80 rods from the mill, five or six trips per day can be made. From four to five hundred board feet is an ordinary load for two horses and a cart or single bob. The cost will vary from $1.75 to $3.00 per thousand, with an average of $2.25.

### BRUSH PILING OR SCATTERING.

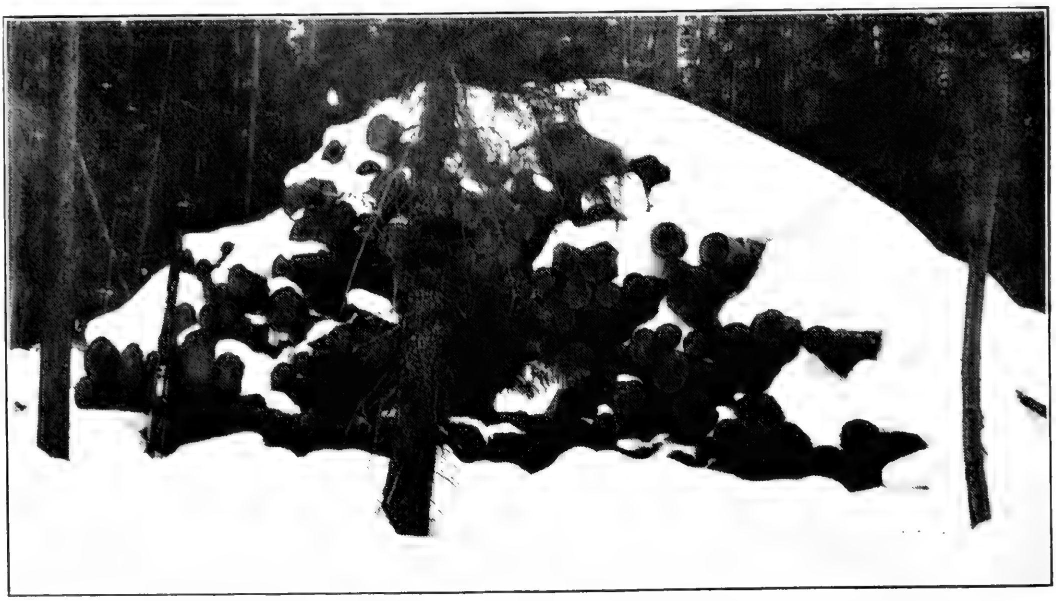
If properly done, there is no appreciable difference between the cost of piling and of scattering brush.

Of the commercial species in the State the cost is highest for Engelmann Spruce and Lodgepole Pine, there being little

10a



Skidding Small Poles on Typical Slope. Skid-road Better Worn and has Less Brush than Usual.



Logs Skidded before Snowfall. Digging out Roads Increases Cost.

PLATE III.

A Good Mountain Lumber Road, White River National Forest.

Logging Road in Early Spring, White River National Forest,
Showing Deep Snow which Increases Cost.

difference in the two species. The larger number of branches in these two species brings the cost above that for Douglas Fir and Western Yellow Pine. The two latter species rank lowest because the trees grow larger and a greater portion of the bole is free from branches.

Brush piling and scattering becomes disagreeable and difficult when snow falls, and cannot be satisfactorily done when snow is more than twelve to eighteen inches deep. This factor enters very little into the cost of Western Yellow Pine and Douglas Fir, for these species grow at lower altitudes, and there is a longer working season free from snow. Cost of piling will increase with the amount of dead material and young growth, because piles must be put where they can be burned with the least injury to the young growth and must not be placed on fallen timber which would catch fire when the brush is burned. Western Yellow Pine is again favored here, for it grows in open stands and piles can be placed with less difficulty. Steep rough ground also adds slightly to the cost of piling because the men can not work so rapidly as on level ground.

An average cost for brush piling in Engelmann Spruce and Lodgepole Pine is 50 cents per thousand and will usually lie between 35 and 75 cents. The cost of piling Western Yellow Pine will vary from 25 to 50 cents with 35 cents as a fair average. Douglas Fir will probably average 40 cents.

### ROADS.

The cost of Western Yellow Pine is lessened by a longer working season and the lower cost per mile for logging roads since this species grows at lower altitudes and on land of less rugged topography. The relative cost per thousand for this species is increased, however, by the fact that the stand is thinner and more road is necessary. Douglas Fir is probably at the other end of the list for it grows on extremely rough, rocky situations and on the sides of steep canyons where road building is very expensive. Engelmann Spruce comes next for it grows at high altitudes. The only items which bring its cost above that of Lodgepole Pine are heavier snowfall and more rigorous climatic conditions.

The cost of lumber roads will usually be least for Western Yellow Pine, with Douglas Fir second, Lodgepole Pine third and Engelmann Spruce greatest. The cost of roads in Western Yellow Pine is least because it is found at lower altitudes and is nearer the valleys where railroads and settlements create markets. The cost increases for the other species in proportion to the altitude of their situation. There are many exceptions to this general rule, since there are many markets in mining camps which are located at high altitudes, nearer the Engelmann Spruce and Lodgepole Pine. Leadville, Aspen, Redcliffe, Creede and Steamboat Springs all furnish markets at high elevations.

It is extremely difficult to quote an average cost for road building. There is a great deal of timber so far from market and in such rugged country that the cost of roads alone would be more than the timber would be worth on the market. More money of course can be spent on lumber roads when the lumber can be hauled to the point of consumption without shipping. This is done by small operators at towns located near a timber supply, such as Steamboat Springs, Del Norte and Monte Vista.

One dollar per thousand is a fair estimate of the average cost of logging and lumber roads combined, and the cost will vary from nothing to six dollars per thousand. Road building is one of the biggest stumbling blocks to successful operating. Many purchasers fail to make any profit or actually lose on their investment on account of underestimating this item.

### SAWING.

Aside from the general factors entering into the cost of manufacture, there is little difference for the different species. Western Yellow Pine can be sawed at a slightly lower cost than the other species because feed is nearer, it has better climatic conditions, the average log is larger, and market is nearer. Engelmann Spruce could probably be sawed a little more cleaply than Lodgepole Pine, because the logs are larger and there is less dry rot. All things considered, there is little difference in the four species. An average cost for all species for the State would probably be $2.50 per thousand with prices varying from $1.75 to $4.00.

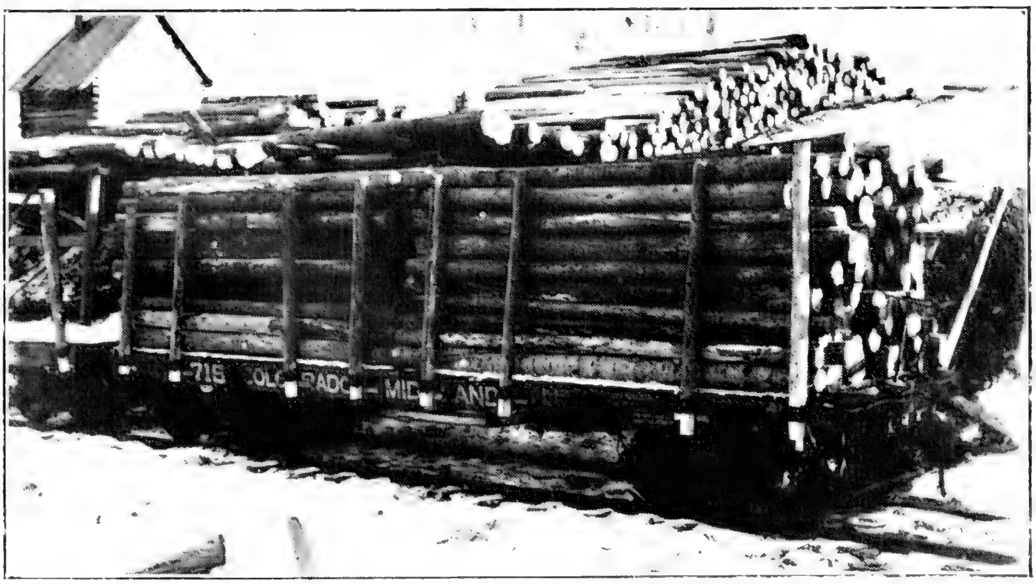
The cost of sawing will vary with the size and equipment of the mill. There are very few mills sawing National Forest lumber in the State with a capacity of over 10,000 feet per day and a large percentage do not average over 5,000 feet. The average mill with a capacity of 10,000 feet will probably saw from 25 to 40 cents per thousand cheaper than one of 5,000 feet capacity for it does not require as much help per thousand feet capacity; one sawyer, one ratchet-setter, and one engineer are required in each mill.

### CURING AND PLANING.

Only a small percentage of the native lumber sold in the

PLATE IV.

Typical Sawmill on a National Forest in Colorado.



Loaded Logs, Sopris National Forest, where Sawmills are at a Distance.

PLATE V.

Typical Load and Outfit for Long Haul, Sopris National Forest.

A "Double Bob" load of Logs Where Sleighing is poor, Sopris National Forest.

State is planed. There are no special factors entering into the cost and there is no appreciable difference for the different species. The cost will vary from $1.50 to $2.50 per thousand, $2.00 being a fair average.

No curing is done further than piling the lumber at the mill for drying and there is no difference in cost for the different species.

### HAULING.

Western Yellow Pine and Douglas Fir will cost slightly more to haul than Engelmann Spruce and Lodgepole Pine, because they are heavier. Lumber roads are usually better for the species growing at lower elevations as discussed under "Roads". As a general thing these species will also be favored by the climatic conditions, which are more favorable at the lower altitudes.

It is difficult to state an average price for this item. The quality of the roads enters very largely into the cost, because it decides the quantity that can be hauled on a load. The road is usually on a slope and frequently the hardest end of the trip is the return of the empty wagon to the mill. One thousand board feet is a fair load for two horses, but where four are used three thousand feet is often hauled at a load. At distances where one trip can be made per day, the average cost of a seven to ten mile haul will be about $4.00 per thousand; for three to six miles it will be about $3.00 per thousand and for ten miles or over it will be more than $4.00. Well dried lumber can be hauled at less cost than green lumber.

### LOADING.

There are no special conditions affecting cost of loading for different species. Where there is room beside the railroad track to construct a platform where the lumber can be piled as unloaded from the wagon, it can be put on the cars at a slightly reduced cost because it does not require so much lifting. An average cost per thousand for loading is 50 cents.

### FREIGHT.

The heavier species will cost more per thousand for shipping, unless shipped on a line where the cars are not weighed. The cost is ten per cent higher for Western Yellow Pine and Douglas Fir. An average load on a standard guage car is 30,000 board feet, which will weigh approximately 100,000 pounds. Freight rates usually vary from six to twenty cents per hundred weight, varying of course with the length of the haul, the rates of the particular road over which it is hauled, and often according to the grade of that part of the road over which it is carried, extra freight being charged for a steep uphill haul. $3.00 per thousand is probably a fair average of the expense for freight.

# FOREST TREES ON THE POLLARD ESTATE AT NEHAWKA, NEBRASKA.

By R. T. Guthrie.

For the purpose of aiding in the collection of definite information on native and exotic trees in Nebraska, a list was recently made of trees growing on the Pollard estate at Nehawka. A similar study was made last year on the Morton estate at Nebraska City, the results of which were published in Volume II of the Forest Club Annual.

Nehawka is only fourteen miles distant from Nebraska City and seven miles from the Missouri River; the soil and climatic conditions are practically the same in both places. All the trees on the estate have been planted within the last forty years by Mr. Pollard, who has been greatly interested in finding trees suited to local conditions. Most of the trees studied were growing on and near the top of a low hill where the majority grow in the open and are branched low or quite to the ground. In only one instance were the trees planted close enough together to kill the lower branches. This was in a shelterbelt about 400 feet long of Austrian Pine (*Pinus austriaca* L.) composed of three rows planted six feet apart. The trees averaged from 34 to 38 feet in height and 8 to 14 inches in diameter at breast height. The trees on the outer sides of the belt were branched to the ground but the branches of the inner row, though persistent, were killed about three-fourths to five-sixths of the height of the trees. No weeds or grass occurred and the forest floor was covered with needles.

Of the 49 tree species and varieties in the following list seven are foreign and the rest are native to the United States.

*Abies concolor* (Gord.) Parry. White Fir. Height 10 feet, diameter 2 inches. Branched to the ground, excluding grass. Pyramidal crown.

*Acer negundo* L. Box Elder. Height 28 feet, diameter 7 inches, clear length 5 feet.

*Acer saccharinum* L. Silver Maple. Height 45 to 48 feet, in a small open grassy park, diameter 4 to 10 inches, clear length 20 feet. Older trees, standing alone were 24 inches in diameter.

*Acer saccharinum wierii* (Pax.) Sudw. Cutleaf Silver Maple. Height 12 feet, diameter 2 inches. Hybrid, propagated by cuttings.

*Acer saccharum* Marsh. Sugar Maple. Height 37 feet, diameter 8 inches, clear length 6 feet.

*Castanea dentata* (Marsh) Borkh. Chestnut. Height 41 feet, diameter 12 inches, clear length 8 feet. Hard to start but makes good growth after the first few years.

*Catalpa speciosa* Warder. Hardy Catalpa. Height 18 feet, diameter 3 inches.

*Cornus alternifolia* L. Blue Dogwood. Height 7 feet, shrubby.

*Cornus asperifolia* Michx. Dogwood. Height 12 feet, shrubby growth.

*Eleagnus angustifolia* Linn. Russian Olive. Height 30 feet, diameter 8 inches.

*Eucalyptus globulus.* Eucalyptus. Height 6 inches. Hard to start. Not likely to become established because of lack of frost resistance.

*Fraxinus lanceolata* Borkh. Green Ash. Height 25 feet, diameter 5 inches.

*Gleditsia triacanthos* L. Honey Locust. Height 40 feet, diameter 26 inches, clear length 10 feet.

*Hicoria minima* Britt. Bitternut (Hickory). Height 33 feet, diameter 6 inches, clear length 8 feet. Natural growth, mixed with Bur Oak (*Quercus macrocarpa*). Open stand permitting the growth of grass about the base.

*Hicoria pecan* Britt. Pecan (Hickory). Height 7 feet, in nursery row. Very hard to start, but has grown well for several years; not very frost resistant.

*Juglans nigra* L. Black Walnut. Height 40 feet, diameter 18 inches, clear length 8 feet, 40 years old.

*Juglans sieboldiana* Maxim. Japanese Walnut. Height 6 feet, in nursery row. Not hardy; frosted back but sprouting.

*Juniperus communis* L. Common Juniper. Height 6 feet, branched to the ground.

*Juniperus scopulorum* Sarg. Rocky Mountain Juniper. Height 10 feet, thin crown, branched low.

*Juniperus virginiana* L. Red Cedar. Height 24 feet, diameter 5 inches, partially shaded, thin crown.

*Larix occidentalis* Nutt. Western Larch. Height 38 feet, diameter 12 inches, clear length 8 feet.

*Magnolia acuminata* L. Cucumber Tree. Height 7 feet, nursery row. Not frost hardy; protected by straw in the winter.

*Morus rubra* L. Red Mulberry. Height 12 feet.

*Picea canadensis* (Mill.) B. S. P. White Spruce. Height 40 feet, diameter 12 inches, branched to the ground.

*Picea excelsa* L. Norway Spruce. Height 34 feet, diameter 9 inches, branched to the ground.

*Picea parryana* Sarg. Blue Spruce. Heighth 18 feet, diameter 10 inches. Branched to the ground, excluding grass. Regular pyramidal head. Very hardy, an excellent ornamental tree.

*Picea rubens* Sarg. Red Spruce. Height 27 feet, diameter 6 inches, branched to the ground.

*Pinus austriaca* L. Austrian Pine. Height 38 feet, diameter 24 inches, in shelter belt.

*Pinus divaricata* Du M. de C. Jack Pine. Height 25 feet, diameter 5 inches, branched to the ground; scrubby growth.

*Pinus ponderosa* Laws. Western Yellow Pine. Heighth 12 feet, diameter 3 inches, branched to the ground, excluding grass.

*Pinus strobus* L. White Pine. Height 42 feet, diameter 20 inches, branched to the ground, excluding grass about the trunks. A row of old trees, one-fourth mile long, has made good growth.

*Pinus sylvestris* L. Scotch Pine. Height 30 feet, diameter 6 inches, clear length 6 feet.

*Populus alba* L. White Poplar. Height 48 feet, diameter 25 inches. Does not make straight growth.

*Populus deltoides* Marsh. Cottonwood. Height 55 feet, diameter 26 inches, clear length 15 feet.

*Populus nigra italica.* Du Roi. Lombardy Popular. Height 38 feet, diameter 7 inches. Not hardy; frozen back and sprouting all down the stem.

*Prunus serotina* Ehrh. Black Cherry. Height 25 feet, diameter 6 inches, clear length 7 feet.

*Pseudotsuga taxifolia* Britt. Douglas Fir. Height 10 feet, diameter 3 inches, branched to the ground, excluding grass.

*Quercus macrocarpa* Michx. Bur Oak. Height 35 feet, diameter 8 inches, clear length 7 feet. Natural growth, very open, allowing the growth of grass.

# A RARE FORM OF ASPEN.

By J. S. Boyce.

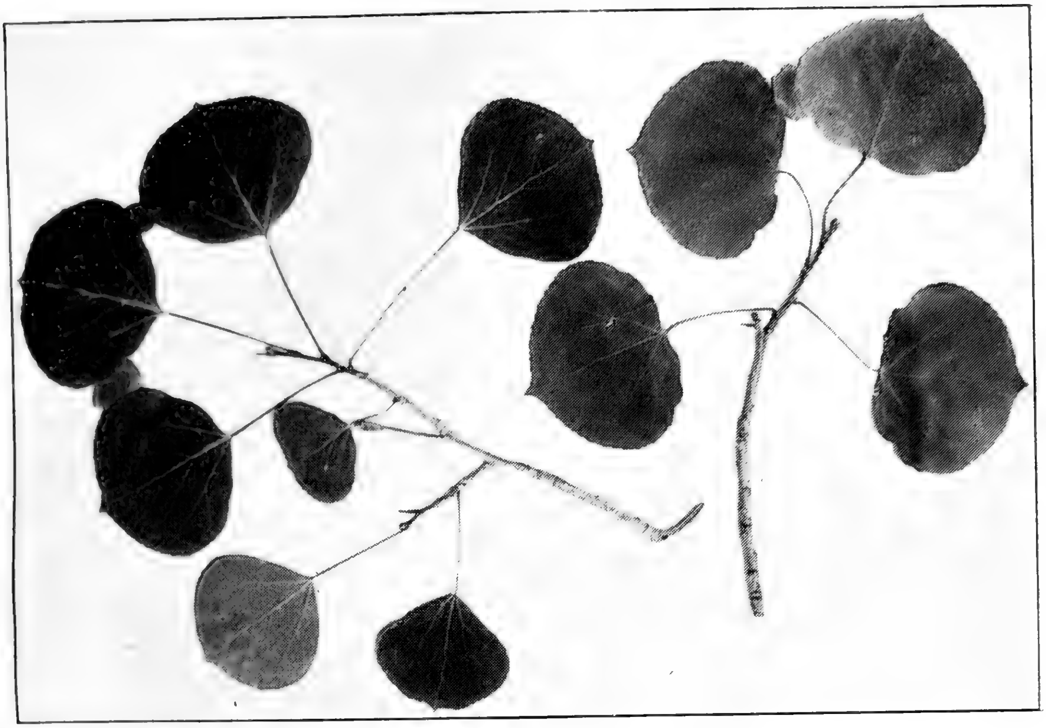
Aspen (*Populus tremuloides* Michx.) is not a common species of the Southwest because there are only a few mountain peaks or ranges which are high enough to cause favorable climatic conditions. One of the best areas for a study of the species in Arizona is to be found on the Coconino National Forest which is located in the mountains of northern Arizona. About the San Francisco peaks the aspen occurs on many slopes at an elevation of 7600 to 8000 feet or higher in intimate mixture with Western Yellow Pine (*Pinus ponderosa* Laws.). At the lower altitude of 7000 to 7300 feet the species is usually confined in detached clumps to the heads of small draws.

The type form of aspen on the Coconino Forest has semi-orbicular sometimes ovate leaves with very slightly pubescent margins. The apex is abruptly narrowed into a short broad point, slightly serrate with small incurved glandular teeth, while the base is cordate-truncate, wavy in outline and without serration. The petioles are compressed laterally and are usually greenish, rather heavily tinged with red. The leaves are a dark green color on the upper side but are lighter on the lower side. In the autumn they turn to a rich golden yellow, an orange red or occasionally a russet brown and the last two colors are particularly noticeable on trees situated in the bottom of small canyons. The bark is prevailingly whitish and of a lighter shade than is found in the Northeast.

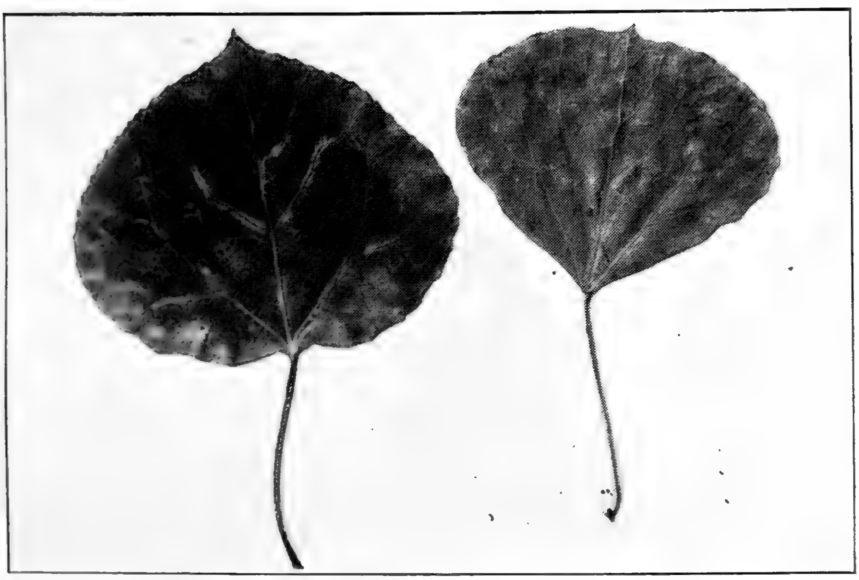
An undescribed type of aspen for this locality was found at an altitude of 8600 feet, aneroid determination, covering about an acre. The stand is located approximately an eighth of a mile northeast of Campbell's Ranch along a trail leading up from the house on the south slope of the San Francisco Peaks. The site is a gentle slope with a southeast aspect where the soil is six inches to two feet or more in depth, rich and composed of fine particles with numerous large granitic boulders and many small rocks.

The trees occur in a few small clumps of pure stands gradually grading into the widely distributed prevailing type. Other species in mixture are Western Yellow Pine, Limber Pine (*Pinus flexilis* James), and Douglas Fir (*Pseudotsuga taxifolia* Britt.). White Fir (*Abies concolor* Gord.) and Arizona Cork Fir (*Abies arizonica* Merriam) are found at the same elevation but not in mixture since none of these species occur in this immediate

PLATE I.



Left Hand Figure—New Type of Aspen.
Right Hand Figure—Usual Type of Aspen.



Left Hand Figure—Usual Type of Aspen.
Right Hand Figure—New Type of Aspen.

area. The ground cover under these clumps of aspen is a decaying leaf litter varying from one inch to three inches in depth with some decaying branches and a dense stand of large ferns.

The site is very favorable as far as moisture conditions are concerned. During the rainy season which commenced after the middle of July and ended early in September of the abnormally dry summer of 1910, this particular vicinity received a little over eight inches of rain. The maximum temperature for the entire year is about 85° F. and the minimum temperature about 30° F. below zero.

The trees have a long clear length with slender crooked branches which stand out almost at right angles from the trunk. This forms a small, open, dome-like crown which in thick stands is very short and gives a squat appearance to the top of the tree. The clear length ranges from ten to thirty feet on most of the large trees. Trees two inches to three inches in diameter at breast height rarely have a clear length of less than five to six feet, which is probably due to some extent to grazing, although this species naturally cleans itself well on favorable sites. A few trees 24 to 26 inches diameter at breastheight and 50 to 60 feet tall were found, which were still making excellent growth. Small trees that have been injured by grazing have a tendency to develop abnormally large leaves the next year, many of which measure nearly five inches in width.

The leaves are almost uniformly broadly obovate, rarely broadly orbicular with a pronounced obtuse base which is regular or slightly wavy in outline, with small, incurved, glandular teeth, a pubescent and a small, often slightly arcuate apex. The leaves are pea green in color on the upper side but much lighter on the lower side with greenish, to greenish slightly tinted with red, petioles. In the fall these leaves change to a lemon color with the petiole the same color or very slightly tinged with red. The young branches are light gray, grayish olive or dark gray in color with sometimes a tinge of green.

The bark on trees up to eight inches in diameter is conspicuously marked with lenticels which vary from one-eighth to one inch or more in length. The bark is always very smooth and never breaks up except on very large trees and then only near the base. The older trees are marked with black rounded protuberances and scar-like marks.

The main points of difference between the two types are in the leaves which differ in shape, the pubescence of the margin, color, serration, apex of tooth, color of petiole, the color the leaves turn in autumn and in the lenticels on the bark of trees up to eight inches in diameter.

# FOREST TYPES AND THEIR RELATIONS TO BURNS ON THE GILA NATIONAL FOREST.

By O. F. Swenson.

It has been well recognized for a long time that different forest types show distinctive injuries and that they are controlling influences in the severity and the destructiveness of forest fires. This is especially true in a mountainous region where topography causes a larger number of variable and abruptly marked types than are to be found over level areas. The result is a greater diversity of burn effect in mountainous regions which is especially true in the Southwest.

The effect of different aspects on type offers the greatest contrast as a rule when the north slopes are compared with south slopes. It is common to find north slopes in the Gila National Forest which support perfect stands of high class timber while the south slopes of the same mountains may support a pronounced desert type of stunted, shrubby vegetation which has little density and ground cover. Again, on a northern exposure, one may occasionally find a stand of one species while in the same locality on southern exposure, there may be a pure high class stand of an entirely different species. Peculiarly enough, the yield per acre may occasionally be the same on these different slopes, though the trees show a wide variation in diameter, height and form factor. These extremely diversified type conditions, brought about by topographical features which in turn affect climatic and edaphic conditions, are the controlling factors in the extent and severity of the forest fires. Consequently a study dealing with fire injuries must involve a consideration of the forest types and their relative influence in the causes of fires, injury to timber and to site, and in methods of fire fighting.

Good opportunity for the study was found in the Mogollon Mountains of the Gila National Forest where the varied topography gives rise to almost every representative forest type found in the Southwest. The following types are the prevailing ones in these mountains:

I. Woodland type.
  1. Conifers over mesas and dry slopes.
  2. Mixed conifers and broad-leaved trees along stream courses.

II. Western Yellow Pine type.

PLATE I.

Woodland Type in Transition Area between Woodland Proper and Lower Western Yellow Pine Type.

Western Yellow Pine Type showing Park-like Nature of Certain Areas.

III. Composite or Transition type.
IV. Fir type.
V. Sub-alpine type.

WOODLAND TYPE.

The coniferous woodland is usually found at an elevation of 5,000 to 7,000 feet over gentle slopes which have a moderate to deep soil of gravel or heavy adobe. Occasionally the type extends higher than this on the south slopes which are exposed severely to the sun, lack in soil depth, and have a severe wind sweep. The principal species are Pinon Pine (*Pinus edulis* Engelm.), Alligator Juniper (*Juniperus pachyphloea* Tou.), One-seeded Juniper (*Juniperus monosperma* Sarg.) and Gambel Oak (*Quercus gambelii* Nutt.). Occasional specimens of Emory Oak (*Quercus emoryi* Tou.) and Canyon Live Oak (*Quercus chrysolepsis* Liebm.) are also found. These species normally occur in orchard-like stands with a density of 0.1 to 0.3 or rarely more. Bunch grass is common and in some cases may form an almost complete ground cover.

In this sub-type, surface fires are almost universal although crown fires have been reported in other regions. The principal causes of fires in this type are from herdsmen and campers. Lightning causes fewer fires in this type than in the higher class forests. Where grazing is severe and the grass is given little opportunity to grow, fires may be rare but if the grass has made a luxuriant growth and has not been grazed, serious damage may result. Where grazing is moderate and herdsmen are careful, there should be only slight danger from fire.

Where cordwood operations have been carried on, fire danger to reproduction may be increased since most of it occurs in the partial shade of the old trees and brush is usually scattered over this reproduction to some extent. In some cases, it may be advisable to lop the brush and scatter it. In general, it is believed that more stringent care should be taken in preventing fires since the brush is naturally widely scattered because of the distance between the trees and because clean cutting has not been practiced on government land to any extent. In normal surface fires, the species suffer according to the following list in which the worst affected species are placed first: Pinon Pine, One-seeded Juniper, Alligator Juniper, Gambel Oak, Emory Oak, Canyon Live Oak.

The open nature of this sub-type and comparatively level land permits easy access to fires. Once the fire is reached, effective fighting may be done by placing the men at considerable distances from each other. Heavy iron rakes, hoes, shovels and burlap or canvas are effective in controlling the fire. The rakes are especially valuable where lanes are necessary while the other tools are best where fallen logs need to be extinguished. Rapid work with heavy burlap or canvas is often the best method of fighting. The man in charge should place his strongest, quickest men at this kind of work and leave the slower, weaker men to extinguish fallen trees and old logs.

The second sub-type is found along stream courses at lower elevations. The principal hardwoods found here are Mexican Walnut *(Juglans rupestris* Engelm.), White Alder *(Alnus rhombifolia* Nutt.), California Sycamore *(Platanus racemosa* Nutt.), and Box Elder (*Acer negundo* Linn.). In places, a large portion of the stand is White Fir (*Abies concolor* Parry) and Douglas Fir *(Pseudotsuga taxifolia* Britton).

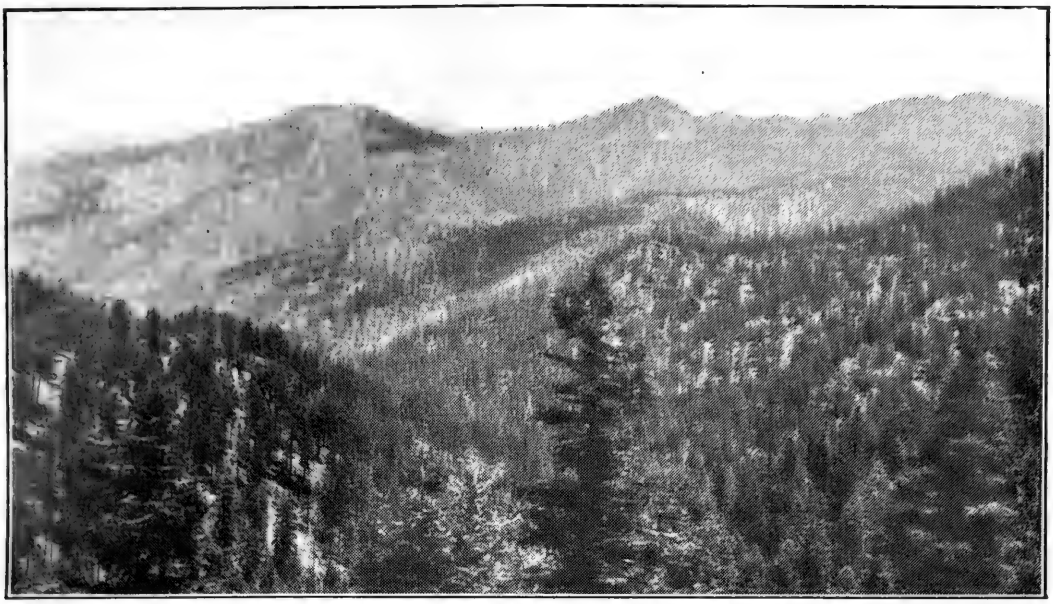
These species occur in fairly dense stands along the streams. This type is of comparatively little importance as far as utilization is concerned but because of the moist situation on which it occurs and the fire resistance of the species, it may be of some aid in fighting fire. It nearly always serves as a natural barrier along which fire may be checked with comparative ease.

### WESTERN YELLOW PINE TYPE.

The Western Yellow Pine type occurs approximately between the elevations of 6,500 and 9,000 feet. However, on the southern slopes, it may be found much higher where soil and moisture conditions are favorable. This species prefers fairly deep loam or adobe. On the north slopes where the soil is rich in humus, this type is rarely found above 8,000 feet, since these conditions favor tolerance, and exclude Western Yellow Pine *(Pinus ponderosa* Laws.). This type is made up almost wholly of Western Yellow Pine although a few scattering trees of Douglas Fir may be found occasionally. On the moister situations, it occurs in fairly dense stands but under average conditions it seldom exceeds a density of 0.4 to 0.5 which is due to the site and light requirements of the species. The reproduction on these moister situations may be extremely dense. In one locality, 476 saplings under 4 inches in diameter were counted on an acre. Such a stand is an exception but fairly dense stands occur often enough to materially accelerate the spread of the fire.

This type supports very little underbrush. In the transition areas between the Western Yellow Pine and coniferous woodland types, the species found in the latter may occur as an under-

PLATE III.



Typical Stand of Western Yellow Pine in Mogollon Mountains at 8,000 to 9,500 Feet Uninjured by Fire.

Dead Western Yellow Pine Struck by Lightning.

story in the scattering stunted stand of Western Yellow Pine. But the greater part of this mixture may be considered coniferous woodland and is treated as such.

Because of the more favorable moisture conditions in the Western Yellow Pine stands, there is even a ranker growth of forage grasses than in the woodland type, thus increasing the probability of destructive fires. These conditions are especially true in the "mesa" country where most of the merchantable Western Yellow Pine occurs.

In most mature stands of timber, reproduction is not very dense and there is very little litter. The opposite is true when reproduction is good. Here the forest floor may be covered with a thick layer of leaf litter, forming ideal conditions for a fire. This combined with the dense stand of timber makes fire in this type destructive to reproduction although it may not affect mature trees. However, the limited amount of underbrush over the greater part of this type, and the fire resistance of the species itself, seldom makes fires destructive.

Lightning is the principal cause of fires in this type, although a few may be traced to the carelessness of campers and cowmen. Occasionally, dead trees and spike tops may be found which because of their dry and "pitchy" nature, may easily be set afire by lightning. From these trees, the fire spreads rapidly if there is a heavy wind or much surrounding grass.

Where there is little or no grazing and there is a rank growth of grass with a large amount of dry material in each tuft, there is a serious menace from fire. If restricted grazing is permitted, as allowed by the Forest Service, fire damage may be largely decreased but not eliminated. Over-grazing would most materially eliminate surface fires but would affect site and reproduction so seriously that it is rarely allowed.

The fighting of fire in this type should be comparatively simple, since there are few fallen logs and there is very little underbrush with which to contend. The nature of the topography and the open condition of the stand make it possible to reach a fire in any portion of this type very easily. The most effective method of fighting the fire would be with rakes and shovels. With this a lane could be made and the spread of fire through the grass effectually stopped. Since grass is the principal factor in spreading fire in this type, such a lane would be a decided check. A plowed furrow, where the nature of the surface soil makes such a thing possible, is also effective. There is a tendency toward better roads in this type making excellent points from which to fight fire.

### COMPOSITE TYPE.

A slight change of aspect to a more easterly or northerly exposure, with a slight increase in elevation, will bring about the conditions necessary to change a pure stand of Western Yellow Pine to a composite type, by increasing the amount of Douglas Fir and proportionally decreasing the amount of Western Yellow Pine. This type should be regarded as a transition type between pure Western Yellow Pine and a mixture of Douglas Fir and White Fir.

This type normally requires a soil which is moister and more loamy than that necessary for the Western Yellow Pine. The increased density of the stand restricts the rank growth of grass. which is so characteristic of the Western Yellow Pine type. Although these conditions very largely eliminate the grass factor in the spreading of fire, they increase the amount and complexity of the underbrush. At the same time the amount of litter is increased because of the increased density of the stand, as well as the consequent restriction of the sun's rays which retards the decomposition of the litter. This increased stand density with the greater amount of underbrush, reproduction and litter makes it apparent why the danger and severity of fires increases very materially.

Surface fires are exceptionally destructive to reproduction in this type because it is mixed with underbrush and surrounded by litter. Very often poles and standards will be in a fairly vigorous state of growth after a fire, merely having had their bark scorched, while the entire stand of young reproduction will have been killed. The methods used in fighting fires in this type are very similar to those advocate for fires in the Western Yellow Pine type. Fire lines are more necessary because of the density of the stand.

### FIR TYPE.

In this type Western Yellow Pine occurs only as an invader, while Douglas Fir and White Fir are the predominating species. The relative proportion of each of these species in the type depends entirely upon the moisture conditions of the site. Where it is very moist and cool, the White Fir is decidedly the predominating species and sometimes excludes Douglas Fir entirely. As the slope changes to a more southerly or westerly exposure, the soil becomes dryer and the fir type gradually merges into the composite type. The White Fir gives way to the Douglas Fir on the dryer soils and this species in turn gives way to Western Yellow Pine on still dryer soils.

PLATE II.

A Scattered Burn in the Composite Type Showing Mature Trees which have Survived the Fire.

Sub-alpine Type Showing Virgin Stand of Alpine Fir and Engelmann Spruce.

This type is found principally along the stream courses and on the north slopes between the elevations of 7,500 and 9,000 feet. It encroaches on the Western Yellow Pine type along the streams, and may be found as low as 7,000 feet on the north slopes of the draws. Typically it occurs in fairly dense stands which often have a density of 0.7 or more but this also depends largely on the soil and moisture conditions. The tolerance of the species causes a dense stand which creates favorable conditions for underbrush and unfavorable conditions for grass to a more pronounced degree than in the composite type. Wherever the forest floor is moist, shady and covered with a heavy mat of litter, the underbrush composed of Aspen *(Populus tremuloides* Michx.) and Mexican Locust (*Robinia neo-Mexicana* Gray.), is very dense and the grass is almost eliminated. Whereever fire has not affected it, the reproduction of White Fir and Douglas Fir is very dense in all stages of growth. This forms a very favorable condition for the rapid spreading of fire and compensates for the absence of grass. The poor fire resistance of these species increases the extent and severity of fires in this type.

White Fir is rendered less fire resistant because it usually becomes infected by a fungus as soon as it reaches the size of standards. In a few years the tree becomes so badly diseased that the leaves fall and the branches die. These dead and dying trees increase the danger of fire from lightning as well as the intensity of fires after they are started. A minor factor, which probably deserves mention, is the presence of a lichen *(Usnea* sp.) on dead and dying trees as well as on some of the vigorous living ones. This lichen burns very readily and may increase the destructiveness of fires to individual trees.

The causes of fires in this type are very much the same as in the composite type. The danger of fire from campers is greater since camp-sites are usually chosen along the stream courses where this type prevails. Frequently campers think they have fully extinguished camp fires which are often still smouldering. These incipient fires burn into the litter, where a breeze may fan the embers into a flame and cause a forest fire.

The fighting of fire in this type is made more difficult because of the underbrush and fallen logs. A back fire would probably have to be resorted to more frequently than in the composite type. In addition to rakes and shovels a saw and ax are usually necessary to clear away smaller logs and heavy underbrush when a lane is being made to check the fire.

### SUB-ALPINE TYPE.

This type is made up principally of Engelmann Spruce *(Picea engelmanni* Engelm.) and Alpine Fir *(Abies lasiocarpa* Nutt.). It requires a very moist, cool site and hence occurs on the northerly exposures above 9,000 feet in elevation. Along stream courses Engelmann Spruce may be found as low as 8,000 feet in mixture with White Fir and Douglas Fir. It rarely occurs in merchantable quantities, however, below 9,000 feet elevation. Wherever the fir type merges into the sub-alpine type, the Douglas Fir comprises a large part of the stand. As the elevation increases the per cent of Douglas Fir decreases, until finally it ceases to be of any inportance above an elevation of 10,000 feet, except in the restocking of burnt-over areas. Alpine Fir is a minor species rarely forming more than 10 per cent of the total stand. Engelmann Spruce is by far the most important species, and occurs in stands which often run as high as 90 to 110 mature trees on a single acre. This is true only in the virgin, unburnt areas. Since this type grows only at the higher elevations it occupies the steeper and more rugged slopes. Rock outcrops are frequent, rendering logging operations much more difficult and expensive. Often large areas are inaccessible because of the adverse nature of the topography.

Almost all of this type has been burnt over at least once within the last natural rotation, and hence there is usually considerable Aspen as well as some Mexican Locust mixed in with the permanent species. The dense nature of the stand naturally causes a heavy layer of litter and there is usually considerable underbrush, although it is rarely as dense as that in the typical fir stands. Prolific reproduction in all stages is usually characteristic of Engelmann Spruce and Alpine Fir, as well as Douglas Fir at the elevations where these species occur in this type.

The reproduction combined with the litter forms conditions very similar to that of the fir stands in regard to fire danger. In addition, a large per cent of the Alpine Fir over 12 inches d. b. h. is in poor condition because of insect attack. As the affected tree approaches maturity it loses its vigor and gradually begins to die. Just as the diseased White Fir increases the danger of fire started by lightning in the fir type so the insect-attacked Alpine Fir increases this danger in the sub-alpine type. Consequently, even though this species forms only a small proportion of the stand, the danger of fire is much more imminent because of its occurence. The danger from lightning-struck trees is also greater because the type occurs on the mountain ridges where lightning strikes most frequently. It is not uncommon to find two or three lightning-struck trees on a single acre in the vicinity of these ridges. Fires started by campers and cowmen are less frequent in this type because of the limited amount of grazing, and the less desirable hunting and fishing localities.

The fighting of fire is even more difficult and complex than in the fir type, chiefly because of the inaccessibility of this region due to topography, and the lack of roads and trails. Adequate natural fire barriers are few, and the construction of artificial barriers is rendered very difficult by the fallen timber and the complexity of the underbrush. However, roads and trails are gradually being built at great expense along the main ridges, and these will form important points from which to control fires. They will also serve to connect look-out stations from which to watch for fires over large areas of the forest. Fire prevention in this and the fir type is more necessary than in lower types and wherever possible the number of fire guards should be increased.

### RESTOCKING OF BURNT OVER AREAS.

Past experiences seem to show that the burns will almost always restock sooner or later. On some areas grasses and sedges have come in before the seedlings of either the temporary or permanent type have had an opportunity to start, and a grass land has prevailed which practically excludes hope of future natural reproduction. However, these instances are rare and usually occur on the exposed southern slopes or in the sub-alpine type.

The coniferous woodland usually restocks directly without the intervention of a temporary type. The few mature trees which escape the fire gradually seed-in the burnt areas. The hardwoods along the stream courses cover such a small area, and are subject to burns so infrequently that their restocking is nearly always adequate.

In the high-class forests, including all remaining types, a temporary type almost always comes in after a fire. In the Western Yellow Pine type this temporary type may be either Aspen or Gambel Oak. In the Mogollon mountains Aspen seems to be the prevailing temporary type species. It may come in within two or three years after the time of burning, or not until five or six years afterward. The density of the Aspen depends on the moisture content and quality of the soil. Where the soil is fairly deep and rich and the moisture content is high the Aspen is so dense that it forms thicket stands. On the drier and more exposed slopes the Aspen occurs in very thin stands, or occasionally may not come in at all. Where Aspen fails grass usually comes in and occupies the area. Where the temporary type of either Aspen or Gambel Oak occurs, the Western Yellow Pine seedlings come in beneath the trees of the temporary type

The method of restocking is very much the same in the composite type, but in the fir and sub-alpine types the procedure is slightly different. Aspen is almost always the temporary type, Gambel Oak rarely if ever being found at these elevations. The Aspen almost always occurs in very dense thickets with some Mexican Locust and when these two species occur on their optimum site, they form a stand that is very nearly impenetrable. After a few seasons the temporary type has succeeded in partially restoring the litter destroyed by fire. In this restored seed bed, and under the shelter and the protection of the temporary type the seeds of trees of the permanent type are enabled to sprout and establish growth. Under the best conditions it usually requires about eight to fifteen years after the time of burning for the seedlings of the permanent type to gain a secure footing. However, the time required depends very largely on the site.

In the fir type the seedlings of the two firs come in directly under the Aspen. The White Fir seedlings often make up as high as 80 per cent of the reproduction of the two species during the first few years, but later the Douglas Fir becomes the more important species.

The method of restocking in the sub-alpine type is more complex. Among the coniferous seedlings which come in under the temporary type Douglas Fir is decidedly in the majority, and the seedlings of the Engelmann Spruce, which is the predominating species in this type, are very few or may be wanting entirely. This may be accounted for in two ways: first, the scanty supply of litter furnished by the temporary type is not sufficient to provide for the reproduction of Engelmann Spruce; second, the Engelmann Spruce is much less fire resistent than Douglas Fir, and where a large part of the mature trees of the latter species survive and continue to bear seed, the former species will be killed entirely and their ability to bear seed will be stopped. In all probability the scarcity of Engelmann Spruce seedlings is due to a combination of these two adverse conditions.

In several areas in this type at high elevations which had been burnt over from forty to eighty years before, the following conditions seemed to be typical. The Aspen had reached maturity and was beginning to deteriorate; some of the trees were dead or partially dead. All conifers from 12 inches to 20 inches d. b. h. were Douglas Fir. The poles and saplings beneath this almost pure stand of Douglas Fir standards were made up of both Douglas Fir and Engelmann Spruce. The seedlings were practically all Engelmann Spruce with the exception of a few Alpine Fir. This seems to indicate that the Douglas Fir came in merely as a second temporary type which possibly increased the amount of litter and humus. These conditions aided by a more perfect crown cover which excludes the sunlight, paved the way for the Engelmann Spruce seedlings which later made up the predominating species in the permanent type. The cycle of the burn effect in this type may therefore be stated as follows:

1. Aspen and Mexican Locust (temporary)
2. Douglas Fir (temporary)
3. Engelmann Spruce with some Alpine Fir (permanent).

The regeneration which has been described seems to be typical in restocking after the usual burn. However, there are a great many exceptions. One area was noticed in a burn in a sub-alpine type where the area was restocking very well with Engelmann Spruce seedlings. The site had been burnt over about seven years previous, and no temporary type of either Aspen or Douglas Fir had come in. This might be accounted for in a measure by the exceptionally moist soil. Another area which had been burnt over 50 or 60 years before, had restocked so heavily with Aspen that all other species were excluded These are exceptions, however, and should not be mistaken for the typical conditions.

# SEED COLLECTING IN LODGEPOLE PINE.

By R. A. Phillips.

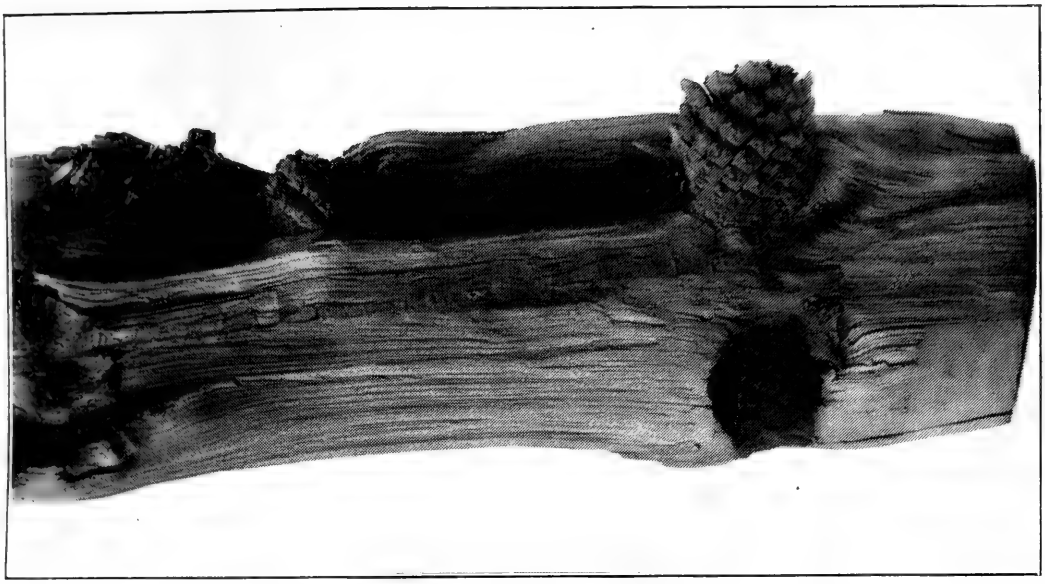
The collecting of tree seeds is an important operation in the practice of forestry. There is considerable planting done each year by the Forest Service to restock the numerous areas denuded by fire and lumbering, as well as to extend the range of some species. In many cases seed collecting is a very costly and difficult operation and can be performed only by experienced men, if the cost is to be kept within reasonable limits. Nearly every year large quantities of seed are collected on the various National Forests, the cost and methods of which vary widely. Many factors such as abundance of seed, cost of labor, equipment and accessibility of locality, cause this variation but the most important factor is the experience and judgment of the collector.

Lodgepole Pine (*Pinus contorta* Loud.) occurs in extensive, gregarious stands throughout many portions of the Rocky Mountains from southern Canada to New Mexico and Arizona. It also occurs to a limited extent in Washington, Oregon and California. In the northern part of its range it occurs as low as 3,000 feet while in southern Colorado it may occur as high as 10,000 feet. It is only a moderately rapid grower and possesses a wood which is chiefly valued for railroad ties. Much of the silvicultural value of the tree is due to its remarkable ability to grow in dense stands over very poor mineral soils. The cones have a tendency to persist on the trees for many years and open usually only under the most favorable conditions. A peculiarity of this species, not yet accounted for, is the opening of cones on some trees while those on trees near by where site conditions appear identical will remain closed for years. Unopened cones have been found imbedded in the wood of thirty years' growth, the seeds of which still retained a fair per cent of germination.

The time for collecting Lodgepole Pine cones varies with the season and the region. As a rule, cones are matured by the first of September or shortly after. Collecting should start immediately after the seed has matured because bad weather and snow may be expected any time after the middle of October. This may interfere seriously with or even prevent further operations. Since Lodgepole Pine cones require two years to mature, the size of the crop may be estimated the year before it ripens.

The cheapest, easiest and most satisfactory method of collecting these cones is to rob squirrel hoards. The squirrels

PLATE I.



Lodgepole Pine Cone Imbedded in 30 Years' Growth.

A Collection of Cones.

begin to collect as soon as the cones are mature and store up great quantities for food during the winter. They cut the cones from the trees by gnawing off small branches or the stem of the cone. When all the desirable cones are cut from a tree, the squirrels come to the ground and gather them in hoards. A hoard is seldom one pile of cones but a number of small piles gathered together over an area of perhaps 20 to 1000 feet in diameter. Within this area they are carefully hidden away under logs, stumps, bushes, stones and in little depressions or tunnels under the ground. They are often found completely buried under old piles of cone scales where squirrels have stored them for years and left the scales after eating the seed. The hoards contain from two or three quarts to ten or fifteen bushels of cones. The latter is an especially large hoard. Where hoards are plentiful a man can easily collect 10 to 15 bushels a day.

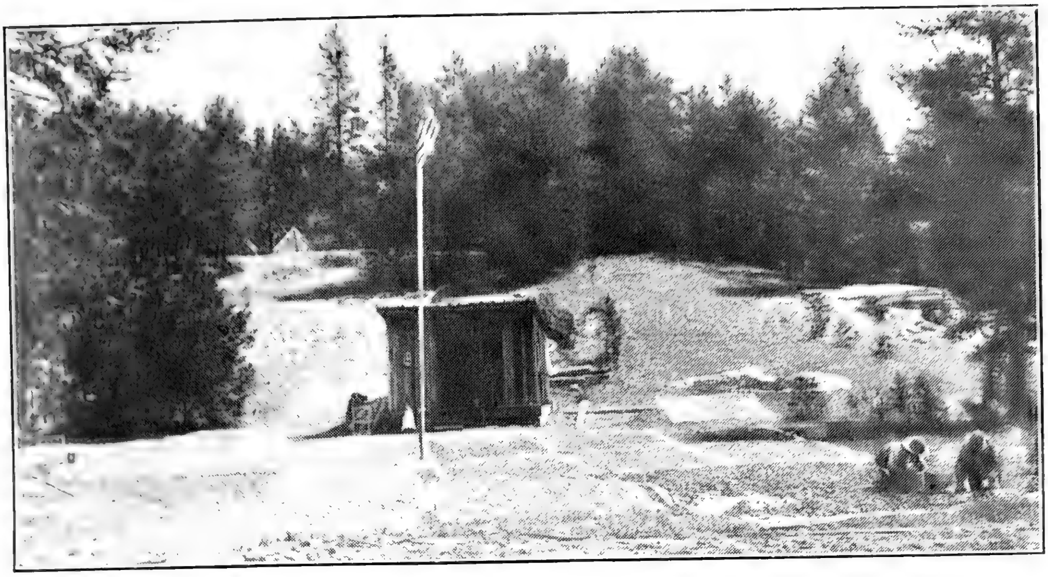
The cones may also be collected by means of ladders, by climbing trees or by following a lumbering operation. Climbing trees or using ladders are slow and expensive methods since the persistency of the cones makes it difficult to sever them from the twig. Trees with low, short branches and a good crown should be selected. Some sort of hook or club is necessary to remove the cones. It is generally considered better to let the cones drop to the ground and to pick them up later, but in some cases a bucket or bag provided with a hook may be taken up into the tree and the cones dropped in as they are picked. Following a lumbering operation is much easier than collecting the cones directly from standing trees.

After the cones are collected, they are placed in sacks and carried to the nearest road or trail where they may be left until taken away on a pack horse or a wagon. The cones are so heavy that it is not practical to carry them any distance. A pack horse can carry from four to eight bushels with little difficulty. Sacks should not be left in the woods any longer than necessary for the squirrels will gnaw holes in them and carry off large quantities of cones. It is a good plan to leave one sack open or place a small pile of cones on the ground, for these will attract the squirrels and so protect the other sacks. It is a better plan to shoot a few squirrels and lay them on the sacks. This acts as a scarecrow and helps to keep other squirrels away. Cones should be taken directly from the woods to the drying quarters where the seed are to be extracted and cleaned. These quarters should be as near the place of collecting as possible for it is much easier to transport the cleaned seed than to haul the cones long distances. Before drying the cones they should be as free from dirt and needles as possible for this debris will get into the seed and make cleaning more difficult. A simple method of removing dirt and needles is to run the cones down an inclined screen fastened in a frame.

Spreading the cones on large sheets of canvas in the sun is the simplest method of opening them. They should be spread in thin layers of about one bushel to thirty square feet of canvas. Where possible the canvas should be placed on platforms or on anything which will hold it from contact with the ground because more or less moisture is likely to be absorbed and prevent rapid opening of the cones. When spread out in this manner some cones begin to open in four or six hours while others show no sign of opening after two months exposure. Three to five days, however, is the average time required for most cones to open and those which have not opened in this time probably never will without additional treatment. If such cones are soaked in water a few hours and than replaced in the sun nearly all of them will open. One of the chief disadvantages of the canvas method is that the cones are subject to all changes in the weather. Cloudy days, rain or snow delay operations and prevent their opening. After once opened, moisture causes them to close. Another disadvantage is that the cones are unprotected from the ravages of birds, chipmunks and squirrels.

The surest and most satisfactory method of opening the cones is by means of artificial heat. The cones are spread out in a building on frames or shelves and submitted to heat from a stove. A very convenient frame can be made from strips one by four inches. These are nailed together in a rectangle and a wire screen is fastened to the bottom. The shelves are supported on two by four standards, on which several may be placed one above the other. In this way heat and air have free access to the cones. When several of these shelves are so placed in a tent or cabin, it gives the appearance of a bunk-house. A cabin is more easily heated although a tent serves the purpose very well. Little precautions such as banking dirt around the sides of the tent and laying wagon covers over the top, aid greatly in holding the heat. An easy way of heating a drying tent or cabin is by means of a small Wilson Air Tight Stove. These burn wood readily and produce much heat. A temperature of 130° to 150° F. may be easily maintained in a tent with such a stove and this will cause most cones to open in 48 hours. They should, however, be dried longer than this for the wider they open the easier the seed may be extracted. The cones should be spread in as thin layers as possible in order to permit free circulation of air. It has been found by experiment that dry air is necessary to open the cones but heat must first be applied to loosen the resin

PLATE II.



Opening Cones by the Out-door Method.

Drum for Sifting Seeds and Cones.

which holds the scales together. The scales may be separated by putting the cones in hot water but they will not open and release their seed until thoroughly dried. Cones on top shelves open first as do those nearest the stove. At intervals of one to two hours the cones should be thoroughly stirred. This exposes all sides to the heat and also shakes out many seed. As the seed fall from the cones they go through the wire netting to the tray below and as each succeeding tray is stirred, the seed fall to the floor where a piece of canvas is stretched to catch them. In this way the seed are kept in the coolest part of the tent so their vitality is not affected by the extreme temperature. After three or four continuous days of heating all cones not open should be soaked in water and dried again.

In a collecting operation the latter part of September, 1910, on the Holy Cross National Forest, a tent 12x16 feet with 5 foot sides was used and heated with a Wilson stove. The sides of the tent were banked up with dirt and two canvas wagon covers were thrown over it to help hold in the heat. The seed trays were fifteen feet long and about four and a half feet wide with bottoms of three-quarter inch mesh chicken wire. Each tray would hold three bushels after the cones were properly spread out. Two large frames were made by placing three trays over each other about eighteen inches apart. When these frames were placed in the tent a space of about three feet was left as an aisle from which the cones could be stirred. The stove was placed in the aisle in the center of the tent with the pipe running out at the back. A canvas wagon cover was stretched on the ground under each frame to catch the seeds as they fell. An average temperature of 140° F. was kept up night and day. The "night man" was on duty until 4:00 a. m. at which time he went to bed and slept until noon. In the afternoon he helped clean seed, cut fire wood and cook supper, besides keeping up the fire in the seed tent. From supper time on, he maintained a good fire in the drying tent and stirred the cones. The fire was easily kept burning until 5:00 a. m. at which time the camp started day work. This method was considered a great saving in heat and time since the nights were quite cold and the cones cooled rapidly when the fire went out.

It is an easy matter to remove seeds from the opened cones. Most of the seeds are removed when the cones are stirred on the drying shelves. Spreading them out on a large canvas and tramping on them is a simple and fairly good method and the few seeds left in well opened cones are not worth the time which would be required to extract them. A revolving churn is an excellent method of removing the seeds and at the same time it separates open from closed cones. A churn may easily be made from a barrel or box by removing the sides and nailing on slats. These slats should be far enough apart to allow the average closed cone to go through but not the larger opened cones. A stick or shaft is placed through the axis of the churn and a crank made on one end. The two protruding ends of the shaft may be placed between the crotches of two trees or on a frame so that it can be easily revolved. A few cross pieces or blocks of wood inside the churn, against which the cones may strike, aid greatly in shaking out the seed. After several minutes churning, the closed cones and seed should have fallen out. The empty cones may then be taken out by removing two or three slats which should be arranged for this purpose. The seed and the closed cones are caught on canvas and are gathered together to be cleaned.

Cleaning seed consists in removing all foreign substances such as dirt, needles, cone-scales and wings. Wings may be removed by either the wet or the dry method. Each method has its distinctive advantages. The wet process is used where great quantities of seed are to be cleaned for it is a quicker method. The seeds are spread out several inches deep on a floor and sprinkled with water. They are then beaten with light leather flails. Too heavy flails break the seeds. When moist the wings come off very readily. This process is not safe unless the seeds are to be used soon, for moisture is likely to injure the vitality. The more commonly used and safer process is the dry method. The seeds are placed in sacks and beaten with flails, rubbed and shaken until the wings are all removed. With such small seeds as those of Lodgepole Pine, not more than five pounds should be placed in a sack if all wings are to be loosened. After a thorough rubbing the seeds are winnowed by a fanning mill or the wind. This blows away the wings, the light worthless seeds, and the finer particles of dirt. If, however, the wings are not all removed, many good seeds will be carried off with them. After two or three fannings most of the remaining dirt is composed of cone scales and needles. This is easily removed by repeated screenings. A very small mesh may be used with Lodgepole Pine as the seeds are small. After a few screenings the seeds are ready for use or for storage.

In no case has it been found practical to store seed for more than three years as the vitality is impaired after that time. For short periods the seed may be kept in sacks and hung in a cool, dry place where they are safe from rats, mice and other pests. However, if seeds are to be stored for any length of time, it is probably best to place them in air-tight cans or jars. It is recommended that before placing in the air-tight vessels the seeds should be dried in a temperature of 30 to 40 degrees Centigrade and also that a small quantity of quick-lime be inclosed to absorb the carbon dioxide which is produced by seed respiration. It is thought that much of this gas is injurious. A deep, cool cellar is an excellent storage place until time for use.

# FROST EFFECT ON FOREST TREES.

By W. K. Eberly.

Although late spring frosts have been quite common in eastern Nebraska for a number of years, only general notes have appeared as to the effects on forest trees. In the future, it is planned to keep a definite record of such injury, as detailed information is needed from both practical and scientific standpoints. It is thought that variable weather conditions following frost damage may have a cumulative injurious effect in some cases and a compensating effect in others.

## LATE SPRING FROST OF 1910.

From April 23 to April 25, 1910, an area of high atmospheric pressure and low temperature extended over the plains region east of the Rocky Mountains from Dodge City, Kansas to northern Minnesota. The pressure ranged from 30.1 to 30.2 inches. At Lincoln, Nebraska, the sky was clear and the temperature fell to 15 degrees Fahrenheit on April 23, reaching 30 to 32 degrees on the following days. The wind came directly from the north and had an average velocity of 20 miles per hour with a minimum of 11 miles. On May 3, ten days later, another heavy frost occured which extended from Concordia, Kansas, north through Nebraska, eastern Wyoming, western Dakotas, Minnesota and east through Iowa. At Lincoln, the weather was again clear, with a northeast wind that had an average velocity of only 7.2 miles per hour. The temperature fell to the freezing point; the pressure and relative humidity were high.

The combination of these climatic factors resulted in severe killing frosts. The damage was very great, all growth was far advanced as a result of the season being six weeks earlier than normal. Many forest trees occuring as individual shade trees or in park-like formation were badly injured. The trees which had leafed out earliest were the ones which usually suffered the most.

Only deciduous species were affected. Not a single injured conifer was observed, probably on account of their greater frost resistance. The injury was generally greatest on the north side of affected trees. Recently transplanted trees and pollarded trees suffered more than those grown in place or those which had not been disturbed for some time. The character and

PLATE I.

Typical Frost Injury on Carolina Poplar.

Frost Effect on Buckeye.

extent of injury to each species will be considered in the following paragraphs.

Box Elder, (*Acer negundo* Linn.) shed 80 per cent of its leaves. The leaflets were injured at the tips and the injury usually extended half way to the base. The remaining half soon became functionless and the whole leaflet was then shed. Often one or two leaflets were injured while the remaining leaflets on the same petiole were unaffected. Two trees which were transplanted this spring were killed. Another tree of the same size standing near these but which had not been transplanted, had only 30 per cent of its leaves injured. Pollarded trees showed more rapid recuperation than unpollarded on both the north and the south side of the tree. The seed of this species, which was two-thirds formed, was prevented from maturing and probably lost most or all of its germination power.

Norway Maple, (*Acer platanoides* Linn.) had 90 per cent of its leaves injured and 60 per cent killed entirely. The lobes and margins suffered most, leaving uninjured only a small area in which large veins were located. A row of trees extending north and south had a distinct zone of defoliation on the north side of each tree. The new leaves almost invariably came from dormant buds close to the ends of the shoots rather than from adventitious buds.

Carolina Poplar (*Populus angulata* Aiton.) and Cottonwood, (*Populus deltoides* Marsh) were both severely injured; 80 to 90 per cent of their leaves were affected. The injury extended from the apex around the margin toward the base. Some of the leaves with this injury remained active but most of them were shed. Small succulent leaves were killed entirely. In large leaves, the injured part folded back parallel to the midrib. The leaves on a mature Cottonwood were twice as badly affected on the north side as were those on the south side. On many trees there was a distinct zone of relatively greater injury which included only the upper one-third to one-half of the crown length. However, a row of pollarded trees extending north and south seemed to show comparatively greater injury at the base of the crown. This was probably due to the faster recuperation of the pollarded part than to greater initial injury.

Four different species of elms were observed. White Elm (*Ulmus americana* Linn.) was more variable than most of its associates. Some individuals were greatly affected, while others of the same age and on the same site showed very little injury. Practically all the youngest leaves were killed entirely. Older leaves had the apex and part of the margin injured. The injured part curled up underneath the leaf rather than folding back as it did on the poplars. Regeneration occured at the end of the twig first and the new growth came largely from dormant buds. Careful count was made of the leaves killed on a row of one year old transplants. The injury varied from 50 per cent on some trees to 98 per cent on others. Here, terminal leaves were most seriously affected and new growth developed from lateral buds. These trees were situated on high ground in a very exposed position. Camperdown Elm (*Ulmus scabra pendula* Loud.) had an average of thirty per cent of its leaves injured. The bases of the injured leaves were persistent. English Elm (*Ulmus campestris* Smith.) was very slightly affected. Slippery Elm (*Ulmus pubescens* Walt.) was not at all affected as the buds did not open until after the frost.

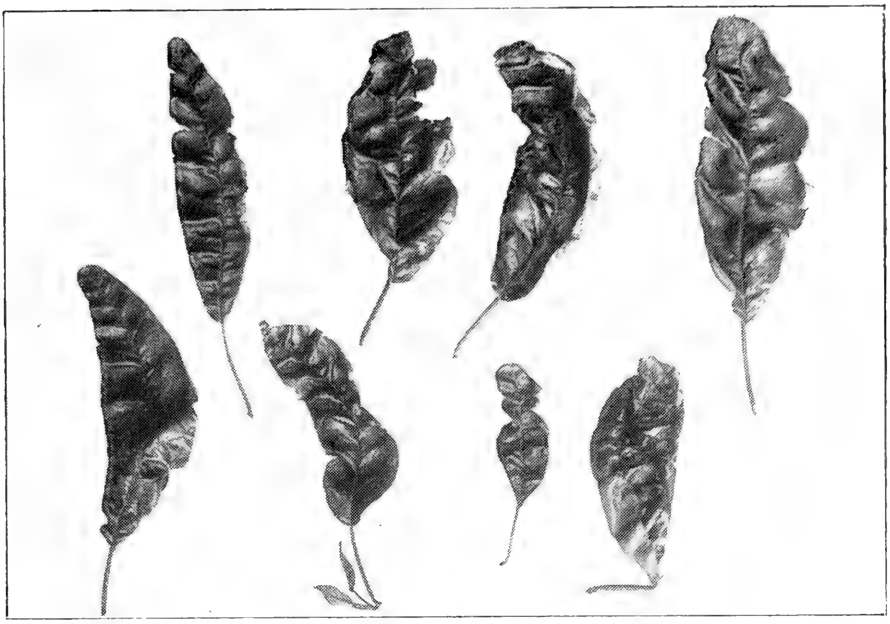
Horse Chestnut, (*Aesculus hippocastanum* Linn.) had every leaf affected. The apex and margins were badly injured, leaving uninjured only a small area containing the midrib. Fully 80 per cent of the leaves were shed, the leaflets falling before the petiole. New leaves were formed quickly from axillary buds which normally would not have developed until the next year. A large number of dormant buds and a few adventitious shoots also developed.

Cucumber Tree, (*Magnolia acuminata* Linn.) at the time the frosts occured had a large number of leaves well developed. The apex and the outer half of all leaves were killed back and the dead part folded in a flap on either the under or the upper surface of the leaf. The uninjured portion was characteristically diamond shaped. The tips of the fruit were just touched by the frost. There was a slight stimulation of dormant buds. *Magnolia grandiflora* Linn. had some of the leaves entirely killed. All those which remained had their tips injured, but their margins were not affected. There was a strong stimulation of dormant buds.

Silver Maple, (*Acer saccharinum* Linn.) had 70 per cent of its foliage injured. The lobe was the zone of most characteristic injury but the tips and the margins up to the point where serrations began, were badly affected. The margin at the serration was free from injury. Most of the injured leaves were shed.

Green Ash, (*Fraxinus lanceolata* Borkh.) is another species which clearly showed more injury on the north side of the crown than on the south side. The leaves were frosted at the apex and along the margins. In two plantations at the Nebraska Experiment Station which had the same exposure and were planted on the same site, one was badly injured while the other

PLATE II.



Typical Frost Injury on Osage Orange.

Frost Effect on Silver Maple.

was scarcely touched. The small leaflets were entirely frozen. In some of the creek bottoms, 80 to 95 per cent of the leaves were killed. Nearly all the terminal shoots died on coppice growth and new growth came from lateral buds. Seedling trees of the same size in the vicinity were not so badly affected.

Osage Orange, (*Toxylon pomiferum* Raf.) had the leaves affected at the tip and along the side. The leaf curled and wrinkled toward the injury since the growing zone was reduced along the dead tissue. The leaf margins toward the north were more injured than the south margins and buds on the north side were also more seriously affected than those on the south. The north end of a plantation which was protected by a shelter belt was not affected in the least although the leaves were further developed than on exposed sites.

Russian Mulberry (*Morus alba tatarica* Loudon.) was not greatly injured. The injury was distributed in definite spots along the margins of the leaves except at the sinuses. Some trees in a very high, exposed position had 50 per cent of the fruit killed. The terminal leaves were principally affected.

Hackberry, (*Celtis occidentalis* Linn.) had 40 per cent of its leaves frosted. The margin and tip suffered most and made the leaf very irregular. Most of the injured leaves showed definite spots where killing occurred. The dead tissue soon dropped out leaving perforations resembling the work of some leaf-eating insect.

Russian Olive, (*Eleagnus angustifolia* Linn.) was affected at the tip of the leaf. The leaf curled and turned back. Whole clusters of leaves were affected.

Honey Locust, (*Gleditisia triacanthos* Linn.) in plantations six feet in height, had the tips of all leaflets killed and in some cases, whole leaves were killed. The tips quicky became yellow and turned back. Black Locust, (*Robinia pseudacacia* Linn.) had the margin of the leaves injured. Only a very few trees of this species showed injury.

Hardy Catalpa (*Catalpa speciosa* Warder.) had its small leaves entirely killed. Leaves which were half-grown or larger had slightly injured tips and margins. The live portion of the large leaves, curled backward with an effect very characteristic of the species. Shoots eight to twelve feet in height in a forest plantation which had been coppiced were severely injured, probably because coppice growth started earlier than seedling trees of the same age or of the same sipe. Japan Catalpa (*Catalpa pagoda*) had the buds frozen back and had many shoots killed. It is never as hardy as the *Catalpa speciosa*.

Black Walnut, (*Juglans nigra* Linn.) had 5 per cent of the leaflets affected. The injury occurred at the tips and extended half way toward the base. The leaflets were shed from the petiole rather than falling with it.

Golden Willow, (*Salix vitellina L.*) had nearly all its leaves from one half to three-fourths frosted. The injury extended diagonally across the leaf. The injury on the leaves of *Salix Babylonica dolasaca* extended from the apex down the sides and went nearly to the midrib. *Salix vitellina* Linn., was similarly affected and also showed that the north side of the trees suffered most.

Basswood, (*Tilia americana* Linn.) had the leaves affected on the sides as well as the tips. The north side of the tree was invariably more seriously affected than the south side. In a row extending north and south on an exposed site, one tree had 50 per cent of the leaves affected while the other five were not injured.

Oaks in woodlot formation showed only the slightest injury. Pin Oak, (*Quercus palustris* Muench.) in the open, had fully one half of its leaves touched. Chestnut, Tulip Poplar, Red Oak, and Mountain Ash were not affected.

It was very noticeable that Green Ash and Box Elder were more seriously injured on low ground than on high ground. Other species might have shown the same effect had they been found on both sites. The base of the crown was the zone in which most species were injured but Cottonwood and Poplar seemed to be exceptions and this may be due to the earlier leafing out in the top of the crown. Many trees in rows running from north to south, showed the north half of each crown equally injured. The effect of such a frost on forest tree growth seems to be a stimulation of dormant and adventitious buds. This year's growth ring will probably be narrower in the trees that suffered an almost complete defoliation.

# A METHOD FOR MAKING TOPOGRAPHIC MAPS.

By L. H. Douglas.

There is a generally recognized need of maps in many phases of forestry. This need makes itself felt especially in forest management where it is necessary to have a concise representation of the area to be managed. Topography, area, distribution of types and the like can be shown at a glance. A map aids in making quick and accurate decisions in logging operations, location of experimental plots and various other operations in management.

The topographic map, showing as it does the lay of the land, is probably fundamental in forest mapping. This map need not be so accurately and carefully prepared as in the case of railroad or mining operations where finer details are needed. This fact is recognized by all foresters and yet, probably in many instances, much needed maps are not made because of the expense and time entailed.

The object of this article is to suggest a method for making topographic maps which will in a measure reduce initial expense and actual time in the field. Only the instrument and field methods for obtaining elevations will be explained in detail since the subsequent steps in making a contour map will not differ from those where the level, transit, aneroid barometer or other similar instruments are used. The instrument is one designed by Professor Roth, head professor of forestry in the University of Michigan. So far as the writer knows it has been used only locally and nothing is claimed for it except that it is an inexpensive, quickly constructed instrument for preparing a rough contour map and that it gives fairly accurate results. It consists of a thin rectangular board mounted at the side and near the upper end of a staff which supports an ordinary staff compass for taking bearings in the field. The board revolves on a horizontal bolt which fastens it to the staff. It is so marked off that by sighting along the top to a point of known distance the elevation of that point can be quickly determined by means of a plumb-line suspended from the top of the board and midway between its ends.

The graduating of the board is based on the geometrical relationship of similar triangles. Plate I shows the plan of the board. The board may be of any convenient size but the larger it is the larger the divisions and consequently the more accurate the readings. Five-eighths by ten and one-half by fourteen inches is a convenient size, in which case AB could be taken as ten inches. This is laid off mid-way between the ends perpendicular to the line which has been made parallel to the top of the board. By proportion $AB:BC = ab:bc$. The horizontal distance, *ab*, from the instrument to the point is now decided upon. For areas with irregular boundaries one hundred feet is most convenient for plotting. In the case of a section of land and its subdivisions, five rods or eighty-two and one-half feet is a convenient horizontal distance in plotting since it is a common multiple of the dimensions of a section, a quarter section, and a "forty."

If a given height is taken, *bc*, for instance two feet, three quantities, *AB*, *ab* and *bc* of the geometrical proportion are known. The fourth quantity will be the size of the divisions along the line, either way from *B*, the zero point, and may be calculated from the three known distances. This gives each division on *cf* a reading of two feet elevation or depression for a given horizontal distance. Let $AB = 10$ inches, $ab = 100$ feet and $bc = 2$ feet as already suggested. From the proportion $AB:BC = ab:bc$. 10.0 inches : $BC$ = 100 feet : 2 feet. Then $BC = 0.20$ inches. Points 0.20 inches apart are laid off along the line *cf* either way from *B* as zero. Every fifth point is numbered either way from the zero by the series 10, 20, 30, 40 etc. since each division represents two feet.

In taking a series of elevations in the field a rod is used which has a mark on it at approximately the height of the top of the board when the board is horizontal. The rodman holds it on the desired point and the top of the board is sighted on the mark. The reading is taken at the intersection of the plumb-line and the line *cf*. If the horizontal distance from the instrument to the rod is fifty feet instead of one hundred feet, the true reading would be one-half of that shown by the board; if eighty-six feet the true reading would be eighty-six per cent and if two hundred feet it would be twice that of the board and similarly for other distances.

It is well to equip the board with sights although experiment has shown that if proper care is taken, readings can be made as accurately by merely sighting along the smooth top of the board. The instrument man, however, is likely to become careless is the course of a day's work and in this case the sights will hold him to a uniform manner of sighting. There is, moreover, less strain on the eyes with sights than without, on account of the absence of a haze which is always seen when sighting along the bare top of the board. A peep sight at the end next to the eye and a cross-hair ring at the opposite end make satisfactory sights.

# PLATE I.

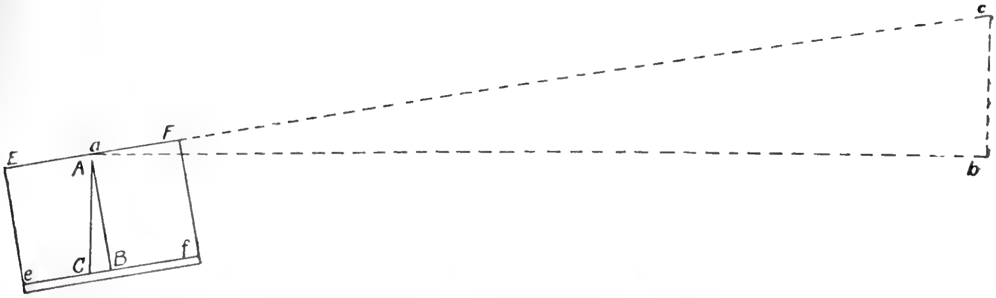
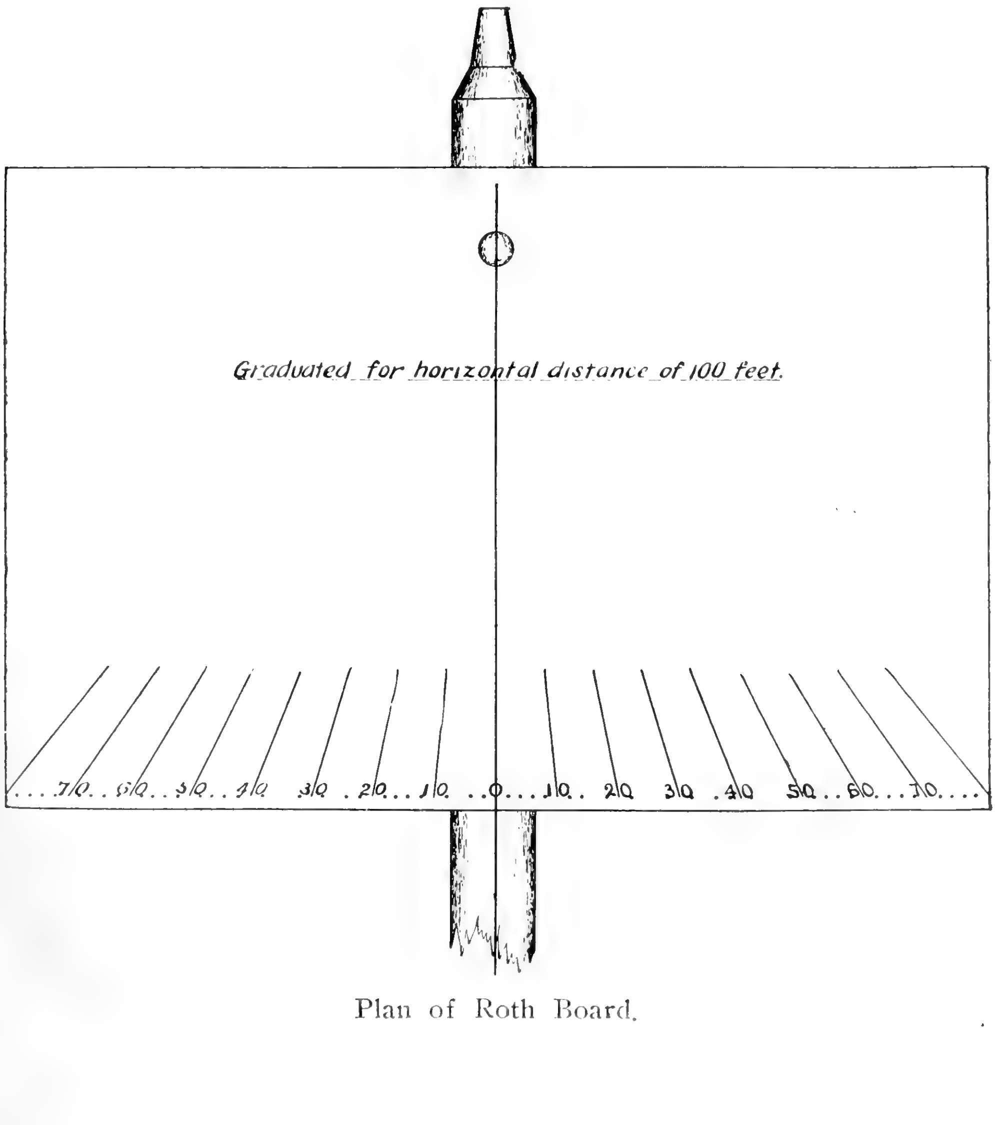



Diagram Illustrating the Principle upon which the Roth Board is constructed.




Plan of Roth Board.

These can be quickly and inexpensively made. The hole in the peep sight should be about one-twentieth of an inch in diameter and the one through which the cross-hair runs should be about one-fourth of an inch. It is well to have one sight fixed and the other adjustable so that the line of sight may be kept parallel to the top of the board and consequently to the line *cf*.

Any convenient material may be used for the board but it is best to have a wood which works easily and which does not readily warp, such as yellow poplar or white pine. The head of the bolt which fastens the board to the staff should be sunk so as not to obstruct the plumb line. The bolt should be at least three-eighths of an inch in diameter to prevent bending. End cleats on the board will help to prevent splitting and will lessen warping.

The staff should be cylindrical, about five feet long, and about one and one-half inches in diameter. It should be so turned at the top that a staff compass can be securely fitted on the end. A sharp pointed metal shoe should cover the lower end to enable the staff to be easily forced into the ground. The board should be bolted as near the top of the staff as possible without interfering with the compass.

In the field, the party may consist of either two or three men. In the case of a three-man party, one runs the instrument and is rear chainman, another keeps notes and directs the work while the third is rodman and head chainman. In case of very irregular topography, where the elevations of many points are required, it is advisable that the instrument man keep notes while the other two locate points for him and hold rods. In this way several points can be taken rapidly from one set-up of the instrument. If there are only two men in the party the instrument man must add note keeping to his duties. A three-man party can do more rapid work than a party of two and there is a more equal division of labor.

Where small areas, forty acres or less, are being surveyed, the traverse of all or part of the area should be run first and all bearings and elevations which control contours noted. Then, such interior elevations as are needed may be taken. If the topography is fairly uniform, points may be promiscuously taken by running out from the traverse. If the topography is very irregular it is well to run lines at regular intervals across the tract from known points on the traverse, obtaining the bearings and elevations of critical points on the cross lines and near them. For larger areas than a "forty," depending on the character of the topography, it is usually best to establish a base line, preferably at or near the middle of the tract. All necessary elevations should be taken on this line and bench marks established at regular intervals from which meander lines can be run to interior points.

Either the co-ordinate or the tabulated system of field note keeping may be used. In the co-ordinate system a sheet of paper is ruled off in squares. Each side of a square is scaled to the horizontal distance *ab* required by the instrument, or some multiple of it, usually the latter. This sheet fastened to a field sketch board takes the place of the ordinary field note book. It is usually desirable to record some actual measurements in addition to roughly plotting them to scale and this can be done on unused parts of the mapping sheet or in a note book. A protractor and small scale may be carried in the field but it is usually sufficiently accurate to roughly plot the points as in plane-table work.

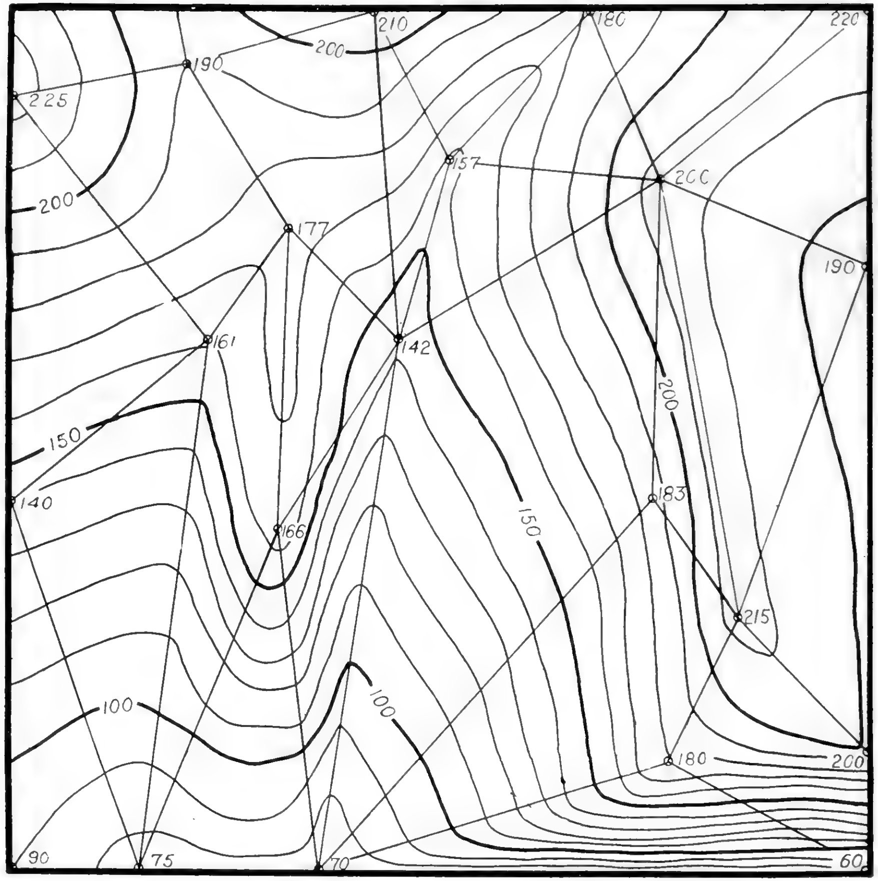
As the elevations are obtained they are immediately plotted on the sheet and those points between which the slope is uniform are connected by straight lines. For instance, two critical points on a ridge should be connected. One of these would be connected with a point at the foot of a valley and this with a point at the head and so on until there is a network of triangles formed by the connecting lines. Since the lines represent slopes which are uniform, they can be interpolated for contours. For instance, it is assumed that if the elevation at one end of the line is thirty-two feet and at the other twenty feet, the difference in elevation would be twelve feet. For every twelfth of the distance along the line of the slope, there would be a change in elevation of one foot, since the line is the hypotenuse of a right angled triangle whose altitude is the difference in elevation. In this instance, if the contour interval were five feet a contour would pass through the point of twenty foot elevation, another would cross the line five-twelfths of the distance and a third ten-twelfths from the twenty foot point or two-twelfths from the thirty-two foot point. Only these contours can cross this line and since all other contours are controlled in the same manner by other connecting lines, no confusion arises as to the course of contours.

In transferring the field sketch to the final map sheet, temporary co-ordinate lines of any desired interval are used, which represent distances equal to those shown by the intervals of the co-ordinate lines on the sketch map. The points and lines just described are then simply copied in pencil from the smaller field sheet. After the contours have been inked everything else may be erased. Plate II is a sketch illustrating this system.

The second system is the ordinary one of tabulating all data in a field note book. Below is an example of such notes taken

PLATE II.

Roth Board in Use.




Map of a Quarter-section showing Data collected in the Field and Contour Lines interpolated.

when an instrument based on a horizontal distance of one hundred feet is used:

| Station | Bearing | Distance Feet | Board Reading | True Reading | Elevation | Description |
|---|---|---|---|---|---|---|
| 1 | | | | | 200 | S. W .Cor. |
| 2 | N60°E | 100 | +16 | +16 | 216 | |
| 3 | N69°E | 100 | + 6 | + 6 | 222 | |
| 4 | N50°E | 50 | — 8 | — 4 | 218 | |
| 5 | N30°E | 100 | — 6 | — 6 | 212 | |
| 6 | N35°E | 75 | — 8 | — 6 | 206 | |
| 7 | N88°E | 60 | + 3.5 | + 2.1 | 208.1 | N. W. Cor. |

The tabulated note system is probably somewhat the more rapid of the two in the field and might be preferred if the surveyor plotted his own notes and had made explanatory sketches of topography in the field. Such, however, is not always the case and it is difficult for one who has never seen an area to make a good map of it from the tabulated notes of another. With the co-ordinate system as described above, the connecting lines, to be interpolated, definitely control the drawing of contours and the delineator does not have to depend on a first hand knowledge of the topography to make a correct map.

The rapidity with which field work can be carried on depends upon the size of the party, the contour interval, the presence or absence of trees and underbrush and upon the character of the topography. As has already been stated, a three-man party can do more rapid work than a party consisting of two. Likewise, an area can be more rapidly covered if the contour interval is ten feet than if it is five or two feet since fewer elevations will be required. Again, it is apparent that more rapid work can be done on treeless areas than where trees and dense undergrowth obstruct the view. In the latter condition shorter sights must be taken and more or less clearing done.

The average area actually covered per day with the instrument by a two-man party has been determined for a treeless area and for one densely wooded. The work on the treeless area was in the sand hill region of Nebraska where the topography is most difficult to map. The hills and valleys are small and irregular and conform to no pronounced drainage lines. Probably more than twice as many elevations were required on this area as on one ordinarily encountered. The average area covered by a two-man party was forty acres, the contour interval being ten feet. Twice this amount would not be an extreme estimate of what could be done on a more favorable area.

Further data was obtained in Ohio in the survey of woodlots which were dense enough to require considerable clearing before sights could be taken. The topography, however, was not so difficult as that in the sand hills, since there were definite drainage lines giving regular valleys and ridges. In one instance an area of eight acres was covered in one-half day. Another area of thirty acres was covered in two days giving an average of about fifteen acres per day. The size of party and contour interval were the same as in the first case.

The accuracy of the instrument has been tested in the field and the sources of error determined. The most important of these errors is probably the measurement of the horizontal distance in the field. The reading of the plumb line and the variation of the depth to which the staff is forced into the ground are also important but if the instrument is correctly constructed and carefully used all errors are largely compensating and, in closing elevations on a traverse, the error should not be more than ten feet and is usually less. In running a traverse of thirty-five hundred feet there was an error of one foot in closing elevations. In another of three thousand feet the error was three feet. In three others varying from five hundred to one thousand feet the error varied from six inches to one foot. Such errors will usually be experienced because of the crudeness of the instrument but will not seriously affect most maps required in forestry.

# TREE PLANTING BY MACHINERY.

By W. R. Martin.

For a long time, there has been a great demand for cheap methods of afforestation and reforestation. So far as forest planting is concerned, this effort has been manifested in broadcast sowing, sowing seeds in seed spots, the use of the corn planter, and in the planting of seedlings. It must be acknowledged that forestation by the use of seedling or transplant stock is costly and will continue to be so. Forestry is concerned largely with rough lands unsuited for agriculture in which the soil is often shallow, stony, and filled with roots or otherwise difficult to handle. The use of machinery, therefore, must be confined to a great extent to hand instruments in which the operator has the power of selection.

Certain level areas such as the prairie region of the Middle West, the Southern Pine region, the Lake States, level portions of California recommended for Eucalypts, and limited areas in other regions might be suited to machine planting of seedling or transplant stock. In some of these areas, notably the prairie states and eucalypt lands plowing is recommended before planting. In Germany it has been proved that surface plowing followed by sub-surface plowing results in a superior growth of many broad-leaved species over that which results when only surface plowing is done.* When level ground is to be planted and the planting season is short or labor is high and of poor quality, the use of a planting machine may be advisable for areas amounting to 20 acres or more. Over twenty years ago a machine was devised by Thomas A. Stratton, a farmer near Lincoln, Nebraska, for tree planting on his timber claim in the southwestern portion of the state. This machine was drawn by five horses with one man driving and one man placing trees in a planting wheel which automatically spaced the trees and released them in the furrow which was immediately filled by two rear wheels. This machine** set 15,275 ash seedlings in one day of nine hours and after further improvements was estimated to have a capacity of 20,000 and 30,000 trees.

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*Mitteilungen uber die Leistungsfähigkeit des verbesserten Eckertschen Schal- und Untergrundflugs nach mehrjährigen Erfahrungen im grössern Kulturbetrieb "Allgemeine Forst- und Jagdzeitung," Mai, 1906, pp. 145 – 149.

**Described with drawings in the "Annual Report of the chief of the Division of Forestry for 1888."

It was, however, much more complex than the machine about to be described.

During the year 1909, the Union Pacific Railroad Company decided to establish a catalpa plantation of approximately 100 acres, two and one half miles east of North Platte, Nebraska, as a possible source of fence posts, railroad ties, and other products. Small plantings of other species were provided as an experiment and for beauty. The actual field work was entrusted to Mr. J. P. E. Rodman, a landscape gardener of the company, who immediately decided to construct a machine which would do the planting. This machine was made without any knowledge of the Stratton machine and was given only a half hour trial before it was shipped to North Platte.

The planting site borders the Platte River and consists of an alluvial top soil of dark, rich, sandy loam which averages eight to ten inches in depth. The subsoil is a fine sand and very wet since it is only 48 inches to water. The year previous to planting, the area had been allowed to grow up in sunflowers and other weeds. This necessitated plowing the land in the fall of 1908 which was done at a cost of $3 an acre. In the spring of 1909 small portions of the site were plowed and all of it was disked amounting to $2.50 an acre. This makes a total cost of $5.50 for preparing the ground.

The machine is drawn by four horses abreast with one man driving and one man setting the trees in the furrow. The doubletree is attached to the end of the plow-beam which in turn is fastened to the tongue and regulated by means of a foot lever. A downward movement of this lever raises the plow beam and brings the plow to the surface. The coulter cuts the sod or breaks the soil in advance of the plow which is 16 inches high, 18 inches long at the top,and 32 inches long at the bottom. The plow makes a furrow about 8 inches wide and 8 to 9 inches deep. The depth is determined by a hand lever which raises or lowers the two front wheels and results in raising or lowering the double mold board. A heavier machine and more power would be necessary to throw a furrow deeper than 9 inches. The machine is supported by two 40 inch front wheels and two 16-inch rear wheels which trail behind the furrow plow. These latter wheels have wide rims and are set at an angle of about 45 degrees. In addition to giving the machine support their principal function is that of covering up the furrow and packing the soil around the seedlings.

The driver occupies a seat which is built on the back end of the tongue while behind this and nearer the ground is the planter's seat. On each side of this seat, within reach of the

PLATE I.

Tree Planting Machine with Moldboard out of Soil.

Tree Planting Machine in Action.

planter, are two basket-like affairs which hold the seedlings. These baskets hold 300 trees of 24 to 36inch stock and could easily be arranged to hold more. A pole is attached on the right hand side of the machine, on which an adjustable shoe is placed for marking the next row.

As the furrow is thrown open by the furrow plow the seedling is placed in it by the planter, who holds the tree upright until the two rear wheels press the soil around it and pack it tightly. Meanwhile the planter has another seedling ready and the operation is continued. Owing to the fact that there were many old weeds in the soil it was necessary that two extra men follow the machine and straighten trees not properly set. Under ordinary conditions, however, two men are a sufficient force to run the machine successfully.

On April 19th, 1910, a test made with this machine gave an average of 18 trees per minute for 10 hours, or 1,080 trees per hour, and 10,800 trees for the day. Although the machine planted as high as 35 trees per minute this speed was cut down by the time taken to turn around at the end of the row and to fill the baskets with trees. This operation required 3 to 4 minutes, and another half minute was required at the middle of each row to change the trees to the right-hand basket from which they could be more readily taken.

The total cost for the day, allowing for four horses and two men, was $8.00. Adding the cost of the two extra men who straightened the trees and received $1.50 each, the total cost was $11.00 per day, amounting to about one-tenth of a cent for each tree planted. The cost of the machine is said to be about $100.00 but its sale price will probably be greater.

The advantages of such a machine for sites similar to the one described can readily be seen. Not only is there a large reduction in the cost of planting but better results can be obtained. Its success must no doubt be attributed to the two rear wheels or rollers which pack the sub-surface soil and still leave a loose mulch on the surface. By this operation the roots are not only brought in close contact with the soil but a dust mulch is formed which conserves the moisture. It is to be hoped that this machine can be adapted for eucalypt planting and for conifers. If adapted for conifers it would be necessary to provide receptacles which would keep the roots of the seedlings moist.

# FORESTRY IN EASTERN CANADA.

By F. J. Pipal.

In trying to settle the question of the future timber supply in the United States, we have often been consoled by the supposition that our sister country, Canada, could spare something from its transatlantic trade with the mother country and help avert a timber famine. What the timber supply of Canada really is and to what extent the United States might be aided from this source, cannot be easily estimated as most of her forests are, as yet, unexplored. The total territory of Canada covers an area of about 3,745,574 square miles, or 2,397,167,360 acres, of which approximately 1,700,000,000 acres are included in forest area. The United States claims less than one-third of this acreage. If, however, the quality of these forests is considered, the odds are in favor of the United States.

Canada lacks the variety of types and the valuable species which are so abundant in certain parts of our forests. There are now, according to Dr. B. E. Fernow, about 150 recognized species and varieties in the Canadian forests. The conifers prevail and are far more important than the broad-leaved trees. They comprise about thirty-two species, namely ten Pines, five Spruces, four Firs, three Hemlocks three Larches, two Junipers, two White Cedars, one Yellow Cedar, one Yew, and one Douglas Fir. The Pacific forests which are the best in the Dominion include twenty important species of conifers and only twenty-five minor species of the 118 broad-leaved trees, thus giving the distinct characteristics of a coniferous forest. The province of British Columbia, which is said to possess the largest compact area of merchantable timber in North America, comprises about 182 million acres of forests, which is several million acres more than the total area of the National Forests of the United States. Douglas Fir predominates in the southern section but in the northern portion Yellow Cedar and Red Juniper, Hemlock, and Spruce are more common.

In 1895, the statistician of the Department of Agriculture, at Ottawa, summed up the conclusions in his report on the "Forest Wealth of Canada", as follows:

1. The first quality White Pine has nearly disappeared.
2. Of second quality White Pine there is a considerable supply.
3. Of other timber woods there is a large supply.
4. We are within measurable distance of the time when,

with the exception of White Spruce as to woods, and British Columbia, as to provinces, Canada shall cease to be a wood-exporting country.

If this were true in 1895, it is all the more true today. It is well known that the lumbermen not only in the United States but also in Canada cut only the best timber and in the last fifteen years they have been cutting it very rapidly, without replacing any.

Canada, whose climate and soil are largely fit only for timber growing, could be made to supply a considerable amount for export. Quebec is the oldest and one of the largest provinces of the Dominion, but so far, practically no attention has been given by the government to caring systematically for the protection and reproduction of the forest. Its land area comprises, in round numbers, about 218 million acres. It abounds in bays, lakes and rivers which afford excellent and, to a great extent, the only transporting facilities for timber, which is Canada's chief product. Of the total land area, 210 million acres are forest and waste land and the remaining eight million acres are devoted chiefly to farming and stock raising.

As the above figures indicate, the Province is rich in forest lands. In the south-eastern portion along the St. Lawrence and Manikuagan Rivers and the Gulf, there is abundance of White and Black Spruce and Balsam Fir, and some White Pine of fairly good quality. In the Saguenay district, the north-eastern section of the Province, there is a considerable amount of White Pine, White Spruce, Tamarack and other less valuable woods. The part west of the Manikuagan reaching to the watershed of the Gatineau River furnished, no doubt, the best White Pine timber of the province. The forests of the south-western portion, along the Ottawa River, contain mainly Aspen, White and Red Pines, Yellow, White and Paper Birches, White and Black Spruces, Arborvitae, and Sugar Maple.

The Province exports much of its forest products each year to the United States and Great Britian. The statistics of 1908 show that Canada's exports amounted in that year to over forty million dollars, a large share of which came from the province of Quebec. It may be of interest to note that more than two-thirds went to the United States and only about one-fourth to Great Britain. Most of the wood cut each year in the Province is manufactured into wood pulp and paper, but lumber and wooden-ware also require a considerable amount.

The wood pulp industry is very extensive and the Province justly claims the second largest pulp manufacturing establishment in the world. This establishment is the Laurentide Paper

Company which exports paper and pulp to all parts of the world. Their mills are located at Grand Mere, a French town of about 5,000 inhabitants located on the St. Maurice River, near the central portion of the Province. The company's forest lands extend mainly north and west of this point. Their holdings comprise a strip extending 160 miles north and south, and about 100 miles east and west. All of this land is in one unbroken tract with the exception of three isolated blocks about fifty square miles each, and one about 228 square miles.

The right to cut timber on these government or crown lands is obtained through a lease which is rather indefinite as to extension of time. In other words, the lease is in effect as long as both parties concerned find mutual satisfaction. As a return for the use of the forests the licensees pay a ground rent, usually so much per square mile, and a stumpage price for all timber cut. The government is supposed to protect the forest lands, but the protection was found to be so inadequate that many of the licensees decided to hire and pay their own fire rangers. The government is also supposed to regulate to a certain extent, and to inspect the cutting and logging operations of its leaseholders, but as in the case of the fire protection, this duty is very much neglected and the lease-holders usually follow their own methods. Notwithstanding the fact that this looks somewhat revolutionary and illegal, it is better for the government in the long run, and surely better for the forest. This is especially true in the case of the Laurentide Paper company, which endeavors to employ the best forestry methods. Other companies of the Province are slowly following.

The forestry division of the Laurentide Paper Company was organized in 1907, by Mr. E. E. Wilson, who had been employed by the company before this time as a surveyor. Mr. Wilson is not technically trained in forestry but he is a good, practical forester. His opportunities are unusual as he has full charge of the work and is free to put into practice any new system of operations that he deems advisable. He has done this so well that perhaps no other large area in North America illustrates the value of practical forestry better than the lands of this company. In other words, what we hear so often recited before the forestry associations, in the forestry class rooms and in many other places, is being actually placed into the woodchopper's axe and saw, and earnest and fairly successful attempts are being made to place it into the woodchopper's head also. The division consists of the manager, head inspector, one clerk who has charge of the department books, a surveyor, who has charge of the maps, about sixteen fire rangers and inspectors, and several assistant foresters. During the last few years a surveying party consisting of twelve or more men has also been employed.

The first duty of the forester was to make a plane-table survey of all lands belonging to the company and draw a set of maps which would be of value in carrying out the forest operations. Prior to this time the maps of the holdings were very inaccurate and often caused some unpleasant experiences. Practically all the survey had to be made along the streams, lakes, old portage lines blazed by the Indian and French trappers, and the boundaries of the leased lands. In connection with the survey, the plane-table man and the chief of the party made brief descriptions of the character of the forest. The maps also show all rapids, roads, farmhouses, burned areas, and other points which may be of value in the work. At the present time the company has a very complete set of maps which render all work simpler and more accurate than it has been in the past.

Another important task was to provide and organize an adequate fire protection service. As has been mentioned before, the government appointed and paid some fire rangers but these occupied themselves with hunting, fishing, and others sports, more than looking after the fire. This resulted in a request by the lease holders for the privilege of hiring and paying their own fire rangers. The privilege was granted. The company employed about eighteen men who acted as fire rangers during the dry and warm season, which lasts from the latter part of May until October, and as inspectors and assistant inspectors from October until April. The month of April is given as a vacation to all men in the forestry division.

The fire rangers patrol the forests by way of rivers and lakes. No roads have yet been constructed in the larger part of the limits and most of the traveling must be done with a canoe. This makes progress rather slow, as the canoe and all baggage must be carried from one lake to another, and around the rapids which are numerous and sometimes very long. The baggage is often carried over extremly rough portages. The use of head straps causes much of the weight to be supported by the strength of the neck and the rest is balanced on the back. The exercise is an excellent one and whoever passes through it, comes out strong and feeling, in the end, that he had gained some experience which is worth while. Many a man has to buy new collars when he comes back from the brush, for his old ones are at least two sizes too small.

The rangers travel in parties of two. They carry supplies enough to last them several weeks at a time. In dry weather they make no stops except to take their meals and camp for the night. Each party is equipped with a canvas canoe, tent, two sleeping bags, cooking utensils, shovel, two axes, and two canvas water buckets. Their duty is to put up fire posters, look out for any signs of fire, such as abandoned camp fires, ground fires and smudges, warn the trappers, hunters, and the settlers who become very careless at times, and explain to everyone who passes through or lives in the territory, why and how fire protection should be practiced and what the penalty is in case any one disregards the fire laws.

Most of the settlers have complied with the regulation and take all necessary precautions to prevent any damage while they are burning brush on their little farms. During the season of 1908, only three fires occurred, none causing much damage. Whenever a forest fire breaks out all able-bodied men in the community are expected to fight it. The Canadian government has provided for this in its laws. The fire rangers, who are invested with the powers of a justice of the peace, have the right of arresting and fining any one who disobeys their instructions and refuses to help. Only one case of a refusal to fight forest fire was recorded for the season. The fire is usually extinguished with sand and water, or beaten with spruce and balsam boughs.

The third important problem of the forester was to make a valuation survey and ascertain the quantity and quality of the timber. The regular strip method, adopted by the United States Forest Service, was used. Strips were run from stream to stream, lake to lake, or stream to lake, as water courses are at present, the only practical limits. The strips were run in gridiron fashion, one mile apart at right angles to the general axis of the streams so that all types were usually included and a fair average condition was obtained. When the distance between stream and lakes could not be covered in two or three days the strips were run inland for a distance of from one to three miles. Longer strips in such cases were abandoned on account of the lack of knowledge of the actual distance and the loss of time in traveling back and forth along the strip, as the party usually returned at night to the same camp. Traveling in the Canadian virgin forest is by no means easy and it may be safely said that every mile requires one hour of hard crawling, climbing, stumbling, and sliding. In a few cases only, the party moved the camp two or three times along the same strip.

The valuation survey party usually consisted of three men, sometimes of only two. When three men were employed one ran the compass line and blazed the trees, another estimated and called out the size of all trees down to six inches in diameter, and the third dragged the tape and recorded the sizes and species of the trees. When there were only two men in the party, the "caller" also blazed the trees and the "recorder" looked after the compass line. The general characteristics of the surrounding forest and the lay of land were always carefully noted and recorded. In the year 1908, two parties worked for a period of three months and covered a territory of about 584 square miles. One party ran an average strip of about one mile and a half in length per day.

The forest as a whole may be considered as a mixed, uneven-aged, coniferous stand with Balsam Fir and Spruce predominating. Birch and Aspen are the leading hardwood trees. Other species, which now and then are found in almost pure stands are Jack Pine, White Pine, and Red Pine. Usually Tamarack, Arborvitae, White Ash, Sugar Maple and Basswood are found singly or in small groves. White Pine, of large size and excellent quality, was found here abundantly at one time but was lumbered about thirty years ago and now occurs with a few exceptions as lonely sentinels left by the lumbermen on account of defects.

### TOPOGRAPHY.

The land is mostly rolling, cut by numerous streams and literally bedecked with lakes. There is at least one lake to every square mile of land. Some of these are several miles long and two or three miles wide. Most of the larger streams can be used for log-driving, especially during the months of May and June, when the water is high. The numerous rapids, however, some of which are more than two miles long, hinder the log-driving operation to a considerable extent and when the water lowers, stops it entirely. Many of the lakes are either entirely or partially surrounded by swamps. In some cases these swamps cover an area of several square miles.

### SOIL.

The soil is mostly a pure sand or a loamy sand. Clay is seldom found. Humus is usually several inches deep and great care must be exercised to prevent ground fires. In some portions of the forest rock is found in great abundance mostly along and near the large streams.

### BALSAM FIR TYPE.

The Balsam Fir type is the most common throughout the region and is often found in pure stands. In mixed stands, it grows best with the spruces or birches. The Balsam Fir trees have an average size of about twelve inches, diameter breast-high, and an average height of 60 to 70 feet. Often trees which attain a diameter of nineteen inches or more are hollow for a distance of ten to twenty feet from the stump, although they appear quite sound. Nearly fifty per cent of all Balsam Fir cut is affected with heart-root, which renders the species less valuable and makes the type undesirable. It has been claimed that more than fifty per cent of the timber in Canada is Balsam Fir. The logs of this species do not drive well.

### SPRUCE TYPES.

White and Black Spruce types are the next most common. The two types often occur together, the Black Spruce in the swamps and the White Spruce on the higher surrounding lands, and often it is almost impossible to draw any line of demarcation between the two types, or separate one species from the other.. Where the birches are commonly found in the White Spruce type the best development is reached. The average diameter breast-high is about fourteen inches but many reach eighteen inches or more. The average height ranges from 65 to 75 feet. This species is always sound and very desirable. Black Spruce, on the other hand, is not so good on account of its slow growth. Very few trees are found over nine inches in diameter. A large percentage of them die before they reach seven inches.

### TEMPORARY TYPES.

Old burn types are of three kinds, namely Aspen, Paper Birch, and Jack Pine types. These are usually found near villages or farming districts where at some time in the past the original forest had been cut clear or, more commonly, burned. Jack Pine is making rapid growth in some localities and can be used for ties. Trees nine inches or more in diameter are not uncommon. Paper Birch and Aspen have as yet no economic importance.

### MIXED TYPES.

Mixed types are very common especially where the topography is rather rough. The type may be either coniferous or hardwood, depending upon the predominating species. As a rule, the mixed coniferous type, with Balsam Fir and White Spruce as the leading species, is the more common. Paper Birch and Sugar Maple are the prevailing hardwoods.

### REPRODUCTION.

The question of reproduction demands careful study. White Spruce is most desirable but usually gives way to Balsam Fir which comes in after logging and wherever possible as an understory in old burns. Excellent examples of tolerant species coming up under the intolerant ones are found in abundance. If no disturbing factors come in, most of the Paper Birch and Aspen types will be replaced in time by Balsam Fir types. Spruce reproduction may be aided considerably by cutting Balsam Fir to a low diameter wherever possible and by leaving a sufficient number of good Spruce seed-trees This has been practiced to some extent during the logging operations and should be continued with more effort and care. White Pine, as far as natural reproduction is concerned, does not have much chance. Some planting of this and other pine species, such as Jack and Austrian Pines, has been tried, and it is hoped will prove successful. Jack Pine seems to find no difficulty in taking possession of the burned-over areas and makes a better growth if it comes in before Aspen or Paper Birch.

Windfalls are common and are sometimes several square miles in extent. The uprooted trees injure and destroy much of the young growth and also form a fire trap. Wherever the cutting is very heavy, all remaining conifers are very often blown over and the inferior species, such as Aspen or Paper Birch, then have a splendid chance to take possession of the ground.

### LOGGING.

The logging operations begin in September and end usually in March. The work is done almost exclusively by Frenchmen, since the Indians prefer trapping and hunting to the lumberman's life. All men are hired by jobbers, or contractors who enter into a contract with the company to cut a given amount of timber on a certain tract and pile it during the season on skidways at a specified place. The cost of logging, including all operations from the felling of the trees to the time they are placed on the landing, varies from five to seven dollars per thousand, board measure (Quebec Rule), depending upon the distance and ease of hauling to the landing place.

The scale of wages paid by the Laurentide Paper Company is as follows:

| | Per month and expenses. |
|---|---|
| Foresters (according to experience) | $45.00 to $100.00 |
| Scalers | 50.00 |
| Inspectors | 50.00 |

Assistant inspectors, and assistant scalers, sawyers, swampers and drivers .......................... 30.00

The "cutting crew" consists of six men; four sawyers, one swamper, and one skidder. The sawyers fell and cut the trees into logs, the swamper trims the logs and clears the way for the skidder. Skidding is done, as a rule, with one horse. The jobber besides supervising the work, blazes and clears the road which is to be used for hauling the logs from the skidways in the woods to the landing place. Each jobber usually employs from two to five "cutting crews". When all cutting is finished, the logs are hauled on sleighs to the landing places. These are located on the banks of lakes or streams on which the logs can be driven in the spring to Grand Mere.

All operations are done according to a set of logging rules which are, in part, as follows:

1. All trees must be cut to and none under the prescribed diameter limit which is nine inches for Balsam Fir on stump, eleven inches for White Spruce, and seven inches for Black Spruce. Seed trees are excepted. These are blazed and marked by the inspector.
2. The stumps must not be higher than two feet.
3. All logs must be thirteen and one-half feet long.
4. No tops shall be left which will make a log thirteen and a half feet long by four inches in diameter at the small end. Also all smaller trees which are broken down by the log trees and all dry and sound Spruce and Balsam Fir on burned over areas must be cut up if they contain logs thirteen and a half feet long by four inches at the small end.
5. Butting, (cutting off and discarding pieces from the butt end which are affected with a rot) is discouraged as much as possible. All logs must be taken out, piled on skidways, stamped and one end painted red. The ends of the logs are painted to distinguish them from those of the other companies, wherever they may be driven on the same river. The stamp marks often become illegible after the logs have been in water a couple of months or longer.

Violation of any of these rules is considered a violation of the contract and the jobber must pay ten cents for every high stump and every large top. They must also pay full market value for all logs, or felled log trees or trees supposed to be cut, which are left in the woods. The company's inspectors supervise the work and report any such violation in their weekly reports which are made out and sent regularly to the company's offices.

This system of rules and inspection was tried for the first time in the season of 1908, and has proved quite successful. Most of the jobbers and their men admitted the unnecessary waste and recognized the need and advantage of conservative lumbering. Only a few men have disregarded these rules. A determination on the part of the manager to enforce these regulations will compel these men to do the work properly or quit.

The inspectors are American men with college training who have studied or expect to study technical forestry. Each one has a French assistant who acts as an interpreter and helps in other ways. Both live in a log cabin built for them by the company. They cook their own meals when working near their cabin; otherwise they eat and sleep with the logging crews. A suggested list of provisions for these two men on one week's trip is as follows:

| | |
|---|---|
| Bacon | 3 lbs. |
| Salt Pork | 1 lb. |
| Flour | 4 lbs. |
| Beans | 2 lbs. |
| Cornmeal | 2 lbs. |
| Oatmeal | 2 lbs. |
| Rice | 2 lbs. |
| Cheese | 3 lbs. |
| Sugar | 2 lbs. |
| Salt | ¼ lb. |
| Coffee....½ lb., or tea | ¼ lb. |
| Molasses | 1 pint. |
| Soap | 1 bar. |
| Matches | 1 box. |

Each inspector has in his charge about ten camps with twenty or more cutting crews. The camps are usually less than a mile apart.

Besides the supervision of the logging camps, the inspectors make growth studies, using the complete stem analysis method. During the cutting season of 1908, about 1,000 trees were analyzed. These included White Spruce, Black Spruce, Balsam Fir, Jack Pine, Red Pine and Tamarack. No representative tables, showing the growth of these species, have as yet been worked out. Judging from the figures already obtained, White Spruce requires about twelve years to grow one inch and the Balsam Fir about ten years. These studies will be continued each year and in time, growth tables will be made.

Scaling is done at the landing places by men hired and paid by the company. The assistant scaler measures and stamps the logs and calls out the diameter to the head scaler who checks and records the logs on proper sheets.

At some time in May, after the ice has broken up and the melting snow has caused the water in the lakes and streams to rise, the logs are rolled into the water and driven down with the current. This work usually lasts until July when low water in the rapids stops further driving.

There is an excellent opportunity, to practice good forestry methods in eastern Canada, especially if certain defects in the government regulations are corrected. The limit holders could do a great deal more in the way of improvement if they were certain that no part of the limit would be withdrawn on short notice. Especially after certain elections, politicians in Canada have a system of dealing out lots from the forest limits to settlers, for so-called agricultural purposes. They may very appropriately be called political lots. In a majority of cases, these areas are not fit for agriculture, and the prospective settler really wants the lot for the timber that is on it. Upon application for such a lot, the license holder is notified to abandon the same by the first of May. He has a right to cut all the timber on it, before this time, to the diameter limit prescribed by the government. But the politician's favorite, who wants the timber, makes his application after the logging operations have been finished and the limit holder has no chance to do any cutting. This is very discouraging to the license holders and, if it happens too often, they have no desire to improve their methods. There is no classification of lands and the officials in charge are usually quite ignorant as to whether a certain portion of land is fit for agriculture or not. It is hoped that this troublesome arrangement will soon be corrected.

# A BUD AND TWIG KEY.

By O. L. Sponsler.

There is need of a compilation of descriptions of buds and twigs which will include only the more important forest trees, and will serve as a basis for a study of twig characters. An attempt is made in this article to fulfill this want. The data was collected from various sources and was found to be a mass of incomplete descriptions. They were checked up with live material whenever possible and often made more complete by addition of greater detail. The material was arranged in key form because that arrangement affords an easy means of comparison and gives prominence to the distinguishing features. It is anticipated that as a key it will not be of especial value. The work will be revised at a later date and will include a few more species and complete descriptions.

All the distinguishing features mentioned are visible with the unaided eye or with a hand lens of about four diameters magnification. The larger divisions of the key are based, wherever possible, upon characteristics which first attract the naked eye. In some cases the sub-divisions are based upon the size of the bud or the twig, or upon the amount of pubescence present. Such distinctions are often variable and unreliable but serve to show a possible difference.

Most of the terms used are common in systematic botany or are self-explanatory. A few however need explanation.

*Tip-scar,* a term used to designate the scar left when the deciduous tip of the twig is cast off. This occurs in twigs of indefinite growth. A few genera have formed the habit of casting the end of the twig in early summer and allowing the growth of the next season to be continued through the uppermost lateral bud.* The scar thus formed is often minute and indistinct as on the Hackberry, or very prominent as on the Catalpa.

*Twig,* the growth of the previous season only.

*Terminal bud,* a term used to designate the bud at the end of the twig when the seasons growth is definite, and when the twig has no deciduous tip.

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*"Twigs of woody Plants", A. S. Hitchcock, The Plant world, Vol. 9, No. 1, January, 1909.

DECIDUOUS BROAD-LEAF TREES.

*I.* Leaf-scars whorled, three (rarely two) at each node, oval with many bundle-scars in a line forming an ellipse, no stipule-scars, no terminal bud, tip-scar prominent, twig large, buds small globular partially sunk in bark. *Catalpa* Scop.

*II.* Leaf-scars opposite, two at each node.

*a1.* Bundle-scars three forming a lunate line.

*b1.* Stipule-scars represented by a line connecting leaf-scars.

*c1.* Terminal bud one-eighth to one-fourth inch long, two or more pair of scales visible, stipular line always present, leaf-scars narrow lunate.

*Acer* Linn. (Except *A. macrophyllum.*)

*d1.* Terminal bud acuminate dark brown, conical with five or six pair of scales visible, twigs brown glabrous, stipular line straight.

*A. saccharum* Marsh.

*d2.* Terminal bud red or greenish with one or two pair of scales visible, buds obtuse or globular.

*e1.* Stipular line between leaf-scars straight, twigs glabrous, usually red or reddish brown, scales glabrous. **A. saccharinum* Linn.
**A. rubrum* Linn.

*e2.* Stipular line usually broad and sharp angled, twigs change from green through several shades of purple and red during winter, often with white bloom, buds changing color with twigs, bud-scales often apiculate, outer pair slightly pubescent, inner scales silky tomentose.

*A. negundo* Linn.

*c2.* Terminal bud long-lanceolate or flattened, one pair of scales visible, stipular line usually present, bundle-scars three often united or indistinct, leaf-scars narrow lunate, especially in those near base of twig.

*Cornus* Linn.

*b2.* Stipule-scars and stipular line absent.

*Cornus* (see above).

*a2.* Bundle-scars five to many, often nearly united, forming a U-shaped line.

*b1.* Terminal buds one-half inch or longer and half as broad coated with wax, many light brown scales, bundle-

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*It is difficult to distinguish between these two species without leaves or fruit. *A. saccharinum* often has apiculate bud-scales and rather long, narrow buds while *A. rubrum* rarely has apiculate scales and usually quite globular buds.

scars five to seven prominent, no stipule-scars, twig large, leaf-scar large shield-shaped, pith large.

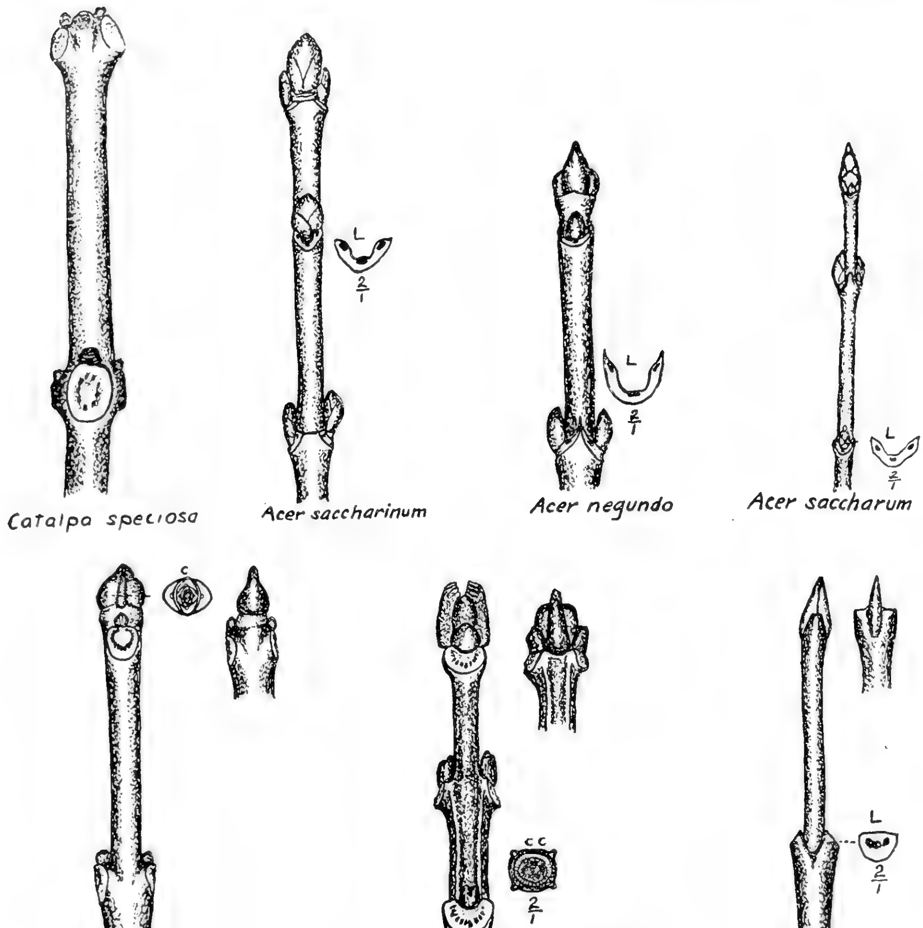
*Aesculus* Linn.

*b2.* Terminal buds one-quarter inch or shorter and nearly as broad, one or two pair of scales visible, light or dark brown felty, many bundle-scars form nearly a solid U-shaped line, twigs large, no stipule-scars, lateral buds small globose, leaf-scars semi-orbicular or lunate.

*Fraxinus* Linn.

*c1.* Twigs four-angled or -winged, buds light brown, outer pair of scales with pinnate apex.

*F. quadrangulata* Michx.




L—Leaf-scar magnified.
C—Cross-section of bud.
CC—Cross-section of twig.

*c2.* Twigs cylindrical, pubescent or glabrous, buds dark brown, scales broad ovate, apex acute.

* *F. americana* Linn.
* *F. pennsylvanica* Marsh.
* *F. lanceolata* Borkh.
* *F. oregona* Nutt.
* *F. nigra* Marsh.

*b3.* Terminal bud one-quarter inch long, scales several smooth red, distinct stipular line connects leaf-scars, bundle-scars five to seven distinct, twig large glabrous green changing to red during winter, leaf-scars crescent-shaped *Acer macrophyllum* Pursh.

*a3.* Bundle-scars many forming an ellipse.
*Catalpa* (see above).

*III.* Leaf-scars alternate, one at each node.

*a1.* Bud at end of twig entirely or partially sunk in bark.

*b1.* Twigs armed with two stipular prickles, bundle-scars three, buds white silky hidden beneath shield-shaped leaf-scar, no terminal bud, tip-scar or dead tip of the twig prominent, twig reddish brown.
*Robinia pseudacacia* Linn.

*b2.* Twigs armed with simple or branched thorns above the buds, several buds superposed, the lower ones hidden beneath the V-shaped leaf-scar, bundle-scars three prominent, no stipule-scars, no terminal bud, tip-scar distinct, twig light yellowish brown glabrous.
*Gleditsia triacanthos* Linn.

*b3.* Twigs without thorns or prickles.

*c1.* Pith salmon colored, twigs very large, buds small two superposed covered with brown hairs, no terminal bud, tip-scar prominent, no stipule-scars, leaf-scar large shield-shaped with three to five large protruding bundle-scars in a U-line, twig reddish brown or light gray.
*Gymnocladus dioicus* (Linn.) Koch.

*c2.* Pith white or yellow.

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*It is difficult to distinguish between these species without leaves or fruit. A cross-section of the terminal bud of *F. nigra* is usually elliptical and shows three pair of bud-scales, while in the case of the other four species the cross-section is more or less four-lobed and usually shows four scales. In the East the twigs of *F. pennsylvanica* are pubescent and the buds small, while *F. americana* and *F. lanceolata* are glabrous and the buds large, but near the Mississippi River and west of it there is much confusion of these three species. The twig of *F. oregona* is often light woolly.

*d1.* Twig large and hairy, bundle-scars six or a few more, bud densely silky grayish nearly surrounded by U-shaped leaf-scar, no stipule-scars, no terminal bud, tip-scar or dead tip of twig prominent, sap white, resinous, pith large yellow.

*Rhus hirta* (Linn.) Sudworth.

*d2.* Twigs small and glabrous, bundle-scars three or rarely five.

*c1.* One bud in axil of each leaf, only white silky top visible, nearly surrounded by U-shaped leaf-scar, no stipule-scars, no terminal bud, tip-scar prominent, twig dark red brown.

*Ptelea trifoliata* Linn.

*c2.* Several superposed buds in axil of each leaf, glabrous, hidden beneath leaf-scar; twig light yellow brown, glabrous.

*Gleditsia triacanthos* (see above).

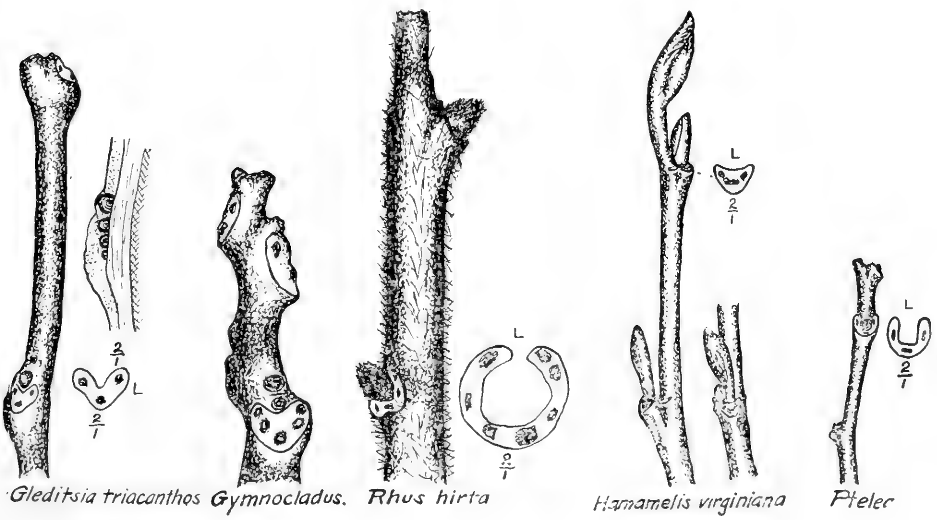
*a2.* Bud at end of twig not sunk in bark.

*b1.* Bud at end of twig irregular in outline, unsymmetrical in form, scales felty.

*c1.* Terminal bud pedicelled, scales with pinnate apex, buds densely tomentose light brown, stipule-scars small, twigs small dull gray-brown slightly pubescent, leaf-scars small broadly crescent-shaped, three or four bundle-scars often united in a single line.

*Hamamelis virginiana* Linn.

*c2.* Terminal bud sessile, no stipule-scars.




L—Leaf-scar magnified.

LC—Longitudinal section showing buds beneath leaf-scar.

*d1.* Pith brown chambered, bundle-scars three, often with two to four small superposed axillary buds, twigs large, leaf-scar three-lobed, three bundle-scars one in each lobe, the lowest bundle-scar U-shaped, terminal buds large gray-brown with three or four irregular scales indistinctly visible.

*Juglans* Linn.

*e1.* Band of pale tomentum elevated between leaf-scar and axillary buds, terminal bud one-half to three-fourths inch long often with pinnate apex, pith usually dark brown, twig greenish brown slightly pubescent.

*J. cinerea* Linn.

*e2.* Without band of tomentum between leaf-scar and buds, terminal bud about one-fourth inch long, pith usually light brown, twig reddish brown slightly pubescent.

* *J. nigra* Linn.
* *J. rupestris* Engelm.

*d2.* Pith nearly white solid, bundle-scars many scattered, axillary buds small quite regular and symmetrical, leaf-scars obscurely three- lobed, terminal buds one-half inch long compressed, usually two scales visible.

*e1.* Terminal bud bright yellow, leaf-scar small.

*Hicoria minima* (Marsh) Britton.

*e2.* Terminal bud covered with a dark brown glandular pubescence,** leaf-scar large with thin membranaceous border around it.

*Hicoria pecan* Britton.

*d3.* Pith white solid often with woody transverse partitions, bundle-scars about five in a U-line, axillary buds small oval, leaf-scars crescent-shaped narrow, terminal buds very narrow about one-fourth inch long, no scales distinct, very dark brown densely silky, twigs small, branchlets with longitudinal shallow grooves.

*Asimina triloba* (Linn.) Dunal.

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*Distinction between these two species is rather difficult from twigs alone. *J. rupestris* has larger terminal buds, usually between one-fourth and one-half inch long, pubescence on twigs remains until the second year, branches in their fourth year are nearly white. *J. nigra* has terminal buds usually a little less than one-fourth inch long, the branchlets in the second year are glabrous.

** United States Forest Service Bulletin 80.

*b2.* Bud at end of twig quite regular in outline but unsymmetrical in form, scales not felty.

*c1.* Buds pedicelled, terminal bud scurfy or slightly tomentose dark red, stipule-scars distinct but small, two bud-scales visible, valvate, bundle-scars three, leaf-scar rounded crescent-shaped.

*Alnus* Ehrh.

*c2.* Buds sessile, scales glabrous bright red or greenish, one large scale makes bud unsymmetrical, usually three scales visible, bundle-scars about eight scattered through the broadly crescent-shaped leaf-scar, stipule-scars distinct, one broad the other linear, no terminal bud, tip-scar prominent, twigs medium size, buds mucilaginous pleasant tasting.

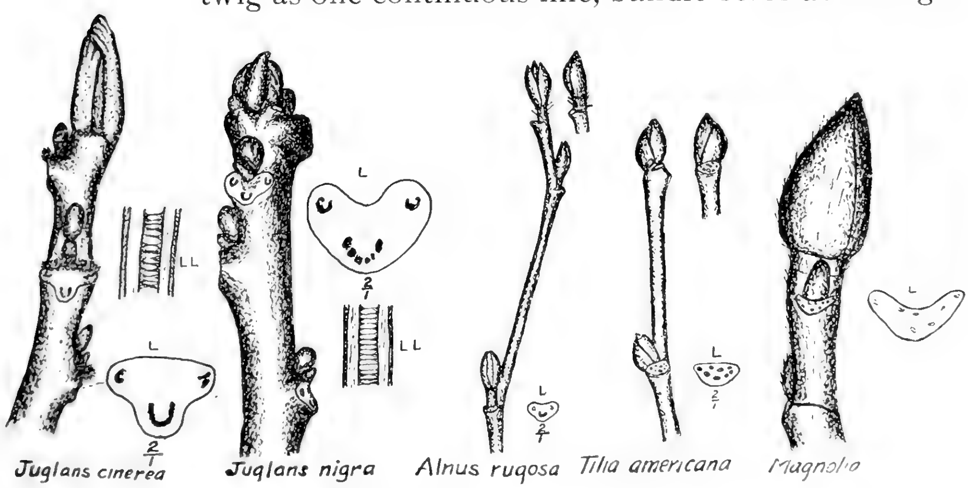
*Tilia americana* Linn.

*b3.* Buds at end of twig regular and symmetrical.

*c1.* Stipule-scars extend half way around twig or farther.

*d1.* Terminal bud large ovate covered with long white hairs, one scale visible, leaf scar large and oval or lunate, bundle-scars about eight in a U-line or scattered, stipule-scars extending completely around twig join to form a narrow continuous line, twig large. *Magnolia* Linn.

*d2.* Bud at end of twig small nearly conical glabrous red or greenish, leaf-scar encircles bud, one scale visible, stipule-scar extends completely around twig as one continuous line, bundle-scars about eight




L—Leaf-scar magnified.
LL—Longitudinal section showing chambered pith.

in a U-line, twig medium size, no terminal bud, tip-scar distinct.

*Platanus occidentalis* Linn.

*d3.* Terminal bud spatulate glabrous greenish red, leaf-scar orbicular, two valvate bud-scales; stipule-scars, encircling twig as a continuous line, meet forming a notch; bundle-scars ten scattered, twig medium size.

*Liriodendron tulipifera* Linn.

*d4.* Terminal bud long lanceolate sharp pointed, many scales light brown glabrous or pubescent at apex, leaf-scar somewhat crescent-shaped or elliptical, stipule-scars not a continuous line, one ends above the other, bundle-scars about six scattered, twig small glabrous reddish-brown.

*Fagus atropunicea* (Marsh.) Sudworth.

*c2.* Stipule-scars distinct but small.

*d1.* Pith white chambered, buds small brown slightly pubescent flattened against twig, stipule-scars minute, bundle-scars three, often united into one line, twigs small glabrous or pubescent, no terminal bud, tip-scar not prominent.

* *Celtis occidentalis* Linn.

*d2.* Pith solid.

*e1.* Buds ovate clustered at end of twig, bud-scales many chestnut brown, bundle-scars many scattered, pith somewhat five-angled, terminal bud present, stipule-scars distinct.

** *Quercus* Linn.

*f1.* Bud-scales loosely imbricated.

*g1.* Twigs glabrous slender, dull red, becoming grayish brown the second year, buds acute strongly angled, scales dark brown minutely pubescent, scarious margins.

*Q. nigra* Linn.

*g2.* Twigs coated with tomentum, stout becoming dark brown often with glaucous bloom, buds obtuse tomentose one-fourth to one-third inch long, outer scales linear lanceolate, inner scales wider and rounded at apex.

*Q. densiflora* Hooker & Arn.

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*Compare *Morus rubra.*

**The descriptions of the Oak twigs given here are taken from Sargent "Silva of North America."

*f2.* Bud-scales firmly imbricated.

*g1.* Buds less than one-fourth inch long.

*h1.* Buds covered with pubescence.

*i1.* Branchlets two years old covered with soft pale pubescence, twigs stout light brown becoming darker the second year, buds brown broadly ovate obtuse about one-eighth inch long.
*Q. minor* (Marsh.) Sargent

*i2.* Branchlets two years old glabrous.

*j1.* Twigs slender light yellowish brown slightly pubescent becoming lighter colored in second year, buds acute scarcely one-fourth inch long.
*Q. lobata* Née.

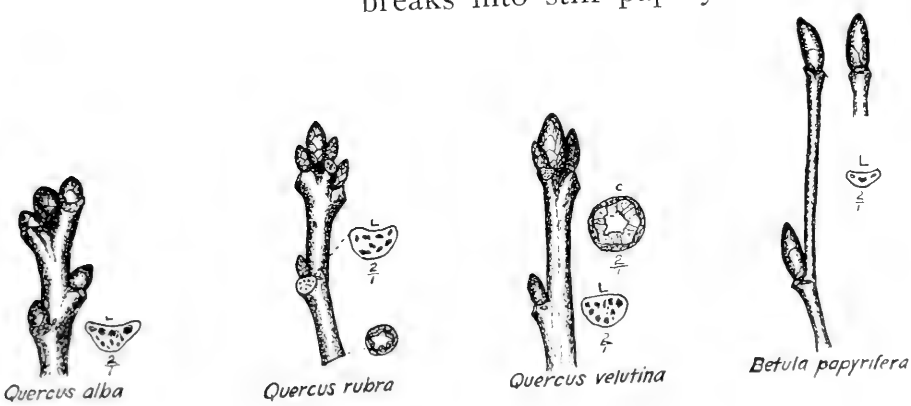
*j1.* Twigs slender light yellowish-brown, or minutely pubescent growing darker or ashy gray in second year, buds obtuse or acute one-eighth inch long light brown. *Q. gambelii* Nutt.

*j3.* Twigs stout light yellowish glabrous becoming ashy gray or light brown in second year, corky wings on branchlet usually appear second or third year, buds broadly ovate, acute or obtuse one-eighth to one-quarter inch long. *Q. macrocarpa* Michx.

*h2.* Buds glabrous or slightly or partially pubescent.

*i1.* Buds obtuse.

*j1.* Bark on branches one inch in diameter breaks into stiff papery sheets, twigs




L—Leaf-scar magnified.
C—Cross-section of twig.

stout light brown glabrous growing darker in second year, buds one-eighth inch long, scales light brown with pale scattered hairs near apex.

*Q. platanoides* (Lam.) Sudworth.

*j2.* Bark not forming papery plates.

*k1.* Buds glabrous dark red-brown one-eighth inch long, broadly ovate obtuse, twigs slender red and lustrous or coated with glaucous bloom becoming ashy gray in second year.

*Q. alba* Linn.

*k2.* Buds tomentose near margin of scales, light brown obtuse, twigs slender glabrous grayish brown becoming ashy gray or light brown, buds one-eighth inch long.

*Q. lyrata* Walt.

*i2.* Buds acute.

*j1.* Bud-scales with scarious margins.

*k1.* Scales erose, light brown lustrous, buds acute one-eighth inch long, twigs slender glabrous light brown growing darker in second year.

*Q. imbricaria* Michx.

*k2.* Bud-scales entire brown, margin light, bud acute one-eighth inch nearly one-fourth inch long, twigs slender glabrous light brown becoming darker in second year.

*Q. acuminata* (Michx.) Houba.

*j2.* Bud-scales without scarious margins.

*k1.* Twig stout pubescent dark brown becoming brown or gray in second year, buds acute one-eighth to one-fourth inch long bright brown scales minutely pubescent.

*Q. digitata* (Marsh.) Sudworth.

*k2.* Twigs slender glabrous lustrous brown growing darker in second year, buds one-eighth inch long gradually tapered to acute apex light brown glabrous or often minutely pubescent.

*Q. palustris* Muenchh.

*g2.* Buds one-fourth inch or longer.

*h1.* Twig conspicuously densely hairy light brown stout, becoming glabrous bright reddish in the second year, buds acute one-third to one-half inch long covered with a dense coat of light rusty tomentum.

*Q. garryana* Dougl.

*h2.* Twigs glabrous.

*i1.* Buds prominently angled acute one-fourth inch long covered with rusty brown hairs, twigs stout light to dark brown becoming darker or ashy gray the second year.

*Q. marilandica* Muenchh.

*i2.* Buds covered with light gray pubescence, one-fourth to one-half inch long, gradually taper to obtuse apex, strongly angled, twigs stout dull red-brown becoming darker in second year, pith yellow.

*Q. velutina* Lam.

*i3.* Buds glabrous or only partially pubescent.

*j1.* Bud-scales with scarious margins, minutely pubescent, scales of inner ranks tomentose on outer surface, buds broadly ovate or oval acute one-fourth inch long, twigs bright red or yellowish brown becoming ashy gray in the second year.

*Q. michauxii* Nutt.

*j2.* Bud scales without scarious margins.

*k1.* Twig light brown stout becoming dark gray or brown in the second year, buds acute or acuminate one-fourth to one-half inch long and narrow in proportion, scales light brown with ciliate margins.

*Q. prinus* Linn.

*k2.* Twig dark red brown slender remaining about the same the second year, buds taper gradually to acute apex, one-fourth inch long light brown glabrous.

*Q. rubra* Linn.

*e2.* Buds solitary at end of twig.

*f1.* Buds long narrow appressed, one cap-like scale glabrous or pubescent, bundle-scars three in a narrow lunate leaf-scar, stipule-scars usually distinct, twigs slender, no terminal bud, tip-scar often prominent.

*Salix* Linn.

*f2.* Bud globular very small, three scales visible, a one-fourth inch thorn accompanying the axillary bud, leaf-scar small round with one bundle-scar or several clustered in the center, stipule-scars very small, twigs small, sap milky, pith of the older branchlets often yellow, no terminal bud, tip-scar indistinct.

*Toxylon pomiferum* Raf.

*f3.* Buds ovate or long oval, apex acute, two to four scales visible.

*g1.* Bundle-scars three, dwarf shoots common, buds long oval about one-fourth inch long, twigs small, no terminal bud, tip-scar distinct.

**Betula* Linn.

*h1.* Twigs dull red, becoming shiny dark yellowish brown the second year, buds slightly resinous.

*B. papyrifera* Marsh.

*h2.* Twigs light yellowish brown, becoming shiny yellowish brown.

*B. lutea* Michx.

*h3.* Twigs very dark red shiny becoming dull reddish brown the second year.

*B. nigra* Linn.

*h4.* Twigs bright red brown shiny becoming dull brown, have wintergreen flavor.

*B. lenta* Linn.

*g2.* Bundle-scars four to six or more scattered, no dwarf shoots, stipule-scars small but distinct, no terminal bud, tip-scar distinct.

*h1.* Pith five-angled, buds glabrous dark brown ovate or oval scarcely one-fourth inch long, twig glabrous brown.

*Castanea dentata* (Marsh) Borkh.

*h2.* Pith round, buds broadly ovate, one-fourth inch long light brown glabrous.

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*Distinction between the species is difficult from twigs alone.

flattened against twig, twig glabrous light brown.

**Morus rubra* Linn.

*f4.* Buds ovate acute, more than four scales visible.

*g1.* Bundle-scars about six to ten scattered, bud appressed, not more than five scales visible.

*Morus rubra* (see above).

*g2.* Bundle-scars three to six arranged in a lunate line.

*h1.* Pith five-angled, terminal bud ovate long pointed, leaf-scar broad, outermost bud-scale directly above leaf-scar, middle one of the three bundle-scars often double, branchlet roughened by elevated leaf-scars.

*Populus* Linn.

*i1.* Terminal bud one-half to three-fourths inch long, resinous.

*j1.* Buds fragrant very resinous, three-fourths inch long and one-fourth inch broad, lateral buds often flattened against twig, twigs stout light or dark orange color lustrous, bud scales slightly pubescent at base, scarious margins.

*P. trichocarpa* Torr. & Gr.

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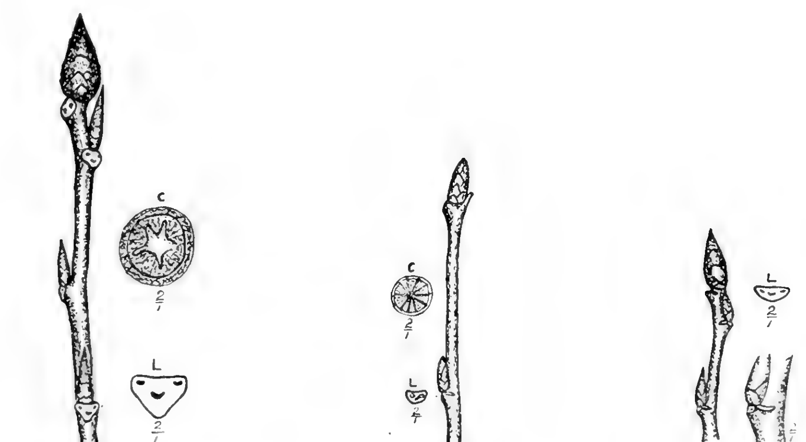
*Compare *Celtis occidentalis.*




P grandidentata — Carpinus caroliniana — P. tremuloides

C—Cross-section of twig.
L—Leaf-scar magnified.

*j2.* Buds not fragrant, one-half inch long, resinous, flattened, slightly pubescent at base, leaf-scar three-lobed truncate or emarginate above, twigs stout often with ridge extending downward from each side of leaf scar. *P. deltoides* Marsh.

*i2.* Terminal buds about one-fourth inch long slightly or not at all resinous.

*j1.* Stipule scars very faint lines or usually none, bud not resinous, axillary buds about one-fourth inch long, terminal bud a little longer, scales slightly pubescent, leaf-scars rounded triangular, twig and bud brown, buds spread wide from twig, not flattened.

*P. grandidentata* Michx.

*j2.* Stipule-scars distinct, buds slightly resinous.

*k1.* Pith orange color, buds broadly ovate, scales slightly pubescent towards base, leaf-buds one-fourth inch, flower-buds one-half inch long, bright red brown, twigs light yellowish stout becoming darker in second year rough with large leaf-scars.

*P. heterophylla* Linn.

*k2.* Pith white, buds narrow conical sharp pointed, scales glabrous shiny, scarious margin, leaf-scars lunate, terminal buds usually about one-fourth inch, lateral buds about one-eighth inch long, twigs and buds red-brown lustrous, outermost bud-scale emarginate, twigs slender.

*P. tremuloides* Michx.

*h2.* Pith round, terminal bud one-eighth inch long, twig has bitter aromatic taste, leaf-scars lunate five ranked on twig, bundle-scars three, many bud-scales glabrous, first pair lateral, stipule-scars distinct but small.

*Prunus serotina* Ehrh.

*Compare *Ulmus americana* and *Ulmus racemosa*.

*h3.* Pith round, no terminal bud, leaf-scars two-ranked on the twig, many bud-scales.

*i1.* Pith-rays in a one-sixteenth inch diameter branchlet distinctly visible with hand lens, twigs about one-thirty-second inch in diameter, leaf-scars very small, stipule-scars minute, bud about one-eighth inch long, twig dark red lustrous becoming when about one-half inch diameter dull gray, tip-scar very small, often dead tip of twig extends past the end bud, bundle-scars three.

* *Carpinus caroliniana* Walt.

*i2.* Pith-rays in small branchlet scarcely or not at all visible with hand lens, twigs one-sixteenth inch or larger.

*j1.* Bundle-scars three to six depressed in corky layer of leaf-scar, tip-scar distinct, stipule-scars small, twigs zigzag usually larger than one-sixteenth

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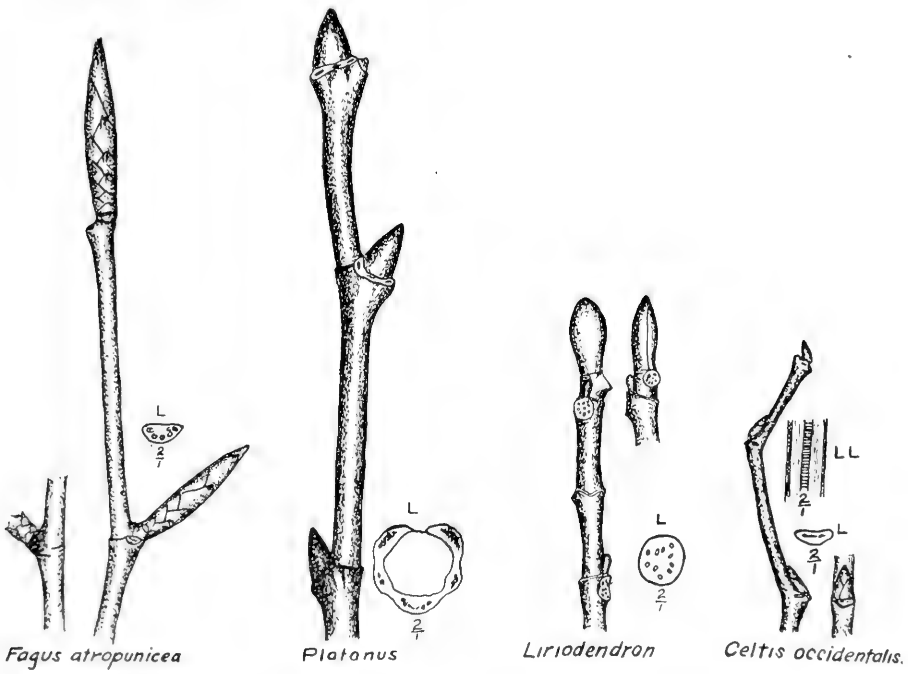
*Compare *Ostrya virginiana, Ulmus americana, Carpinus caroliniana* and *Prunus serotina.*




L—Leaf-scar magnified.
LL—Longisection showing chambered pith.

inch, light brown, bud scales with rounded apex.

**Ulmus* Linn.

*k1.* Buds broadly ovate obtuse dark brown, outer scales with rusty brown hairs, next scales within covered with thick rusty tomentum, buds one-fourth inch long, oval leaf-scars, twig light grayish or brownish slightly roughened, becoming darker second year, bundle-scars three, tip-scar not prominent.

*U. pubescens* Walt.

*k2.* Buds ovate acute slightly flattened one-eighth inch long, scales glabrous bright chestnut brown, leaf-scars oval or semi-orbicular, bundle-scars three rarely four, twig reddish brown.

*U. americana* Linn.

*k3.* Buds ovate one-fourth inch long, scales brown slightly pubescent, margin ciliate with soft white hairs, bundle-scars four to six in rather irregular line, leaf-scars orbicular or semi-orbicular or triangular, twig light brown glabrous or minutely pubescent.

*U. racemosa* Thomas.

*j2.* Bundle-scars three raised slightly above surface of very small lunate leaf-scar, stipule-scars minute, twigs one-sixteenth inch rarely larger, buds about one-fourth inch long, bud-scales light brown with obtuse apex, twigs red-brown lustrous becoming when about one-half inch diameter dull brown.

** *Ostrya virginiana* (Mill.) Koch.

*c3.* Stipule-scars none.

*d1.* Bud-scales felty, bundle-scars many scattered, pith angled, twigs very tough, terminal buds broadly

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*Compare *Carpinus, Ostrya,* and *Prunus.*

**Compare *Carpinus caroliniana* and *Ulmus americana.*

ovate, four or more scales or scars left by early deciduous scales.

*Hicoria* Raf.

*e1.* Outer scales deciduous in autumn or early winter.

*f1.* Bud-scales two exposed, leaf-scars small more or less obscurely lobed, terminal bud about one-fourth inch long dome-shaped with acute apex.

* *H. glabra* (Mill.) Britton.

*f2.* Terminal buds one-half to three-fourths inch long, three or four outer scales deciduous in autumn, exposed scales densely tomentose or silky, leaf-scars more or less obscurely lobed.

* *H. alba* (Linn.) Britton.

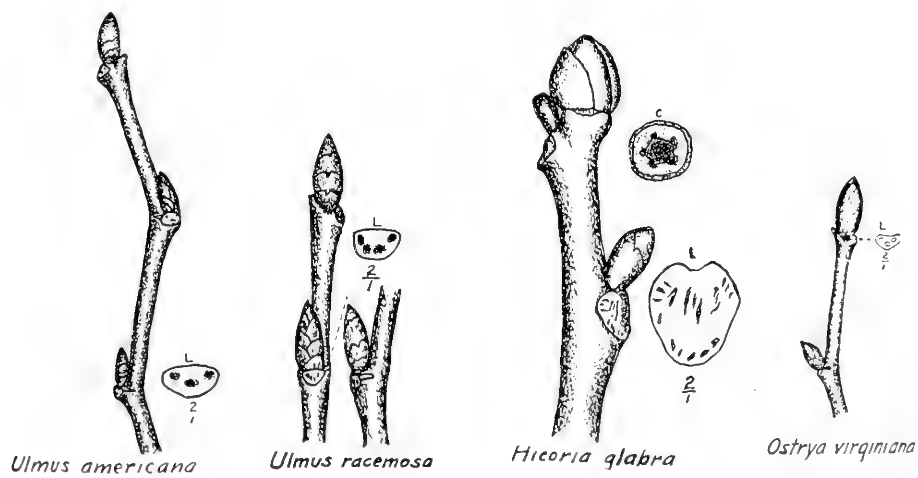
* *H. ovata* (Mill.) Britton.

*e2.* Outer scales remain until spring, terminal bud three-fourths to one inch long, leaf-scar three-lobed, twigs stout, outer scales eleven or twelve, leaf-stocks of previous year often persist.

* *H. laciniosa* (Michx.) Sargent.

*d2.* Bud-scales glabrous or slightly pubescent, bundle-scars one or three, pith round.

*It is difficult to distinguish between the species of this group of Hickories even when all characteristics, leaf, fruit, bark, etc. are at hand, for there seems to be a great many intermediate forms. *Hicoria alba* and *Hicoria ovate* are especially hard to separate definitely.




C—Cross-section of twig.
L—Leaf-scar magnified.

*e1.* One prominent bundle-scar transversely elongated.

*f1.* Terminal bud one-fourth inch or longer, broadly ovate, obtuse apex, four to six greenish red scales visible with rounded apex, glabrous, leaf-scar semi-orbicular or broadly crescent-shaped, twig bright green lustrous brittle, spicy aromatic taste, pith mucilaginous one-half diameter of twig.

*Sassafras sassafras* (Linn.) Karst.

*f2.* No terminal bud, tip-scar distinct, buds one-eighth inch long broadly ovate flattened against twig, acuminate apex, scales two dark brown lustrous, leaf-scars semi-orbicular, twigs slender light brown or gray becoming darker in second year.

*Diospyros virginiana* Linn.

*e2.* Bundle-scars three.

*f1.* No terminal bud, tip-scar distinct, buds two superposed the larger one scarcely one-sixteenth inch long, appressed, nearly hemispherical, scales two rarely three visible, dark brown, smaller bud nearly hidden between upper one and the rounded triangular leaf-scar, twig brown speckled with gray, glabrous.

*Cercis canadensis* Linn.

*f2.* Terminal bud one-eighth to one-fourth inch, more than four scales visible.

*g1.* Pith solid with woody transverse plates about one-eighth inch apart visible with hand-lens, terminal bud one-fourth inch long obtuse, scales six or seven visible, dark reddish slightly pubescent, leaf-scar lunate, twig glabrous or nearly so, light brown becoming darker the second year.

*Nyssa sylvatica* Marsh.

*g2.* Pith homogeneous.

*h1.* Leaf-scars broadly lunate or semi-orbicular, terminal bud acute about one-fourth inch long, scales polished, ciliate margin, bundle-scars large annular, pith large in twigs, branchlets often winged after second year.

*Liquidambar styraciflua* Linn.

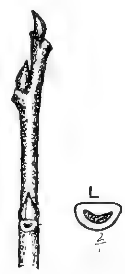
*h2.* Leaf-scars narrowly lunate, buds nearly globular, numerous scales rounded or obtuse at apex, chestnut brown lustrous, twigs glabrous, usually armed with thorns.

*Cratægus* Linn.

*d3.* Bud-scales slightly pubescent, inner ones silky tomentose, bundle-scars five, terminal bud about one-half inch long ovate acute, scales three or four visible dark red, leaf-scar narrow lunate, lateral buds small, two scales visible, twig stout red-brown glabrous becoming darker in second year, on branchlets outer papery layer of bark easily separable from green layer beneath.

*Pyrus americana* (Marsh.) de. C.


Sassafras sassafras




Diospyros virginiana

L—Leaf-scar magnified.

# NEBRASKA FOREST FUNGI. II.

## SOME LEAF-INHABITING FORMS.

By Raymond J. Pool.

Each of the main groups of fungi furnishes a number of species that attack the leaves of forest trees. Many such attacks are so slight that they are hardly noticed while others assume extremely destructive proportions. The ravages of fungous pests of economic importance usually depend upon the virulence of the diseases caused by parasitic forms and upon the rapidity of their dissemination. Some are extremely virulent diseases but infection travels so slowly that the disease is of little importance. In some cases it seems that its spread is checked or finally inhibited completely by its own ravenous nature. And again there are numerous diseases not nearly so virulent that spread with great rapidity and hence the summation of destruction becomes very great over a wide territory. Leaf fungi are apt to behave in this manner.

We have in reality obtained, at present, but the merest beginning of a complete knowledge of the physiology of leaf fungi, notwithstanding the seeming voluminous literature upon the subject. True, we know something of how the parasitic fungus enters the host plant, and some of the general morphological reactions of the latter to such an attack. But when we think of the complications introduced by the heterœcious habit and by the seeming ease of adjustment of parasitic fungi to differing host-physiology without any apparent morphological response, we are forced to confine our statements to generalities. At present we merely classify certain external and internal evidences and call these "symptoms of disease", which procedure are of course one of the first steps in a logical investigation. Thus we generalize and say that such a disease as the Tar Spot of the maple is injurious because "it draws nourishment from the host that would otherwise go to the upbuilding of host tissue", and "that the photosynthetic area is considerably reduced." All this is *probably* true, but is that all of the question?

Very naturally the next thing considered is some suggestion for treatment or eradication of the disease. The many mistakes that have been made not only in diagnosis, but also in suggested and attempted remedial measures, show quite well the present conditions of affairs. No one contemplating entering this line of investigation need be discouraged for, altho the field may seem old and already well worked, there is an abundance of material still available for investigation, and I feel that the really "startling disclosures" are still in the future. We have so far but a few very slender threads that serve merely as hints of the nature of the well-woven fabric that must yet be many years in the weaving.

A complete list of the fungi found growing upon the leaves of our forest trees and other woody plants would cover a number of pages. Many of these are parasitic, many saprophytic, and some are probably on the border line between these two great types of nutrition. In some of the genera of *Fungi Imperfecti* that are so common as "spot fungi" there are many species of very doubtful validity. It is frequently quite impossible to identify such species by published descriptions, and it would seem at times that species had been made for such fungi upon the slightly varying characters that might well be produced by very slightly different host-physiology; characters that are very fleeting and unstable. Over and over again in working with such forms I have been puzzled because the spores were a little too long, or the constrictions at the septæ not deep enough, or the spots not of the right color to "fit" the type description. Those who have worked in *Cercospora* or *Septoria* appreciate this nature on the part of many fungi. And the peculiarity becomes more conspicuous the more one studies.

I have not attempted to prepare a complete monograph of the leaf fungi of Nebraska forest trees in the following pages, but have merely indicated a number of the most common forms from the various groups. Much more detailed work must be done before a comprehensive treatment of the question can be forthcoming.

## ASCOMYCETES.

*Phacidiaceae:*

In this family (usually classified with the *Discomycetes*) the apothecia develop with a surrounding stroma which is usually coherent with the substratum. In the beginning the apothecia are closed and sunken. Later they become disk-like or elongate, single or grouped, and more or less erumpent, and finally they acquire a tough and leathery, or even carbonous texture. They open by a circular or transverse split and the edges become turned back as more or less irregular lobes. Some species in the family develop copious conidia over the stroma preceding the formation of the apothecia. The most conspicuous member of the family that occurs in Nebraska is the "Tar Spot" of the Maple.

*Rhytisma acerinum* (Pers.) Fr.

This fungus producing the disease of the maple commonly known as "tar spot" or "black spot" is very common in the state during some seasons. The jet black affected areas of the leaf are very conspicuous especially in the late summer when they are fully developed. The first symptoms of the disease are seen in the appearance of roundish, yellowish, thickened areas soon after the leaves have reached their full size. Soon the areas become slightly depressed on the lower side of the leaf and slightly raised on the upper side. A cross section at this time shows that beneath the epidermis the mycelium has become compacted into a stroma-like tissue, and that myriads of unicellular curved conidiospores are being abjointed from short conidiophores or basidia arising from the stroma. These spore-bearing areas are quite completely covered by a membranous tissue which later becomes somewhat broken. It is supposed that these spores, as usual, serve to spread the disease during the growing season. The conidial stage is usually referred to the form genus *Melasmia* among the *Fungi Imperfecti*.

As the season advances these spots gradually acquire a tough, leathery consistency on the upper side and become black externally. Internally the spots, which may be a centimeter across, are pure white. The whole spot is in reality made up of sclerotial tissue with a rather firm enclosing membrane. At this time the spots are much thicker than the normal leaf, and they continue to increase in thickness until the leaf falls from the tree, so that at leaf fall they may be three or more times as thick as the uninfected portions of the leaf. In this condition the fungus passes the winter. See fig. 12. If the black spots are examined with the hand lens at this time it is

Fig. 12. *Rhytisma acerinum* on maple.

seen that the surface is rather uneven, rendered so by the complex of low ridges that gives a peculiar wrinkled appearance to the surface of the spots. By the following spring there have developed in the sclerotial masses many complex apothecia which rupture the surface along the ridges in the black wrinkled surface. These openings appear as very fine elongated fissures, so that at this time the surface becomes cut and lacerated. The asci are club-shaped with long stalks, and contain eight long, narrow, pointed spores.

When this parasite developes to the degree that characterized its activity in certain parts of the state during the season of 1910 it certainly decreases the efficiency of the photosynthetic machine to a considerable degree. Many very badly infected trees were found in Cass County. On some of these considerably more than one half of the leaf area was covered by the spots of this organism, and the total extent of infection was of course much wider than the spots indicated. The above species is very common on *Acer saccharinum* L. in eastern Nebraska.

Other species of *Rhytisma,* such as *R. salicinum* (Pers.) Fr. on various species of *Salix,* are quite widespread although not so conspicuous as the above species since willows are not so commonly cultivated as maples and the spots on willows are not so prominent nor so large as those on the maples.

*Exoascaceae:*

Within our borders this group of fungi is important mainly as producing disease in certain wild and cultivated fruit trees belonging to the *Rosaceae.* The family is composed largely of parasitis species which live in the intercellular air spaces of Drupaceous hosts. The commonest and most widespread species are *Exoascus deformans* (Berk.) Fuckel, causing the "leaf curl" of the peach, and *E. pruni* Fuckel, causing the so-called "plum-pockets" on varieties of plums. They are consequently of little importance to the forester in Nebraska. However in other regions certain species very commonly produce deformities of the leaves and fruits of forest trees. A number of species are known that possess a perennating mycelium, while in the greater number of the species in the family all of the mycelium is used up in the formation of asci. The asci are formed at the ends of hyphae just beneath the epidermis of the host. The asci are usually exposed at maturity and in considerable abundance so that a powdery nature is given to the surface of the infected portions. Some of the perennial species form "witches' brooms" on species of *Alnus.*

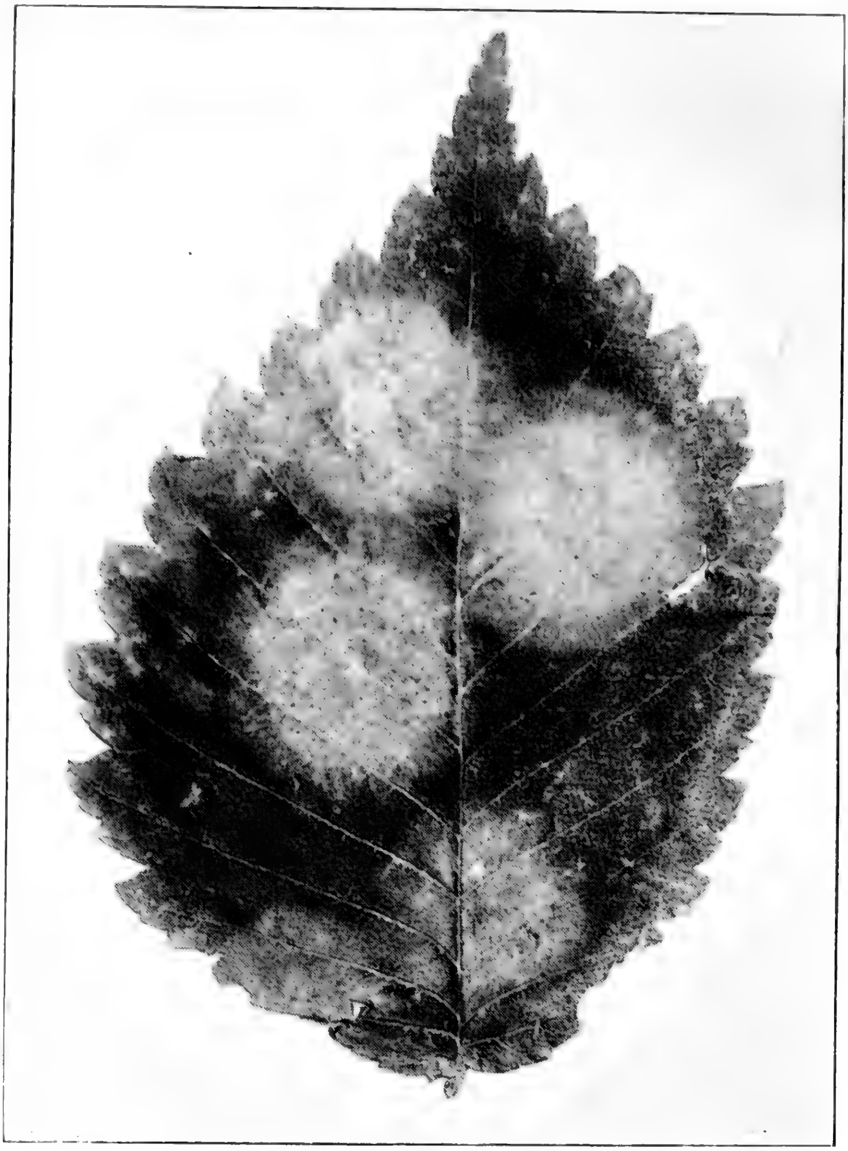


Fig. 13. *Uncinula macrospora* on the Elm. Notice the colonies showing radial growth.

*Erysiphaceae:*

These parasitic fungi are commonly known as "Powdery Mildews" because of the powdery nature given by them to the surface of the infected tissues. The "powder" is in reality composed of myriads of the asexual conidiospores that are formed in chains on simple scattered conidiophores. The filamentous, silky- white, septate mycelium often forms conspicuous colonies over the leaves of some of our forest trees such as the Elm, Willow, and Cottonwood. See fig. 13. Upon the same mycelium that produces the conidiospores the perithecia are formed, later in the summer, usually in more or less restricted areas or sometimes scattered well over the whole surface of the leaf. The perithecia are at first tiny white specks which gradually deepen in color through light yellow, orange, brown, and finally become black at about the time that the leaves begin to fall, or sooner. When they occur in colonies the youngest individuals are at the periphery of the colony and the oldest ones near the center of the radiate colony. This character is often shown very distinctly in the Elm Mildew. The mature perithecia are usually dark brown or black and in shape are spherical or lens-shaped. In many of the species certain cells of the outer wall of the perithecium are extended into peculiar appendages the tips of which are characteristically modified for the various genera and species. The number of asci per perithecium varies from one to many. The asci are usually oval or ovoid cells and contain from two to eight simple, hyaline spores. The species are mostly leaf parasites.

### *Microsphaera*

The perithecia in this genus are globose or globose-flattened. There are several, 2–8 spored asci. The appendages are free from the mycelium, branched at the tip in a definite form, usually several times dichotomously divided and ornate.

*Microsphaera alni* (Wallr.) Wint.

The mycelium of this species covers both sides of the infected leaves as thin effused areas that are either evanescent or persistent. The perithecia are scattered or densely gregarious, 66–110 microns in diameter. The appendages are very variable in number and length with tips more or less closely 3–6 times dichotomously divided with the tips of the ultimate branches regularly and distinctly recurved. The asci are more or less oval and vary in number from 3–8. On: *Quercus macrocarpa, Q. rubra,* and *Syringa vulgaris.*

*Microsphaera alni vaccinii* (Schwein.) Salmon.

This variety is very much like the species but is usually confined to the upper surface of the leaves, and the perithecia are, on the average, smaller. The branching of the appendages is also irregular, being sometimes loose and widely forked. The variety is quite common on *Catalpa catalpa,* and *C. speciosa.*

*Microsphaera grossulariae* (Wallr.) Lev.

This species may be restricted to the upper side of the leaves or it may occur on both sides. The perithecia are scattered or densely gregarious. The appendages number from 5–22, with tips 4–5 times dichotomously divided. Branches of the first and second order are very short, all of the segments deeply divided, ultimate branches forming a narrow fork, tips not recurved. Asci 4–10. On: *Sambucus canadensis.*

*Microsphaera diffusa* C. & P.

The persistent mycelium covers both sides of the leaves in this species, in thin effused areas. The perithecia are scattered or gregarious. The appendages are 4–30, branching of the tips diffuse and irregular, tips of the ultimate branches not recurved. On: *Symphoricarpos occidentalis,* and *S. symphoricarpos.*

*Phyllactinia*

The perithecia are very large in this genus, and are flattened or lenticular. The appendages are few, equatorially placed, rigid, needle-like with a large bulbous inflation at the base. See fig. 14.

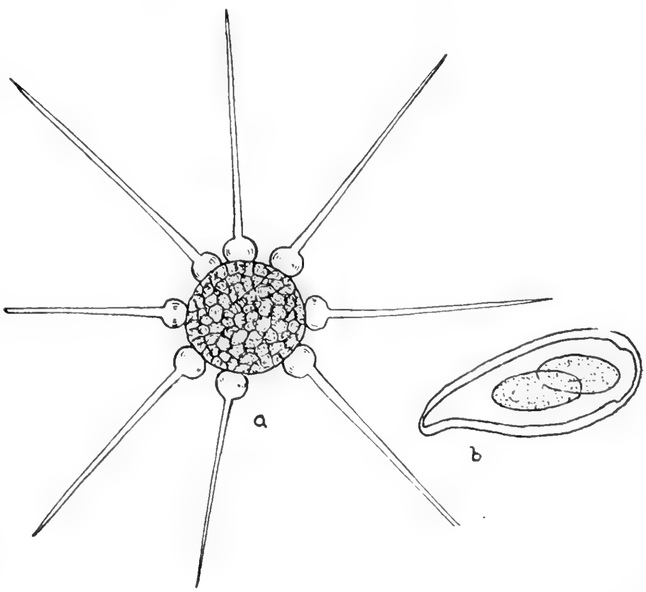


Fig. 14. *Phyllactinia.* a. Perithecium with appendages. b. Ascus with spores. Highly magnified.

*Phyllactinia corylea* (Pers.) Karst.

In this species the perithecia are large, flattened-lenticular, and the appendages are few. The appendages are equatorially placed, rigid, acicular, with a large bulbous inflation at the base. See fig. 14. In this, the only species, the mycelium is usually confined to the lower surface of the leaf. The perithecia are widely scattered over the scanty mycelium. The conspicuous needle-like appendages form a ring about the large perithecium, but they are easily broken off. The asci number 4–8, with usually two large well developed spores per ascus. On: *Celastrus scandens, Cornus stolonifera, Fraxinus lanceolata, Ostrya virginiana,* and *Xanthoxylum americanum.* The large black perithecia and the fringe of odd appendages that may be seen with a hand lens are sufficient to distinguish this species.

### *Podosphaera*

Perithecia globose or somewhat flattened. Ascus solitary. Appendages confined to a small apical group or scattered over the whole upper half of the perithecium, dichotomously branched at the tip, branches simple and straight, or commonly swollen and knob-like at the tips.

*Podosphaera oxyacanthae* (DC.) DeBary.

The perithecia of this genus resemble those of Microsphaera very much. The greatest difference is that here they contain a single ascus while in *Microsphaera* there are usually a number of asci. The above species occurs upon both sides of the infected leaf, the woolly mycelium being persistent in patches or wholly evanescent. The perithecia are scattered or clustered. The spreading appendages number from 5 to 30, and are dark brown for about half their length the tips are 2–4 times dichotomously divided, the branches usually short and equal, with the ultimate branches knob-like. On: *Amelanchier bortryapium, Prunus americana, P. besseyi, P. demissa, P. serotina, P. virginiana.*

*Podosphaera tridactyla* (Wallr.) DeBary.

It is a question whether or not this species may be a mere variety of the above species. Its small apical cluster of erect appendages seems to separate it quite well from *P. oxycanthae.*

### *Uncinula*

The character that distinguishes this genus from all others is its free, simple appendages which are recurved or coiled at the tip. The perithecia are globose, and there are many asci.

*Uncinula macrospora* Peck.

*Uncinula* has characteristic appendages in that the tips are very typically coiled or uncinate. The mycelium covers both sides of the leaf, and is usually evanescent. In this species the perithecia are closely gregarious in small patches or scattered evenly over the whole leaf. The appendages are numerous, 50–130 or more, simple, smooth colorless, with the tip simply coiled. Very common on *Ulmus americana.* See fig. 13 and 15.

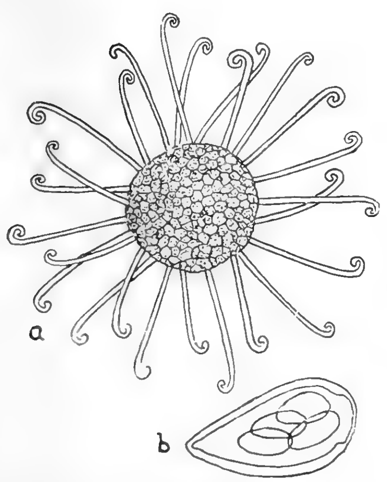



Fig. 15. *Uncinula.* a. Perithecium with appendages. b. Ascus with spores. Highly magnified.

*Uncinula circinata* C. & P.

This species is confined mostly to the lower sides of the leaves. The mycelium is evanescent, or persistent in definite spots. The perithecia are usually scattered. Appendages densely crowded, tip coiled. This is the common mildew on *Acer saccharinum.*

*Uncinula salicis* (DC.) Wint.

This species is found very commonly on species of *Salix.* It differs little from the above species. The common hosts are: *Salix amygdaloides, S. cordata, S. fluviatalis, S. humulis, S. sp.* and *Populus deltoides.*

*Sphaeriaceae:*

This family of black fungi is characterized by the presence of brown or black perithecia that are typically globoid, often with a beaked ostiole. The perithecia are simple, clustered or imbedded in a stroma; they are membranous, coriaceous, or carbonous, and they dehisce by a round pore or ostiole. When the perithecia are imbedded in a stroma each perithecium is distinct from the substance of the stroma, not a mere locule in the stroma. The mycelium is scanty and immersed after the perithecia are formed, rarely persisting in the form of a subiculum. Many species in the family produce, especially in their conidial stages, very destructive plant diseases.

*Sphaerella*

The perithecia in this genus are thin-membranous, globose-lenticular, and are covered by the epidermis of the host or soon erumpent. The ostiole is usually short papillate. The asci are 8-spored, and are accompanied by paraphyses. The spores are elliptical or oblong, 2-celled and hyaline, or slightly colored.

*Sphaerella nigrita* Cook.

Perithecia somewhat immersed on the lower side of the leaf in orbicular discolored spots. Asci clavate, spores elongate-elliptical, uniseptate, hyaline,15–4 microns. On fallen leaves of *Quercus macrocarpa.* The more or less irregular orbicular spots with their clusters of perithecia on the under side of the leaves are from 3–6 mm. in diameter and give an appearance of sooty blotches scattered over the affected leaf.

*Dothideaceae:*

A stroma is typically produced in this family, in which the perithecia are more or less completely sunken and reduced to locules, that is, there is not the definite black perithecial wall that clearly differentiates the perithecium from the substance of the stroma as in the *Sphaeriaceae*. Otherwise the two families are very similar.

### *Dothidella*

In this genus the stroma is well developed and is discoid or effuse, thin and black. The asci contain eight ovoid or oblong, uniseptate, hyaline spores.

*Dothidella ulmea* (Schw.) E. & E.

The perithecia are imbedded in the leaf parenchyma either singly or in clusters of 2–8 connected by stromatal cells, their bases projecting and forming tuberculiform heaps on the upper surface of the leaf, while their black papillate ostioles appear through the ruptured epidermis on the lower side of the leaf. The asci are oblong-cylindrical, 55–8 microns. The eight spores become unequally 2-celled by a septum formed near one end. The species is very common on the leaves of *Ulmus americana*. Before the leaves have fallen the fungus is often very evident because of the scattered areas composed of the black fungous bodies. It is only after the leaves have lain on the ground through the winter that the fungus is found to be mature, although it is conspicuous long before leaf fall. In fact, the external appearance in the spring is little different from that in the fall.

## BASIDIOMYCETES

There are few *Basidiomycetes* that attack the leaves of forest trees in this state, a truth that holds quite generally for all places. Among the most important leaf *Basidiomycetes* are the Rust Fungi, forms that are very commonly classified with this group. The following are the commonest rusts of Nebraska forst trees.

*Uredinaceae:*

The *Uredinaceae,* or Rust Fungi, are obligate parasites possessing several forms of spores, one or a number of which may be omitted from the life cycle of certain species. These spore forms are pycniospores, produced in very small flask-shaped, pycnidium-like receptacles called pycnia, and usually accompanied by the next spore form, the aeciospores, formed in the so-called "cluster cups" or aecia, of varying structure. The urediniospores come next in regular order, produced in sori or uredinia; and finally the teliospores, which upon germination, give rise to the basidiospores complete the typical round of life so far as spore formation is concerned. The teliospore is the form that is usually present, no matter if a number of the other spore forms are absent. Many species of the rusts are heterœcious, among which are some of the most destructive diseases known.

### *Aecidium*

In this genus the peridium enclosing the aeciospores is cup-shaped or urn-shaped, rarely cylindrical, the margin often crenate or laciniate and revolute. The aeciospores are globose or angular, continuous, smooth or verrucose, orange-yellow, produced in chains.

*Aecidium fraxini* Schwein.

Pycnia numerous, scarcely elevated above the upper surface of the leaf. Aecia usually very abundant, elongate, cylindrical, finally lacerate with the subdivisions reflexed. Aeciospores elliptical or globose, episporium thin, rough, 24–32 x 21–24 microns. This species is sometimes very abundant on the leaves of *Fraxinus lanceolata,* causing distortion and curling both in the blades and petioles.

### *Melampsora*

Teliospores dark, unicellular; sori arising from dark spots which burst through the epidermis. The yellow urediniospores, with an episporium beset with fine prickles, break through the epidermis in more or less orbicular spots or sori, and are very conspicuous during late summer.

*Melampsora populina* (Jacq.) Lev.

Uredosori roundish, at length reddish-yellow, often confluent. Urediniospores elliptical or ovoid 28–38 x 15–20 microns. Teliosori on the upper side of the leaf, often confluent, at first reddish-brown, finally dark brown. The urediniospores are usually accompanied by paraphyses. Very common during July and August on *Populus deltoides* and other poplars.

*Melampsora salicina* Lev.

This is a collective name since there are now several species recognized within the old species. The various forms occur upon species of *Salix,* such as *S. alba, S. cordata, S. longifolia, S. nigra,* etc.

## FUNGI IMPERFECTI

### *Sphaeropsidales.*

In this order the conidia are borne on simple or branched threads, so-called basidia, in a perithecium-like fruit called a pycnidium. The pycnidia are globose, conic, elongate, dimidiate,

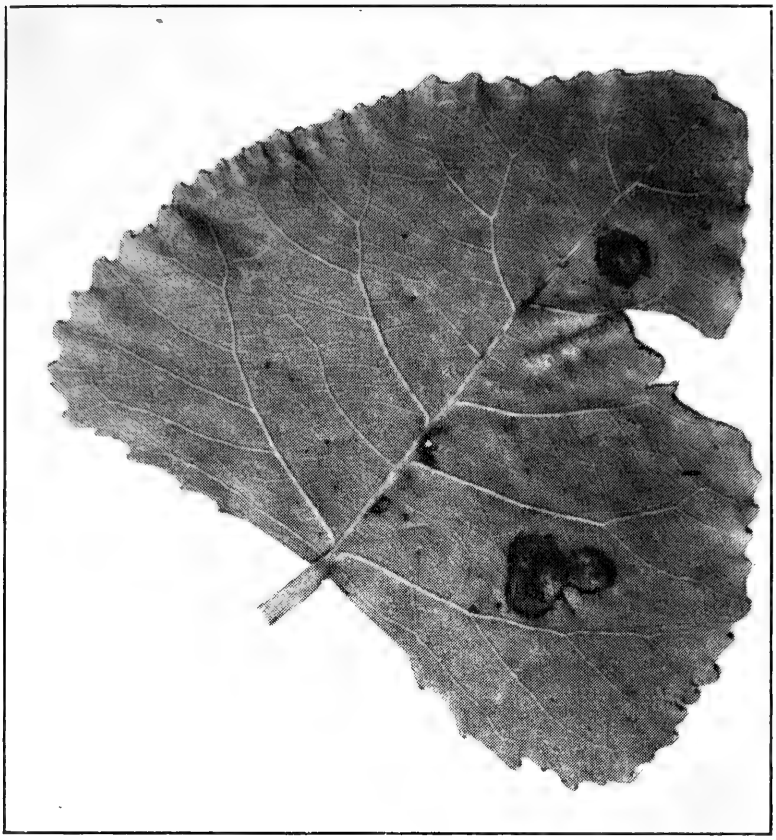


Fig. 17. Phyllosticta on Populus deltoides.

Fig. 18. Phyllosticta on another species of Populus.

or cup-shaped, membranous, coriaceous, carbonous, or sometimes somewhat fleshy, usually black, sometimes bright colored. Externally the members of the group resemble certain of the *Sphaeriaceous Ascomycetes.*

*Sphaeroidaceae:*

Here the pycnidia are globose, conic or lens-shaped, membranous, carbonous, or somewhat coriaceous, black, immersed or superficial, single or in a stroma. The conidia are 1–many-celled, hyaline or dark. The following are some of the most common members of the family.

*Phyllosticta.*

In this genus the black pycnidia are scattered about in small sharply defined discolored spots on living leaves. The tissue in the spots usually turns to a dull brown, or in some cases almost white, and is very clearly marked off from the living tissue of the leaf. The pycnidia are conspicuous as black specks dotted over these discolored areas. They usually originate beneath the cuticle, and are thin-walled structures with a nearly round pore above. See fig. 16. The spores are ovate, oblong, elliptical or globose, hyaline. The basidia are either inconspicuous or none.

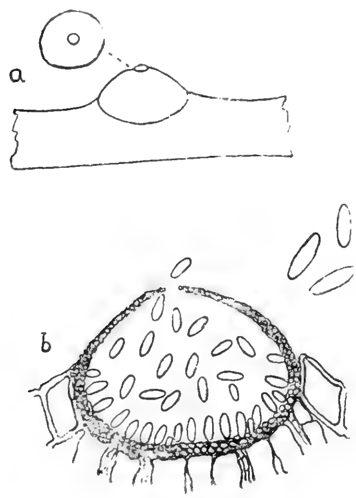


Fig. 16. *Phyllosticta.* a. Habit upon the leaf. b. Enlarged pycnidium. All highly magnified.

*Phyllosticta populina* Sacc.

Discolored spots angular, whitening out in drying with a dark colored margin. Pycnidia dot-like, few to many, scattered over the discolored spots. Spores elliptical or oval, slightly olive-colored, 4–6x2–3 microns. Occurs on the leaves of *Populus deltoides* as widely scattered spots that vary from 3–10 mm. in diameter. See fig. 17 and 18.

*Phyllosticta serotina* Cook.

Spots rusty-brown, circular, border darker. Pycnidia dark brown, on the upper side of the leaf, scattered, dot-like. Spores hyaline, elliptical-lanceolate, 12x4–5 microns. Common on *Prunus serotina.*

*Phyllosticta minutissima* E. & E.

Spots on both sides of the leaf, irregular in outline, 4–9 mm.

in diameter, reddish-brown above with a lighter colored, shaded border, paler below. Pycnidia upon the lower side of the spots, minute (80 microns in diameter), globose, numerous, filled with elliptical hyaline spores 2x0.5 microns. On the leaves of *Acer glabrum* from northwest Nebraska.

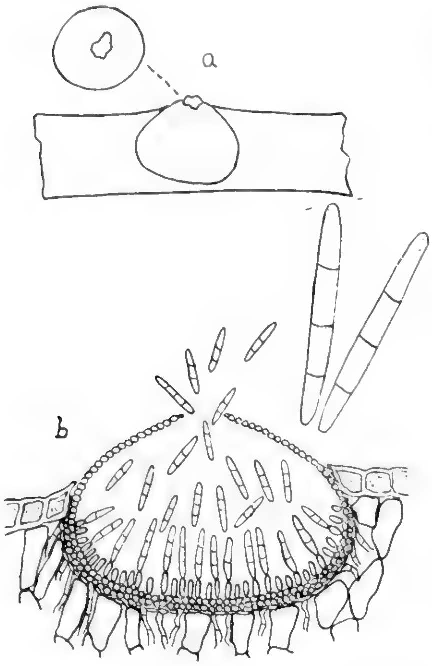



Fig. 19. *Septoria.* a. Habit upon the leaf. b. Pycnidium very much enlarged. All highly magnified.

*Septoria*

In *Septoria* the pycnidia occur on brownish or whitish deadened areas in the leaf as in *Phyllosticta*. The diseased tissue is sharply defined so that the spots are very conspicuous in contrast to the green surrounding tissue. The pycnidia are sub-cuticular as in the former genus, and they are also very similar to those of *Phyllosticta* in shape. But in *Septoria* the spores are rod-shaped or thread-like, and many septate and hyaline. Thus the nature of the spore is seen to be the greatest difference between this genus and the preceding one. See fig. 19.

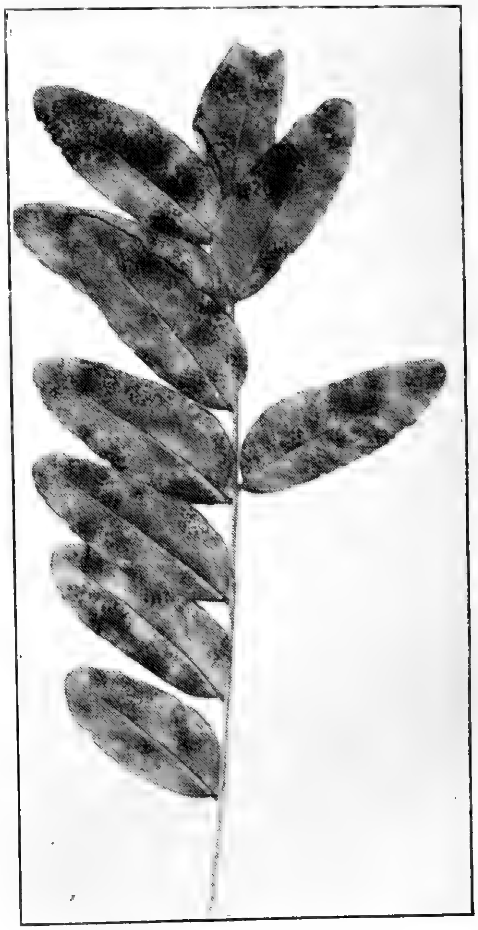


Fig. 20. *Leptostroma* on *Gleditsia* showing pycnidia. Actual size.

*Septoria acerella* Sacc.

Discolored spots angular, mainly conspicuous on the upper side of the leaf, small, whitish, pycnidia few, lenticular, minute. Spores rod-shaped, slightly curved, septate, hyaline, 21x2 microns. Quite common on *Acer negundo.*

*Septoria argyraea* Sacc.

Discolored spots yellowish, often with a dark margin, on the upper side of the leaf. Pycnidia dot-like, lenticular, clustered. Spores cylindrical, straight or flexuous, hyaline, 25x3 microns. On *Elaeagnus argentia.*

*Septoria pruni* Ellis.

Pycnidia in brown deciduous spots, 1–2 mm. in diameter, and immersed in the dead tissue. Spores cylindrical, curved, obtuse at the ends, 4–6 septate, 40x2 microns. Common on *Prunus americana.*

Other species:

*Septoria cerasina* Peck. on *Prunus serotina; S. corylina* Peck. on *Corylus americana; S. cornicola* Desm. on *Cornus sp.; S. rhoina* B. & C. on *Rhus glabra; S. sambucina* Peck. on *Sambucus canadensis.*

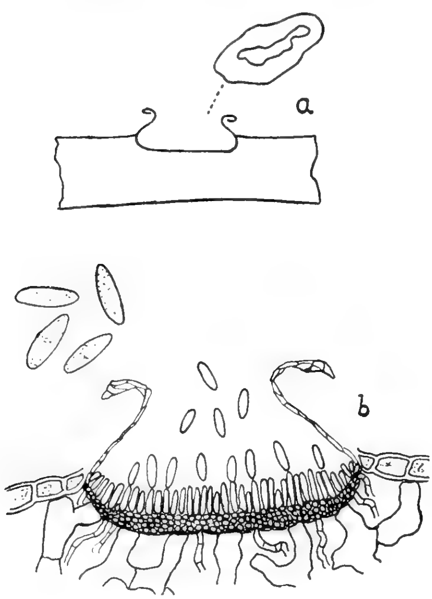



Fig. 21. *Leptostroma.* a. Habit upon the leaf. b. Section of pycnidium. All highly magnified.

*Leptostromaceae:*

In this family the pycnidia are membranous or sometimes carbonous, and usually black in color, more or less distinctly dimidiate or scutiform, erumpent or superficial. The pycnidia do not open by a regular pore but by the breaking open of the pycnidium and the formation of an irregular narrow or linear cleft. See fig. 21.

*Leptostroma*

Pycnidia dimidiate, flattened, elongate, superficial or subcuticular, dark, opening by a more or less irregular cleft. Spores ovoid, oblong or sausage-shaped, continuous, hyaline or very slightly colored.

*Leptostroma hypophylla* B. & Rav.

Pycnidia on the lower side of the leaf, flattened, membranous, 1–2 mm. in diameter, thickly scattered over the part of the leaf occupied, which eventually turns dark brown or black because of the many pycnidia present. Sometimes the pycnidia are formed in definite colonies. The spores are oblong, hyaline, 4–1 microns, continuous, borne on densely fasciculate basidia 10–12 microns long. The pycnidia often break open by an irregular cleft, and then the membranous walls become folded back as shown in fig. 21. On living leaves of *Gleditsia triacanthos.* During the season of 1910 the Honey Locust was very badly infected with this fungus, (see fig. 20.) the leaflets often being completely covered by the densely aggregated black pycnidia.

### *Piggotia*

Pycnidia flattened, thin, membranous sub-cuticular, opening not by a regular ostiole, but variously perforate, not cleft as in *Leptostroma.* Spores oblong or cylindrical, continuous, hyaline. Basidia cylindric.

*Piggottia fraxini* B. & C.

Pycnidia occuring in clusters, forming black granular spots scattered in the lower surface of the leaf, breaking through the cuticle in roughened groups. Spores oblong, very small, 5–7 microns long. Very common on the fallen leaves of *Fraxinus lanceolata.*

### *Discosia*

Pycnidia broadened to disciform, almost superficial, easily separating, dark, often black, with or without an ostiole, membranous. Spores oblong, somewhat curved, 2-many septate, often 3-septate, 1-ciliate, hyaline or dilutely colored, borne upon rod-like basidia.

*Discosia artroceras* (Tode) Fr.

Pycnidia clustered, orbicular, black, shining, at first convex, at length depressed near the dot-like ostiole, finally collapsing then wrinkled or folded. Spores sausage-shaped, provided at each end with a bristle or cilium, 3-septate, hyaline or yellowish, 18–4 microns, bristles 10–15 microns long. Quite common on *Platanus occidentalis* and *Quercus sp.*

### *Melanconiales*

In this order of imperfect fungi, well developed, typical pycnidia are lacking, or they are typically reduced to a stratum merely. These strata are sub-cuticular, typically bearing basidia of various sorts upon which the spores are formed, constituting masses or acervuli which are immersed or erumpent, black, gray, or light colored, waxy, corneous or somewhat membranous in certain cases, but lacking the more or less well developed jacket of sterile tissue characteristic of the pycnidium of the *Sphaeropsidales.*

*Melanconiaceae:*

With the Characters of the order.

*Marsonia*

In this genus the acervuli are always long covered by the epidermis or cuticle, they are globose-discoid in shape, and pale. Spores ovoid, fusoid, or oblong, 1-septate, hyaline.

*Marsonia juglandis* (Lib.) Sacc.

Spots on the upper side of the leaflets, circular, or irregular, dark, becoming ashen colored. Acervuli flattened, rough, brown, very small, scattered over the discolored spots. Spores fusoid, curved, pointed at the ends, 1-septate, hyaline, 20–25x5 microns. Common on the leaflets of *Juglans nigra.*

*Marsonia martinii* Sacc.

Discolored spots on both sides of the leaf, minute, yellowish. Pustules or acervuli gregarious in the center of the spots, often on the lower surface, globose, minute. Spores fusoid, curved, acute at both ends, 1-septate, slightly constricted at the septum, hyaline, guttulate, 15x2.5 microns. Basidia very short, greenish. On fallen leaves of *Quercus macrocarpa.* The discolored spots with the orange or yellow pustules are usually very evident after the leaves fall.

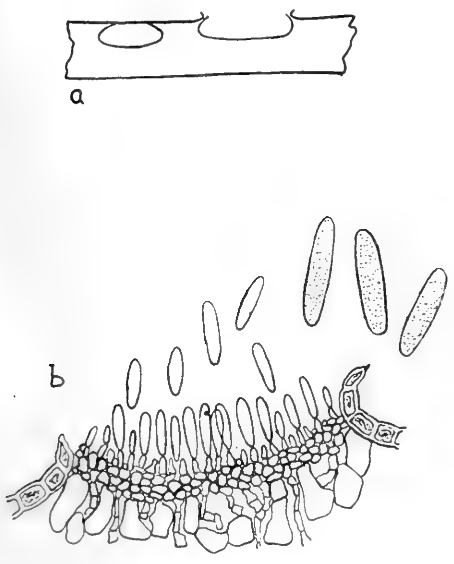



Fig. 22. *Gloeosporium.* a. Habit of acervuli in leaf. b. Section of acervulus on leaf. Highly magnified.

*Marsonia castagnei* (Desm. & Mont.) Sacc.

The orbicular, confluent, brown, spots of this species occur on the upper side of the leaf. The spores are oblong-clavate, 1-septate, not at all or only slightly constricted at the septum, hyaline, very short pedicillate, 18–20x7–8 microns. On *Populus alba.*

### *Gloeosporium*

This genus is characterized by waxy acervuli that are sub-epidermal, cup-shaped or cushion-like, finally often erumpent, pale or dark. Spores ovate-oblong, continuous, hyaline, often occuring in waxy masses. The basidia are typically rod-like or thread-like and fascicled. See fig. 22.

*Gloeosporium accrinum* West.

Acervuli on the lower surface, dark-reddish, few. Spores somewhat elliptical-oblong, erumpent in pale waxy masses becoming reddish. On *Acer saccharinum.*

*Gloeosporium septorides* Sacc.

Spots white or yellowish, surrounded by dark lines. Spores rod-shaped or fusoid, curved, becoming obtuse at each end, always continuous, hyaline, 20x2 microns. On *Quercus macrocarpa, Q. coccinea.*

Other species:

*Gloeosporium celtidis* E. & E. On *Celtis occidentalis.*
*Gloeosporium decipiens* E. & E. On *Fraxinus lanceolata.*

### *Mucedinales*

In this third order of imperfect fungi the hyphae are more or less well developed and form a cobwebby or slightly compacted mycelium, but rarely forming definite strata or stromata; the fertile hyphae are never enclosed in a pycnidium, typically superficial. There are two quite distinct families as follows:

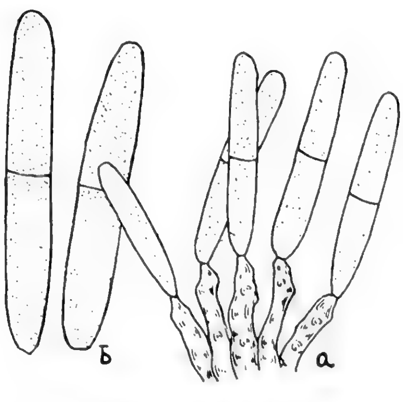



Fig. 23. *Ramularia.* a. Cluster of spores. b. Two spores enlarged. All highly magnified.

*Mucedinaceae:*

Hyphae hyaline or bright colored, fragile, lax, cohering in fascicles; spores hyaline or bright colored, of various shapes and kinds of septation, borne on simple or much branched hyphae.

### *Ramularia*

Fertile hyphae well developed, simple or vaguely branched, denticulate or roughened above. Spores ovate to cylindrical, various, typically 2-many septate, hyaline, rarely bright colored. See fig. 23.

*Ramularia celtidis* E. & K.

Discolored spots bearing the fertile hyphae on both sides of the leaf, small (1–2 mm.) round, with a thin, white center and a brown margin limited by a well defined, narrow, slightly raised line. Hyphae very short, entire, hyaline, in little tufts which appear like fine powder sprinkled over the spots. Spores long, nearly cylindrical, hyaline, slightly curved or straight, 1–3 septate, 25–50x2 microns. On living leaves of *Celtis occidentalis.*

### *Cylindrium*

Fertile hyphae very short, nearly obsolete, hardly differing from the spores. Spores in chains, elongate-cylindrical, obtuse at both ends, hyaline or bright colored. The very fine clusters of hyphae and spores give a powdery appearance to the discolored fruiting spots.

*Cylindrium elongatum* Bon.

Tiny clusters of fruiting hyphae white and loose. Chains of spores long, flexuous, cylindrical-fusoid, 15–18 microns long, 2 microns wide, hyaline or whitish, with an oil drop at each end. Hyphae very short or obsolete. On the fruits and leaves of *Quercus.*

*Dematiaceae:*

Hyphae dark or black, cobwebby, loose, usually rigid. Spores typically dark but sometimes the hyphae are dark and the spores clear, or the spores dark and the hyphae clear. This family is more or less parallel with the *Mucedinaceae* and there are many intermediate forms.

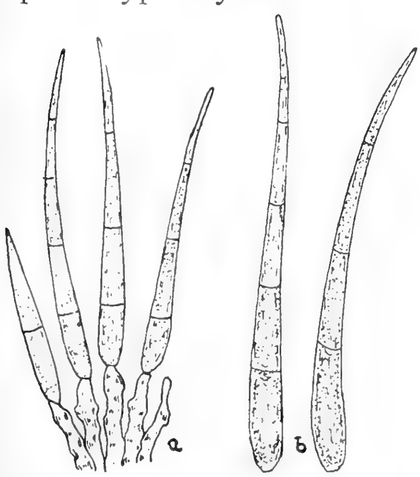



Fig. 24. *Cercospora* on Gymnocladus. a. Cluster of spores. b. Two spores enlarged. All highly magnified.

### *Cercospora*

Fertile hyphae well developed, smooth or somewhat roughened above, simple or branched, dark, often in tiny congested tufts scattered over definitely limited, discolored areas of the leaf. Spores long, of various shapes, vermicular, often curved, septate, dark, olivaceous, rarely nearly hyaline. See fig. 24. This genus is composed of hundreds of described species that are parasitic upon a wide range of hosts. These numerous species are distinguished with difficulty, often intergrading in a most puzzling manner. The host plant is about the only key to the species, and often this criterion fails. Some of our common species follow.

*Cercospora condensata* E. & K.

Fascicles of fertile hyphae on brown or dirty-white, round spots with an obscure dark border. The hyphae are brown, obtuse and somewhat roughened above, 30–80x4–5 microns; densely compacted so as to form tiny, dark, tubercle-like fascicles resembling perithecia. Spores slender-clavate or cylindrical, 6–9 septate, 60–75x4 microns. On leaves of *Gleditsia triacanthos.*

*Cercospora glandulosa* E. & K.

Spots on the lower side of the leaf, becoming reddish-brown, limited above by a slightly raised border. Hyphae cespitose as in the above species, brown, stout, somewhat undulate above, 50–70x4–5 microns. Spores hyaline, slender, 3–5 septate, 70–100x3 microns, gradually narrowed above. Common on leaves of *Ailanthus glandulosa.*

*Cercospora gymnocladi* E. & K.

Spots mostly on the upper side of the leaf. Hyphae on grayish-brown spots 3–4 mm. in diameter with a discolored border, in minute dot-like tufts, simple, continuous, brown, 18–2.5x4 microns. Spores obclavate-cylindrical, brown, 3–6 septate, 40–50x5–6 microns, often much shorter, on *Gymnocladus dioicus.* Other species:

*Cercospora circumscissa* Sacc. On species of *Prunus.*
*Cercospora negundinis* E. & E. On *Acer negundo.*
*Cercospora rhamni* Fuckel. On *Rhamnus caroliniana.*

### *Ceratophorum*

Sterile hyphae few, creeping over the discolored spots; fertile hyphae very short or little different from the spores. Spores fusoid to cylindrical, 2-many septate, sooty, upward 1–3 toothed, incurved, pale.

*Ceratophorum ulmicolum* E. & K.

Spots on both sides of the leaf, orbicular, dirty-brown with a small white center. Spores fusoid, attenuated below into a hyaline, obtuse base, and prolonged above into a curved, hyaline beak, swollen, dark or olivaceous, 5–7 septate near the middle, 60–100x11–14 microns. On living leaves of *Ulmus pubescens.*

*(To be continued)*

# THE SEASONING AND PRESERVATIVE TREATMENT OF WESTERN YELLOW PINE.

By O. F. Swan.

This paper presents a brief account of one part of a study on pole timbers conducted in California. It will give a good idea of the objects in view and the methods employed in an investigation of this character. The present study was made from the point of view of pole consumers in California, where Western Red Cedar is now the principal species used for the purpose.

As the price of cedar poles advances, the question of preservative treatment to increase their service and of finding other and cheaper substitute timbers grows in importance to pole consumers in California. An investigation of the possible sources of future supply for the Pacific Coast indicates that the Western Yellow Pine of the Sierras is the most promising species to be considered in this connection. Other species are short in quantity or intrinsically unsuited for poles. It is probable then that cedar will be used until it becomes much more profitable to use a substitute timber in certain regions. The natural timber to fall back upon is Western Yellow Pine.

The plan of the experiments was as follows:

1. To conduct seasoning and treating experiments upon Western Red Cedar in order to find methods of increasing its life in the soil, since that species is destined for some time to be the species used by most consumers.

2. To conduct similar experiments upon Western Yellow Pine, the species which is apparently destined gradually to displace Western Red Cedar to a great extent in parts of the West.

## THE SEASONING OF WESTERN YELLOW PINE.

Seasoning means much more than drying out the water in the wood. The sap in timber is a complicated chemical structure, and is subject to characteristic seasonal changes. Thorough drying out of the water results in the destruction of this sap as normally constituted. There is a disintegration by many chemical changes. The addition of water to seasoned timber, such as occurs when seasoned poles are in service, therefore can not reproduce the original internal conditions. These changes are beneficial in the utilization of timber because the original sap is a good fungus food, but once dried, it loses very largely its property as a culture bed for decay-producing fungi.

Seasoning, therefore, means longer life of the timber because of the partial destruction of a fine fungus foothold, and because most fungi can not thrive without a greater amount of moisture than is present in seasoned timber. The increase in the life of poles due to seasoning is, however, proportionally very small. I feel that some investigators have valued the increase in life due to this single factor far too high.

The original watery sap fills not only the cells but permeates the cell walls making them pliable. Partial seasoning takes the free cell sap, while longer seasoning also removes the fluid from the cell walls, which makes the timber much stronger than when green. After being once thoroughly seasoned, timber is very unlikely in any condition of service to take up enough water to reach the original state of weakness.

Seasoning means, further, a considerable loss of weight. Freight tariffs often seem to make the weight consideration of secondary importance, but a keen realization of the importance of this matter may be gained from the statement that Western Yellow Pine poles lose 55 per cent of the green weight in seasoning, and that this amounts, on an average, to 920 pounds per 40 foot pine pole. Transportation and handling charges due to this excess weight of unevaporated water deserves much attention.

When it is granted that a preservative treatment of timber will, in a given case, result in great advantage, the importance of seasoning as a preparation for such treatment can not be too strongly emphasized. Not only are the cells left free to take up the preservative, but the wood has become more porous. Further, water and oil have no affinity, and the presence of water hinders the entrance of oils for that reason. Treatment before seasoning may imprison sufficient water, with the ever-present fungous spore and make interior conditions, deeper than the preservative penetrates, suitable for the life of the fungus. Therefore seasoning is important both to prepare the wood for taking the preservative freely, and also to make sterile conditions beyond the treatment.

The advantages of seasoning may be summarized as follows:

1. It increases the strength of the wood.
2. It renders it more resistant to decay.
3. It saves cost of handling, through marked reduction of weight.
4. It prepares the wood for preservative treatment.

These considerations dictate the line of experiments in seasoning poles. The object of these seasoning experiments is to prepare the wood for preservative treatment while making a careful study of the following points:

1. What is the length of time required to season poles to an air dry condition?

2. What is the difference in the rate of seasoning of poles cut at different seasons of the year?

3. What is the shrinkage in circumference of poles due to seasoning?

4. What increase of decay resisting power is secured by seasoning poles?

5. What is the increase in the penetration of preservatives into seasoned as compared with wood in partially seasoned stages?

6. What is the effect of the season of cutting upon endurance in the soil?

7. What is the effect of the time of seasoning upon checks or splits in the poles?

8. What are the best methods of piling or skidding poles while seasoning?

9. Securing exact data on the rate of seasoning or water content at any time of timber cut seasonally.

Poles cut each season of the year were weighed monthly until air dry.

The following table shows the rapid loss of weight during seasoning of pine poles according to the time of year in which they are cut.

TABLE 1. SEASONING OF WESTERN YELLOW PINE POLES, MADERIA COUNTY, CALIFORNIA.

| Month | Autumn Cut | | Winter Cut | | Spring Cut | | Summer Cut | |
|---|---|---|---|---|---|---|---|---|
| | Weight per cu. ft. | per cent of green weight lost | Weight per cu. ft. | per cent of green weight lost | Weight per cu. ft. | per cent of green weight lost | Weight per cu. ft. | per cent of green weight lost |
| October | | | | | | | 31.8 | 51.0 |
| November | 64.1 | | | | | | | |
| December | 54.0 | 15.8 | | | | | | |
| January | 51.3 | 20.0 | | | | | | |
| February | 52.6 | 17.9 | | | | | | |
| March | 54.1 | 15.6 | 66.6 | | | | | |
| April | 50.4 | 21.4 | 62.6 | 6.0 | | | | |
| May | 46.0 | 28.2 | 56.2 | 15.6 | 65.2 | | | |
| June | 41.7 | 35.0 | 47.7 | 28.4 | 51.5 | 21.0 | | |
| July | 36.6 | 41.4 | 40.4 | 39.3 | 44.4 | 31.9 | | |
| August | 33.7 | 47.5 | 36.0 | 45.9 | 39.8 | 39.0 | 64.8 | |
| September | 30.3 | 52.7 | 32.8 | 50.8 | 36.2 | 44.5 | 40.3 | 37.8 |
| October | | | | | 32.6 | 50.0 | 33.8 | 47.8 |

Average 40 foot pole contains 26.1 cubic feet.
Oven-dry weight is 26.2 pounds per cubic foot.

Attention is called to the following points apparent from Table 1.

1. Poles cut at any time of the year eventually season until 50 to 55 per cent of the original green weight has evaporated. For pine poles this is the air dry condition.

2. Green pine poles hold, on an average, 870 pounds of water which may be evaporated in from 3 to 9 months. Costs of handling poles during skidding, wagon transportation and freighting make it important and desirable to know at any given time the extent of this loss of weight during seasoning and to foresee the rate of this loss at all periods in order to choose economical times so far as possible for handling the timber. This table holds good for the future and given the approximate time of the cutting of pine poles, their weight at any time can be foretold. Further their relative fitness for preservative treatment is immediately apparent from an inspection of the tables.

3. 40 foot poles cut at any time before August have lost 40 per cent of their grown weight or 663 pounds each by the following September.

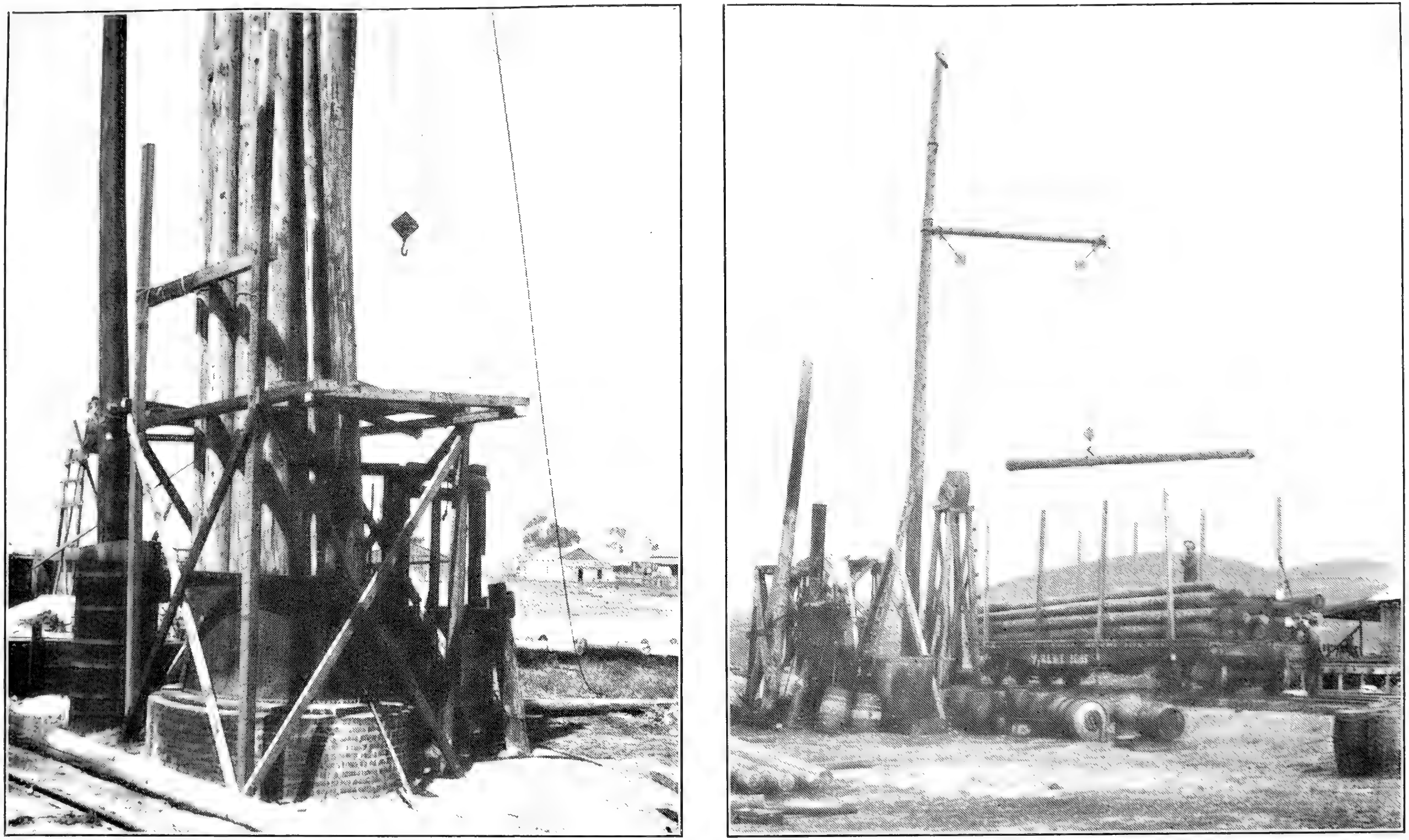
4. No season's cut of poles is dry before a later cut as is the case with some pole timbers.

5. After 50 to 55 per cent of green weight is lost the seasoning continues very slowly until some poles lose 62 per cent of their green weight before the end of the second year.

6. The time required for seasoning varies from two to ten months according to the time of cutting.

Table 2 shows the loss in handling poles before they are air dry. The speed of seasoning affects the fiber of the wood considerably, and therefore its strength, through strains set up due to uneven shrinking. These strains often result in checks or splits. In slow, even seasoning there is much less strain as the internal moisture has more opportunity to become evenly distributed. In this action there is a vast difference between poles cut in fall and those cut in summer, as is shown in Table 3.

PLATE I.



Dipping Poles, Open-tank Treatment, and Loading with same Steam-hoist.

TABLE NO. 2. FREIGHT TABLE.

Excess weight handled in terms per cent of seasoned weight if shipped any given number of months after cutting.

| Time Shipped | Season of Cutting | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Autumn | | Winter | | Spring | | Summer | |
| Months from time of cutting | Per cent | Pounds per pole | Per cent | Pounds per pole | Per cent | Pounds per pole | Per cent | Pounds per pole |
| 0 | 100.0 | 836 | 100.0 | 836 | 100.0 | 836 | 100.0 | 836 |
| 1 | 68.4 | 572 | 88.0 | 736 | 58.0 | 485 | 24.4 | 204 |
| 2 | 60.0 | 502 | 68.8 | 575 | 36.2 | 303 | 4.4 | 37 |
| 3 | 64.2 | 537 | 43.2 | 361 | 22.0 | 184 | 0.0 | 0 |
| 4 | 68.8 | 575 | 21.4 | 170 | 11.0 | 92 | 0.0 | 0 |
| 5 | 57.2 | 473 | 8.2 | 69 | 0.0 | 0 | | |
| 6 | 43.6 | 364 | 0.0 | 0 | | | | |
| 7 | 30.0 | 251 | | | | | | |
| 8 | 17.2 | 144 | | | | | | |
| 9 | 5.0 | 42 | | | | | | |
| 10 | 0.0 | 0 | | | | | | |

NOTE: The average green 40 foot 8 inch pole weighed 1672 pounds. The seasoned weight is taken at 50 per cent green weight,836 pounds. 836 multiplied by the percentage indicated above gives the weight of unevaporated water that would be handled per pole at any given time after cutting.

TABLE 3. MONTHLY RATE OF SEASONING.

Per cent of green weight lost each month.

| Month | Fall cut per cent | Winter cut per cent | Spring cut per cent | Sum. cut per cent |
|---|---|---|---|---|
| First | 15.8 | 6.0 | 21.0 | 37.8 |
| Second | 4.2 | 9.6 | 10.9 | 10.0 |
| Third | – 2.1* | 13.2 | 8.1 | 3.2 |
| Fourth | – 1.3* | 10.9 | | |
| Fifth | 5.8 | 6.4 | | |
| Sixth | 6.8 | 4.9 | | |
| Seventh | 6.8 | | | |
| Eight | 6.4 | | | |
| Ninth | 6.1 | | | |
| Tenth | 5.2 | | | |

* Gain in weight due to snow and rain.

Poles were seasoned in sets of 25 under various chosen conditions. The results of these experiments are as follows:

1. Poles cut at the same time lose weight at very nearly the same rate, generally within 5 per cent and sometimes within 10 per cent. As the seasoning reaches its final stages this difference tends to become zero.

2. Exposure to sunlight alone does not materially increase the rate of seasoning.

3. Exposure to air currents makes a material difference after 3 months seasoning. Good air circulation may make a difference of 10 per cent in the stage of seasoning after three months.

4. Poles should be piled on skids, to allow a free air circulation on all sides, at least a foot above ground free from heavy growth.

5. Soaking in water from two weeks to three months does not result in any gain in time of seasoning. Soaked poles dry out much more rapidly but do not pass unsoaked poles in stage of seasoning.

6. Direction of the poles on skids has no appreciable effect on rate of loss of weight.

## THE PRESERVATIVE TREATMENT OF WESTERN YELLOW PINE.

While in many ways admirably adapted for use as a pole timber, Western Yellow Pine in the natural state lacks one important quality necessary for such use. That is, durability in contact with the soil.

Experience in this country and especially in Europe convinces us that if certain chemicals or oils can be introduced into the species at hand, the increase of its life under conditions favoring decay, is a certainty. So effective are such treatments upon susceptible species of timber that it is of prime importance to ascertain the possibilities of impregnating an untried species with the various preservatives.

The object of treating experiments is to secure the following information upon the species:

1. Will the species handled absorb preservatives?
2. What quantities of such preservative will it take?
3. How can the quantity be controlled?
4. What is the cost of treating in each case?
5. What is the added life due to each treament?
6. How can poles be most economically handled during treatments?
7. What method of treating can be best employed to secure the right absorption of each preservative?

8. What is the annual service charge for poles under each type of treatment?

With these objects in view many original experiments with schemes for treating and new plans for handling poles during treatments were evolved, meeting with final success.

For these tests the poles of each seasonal cut were apportioned for different types of treating experiments. It is a part of the plan to keep each pole under complete record from the time of cutting until it is removed from the pole line. This includes a complete record of the treatment received. Each pole is branded with a number and maps are made of experimental pole lines showing its location. Experiments were conducted with 730 pine poles.

Liquid preservative substances can be applied directly to the butts of poles with a brush. This type of treatment is far less effective than any of the forms of tank treatment but is less expensive. The treatment adds only a short time to the life of the pole because only the surface is coated with the preservative while a large area is exposed to infection in the season checks, the surface area of which in a given zone may be equal to the surface of the pole. In that case only half of the exposed surface would be coated by a brush treatment. Further, it is subject to abrasion in handling. The absorption and penetration depend largely upon the dryness of the timber.

The oil heated to about 200 degrees F. is applied with a large paint brush. A second coat is given a day or two later. The following absorptions were secured on thoroughly seasoned Western Yellow Pine:

TABLE 4. WESTERN YELLOW PINE—POLE BUTT 6 CUBIC FEET. Absorption by brush treatment.

| | Pounds per cubic foot | | | Penetration | | |
|---|---|---|---|---|---|---|
| | 1st coat | 2nd coat | Total | Minimum inch | Maximum inch | Average inch |
| Carbolineum | .5 | .3 | .8 | 1/16 | 1/2 | 3/16 |
| Creosote | .4 | .2 | .6 | 1/16 | 1/4 | 1/8 |

The carbolineum penetrated the pine more readily than creosote. Carbolineums cost from three to five times as much as creosote.

A special tank was designed in an attempt to enclose the butt of a pole tightly enough to permit great pressure being applied to inject preservatives. The difficulties in the way of success of plans of this nature are, that it is almost impossible to secure an oil-tight mechanical grip upon the lower end of the pole. Leakage is due mainly to season checks. This apparatus was tried with a number of poles and while a pressure of 15 pounds per square inch was maintained for a short time, this line of experimentation was abandoned because of the high handling charge and because equally good results were obtained by open tank methods.

The experimental plant consisted of a heavy round iron tank eight feet deep and seven feet in diameter in which to stand the poles; and two very small galvanized iron tanks for use as cold bath dips, or for special experiments as with crude oil where only a small quantity of the preservative could be used for the bath. There was also a 3,000 gallon storage tank of galvanized iron in which to store the creosote while giving the zinc treatments. The poles were handled by means of a donkey hoist engine with steel cable and a mast and boom.

The open tank method of treating timber depends upon the two propositions (1) that dry wood is a porous material full of air and (2) that air expands and contracts very noticeably when heated and cooled. The propositions are practically applied by heating wood in a hot bath of any liquid preservative, expanding the air contained in the wood until a part of the air escapes and then cooling the wood by a cold bath until the contained air shrinks in volume and draws a quantity of the preservative into the wood.

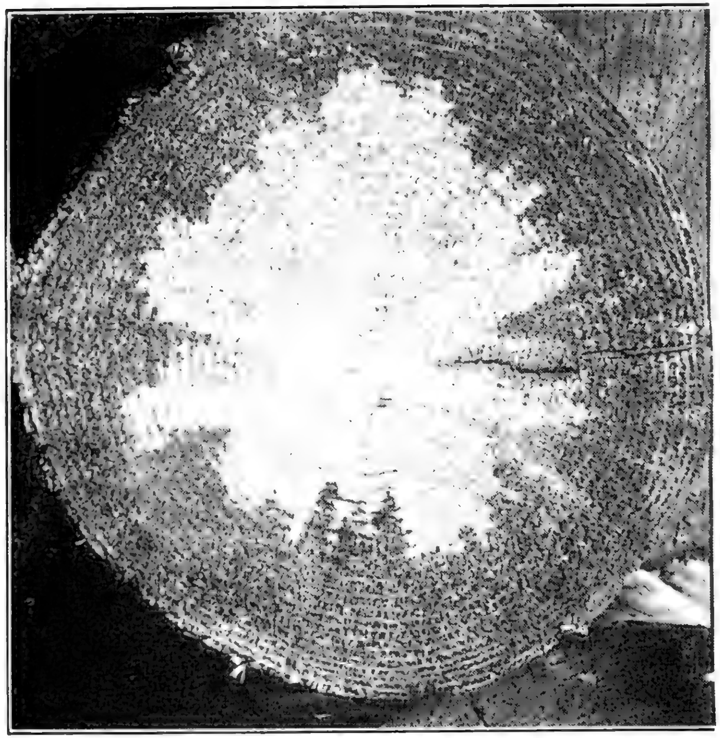
Success with this method depends upon the characteristic wood structure of the species handled. Each species presents new problems that must be solved before it can be treated to best advantage, that is, of securing the deepest penetration with the smallest quantity of preservative. Western Yellow Pine can be very effectively treated by this method.

The first series of runs with the creosote consisted in treating the poles with a single long hot bath of oil heated at 170° to 200° F. for three hours and then allowing the bath to cool to air temperature. This treatment requires from 15 to 24 hours. The results are tabulated below.

TABLE 5. POLE TREATMENTS WESTERN YELLOW PINE.
Creosote—Open Tank.

| Time of cutting | Number poles averaged | Absorption per cubic foot pounds | Penetration inches | Moisture content per cent of green weight lost |
|---|---|---|---|---|
| Fall | 11 | 15.03 | 4.3 | 48. |
| Winter | 22 | 11.03 | 2.7 | 51.5 |
| Summer | 2 | 1.92 | 1.0 | 55.2 |
| Spring | 3 | 12.20 | 3.4 | 50.1 |
| Average | 42 | 13.02 | 3.08 | 50.5 |

PLATE II.



Cross-section, 14 Inches in Diameter, Western Yellow Pine Impregnated with Creosote by Open-tank Treatment.

Apparatus for Weighing Poles to Determine Stage of Seasoning.

In the tables throughout this paper the absorption is given in pounds per cubic foot of the treated section of the pole. The lower seven feet of the poles contain, on an average, 6.25 cubic feet. The penetration is given in inches at a point about 5½ feet from the butt of the pole.

The following points were brought out:

1. The time of cutting the poles shows a marked influence on absorption not only in this case but with other preservatives. Summer-cut poles are difficult to treat while the Autumn-cut takes the preservative most readily.

2. Good absorption can be secured without heating the oil to temperatures resulting in evaporation of the creosote. 130° F. was used as a maximum temperature with good results in test runs.

3. An average absorption of 13 pounds per cubic foot and a penetration of 3 inches was secured by this treatment.

These poles have a heavy treatment. The wood cells are full of free oil and as the poles were removed from the cold oil they carried large amounts of it on their surface, much of which is wasted.

In an effort to overcome these disadvantages the next series of treatments were given as the preceding series except that the oil was again heated to about 200° F. several hours before the poles were removed. The object of reheating is to expand the air again in the wood and force the excess oil from the outer cells.

The results are presented in Table 6.

TABLE 6. POLE TREATMENTS WESTERN YELLOW PINE.
Creosote—Open Tank Re-heated.

| Time of cutting | Number poles averaged | Absorption per cubic foot pounds | Penetration inches | Moisture content, per cent of green weight lost |
|---|---|---|---|---|
| Summer | 20 | 7.10 | 2.2 | 54 |
| Winter | 14 | 5.45 | 1.3 | 52 |
| Fall | 9 | 14.16 | 5.25 | 54 |
| Spring | 13 | 11.67 | 4.3 | 54 |
| Average | 56 | 8.88 | 3.3 | 53 |

It is apparent that with the exception of the Summer-cut poles, each cut has taken up less oil per cubic foot. The average penetration is better than in the series in which the poles were not reheated. The average absorption of 8.9 pounds of oil per cubic foot with a penetration of 3.3 inches at the ground line is a satisfactory amount of oil for the result secured. Further, when poles are removed hot from the oil, the outer coating of oil which they carry on their surface, is drawn into the pole, by the interior air contracting, before it reaches the ground from the derrick. Borings in poles treated in this manner show that the outer part of the wood is free from excess oil for a depth of 2 inches, while in the deeper part of the boring, creosote is found free in considerable quantity.

The third plan tried with a single tank system consisted in heating the poles in hot creosote several hours allowing the oil to cool about 20°, which required an hour and then removing the poles from the partially cooled oil. The 20° fall in temperature draws in a small quantity of oil. The pole being now removed and allowed to cool to air temperature the air contracting in the wood draws the free oil in very deep, coating each passageway as it sinks in, until no free oil is left in the cells. This secures the greatest protection for the smallest amount of creosote. The treatment is very successful resulting in a penetration of 3 inches with five pounds of oil per cubic foot of wood.

The preceding results were secured with a single bath treatment. Much time can be saved with an equipment containing two baths of the preservative, one hot and one cold. This may be accomplished either by two tanks, or by an arrangement for quickly changing the oil in the single tank. In this way the effect of the previously described 18 hour treatment can be secured in five hours or less.

In the dry weather of summer, if the poles are thoroughly seasoned, penetration of 2 to 3 inches with 6 pounds of oil per cubic foot can be secured by heating the poles for one hour in oil at 130° F. and then plunging them into air cold oil for from 2 to 5 minutes. The poles are removed very hot, the surface oil is immediately drawn in and the poles are dry before they strike the ground.

The important conclusions to be drawn from the tank treating experiments with creosote upon Western Yellow Pine are:

1. Poles should be well seasoned before treatment —seasoned until they have lost 50 per cent of their green weight.

2. Poles should be separated according to season of cutting before treatment is possible. Summer-cut pine poles should not be treated with other poles as they require a severer treatment.

3. Very old poles should not be treated in the same run with timber just seasoned.

4. Seasoned pine can be very successfully treated with creosote with absorptions up to 15 pounds of oil per cubic foot of treated timber and penetrations as deep as five inches.

5. The desirable form of treatment is an empty cell treat-

ment which coats the interior of the walls and leaves no excess oil in the wood.

6. The above treatment can be given with six pounds of oil per cubic foot or with 4½ gallons to the average 40 foot 8 inch pole.

7. The quantity of oil used can be controlled.

8. The time of treatment will vary according to the moisture condition of the timber as affected by relative humidity and recent rains.

9. Seasoned timber can be very successfully treated with creosote in from one to five hours according to its moisture condition.

10. Green and half seasoned poles cannot be creosoted successfully in an open tank.

11. Poles not well seasoned should be treated by heating for several hours at 215° F. and plunging into cold oil until the poles are cold. This is a forceful treatment and the result will depend upon the moisture condition of the poles.

12. The treatment is best applied to seasoned poles as follows:

A. By heating the poles for one hour at 180°, cooling the oil to 160°, reheating to 200° and withdrawing the poles hot.

B. By heating the poles for one hour at 180°, plunging them in cold oil for five minutes and removing.

C. By heating as above and boiling in cold oil until desired absorption is secured and then removing.

Similar experiments with zinc chloride in solution and with crude petroleum are included in the summary in the following table:

TABLE 7.

| Preservatives | Application | Average actual results secured. | | Treatment recommended. pounds per cubic feet |
|---|---|---|---|---|
| | | Absorption pounds per cubic feet | Penetration inches | |
| Creosote | Brush—1 coat | .4 | 1/16 | Same |
| Creosote | Brush—2 coats | .6 | 1/8 | Same |
| Carbolineum | Brush—1 coat | .5 | 1/8 | Same |
| Carbolineum | Brush—2 coats | .8 | 3/16 | Same |
| Creosote | Tank—full cell | 13.0 | 3.0 | 10.0 |
| Creosote | Tank—empty cell | 8.9 | 3.3 | 6.0 |
| Crude oil | Tank | 3.5 to 10 | 1 to 3 | 6.0 |
| Zinc chloride | Tank | 17.9 (solution) | Complete | 1/2 lb zinc chloride |

Table 8 shows the cost of treating poles according to method and preservative.

TABLE 8. POLE TREATMENT—WESTERN YELLOW PINE.

Comparative cost of treatment, standard 40-foot pole, weighing 800 pounds treating 6¼ cubic feet.

| Preservative | Application | Quality | | Value | | Cost | |
|---|---|---|---|---|---|---|---|
| | | Per cu. ft. pounds | Per pole pound | Per pound cents | Pe pole cents | Handling charge per pole | Total cost of treatment per pole |
| Creosote | Brush 1 coat | .4 | 2.50 | .0235 | .06 | .05 | .11 |
| " | Brush 2 coats | .6 | 3.75 | .0235 | .09 | .10 | .19 |
| Carbolineum | Brush 1 coat | .5 | 3.13 | .066 | .21 | .05 | .26 |
| " | Brush 2 coats | .8 | 5.00 | .066 | .33 | .10 | .43 |
| Creosote | Tank | 10.0 | 62.50 | .0235 | 1.47 | .35 | 1.82 |
| " | " | 6.0 | 37.50 | .0235 | .89 | .35 | 1.24 |
| Crude petroleum | Tank | 6.0 | 37.50 | .007 | .26 | .35 | .61 |
| Zinc Chloride | " | .5 | 3.12 | .06 | .19 | .35 | .54 |
| Creosote and | | 1.0 | 6.25 | .0235 | .15 | | |
| Zinc Chloride | " | .5 | 3.12 | .06 | .19 | .35 | .69 |

In the above table the cost of preservatives is taken as follows:

Creosote.......................... $.20 per gallon
Carbolineum...................... .60 " "
Crude petroleum.................. .05 " "
Zinc Chloride.................... .05 " pound

The following table shows the comparative cost of maintaining a 40-foot pole, according to treatment, at Fresno, Calif.

The table shows very plainly that treating pays. The greater the value of the pole when finally set in line the greater is the balance in favor of treatment.

When cedar poles are quoted at $8.00 in Fresno, Cal., pine can not be used more economically unless it is creosoted or treated with zinc chloride. But at points where freight and teaming charges add several dollars to the cost of each timber the balance swings more and more to pine under any treatment as will be apparent by computing the proper annual charge for

TABLE 9.

| Species | Treatment | Cost | | Estimated average life | Equivalent annual charge at 5 per cent | Added life necessary to pay for treatment ** |
|---|---|---|---|---|---|---|
| | | In yard | In line * | Years | | Years |
| Cedar | None | $8.00 | $11.00 | 10 | $1.425 | |
| Yellow Pine | None | 5.00 | 8.00 | 3 | 2.94 | |
| Yellow Pine | Crude oil | 5.61 | 8.61 | | | ½ |
| Yellow Pine | Creosote Brush | 5.19 | 8.19 | 4 | 2.55 | ⅛ |
| Yellow Pine | Carbolineum Brush | 5.43 | 8.43 | 5 | 2.01 | ¼ |
| Yellow Pine | Zinc chloride | 5.54 | 8.54 | 9 | 1.20 | ½ |
| Yellow Pine | Creosote 10 lbs | 6.82 | 9.82 | 20 | .78 | 1¼ |
| Yellow Pine | Creosote 6 lbs | 6.25 | 9.25 | 20 | .74 | ¾ |

* Including framing, hauling and erecting but not stepping, shaving or painting.

** Estimating the life of untreated pine at 3 years, which is a very liberal estimate.

the pole in the line. As a pole timber, yellow pine is harder to shave and to climb than cedar. It grows in perfect pole form.

The results of the study emphasize the importance of thoroughly seasoning and treating this timber before use. If possible the empty-cell tank treatment with creosote should be applied. The next treatment in value is that with zinc chloride which requires a less expensive plant. Finally wherever it is impossible to give a tank treatment, brush treatments with creosote or carbolineum more than pay for the added cost.

The poles used in these experiments are now in service in a California power line. After three years none of the poles treated in the tanks with creosote, zinc chloride, or crude petroleum show sign of decay. The brush treated poles are beginning to decay while untreated stubbs from poles cut each season, which were set as checks, were rotted off completely in less than two years.

# A METHOD OF USING THE ANEROID BAROMETER IN CONTOUR MAPPING.

By C. F. Korstian.

One of the principal features of the reconnaissance work done on the Snoqualmie National Forest in 1910, was the collection of data for a topographic description of the Forest. This data was intended to check existing maps and show increased topographic detail and minor features not previously located. The best maps up to this time were too general for the requirements of the Forest.

The topography of the area included within the boundaries of the Forest is, in general, quite rugged. The mountain slopes vary from moderate to precipitous; cliffs one hundred to two hundred feet high are numerous and the mountains often rise 2,500 to 4,000 feet above the valleys. In that part of the Forest in which the reconnaissance was made, the absolute elevation of the highest peaks ranged from 5,000 to 9,000 feet above sea level. A rise of 400 to 500 feet for each strip acre, ten chains in length, was not uncommon. For obtaining elevations in this work aneroid barometers were used almost exclusively. Most of them were small enough to be carried in the pocket and read only to units of 100 feet. However, ten-foot readings could easily be interpolated. A few of the instruments were graduated to ten-foot units and could be interpolated to one-foot readings, but they do not register as high elevations as those with graduations of 100 feet. In taking elevations for most contour maps, aneroids with units of 100 feet give sufficiently accurate results to warrant their use.

Before reading the aneroid it is always advisable to tap gently on the glass cover to make sure that the system of levers is in proper working order. It should then be held in a horizontal position directly in front of the eyes, and by glancing along the needle the reading can be made directly over the point, and the readings will all be uniform.

On account of the variation in atmospheric pressure from time to time, it was considered necessary on this reconnaissance work to keep from two to four aneroids in camp, and to read them approximately every hour. There is an advantage in using two or more aneroids in camp, for the average of their readings gives greater accuracy. The man who stayed in camp to take these readings employed the time in transferring the field sketches to a four inch scale standard map sheet. The fluctuation in the atmospheric pressure is due largely to the changes in humidity. In cloudy weather when the humidity is great there is a low atmospheric pressure and in clear weather when the air is less humid there is a high pressure. The humidity also varies with the time of day and is usually lowest late in the afternoon. This makes it necessary to obtain the hourly readings of the several aneroids kept in camp in order to determine the corrections which should be made to compensate for the changes in atmospheric pressure. These readings covered a period of twelve hours during the day, starting at about seven o'clock in the morning, and were set down in tabulated form. The interval between readings was not necessarily an exact hour, but was as near an hour as could be made conveniently. The averages were plotted and a curve drawn from which the pressure at the exact hour was read. The pressure in feet was usually plotted on the ordinates and the time to the minute on the abscissae. The average of the first readings taken in the morning was used as the initial point of the curve. The other points were obtained by subtracting this figure from the averages of the other sets of readings. All positive differences were plotted above the zero line and all negative differences below, and the curves drawn were rounded because the pressure does not vary as abruptly as is shown by a line connecting the points. The actual pressure if registered continually would give a rounded curve. A table giving the constant corrections for the exact hours of the day was read from the curve. The accompanying tables and curves illustrate the method of computing a table of constant hourly corrections for a given day. The data used is copied from field notes. The first column gives the time at which the aneroids were read in camp and the next columns show these readings. The column of averages gives an arithmetical average of all readings taken at the same time. The last colunm shows the difference between the average at a given time and the average of the first set taken in the morning, which was considered as zero, or it shows a correction based on the arithmetical mean. The correction could be computed for the exact hour from these figures, but the graphic method, shown by the curves, affords an easier means of obtaining as good or perhaps better results. The last table gives a series of corrections for the exact hour, read from the three curves (Plate I).

DATA FOR HOURLY CORRECTIONS.
Taken on a clear day.

| Time | Aneroid No. 1 | Aneroid No. 2 | Aneroid No. 5 | Average | Difference |
|---|---|---|---|---|---|
| 7:00 A. M. | 1565 | 1480 | 1600 | 1548.3 | 0.0 |
| 8:15 | 1590 | 1460 | 1595 | 1548.3 | 0.0 |
| 9:10 | 1580 | 1450 | 1570 | 1533.3 | —15.0 |
| 10:05 | 1615 | 1485 | 1620 | 1573.3 | +25.0 |
| 11:05 | 1620 | 1500 | 1635 | 1585.0 | +36.7 |
| 12:55 P. M. | 1635 | 1500 | 1590 | 1575.0 | +27.7 |
| 1:05 | 1635 | 1510 | 1585 | 1576.6 | +28.3 |
| 2:15 | 1640 | 1555 | 1610 | 1601.6 | +53.3 |
| 2:55 | 1660 | 1545 | 1605 | 1603.3 | +55.0 |
| 3:45 | 1670 | 1565 | 1640 | 1625.0 | +76.7 |
| 5:05 | 1675 | 1575 | 1650 | 1633.3 | +85.0 |

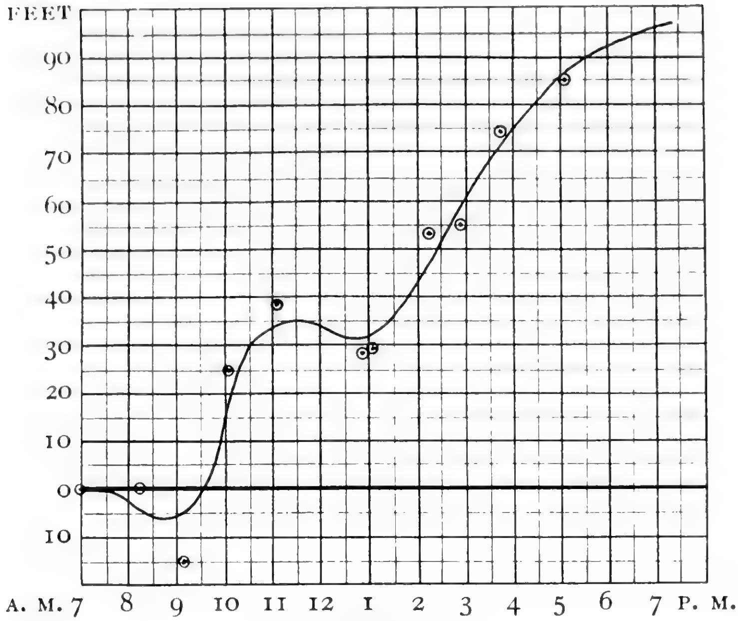
DATA FOR HOURLY CORRECTIONS.
Taken on a day with cloudy forenoon and clear afternoon.

| Time | Aneroid No. 2 | Aneroid No. 7 | Average | Difference |
|---|---|---|---|---|
| 7:30 A. M. | 1460 | 1385 | 1422.5 | 0.0 |
| 8:30 | 1460 | 1380 | 1420.0 | — 2.5 |
| 9:30 | 1460 | 1360 | 1410.0 | —12.5 |
| 10:30 | 1460 | 1360 | 1410.0 | —12.5 |
| 11:30 | 1480 | 1370 | 1425.0 | + 2.5 |
| 1:00 P. M. | 1465 | 1350 | 1407.5 | —15.0 |
| 2:20 | 1480 | 1370 | 1425.0 | + 2.5 |
| 3:00 | 1475 | 1370 | 1422.5 | 0.0 |
| 4:00 | 1465 | 1380 | 1422.5 | 0.0 |
| 5:00 | 1515 | 1400 | 1457.5 | +35.0 |
| 6:20 | 1525 | 1410 | 1467.5 | +45.0 |

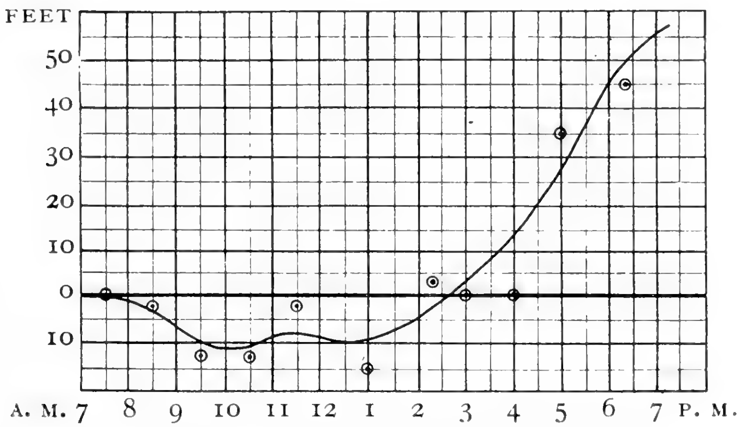
DATA FOR HOURLY CORRECTIONS.
Taken on a cloudy day.

| Time | Aneroid No. 1 | Aneroid No. 7 | Aneroid No. 22 | Average | Difference |
|---|---|---|---|---|---|
| 7:00 A. M. | 2310 | 1345 | 1435 | 1696.6 | 0.0 |
| 7:55 | 2290 | 1350 | 1440 | 1693.3 | — 3.3 |
| 9:15 | 2275 | 1315 | 1315 | 1668.3 | —28.3 |
| 10:25 | 2275 | 1325 | 1415 | 1671.3 | —25.3 |
| 11:45 | 2265 | 1320 | 1415 | 1666.6 | —30.0 |
| 1:15 P. M. | 2280 | 1365 | 1430 | 1661.3 | — 5.3 |
| 3:00 | 2275 | 1350 | 1415 | 1680.0 | —16.6 |
| 4:00 | 2265 | 1355 | 1420 | 1680.0 | —16.6 |
| 5:10 | 2265 | 1340 | 1410 | 1671.6 | —25.0 |
| 5:55 | 2275 | 1340 | 1415 | 1676.6 | —20.0 |

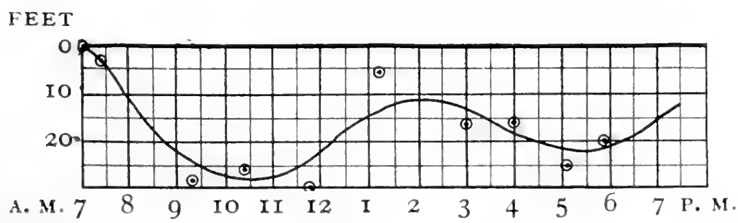
# PLATE I.




For Clear Day.




For Cloudy Forenoon and Clear Afternoon.




For Cloudy Day.

DAILY CORRECTIONS CURVES.

HOURLY CORRECTIONS.
Read from curve for the exact hours.

| Time | Clear Day | Cloudy A. M. Clear P. M. | Cloudy Day |
|---|---|---|---|
| 7 A. M. | 0 | 0 | 0 |
| 8 | 0 | 0 | +10 |
| 9 | + 5 | + 5 | +20 |
| 10 | —15 | +10 | +30 |
| 11 | —35 | +10 | +30 |
| 12 | —35 | +10 | +20 |
| 1 P. M. | —30 | +10 | +15 |
| 2 | —45 | + 5 | +10 |
| 3 | —60 | 0 | +15 |
| 4 | —75 | —15 | +15 |
| 5 | —85 | —30 | +25 |
| 6 | —90 | —45 | +20 |
| 7 | | —55 | +15 |

The strip method of valuation survey was used, and five per cent of the area was actually covered. Strips one chain wide and twenty chains apart were run across a section starting at a point ten chains from the section corner. The United States Geological Survey ran along the section lines when collecting data for their contour maps, so this offset of ten chains prevented covering the same ground twice. The topography for ten chains on either side of the strip was mapped on a field sketch. In surveyed country the strips extended in either a north and south or an east and west line. As far as possible, they were run in the direction of the slope up the mountain side. In unsurveyed country a base-line was meandered along a valley or stream bed, and the distances and elevations were obtained from stadia readings. Whenever possible the base-line was tied in to land surveys or to permanent land marks which had previously been located by the Geological Survey. From this line all strips were run up the slopes.

Each crew carried one aneroid which was read on every decided change in gradient, on every ridge, peak, cliff, and on the banks of lakes and streams, and at water level. The elevations were recorded directly on the field map at the place where the topographic feature occurred. The aneroid was also read at the beginning and the end of each strip-acre and the elevations recorded on the sketch. In making the field sketch, a contour interval of thirty-three and one-third feet was used.

The elevations of the reconnaissance camps were determined either from United States Geological Survey bench marks or from elevations of previous camps. The data which was used in determining the elevations of reconnaissance camps No. 3 and No. 4, as given below, illustrates these two methods.

Camp No. 3 was located about five miles from a Geological Survey bench mark which was 2808 feet above sea level. After finishing the day's work in the field, one of the crews took two aneroids to the bench mark and obtained readings at 8:24 o'clock that evening which gave an average of 2855. The correction curve, made from hourly readings of that day showed, that if the aneroids could have been transferred from the bench mark to the camp without the loss of more than a few minutes they would have dropped from 2855 to 1515, thus showing a difference in elevation of 1340 feet between the two points. The elevation of the bench mark was 2808, that of the camp was 1340 feet lower, or 1468 feet above sea level.

The next morning the crew returned to camp and the aneroids were again read, giving an average of 1430 at seven o'clock. A second computation was made, using this figure and the one obtained the night before. If no correction were necessary for the variation in atmospheric pressure the elevation of the camp would have been 1425 feet lower than the bench mark (2855, the reading at the bench mark at 8:24 in the evening, minus 1430, the reading in camp the next morning at seven o'clock, gives a difference of 1425 feet), or it would be 1373 feet above sea level. It was necessary, however, to apply a positive correction, since the curve of the previous day showed that the reading made at seven o'clock in the morning was 85 feet lower than that at 8:24 the previous evening in camp. Applying the positive correction, that is, adding 85 to 1373, the computed elevation of the camp, which assumes that no atmospheric variation is considered, was accepted as 1458 feet from this set of figures. The average of these two methods gave 1463 feet. Another series of similar computations gave 1454 feet as an average. The mean of all these computations gave 1458 feet as the true elevation of the camp No. 3.

It was customary in establishing a new bench mark, to make three sets of observations when working from a Geological Survey bench mark, and at least five sets of readings when working from a camp elevation. As many more readings were taken as could be conveniently obtained, depending upon the distance between the two points. It was assumed that the United States Geological Survey bench marks were much more accurate than those established by the reconnaissance crew. The data given in the folowing table was obtained while moving from reconnaissance camp No. 3 to camp No. 4. In addition to the aneroid readings taken by each crew in moving, readings were made by the men who did the packing when going back and forth between the two camp sites. Each set of figures consisted of the date and the time at which the readings were taken at each camp site.

DATA TAKEN IN ORDER TO ESTABLISH A NEW BENCH MARK WHEN WORKING FROM A CAMP.

| Set No. | Aneroid No. | Date | Reading at Camp 3 | Time at Camp 3 | Reading at Camp 4 | Time at Camp 4 |
|---|---|---|---|---|---|---|
| 1 | 22 | 8–17–1910 | 1560 | 7:50 A.M. | 2020 | 10:20 A.M. |
| 2 | 2 | 8–17 | 1495 | 10:20 A.M. | 2020 | 10:20 A.M. |
| 3 | 7 | 8–17 | 1485 | 10:20 A.M. | 2005 | 3:40 P.M. |
| 4 | 1 | 8–14 | 2270 | 1:00 P.M. | 2740 | 3:40 P.M. |
| 5 | 5 | 8–14 | 1340 | 1:00 P.M. | 1840 | 3:40 P.M. |
| 6 | 6 | 8–14 | 1580 | 1:00 P.M. | 2040 | 3:40 P.M. |
| 7 | 1 | 8–14 | 2320 | 6:05 A.M. | 2740 | 3:40 P.M. |
| 8 | 5 | 8–14 | 1420 | 6:05 A.M. | 1840 | 3:40 P.M. |
| 9 | 6 | 8–14 | 1610 | 6:05 A.M. | 2040 | 3:40 P.M. |
| 10 | 22 | 8–17 | 1670 | 5:30 P.M. | 2080 | 3:35 P.M. |
| 11 | 22 | 8–18 | 1500 | 2:30 P.M. | 1910 | 5:35 P.M. |

After the necessary corrections had been made for the variation in atmospheric pressure the following table was obtained, which shows the relative elevation of camp No. 4, above camp No. 3.

| Set No. | Difference in elevation |
|---|---|
| 1 | 435 feet |
| 2 | 395 " |
| 3 | 460 " |
| 4 | 450 " |
| 5 | 480 " |
| 6 | 440 " |
| 7 | 435 " |
| 8 | 435 " |
| 9 | 445 " |
| 10 | 450 " |
| 11 | 435 " |

An average of the eleven sets gave 440 feet as the relative difference in elevation between the two camps, making the absolute elevation of camp No. 4, 1893 feet. Two sets of readings were also taken between camp No. 4 and the United States Geological Survey bench mark, 3018 feet, from which the elevation of the camp was computed to be 1853 feet above sea level. Each of these thirteen sets of readings, was given the same weight in averaging, so that the accepted elevation of the camp was eleven-thirteenths of 1893 plus two-thirteenths of 1853 or 1887 feet above sea level.

The determination of the elevation of a side camp sent out from a main reconnaissance camp was but slightly different. When a party started out for a trip extending over a week or more they set their aneroid at the elevation of the main camp before they left. Upon their arrival at the site of their temporary or side camp, the aneroid was read and recorded and either this figure or an arbitrary figure was assumed as the elevation of the site. When the party left this site to return to the main camp the aneroid was set at this assumed elevation and was read upon their arrival at the main camp. These two sets of figures were used to determine the true elevation of the side camp. In working from the temporary camp the aneroid was set at this assumed elevation every morning and read upon returning in the evening. All readings taken during the day were referred to this assumed elevation and later corrected in the main camp where a constant figure was allowed for the difference between the assumed and true elevation in addition to the atmospheric correction.

Before the field sketches were copied on the final sheet they were corrected for elevation. The aneroid readings shown on the field map were accompanied by the exact time at which they were taken. In making the corrections on the sketch the readings were crossed out and the true elevations placed above them. The true elevation was obtained by adding the correction for the hour to the aneroid reading, or subtracting it, depending upon whether it was a positive or a negative correction.

The aneroid barometer is especially suitable for use in a mountainous country with a very rugged topography. Elevations can be taken with the aneroid in country which is so rough that other instruments cannot be used, for it can be carried in the pocket. The elevation of any cliff or peak which can be scaled may be obtained. The aneroid is desirable to use in a country such as the west slope of the Cascade Mountains, which has a dense growth of underbrush and reproduction. In such a locality the use of the level or stadia is impossible without an extra man to cut brush ahead of the instrument man. Because of the small amount of time necessary to read the aneroid and sketch in the contours on the field map, it is a very desirable instrument for taking fairly accurate elevations, especially if it is done in connection with other work such as reconnaissance. When carefully used the aneroid barometer gives fairly accurate elevations.

## PROFESSOR FRANK JAY PHILLIPS.

By F. B. Moody.

With deep regret the announcement is made of the sudden and untimely death of Frank J. Phillips, Professor of Forestry in the University of Nebraska. He died at his home in Lincoln, February thirteenth, nineteen hundred eleven.

Professor Phillips was born in Grandville, Michigan, September twenty-fifth, eighteen hundred eighty-one. After graduating from the Grandville High School he worked his way through the Michigan Agricultural College, and completed the work in nineteen hundred three with the degree of Bachelor of Science. The same year he entered the Branch of Extension in the Bureau of Forestry studying forest conditions throughout the Middle West until the fall of nineteen hundred four. His intense interest in forestry together with his great love for outdoor life caused him to take up that study in the University of Michigan Forestry School where he received the degree of Bachelor of Arts in nineteen hundred five, and the degree of Master of Science in Forestry in nineteen hundred six. After completing this course in the University he received an appointment as Forest Assistant in the Forest Service and spent a year in the Southwest. In nineteen hundred seven he was appointed Professor of Forestry in the University of Nebraska, which position he held until his death.

Professor Phillips was a self-made man in every sense of the word. By hard knocks he had learned the practical side of forestry and his knowledge, coupled with keen powers of observation and a brilliant mind, served to make him a splendid leader and teacher, whose enthusiasm, cheerfulness and great appreciation of the efforts of others, will leave a lasting impression upon all who knew him.

# The
# Forest Club Annual
## Volume IV. 1912.

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# INDEX

# GRAZING INVESTIGATIONS ON OUR NATIONAL FORESTS.*

Arthur W. Sampson.

The magnitude of the stock industry on National Forests over which the Branch of Grazing of the United States Forest Service has supervision may be realized when it is recalled that on 125,000,000 acres of grazing land within National Forests in the year 1910, 9,000,000 head of stock were grazed. Of this number, about 75 per cent were sheep, the balance being made up of cattle, goats, horses, and swine, named in their order of abundance. The grazing fees amounted to about $970,000, exceeding the revenue from timber sales by more than $29,000. Aside from the many perplexing and intricate problems of grazing administration the Branch of Grazing is carrying out a number of range investigations.

The stockman of today is no longer "the monarch of all he surveys." In the beginning he was not restricted to any definite locality but was free to graze his stock wherever natural conditions offered the greatest possibilities. It seemed in the beginning that the forage crop was inexhaustible, but the alluring possibilities of the stock raising industry throughout the West soon resulted in overstocking, and the injudicious removal of the forage crop, as the inevitable result of the lack of a system of range management during the "free for all" grazing period, soon made apparent the serious reduction of the natural forage supply.

One factor which greatly added to the possibilities of the stock industry and which possibly contributed more than any other to the depletion of the natural range lands was the development of hay production on the lands susceptible to irrigation in the vicinity of the higher mountain lands. As long as the stock was entirely dependent upon the range the year round, the limited amount of winter forage produced made it impossible for the stockman to range so many stock as to

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seriously injure the more abundant summer range. But with the rapid increase in stock and the assurance of hay for protection through at least a part of the winter, the accessible portions of the spring, summer and autumn lands were soon grazed so far beyond their carrying capacity that portions were rendered virtually useless for foraging purposes. In many instances the lands were so seriously impoverished that after they were placed under governmental jurisdiction and the individual permit system put into effect they failed to regain their former productiveness.

Owing to the great importance of the summer ranges to the grazing industry, the question of range improvement was strongly agitated by stockmen in various communities. Finally the Government was called upon to make a critical study of the conditions and attempt to find some practical means of improving the existing conditions. In the spring of 1907 the Forest Service, in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture, began investigations.

In the brief space of a short article it is a difficult matter to give an adequate impression of the grazing investigations that are being carried out. In the space given it will only be possible to treat briefly of a few of the more important technical problems with which we are concerned.

In a broad way, the investigations with which this paper will deal naturally fall under two main topics; first, a study of the improvement in the carrying capacity and quality of the range forage crop; and second,a study of grazing in relation to the reproduction of timber species. The task of increasing the productivity of the native range lands is treated under four heads as follows:

1. Range reconnaissance.
2. Improved methods in handling stock.
3. Reseeding to cultivated forage plants.
4. Natural revegetation of the range.

The study of grazing in relation to the reproduction of timber species will be discussed under the single head of "Effect of Grazing on Forest Reproduction."

### GRAZING RECONNAISSANCE.*

Anyone who is familiar with business principles knows

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*The section on Grazing Reconnaissance was prepared by Mr. W. A Dayton.

that in order to be informed of the character and condition of a business an inventory must occasionally be taken. In just this way the Branch of Grazing of the Service is engaged in a line of activity known as "Grazing Reconnaissance," taking an inventory of its forage assets and liabilities comprehended by the whole of the public domain under the control of the Forest Service. It is analogous to the timber reconnaissance conducted by the Branch of Silviculture. Ascertaining as it does any depleted, unusual, or improperly-used areas, as preliminary to extensive practical and scientific studies, reconnaissance is invaluable.

Reconnaissance is a new departure in grazing annals, the work having been inaugurated on the Coconino Forest, in northern Arizona, in April, 1911. As no men with the requisite training and experience were available to superintend this work a special examination to secure eligibles, to be known when appointed as "Grazing Examiners," was held last March. The examination covered questions in general botany, plant physiology and ecology, engineering, and practical questions as to the handling of stock on the range. Four men passed the examination and they were each placed in charge of a field party in one district.

The work naturally divides itself into three parts: mapping, descriptive reports, and plant collecting.

The reconnaissance maps will eventually give of each Forest a complete classification of its entire area into types and subtypes of grazing land, ten acres or larger in area, and will show the location, acreage, and condition (i.e., whether normal, overgrazed, or poorly stocked) of each type and subtype, the part grazed and ungrazed, whether summer, winter or year-long range, the type and state of development of all water facilities, the topography of the forest, and all roads, trails, driveways, drift fences, corrals, and telephone lines.

The descriptive reports cover all details of value to grazing administration which cannot be represented on the maps. For example, occurrence of poisonous plants or of range-destroying pests, such as prairie dogs, are carefully noted.

The plant collections will ultimately furnish authoritative lists of the local economically valuable grazing plants and also of such poisonous species as may occur.

Grazing land is divided into eight types, viz:

1. *Open grass land* (other than meadows). This type includes bunchgrass areas, gramagrass areas, and other open grass lands not meadow in character.

2. *Meadows.* This includes the wet meadowlands where sedges, etc., predominate and those moist, meadowlike areas which occur usually as open parks in the timber.

3. *Weed.* This type embraces all untimbered areas where weeds are the predominant forage. It includes aspen range where weeds are the predominant forage. It does not include small weed areas in coniferous forests.

4. *Browse.* This includes all lands, outside of conifer timber, where browse is the prevailing forage.

5. *Sagebrush.* This type includes all lands where sagebrush predominates.

6. *Timber range,* supporting a stand of grasses, weeds, and browse. This type includes all range in coniferous forests.

7. *Waste range* in dense timber and brush. This includes all timbered and brush areas which are valueless for grazing purposes.

8. *Barren land.* This type includes all areas where *naturally* there is no vegetation.

In addition to these eight main types provision has been made for the representation of such subtypes as may be necessary to indicate all the important diversities of range. Also, in case the eight general types do not represent all the types of a particular district, the District Forester may decide upon an additional type or types. The eight grazing types referred to are represented on the maps by crayons of various colors, but, owing to the inconvenience of carrying the crayons into the field, numbers (from 1 to 8) are temporarily employed to designate the several types.

| | |
|---|---|
| 1. Yellow | 5. Black |
| 2. Orange | 6. Green |
| 3. Red | 7. Ultramarine |
| 4. Olive-drab | 8. (Diagrammatic of scabland) |

Range normally stocked is represented in solid color; overgrazed areas are indicated by horizontal hatching in type color; while poorly stocked range is represented by vertical hatching in type color.

The mapping and note taking are done in the field by the men working individually. Blank forms are used providing for a representation of one section on a scale of 4 inches to the mile; 100 feet contours are shown, and, if the country has been covered by a reliable survey, these contours are usually copied from such survey; otherwise they are ordinarily made from aneroid readings. Each section is crossed on the quarter or forty lines as often as may be necessary to make the results reliable. Timbered sections are crossed at least twice on the forty lines. In surveyed country section lines are used as base lines; in unsurveyed localities the mapping is done from base lines consisting of parallel lines in a cardinal direction, projected from an established public survey, or, if the country be very rugged, accurately surveyed traverse lines are run up main canyons for the purpose. As soon as camp is reached the types are colored by the proper crayons. With the coming of "the next rainy day," or at some other convenient season, the maps and data are transferred to another sheet, and the whole material will eventually be transferred to Forest Atlas sheets, when the maps will be on the scale of 1 inch to the mile.

### STOCK MANAGEMENT.

Any system of range control which will protect the lands from being continuously cropped before the forage growth is sufficiently advanced to continue its development, and which will regulate the number of stock so as to prevent excessive trampling and close grazing, will result in deriving the highest returns both to stock and range. Few if any perennial herbaceous plants will not continue their natural growth when cropped moderately at one time or other during the growing season. If, however, the vegetation is removed several times during the growing period, the plants are unable to elaborate the food material necessary to growth, and they struggle along, producing an abnormally small amount of forage until the range is brought under the proper control and the original vigor of the plants is restored.

The more freedom stock are given when grazing the less acreage is required for their maintenance and the better is the condition both of the stock and range at the end of the season. The question of fencing and thereby preventing the straying of the grazing animals without driving and dogging the stock, as on the open range, which causes varying degrees of destruction to the lands, has been tested by a number of stockmen both on private holdings and on leased lands. In the spring of 1907 the Forest Service inaugurated an experiment on the Wallowa National Forest to test the results to range and stock when the latter are pastured. An area of sufficient size to support a band of 2,500 ewes and lambs during the summer grazing period was fenced coyote-proof. Contrary to the opinion of various stockmen it was found that when sheep are left to shift for themselves, without a herder, they soon become accustomed to the conditions and graze contentedly. In the absence of predatory animals, dogs, and other disturbing elements to excite the band and cause the sheep to scurry and run together, and thereby wear out the range, they graze openly and quietly. They bed, often in several small bunches, wherever they happen to be grazing when night overtakes them, instead of being collected in a single compact bunch where they may unite for a succession of nights and be guarded against predatory animals by a herder.

The experiment has proven that only from 65 to 80 per cent as much range is required for sheep under pasturage conditions as when they are herded in the same size bands on open range of similar character. It is self-evident that less forage would be wasted on a range where the band is not suddenly driven off the bed ground by dogs and jammed onto the range type which suits the ideas or convenience of the herder than where such a destructive system is followed. When allowed to respond to its own inclinations, the ewe with her lamb wanders slowly and leisurely away from the bed ground, selecting her own favorite range type and choice of forage. When handled in this manner, stock are invariably in better condition of flesh when they leave the range at the end of the season than stock grazed on an identical range where they are more or less closely herded and handled by dogs to the usual extent. The matter of fencing, in the case of cattle, has not been carried out in conjunction with this experiment. Many stockmen, however, are convinced that cattle can not profitably be run in pastures. This has been tested on a small scale under range conditions of private holdings and on leased lands. It is alleged that range cattle, owing to their unfamiliarity with fences, seem to be unadapted to pasturage conditions. Instead of grazing contentedly in a pasture as sheep are found to do, cattle wear themselves out through restlessly wandering along the fence line.

This condition has not manifested itself upon National Forests along drift fences and in community enclosures (the latter merely being large pastures), and it would seem that the cause for the unsettled, restless character of the stock might be due to a lack of highly-relished forage. Frequently the carrying capacity of a range is overestimated. In certain cases it seems to be presumed that the elimination of nomandic stock through fencing does not increase the forage supply at all, for in many cases more stock are grazed after fencing than the previous carrying capacity would warrant. Within the last couple of seasons, however, the writer has observed that the most aggressive and successful stockmen are running a large number of cattle under the pasturage system, especially in localities where the natural grazing lands are becoming more and more limited.

The pasturage experiment with sheep has definitely proven that stock on the open range, so far as possible, should be handled as much in the same manner as they conduct themselves in an enclosure as is possible. For example, instead of using the same bed ground for sheep for a succession of nights and in the place of grazing a large range area to its utmost capacity from a single camp, destroying a large amount of forage through trampling, the band should be bedded where night overtakes it. Open grazing should be practised at all times, avoiding reckless herding and massing together through the injudicious and excessive use of dogs.

The record of the experiment in 1909 in the Wallowa National Forest* showed that among the other advantages of the pasturage fence in handling sheep on the range may be mentioned protection from predatory animals, economy

*"The Pasturage System for Handling Range Sheep—Investigations during 1909," by J. T. Jardine, U. S. F. S. Circular 178.

in handling, relative immunity from poisoning, increase in lambs saved at lambing time, and improvement in the quality and amount of wool.

### RESEEDING TO CULTIVATED FORAGE PLANTS.

The wide diversity in the character of the native grazing lands and in the general condition controlling growth naturally results in considerable deviation in the adaptability and establishment of introduced or cultivated forage species.

In general the conditions existing on the major portion of the grazing lands are antagonistic toward the successful establishment of cultivated grazing plants. The primary reasons for failure are unsuitable topographic features and extreme aridity coupled with inferior soils. Certain lands are so rough and have such poorly disintegrated soils that very little moisture is available during the important grazing season. In other localities the precipitation during the grazing season is so slight that even the most drought-resistant native vegetation makes poor headway. In general, the mountain ranges and especially the meadows respond best to artificial reseeding.

Of the many forage species tested on the National Forests relatively few have given satisfactory returns. In the selection of the species three chief facts are considered; first, the natural requirements of the plant and the nature of the habitat to be seeded; second, economy of expenditure based on cost of seed per pound and the amount required to insure a satisfactory cover; and third, the time required for the development of a satisfactory stand and the ability of the species to withstand trampling.

The requirements of the different species, the cost of the seed, and the ability of the plant to withstand the sharp-cutting hoofs of the sheep vary widely. As a concrete example, redtop succeeds better than any other known cultivated forage grass on poorly drained bogs where the soil is acid in character. It makes an excellent turf and is not easily injured by trampling. On the other hand, Hungarian brome is wholly unsuited to such a habitat but is better adapted than any other to arid localities. Timothy is adapted to a very much wider range of conditions than either of the species mentioned.

It is fairly drought resistant and yet it can be depended upon to make a good stand in moist meadows.

Judging from the experiments, the most promising cultivated species for range reseeding on the lands studied, naming them in order of their importance, are timothy, Hungarian brome, Italian rye, red top, Kentucky bluegrass, alsike and white clover, orchard grass, tall meadow oat grass, Canadian bluegrass and hard or sheep fescue. In all cases, except in parts of the Southwest, as on the Coconino National Forest, fall seeding has given much better results than sowing in the spring.

Since the inauguration in 1909 of carefully planned experiments in forage reseeding on the National Forests, not including the recently initiated experiments in 1911, 329 reseeding plats have been established and reported upon. Of this number 111 or 33.8 per cent have been successes or partial successes and 123 or 37.4 per cent have failed. The remaining experiments have either not been reported or the results are still uncertain.

The causes of failure are shown in the following table:

| Causes of Failure | Per Cent |
|---|---|
| Drought | 54.5 |
| Lack of soil treatment | 22.8 |
| Improper time of sowing | 5.7 |
| Unexplained | 4.1 |
| Low temperature | 2.5 |
| Erosion | 1.6 |
| Excessive plant competition | 1.6 |
| Improper time of sowing and drought | 1.6 |
| Native plant competition and low temperature | 1.6 |
| Low temperature and excessive moisture | 0.8 |
| Drought combined with failure to cover seed | 0.8 |
| Inferior soil | 0.8 |
| Drought and competition with native vegetation | 0.8 |
| Improper selection of species | 0.8 |

NATURAL REVEGETATION OF THE RANGE.

The very term "revegetation" when used in connection with range lands presupposes a reduction in their former productiveness. It is natural to presume that during the initial period of overgrazing the most highly relished species would be the first to give way during the gradual process of elimination and that eventually there would remain only the objectional or unpalatable species. This, however, is not the general rule, for few herbaceous plants cease to grow as a result of the removal of the aerial parts. By far the greatest injury is brought about through the impoverishment of the root system by pruning and exposure. The hardiest and most strongly-rooted species, usually perennials, persist to the very last. If grazing is continued, even the perennial plants, which are the most valuable, may be completely eliminated and the lands are invaded by annual weeds of little or no forage value.

Experiments to devise an effective means of natural reseeding the grazing lands on National Forests were started on the Wallowa National Forest in northwestern Oregon in the spring of 1907. Data was ascertained covering the following points:

1. To determine the relative importance of the native grasses and forage plants by studying (1) their abundance, distribution, seed habits, and forage value, and (2) their life history so far as concerns the handling of these lands as grazing areas.

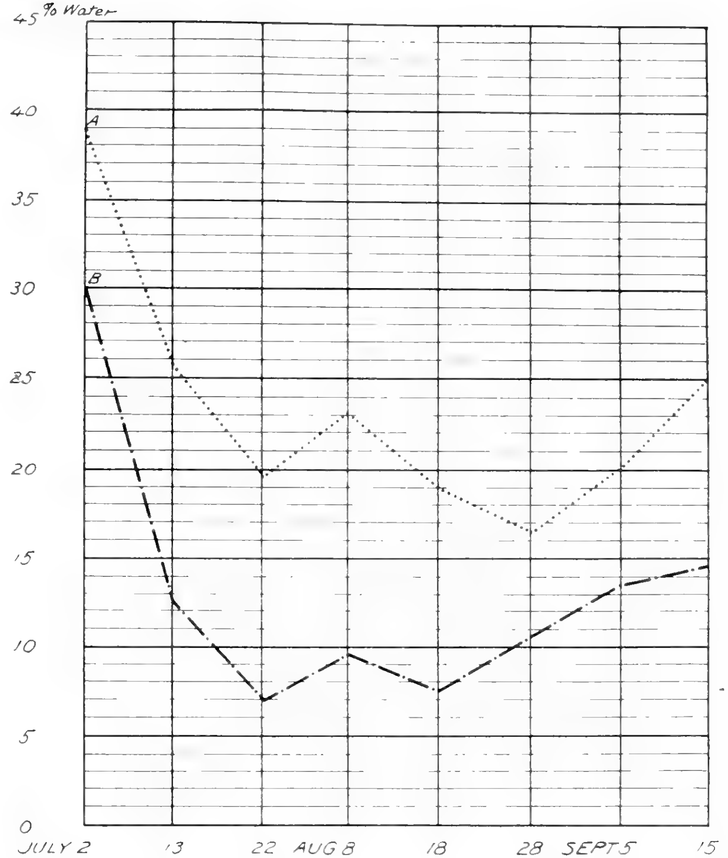
2. To ascertain the rapidity and extent to which the important forage plants are regenerating upon areas overgrazed in various degrees, both under the present range management and upon areas exempt from grazing animals.

3. To determine what plants under the present grazing system are succeeding upon depleted range areas, and how, by natural reseeding, the best grazing species may be reproduced.

As a preliminary step to the inauguration of this experiment, in order to know at what time it was safe to admit stock to graze the depleted areas without possible injury to the seed crop, it was of paramount importance (1) to learn what species constitute the leading forage plants and (2) to determine for each of these the period at which the flower stalks are produced and when the seed is matured and disseminated. Information pertaining to the most valuable forage plants was ascertained by following the sheep as they leisurely grazed the different range types under the varied conditions during the progress of the season, noting their choice of

## PLATE I

Two-year-old Plant of Festuca vividula Showing the Remarkable Root Development.




Simultaneous reading showing behavior of soil moisture taken at depth of seedling roots and at a depth of 8 inches Hudsonian Zone main growing period

A-Samples taken 8 inches deep

B-Samples taken at depth of seedling

forage. No less than forty species were found to have special value at one time or other during the season. It was learned that mountain bunchgrass *(Festuca viridula)* was by far the most valuable forage plant in the Wallowa (Blue) Mountains, where it occurs at from 6,500 to 8,500 feet elevation, mainly in open parks and bald buttes. Like the majority of the forage species, mountain bunchgrass in 1907 and subsequent seasons completed putting forth its flower stalks in most situations by August 15, and the seed crop was, for the most part, matured and dispersed during the last week in August and the first week in September.

During the season of 1907 the most valuable information secured in the initiation of natural reseeding was the following:

1. After the main seed crop had ripened there remained one-fifth of the summer grazing season.

2. Mountain bunchgrass and the majority of the preeminent forage plants are relished by sheep after the seeds have dropped and the herbage is partly air-cured.

Based upon this and additional facts, a definite plan for an experiment in natural reseeding was drawn up and inaugurated in 1908. The main plans of the experiment were: (1) on certain sheep ranges in need of reseeding and occupied by a single band of sheep, a portion of the range which normally supported the band for one-fifth of the summer season was to be closed to grazing until the seed crop had ripened; (2) that the areas and their exact boundaries were to be decided upon by the Forest officers in charge in consultation with the stockmen to whom the allotment had been assigned; (3) that when the seed crop was matured the range would be moderately grazed at any time during the remainder of the season; and (4) that the same areas should be closed to sheep on the following year in order to give the seedlings a good opportunity to develop a strong enough root system to withstand trampling, and also to permit a second seed crop to be developed and disseminated if the first year's seeding was unsuccessful. In the season of 1908 a good seed crop was produced and the experiment was successfully carried out as planned.

A study of the condition of the vegetation on ranges that had been comparatively early and closely cropped for a number of seasons showed that the highly relished species were so weakened as the result of being repeatedly deprived of their leafy herbage and consequent suffering from starvation, that the flower stalks, if produced at all, were sent up too late for the seed to reach maturity prior to inclement weather. This condition, however, was overcome by the deferred grazing system, i.e., protecting the ranges until growth had ceased, for then the necessary nutrients had been stored in the roots and crowns.

It was interesting to note that on the areas set aside for the natural reseeding experiment the recovery of the weakened vegetation was quite as rapid as upon small areas protected yearlong from grazing. On the latter areas, as on the deferred grazing lands, the vegetative growth increased rapidly and the flower-stalk production and seed maturity were completed about the time that these functions were begun on the ranges grazed at the usual period. On the yearlong protected areas, however, practically no forage seedlings have come in and in this respect they differ from the deferred grazing experimental areas. On the deferred grazing lands, before putting into effect the natural reseeding scheme, none of the forage plants eaten with avidity were reproducing. The only seedlings found were from seed of early-maturing, unpalatable plants, the predominating species being a useless sedge, locally called sickle sedge *(Carex umbellata brevirestris)*. In 1909, however, after one season's trial of natural reseeding, all the valuable range plants, including mountain bunchgrass, were producing abundantly. As a result of the development and maturity of the seed crop these ranges exceeded by 90 per cent the seedling stand in existence prior to the reseeding test. The matter of reproduction is largely dependent upon the planting of the seed crop. When sheep graze the range after the seed has fallen it is well ground into the soil and a high per cent of germination is assured. On the contrary, when the lands are entirely closed to grazing the seed can only get into the soil through the action of natural agencies. On the yearlong protected areas it is found that only the species bearing prominent awns or beards in conjunction with the seeds, like porcupine grass *(Stipa occidentalis)*, are reproducing. On the grazed areas, then, not only a better seedling stand is secured but the forage crop is utilized.

In certain habitats on the experimental allotments the forage seedlings occurred so densely in the beginning of the season that individual competition was sure to enter in and eliminate the weaker ones. From a large number of counts in the varied localities it was found that virtually one-half of the original stand was killed by adverse physical conditions and the greatest injury occurred during the fore part of the season. While the upland ranges enjoy more precipitation than those of lower elevation, the friable surface soil to a depth of 2 or 3 inches, dries out readily, and the lack of water is the primary cause of the loss of seedlings. A few inches beneath the surface layer an abundance of moisture is nearly always present at any time during the season. It is found that forage seedlings of average moisture requirements succumb when the soil in the vicinity of their roots varies from five to nine per cent. The curves in Plate I show the relation of soil moisture during the growing season in the soil stratum in which the forage seedlings grow and in the soil in which the established plants have their roots.

It will be observed that there is a correlated behavior in the water content in the two soil strata, yet the per cent of water decreases perceptibly more rapidly in the upper layer. The figure also shows that the driest period of both depths of soil in 1909 occurred between July 15 and 25. At this time the seedlings had a meager root system and fully four-fifths of the loss occurred between those dates. By the end of the second season the seedlings are so deeply rooted that drought is not liable to injure them. (See Plate I.)

In order to secure reproduction from the valuable native range plants to such an extent as to materially increase the forage supply within a reasonable length of time, it is evident that the range must support at least a sparse stand of the species valuable for grazing. The time required for a thorough re-establishment of the forage crop will largely depend upon the density of the forage stand, vigor of the vegetation, the seed habits and vitality of the seed crop, the climatic conditions and the care with which the lands are grazed during the time required for the new growth to become established. On lands where the forage crop has been but slightly decreased, and even in the case of a half normal stand, deferred grazing for a single season may bring about the desired results.

Certain grazing lands which have been subject to destructive grazing to a point where the original palatable plants have been virtually replaced by useless weeds could not be reseeded by deferred grazing. Such lands can often be successfully seeded to cultivated plants, as already pointed out.

Depleted lands of unusually high altitudes, and consequently characterized by a short growing season, are restricted in the possibilities of natural reseeding owing to the limited grazing period remaining after the seed crop matures. However, the valuable grazing lands near or exceeding the timberline are much limited.

On the Wallowa National Forest in the season of 1911 ten high mountain grazing allotments were selected for deferred grazing. Owing to the practicability of this means of reseeding the stockmen are eager to take advantage of it.

### EFFECT OF GRAZING ON FOREST REPRODUCTION.

The primary object in the creation of National Forests was the conservation of the timber and water. In the beginning grazing was unrestricted, but it was soon generally conceded that grazing on Forest ranges must be controlled. In some localities little was known of the past history of the lands and in some cases their condition seemed to warrant the total exclusion of sheep and goats. Owing to the fact that the condition of the ranges was considered as evidence that sheep grazing was injurious to forest growth, this class of stock was eliminated from certain forests in the more arid regions for a decade or so.

It was not until the year 1910 that the Branch of Grazing undertook a critical study to investigate the effect of grazing on forest reproduction. The first investigation was carried out on the Coconino National Forest in northern Arizona by Messrs. R. R. Hill, Grazing Examiner, and W. A. Dayton, Plant Ecologist. The study in 1911 was confined to the Shasta National Forest in northern California and was prosecuted by Mr. W. A. Dayton and the writer.

In a broad way the object of this study was to determine the amount and seriousness of injury to timber species, from a silvicultural standpoint, due to all classes of stock, and to ascertain the season of greatest injury and such other correlated factors, topographic, climatic, edaphic, or administrative, as might be relevant.

The data was obtained by means of sample plots or quadrats of varying size according to location. In order to include a variety of conditions, it was the aim to establish a large number of small plots rather than a small number of large ones. Within the plot every seedling and sapling was examined for injuries and the character and year of the damage was noted. Further, the reproduction was classified according to height growth. Plants six inches and less in height were placed in the seedling class while those over six inches were called saplings. The latter were divided into five classes, Class 1 constituting the 1-foot height, i.e., from approximately 6 to 18 inches, etc. Height records were thus taken in six classes, viz., from 6 inches to 5 feet. In addition to the notes recorded pertaining to injuries, a number of saplings grazed in varying degrees of seriousness were photographed with the idea of rephotographing *in situ* from time to time to show the possibilities of recovery from the different mechanical abuses.

Virtually all the lands within the Shasta Forest boundary support timber species. The main zone (2,000 to 6,000 feet) is composed of a mixture in varying proportions of Western Yellow Pine, Sugar Pine, Douglas Fir, Incense Cedar and White Fir, named in their order of local importance. In the lower limits of this zone, and extending more or less sparingly to an altitude of about 4,000 feet, occur several species of oak. Immediately above the Yellow-Sugar Pine and Cedar zone occur the Lodgepole Pine and Red Fir.

In all, 37 quadrats were plotted covering a total surface of 27,051 square feet; 13 plots having a total of 11,151 square feet were established on cattle ranges, 17 plots having 11,170 square feet on sheep lands, and 7 plots with a total of 4730 square feet on goat ranges.

For the purpose of making detailed studies as to the invasion and succession of timber species on lands exempt from foraging animals, and to obtain comparative data on this matter on the open range, a few plots have been established on areas fenced against stock. These areas are, in all cases, adjacent to the plots which represent the conditions on the open range.

As shown in the accompanying table (No. 1) the plots examined during the vernal season of 1911 contained a total of 4,570 seedlings and saplings. The plots on the cattle range had 1,261 seedlings and saplings, among which 41 specimens or 3.25 per cent of the total were grazed and 37 or 2.93 per cent were injured by trampling. On the sheep ranges 29.08 per cent and 0.26, respectively, were grazed and trampled, while on the goat areas 6.26 and 0.06 per cent, respectively, were grazed and trampled.

Table 1.—Grazing injuries of all species—first count:

| Class of Stock Grazed | Grazed | | Ungrazed | | Trampled | | Killed | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % | |
| Cattle | 41 | 3.25 | 1183 | 93.82 | 37 | 2.93 | 0 | 0.00 | 1261 |
| Sheep | 442 | 29.08 | 1073 | 70.59 | 4 | 0.26 | 1 | 0.07 | 1520 |
| Goats | 112 | 6.26 | 1676 | 93.68 | 1 | 0.06 | 0 | 0.00 | 1789 |
| Total | 595 | 13.02 | 3932 | 86.04 | 42 | 0.92 | 1 | 0.02 | 4570 |

Table 2.—Grazing injuries of all species—second count:

| Class of Stock Grazed | Grazed | | Ungrazed | | Trampled | | Killed | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % | |
| Cattle | 178 | 6.12 | 2674 | 91.95 | 49 | 1.69 | 7 | 0.24 | 2908 |
| Sheep | 625 | 36.38 | 1070 | 62.28 | 16 | 0.93 | 7 | 0.41 | 1718 |
| Goats | 758 | 22.90 | 2546 | 76.92 | 5 | 0.15 | 1 | 0.03 | 3310 |
| Total | 1561 | 19.67 | 6290 | 19.26 | 70 | 0.88 | 15 | 0.19 | 7936 |

The notable features of contrast found in the autumn count (Table 2), after the season's grazing, as compared with the vernal record, are: first, the increase in the number of grazed species on the goat ranges, and second, the greater number of killed specimens. In the latter case, two Douglas Fir seedlings were pulled up by the roots on a plot on the sheep range; one sapling of White Fir was deprived of bark on the goat range; the remaining had received general injuries at various times of such seriousness as to finally kill them.

It is understood that the character of the injuries and the species in question were recorded in all cases. This can not be shown without elaborate tabulations. It may be said, however, that Sugar Pine and Western Yellow Pine are the most palatable and consequently are more frequently injured than any other species. Incense Cedar is only browsed by goats, which, it should be added, are by far the most destructive class of stock to forest reproduction. As an example of preference for species it may be mentioned that in the autumn (second count) 62.54 per cent of Yellow Pine saplings and seedlings and 10.12 per cent of Incense Cedar were browsed on the goat ranges.

This study on the relation of grazing to the reproduction of timber species has disclosed facts to show that goats are seriously destructive, but that the presence of sheep and cattle is not a serious matter to the reproduction of the young timber growth. In many localities where serious injury has resulted from sheep and cattle grazing, the injury is rather due to faulty handling such as premature grazing or overgrazing. Regulated grazing and good management are not liable to prevent or destroy the subsequent establishment of our forests, but when we think of the high value of grazing as preventing the running of fires, I am strongly inclined to think that moderate grazing should be encouraged.

# TREES OF OMAHA.

S. V. Fullaway, Jr., and W. R. Chapline, Jr.

As a further step in the attempt of the Forestry Department of the University of Nebraska to obtain a complete list of the trees, both native and exotic, of the state, this study was made in the spring of 1911. Similar studies, made at the Morton Estate, Nebraska City, and at the Pollard Estate, Nehawka, were published in Volumes II and III respectively of the Forest Club Annual.

The trees, from which the following list was compiled, were found in all parts of the city; the study was made in the parks, on the boulevards, at Forest Lawn Cemetery and the Joslyn Estate and along many of the streets. Much credit in making this a complete list is due to W. A. Adams, Superintendent of the Omaha Park Commission; J. Y. Craig, Superintendent of the Forest Lawn Cemetery, and I. M. Roman, Head Gardener of the Joslyn Estate.

The list comprises 171 species, of which 38 are native to Nebraska. It gives both the scientific and common name, the maximum diameter and height, the native habitat and the location in the city of at least one specimen of each of the more important trees that are rare in this region.

## TREE LIST OF OMAHA.

*Abies balsamea* Mill. Balsam Fir.

Height 10 feet. Diameter 2 inches. Native to the United States.

*Abies concolor* Lindl. & Gord. White Fir.

Height 30 feet. Diameter 5 inches. Native to the United States. Fine specimens at Forest Lawn Cemetery.

*Acer circinatum* Pursh. Vine Maple.

Height 8 feet. Native to the United States.

*Acer negundo* L. Box Elder.

Height 60 feet. Diameter 48 inches. Native to Nebraska.

*Acer palmatum* Thunb. Japanese Maple.
Height 3 feet. Native to Japan.

*Acer palmatum* var. *dissectum* Koch. Cut-Leaf Weeping Japanese Maple.
Height 30 feet. Diameter 8 inches. Native to Japan.

*Acer platanoides* Linn. Norway Maple.
Height 8 feet. Native to North Europe. Hard to start but does well later.

*Acer platanoides,* Linn. var. *dissectum* Jacq. Cut-Leaf Norway Maple.
Height 50 feet. Diameter 18 inches. Native to Europe.

*Acer polymorphum* Sieb. & Zucc. Japan Maple.
Height 8 feet. Native to Japan.

*Acer saccharinum* Linn. Silver Maple.
Height 80 feet. Diameter 20 inches. Native to Nebraska. Some fine specimens.

*Acer Saccharinum* Linn. var. *wieri* Schwer. Wier's Cut-Leaf Maple.
Height 30 feet. Diameter 12 inches. Native to United States.

*Acer saccharum* Marsh. Sugar Maple.
Height 30 feet. Diameter 10 inches. Native to the United States. Slow to start, slow grower but makes a good shade tree.

*Aesculus glabra* Willd. Ohio Buckeye.
Height 12 feet. Diameter 3 inches. Native to the United States. Grown from seed.

*Aesculus hippocastanum* Linn. Horse Chestnut.
Height 25 feet. Diameter 8 inches. Native to Europe.

*Aesculus rubicunda* Loisel. Red Flowered Horse Chestnut.
Height 12 feet. Diameter 6 inches. Handsome and desirable.

*Ailanthus glandulosa* Desf. Tree of Heaven.
Height 40 feet. Diameter 14 inches. Native to China. Fine specimens in Hanscom Park.

*Alnus europea* Linn. Smooth Alder.
Small. Native to Europe.

*Alnus glutinosa* (Linn.) Gaertn. European Alder.
Height 35 feet. Diameter 10 inches. Native to Europe and Africa.

*Alnus oregona* Nutt. Red Alder.
Height 50 feet. Diameter 15 inches. Native to the United States. Large fine trees.

*Amelanchier canadensis* (Linn.) Medic. Service Berry.
Height 10 feet. Native to the United States.

*Amygdalus persica* Linn. Peach.
Height 15 feet. Diameter 3 inches. Native to China.

*Aralia spinosa* Linn. Hercules' Club.
Height 10 feet. Diameter 2 inches. Native to the United States.

*Araucaria exelsa* Brown. Norfolk Island Pine.
Height 5 feet. Native to Norfolk Islands.

*Betula alba* Linn. European Birch.
Height 30 feet. Diameter 6 inches. Native to Europe.

*Betula alba* Linn. var. *pendulata lacinata* Linn. Cut-Leaf Birch.
Height 40 feet. Diameter 14 inches. Native to the United States.

*Betula papyrifera* Marsh. Paper Birch.
Height 60 feet. Diameter 12 inches. Native to Nebraska. Several fine specimens at 29th Ave. and Poppelton.

*Betula populifolia* Marsh. White Birch.
Height 35 feet. Diameter 8 inches. Native to the United States. Number of fine specimens in Elmwood Park.

*Carpinus caroliniana* Walt. Blue Beech.
Height 40 feet. Diameter 8 inches. Native to Nebraska. At Bemis Park.

*Castanea dentata* Borkh. Chestnut.
Height 45 feet. Diameter 12 inches. Native to the United States. Several fine specimens at 33rd Street and Francis.

*Catalpa catalpa* Karst. Common Catalpa.
Height 20 feet. Diameter 12 inches. Native to the United States. Not very hardy here.

*Catalpa kaemferi* Sieb. & Zucc. Chinese Catalpa.
Height 16 feet. Diameter 4 inches. Native to China.

*Catalpa speciosa* Warder. Hardy Catalpa.
Height 40 feet. Diameter 22 inches. Native to the United States.

*Celtis occidentalis* Linn. Hackberry.
Height 75 feet. Diameter 16 inches. Native to Nebraska. Park Ave. and Poppelton.

*Cercis canadensis* Linn. Red Bud.
Height 20 feet. Diameter 6 inches. Native to eastern Nebraska. Does best in ravines along river banks.

*Cornus florida* Linn. Flowering Dogwood.
Height 15 feet. Diameter 2 inches. Native to the United States.

*Cornus stolonifera* Michx. Wild Red Osier.
Small. Native to the United States.

*Corylus americana* Walt. Hazel Nut.
Small. Native to Nebraska.

*Crataegus coccinea* Linn. Red Haw.
Height 30 feet. Diameter 14 inches. Native to the United States. Fine specimen. Park Ave. and Marcy.

*Crataegus crus-galli* Linn. Cockspur.
Height 30 feet. Diameter 7 inches. Native to the United States.

*Crataegus oxyacantha* Linn. English Hawthorn.
Height 20 feet. Diameter 3 inches. Native to Europe.

*Cupressus marcrocarpa* Hartw. Monterey Cypress.
Height 3 feet. Joslyn Place. Native to the United States.

*Dammara australis.* Kauri Pine.
Height 15 feet. Diameter 2 inches. Native to India.

*Eleagnus angustifolia* Linn. Russian Olive.
Height 20 feet. Diameter 10 inches. Native to Europe and Asia.

*Eucalyptus globulus* Labill. Blue Gum.
Height 4 feet. Joslyn Place. Native to Australia.

*Euonymus atropurpureus* Jacq. Waahoo.
Small. Joslyn Place. Native to the United States.

*Fagus atropunicea* Marsh. Beech.
Height 6 feet. Diameter 1 inch. Joslyn Place. Native to United States.

*Fraxinus americana* Linn. White Ash.
Height 50 feet. Diameter 14 inches. Native to Nebraska.

*Fraxinus excelsior* Linn. European Ash.
Small. Native to Europe.

*Fraxinus lanceolata* Borkh. Green Ash.
Height 70 feet. Diameter 20 inches. Native to Nebraska.

*Fraxinus nigra* Marsh. Black Ash.
Height 8 feet. Native to the United States.

*Gleditsia triacanthos* Linn. Honey Locust.
Height 50 feet. Diameter 20 inches. Native to Nebraska.

*Grevillea robusta* Cunn. Silk Oak.
Small. Joslyn Place. Native to Australia.

*Gymnocladus dioicus* Koch. Coffee Tree.
Height 50 feet. Diameter 16 inches. Native to Nebraska.

*Hamamelis virginiana* Linn. Witch Hazel.
Height 9 feet. Diameter 2 inches. Native to Nebraska.

*Hicoria glabra* Britt. Pignut.
Height 45 feet. Diameter 10 inches. Native to Nebraska.

*Hicoria minima* Britt. Bitter Nut.
Height 30 feet. Diameter 9 inches. Native to Nebraska.

*Hicoria ovata* Britt. Shagbark (Hickory).
Height 35 feet. Diameter 8 inches. Native to Nebraska. Several fine specimens at Riverview Park.

*Ilex opaca* Ait. American Holly.
Small. Native to the United States. In nursery at Elmwood Park.

*Juglans cinerea* Linn. Butternut.
Height 25 feet. Diameter 8 inches. Native to Nebraska.

*Juglans nigra* Linn. Black Walnut.
Height 45 feet. Diameter 12 inches. Native to Nebraska. Grove at Spring and Boulevard.

*Juglans regia* Linn. English Walnut.

Height 6 feet. Diameter 2 inches. Joslyn Place. Native to Europe and Asia.

*Juniperus communis* Linn. Dwarf Juniper.

Height 12 feet. Diameter 4 inches. Native to the United States and Old World.

*Juniperus sabina* Linn. Scrubby Red Cedar.

Small. Native to Europe and Asia. Fine for covering steep banks.

*Juniperus virginiana* Linn. Red Juniper.

Height 30 feet. Diameter 7 inches. Native to Nebraska.

*Juniperus virginiana* Linn. var. *albo-variegata* Hort. Silver Cedar.

Height 10 feet. Diameter 2 inches. Native to the United States. Fine specimens Forest Lawn Cemetery. Hard to propogate.

*Koelreuteria paniculàta* Laxin. Chinese Varnish Tree.

Height 16 feet. Diameter 3 inches. Native to China.

*Larix americana* Michx. Tamarack.

Height 15 feet. Diameter 3 inches. Native to North America.

*Larix europaea* D. C. European Larch.

Height 20 feet. Diameter 8 inches. Native to Europe. Fine for poor, dry sites.

*Lepargyraea argentea* Nutt. Buffalo Berry.

Small. Native to the United States.

*Ligustrum vulgare* Linn. Privet.

Small. In nursery at Elmwood Park. Native to the United States.

*Liquidambar styraciflua* Linn. Sweet Gum.

Small. Native to the United States. Not hardy here. Specimen at Joslyn Place.

*Liriodendron tulipifera* Linn. Tulip Tree.

Height 50 feet. Diameter 14 inches. Native to the United States. Fine specimen at 30th Street and Woolworth. Hard to start.

*Magnolia foetida* (Linn.) Sarg. Evergreen Magnolia.

Small. Native to the United States.

*Magnolia fraseri* Walt. Fraser's Umbrella.
Small. Native to the United States.

*Magnolia soulangeana* Soul. Soulange's Magnolia.
Height 6 feet. Diameter 2 inches. Native to China and Japan.

*Malus ioensis* Britt. Western Crab.
Height 20 feet. Diameter 6 inches. Native to the United States.

*Malus malus* Linn. Apple.
Height 25 feet. Diameter 4 inches. Native to the United States.

*Malus floribunda* Sieb. Double Flowering Apple.
Height 8 feet. Diameter 2 inches. Native to the United States.

*Morus alba* var. *tartarica* (Linn.) Loud. Russian Mulberry.
Height 30 feet. Diameter 14 inches. Native to Europe.

*Morus alba* var. *pendula* (Dipp.) Sudw. Weeping Mulberry.
Height 8 feet. Native to the United States. Hardy even on dry sites.

*Morus rubra* Linn. Red Mulberry.
Height 15 feet. Diameter 2 inches. Native to Nebraska.

*Ostrya virginiana* Willd. Hornbeam.
Height 25 feet. Diameter 6 inches. At Riverview Park. Native to Nebraska.

*Paulownia tomentosa* (Thumb.) Steudel. Paulownia.
Height 10 feet. Native to Japan and China.

*Picea canadensis* B. S. & P. White Spruce.
Height 18 feet. Diameter 3 inches. Native to the United States.

*Picea excelsa* Link. Norway Spruce.
Height 30 feet. Diameter 8 inches. Native to Europe.

*Picea mariana* B. S. & P. Black Spruce.
Height 12 feet. Diameter 2 inches. Native to the United States.

*Picea parryana* (Andre.) Parry. Blue Spruce.
Height 35 feet. Diameter 12 inches. Native to the United States.

*Pinus austriaca* Hoss. Austrian Pine.
Height 30 feet. Diameter 18 inches. Native to Europe.

*Pinus cembra* Linn. Swiss Stone Pine.
Height 5 feet. Bemis Park. Native to Europe.

*Pinus divaricata* Du. Mont de Cours. Jack Pine.
Height 8 feet. Diameter 3 inches. Forest Lawn Cemetery. Native to the United States.

*Pinus flexilis* James. Limber Pine.
Height 4 feet. Native to the United States. Elmwood Park.

*Pinus lambertiana* Dougl. Sugar Pine.
Height 15 feet. Diameter 3 inches. Elmwood Park. Native to the United States. Only one specimen. Doing well.

*Pinus montana* (Mill.) Mughus. Mughus Pine.
Height 12 feet. Native to Europe. Several fine specimens. Does very well here.

*Pinus ponderosa* Laws. Western Yellow Pine.
Height 20 feet. Diameter 8 inches. Elmwood Park Native to the United States.

*Pinus ponderosa scopulorum* Engelm. Rocky Mountain Yellow Pine.
Height 25 feet. Diameter 8 inches. Elmwood Park. Native to Nebraska.

*Pinus rigida* Michx. Pitch Pine.
Height 12 feet. Diameter 3 inches. Riverview Park. Native to the United States.

*Pinus resinosa* Ait. Norway Pine.
Height 25 feet. Diameter 8 inches. Native to the United States. Does better than Scotch Pine even on dry and exposed sites and is better looking. Forest Lawn Cemetery.

*Pinus strobus* Linn.- White Pine.
Height 40 feet. Diameter 10 inches. Native to the the United States. Several fine specimens.

*Pinus sylvestris* Linn. Scotch Pine.
Height 30 feet. Diameter 8 inches. Native to Europe.

*Platanus occidentalis* Linn. Sycamore.
Height 85 feet. Diameter 20 inches. Fine specimen. Native to the United States.

*Populus alba* Linn. White Poplar.
Height 80 feet. Diameter 30 inches. Native to Europe and Asia. Fine specimens.

*Populus alba* Linn. var. *bolleana* Louche. Bolle Poplar.
Height 35 feet. Diameter 8 inches.

*Populus angulata* Ait. Carolina Poplar.
Height 75 feet. Diameter 20 inches. Native to the United States. Fine specimens at 29th Ave. and Shirley.

*Populus balsamifera* Linn. Balm of Gilead.
Height 40 feet. Diameter 12 inches. Native to Nebraska.

*Populus deltoides* Marsh. Common Cottonwood.
Height 100 feet. Diameter 48 inches. Native to Nebraska.

*Populus grandidentata* Michx. Large Toothed Aspen.
Height 60 feet. Diameter 18 inches. Native to the United States. Fine specimens.

*Populus nigra italica* Du Roi. Lombardy Poplar.
Height 85 feet. Diameter 20 inches. Native to Europe. Fine specimens.

*Populus tremuloides* Michx. Aspen.
Height 35 feet. Diameter 10 inches. Native to Nebraska.

*Populus pyramidalis* Spach. Pyramidal Poplar.
Height 55 feet. Diameter 14 inches. Fine specimen. Native to Asia.

*Prunus americana* Marsh. Wild Plum.
Height 8 feet. Diameter 1½ inches. Native to the United States.

*Prunus avium* Linn. Sweet Cherry.
Height 20 feet. Diameter 5 inches. Native to Europe.

*Prunus cerasus* Linn. Sour Cherry.
Height 40 feet. Diameter 10 inches. Joslyn Place. Native to Japan.

*Prunus demissa* (Nutt) Walp. Western Choke Cherry.
Height 20 feet. Diameter 6 inches. Riverview Park. Native to the United States.

*Prunus domestica* Linn. Common Plum.
Height 18 feet. Diameter 4 inches. (Probably) Native of Europe.

*Prunus serotina* Ehrh. Black Cherry.
Height 25 feet. Diameter 4 inches. Miller Park. Native to Nebraska.

*Pseudotsuga taxifolia* Britton. Douglas Fir.
Height 25 feet. Diameter 8 inches. Native to the United States. One of the best evergreens to plant here.

*Ptelea trifoliata* Linn. Hoptree.
Height 10 feet. Native to the United States.

*Pyrus communis* Linn. Common Pear.
Height 20 feet. Diameter 6 inches. Native to South Europe and Asia.

*Quercus coccinea* Moench. Scarlet Oak.
Height 40 feet. Diameter 16 inches. Native to Nebraska.

*Quercus ilicifolia* Wang. Barren Oak.
Height 20 feet. Diameter 6 inches. Native to the United States.

*Quercus lyrata* Walt. Overcup Oak.
Height 45 feet. Diameter 10 inches. Hanscom Park. Native to the United States.

*Quercus macrocarpa* Michx. Bur Oak.
Height 45 feet. Diameter 22 inches. Native to Nebraska.

*Quercus palustris* Muenchh. Pin Oak.
Height 15 feet. Diameter 1½ inches. Native to the United States.

*Quercus robur* Linn. English Oak.
Height 15 feet. Diameter 2 inches. Native to Europe.

*Quercus rubra* Linn. Red Oak.
Height 65 feet. Diameter 24 inches. Native to Nebraska.

*Quercus velutina* Lam. Yellow Oak.
Height 20 feet. Diameter 12 inches. Native to Nebraska.

*Rhamnus caroliniana* Walt. Yellow Buckthorn.
Height 8 feet. Native to Nebraska.

*Rhus copallina* Linn. Dwarf Sumach.
Height 15 feet. Native to the United States.

*Rhus cotinus* Linn. Smoke Tree.
Small. Native to Europe and Asia.

*Rhus glabra* Linn. Smooth Sumach.
Height 10 feet. Diameter 2 inches. Native to Nebraska.

*Rhus hirta* (Linn.) Sudworth. Staghorn Sumach.
Height 7 feet. Native to the United States.

*Rhus typhina* Linn. var. *larciniata.* Cut-Leaf Staghorn Sumach.
Small. Native to the United States.

*Robinia pseudacacia* Linn. Locust.
Height 40 feet. Diameter 8 inches. Native to Nebraska.

*Ginkgo biloba* Linn Smith. Ginkgo.
Height 25 feet. Diameter 7 inches. Native to China.

*Salix babylonica* Linn. Weeping Willow.
Height 40 feet. Diameter 20 inches. Fine specimen. Native to Europe.

*Salix babylonica* var. *dolorosa* Rowen. Wisconsin Weeping Willow.
Height 40 feet. Diameter 16 inches. Fine specimen. Native to the United States.

*Salix interior* Roule. Sandbar Willow.
Height 18 feet. Diameter 6 inches. Native to Nebraska.

*Salix cordata* var. *lutea* (Nutt.) Bebb. Yellow Willow.
Height 20 feet. Diameter 6 inches. Native to the United States.

*Salix missouriensis* Bebb. Missouri Willow.
Height 30 feet. Diameter 8 inches. Native to the United States.

*Salix nigra* Marsh. Black Willow.
Height 50 feet. Diameter 16 inches. Native to Nebraska.

*Salix pentandra* Linn. Laurel Leaf Willow.
Height 30 feet. Diameter 4 inches. Native to Europe and Asia.

*Salix vitellina* Linn. Golden Willow.
Height 30 feet. Diameter 12 inches. Fine specimen. Native to the United States.

*Sassafras sassafras* (Linn.) Karst. Sassafras.
Small. Native to the United States. In nursery at Elmwood Park.

*Sciadopitys verticulata* Sieb. & Zucc. Jap Umbrella Tree.
Height 4 feet. Native to Japan.

*Sorbus americana* Marsh. Mountain Ash.
Height 25 feet. Diameter 6 inches. Native to the United States.

*Sorbus aucuparia* Linn. European Mountain Ash.
Height 10 feet. Diameter 2 inches. Native to Europe and Asia.

*Sorbus aucuparia pendula* Hort. Weeping Mountain Ash.
Height 8 feet. Native to Europe.

*Tamarix gallica* Linn. Tamarisk.
Height 12 feet. Diameter 4 inches. Native to Europe.

*Taxodium distichum* Rich. Bald Cypress.
Height 25 feet. Diameter 10 inches. Native to the United States.

*Taxus floridana* Nutt. Florida Yew.
Small. Joslyn Place. Native to the United States.

*Thuya occidentalis* Linn. Arborvitae.
Height 20 feet. Diameter 3 inches. Native to the United States.

*Thuya occidentalis aurea* Gord. Mehan's Golden Arborvitae.
Height 12 feet. Diameter 2 inches. Native to the United States. Most hardy *Thuya* here.

*Thuya orientalis* Linn. Oriental Arborvitae.
Height 15 feet. Diameter 2 inches. Native to Asia and Japan.

*Thuya plicata compacta* (Carr.) Beisan. Globe Dwarf Arborvitae.
Height 4 feet. Native to the United States.

*Tilia americana* Linn. Basswood.
Height 60 feet. Diameter 14 inches. Native to Nebraska.

*Tilia ulmifolia* Scopoli. European Linden.
Height 25 feet. Diameter 8 inches. Native to Europe.

*Toxylon pomiferum* Raf. Osage Orange.
Height 30 feet. Diameter 10 inches. Native to the United States.

*Tsuga canadensis* Carr. Hemlock.
Height 25 feet. Diameter 3 inches. Native to the United States.

*Ulmus americana* Linn. White Elm.
Height 90 feet. Diameter 34 inches. Native to Nebraska.

*Ulmus americana aure* Temple. Bright Yellow Leaved Elm.
Height 12 feet. Diameter 4 inches. Native to the United States.

*Ulmus americana pendula* Ait. Weeping American Elm.
Height 60 feet. Diameter 36 inches. Native to the United States.

*Ulmus americana* var. Feathery Elm.
Height 40 feet. Diameter 14 inches. Native to the United States.

*Ulmus campestris* Smith. English Elm.
Height 30 feet. Diameter 16 inches. Native to Europe and Asia.

*Ulmus campestris monumentalis* Rinz. Pyramidal English Elm.
Height 40 feet. Diameter 20 inches. Native to Europe.

*Ulmus campestris pendula* Hort. Weeping English Elm.
Height 40 feet. Diameter 12 inches. Native to Europe.

*Ulmus campestris* var. Variegated Leaved English Elm.
Height 10 feet. Diameter 4 inches. Native to the United States.

*Ulmus pubescens* Walt. Slippery Elm.
Height 70 feet. Diameter 16 inches. Native to Nebraska.

*Ulmus montana* With. Scotch Elm.
Height 12 feet. Diameter 3 inches. Native to Europe and Asia.

*Ulmus racemosa* Thomas. Cork Elm.
Height 12 feet. Diameter 1 inch. Native to Nebraska.

*Ulmus scabra* Mill. Camperdown Elm.

Height 12 feet. Diameter 3 inches. Native to Europe.

*Viburnum prunifolium* Linn. Nanny Berry.

Small. Native to the United States.

The Omaha Park Commission does considerable planting in the parks and on the boulevards. For this purpose a nursery is maintained at Elmwood Park. There are also several thrifty plantations in the different parks which are mentioned below:

| Park | Species | Diam. Inches | Height Feet | Spacing in Feet |
|---|---|---|---|---|
| Fontenelle | Elm | 8 | 30 | 10x10 |
| | Basswood | 2 | 6 | 20x6 |
| | White Oak | 5 | 15 | 10x10 |
| | Hackberry | 7 | 25 | 10x10 |
| Elmwood | White Pine | 6 | 20 | 10x10 |
| Fontenelle | Scotch Pine | | 20 | 10x10 |
| | White Pine | | 20 | In Mixture |
| | Bull Pine | | 20 | |
| | Jack Pine | | 5 | |
| Miller | Ash and Cherry | | | |

To determine the most numerous as well as the most suitable shade trees, an accurate count was made of the species of street trees on 80 blocks in four different sections of the city. Taking these figures as a basis a rough percentage was made of the different species occurring as shade trees in the city.

Maple. *(Acer saccharinum)* 42 per cent.

Best spacing 20 feet to 30 feet. City has planted soft maple on the 19th Street boulevard with a spacing of 30 feet.

Elm *(Ulmus americana)* 15 per cent.

Spacing 20 to 30 feet.

Box Elder *(Acer negundo)* 9 per cent.

A great number of these were found in the northwestern part of the city where it is not as well settled.

Carolina Poplar *(Populus angulata)* 6 per cent.
Spacing 20 feet. Planted as a street tree to some extent.

Cottonwood *(Populus deltoides)* 6 per cent.

Catalpa *(Catalpa speciosa)* 5 per cent.

Sycamore *(Platanus occidentalis)* 3 per cent.

Oaks *(Quercus)* 3 per cent.

Hackberry *(Celtis occidentalis)* less than 1 per cent.

Basswood *(Tilia americana)* less than 1 per cent.

For shade and ornamental trees the following are some of those recommended by W. R. Adams:

Hardwoods.

1. Ashes *(Fraxinus)*
2. Basswood *(Tilia americana)*
3. Birch *(Betula)*
4. Elm *(Ulmus americana)*
5. Hackberry *(Celtis occidentalis)*
6. Honey Locust *(Gleditsia triacanthos)*
7. Maple *(Acer saccharinum)*
8. Oaks *(Quercus rubra, Q. coccinea, Q. macarocarpa)*
9. Poplars *(Populus)*
10. Sycamore *(Platanus occidentalis)*

Conifers.

1. White Pine *(Pinus strobus)*
2. Austrian Pine *(Pinus austriaca)*
3. Scotch Pine *(Pinus sylvestris)*
4. Douglas Fir *(Pseudotsuga taxifolia)*
5. European Larch *(Larix europaea)*
6. White Fir *(Abies concolor)*.

White Pine and Aspen were generally found to be infected by San Jose Scale and diseased buds occurred frequently on Oak, Ash, and Elms.

# NOTES ON WINTERKILLING OF FOREST TREES.*

Carl P. Hartley.

The observations given below were made in District 2 of the United States Forest Service, which includes Colorado, Kansas, Nebraska, part of South Dakota, and Wyoming. The national forests in this region are administered by the Forest Service office at Denver, with which the writer has been cooperating. The observations here reported are not complete or conclusive, but may be of value to those who are interested in the problems connected with winter injury to forest trees.

Winterkilling is a name under which different types of injury are grouped because of the unfortunate lack of knowledge as to the distinctions between the types and the factors which cause each type. The study of winter injury in the forests is not of any great immediate economic importance, because there is relatively little chance to prevent it even after the controlling factors are known. However, notes on its occurrence, and especially on the chinook type of injury which occurred in the Black Hills Forest in 1909, will be of some interest to foresters as well as to pathologists.

The first type of winterkilling to be considered is that which is believed to be most common. This typically affects reproduction, and does little harm to saplings and older trees. The tips of the branches which are less than one year old, are especially subject to injury, but where the damage is serious, the tree may be partially or completely killed. On exposed hillsides Lodgepole Pine *(Pinus contorta)* reproduction has been seen which was turned entirely brown by the large number of winterkilled trees. To what extent smaller trees, both natural regeneration and stock resulting from direct seeding, are killed during their first two or three winters is not known to the writer; some loss undoubtedly occurs. Winter injury during the first winter after planting is sometimes an important factor in reducing the stand in the sand-hill plantations on the Nebraska Forest.

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It is impossible to say why typical winter injury usually kills only the younger growth when only part of the tree is affected. If the death of the tissue were simply due to being frozen, as is the case where untimely frosts catch trees during the growing period, especial injury to tips of the branches would be only what one would expect. However, winter killing is usually supposed to be caused by drying of the tissues at a time when the frozen condition of the soil and trunk prevents enough water being taken up to supply the loss from evaporation or transpiration. Repeated alternate freezing and thawing of vegetative tissue especially exposed to the sun or on southwest exposures is also a method of injury. Neither of these causes of injury can fully and certainly explain the extreme susceptibility of the youngest growth. If the trouble be due to drying during the warmer weather, it should theoretically be the older, rather than the younger tissue which would die first; at least, in herbaceous plants we know that the younger leaves suffer least in times of drouth.

Most of the supposedly winterkilled twigs on young conifers in forests show a brown discoloration of the bark at the base of the injured portion of the twig. This is probably due, not to the presence of any organism, but rather to infiltration with resin after the death of the tissue beyond the injury. There can be little doubt that the disease is due to physical factors; wind or insolation being plainly indicated as one of them by the greater prevalence of the disease on certain sides of the tree and on certain slopes. We do not know all of the factors, or just how they work.

Death of the young growth exactly similar to this winter injury can take place at other times during the winter, and without any frost whatever. Such an occurrence was observed by the writer in May of 1909, on young Jack Pine *(Pinus divaricata)* which had been planted in the Nebraska sand-hills six years earlier. The injured trees were not under constant observation, so the exact date of injury was not ascertained, but it occurred during reasonably mild weather at a time when there was no frost. The injured trees were on a steep slope with north and northeast exposure, and on the plain at the base of this slope. Just what could have caused this injury it is impossible to say. That the cause was a physical one is indicated by the simultaneous and sudden appearance of the trouble on both isolated and massed trees, and by the failure of tests in moist chambers and cultures to develop any known parasites from the killed twigs.

The only special significance of the observations of this case of spring injury in Nebraska is that some of the tip injury found in forests, and commonly called winterkilling, may have occurred at other times of the year, and that freezing temperatures may not have any necessary connection with certain types of winter injury.

The statement of a Forest Service officer, that on the Colorado National Forest the needles of a young Lodgepole Pine frequently die while covered with snow drifts, is of interest as indicating an entirely different type of winterkilling. Since snow is excellent protection against excessive loss of water, and against alternation of freezing temperatures with those much above freezing, it is hard to offer any purely physical explanation of this. Possibly the trouble is of the same order as the Schutte or leaf-cast disease of German forest trees, which often kills seedlings covered with heavy mulch. If a parasite should be found to work in the needles of the plant when thus buried in snow, so that their temperature never goes materially above 32° Fahr., we would have a very interesting phenomenon.

The most interesting type of winterkilling is the chinook type, of which an excellent example appeared in the Black Hills Forest in South Dakota in 1909. The following weather records were taken by Mr. E. F. Irwin at Lead, during January. The thermometer used was Fahrenheit, and readings were taken at 4:30 P. M.

| Date | Temperature | | | Wind | | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum | Range | Direction | Force | Sky |
| January 1 | 42 | —4 | 46 | ............ | Calm | Clear |
| 2 | 48 | 32 | 16 | ............ | Calm | Clear |
| 3 | 48 | 35 | 13 | ............ | Calm | Clear |
| 4 | 42 | 0 | 42 | ............ | Calm | Cloudy |
| 5 | 22 | —26 | 48 | N. W. | Medium | Part Cloudy |
| 6 | —12 | —21 | 9 | S. E. | Medium | Part Cloudy |
| 7 | 38 | —14 | 52 | East | Medium | Part Cloudy |
| 8 | 57 | —18 | 75 | N. W. | Strong | Part Cloudy |
| 9 | 43 | —9 | 52 | East | Medium | Part Cloudy |
| 10 | 19 | —23 | 42 | ............ | Calm | Clear |

According to a technical report by Forest Assistant John Murdock, Jr., which Supervisor Paul Kelleter permitted the writer to inspect, drops of 40 or 50 degrees in a single hour occurred. Mr. Irwin states, presumably referring to the drop in temperature of January 8, that the change was immediately preceded by a heavy fog.

Mr. Murdock states that there was snow in the northwest part of the forest, but little elsewhere. It appears that snow on the ground had little influence. In general, he states that the ground was frozen quite deeply. He says that needles of the Western Yellow Pine *(Pinus ponderosa)*, the dominant tree in this region, began to turn brown when warm weather started after this period of chinooks and freezes. He estimated the area on which there was damage as not less than 40,000 acres, on one-third of which area the damage was to reproduction; on two thirds of the remaining area the proportion of the mature stand killed ranged from 0 to 2 per cent; and on the remainder, two-ninths of the total affected portion, four to five per cent of the mature stand is said to have been killed. The total amount of timber killed is given as not over 3,000,000 feet B. M., scattered through the roughest and most inaccessible parts of the forest. He says that in the northern part of the forest, the northwest slopes were most injured, while in the eastern part the northeast slopes were hardest hit; that everywhere the north sides of the trees were most injured; that degree of slope seemed to have little influence, and density of stand no effect whatever. Sites based on sandstone, limestone, porphyry, and granite are said to be all equally injured. Basal branches, which were covered with snow during the winter, were uninjured.

Observations made near Deadwood by the writer in September, 1909, in general agreed with Mr. Murdock's statements. Injury was mainly on the upper parts of slopes, and on the ridges. Trees on the upper northwest slopes were most injured, while those on the tops of the hills and on the upper north and upper west slopes were somewhat less injured. Injury to trees on northeast slopes was not so great at this point. Some trees were killed also on upper slopes having southerly exposures. The greater injury at the higher points and slight injury in the valleys and on the lower slopes was conspicuous.

In at least one case depth of soil could not have had any influence. Adjacent trees, some growing in soil four feet deep, and others in soil a little over one foot deep, were equally injured, or if any difference could be said to exist, it was in favor of the shallower soil.

In the vicinity of Deadwood, close stands of reproduction, 5 to 7 feet in height, were so badly injured that more than half of the trees in a patch ten or fifteen yards square were killed. In general, trees of this age were more severely injured than mature trees, when the two ages were on the same site. However, since a relatively greater part of the reproduction is on the lower slopes, the proportion of injury in the younger stands was probably no greater than in the older ones.

The most interesting thing about this type of winter-killing was the uniform difference in susceptibility to injury between needles of different ages. As one would expect, where part of a single needle was injured, it was always the part toward the tip, while the part near the base remained healthy. Where a portion of the needles were injured, these needles were always the older ones, while the younger needles were unharmed. Where a tree was so severely injured that only a few of its needles survived, these surviving needles were sure to be those produced in 1908. If the tree was less severely injured, the 1908 needles might all be in perfect condition, the 1907 needles somewhat injured at the tips and the needles of 1906 entirely or almost entirely killed, while all of the needles older than 1906 would be killed. In cases of slight injury only the oldest one or two generations of persisting needles were hurt. This means that the outer needles of the trees, which were farthest from the water supply, were always the ones which survived. Assuming that the cause of death was transpiration during the sudden warm periods indicated in the weather records quoted, it might follow that the younger needles have a stronger pull on the water supply than the older ones. This advantage of young leaves over old ones in competition for water supply is seen in herbaceous plants in the way drouth results in the withering of the older leaves while the younger leaves still seem healthy. That somewhat the same difference in water obtaining power should exist between the younger and older needles of coniferous trees seems quite reasonable.

The needles which were only partly killed by the chinook apparently held their own throughout the season of 1909, but by September 24 those that had been killed back more than half their length were drying up and seemed to be about to drop. Of course the oldest of these had already persisted as long as they normally would, and would have fallen, injury or no injury, but others would have stayed on for two or three years longer, had it not been for the winter injury.

In cases of severe injury all the needles on the trees were killed. Some of these defoliated trees were killed outright. A very few were partially killed, but part of the branches continued to grow during 1909. In many such cases the buds on living branches appeared to be so injured that they were unable to develop properly during 1909; instead of normal increase in length of the twigs with formation of many new needles of normal size, there was very slight growth in length of the twig, and a few needles, twice the normal length were formed. That is, the prevention of length growth of the twigs, due to partial failure of the bud, resulted in increased needle growth just back of the injury. These abnormal needles can therefore be considered analogous to the water-sprouts or "suckers" just back of the points of pruning, which are familiar results of cutting back broad-leaved trees. A great many of the trees which were partly killed and which made weak or abnormal growth during 1909 were found dying in September; this was accompanied by the presence of a brown discoloration or of beetle larvae in the bark. Whether all of these would have died as a direct result of the winter injury, or whether the immediate causes of death were bark beetles or facultative parasitic fungi encouraged by the weakened condition of the tree, was not determined. Cultures made from the patchy discolorations in the bark of dying trees not injured by insects produced no fungus likely to be parasitic.

Practically all of the defoliated trees which were not killed outright suffered no real harm. Growth was resumed in the normal manner in the spring of 1909. In the older trees growth is so slow that whether or not the growth in 1909 was materially decreased by the defoliation was not determined. On the younger trees which were defoliated but whose branches were not killed, Murdock considered the growth of 1909, both in diameter and length, to be normal. In most cases seen by the writer, length increase in such trees was practically normal, but in part of them it did not seem normal. Nevertheless it is noteworthy that complete or nearly complete defoliation of four years' growth of pine needles should have no distinct effect on the growth of the following season. It would be interesting to determine if more decrease of the growth of 1910 than of 1909 was caused by the chinook.

All of the above observations are on *Pinus ponderosa*. The only other conspicuous conifer near Deadwood is the Black Hills Spruce *(Picea canadensis)*. This grows on the lower and moister sites, near the streams. Injury occurred to those exposed, but the Spruce appeared to the writer to be fully as hardy as the Pine in the places where they grew side by side, so that comparison was possible. No Spruce which was killed entirely was seen by the writer in the vicinity of Deadwood or along the C., B. & Q. railroad to the south of Deadwood.

In the case of the Spruce the type of injury was quite different from that of the Pine. Instead of the needles of certain ages being killed, the branches or branchlets which were most shaded or were growing least vigorously were killed outright, while on parts of the tree there was no damage to needles of any age.

On the hills where the Pines were injured are also small Birch and Aspen trees. Injury to these took the form of killing back the latest growth, with the consequent formation of watersprouts. The Birch seemed to be rather more easily injured than the Pine, while the Aspen was less susceptible than Pine.

The data available as to the exact weather and soil conditions prevailing in this case of chinook winterkilling, and detailed knowledge of the way in which winter injury works, are so incomplete that it is impossible to do more than guess at the factors concerned in the present instance. Why the higher sites and the northerly exposures were the most injured there is no way of telling, though exposure to wind was probably an important factor. The great ranges of temperature recorded, between 42 and 52 degrees on a number of days, and 75 degrees on January 8, would seem sufficient to cause much injury. However, the mere fact that the temperature went so low following warm days is hardly sufficient explanation, because a temperature 15 degrees below zero probably freezes cell sap little more than would a temperature of fifteen degrees above zero. The conditions probably most important in causing injury appear to the writer to be these: that after a temperature many degrees below zero, a strong warm wind from the northwest sprang up on January 8, with the temperature rising to 57 degrees. This must have resulted in fairly rapid loss of water from the needles in parts of trees exposed to this wind, while the trunks and even the branches were still frozen solid. The slender supply of water in the needles and the smaller twigs would manifestly be unable to stand much transpiration loss, when it could not be replenished from the larger stems. The killing might of course have been the cumulative effect of the transpiration of the three days, January 7, 8, and 9, throughout which the larger parts of the stems could not have been really well thawed out at any time. However, northwest exposure seems to have been very important in determining the location of injury, in this part of the Forest.

On January 8 a strong wind is recorded in the same part of the Forest. In view of these facts, it is likely that the conditions prevailing January 8 were at least the most important factors, even if not the only ones, in causing this injury.

At the Fremont Experiment Station, near Pike's Peak, Colorado, at an altitude of 9,000 feet, the same type of injury occurred to *Pinus ponderosa* as in the Black Hills. It was not severe enough to have any serious results. At slightly lower altitudes at Pike's Peak, White Fir *(Abies concolor)* was also injured during this same winter, the type of injury in this case being the same as described for *Picea canadensis* in the Black Hills. Information secured chiefly from Dr. G. G. Hedgcock makes it appear that chinook injury occurred at certain altitudes in many places from the Black Hills west into Oregon, and in this territory is commonly referred to as "Red Belt." Lodgepole Pine was also considerably injured in these localities, though not so badly as Yellow Pine. It is expected that Dr.

Hedgcock will publish the results of his work on this trouble in the near future.

Another peculiar case of winterkilling occurred near Lincoln, Nebraska, during the winter of 1909-1910. The fall was late and there was a great deal of rain in November with cold weather starting suddenly in December. Snow was on the ground all winter, and most of the time was quite deep; constant snow cover throughout the winter is very unusual in this locality. Spring was very early, but the winter was considered by the people in the region a very hard one. Most of the following notes on injury to conifers refer to trees which had been set out in nursery rows 6 years earlier. At the time of planting they were seedlings about two years old. They were fairly well protected, both by themselves and by older trees. The situation of nearly all of these conifers was near the top of a gentle slope with southwest exposure. The soil is a silt loam. The injury to different trees will be treated separately.

### Spruce *(Picea).*

Nearly all of these trees were Blue Spruce *(P. parryana)*, most of them in the nursery row, but one or two on the brow of the hill with no protection whatever. They suffered no injury.

### Scotch Pine *(Pinus sylvestris.)*

Of the trees in the nursery row, one-third or more of the foliage had turned brown by the middle of March. By May about half of the trees had lost practically all of the needles grown in 1909. A few trees came through uninjured, the rest with part of the 1909 needles killed. Of those seriously hurt a few were killed outright, with the exception of the lowest branches, which in all cases came through with little injury, presumably due to protection by snow. A large number of the trees lost all their needles, but pushed buds on the naked stems rather weakly. In some cases needles showed alternating dead and living areas, though where only part of the needle was injured, it was always the tip that was most affected. Where parts of the needles on a tree were injured, 1909 needles always suffered very much the worst, while 1908 needles, and 1907 needles where present, were injured less than the 1909 needles, but showed no difference in susceptibility between each other. Needles formed during the latter part of the 1909 growing season were much more resistant than those formed in the early part of the season; the terminal third or fourth, or in some cases twentieth of the season's growth always survived if there was any survival whatever among the needles of this year. Marked individual variations in resistance were manifest, in trees standing side by side of the same age and height. In general, however, trees that had grown the slowest were hardest hit, possibly on account of having smaller proportions of their roots at a low depth.

Trees which had been set out 16 to 20 years earlier were scarcely injured at all, irrespective of exposure. Some of them were much more exposed than the young trees which suffered.

Western Yellow Pine *(Pinus ponderosa)*.

Whether or not these trees are typical of the species or belong to the form known as *scopulorum* was not determined. Six-year-old trees in the nursery row which had made a very rapid growth, had a number of terminal shoots killed back. both stem and needles, on the northwest and north sides. Part of the trees originally in this nursery had been transplanted again two years earlier to a north slope where they were only protected from southeast wind. These trees were not at all injured.

White Pine *(Pinus strobus)*.

The trees in the nursery row, side by side with the seriously injured Scotch Pine, suffered no injury.

Slightly older trees, planted earlier than the trees in the nursery row and where they were more exposed, had about one-third of the terminal growth of the branchlets killed back, especially on the northwest side, and many needles on the surviving terminals were killed back part way from the tip. The terminal growth on the leaders of the branches and on the main leader of the tree were more resistant.

Trees which were 19 or 20 years old, and had been set out in exposed positions on the hill top 8 or 9 years before, were injured somewhat more than those mentioned above.

Austrian Pine *(Pinus austriaca)*.

A single tree about 8 years old, which two years earlier had been transplanted with a ball of earth to a position with full north and northwest exposure, lost all of its 1909 needles while the 1908 needles were slightly injured, but the buds were unhurt and growth started vigorously. Trees about 19 years old were unhurt except that terminal growths were occasionally killed back on the northwest side.

Arbor Vitae *(Thuya occidentalis).*

Several trees of a pyramidal variety of *T. occidentalis,* about 6 feet high, which had been somewhat injured by the previous winter, were nearly all killed. A dwarfed variety of *Thuya,* apparently the Chinese Arbor Vitae, was uninjured.

Cedar *(Juniperus, sp.).*

Several well established trees of Red Cedar from central Nebraska were uninjured. It is not known whether these were *J. virginiana* or *J. scopulorum.*

Broad-leaved Trees.

Large numbers of trees of the Early Richmond Cherry, of various varieties of Apples *(Pyrus sp.),* and of American Elm *(Ulmus americana),* and smaller numbers of Silver Maple *(Acer saccharinum),* Catalpa *(Catalpa catalpa),* Black Cherry *(Prunus serotina),* Sycamore *(Plantanus occidentalis),* and Snowball and Bridal Wreath bushes, and Virginia Creeper, were unhurt. Wistaria, which was on the east side of a house, and Peach orchards throuhout this part of the country were very seriously injured during this winter.

The permanent damage to the conifers, aside from the pyramidal Arbor Vitae and the worst injured Scotch Pine was slight. A number of the Scotch Pines were entirely killed or so nearly killed that they had to be cut out. The trees which were about to start growth on most of their branches in the spring of 1910 survived and were in good health apparently in the fall of 1911, though their scanty foliage still rendered them somewhat unsightly.

The different behaviors of the various species in this case is quite interesting. The greater susceptibility of the younger trees is very obvious, and the manner in which different coniferous species of the same genus were affected is peculiar. It is entirely possible that these different types of injury were produced at various times by different types of climatic conditions. In this case the injury to young Scotch Pine resembled the chinook injury in the Black Hills on Yellow Pine, in that the injury was primarily to needles and twigs, and branches were only killed in the most severe cases. However, the killing of Scotch Pine needles was in one way just the reverse of the Black Hills chinook type. At Lincoln the last year's growth in the Scotch Pine was the most susceptible, while in the Black Hills it was the most resistant. The injury to *Pinus ponderosa* at Lincoln, however, was terminal twig killing, which was entirely different from the chinook type of the preceding winter on the same species in the Black Hills. The superior resistance of Scotch Pine needles formed late in the season over those formed earlier in the same season is of interest. The fact that terminal growths of the leaders of White Pine branches were less susceptible than terminal growths of lateral branchlets, is also noteworthy. Just what weather factors caused most of the trouble at Lincoln cannot be said. Anyone who cares to look up possible clues can examine complete weather records taken at the Lincoln station of the Weather Bureau, only 3 miles from the injured trees. I believe these include constant graphic records of wind velocity, wind direction, temperature, and relative humidity. Pressure of other problems will prevent the writer going further into this matter.

Some winterkilling occurs at the Forest Service nurseries in this District. In general, however, *Pinus ponderosa* beds require no protection. At Monument, Colorado, I am told that light mulch is needed to prevent winterkilling Douglas Fir. At Halsey, in the sand hills of western Nebraska, so little winterkilling in the nursery beds has so far occurred that at present mulch on the *Pinus divaricata, P. sylvestris, P. ponderosa* and *P. austriaca* beds which are grown there is considered unnecessary.

Real winterkilling should not be confused with death of nursery stock under heavy mulch, which is probably a parasitic trouble. In the near future it is expected that a circular will be issued by the Bureau of Plant Industry in which winterkilling and related diseases in coniferous nursery stock will be more fully discussed. Death under heavy snow covering may also be a parasitic trouble, and certainly is not caused in the same way as winterkilling of uncovered stock.

# NOTES ON FOREST CONDITIONS IN NORTHWESTERN NEBRASKA.

Raymond J. Pool.

The position of Nebraska is unique from a phytogeographical point of view. The state lies near the geographic center of the United States with its long axis of over four hundred miles extending in an east and west direction. From these facts it must be appreciated that there are possibilities of great differences in climatic and soil conditions over the two extreme ends of the state. As truly as the climate, soil and general life relations of the southeastern corner of the state are somewhat similar to those conditions in the Mississippi-Ohio valley region, so these relations in the northwest corner of the state, over five hundred miles away, are very similar indeed to those conditions as we find them in the foothills of the Rocky Mountains and in the Black Hills to the northward. In following a line thus drawn one passes from a region into which the arborescent vegetation has migrated from the great southeastern hardwood forest complex, through the prairie and sand-hills regions to a strikingly different region characterized by arborescent vegetation that has come into the state mainly from the Rocky Mountains and Black Hills. In the southeast, with an average annual precipitation of about 33 inches and a mean annual temperature of 53 degrees F. and an altitude of 850 feet, the forest vegetation is composed of deciduous broadleaf species, while in the northwest with an annual precipitation of about 17 inches, a mean annual temperature of 44 degrees F. and an altitude ranging about 4,000 feet, the forest is composed of evergreen coniferous species. These two primary areas of forest invasion are in the main, forever effectively separated by the great barrier interposed in the form of prairie and arid sand-hill land. The one notable case of the meeting of tree species from these two opposite centers is seen along the Niobrara River in the north-central portion of the state where *Juglans nigra* meets with *Pinus ponderosa.*

From the fact that Nebraska is mostly a prairie state many people are commonly of the opinion that our state is a level or rolling plain throughout. A trip to the northwest would quickly and effectively remove this mistaken impression. In Northern Sioux and Dawes counties the gently undulating grass-covered surface of the high plains suddenly gives way to a topography characterized by deep, rocky canyons and towering walls with dome-shaped rocks and perpendicular sides, and a conspicuous arborescent vegetation in which *Pinus ponderosa* is the most evident tree species. I shall deal in this paper mainly with that portion of this region known as "Pine Ridge" as it occurs in Sioux county, although the region with its pine clad slopes extends as a narrow tongue for many miles farther eastward.

Geologically the region under discussion is a portion of the Arikaree formation. The gray or buff colored calcareous sandstones of this formation are everywhere conspicuous either as flat-topped ridges, towering walls and pinnacles, or steep talus slopes. The rock is only slightly stratified. Their bedded nature is most evident near the top of the formation as it occurs here, but in most places the stratification is not at all evident. A honey-comb rock structure with many protruding fossils or flinty projections is very common and conspicuous throughout the region. Through this rather soft and easily weathered rock many canyons have been cut. Such canyons usually extend in a northerly direction from their heads in the High Plains for from two to six or more miles through the rock and emerge into the lowlands or Bad Lands north of "Pine Ridge" several hundred feet below the table lands to the southward. From the northern face of the series of ridges these canyons with their streams converge in the Hat Creek basin, draining by means of this stream toward the northeast. The standstone has fallen down from the sides of rugged cliffs and buttes, often towering several hundred feet above the canyon bottoms, to such a degree that steep talus slopes are everywhere present. In fact "Pine Ridge" is not a *ridge* at all, but may be more accurately described as an escarpment extending as a narrow tongue for about half the distance across the northern portion of the state, which is composed especially in the west, of a succession of short north and south canyons with many laterals the steep sides of which are talus slopes formed from the crumbling rocks of the Arikaree formation, and covered with a scattered stand of *Pinus ponderosa.*

Three great types or formations of plants may readily be distinguished throughout this area as it occurs in Sioux county. These formations are primarily determined by topography and edaphic conditions.

The Ridge and Butte formation is seen covering the more or less level and linear, or broad and irregular table-lands at the tops of many of the ridges and buttes that have persisted as the canyons have been cut through the great escarpment. This is the least forested formation of the three since the soil conditions and vegetative characters are very similar to those relations typical of the High Plains to the south. In fact this is merely the grassy formation of the High Plains which has been cut and dissected by erosion and has then persisted as narrow tongues, isolated areas at the tops of buttes, or broader plateaus when the most of the surrounding surface has receded under the action of the eroding forces that hollowed out the canyons from the rocks of the Arikaree. These areas often connect with the main grass formation which approaches the escarpment from the south. In some places they become more or less wooded and extend entirely through the region to the northern or lower side of the escarpment. Naturally then this formation is seen in its best development toward the upper or southern portion of the region where the canyons head and where the divides are relatively broad.

The soil here is thin and light and inclined to be more rocky than farther back in the main body of grassland that covers the High Plains. A very thin layer of darker soil with a little humus often covers the surface over small areas. Outcrops of the Arikaree formation are common along the upper portions of the canyons while deeper down these rocks form the rims or irregular margins of this plant formation.

The vegetation of the ridges and buttes is characterized by the presence of many species of plains plants, especially of the grasses and legumes. *Andropogon scoparius, Stipa comata, Koeleria cristata,* and *Agropyron tenerum* are the dominant grass species. Besides these grasses which make up the bulk of the vegetative covering on the open ridges there are many species of less abundance, some of which are however quite conspicuous. The three common western cactuses, *Opuntia polycantha, Opuntia fragilis,* and *Cactus viviparus* are more or less conspicuous members of this formation.

It occasionally happens that the ridges have become so narrowed that practically all surface soil has been moved away taking the grasses with it. A substratum of almost bare rock is then left exposed. In such places one finds an association of mat and rosette plants among which the following species are common: *Arenaria hookeri, Sedum stenopetalum, Picaradenia acaulis, Phacelia heterophylla, Eriogonum flavum,* and *Homalobus caespitosus.* These are all acaulescent or low-stemmed plants which grow aggregated into dense cushion-like mats, or plants with a basal tuft or rosette of leaves. This peculiar growth-form seems to be related to low water content and infertility of the soil.

But on the whole the vegetation of the ridges and buttes is grassland fringed with *Pinus ponderosa,* with now and then individuals or clumps of this species scattered over the lower lying portions of the formation. In some places the soil has become badly broken and has thus enabled the pines to invade and establish themselves in considerable numbers over rather extensive stretches of this formation. In such places the appearance is that of a prairie dotted with pine trees.

The *Pinus ponderosa* formation, the second in our series, is a well defined formation both as to topography and composition. The formation is invariably confined to extremely xerophilous situations of which talus slopes and steep sides of canyons and buttes are the most common. From the fact, as given above, that Pine Ridge is a great complex of steep talus slopes and ridges covered to a varying density with a coniferous forest, one can form some idea of the importance of this formation. Here in northwest Nebraska is found our most extensive woodland or forest area.

Many stages in the development of this pine formation may be traced within the region in which these studies were made. Starting with the bare young talus slope it is possible to build up a series of plant successions which ultimately culminate in the fully stocked canyon sides characterized by a xerophilous vegetation of which *Pinus ponderosa* is the most conspicuous species. Large burly trees of *Juniperus virginiana* are not infrequent among the pines in some of the canyons. Over hundreds of acres in this part of the state where the Arikaree is exposed one finds such a characteristic and striking vegetation.

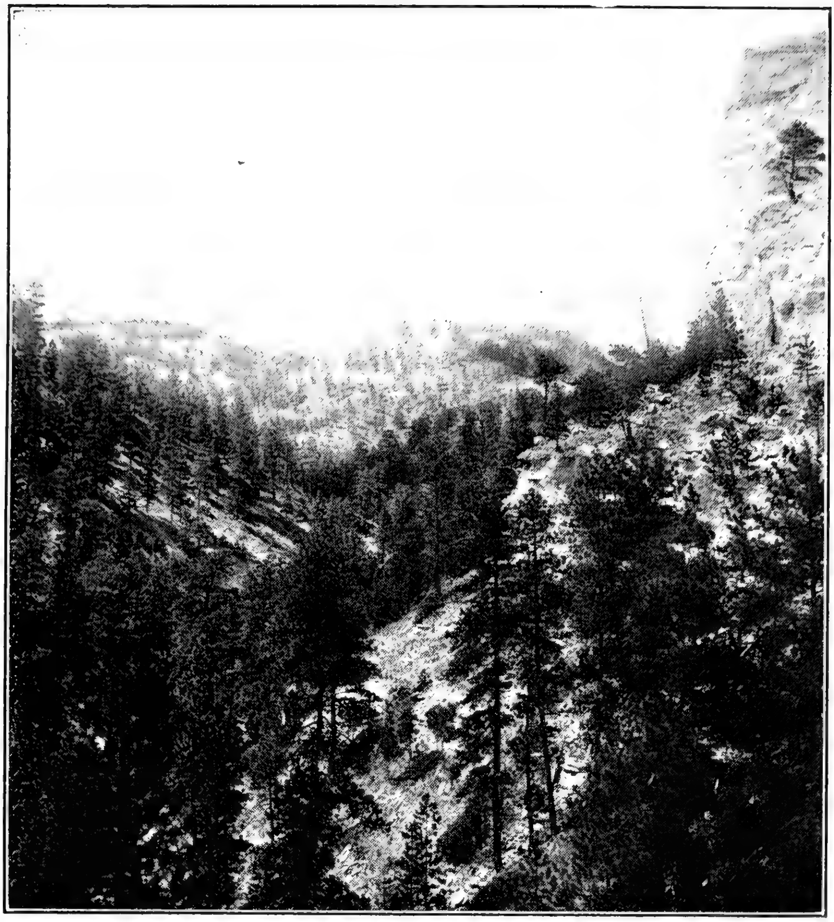
Among the pioneers on such slopes, at a time when the substratum is of very dry and sterile bare rock with little or no organic matter, are many mat and rosette herbaceous or woody perennials such as *Arenaria hookeri, Paronychia jamesii, Phlox douglasii, Homalobus caespitosus, Pseudocymopteris tenuifolius, Hymenopappus filifolius,* and *Gilia caespitosa.* Frequently a very young slope may show but one or two individuals of some of the species, or on older slopes the species and individuals may be of sufficient abundance to form a rather conspicuous plant association. Still later a number of grasses among which *Calamagrostis canadensis, Eriocoma cuspidata,* and *Stipa comata* are most common, come in and add their influence in preparing the soil for future invaders. *Yucca glauca* is a rather early arrival and soon becomes a prominent member of the accumulating talus flora. Such soil-forming and binding species as these after years of growth and extension convert the former rather unstable slope into a substratum favorable to invasion by less efficient species. Finally pine seeds find lodging, germinate, the seedlings become thoroughly established, and the forest cover then begins to take on form. The hardy pioneer species persist for many years among the developing forest trees until eventually on the most thoroughly wooded slopes they are nearly all shaded out, and in such places the only ground cover left is the accumulating layer of pine needles dotted with cones.

The commonest aspect of this formation is that of the open woodland. The tendency of *Pinus ponderosa* to develop a park-like formation is well known, and we get here as in the Black Hills and in the foothills of the Rocky Mountains the characteristic open forest of this speices. The trees are of medium size, rarely attaining a height of more than sixty feet. The trunks are stocky with a short clear length and a diameter rarely if ever exceeding thirty-six inches. The crown is composed of short stout branches which are frequently twisted and distorted in various ways. The long bristly leaves are arranged in characteristic tufts at the ends of the ultimate branches. Very frequently in the open the branches extend almost to the ground with no clear length of trunk at all. Such trees are scattered here and there among the scattered grasses and yuccas, seldom except in the deeper canyons becoming sufficiently aggregated to shade out practically all ground cover. In some of the canyons a denser forest aspect prevails. Here the trees are taller with a longer clear length and the crown is shorter and more compact than in the open aspect of the formation. When this maximum density is attained all ground cover is excluded except such things as the wintergreens, *Pyrola chlorantha* and *P. secunda* and a number of saprophytic species of fungi. The soil becomes richly filled with much organic matter and is deeply overlaid by a layer of pine needles. Even here however the soil is dry.

*Pinus ponderosa* is a frequent though not an especially abundant seeder in this locality. Local cone production occurs every year but the frequency of seed years is uncertain. The seeds are often carried down the slopes in a striking manner and one frequently finds a cluster of seedlings on the lower sides of seed-bearing trees standing on steep slopes. In some of the canyons with scattered stands I found thickets of seedlings ranging in height from 3 to 8 feet, so dense as to recall the seeding habit of lodgepole pine. Dense seeding is not typical for *Pinus ponderosa*, and its unusual reproductive capacity here is rather difficult of explanation from the data that was secured during the past summer. The phenomenon may be due in part to the absence of such great numbers of chipmunks and other seed destroying rodents that are so common farther west.

At the head of practically every canyon in the region the pine is seen to be slowly invading the grass formation. This invasion is made possible by the exposure of newer and newer rock areas by erosion forces that slowly remove the grassy sod from the uplands. These facts are especially striking at the heads of canyons where the pines follow the outcropping rocks of the Arikaree series. From these many centers the pine then slowly extends its range farther up the canyon.

PLATE I



Pine Clad Slopes With Cliff Above.

Pines Slowly Invading the Grass Formation at the Head of Canyons. The Light Areas are Rock Outcrops.

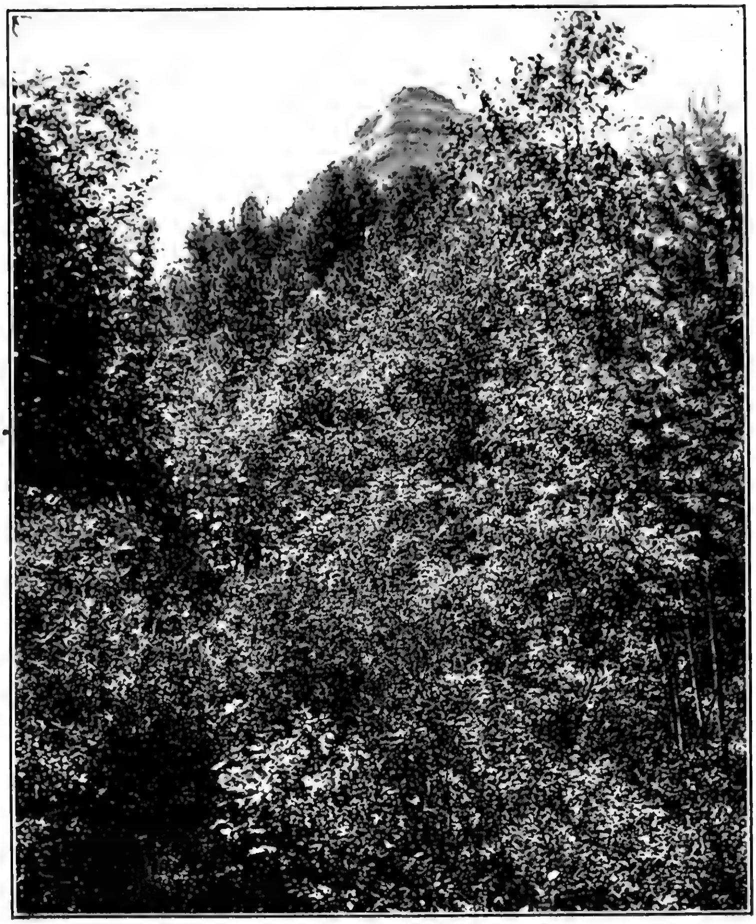
A forest fire swept over one of the larger canyons during the season of 1910, so that an excellent opportunity was afforded to investigate some of the phenomena in connection with this event, and especially to note some of the more conspicuous pioneers in the succession after the fire. Practically all of the pines had been killed over an area of about 640 acres. Some of the trees still showed some green leaves at the tops and a few live trees were found in a protected pocket in the bottom of the canyon. Other than these cases the destruction had been absolute. The fire was most destructive on the slopes facing east and northeast. Apparently there was a northeast wind at the time of the fire. The ground was burned clear of vegetation, there being left much ash and charcoal scattered over the surface. Frequently cases were found where the fire had smouldered along for many days in the root system of a tree eventually resulting in the complete destruction of the larger roots, leaving a number of odd holes with reddened walls that marked the former position of the main roots of some large tree. The surface rock was also exposed in many places standing out in marked contrast as compared with the ground in the unburned forest.

No seedlings of the pine or other tree could be found in June when the examination was made. However, a number of species of herbaceous plants were abundant and there were also numerous cases of new shoot formation from the partially buried shrubs and biennials that had escaped the fire. The most abundant pioneer on all exposures was the Dogbane, *Apocynum androsaemifolium*. This species is usually more or less scattered over open areas on the slopes. From such spots as this on the border of the burn great quantities of the light seeds were scattered over the exposed soil in the burned area. The bushy individuals had come up in such great abundance as to completely dominate the burned area in June. The Dogbane behaves here in exactly the way that the Fire Weed covers burned soils in other regions the first year after a forest fire. On all sites, especially where the fire was most severe, the plant covered the ground at the rate of 6 to 25 individuals per square yard for wide stretches with its characteristic much-branched stems and multitudes of pink flowers. It dominates in exactly the manner of the Fire Weed. *Lathyrus* *ornatus* also covered areas of 50 to 75 square yards with its low bluish-green individuals. These groups are very distinct because of the color and more or less matted form of the plants. Species of *Symphoricarpos, Prunus, Rhus,* and *Rosa* were becoming evident as shoots from unburned root systems. *Macrocalyx nyctlea* was abundant in the clayey situations and *Lygodesmia juncea* in the more sandy places. Besides these shrubs and herbaceous plants there were a number of species of grasses that gave character to the new vegetation over restricted areas. On the east side of the canyon the fire did less damage to the ground cover and the trees were not so badly scorched. The sod was not so badly killed out so that the invasion of the Dogbane was not especially noticeable there except in small areas where ground cover destruction was conspicuous.

From the lower portions of the slopes the coniferous inhabitants frequently invade the third and climax formation of the region, the mesophytic canyon bottoms. A rather large number of grasses and other herbaceous species of the moister forests, as well as a few shrubs have also wandered from the deeper shade and have become established among the pines on the lower stretches of that formation. It often happens that such plants as these make up the bulk of the ground cover on the lower slopes, while on the upper slopes most of the ground cover species have wandered in from the ridge formation above. The pines are, however, few that are found in the moist soil of the canyon bottoms through which a small, clear stream usually runs.

Just as the ridges are tongues of upland cutting through the escarpment so the canyon bottoms are usually narrow tongues of lowlands extending from the heads of the canyons to the Hat Creek basin north of Pine Ridge. In these places a deciduous forest formation contrasts very sharply with the conifer covered slopes above. Viewed from high up the slope these tortuous light green lines are very clearly differentiated from the dark green pines on both sides. The important characteristic tree species in these places are *Populus fremontii, Populus tremuloides, Acer negundo, Fraxinus lanceolata, Ulmus americana, Celtis occidentalis, Salix nigra, Acer glabrum* and *Betula occidentalis.* Smaller trees such as *Prunus ameri-*

PLATE II



A Dense Mixed Forest. A Rocky Ledge High Above the Birches, Aspens and Pines.

The Dogbane, a Conspicuous Pioneer After Forest Fires in This Locality.

*cana* and *Prunus melanocarpa,* are common. Now and then an individual of *Pinus ponderosa* is seen among the tangle of deciduous trees. The cottonwood is the largest tree in the region. Specimens of this species four and one-half feet in diameter were found. The elm frequently attains the size of two feet in diameter. Many of the larger trees were gnarled and twisted, seeming to indicate that they had been subjected to severe wind storms. Underneath the large trees and the secondary layer of small trees there is a tertiary layer composed of many species of low shrubs belonging to the genera *Rosa, Ribes, Cornus, Rubus, Rhus, Symphoricarpos* and others. *Clematis, Vitis,* and *Parthenocissus* are common lianas that frequently convert the forest into an almost impassible jungle. In addition to all these woody plants there are many species of herbaceous plants too numerous to mention in this paper. On the whole this formation reveals the densest and most varied vegetation of, northwest Nebraska. The vegetation shows a decided alliance with that of the Black Hills and the Rocky Mountains. This fact is especially well seen in the herbaceous species. The presence of the Birch and Aspen in the deeper canyons suggests a strong relation to a northerly flora. The soil of the formation is a rich sandy loam with considerable humus and a relatively high water content. There is usually a layer of decomposing leaves and stems that harbors many species of saprophytic fungi.

This formation follows far out into the Bad Lands and mesas of Hat Creek basin to the north. From the tops of the ridges narrow tongues of deciduous growth may be traced for many miles along the stream courses in a general northeasterly direction until lost in the hazy distance. It is along these streams that drain northward that the beaver is still active. Along the small stream that emerges from War Bonnet canyon these little animals have let their presence be known in the form of many dams and fallen trees of various ages. At present their operations are far out upon the plain from the mouth of the canyon, and they seem to be going farther out. They have left in their wake a wrecked forest. Hardly a single large tree has been left standing. The cottonwood especially has fallen prey to their sharp teeth and many large trees of this species lie where the beavers have felled them.

As one looks down such a stream he cannot but compare the appearance to a similar area that has been swept by a tornado.

The streams that emerge from the canyons and enter the Bad Lands have an interesting history. For many rods, sometimes perhaps for a mile or more, the straggling arborescent vegetation of the mesophytic canyons follows such streams. The volume of water in the stream gradually diminishes until it is a mere rivulet scarcely trickling over the shale bed. Finally drought is extreme and all flow ceases and then very soon the water disappears completely into the clayey soil. The woody vegetation that follows out such streams becomes dwarfed and unnatural. The trees are stubby specimens with small thick leaves, and many of their herbaceous associates are so different that they might well be given different specific names. Now and then, however, one finds a large cottonwood far out in the Bad Lands that has succeeded in maintaining a foothold where most of its relatives have perished. Dwarf specimens of *Juniperus virginiana,* in heavy fruit, were common on the extremely dry sides of the Bad Lands gullies which support a very meager flora.

Portable sawmills have been operated in this region for many years so that much of the timber suitable for lumber has been cut and sawed into dimension stuff for local consumption. Little lumber has been exported to distant localities from these forests. The species that have been utilized are Pine, Cottonwood and Elm. The region is one in which there is great opportunity for the working out of practical forest principles. A careful study of forest conditions and the adoption of a well prepared working plan would result in making the forests of Pine Ridge a much more useful and valuable asset.

PLATE III

The Deciduous Leaved Forest in the Bottom of a Canyon. The Large Trees are Elm and Cottonwood.

A Sample of Many Cottonwoods Sixteen Inches in Diameter and Larger Cut by Beavers.

# FOREST CONDITIONS IN THE NORTHERN OZARKS OF ARKANSAS.

W. W. Bennett

The area from which the material for this article was collected lies in the north central portion of Arkansas in Stone, Baxter, Marion and adjoining counties, and comprises the northern portion of the Ozark National Forest. The area is bounded on the north and east by the White River, on the northwest by the Buffalo Fork of White River and on the south by the Missouri and North Arkansas Railroad. It is of the typical Ozark type of hills with a forest cover of mixed hardwoods with now and then a group of Shortleaf Pine and scattered stands of Red Cedar.

The elevation of the region varies from 600 to 2,000 feet above sea level with a relative elevation of 300 to 500 feet. The hills appear to have no definite arrangement and are cut up by numerous small gulches and canyons. The tops of the ridges are narrow, from only a few rods to seldom more than one-half mile in width and descend into the gulches below by steep slopes. The smaller gulches and canyons are narrow, with steep rocky slopes and in many cases with perpendicular cliffs making the adjoining hills practically inaccessible. Along some of the larger streams the bottom lands are flat but are usually not over one-fourth mile wide.

The soil is, as a rule, shallow and rocky, but along some of the larger streams is sometimes fairly deep and free from stones. On the ridges it is of a coarse sandy nature, dry and shallow and intermixed with sandy or flinty rocks. On the slopes it is the same general nature as on the ridges, but on the more gradual slopes, especially the north, it is moister, contains a greater amount of humus and is more fertile. Along the gulches the soil is usually deeper and freer from stones than on either the slopes or ridges and along the larger streams it is a sandy loam, comparatively free from stones and readily tillable. To one accustomed to the deep loam soils of the prairie states the soil of this region has a surprising fertility. Areas which are covered with stones from 1 inch to 3 inches in diameter, and which appear little better than rock piles yield fair crops of cane and corn when properly cultivated, and the sandy soils along the streams yield good crops of cotton.

TYPES.

The diversity of soil and moisture conditions and of elevation and exposure causes a great variation in the forest growth both as to distribution of species and the development of the individual trees. It is not possible to divide the area into distinct and separate forest types but there may be a rough classification according to site and the distribution and development of species into Ridge Type, Slope Type and Gulch Type (or Valley Type). There is no distinct line of division between any of these types, each grading insensibly into the other and differing from the adjoining only in the number of species represented or the better development of the individual trees of the same species.

The Ridge Type is that portion of the area represented by the tops of ridges and the upper portion of the slopes. The dry sandy more or less rocky soil contains practically no humus and is in general the least fertile soil of the region. The forest growth of this type is composed of the following species listed approximately according to their abundance:

White Oak *(Quercus alba)*
Black Oak *(Quercus velutina)*
Hickory (mostly *Hicoria glabra)*
Post Oak *Quercus minor)*
Black Jack *(Quercus marilandica)*
Shortleaf Pine *Pinus echinata)*
Hickory *(Hicoria villosa)*
Sassafras *(Sassafras sassafras)*.

As a rule, the stands are open with the larger trees forming the major portion of the stand. The older trees are mature and are deteriorating. Many are stag-headed and others hollow at the butt, making such timber inferior in quality. This is especially true of White Oak and Black Oak. In general the stand of poles is poor and only occasionally is there a well stocked area, while reproduction of seedlings and saplings is scarce on account of repeated fires.

It is on the ridges and the upper portion of the southern exposures that Shortleaf Pine is most common. Occasionally it forms pure stands of considerable extent but in many instances it is associated with White Oak, Black Oak and Hickory. On sites where this species thrives well it should be favored over the hardwoods since it is faster growing and will produce a larger amount of material in a shorter time. At present, reproduction of this species is poor, but that it should not be difficult to get good reproduction can be seen by the dense growth of seedlings on abandoned fields. It is possible that it will be more difficult to secure good reproduction within the forest than in the open, but if fires are kept out after the forest is opened up the Pine should at least hold its own on areas where it is now the predominating species.

The Slope Type comprises a larger per cent of the area than any other type and this type may again be divided, according to exposure, into the north and northeast slopes and the south and southwest slopes. The first of these types in many instances supports the largest stand and the largest and best developed trees to be found in the region. The soil is much moister, contains more humus, and is in general more fertile than that of the ridge type. White Oak is usually the predominating species and reaches its greatest size and best development on this site. Other species occuring here as scattered well developed individuals are:

Walnut *(Juglans nigra)*
White Ash *(Fraxinus americana)*
Shagbark Hickory *(Hicoria ovata)*
Shellbark Hickory *(Hicoria laciniosa)*
Butternut Hickory *(Hicoria minima)*
Red Oak *(Quercus rubra)*
Spanish Oak *(Quercus digitata)*
Texan Oak *(Quercus texana)*
Sugar Maple *(Acer saccharum)*
Basswood *(Tilia americana)*

The following are also common to this type but are small and of little commercial importance:

Box Elder *(Acer negundo)*
Service Berry *(Amelanchier canadensis)*
Red Maple *(Acer rubrum)*

Redbud *(Cercis canadensis)*
Cherry *(Prunus serotina)*
Bur Oak *(Quercus macrocarpa)*
Chestnut Oak *(Quercus prinus)*
Cow Oak *(Quercus michauxii)*
Sassafras *(Sassafras sassafras)*
Elms *(Ulmus americana)*
*(Ulmus alata)*
*(Ulmus pubescens)*
*(Ulmus racemosa)*

Reproduction on the north slopes is better than on the ridges, but fires have had their influence in keeping down young growth and practically all of the reproduction is of sprout origin.

In contrast to the fertile soil and good growth of trees on the north and northeast slopes, the more exposed south and southeast slopes present a far different condition. The soil is dry and shallow and the limited number of species which they support are poorly developed. The hot summer sun has dried out the soil and furnished a favorable condition for fires which have repeatedly burned over the area. On the slopes where this drying condition and burning has been most severe Red Cedar, *(Juniperus virginiana)*, is the predominating species. These areas are locally known as "cedar brakes." White Oak, Red Oak and Post Oak are usually found in association with the Red Cedar but the trees are small, crooked and defective, and are of little commercial importance.

The Gulch Type comprises a small area along the streams. Soil and moisture conditions are favorable to tree growth and it is in this type that the greatest number of species are represented. All of the species mentioned in the Ridge and Slope types may be found in the gulches with the addition of the following which are limited mostly to this type:

Sweet Gum *(Liquidambar styraciflua)*
Sycamore *(Platanus occidentalis)*
Hackberry *(Celtis occidentalis)*
*(Celtis mississippiensis)*
River Birch *(Betula nigra)*
Hornbeam *(Ostrya virginiana)*
Ironwood *(Carpinus caroliniana)*

Of the typical Gulch Type trees, Sycamore and Sweet Gum are by far the most abundant and most important.

TABLE SHOWING STAND ON TIMBER SALE AREA OF 4,600 ACRES.

| Species | Cutting Limit D. B. H. Inches | Av. Height Feet | Av. D. B. H. Inches | Trees Per Acre | | Av. stand ft. B. M. per acre | Total Feet B. M |
|---|---|---|---|---|---|---|---|
| | | | | Av. No. | Per Cent | | |
| White Oak | 16 | 80 | 22 | 1 | 12.5 | 217 | 1,000,000 |
| Red Oaks | 12 | 75 | 17 | 4 | 50.0 | 563 | 2,589,406 |
| Hickory | 12 | 65 | 14 | 1 | 12.5 | 65 | 297,367 |
| Gum and Others | 12 | 85 | 20 | 1 | 12.5 | 171 | 786,860 |
| Short Leaf Pine | 12 | 80 | 18 | 1 | 12.5 | 317 | 1,459,174 |
| Total | | | | | 100.0 | 1333 | 6,132,807 |

TABLE SHOWING REPRODUCTION AND STAND TO BE LEFT ON SAME AREA.

| Species | Seedlings less than 5 feet high | | Trees between 5 feet high and 6 in. D. B. H. | | Trees over 6 in. D. B. H. to be left | | Total no. feet B. M to be left. |
|---|---|---|---|---|---|---|---|
| | No. per A. | Per Cent | No. per A. | Per Cent | No. per A. | Per Cent | |
| White Oak | 35 | 26 | 25 | 28 | 24 | 29 | 1,598 |
| Red Oaks | 40 | 32 | 23 | 25 | 23 | 27 | 281 |
| Hickory | 25 | 18 | 18 | 20 | 18 | 21 | 32 |
| Gum and Others | 20 | 15 | 15 | 16 | 11 | 13 | 85 |
| Short Leaf Pine | 12 | 9 | 10 | 11 | 8 | 10 | 158 |
| Total | 132 | 100 | 91 | 100 | 84 | 100 | 2,154 |

## FIRES.

Fires have been a great menace to the forests of this region. For the past generation or two it has been the custom of the inhabitants to burn the woods each year in order, as they believe, to keep out the brush, improve the grazing and to eradicate the Texas Fever Tick. Practically all of the fires are ground fires and although they do little damage to the mature timber they destroy reproduction of seedlings and saplings. Originally the forest was composed of an open stand of tall straight trees and it is common to hear an old resident say: "The woods were so open you could see a deer for a half-mile." However, the burning year after year has kept the young growth burned off leaving the stools in the ground ready to send up numerous sprouts each spring.

It follows that when fire is kept out for a few years a dense undergrowth takes possession of the ground, and it seems that the forest must go through a "brush" stage before another stand can be obtained. However, if fire is kept out it is certain that the undergrowth will gradually become more open and the basis for a future stand will be assured.

The Forest Service has done much toward controlling fires by the erection of a number of look-out stations upon the highest mountains. These stations are provided with instruments and charts so that fires can be accurately located almost as soon as they are started. This makes it possible to get men to the fire before it has gained much headway. The system would do much to decrease the amount of area burned over each year, but the fire question can never be solved until a more favorable public sentiment is secured.

### UTILIZATION.

One of the greatest problems of forest management in the Ozarks is the close utilization of the present mature timber. In the past only the best timber has been cut out by small operators with small portable mills. The stave and heading mills have used only White Oak of large size and best quality and in most cases used only the clear length of the tree, leaving a large amount of good material in the woods. Stave bolts and heading bolts must be 14 inches in diameter at the small end, and it is evident that a large amount of material is left in the tops which might be used for ties, furniture stock, etc. The small sawmills probably practiced closer utilization of the individual trees than the stave and heading mills but these also used only the largest and best trees of White Oak and Shortleaf Pine.

The manner in which these operations have been conducted not only causes a waste of good material, but inferior species are left to become the dominant trees and to seed up the ground. It is the policy of the Forest Service in Timber Sales to encourage the purchase of timber by companies who have machinery with which they can manufacture several classes of product. In connection with stave and heading operations it is desirable that there be equipment for the production of wagon stock, furniture squares and other small dimensions. With this equipment the operators can not only use more of the individual trees which are cut, but can also use Gum, Hickory, and other species which otherwise would not be used. In order to encourage the use of inferior species and closer utilization of better species the Forest Service specifies in Timber Sale contracts that all trees above a certain diameter must be felled and paid for, even if they are not taken from the woods. There is possibly but one mill in this region which is properly equipped to carry on conservative lumbering, but it is reasonable to believe that there will be a marked improvement along this line in the near future.

With the proper treatment the forests of this region should become much more valuable in the production of hardwood timber than they have been in the past. The area is naturally and typically forest land and only a small percent can ever become valuable for agricultural purposes. In harvesting the present stand care must be taken in cutting so that the more valuable species will be given preference, and reproduction must be protected from fire before a second crop can be assured.

# A METHOD FOR DETERMINING THE EFFECTS OF FORESTS UPON RUN-OFF IN THE ROCKIES.

R. D. Garver.

In the determination of this most important question,* the effects of forests upon run-off and water supply, there seems but one general plan, i.e., the comparison of two areas similar in every respect except forest cover. In the selection of the two areas to be compared and the inauguration of the plan of procedure to bring about comparison it seems very important that the following points be carefully considered.

The experiment should be represented by areas which are component parts of the mountain region in which the study is to be made and should represent typical average conditions. In order to choose areas that will meet the above requirements the following considerations are offered: the areas chosen for study should include both sides of a valley and take in (1) the entire altitudinal range from the perpetual snow line to the arid zone occupied by the Yellow Pine type or, (2) they should lie at middle altitude in the zone between 9,000 feet and 11,000 feet. The latter seems the most desirable because of the ease in selection and the greater simplicity of the areas involved. Another important factor in favor of this alternative is the condition found in the Englemann Spruce type and the area above timber-line where the soil is always moist and in consequence continually feeds and perpetuates stream-flow, while areas lying at low elevations furnish little ground water and streams dependent upon such supplies may become dry regardless of forest cover or other conditions influenced by slope or aspect.

To be representative of the Rockies the slopes of the watersheds should be steep but not precipitous. The general direction is an important factor and upon further consideration it appears that a watershed with a northerly or southerly as-

*Centralablatt fur Das Gesammte Forstwesen, January, 1907. Silvical Report, Dist. 2, 1909.

pect would not be desirable since the exposure would not be typical. The mean or average watershed then, should drain to the east or west, so that one slope will be exposed to the south and the other to the north. In this way the effect of insolation on the two slopes will be fused in the behavior of the stream which drains both.

To obtain average surface conditions the soil on the watersheds must be consistent with the steep character of the slopes and the geologically young state of the Rockies, i.e., a fine loam lying in a thin layer intermixed with much rocky debris and numerous outcrops. The amount of humus in the soil is of course an important agent in retarding percolation of water and should be considered quite carefully in order that an average may be obtained.

To avoid any changes in geological structure or precipitation the areas for study should be contiguous or nearly so. They should lie on the same general slope of a simple, narrow mountain range or on a spur well removed from the higher ground. The presence of high mountains behind the watersheds, even though the drainage is apparently in an opposite direction, may complicate matters since such a drainage area might be furnishing a great deal of underground water to the streams being measured. The experiment should be located where the precipitation is moderate and yet large enough to give the drainage stream a minimum flow of 0.5 cubic feet per second. Here again the middle altitude seems most desirable for fulfilling the above requirement.

With the points just enumerated in mind, two watersheds should be selected with the utmost care and consideration in order that the results obtained will be convincing in every respect and a provision made for every contingency. In the inauguration of the experiment, one of two plans may be used; (1) the experiment may be started with the two areas having a forest cover about equal or, (2) with one of the areas bare and the other forested. In the first plan observations of climate and stream flow should be carried on for a period of two years, then one watershed should be denuded; in the second, the area now bare should be brought into a forested condition during the period of observation. The experiment cannot be considered absolutely reliable or complete unless simultaneous records are obtained with the conditions of cover in contrast and simultaneous records with the conditions of cover about equal. Because of the shorter period required and the more certain conditions in bringing about the change the first method seems best.

Therefore, beginning with the watersheds forested, records should be obtained for a period of two years to bring about a comparison under their present conditions. One watershed should then be denuded, after which its records should show the extreme flood conditions and the large amount of silt brought down at this particular time. When, after several seasons grass begins to appear on the area sheep or cattle might be turned in and the effects of excessive grazing thereby shown. After this the watershed should be allowed to return to its natural forested condition. Any difference that might have been noted in the behavior of the two streams with their conditions of cover in contrast should now decrease proportionately as their former similiarity of cover conditions is approached.

In order to collect the necessary data from which to draw conclusions a rather complicated set of apparatus is needed. It is quite impossible to find two watersheds exactly equal in area, cover, topography and altitudional range, so all calculations should be expressed in percentage. The apparatus used on one watershed should be an exact duplicate of that used on the check area.

At the lower end of each watershed a dike and settling basin should be constructed. The dike is merely an eight inch wall built across the stream, having bed rock for its foundation in order that no water may pass off without first being measured. That the dike be set on bed rock is highly important since it is found that a large amount of water is slowly flowing downward between the bed rock and the overlying strata, and but for this precaution it would never be measured and a large error in the total flow would be the result. The surface water and the underground water is obstructed by this dike and compelled to rise until the rectangular opening in the top is reached, there to flow over and be caught in the settling basin, which is constructed just below. The settling basin is for the sole purpose of measuring the silt brought down. The run-off is collected in the basin and allowed to stand for some time, so that the silt held in suspension may settle. It is thought that a period of two hours is a sufficient time for the sediment to settle, and necessarily the basin should be large enough to hold the discharge for this length of time. If it is found that the water does not pass out of the basin perfectly devoid of sediment, samples of the water as it passes out should be taken and the silt found therein should be figured for the total flow and added to that collected in the basin. One corner of the basin should be lowered to facilitate the measurement of the silt. As a means of diverting the water when it becomes necessary to measure the silt in the basin, a large pipe with a screw cap should be placed in the dike just below the opening into the basin. When this cap is removed the water is diverted through the pipe and the water level brought below the opening into the basin. To empty the basin a siphon or drain pipe may be used.

To measure the actual waterflow a weir, forming the outlet, should be placed in the lower end of the basin. A weir of triangular form is recommended in this case and is merely a right-angled notch cut in a steel plate, through which the water flows. A weir of this form seems best for two reasons; first, it most easily provides for the lowest possible flow and also for the maximum which may equal from twenty to thirty times the average, and second, the water passing through the weir has the same general shape at all heights. The height of the water in the weir is all that is necessary to calculate the discharge as will be seen from the following formula in which Q equals the flow expressed in cubic feet per second and h the height of the water in the weir, the number being a constant for this particular form of weir:

$$Q=2.635h^{5/2}$$

The water heights should be obtained by hook-gage readings at intervals to check the waterstage register which gives a continuous record of the water height in the weir. The hook-gage consists of a hook attached to the lower end of a sliding bar in a stationary frame. To measure the height of the water in the weir the hook-gage is dropped below the surface of the water, then by means of a tangent screw is slowly raised until the point of the hook makes a star on the surface of the water. The height is then read on a scale fastened to the stationary part, the zero point of which corresponds to the bottom of the weir. A vernier is used to read to thousandths. The waterstage register is composed of a drum upon which is placed a specially ruled sheet and the height of the water in the weir as indicated by the float which actuates the drum, is recorded on the sheet by a pen. This pen is held perpendicular to the axis of the drum, and moves in a direction parallel to it at a constant rate by the aid of clock-work. In order to free the float from wave action in the basin a still-well should be constructed and the float placed therein. The still-well in this case should be a cement pillar which has a hollow center large enough to admit a float twenty inches in diameter, the water entering the still-well at the bottom through a small pipe connecting with the basin. A large float is recommended since it more easily overcomes the friction of the instrument and thus provides for the recording of slight as well as marked changes in the water height. This is true since the large float retains the same relative position with reference to the water height at all times because it so easily operates the drum, while if a small float were used the change in the water height would have to be somewhat greater in order to provide sufficient power to overcome the resistance of the instrument. If it is not found possible to take hook-gage readings in the still-well containing the float, another should be constructed, a six inch iron pipe making a very good one.

It is of course very important that streamflow measurements be supplemented by records of temperature and of conditions controlled by temperature. To gain this end, three meterological stations should be established on each watershed, two of which should be located at the lower end, one on a north slope, the other on a south slope at practically the same elevations, the other at the upper end. During the winter the depth and water equivalent of the snow at different elevations and different conditions of slope and aspect should be carefully measured after each snowfall and in no case should the interval between measurements be greater than seven days, even though no snow falls. Then, during the spring thaws, measurements should be taken every other day so that the effect of slope, cover, etc., may be determined.

The following factors seem most important and hourly records of them should in any case be obtained though a large outlay of self-registering instruments is required:

Streamflow
Precipitation
Air and soil temperature
Evaporation
Humidity
Wind velocity and direction.

The run-off from each watershed in cubic feet should be determined for the year and expressed in per cent of the precipitation. Evaporation is a very important factor in water-loss and special precautions should be taken in order that accurate records may be obtained with the conditions of cover in contrast. The time and degree of floods and low water stages as related to precipitation and thaws of known intensity should be determined. Lastly, the silt deposited in the basin should be most carefully measured since the effect of forests upon the retardation of erosion is a very important question. With accurate records of the above enumerated factors it seems possible that some conclusion could be drawn which would help to settle the question of the effect of forests upon run-off, erosion, and water supply.

# METHODS OF RECONNAISSANCE ON THE NATIONAL FORESTS.

J. R. Bruff.

It is the purpose of this article to give an idea of the methods of reconnaissance on some of our National Forests. The material was obtained from students, who had spent their summers in this kind of work on seventeen forests in the six different administrative districts.

The object of carrying on reconnaissance work is to obtain an idea of the condition of the forests with a view to establishing a somewhat satisfactory basis for management. The forests on which the work was done were mostly inaccessible places where timber sales were few and the timber itself of such poor grade that it would scarcely pay, at present, to overcome the difficulties of getting it out. Thus any accurate valuation survey would be out of the question, so an approximation is obtained by reconnaissance.

The work was made to include not only an estimation of the timber but also topographic and type maps and a general description of the forest conditions. The timber estimates were made on a small per cent of the area and from this the volume for the entire area was computed. The areas on which the timber was estimated were found to vary from as low as one per cent of the entire area up to ten per cent, while five percent was the most common. The forests on which ten per cent of the area was estimated contained good timber and the work was made accurate for use in timber sales. Where less than ten percent was estimated the work was, in most cases, too much of an approximation to be accepted for timber sales.

In carrying on this work, a crew of six to ten men was sent out by each forest. The outfit for the crew was such that camp could be easily moved from one locality to another as the work progressed. In most cases it was possible to hire a team and wagon to move camp, although several forests were so rough and unsettled that pack horses had to be used. The crews were composed chiefly of students studying forestry, a cook, and a Forest Assistant in charge. Occasionally Forest Rangers and Fire Guards would form a part of the personnel. From the main camp in which the crew was located all the immediately surroundingly country was worked and the camp could then be moved to new territory. It often was necessary to send out a part of the crew to a side camp for a few days to work out inaccessible country or to get scattered sections not included within the body of the forest. When trips of this sort were necessary, it was customary for each man to pack his blankets and provisions on his back.

In subdividing the areas for reconnaissance, the government survey system was used. Thus in surveyed country, section corners were used from which to work, while in unsurveyed territory base lines were used. These lines were usually meandered in order to keep to some trail or valley. Where base lines were necessary, it was the custom to keep a base line crew in the field establishing corners for the estimating crew to work from. These corners were temporary and in some cases more or less permanent, and were established at such points that the work would conform with the government system of surveys, and thus estimates were obtained for forties, quarter-sections, etc. These base line stations were made permanent on some of the forests because they would have future value in case of timber sales, homesteads, mineral claims, etc.

On some forests the country had been surveyed so many years ago, that the majority of the section corners were missing. In such cases short base lines were run from those corners that could be found. These short lines demanded none of the great accuracy required for the base lines in the unsurveyed country, but were run with Jacob staff and compass by men of the estimating crew.

The methods used in estimating were of two general kinds, known as the "strip" and the "sample plot" methods. The former consists of estimating the timber on a strip one chain, or rarely two chains, wide. The one-chain strip when run through the center of a forty gives a rectangular area one chain wide and twenty chains long, which contains two acres, or five percent of the entire forty. It is evident that if the strip is a fair representative of the forty that the estimate should be multiplied by twenty to get the total stand for that area. This is the method which several of the forests followed, even when the strip was a poor representative, but only when much larger areas than forties were considered as units. This was done on the assumption that the errors incurred were compensating for a large territory, that is, that where one strip would be an under-estimate for a forty, another would be an over-estimate and thus in the long run an approximate volume would be obtained. Other forests using the strip method attempted to get a correct volume for each separate forty by multiplying the two-acre estimate by a figure greater or less than twenty according to whether the two acres estimated contained poorer or better timber than the average for the entire forty. To determine this correction factor for a forty, the cruiser must be experienced and must show good judgment. He must observe carefully the timber on both sides of the strip and determine the relative condition of the timber on the estimated strip with that on the rest of the forty. Poor judgment in the use of the correction factor, making it too large or too small, will cause a large error in the computed stand for the forty.

To get a ten percent estimate by the strip method, two lines were run through a forty and in one case one strip two chains wide was used. For the two and one-half percent work the strips were run between forties, thus making two strips through each section. Then by applying a separate correction factor for the forty on either side of the strip the volumes of the respective forties were obtained. This method of running between forties was used chiefly in case of large burns, parks, grass land, brush areas, barren land, etc.

In using the strip method it was customary to have two men in each field party. Often, however, three men were used, especially if some of them were new at the work, while on one forest, parties were composed of four men. The duties of the individuals were in the main the same on the different forests. Where the usual two-man party was used, one did the topographic work and the other the silvicultural. The first, or compassman, directed the course, with a Jacob staff and compass, and kept the distance by pacing. There were only one or two cases where chaining was used for more than a mere check. The compassman also obtained elevations by means of an aneroid barometer and sketched streams and ridges on a field map, recording elevations in a note book, or more commonly perhaps, sketching them as contours on the field map. Types were outlined on the field map with colored crayons by the compassman, and on one forest, age classes were also mapped in. (In one case the estimator did the type mapping instead of the compassman.) Topographical maps were made on all the forests except one where a recent dependable government survey made such maps unnecessary. The contours used ranged from ten to one hundred feet, depending on the character of the country. The compassman in several cases aided the estimator in judging the forty correction factor, in laying out sample plots to find the amount of immature growth present, and in making the general forest description.

The estimators' duties were in general to estimate the merchantable timber in D. B. H. classes and sixteen-foot logs. In a recent Forest Service valuation survey in Virginia the logs were recorded in different lengths varying with the species, and in the case of one species the height of the tree was recorded. Two-inch D. B. H. classes were used mostly while one-inch classes were not uncommon in case of small timber. On one forest the three-inch class was used. Ocular estimates were made almost exclusively, although calipers and the Biltmore stick were often used as checks. Calipering all of the trees was exceptional. The estimates were kept separate for the leading species by forties, and the minor species grouped, although a few kept even the minor species separate. The estimator determined the forty correction factor and also a deduction percent for defects for each species on the forty. Besides this estimation of merchantable timber he would make an approximation of the immature growth present and also write a description for each forty, although sometimes only one description was made for a whole section. These descriptions were a very important part of the reconnaissance work and included as some of the important points: (a) Condition of the timber, whether an old decadent, mature or young stand; whether fire injured, fungus injured, attacked by insects; whether low and limby, or tall, clean, and sound. (b) Topography, giving average degree of slopes. (c) Aspect. (d) Rock, amount present, kind and form. (e) Soil, kind and depth. (f) Ground cover, and litter, kind and amount. (g) Underbrush, species and density. (h) Ease of logging. (i) Possible saw-mill locations and power sites. (j) Grazing. (k) Recommendations for future use.

In three-man parties the duties of the compassman were the same except that since chaining was more frequent, he acted as head chainman. A tallyman acted as rear chainman and wrote the forest description as well as tallying trees and chains. The third man would caliper and call out diameters. In case of four men in a party the extra man calipered; otherwise the party was the same as with three.

The sample plot method, as the table below shows, was used on several of the Forests. This method consists of running the usual lines, but estimating only at certain points where a circle with an area usually of one-quarter acre, is estimated. Sometimes only one of these plots was taken in a forty but more frequently there were two or three, especially if there was a change of type, in which case there was always a separate plot for each type. The area of each type in a forty was estimated, the volumes of the plots were reduced to acre units; from these the total volume was computed.

In using this method it was the custom for one man to work alone in the field, procuring the data described in the strip method. This is an effective factor in reducing the cost of operation, but a much smaller percent of the entire area is actually estimated. However, on one forest using the sample plot method an estimate of five per cent of the entire area was obtained. This was done by estimating half-acre plots every five chains, making two acres for each forty.

On two forests even sample plots were dispensed with. The cruiser passed through the forty making a lump estimate in board measure for the various species on the entire area. This method is uncommon and demands considerable experience for its safe use. In this case as in the foregoing, one man could work alone in the field, thus increasing the amount of land covered each day per man.

TABLE COMPARING RECONNAISSANCE METHODS.

| District | State | Forest | Men in Crew | Men in Party | Method | Per Cent. Est. | Measurements | Paced or Chain | Trans-portation | Cost per A. |
|---|---|---|---|---|---|---|---|---|---|---|
| I | Mont. | Bear Tooth | 4 | 2 | 1-Chain strips | 5(2.5) | Ocular | Pace | Pack and Wagon | $0.05 |
| I | Mont. | Flathead | 9 | 3 | 1-Chain strips | 10 | Caliper all | Chain | Wagon | —— |
| I | Mont. | Helena | 10 | 2 | 1-Chain strips | 5(2.5) | Ocular | Pace | Wagon | —— |
| I | Mont. | Kootenai | 10-16 | 2 | 1-Chain strips | 5. | Ocular (Caliper & Biltmore stick) | Pace | Pack | —— |
| I | Wyo. | Big Horn | 7 | 1(2) | ¼-A. plots, 3 plots to forty | 1.87 | Ocular (Caliper at first) | Pace | Wagon | —— |
| II | Colo. | Arapaho | 5 | 4 | 1-Chain Strips | 10. | Caliper | Pace | Wagon and Pack | 0.07 |
| II | Colo. | Cochetopa | 4 | 1 | ¼-A. plots, 1 plot to forty | .67 | Ocular | Pace | Wagon | —— |
| II | Colo. | Colorado | (4)5 | (3)4 | ½-A. plots, 4 plots to forty | 5. | Ocular (Caliper) | Pace | Wagon | 0.03 |
| II | Colo. | Holy Cross | 6 | 1 | ¼-A. plots, 1 plot to forty | .62+ | Ocular | Pace | Wagon and Pack | 0.02 |
| III | Arkansas | Ozark | 9 | 2 | 1-Chain Strips | 5. | Ocular | Pace | Wagon | 0.05 |
| III | New Mex. | Gila (1910) | 7-12 | 1 | ½-A. plots, 2 plots to forty | 2.5 | Ocular | Pace | Pack | —— |
| III | New Mex. | Gila (1911) | 8-11 | 1 | ½ A. plots, 2 plots to forty | 2.5 | Ocular | Pace | Pack | 0.035 |
| III | New Mex. | Jemez | 10 | 1 | Lump est. for entire forty | ........ | ........ | Pace | Wagon | —— |
| III | New Mex. | Pecos | 5 | 1 | Lump est. for entire forty | ........ | ........ | Pace | Pack | —— |
| IV | Ida. Mont. Wyo. | Targhee | 9-13 | 2 | 1-Chain strips | 2.5(5) | Ocular, Bilt. Stick | Pace | Pack (Wagon) | 0.017 |
| V | Calif. | Tahoe | 6-8 | 2 | 2-Chain strips | 10. | Ocular, Bilt. Stick | Pace | Wagon | —— |
| V | Calif. | Trinity | 5-9 | 2(3) | 1-Chain strips | 5(2.5) | Ocular, Bilt. Stick | Chain (Pace) | Wagon | 0.02 |
| VI | Wash. | Snoqualmie | 15-20 | 2 | 1 Chain strips | 5. | Ocular (Bilt. Stick) | Pace | Pack | —— |

Data as to the costs of carrying on reconnaissance work were difficult to obtain, but from the figures available, as the following table shows, it seems to average about four cents an acre. The costs varied greatly according to the character of the country worked, the amount of accuracy required, the distance from the base of supplies, etc. One factor which greatly increased the cost was the necessity of keeping a base-line crew in the unsurveyed and poorly surveyed country.

# FOREST ROADS AND TRAILS.

Ernest Wohlenberg.

In the past the construction of forest roads and trails was in the hands of individuals and private concerns and for that reason very little literature was published and only a small amount of data was collected. During the past few years the United States Forest Service has done a great deal of work in the development of the forests of the west, part of which consisted in building roads and trails. The development and protection of any forest region under forestry principles depends upon its accessibility, which means that roads or trails are necessary. Under the old methods of lumbering the land was devastated of its good timber or cut clean with no thought of the future, but now economic conditions have changed. The price of stumpage, the growing scarcity of standing timber and the common-sense conservation policies all demand better protection and closer utilization of the forest, and in order to obtain this the woods must be opened up by roads and trails. The immense forest fires in the Northwest during the summer of 1910 indicate one great necessity of having the forest accessible.

The search for material for this article has extended over the entire country, but very little literature could be found. Valuable information has been taken from notes on Professor Chapman's lectures at Yale University and from W. E. Herring's lectures given at the State University of Washington. An attempt was made to collect specific examples of roads and trails which have been built in all the different forest regions of the United States, but it was impossible to obtain information from some of the regions.

### USES OF TRAILS.

Trails are for the use of the general public and of forest officers. The first trails on the present forests in different parts of the country were built mostly by miners, homesteaders and stockmen. These trails were used entirely by the general public, and in this way the country was partially opened up and developed. The main object in building these trails was accessibility. At present the main objects besides (1) accessibility, are, (2) administrative purposes, (3) routes for packing purposes (to mining camps, etc.), (4) pleasure (scenic trails), (5) fire lines, to a small extent, and (6) stock trails. The forest should be made accessible so that any part can be reached in a reasonable amount of time and routes of travel should be made for administration. Occasionally trails are built by private parties to provide a route for packing purposes, to remote mining camps. Scenic trails are built either by the state or by private parties, for both pleasure and accessibility. Trails are also used for fire lines but due to their narrowness are not of great value for this purpose. Stock trails are built for moving stock over rough country from one range to another.

### USES OF ROADS.

The first roads constructed in the forest regions of the west were built for stage lines and for freighting purposes; logging had not been developed to any extent in the Rocky Mountains. At present the purposes of building roads are for (1) freighting, (2)logging, (3) stage lines, (4) pleasure, (5) fire lines. Freighting is a very important item where camps and towns on a forest are located at a distance from the railroad. Where logging is going on in the Rocky Mountains, roads must be built on account of the extreme roughness of the country. Roads, because of their greater width, are well adapted for use as fire lines. In more level regions fire lines can be used as roads.

### CONSTRUCTION OF TRAILS.

Trails on the forest at present may be classified as: (1) main trails, (2) secondary trails, (3) spur trails. Main trails are those connecting ranger districts of the forest. They should be well worked, well brushed out and well blazed, and should have a fairly wide tread with a maximum grade of from ten to twelve per cent, for most of the traveling in the district will be on them. Secondary trails are those connecting the main trails. They should also be fairly well worked and blazed, and have a maximum grade of twelve to fifteen per cent. Spur trails are usually short trails connecting lookouts with the more important trails. These spur trails are used only by the fire guards and therefore it is not necessary to do a great deal of work on them. They can be blind trails and need only be brushed out enough so that a horse can get through with ease, which would mean a cleared space of four or five feet. A grade of fifteen to twenty per cent would be permissible.

The first and most important consideration in trail construction is always the location work. Grade is always the determining factor in location. Where it is steep, switchbacks should be resorted to. The methods used in location are, (1) compass and Abney hand level (accurate), (2) hand level only (fairly accurate) and (3) ocular leveling (inaccurate). A route should first be reconnoitered and definitely decided upon before it is staked out. The main points can be sketched in on a map by means of a compass and hand level. On long distances it is best to use both a compass and hand level. On short distances the hand level will be sufficient. Laying out by eye is a poor method and inaccurate at its best. The route should be staked every 50 to 100 feet and blazed, but as a usual thing routes are laid out by blazing only. The blazes should be made close together along the trail so that there will never be any trouble in following them; a long blaze with a horizontal notch above is used on Forest Service trails. Location should always be from the top of a hill to the bottom otherwise the maximum grade is apt to be exceeded, because in locating from the bottom there is danger of making the grade steeper than necessary. Location work can be done very well with a crew of three men and costs from $2.00 to $10.00 per mile.

There are several choices for trail routes, (1) valley or canyon, (2) ridge route, (3) trails crossing mountains, and (4) foothill grade. The use of one of the first two routes depends somewhat on the nature of the country. Where the canyons are extremely steep, narrow, and full of boxes or interrupted by cliffs, the ridges and sidehills can be followed without much trouble. Where sidehill routes are resorted to, the south sidehills should be used because they are passable three weeks earlier in spring and later in autumn than north hillsides. Where the country has been worn down, the valleys have a gentle grade and are quite wide so that they make good trail routes. Where mountains are crossed the route is usually expensive and contains steep grades. The foothill grade is undesirable because there is so much winding in and out around the heads of canyons in order to keep an even grade, that the trail is bound to be extremely long.

In the southwest where cattle graze on the forests to some extent, it is found that they are very good engineers in the location of trails; as a number of trails on the Gila National Forest of New Mexico are old cattle trails which have been brushed out and blazed. In going up a grade cattle resort to switchbacks and always travel where the going is best, keeping an even grade. In traveling down a ridge or canyon they always pick out the smooth spots and many of these trails located by cattle are just as good as those located by man.

The factors which influence the building and cost of trails are: (1) grade, (2) width of cleared space and the tread, (3) nature of the soil, (4) cost of labor, (5) distance for packing supplies, (6) distance men walk to work, (7) cost of supplies, and (8) supervision. Grade, as said before is the determining factor of location; the steeper the grade, the greater the length of the trail and consequently the greater the cost. The greater the amount of brush, the wider the space brushed out and the wider the tread the greater the cost. The cleared space varies from 6 to 14 feet, and the tread varies from 1 to 4 feet. Ordinarily a tread of 18 inches is wide enough, for a horse will almost invariably travel on the lower side of a trail and always in the same place, so if the trail is wider than 18 inches the inside will just fill up with sliding material and the extra cost in excavation will be thrown away. On turns, trails are widened and on switch backs the width is doubled. The trail bed should be flat. Excavation should be made into the bank instead of building up the lower side of the trail, because on steep slopes earth thrown out of the trail makes a poor footing. The nature of the soil affects the cost of excavation. The cost for excavation of sand would probably be the greatest as the greatest amount of material would have to be taken out. The bank on the upper side of an excavation should slope away from the trail, the angle differing with the nature of the soil, as follows:

| | | | |
|---|---|---|---|
| Sand, angle of repose | $23\frac{1}{2}°$ | or | 43% |
| Earth, angle of repose | 33° | or | 65% |
| Dry clay, angle of repose | 45° | or | 100% |

The greater the cost of labor the greater the cost of the trail to a certain extent. In some cases it is cheaper to hire a good crew and pay them good wages than to hire an inefficient crew at a low wage. The greater the distance the men walk to work the greater the cost of the trail because even when the time of going to and from work is taken outside of the regular eight hour day, which is usually the case, a large amount of walking and climbing before and after work will tire and worry the crew so that they will not be as efficient as otherwise. The supervision of the crew is the most important factor of all because if the work is not arranged as it should be the trail will be expensive under the most favorable conditions.

The size of the crews varies from 2 to 15 men. In crews of 8 to 15 men it is necessary to have a cook, a packer, and a foreman. The brushing out can be done by 2 to 4 men while 5 to 8 can do the grading. Small crews vary from 2 to 5 men. The men do their own cooking and a ranger has general supervision over the work. The tools ordinarily used are axes and brush hooks for brushing out; cant hooks and peavies for moving logs; shovels, picks, and mattocks for grading. Where small crews are at work and the slopes are not too steep the trail is brushed and blazed, and left in that condition for travel to cut out the tread. A method similar to this was followed in connection with the Gila reconnaissance work in New Mexico in the summer of 1911. The reconnaissance party was working in a fairly open country in which there were scarcely any trails. The packers were sent ahead to locate a route to the next camp and to blaze and brush out the trail to a width of about 4 feet. Then when the pack outfit, which consisted of about 18 burros and 2 horses went over this route it would be fairly well cut out so that with a little extra work a good trail could be built.

On side-hill locations where water will run down a trail, it is always best to put in water bars, that is, small ditches 2 inches to 4 inches deep running diagonally across the trail and banked on the lower side with earth or a small log sunk a few inches in the ground. These will turn the water and prevent any great amount of washing, which might ruin a trail. The number of water bars will vary with the grade of the trail and the degree of slope of the side hill on which the trail is located. It is much cheaper to put them in when building the trail than afterwards. Under ordinary conditions they can be located from 50 to 75 yards apart.

In locating a trail, cliffs and rocky outcrops should be avoided because powder work is very expensive. Occasionally when a trail affords so many advantages that a high cost is permissible a great deal of rock work can be done. The two materials used for blasting are dynamite, which costs from 10 to 15 cents per pound, and black bowder which is about the same price. Dynamite, when exploded works instantaneously with a sharp shock while black powder works slower and exerts more of a shoving force. The cost of rock work varies from $ .50 to $1.50 per cubic yard.

In general in building trails the country should first be reconnoitered and the route fully decided upon. The trail should then be located by stakes or blazes and the route cleared and brushed out to the specified width. The grading work should then be done and the tread made the specified width. Signs showing the distance from important points and from water should be put in every mile if possible and never less than every 4 or 5 miles.

### ROAD CONSTRUCTION.

The use of a road largely determines the amount of work which should be done upon it. Freight roads and stage roads as a rule should be well worked and kept in good condition and if there is a great amount of traffic they should be double tracked or turn-outs made along the way, while for logging purposes it is not so necessary to have a well worked road as it is only used temporarily, the road being abandoned as soon as the timber is cut. The maximum grade for the former road should be 7 per cent, but for a logging road, especially where all logs are hauled down hill, the maximum grade may be greater but should rarely exceed 12 per cent, and then only for short distances. Where roads are used for fire-lines, and fire protection is more important than traffic, the only work necessary is that of clearing the space.

The location of a road is more important than that of a trail, because the former demands a gentler gradient and requires a greater amount of money in its construction. Since grade is the determining factor in locating roads a transit should be used for that purpose, because of its accuracy. Heavy rock work and the construction of bridges should be avoided on account of the great expense. Side hills are the best for location since they are driest, have the best drainage and the best surface, and require less repairs, although the grading at the beginning will probably cost more. Routes of avalanches should be avoided, also routes in deep cuts, because the latter will fill up with snow. Switch-backs should not be used, for the sharp turns are not adapted to wagon traffic. The cost of location varies from $5 to $50 per mile.

The factors which influence the cost of roads do not vary a great deal from those affecting trails. They are (1) grade, (2) width, (3) amount of brushing out, (4) amount of grading, (5) drainage, (6) rock work, (7) distance for hauling supplies, (8) cost of labor, and (9) supervision. The steeper the grade the greater the length of the road. As the maximum grade for most roads is from 6 to 7 per cent a steep grade will greatly increase the length of the road. The width of the roads varies from 8 to 12 feet for single track roads and 16 to 20 feet for double track. The width of the road naturally affects the amount of brushing out. In heavily timbered localities the clearing is a very expensive item as it is difficult to remove the stumps and to roll the logs out of the way. The amount of grading is a factor which influences the cost, depending on the steepness of the hillside and the number of stumps to be removed. A road should be so built that it is well drained; side ditches should be put in which have cross drains every 100 to 200 feet. In cheap roads the drains will not be covered, while in well built roads, culverts of rocks or wood should be put in. Rock work cannot be avoided as readily in road as in trail construction and hence adds much to the expense. The supplies will be hauled by wagon which costs only about one-third as much as by pack horses, hence the distance is not as important as in trail work. The cost of labor will affect road building the same as trail work. Supervision again is the most important factor of all.

In construction of roads, stumps and rocks should be removed by using powder or dynamite as it is much cheaper than by manual labor, because much time would be unnecessarily wasted in grubbing out stumps. All work possible should be done by teams, since hand grading in construction of roads is very expensive on account of the large amount of material to be removed. In building single track roads, turn-outs should be built about 50 feet in length so that vehicles can pass each other. The length of the intervals between turn-outs would depend entirely upon the amount of travel expected on the road. In grading there should be more fills than cuts, because fills will drain better. In rock work the walls should slant away from the road so that debris will not be continually dropping down.

Drainage is an important item in road building. On level ground both sides should be ditched to a depth of about 1 foot and a width at the top from 2 to 3 feet. On hillsides the road should slope toward the hill with a ditch on the inner side. In swampy places a ditch 2 feet deep and 2 feet wide should be put on each side and a fairly high crown left in the center if possible.

### SPECIFIC EXAMPLES OF TRAIL BUILDING.

A few examples of trail building and the methods used have been obtained from different regions. There is no uniform system of keeping accounts for construction work of this kind in the Forest Service, and consequently the system of giving the cost varies with nearly every example. On account of this variation it is almost impossible to compare the cost of the different operations of construction in the various regions.

### *Kootenai National Forest, Montana.*

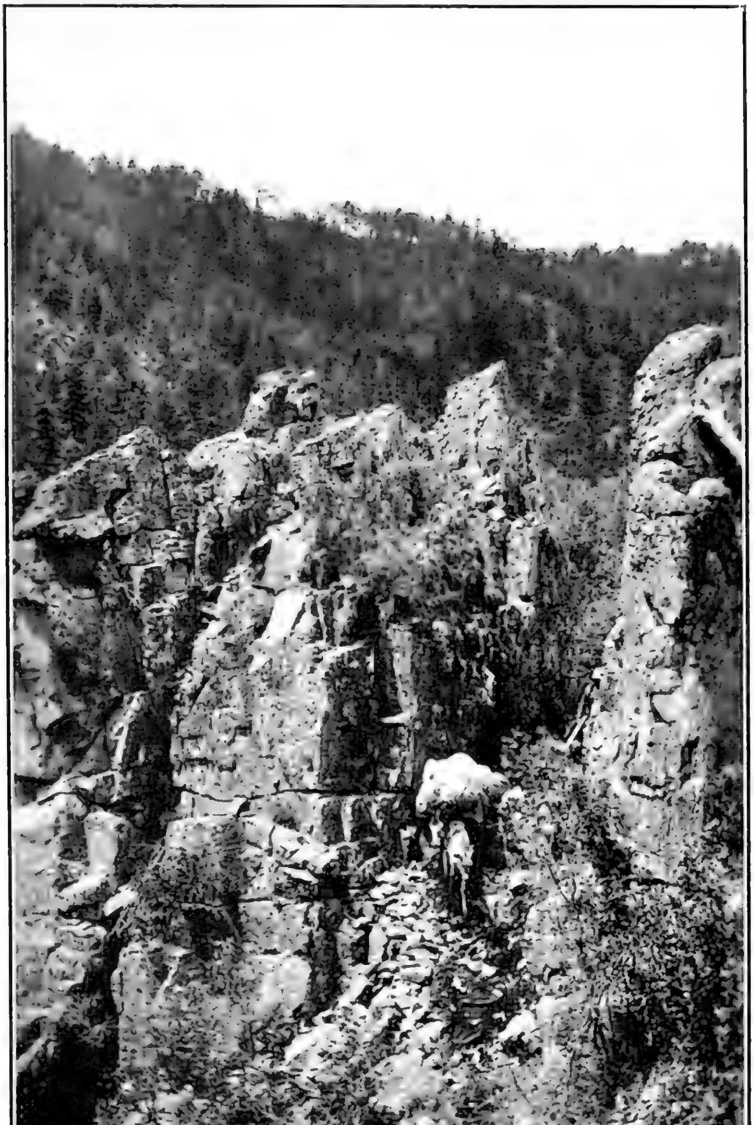
The figures are general for trails on this forest. Crew of 10 men with five pack horses. 1 foreman, 3 axmen, 1 cook, 2 sawyers, 1 packer, 2 graders.

Equipment, besides regular camp equipment;

1 grindstone, 1 rock hammer, 1 cross-cut saw, 1 peavy, 1 set of saw-sharpening tools, 5 chopping axes, 2 mattocks, 2 shovels, 1 pick.

When rock work was done the following additional equip-

PLATE I



Trail Built Around a Canyon Box by Packers of Gila Reconnaissance Crew, 1911.

ment was used: 1 bellows, 1 striking hammer, 1 anvil, 2 picks, 1 sharpening hammer, 1 shovel, several drills, 1 rock hammer, dynamite, fuse, and caps.

The maximum grade was 15 per cent, the width of tread 15 inches. Rock work was often unavoidable. The crew averaged one-third of a mile per day. The cost of subsistence including moving was $1.00 per day per man. The average cost of trails was from $90.00 to $100.00 per mile.

The cost of different items based on $100.00 per mile was as follows:

| | |
|---|---|
| Cutting or brushing out | $ 40.00 |
| Grading | 20.00 |
| Subsistence, including cost of cooking and packing | 30.00 |
| Cruising and supervision | 10.00 |
| Total | $100.00 |

*Flathead National Forest, Montana.*

Sixty-seven miles of trail were built, requiring seventy days to complete the work. Two bridges with spans 57 feet and 35 feet respectively were built, but the cost was not kept separate from that of the trail work. Width and grade were not given.

| | Per Day | Per Mile |
|---|---|---|
| 15 men at $2.00 | $30.00 | $31.40 |
| 1 foreman at $3.00 | 3.00 | 3.16 |
| 1 cook | 2.50 | 2.65 |
| 2 packers, 1 at $2.50; 1 at $3.00 | 5.50 | 5.75 |
| 6 hired pack horses | 6.00 | 6.30 |
| 2 men blazing trail at $3.75 | 7.50 | 7.42 |
| Board at $0.70 per man per day | 13.50 | 14.15 |
| Total | $67.80 | $70.83 |

This is considered a little high in this region. The cost would have been about $65.00 without bridge construction.

*Lolo National Forest, Montana.*

A trail was built in 1908, 100 miles long, 6 feet wide, width of tread was not given. There were 8 men in the crew;

horses were furnished. Laborers received $2.00 per day and board. A foreman and a cook each received $75.00 per month. Board cost $17.00 per man per month.

Average cost per mile—grading roughly done:

| | |
|---|---|
| Open ridge | $ 10.00 |
| Ordinary ridge | 30.00 |
| Bottoms (good) | 20.00 |
| Side hills (open) | 15.00 |
| Slide rock (loose) | 50.00 |
| Blasting | 100.00 |

Average of all conditions $37.50 per mile.

*Arapaho National Forest, Colorado.*

The Illinoi Trail was 8¼ miles long. Four men were employed at $3.00 per day. They paid their own board. About 500 feet of corduroy was put in swampy places. Very little grading was done but much ax and saw work was necessary for clearing. The trail followed a creek bed so that there were no extreme grades.

Cost:

| | |
|---|---|
| 1 man 22 days | $ 66.00 |
| 1 man 12 days | 36.00 |
| 1 man 4½ days | 13.50 |
| 1 man 26 days | 78.00 |
| Total 8¼ miles | $193.50 |

The cost per mile was $22.76.

In general, on the Arapaho National Forest trails are laid out by an experienced man while temporary laborers do the grading. The maximum grade is 15 per cent. Corduroy work is avoided because it is very expensive. Guide signs are put in every 5 to 6 miles. In the fiscal year 1909-1910 about 53 miles of trail were built at an average cost of $22.96 per mile. In the fiscal year 1910-1911 about 24 miles of trail were built at an average cost of $12.65 per mile.

*Pike National Forest, Colorado.*

Trails at Fremont Experiment Station were extremely wide, being almost single track roads. A trail one mile long, 6 feet wide, and with a maximum grade of 10 per cent, on which much cutting and dynamiting was done, cost $321.07. Another trail was built around a mountain having a slope from 30 to 50 per cent. The maximum grade of the trail was 12 per cent, width 6 feet. It was 2 miles long and cost $59.82, or $29.91 per mile.

*Gila National Forest, New Mexico.*

The crew consisted of 1 ranger and 2 guards. About 8 miles of trail was remodelled and 9 miles of new trail built. The time put in was 2 weeks. The trail was brushed out, blazed and graded at the following cost:

| | |
|---|---|
| Remodelling | $ 3.00 per mile |
| New trail | $12.00 per mile |

In the Black Range, which is one part of the Gila Forest, 19 miles of trail were built. The crew consisted of 1 American at $3.00 per day and 2 Mexicans at $2.00 per day. The trail was brushed out, blazed and graded. Men boarded themselves. Cost per mile ........ $15.40

*Jemez National Forest, New Mexico.*

About 12½ miles of trail were built for the purpose of opening up a fire patrol route and a sheep driveway. The equipment consisted of 3 picks, 1 root axe, 2 mattocks, 1 crowbar, 2 shovels, 1 cross-cut saw, 3 axes, and 1 grindstone. The first mile had a maximum grade of 15 to 20 per cent, the balance a maximum of 12 to 15 per cent. On this trail 2½ miles were graded through granite rock and oak brush, 4 miles on a mountainside through bunch grass, and 6 miles were cut through fallen timber. The tread was 3 feet wide and the cleared space 8 feet.

Cost:

| | |
|---|---|
| 2 laborers 29 days at $1.50 | $87.00 |
| 1 laborer 16 days at $1.50 | 24.00 |
| 1 laborer 14 days at $2.00 | 28.00 |
| 1 ranger 20 days at $2.50 | 50.00 |
| Tools purchased | 2.15 |
| Total | $191.15 |

The average cost per mile was a little less than $16.00.

*Pecos National Forest, New Mexico.*

The purpose of building these trails was for fire patrol and convenience in traveling. Their average width of tread was 2 feet, cleared space, 6 to 8 feet.

TABLE OF TRAILS ON THE PECOS.

| TRAIL | Number of 8 hr. days. | Time, hrs. | Rate of pay for 8 hr. day | Number men | Maximum Grade per cent | Length of Trail | Cost per Mile |
|---|---|---|---|---|---|---|---|
| Round Mt. | 40 | 144 | $1.50 | 1 | 14 | 2½ | $38.88 |
| | | 248 | 2.00 | 2 | | | |
| Grass Mt. | 24 | 80 | 1.50 | 1 | 14 | 2 | 21.75 |
| | | 112 | 2.00 | 2 | | | |
| Rociada | 21½ | 192 | 1.50 | 7 | 15 | 2½ | 14.44 |
| Gallinas— | | 72 | 1.50 | 2 | 12 | | |
| Noisy Brook | 10 | 8 | 1.00 | 1 | & less | 4 | 3.62 |
| Big Cross | 43¼ | 346 | 1.50 | 3 | 14 | 2 | 32.50 |
| Rio La Casa | 25 | 220 | 2.00 | 2 | 16 | 2½ | 22.00 |
| | | 596 | 1.50 | 2 | | | |
| Rio Chiquito | 103¾ | 218 | 2.00 | 1 | 10 | 6 | 27.71 |
| | | 240 | 2.50 | 1 | | | |
| Indian Creek | 65 | 280 | 2.00 | 2 | 15 | 5 | 44.00 |
| Manzanares | 28 | 224 | 1.75 | 2 | 10 | 6 | 8.16 |
| | | 136 | 2.00 | 1 | | | |
| Angustura | 34 | 136 | 2.50 | 1 | 14 | 3 | 25.50 |
| La Junta | 18 | 48 | 2.50 | 1 | 14 | 4 | 17.50 |
| | | 96 | 2.00 | 2 | | | |
| Duranes Canyon | 6 | 16 | 2.50 | 1 | 16 | 2 | 6.50 |
| | | 32 | 2.00 | 2 | | | |
| Barillas Peak | 19¾ | 146 | 1.75 | 1 | 8 | 8 | 14.96 |
| | | 168 | 2.00 | 1 | | | |
| | | 244 | 1.50 | 4 | | | |
| Alamitos | 8 | 32 | 2.50 | 1 | 10 | 3 | 6.00 |
| | | 32 | 2.00 | 1 | | | |
| Auga Frio | 6 | 32 | 2.00 | 2 | 10 | 2 | 6.50 |
| | | 16 | 2.50 | 1 | | | |
| Totals | 429¼ | 429⅝ days | $1.69 avg. | 48 | | 54½ | $16.66 avg. |

This table shows the average crew to be from 3 to 4 men. The average amount of time to build one mile of trail is 7.88 eight-hour days for one man. The average cost is $16.66 per mile.

*Plumas National Forest, California.*

On the North Fork Trail, 3 miles in length, 75 per cent was through granite cliffs, causing heavy rock work. The trail had a 3 foot tread and a 10 per cent grade.

Itemized cost, per mile:

| | |
|---|---|
| Labor, 6 men at $2.50 per day | $230.00 |
| Hauling material | 3.67 |
| Explosives | 46.05 |
| Tools | 5.18 |
| Coal | 1.05 |
| Total per mile | $285.93 |

This was considered a very expensive trail.

The Merrimac and Robinson trail was built through fairly easy country where very little rock work was required. The maximum grade was 18 per cent, the tread 2½ to 3 feet wide, cleared space 8 feet wide. The cost was $83.00 per mile which is considered a good average for the Sierras.

*Tahoe National Forest, California.*

A trail from Westville down the north fork of the American river, had first a drop of 2,000 feet and then a rise of about 1,950 feet. Its total length was 8.2 miles. The first part of the trail was built through brushy and steep country and in the latter part considerable rock work was necessary. The experiment of plowing the trail with two horses and a sidehill plow was tried, but was not successful on account of the many roots encountered. One bridge was put in at a cost of $337.50. The tread of the trail was 3 feet wide, average grade 10 per cent and maximum 15 per cent. A crew of 5 men was used. The average cost of powder and fuse per mile was $2.75.

| | |
|---|---|
| Cost of bridge and trail | $1609.00 |
| Cost of bridge | 337.50 |
| Cost of trail | 1271.50 |
| Cost per mile | 155.63 |

This cost is considered high. The trail was built in three different periods coming in three successive fiscal years. This necessitated the breaking in of a new crew every year and added considerably to the cost.

*Siuslaw National Forest, Oregon.*

Trail building is very expensive in this region because the heavy rainfall causes very rank and dense vegetation. There is also much fallen timber and many old stumps. In location the Abney hand level was used and the route was marked by blazing. A crew of 10 men and a cook are ordinarily employed. Trails are cleared to a width of 12 feet. The grade does not exceed 10 per cent and the tread is 18 inches wide. Small bridges or culverts are built over streams

Tools for crew of 10 men:

4 peavies.
2 seven-foot cross-cut saws.
10 axes.
6 long handled shovels.
1 leveling shovel. (resembling a hoe.)
6 brush hooks.
1 grindstone.
whetstones and files.
1 lifting jack.

Levels are run along the preliminary survey and any corrections necessary to keep the grade are made, stakes are set, and the swampers follow, clearing the brush. Then the sawyers cut the down logs and roll them out of the way, and the graders follow and dig out the tread to the required width. One man follows the graders scooping out the loose dirt and leveling the trail, which is then considered complete. About 70 miles of trail have been built at an average cost of $200.00 per mile, which includes both cash outlay and forest officers' time for surveying and construction.

Detailed cost of constructing 17 miles of trail:

| | Cost Per Mile | Total Cost |
|---|---|---|
| Surveying | $15.47 | $262.94 |
| Tools | .49 | 8.32 |
| Powder | 18.46 | 313.90 |
| Packing | 8.84 | 150.35 |
| Cook (wages) | 9.82 | 167.04 |
| Swamping | 23.08 | 392.44 |
| Sawing logs | 38.06 | 656.45 |
| Rolling logs | 16.97 | 288.57 |
| Blasting | 6.38 | 108.49 |
| Grading | 57.79 | 982.47 |
| Moving camp | 8.81 | 149.87 |
| Total | $204.72 | $3480.84 |

The cost of tools included only additional tools required to replace those worn out, lost or broken.

There are not enough examples to give a good average for every region with the exception of New Mexico. Nevertheless a comparison of what might be considered an average from each region is given in the following table:

| Region | Men in Crew | Maximum Grade | Tread Inches | Cleared Space Feet | Cost Per Mile | Days for 4 Men to Build 1 Mile of Trail |
|---|---|---|---|---|---|---|
| Montana | 10 | 15 | 15 | 12 | $ 75.00 | 5–7 |
| Colorado | 4 | 15 | 24 | 6 | 20.00 | 2 |
| New Mexico | 4 | 15 | 24 | 6–8 | 16.50 | 1½ |
| California | 6 | 15 | 36 | 8 | 100.00 | 8–10 |
| Oregon | 10 | 15 | 18 | 12 | 200.00 | 18–20 |

This comparison shows that in the more open regions smaller crews are used. The maximum grade is approximately the same. The tread for nearly all trails varies from 1 to 2 feet. The cost is the least in the regions having open stands, in spite of rough topography, while it is greatest in the dense stands even where topography is not as rough, mainly because more clearing out must be done than in the more open region. From these averages an average trail can be suggested as follows: tread 18 inches, grade 15 per cent, cleared space 8 feet, and cost $60.00 per mile.

SPECIFIC EXAMPLES OF ROAD BUILDING.

Very little data can be collected on roads because most roads are built by private parties and often correct and itemized accounts are not kept.

*Malheur National Forest, Oregon.*

An old road 3 miles long with a level grade rarely exceeding 1 per cent and a right of way 40 feet wide was rebuilt. A good deal of grading, some rock work and blasting was required and many stumps had to be chopped out or blasted. Cribbing was done along one side of the road. Supplies were hauled 28 miles. The crew consisted of 10 men at $2.50 and a foreman at $3.00 per day for an eight hour day. Board was furnished.

| Cost: | |
|---|---|
| Hauling | $ 10.00 |
| Wages | 864.21 |
| Supplies | 98.25 |
| Tools | 20.52 |
| Total | $992.98 |
| Cost per mile | $330.99 |

*Gila National Forest, New Mexico.*

A road 10 miles long was built for freighting lumber in September, 1909. It ran up a canyon which had an even grade not exceeding 5 per cent. The road was single tracked and about 8 to 10 feet wide. All work was done with picks and shovels and boulders were shot out with powder. The crew consisted of from 10 to 15 Mexicans at $1.50 per day. It took 15 days to build the road. 50 pounds of powder were used, costing $7.50.

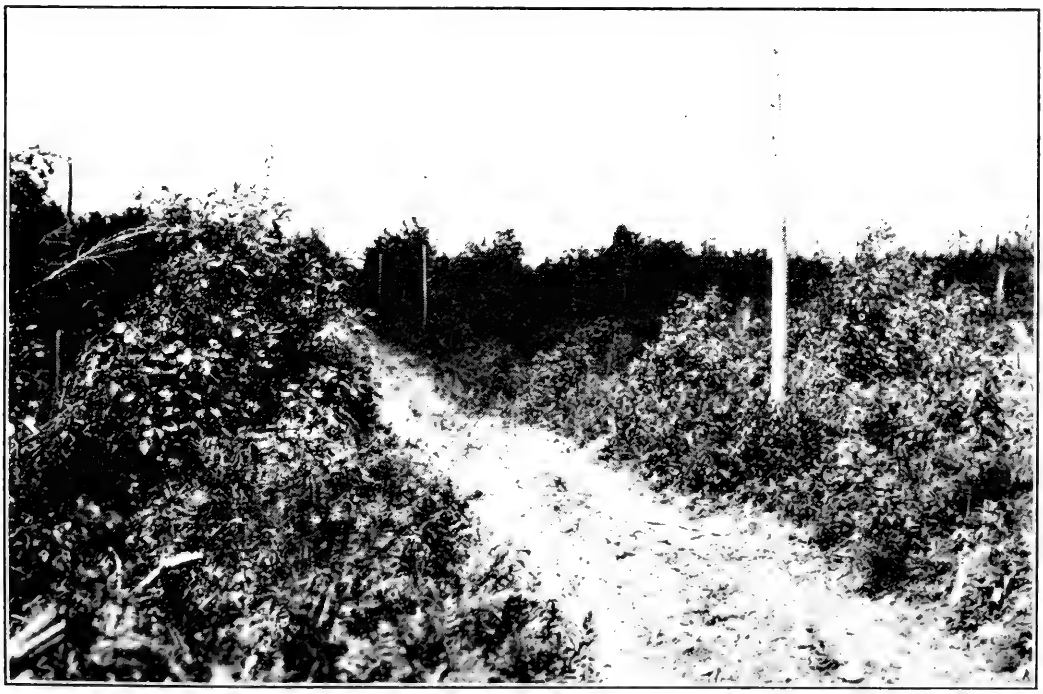
| | |
|---|---|
| Total cost of road | $700.00 |
| Cost per mile | $ 70.00 |

Upkeep costs $10.00 per mile per year.

Another road 1½ miles long was built by the same sawmill owner, up a grade of from 6 to 12 per cent. The road

PLATE II

A Road on the Gila National Forest, New Mexico, Which Cost $466.00 per Mile.



A Fire Line in Wisconsin, Used as a Road.

was built 8 to 10 feet in width. Work was done with picks and shovels as teams could not be used because of the great amount of rocks. The crew consisted of Mexican labor at $1.50 per day and American labor at $3.00 per day. It took about one month to build the road and the crew varied from 1 to 10 men. 60 pounds of powder at 15 cents, 400 feet of fuse at $1.50, and 2 boxes of caps at 75 cents were used, totaling $18.50.

| | |
|---|---|
| Total cost | $700.00 |
| Cost per mile | $466.66 |

The cost of upkeep when logs are being hauled is from $30.00 to $40.00 per mile per year.

The Grand Central Mine Road is 23 miles in length. It was built on an easy grade in the foothills of the Black Range. It is extremely long because it heads up many canyons. In many places it was cut out of solid rock. It was built in 1903.

| | |
|---|---|
| Total cost | $69,000.00 |
| Cost per mile | $ 3,000.00 |

*Alabama.*

No figures were obtained for roads used for logging purposes in this region. The roads are built with an average width of crown of 10 feet and a grade of from 1 to 16 per cent. Colored labor at an average of $1.75 per day is used almost entirely. The tools used are turning plows and wheel and drag scrapers.

*Adirondacks of New York.*

The cost of logging roads built by the Brooklyn Cooperage Company vary from $100.00 to $1,200.00 per mile. The cost is high in the swamps.

*Wisconsin State Forest Reserve.*

Fire lines here are occasionally used for roads. Some fire lines are made along old railroad grades while others are cut through the timber. Many old lines of logging railroads have been abandoned and are easily cleared.

Examples of fire line work in Villas County.

No. 1.

| | |
|---|---|
| Team labor on fire line 2½ miles long | $ 20.08 |
| Men's labor | 20.70 |
| Ranger's labor | 18.00 |
| Board for men and team | 30.22 |
| Total cost | $ 89.00 |
| Cost per mile | $ 35.60 |

Width of fire line, 2 rods; ploughed strip, 1 rod.

No. 2.

| | |
|---|---|
| Team labor on fire line 256 rods long | $ 21.90 |
| Men's labor | 24.10 |
| Ranger's labor | 21.00 |
| Board for men and team | 35.04 |
| Total cost | $102.04 |
| Cost per mile | $125.05 |

The above fire lines were made without reference to old railroad grades.

The following were made from old railroad grades.

| | |
|---|---|
| Cost of pulling ties on 3 miles of old railroad grades | $ 35.00 |
| Team work | 20.08 |
| Board for men and team | 25.92 |
| Total | $ 81.00 |
| Average cost per mile | $ 27.00 |

The average cost of pulling and piling ties from old railroad grades is about $12.00 per mile; the average cost of burning the same, about $35.00 per mile. Four men burn about 100 rods per day. Two men and a team can, under favorable conditions, plow about 90 to 100 rods of old railroad grade per day. The average cost of roads or fire lines made from old railroad grades, burning not included, is about $35.00 per mile. Old railroad grades are left in shape so that they may be used as either fire lines or roads. Fire lines made without reference to old railroad grades, and which are about 2 rods wide cost about $135.00 per mile. The maximum this season was $184.04, and the minimum was $57.69 per mile.

A comparison of roads in general cannot be made because of the few examples and also because of the great variations in the use and construction of roads under different conditions. Forest roads as a rule are single tracked and from 8 to 10 feet in width with a maximum grade of 6 to 7 per cent. The figures given by Mr. Greeley of the United States Forest Service, for the cost of roads in District I, are from $100.00 to $1,000.00 per mile with an average cost of about $500.00 per mile.

Just at present, trails are of much more importance to the United States Forests than roads, because they are much cheaper and can be built in more inaccessible country. Very few roads have been built by the Forest Service, while a great many miles of trail have been constructed during the last few years. The great need of forests at present is an adequate fire protection, for which the trail will suffice, as far as the traveling over the country is concerned. In 1910 an appropriation of $600,000.00 was made for improvements, of which a considerable sum was used for roads and trails, as 2,225 miles of trails and 320 miles of roads were built. In 1911 this appropriation was cut down to $275,000.00. Plans are now prepared for individual forests, which call for the building of over 30,000 miles of trail and 7,000 miles of road at an estimated cost of $3,000,000.00. Several of the states have plans for road and trail construction, notably Wisconsin, Minnesota and a few of the eastern states. In the majority of states however, forestry work does not include road and trail building.

# SHADE TREES FOR STREETS AND PARKS

W. J. Duppert.

One of the most evident present day tendencies is the gathering of population in towns and cities. As these centers become more densely populated the problem of municipal government and the amelioration of the conditions of city life become more acute. Many of our municipalities have, within recent years come to a realization of the fact that shade trees are material aids to the healthfulness and attractiveness of cities and towns and have given much attention to the principles underlying their selection and care. It is hoped that an intelligent appreciation of the requirements of city trees, such as exists in many of the cities of our own country and of Europe, will thus be awakened.

In the treatment of the subject a discussion of the value of shade trees, together with a short account of the species found in various cities, has been given first attention. The merits of the most common trees are next considered and those which have been found by experience to be best fitted for street planting are discussed at some length as well as those which have failed in some respects to fulfill the rigid requirements demanded. Finally the work of planting, protecting, and other operations in the general care of street and park trees are discussed briefly.

The beneficial effects of trees can be seen everywhere. In order to more fully appreciate some of the best influences it is only necessary to travel from a city with few or poorly cared for trees, to one with well shaded streets and beautiful parks. The beauty to be found in a street or avenue which is well planted not only adds pleasure to the inhabitants of the city but also increases the value of the adjoining property and serves to attract men and money to the city. The beautiful avenues of trees such as the sycamores of Paris, the lindens of Cologne, the horse chestnuts, lindens, elms, maples and sycamores of Bonn, and the lindens of Berlin are the source of pleasure to all visitors to those cities. In our own country Washington is noted for its oaks. The Norway Maple and Sycamore are also being propagated in the municipal nursery of Washington, and freely planted with good success. Kansas City is justly famed for its parks, boulevards and beautiful avenues of elms and maples. Memphis, Tennessee, is another city which has expended large sums of money to secure suitable trees for the many parks and boulevards and today stands at the head of American municipalities in the per capita area devoted to parks. The Park Department of Buffalo, N. Y., spent $267,000 in 1910, and through its Bureau of Forestry, planted 3250 trees and pruned about 6,000 trees already on the streets. East Orange, N. J. with a population of 45,000, which is approximately that of Lincoln, Nebraska, has since 1905 employed a tree expert to look after the street and park trees. Many streets have been planted to better species of trees than were formerly found there and many trees have been set out on newly established streets. Pruning and spraying have also received attention so that the streets present a very fine appearance to the visitor and are a source of great pleasure and satisfaction to those who live there.

Trees promote the health of the inhabitants of a city by lessening the intense heat of summer and by purifying the air. The direct rays of the sun are cut off and impure air and gases are taken up by the leaves. The roots, by absorbing much water which would otherwise be left in the soil, make cellars and basements drier. Trees also aid, to a certain extent, in the circulation of air due to differences in temperature above and below the trees.

Trees also have a distinct economic importance. They not only increase in value very rapidly after planting but the value of the property abutting the streets along which trees have been planted is increased to a large extent. No one cares to purchase a piece of property to use as a home without having some trees to cut off the rays of the hot summer's sun and to check the force of strong winds which blow during the greater part of the year. The first cost of planting is very small when the value of the trees in later years is taken into consideration.

The influence of trees in making people happier and better has long been known. The saying "Show me your town or city and I will tell you the kind and quality of your citizens", was never more correct than it is today. Every municipality of modern progressive tendencies possesses three assets—its industries, its commerce and its appearance. It is a well known fact that the morals of a people are in direct relation to their environment. Improve the appearance of your city and you aid in the cultivation of local pride and civic patriotism without which no city can make progress.

SELECTION OF TREES FOR STREETS.

In the selection of trees one of the most important considerations is to choose those which can withstand the unfavorable conditions under which they are forced to grow. The soil along most of our streets is so poor in quality that many trees die of starvation. There may be plenty of soil but the removal of the leaves, the leaching of the soil by continual rains and the filling in of soil along the streets where grading is taking place often produces conditions under which it becomes impossible for trees to secure sufficient nourishment and consequently they become sickly and soon die. The pale green or yellow foliage, the presence of many dead branches and the slender drooping crown are all evidences of improper food conditions.

Lack of ventilation and good drainage are frequent causes of the death of trees. Too much water causes trees to suffer as much as from drouth since surface roots are developed which are sure to die during the drouth which usually follows. A wet soil does not admit the circulation of air, which is necessary to good growth. The free circulation of air is also prevented by filling in around the roots and by packing and tramping the surface soil. Pavements prevent evaporation of water from the surface and also prevent water from reaching the soil. In time of drouth it is often of advantage to the tree to have evaporation from the surface of the ground lessened since trees which would otherwise suffer from lack of moisture may then have an amount sufficient for continued growth.

Street trees which are unprotected from cold winter winds which sweep down the streets often suffer from deformities and breaking of branches. Many trees found in windy situations have their branches turned in one direction, and in some cases branches are torn off and the trees are left to present an unsightly appearance. When the roots of trees are found near the surface of the ground, a long-continued spell of cold weather may cause them to be winter killed.

Gas is often the cause of the death of many trees. If a gas-main springs a leak, the soil in the vicinity will soon become filled with poison and the roots which penetrate the soil, coming in contact with this will absorb gas and soon die. In cases of gas poisoning, the only remedy is to renew the soil as soon as evidences of its effect are noticed.

Smoke issuing from the stacks of furnaces in which soft coal is used contains a vast amount of soot which gathers upon the leaves and bark of trees, filling up the breathing pores, thus retarding the leaves in the performance of their normal functions. Besides the soot present in the smoke of soft coal, a gas is also generated from the sulphur which is present. This gas not only poisons ths leaves, but tends to extract the water from them, thus causing an excessive amount of evaporation.

Electric wires coming in contact with trees are sure to cause damage since the insulation is soon worn away and the death of the tree is sure to follow. In stringing the wires workmen often cut out the tops of trees, leaving them in an unsightly condition, allowing fungi to enter the stubs of branches which remain, thus bringing decay to the trunk of the tree. This source of injury is altogether too common in American cities. Not until electric light and telegraph companies are made to appreciate the fact that as public service corporations, they are obliged to observe the rights of public and private property owners, will this wholesale destruction of trees cease.

In making improvements along the streets, many trees are unnecessarily sacrificed. Guy ropes are frequently attached while buildings are in process of construction and unless the trees are protected, the bark is often broken and the injury resulting allows disease to enter and death is sure to follow. Brick and stones are often heaped around trees and the bark loosened, causing serious injury. Teamsters carelessly allow wagon wheels to come in contact with trees, thus removing the bark. In all cases injuries of this kind can be prevented if the trees are protected by a covering of boards, a cylinder of iron or other material substantial enough to bear the strain put upon it.

If horses are tied to trees, they are almost sure to cause injury by gnawing the bark from the trunk and lower branches. A wire netting placed around trees in localities where horses are likely to be tied will prevent this kind of injury.

### QUALITIES THAT STREET TREES SHOULD POSSESS

*Hardiness.*

All trees should possess certain characteristics in order to be desirable for street planting. In the first place, a tree must be hardy and capable of withstanding unfavorable conditions such as poor soil, drouth, smoke, gases, heat and dust. It must possess strength to resist strong wind, sleet and snow, and must have the ability to recover its normal position when the pressure is removed. It must also endure transplanting well and be easily propagated.

*Form.*

A street tree should have a straight stem, a round, well-shaped crown and should be symmetrical in growth. The natural habit of growth should be preserved as far as possible, but the requirements of the public may demand some pruning. Low branching or crooked trees have no place along the streets and should be confined entirely to the lawn.

*Immunity.*

Insects and fungi cause much injury to trees especially when in a weakened condition. Some species are more subject to injury than others; the lindens and horse chestnuts suffer severely while the oaks are comparatively immune. It is desirable to secure trees which are ordinarily free from pests so that much trouble and expense may be avoided.

*Shade-production.*

Trees should possess enough leaves to furnish shade without depriving the street of all sunlight, preventing the growth of grass underneath, and at the same time allowing a rapid evaporation of water from the street after rain. A desirable tree is one that is not greatly affected by changes of moisture but will retain its foliage in good condition throughout the summer and will attract our attention by its brilliant autumnal coloring.

*Cleanliness.*

Trees which are continually shedding their leaves, bark, twigs, flowers or fruit, have no place on the streets, since they make the side-walks untidy and unsightly. Those which possess attractive flowers and fruit cannot be planted because passersby will often mutilate the trees in their attempt to secure them.

*Longevity.*

When trees are planted it is desirable to secure shade as soon as possible, but in order to obtain this result short-lived species should not be planted. A more desirable species costs but little more and will furnish shade and protection, besides adding beauty to the street for several generations.

### SPECIES TO BE RECOMMENDED.

Many points need to be considered in the choice of material for street planting. It is always advisable to use several species because of the conditions which exist in the various parts of the city. Frequently two or more species will need to be planted on the same street, due to changes in soil or moisture. A careful study of local conditions extending over a period of years is necessary in determining what species to plant. It is safe to say that only a limited number of trees is suitable for planting in any locality.

A list of the trees which are generally considered best for planting may prove helpful to the planter or one interested in the selection of species for street and park work.

### The Maples.

This genus, comprising many species of medium and small sized trees, contains some of the most satisfactory trees for street and ornamental purposes of wide range adaptive to a variety of soils and most easily transplanted.

### Norway Maple (*Acer platanoides* Linn.).

This European tree is the best maple for street planting since it is hardy, a rapid grower and is adapted to almost any soil and situation. It grows a round, compact crown which is often low and which forms a dense shade unless it is skillfully pruned. It is well adapted to city conditions and is free from serious pests. The tree is always rich in appearance, putting forth its leaves early in the spring and is attractive in late summer when most trees show the effects of heat and drouth. The leaves turn a clear yellow before falling.

Sycamore Maple (*Acer pseudoplatanus* Linn.).

This maple is also European but is not so desirable as the Norway Maple since its crown is not so compact and the tree is not so hardy. In appearance it is quite distinctive, having large, dark green, thick leaves and long, reddish stems. It is also subject to the attacks of borers which lessens its value for street use.

Sugar Maple (*Acer saccharum* Marsh.).

Hardy, erect and developing a compact crown of globular outline, the Sugar Maple is an ornament on any street. When set the trees should be from forty to forty-five feet apart to allow for the proper development of the broad, round-topped crown. The leaves grow profusely during the summer and in autumn show beautiful coloring in yellow, orange and red. The tree is not well adapted to a dry, hot climate and is not so desirable as the Norway Maple for planting in the middle west.

Red Maple (*Acer rubrum* Linn.).

This tree is less stiff and regular in its method of branching than the Sugar Maple, but grows a low, compact crown. The bright scarlet flowers and fruit which appear in early spring and the dark green foliage of summer make the trees beautiful until the scarlet foliage of autumn makes it one of the most attractive of any of our brilliantly colored trees. It is seldom attacked by pests. When planted on streets the trees should be placed about thirty-five to forty feet apart.

Box Elder (*Acer negundo* Linn.).

The Box Elder is native from Manitoba south and has a wide natural range. Its ash-like foliage in summer and its green branchlets in winter are the chief attractions. The tree makes rapid growth and forms a compact rounded crown but is short lived and very crooked except under the best conditions. It is planted extensively through the middle west but cannot be recommended where better species of maples will grow.

Silver or White Maple *(Acer saccharinum* Linn.).

This species is irregular in outline, with a rather open, straggling, spreading branch system with long, slender, often pendant branchlets. The foliage is deeply cut, pale green above and silvery white beneath, and when blown by a breeze gives the entire tree a silvery appearance. It grows rapidly on good soil but unfortunately the long weak branches are easily broken by the wind. Because of this fault the streets are always strewn with branches after every storm. Decay soon enters the stubs which are left, follows down the trunk and then the tree presents an unsightly appearance. Where other species can be secured, the Silver Maple should always be avoided.

## The Poplars.

Cottonwood *(Populus deltoides* Marsh.).

Planted very extensively in many cities because of its rapid growth, this species possesses many characteristics which make it undesirable for street planting. It develops a long open crown which nurserymen recommend to be cut back in order to cause the tree to spread. The result of this kind of treatment is to have many stubs in a small crown while the trunk has made normal growth. The wood is weak and brittle, and in storms, many branches are broken off, disfiguring the trees and becoming a source of danger. The roots growing near the surface often raise flagstones and concrete walks, and push curb stones out of place. The roots will enter sewer pipes and form a mass of fibers closing the pipes. The staminate flowers fall on the walks and cause them to become slippery. The pistillate flowers open, spreading a white cottony mass of seeds on the walks and some are blown by the wind into the meshes of screens or stick to theclothing of passersby. The leaves often begin to drop in June and during the entire summer the street will be littered until they have all fallen in autumn.

Because of its many bad habits and few redeeming features many cities have forbidden the planting of poplars and have ordered the removal of those already planted. In Albany, New York, an ordinance was passed in 1871 which provides that no person in that city shall plant or maintain a

Cottonwood and any person who allows such trees to remain on his street premises is guilty of a misdemeanor, punishable by a fine of ten dollars. As a result of this law, which is still in force, all the Cottonwoods were cut down.

Every part of the tree possesses some undesirable feature. Because of this fact poplars should not be planted where other species can be grown. If used at all the trees should be removed as soon as better species have grown to take their places.

Lombardy Poplar *(Populus nigra italica* Meunch.).

This tree is sometimes available for narrow streets where the tall, narrow, erect form may add much beauty. The branches, which are of almost equal length, grow upward at a sharp angle with the trunk. They may be planted close together when the form good windbreaks. The trees are short lived and it is seldom advisable to use them for street planting.

The Oaks.

The desire of most tree planters is to secure trees which grow rapidly. When the oaks are mentioned for use on the streets they are often spoken of as "slow growers" and considerable difficulty is experienced in order to convince many people that they grow as rapidly as some other valuable species such as the hard maples. Some of the finest streets of eastern cities are planted with oaks and the adaptibility of the various species to a variety of conditions make them valuable for planting in other parts of the country. Furthermore, rapidity of growth is not the most desirable quality of shade trees but if trees are properly cared for in the nursery by transplanting frequently they will become more thrifty and grow much more rapidly when planted along the streets.

Pin Oak *(Quercus palustris* Linn.).

This species is planted more extensively than other members of the oak genus. Its typical pyramidal form, the rather short, slender, pendulous branches and the deeply cut unsymmetrical leaves give the tree a characteristically beautiful appearance. The brilliant scarlet coloring in autumn is its crowning glory. The tree is a rapid grower and is readily transplanted, which adds to the value for use in planting.

Red Oak *(Quercus rubra* Linn.).

Growing more rapidly than any other oak and possessing a large symmetrical round or oval shaped crown, the Red Oak is one of our best street trees. The deeply cut leaves, dark green and glossy above and pale green beneath, turning red in autumn, make this tree an object of beauty during the entire summer and autumn. It is adapted to a variety of soils and is one of the easiest and best to plant.

Scarlet Oak *(Quercus coccinea* Muench.).

This tree is less extensively planted than either the Pin Oak or the Red Oak. The round dome-like crown covered with leaves which are a bright green and which are borne on slender petioles and are thus allowed to respond to the faintest breeze forms one of the most attractive species of all the trees found in our cities. The leaves turning to a brilliant scarlet in autumn add a touch of color to a street or park scene which cannot be excelled. Unlike most other species are commonly planted the Scarlet Oak will grow on a dry site.

White Oak *(Quercus alba* Linn.).

This is the most stately and beautiful of our oaks and is justly called the king of the forest. It is a vigorous tree growing to great size and lasting a great many years. A fully developed, broad crowned tree covered with bright green foliage is a most impressive sight. The red and russet colored autumn leaves give it a splendor when the leaves of other trees have fallen. The late shedding of leaves is often objectionable since the walks are covered with litter which has to be removed. It grows more slowly than either the Pin Oak, Red Oak, or Scarlet Oak and grows best in a good loam soil. It cannot be recommended before other members of the genus which have been mentioned.

The Lindens.

American Linden *(Tilia americana* Linn.).

This tree is used quite largely as a shade tree because of its rapid growth, its upright form and rounded outline and its abundant light green foliage. The leaves are heart-shaped and always one sided. The tree is subject to the attacks of insects and the leaves are attacked by a fungus giving them the appearance of being covered with soot. A good rich soil is needed and a great amount of moisture is necessary in order to keep the tree in proper condition.

European Linden (*Tilia europea* Linn.).

Superior to the American Linden on account of its smaller, more compact crown and denser foliage, few trees surpass the European Linden as a shade tree. The branches are drooping when left to grow naturally but when trimmed they take a graceful upward turn. The tree is also subject to insect attacks but is generally less subject to injury due to unfavorable conditions in the city than is the native tree.

The Elms.

White or American Elm (*Ulmus americana* Linn.).

This species is especially adapted to planting on wide streets and requires a deep, moist soil. The tree develops a large, broad-topped, over-arching crown with gracefully drooping branchlets. The foliage generally remains for a long time but has no brilliant coloring in autumn. Insect enemies are quite numerous especially in eastern cities, and spraying is resorted to in order to prevent its defoliation. It should not be planted unless there is plenty of room for the crown to develop, since on the ordinary street there is no room for full growth, and consequently the beauty of the fully developed crown is not attained.

English Elm (*Ulmus campestris* Linn.).

This European species is often planted in place of the native tree. It has nothing to recommed it over the White Elm and is less striking in form and even more subject to insect enemies than is the native species.

The Sycamores.

American Sycamore (*Plantanus occidentalis* Linn.).

The Sycamore grows to good size over a large range and develops into a splendid and shapely tree. The tree is hardy, grows rapidly, and when properly pruned forms a compact, well-rounded crown. The leaves are large but do not form too dense a shade. The young leaves are often attacked by a fungous disease which causes them to turn brown and shrivel up. There is no attractive coloring and the tree is rather uncleanly because of the continual shedding of its bark. It is adapted to most soils, enduring considerable moisture, but requiring considerable light.

Oriental Plane (*Platanus orientalis* Linn.).

This tree possesses the desirable characteristic of rapid growth together with other admirable features of good shade trees. Is is hardy and forms a compact, rounded crown with somewhat denser foliage than the American Sycamore. It is free from fungus diseases and shows a very white skin when the outer bark is shed. Because of the ability to shed its bark the genus of planes is valuable for planting in locations where soot and dirt are present. With the Ailanthus these trees are well adapted to portions of cities where smoke and dust abound.

Horse-Chestnut (*Aesculus hippocastanum* Linn.).

This species is an object of beauty when the leaves first appear in spring. The regular symmetrical, cone-like crown is covered with a profusion of magnificent flowers which is an ornament to any street or lawn. It is especially subject to enemies and the leaves drop early when there has been a period of drouth. Although the tree is tenacious of life it can scarcely be recommended for extensive street planting but may be used very well to a limited extent for park purposes.

Tulip Tree (*Liriodendron tulipifera* Linn.).

The fine symmetrical form, straight trunk and conical outline make this tree one of the largest and most beautiful of all our trees. The leaves are unique, the "chopped off" ends and glossy appearance giving them an individuality of their own. Because the leaves have the fluttering habit of the poplars it is often called Yellow Poplar. The color of the wood gives it the name White-Wood; while the resemblance of the flower to the tulip gives it the name of Tulip Tree. The tree is practically free from insect attacks but the tendency to drop its leaves continually during the summer, the brittleness of its branches and the difficulty in transplanting it are objections to its use for street purposes.

White Ash (*Fraxinus americana* Linn.).

This tree possesses many of the desirable characteristics for city planting. The leaves growing in irregular masses are of light color and never so dense as to exclude the light. Its crown, either rounded or pyramidal, is well adapted to use on the streets, but the late appearance of the leaves in spring and the dropping of the leaves early in autumn are objections to its use. It is adapted to wet and compact soils, but will thrive best on dryer sites.

Hackberry (*Celtis occidentalis* Linn.).

This species resembles the elm in general appearance but has a more compact and spreading crown and a denser foliage. It is tolerant of many soil conditions, being found along streams and also on drier sites, and is comparatively free from diseases. The peculiar warty appearance of the bark is a distinguishing feature.

Ginkgo (*Ginkgo biloba* Linn.).

This tree was imported from China. It is hardy and gives promise of becoming a valuable shade tree. It is entirely free from insect attacks and makes a desirable species to plant as single specimens on lawns or near houses. The city of Washington has used the tree quite extensively for street planting. The fern-like character of the leaf is peculiar and has led to the name of Maiden-hair Tree.

Hardy Catalpa (*Catalpa speciosa* Linn.).

The large heart-shaped leaves and pyramid-shaped clusters of flowers make the catalpa in spring-time one of our most beautiful ornamental trees. The short trunk with long straggling branches which form an irregular crown is not at all attractive except during the period of flowering. The pods hang on the tree during the winter and as they fall to the ground, they break open, allowing their seeds to be tossed about by the winds to litter the street. It is not satisfactory for street planting.

Alianthus* (*Alianthus glandulosa* Dest.).

This tree has many characteristics which render it unfit for street planting. The unpleasant odor given off at blos-

*Ailanthus is not hardy in Nebraska.

soming time together with the ease with which it suckers from the roots are qualities which a street tree should not possess. Young trees, if properly trained, present a graceful appearance in spring time when the leaves first unfold. The leaves are green until late in the fall when frost occurs. The branches look clumsy in winter because there are few small, lateral branches and in severe winters the twigs are frosted back. The tree grows in barren soil and thrives in regions of smoke and dust. When a tree is wanted, not for its ornamental qualities but for its ability to endure adverse conditions the Ailanthus should be given first place.

Black Locust (*Robinia pseudacacia* Linn.).

This species is often used for ornamental and street purposes. It is a rapid grower and adapts itself to almost any soil. The flowers occur in large, fragrant, white clusters which have a most attractive setting against the dark green foliage. On the better sites it develops a round or elliptical crown while on the poorer sites it is ugly, straggling and generally unsatisfactory. The locust borer disfigures the lower part of the trunk and often weakens the tree so that it is broken down by wind. Altogether this is a poor species for street planting when other species can be grown.

### PLANTING SHADE TREES.

When trees are taken from the nursery to be planted on the streets it is necessary to exercise great care in order to allow the trees to make vigorous growth after being placed in their new home. As has well been said, "Transplanting a tree from one site to another is a surgical operation during which the patient needs special attention." In digging up a tree it is advisable to leave as many rootlets as possible in order that it may be enabled to supply the moisture so necessary to good growth. If the root system is not kept intact then it becomes necessary to cut back branches to maintain the balance between roots and crown. The ground must be prepared where the tree is to be planted. If the soil is fertile and there is good drainage a hole can be made large enough to receive the roots in their natural position so there will be no crowding, and the same soil may be put over the roots. If the soil is poor, fertile soil must be hauled in to be placed about the roots in order to provide the nourishment needed by the tree.

Spacing on the street should receive more careful attention than is ordinarily given. Knowledge of the usual spread of the crown will determine the distance of planting. The branches of adjacent trees should not touch but there should be a little space between the crowns. This is necessary to prevent the grass from being killed and also keep the soil beneath the trees from remaining damp after rains.

Of equal importance with the spacing along the street is the arrangement in the parking strips. Ordinarily trees should be planted along the streets at equal distances from the sidewalk and curb. This will allow the roots plenty of room in which to grow and not interfere with either. When trees are planted too near, the roots often raise the walks or push the curbing out of position.

Trees may be planted at any time after the fall of the leaves in autumn and before the opening of buds in spring. In regions subject to severe winters it is best to delay planting until spring. The freezing and drying out of the soil during the winter is quite liable to injure the roots of trees planted in the fall.

When trees are planted they should be protected by stakes to prevent swaying by the wind, which loosens the roots and causes the trees to lean. A guard should also be provided to shield young trees from the bites of horses and prevent other injuries to the stem.

## SOME PERMANENT SAMPLE PLOT STUDIES.

C. F. Korstian.

The study of permanent sample plots originated in Germany in 1860. They were established principally for the study of the development of stands and were to serve as a foundation for the calculation of additional growth and for the construction of growth and yield tables.[1] Accurate data was collected from the plots every three to five years. Work of a similar nature was instituted for the United States Government in 1904 by H. S. Graves and G. H. Myers. This work[2] was intended to cover the following points:

1. To determine the results of different degrees of thinning.
2. To test the effect of the removal of the old trees on those left standing.
3. To study the natural reproduction and the development of the young trees under given conditions.
4. Description plots located in the lumber woods, to observe the results of different kinds of lumbering. In these plots the trees were not measured but a very detailed description of the woods was made before and immediately after logging.

W. D. Sterrett, in an address delivered before the Society of American Foresters February 14, 1907, on "The Objects and Methods of Establishing Permanent Sample Plots,"[3] says that the important lines of investigation in permanent sample plot work should include the following subjects:

1. Growth and yield of the stand.
2. Natural reproduction.
3. Sprout reproduction.
4. Artificial reproduction.
5. Effects of thinning.
6. Effects of fires.
7. Effects of grazing.
8. Growth of trees left after partial clearances, as in lumbering.

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[1]Dr. H. Martin, Die Forsteinrichtung, p. 69, 1910.
[2]H. S. Graves, Forest Mensuration, p. 344, 1906.
[3]Proceed. Soc. Am. For., Vol II, No. 1, p. 63, 1907.

The author points out a great variety of silvical facts which may be obtained in connection with these studies.

C. G. Bates in writing on "Sample Plots for Forest Studies"[1] discusses the importance of ecological methods in forest investigations, especially the problems of silviculture. He shows that concrete data is much more valuable and convincing than an abstract assertive description.

In a later paper[2] Mr. Bates mentions a new departure in permanent sample plot study. The Forest Service and the Weather Bureau are co-operating in an experimental streamflow study. In this case the forested and non-forested watersheds are the sample plots. Accurate measurements of meteorological factors are being made to determine their influence on the ecological and silvical factors.

Practically all of the permanent sample plot studies which have been made heretofore were for the purpose of studying directly or indirectly the silvical or silvicultural factors influencing the forest. Now that the organization and much of the preliminary reconnaissance has been completed by the Forest Service much attention is being turned toward investigative work. It is only within the past two or three years that the establishment of permanent sample plots on the National Forests of District 5 of the Forest Service has been undertaken. The chief purpose of these plots has been to study growth and reproduction. A number of such plots were established in northeastern California on the Tahoe National Forest during the past season. On one of these a new study was undertaken in connection with growth and reproduction. This study is intended to show a comparison between the ultimate net returns from regulated and unregulated cuttings and at the same time a collection of data can be made which could be used in a later study of the effect of marking on Government timber sale areas.

A brief description of this part of the Forest may aid in a better understanding of the methods of study. This plot is located on a Government timber sale area containing about one hundred and sixty acres of Jeffrey Pine and White Fir, which had been cut over the previous year. This portion of the Forest lies on the east slope of the Sierra Nevada mount-

[1]Forest Club Annual, Uni. of Nebr., Vol II, p. 55, 1910.
[2]Proceed. Soc. Am. For., Vol VI, No. 1, p. 53, 1911.

ains at an elevation of about 6,800 feet above the sea level. It is about one mile from Independence Lake, on the headwaters of Sage Hen Creek, a sub-tributary of the Truckee River. The east slope is much steeper than the west because the entire range may be considered as an immense block upheaved from its eastern margin and tilted westward. The prevailing winds blow landward from the Pacific and as they strike the Sierras they lose a portion of their moisture and are deflected upward. This causes a sharp diminution in rainfall and snowfall between the crest of the ranges and the eastern foothills. The climate is decidedly local. Observation of the climate of the Sierras[1] for the past thirty years show the following results at three different stations in the Tahoe National Forest:

TABLE 1.

| Station | Elevation | Mean Annual Temperature | Mean Annual Precipitation | Mean Seasonal Snowfall in Inches |
|---|---|---|---|---|
| Summit | 7,017 | 42.1 | 48.07 | 447.0 |
| Truckee | 5,819 | 43.9 | 27.12 | 191.6 |
| Boca | 5.531 | 43.8 | 20.84 | 148.5 |

Taking these stations as being typical for places having the same elevation on the east slope it can be said that at an elevation of 6,800 feet there is a mean annual precipitation of about thirty to thirty-five inches. From seventy to ninety per cent of the total precipitation falls as snow during the winter, which almost completely disappears by the middle of the growing season except at high altitudes where there is perpetual snow. Mean monthly precipitation tables show that less than five per cent of the annual precipitation occurs during the growing season. A semi-arid condition is the result, especially during the latter part of the season. The rate of growth on the east slope of the Sierras is much less than that on the west side, the timber resembling that in the arid Southwest more than the heavy stands of the true Pacific slope.

The mountains in this part of the Tahoe National Forest are not very rugged. The area has a gentle southeast slope, rising more abruptly to the north and west as the top of the

[1]U. S. Dept. Agri., Weather Bureau, Summary of Climatological Data for U. S., Section 15.

ridge is approached. The surface is smooth, rendering logging easy.

The soil is of a volcanic origin. On the slopes there is a sandy loam derived from the underlying breccias and the decomposition of andesite, intermixed with humus derived from decaying vegetable mould. It is of fair fertility and where deep enough and where moisture is available, can support an excellent forest growth.

The ground-cover consists principally of squawmat *(Ceanothus prostratus* Benth.) and a small sunflower. On the timbered areas little or no grass occurs but in the valleys near streams or springs some grass is found, either of the wet or dry meadow variety.

The underbrush in pure Jeffrey Pine is principally Sage Brush *(Artemisia rigida* Gray). Somewhat higher and confined more to the slopes, Manzanita *(Arctostaphylos manzanita* Parry.) Snow Brush *(Caenothus velutinus,* Dougl.), Chinquapin *(Castanopsis chrysophylla* (Dougl.) A. DC.) and the Scrub Cherry *(Prunus demissa* (Nutt.) Walp.) become quite abundant, especially on the north slopes.

The Jeffery Pine type predominates at this elevation. The more important trees of this type are Jeffery Pine, *(Pinus jeffreyi* "Oreg. Com.") and White Fir *(Abies concolor* (Gord.) Parry.) Less important and scattered species are Lodgepole Pine*(Pinus contorta* Loud.), Incense Cedar*(Libocedrus decurrens* Torr.), Western Juniper *(Juniperus occidentalis* Hook.), Sugar Pine *(Pinus lambertiana* Dougl.) and California Red Fir*(Abies magnifica* Murr.). The average composition of the Jeffrey Pine type in virgin stands is as follows:

| | |
|---|---|
| Jeffery Pine | 77% |
| White Fir | 21% |
| Other species | 2% |

The virgin stands of this type average about 16,000 board feet per acre. The White Fir increases with altitude and soil moisture while the Jeffery Pine drops out and the Red Fir appears, thus becoming the transition between the two types. The density of the stand is determined by soil and moisture conditions where there is a large proportion of Jeffrey Pine while if there is a considerable amount of fir present crown competition often determines the density. The forest is an old uneven-aged stand composed chiefly of overmature and mature trees with a very few of the younger age classes. The mean annual growth for the type has been estimated to be 50 board feet per acre.

Reproduction along the higher portion of the timber sale area is exceptionally good, where it is distributed locally in patches. A dense growth of underbrush which occurs just above the area would be encouraged to take possession of the ground if cutting were too heavy. Three permanent sample plots, each two chains square, laid out for a reproduction study gave the following counts:

TABLE 2.

| | Jeffrey Pine | | White Fir | |
|---|---|---|---|---|
| | Seedlings | Saplings | Seedlings | Saplings |
| Plot 1 | 9 | 0 | 24 | 2 |
| Plot 2 | 7 | 0 | 166 | 196 |
| Plot 3 | 10 | 0 | 88 | 18 |
| Average per acre | 21.6 | 0 | 241.6 | 180.0 |

These figures show that of the entire reproduction on the plots an average of only 4.7 per cent is Jeffrey Pine. In this respect the area is not typical of the type for in pure stands of Jeffrey Pine the reproduction averages eighty per cent Jeffrey Pine and twenty per cent White Fir while in a mixed stand such as the one which is being considered the reproduction runs 60 per cent White Fir and 40 per cent Jeffrey Pine.. This gross abnormality was considered when choosing this sale area because of the opportunity to observe the behavior of reproduction in culled stands which have a high proportion of White Fir.

A permanent sample plot containing twenty acres was laid out on the above-mentioned Government timber sale area. The plot was laid out at right angles to the contours so that average conditions would be obtained. A standard compass was used to get the alignment and the distance was chained. After the entire distance around the plot has been covered and the error of closure found, the courses and distances were checked and the slight error of closure was uniformly distributed. The second time around the plot every two-chain point on the perimeter was marked by a small temporary stake which was later replaced by a permanent one. These were made of Yellow Pine four inches square and about two and one-half feet long. Much time was saved by securing them dressed and sharpened ready to set, at a nearby sawmill. They were driven into the ground a short distance and then surrounded by a mound of rocks. This precaution was taken because an ordinary slender stake driven into the ground would soon topple over under the great pressure of the deep snow. Each stake was scribed S3/11 on one side facing outward from the plot denoting that it was Silvics Plot Number 3, established in 1911. The corner stakes were scribed on two surfaces each facing away from the plot. The plots are numbered so that a definite description may be filed in the office and as data is collected that also may be added to the file for that particular plot.

In marking this timber sale the principles of the shelter-wood system were followed. The main points considered were (1) to stock the cut-over land as fully as possible with Jeffrey Pine and (2) to secure a second cut in thirty years. All pine above twenty inches in diameter breast-high not needed for seed and all merchantable fir above eighteen inches was marked. Where the reproduction was poor the marking was light, leaving a large number of seed trees, but where reproduction was better the marking was heavier. Many of the smaller sized White Fir were used for chute poles and other small material used in exploitation. The utilization of White Fir to as low a diameter limit as the trees are merchantable is advocated in order to reduce the proportion of this species in future reproduction. No large openings were made in the present stand since the exposed ground would be in danger of reverting to chaparral or of becoming so dry from excessive evaporation that no reproduction would follow cutting. Where the stand of Jeffrey Pine was insufficient to reseed thoroughly and protect the cut-over area enough sound thrifty White Fir was left to form a fairly even crown cover. Several of the larger White Fir which had been marked were left by the loggers because they were found to be defective.

On this sale approximately two-thirds of the timber was removed. The virgin stand on this twenty acre plot averaged about 34,000 board feet per acre. The cut averaged 22,000

PLATE I

The Sample Area as it Appeared Before Cutting.

The Sample Area as it Appeared After Cutting.

board feet per acre. About 12,000 board feet per acre was left on the area as seed trees and immature unmerchantable material.

On the entire plot seven Jeffrey Pine and two White Fir were windthrown. These trees represent about 375 board feet of pine and 150 feet of fir per acre or about one per cent of the volume of the entire stand.

The number of trees left standing and the number cut from the plot for each two inch diameter class is shown in the following table:

TABLE 3. STAND BEFORE AND AFTER CUTTING.

| D. B. H. | Jeffrey Pine | | White Fir | |
|---|---|---|---|---|
| | Trees Left Standing | Trees Cut | Trees Left Standing | Trees Cut |
| 6 | 4 | | 8 | |
| 8 | 10 | | 9 | 1 |
| 10 | 13 | | 5 | 1 |
| 12 | 20 | | 11 | |
| 14 | 27 | | 9 | 7 |
| 16 | 30 | | 2 | 6 |
| 18 | 21 | 1 | 1 | 11 |
| 20 | 29 | 2 | 1 | 6 |
| 22 | 42 | 2 | 4 | 5 |
| 24 | 32 | 9 | 3 | 8 |
| 26 | 36 | 5 | 1 | 18 |
| 28 | 39 | 9 | 2 | 11 |
| 30 | 27 | 24 | | 6 |
| 32 | 17 | 11 | 2 | 9 |
| 34 | 17 | 23 | 3 | 6 |
| 36 | 8 | 18 | | 9 |
| 38 | 6 | 11 | 1 | 5 |
| 40 | 4 | 12 | 1 | 5 |
| 42 | | 10 | | 5 |
| 44 | 2 | 8 | 1 | |
| 46 | | 3 | | 2 |
| 48 | 1 | 1 | | 4 |
| 50 | | 4 | 2 | 1 |
| 54 | 1 | 1 | | |
| 60 | | 1 | | |
| 64 | | | 1 | |

As mentioned above this plot was to serve for several different studies. The reproduction study will be used to determine[1] the amount and character of the reproduction secured on a cut-over area and the rate of growth and any other

[1] S. T. Dana, "Silvical Work on the Tahoe," The Tahoe, Vol. I, No. 2, p. 5, 1911.

changes that may occur in the stand, such as windfall, insect, or fungus attacks. Small plots two chains square were laid out and staked as in the large plot. These were carefully mapped and described showing both the tree and shrub growth which might in any way influence reproduction. The seedlings and saplings on the area were counted by species. The results of these counts were given under the discussion of the reproduction. By making periodic studies on these plots, perhaps annually, to record the reproduction and every five years to take growth measurements on the larger trees, it can be determined whether the White Fir is really decreasing or is increasing in proportion to the Jeffrey Pine. The inferiority of the White Fir is due not only to the softness and brittleness of the wood but also to its susceptibility to fungus attacks. Toward the lower limits of its range the lesser mistletoe *(Arceuthobium occidentale* Eng.), causing "witches brooms," is quite abundant. This first weakens the healthy tree which is soon attacked by a heart rot fungus *(Polyporous schweinitzii* Fr.). It is the fruiting bodies, the "conch", of this fungus which warn the woodsmen of the unsound condition of the tree.

If the growth study alone were to have been made, it would have been necessary to measure only the diameter breast-high of all the trees and the heights of five to ten per cent of the trees on the plot. But as a study of the marking was also to be made, each tree over six inches in diameter breast-high and every stump was accurately located so that their exact position could be shown on a map of the plot. (Fig. 1). To do this strips two chains apart were run across the narrow way of the plot starting one chain from a corner. Stations were established on these strips every two chains from which the bearing and the distance of the trees and the stumps were obtained.

All trees, six inches and over, breast-high, were measured, at four and one-half feet from the ground, to tenths of inch with a diameter tape and the point of measurement was marked by a sixteen gauge galvanized iron tag nailed to the tree. These tags were about one and three-quarters inches in diameter with a one-eighth inch hole punched at the top of the tag about one-eighth inch from the outside edge. The numbers were one-half inch in height stamped one-half inch from the base of the tag. The tags were fastened to the trees with No. 12, 6d. copper nails. On old mature trees they were driven in their entire length but on small growth or where the bark was thin, they were driven in to only about one-half inch from the head to allow for the growth of the next five years since the growth study plots are to be remeasured at the end of periods of that length.

The total heights of twenty per cent of all the trees were measured with a Forest Service standard hypsometer; the distance from the base of the tree in each case was carefully measured with a tape. The clear length to the first living limb and the merchantable length to an estimated eight-inch limit was also measured for these trees. The age was estimated from figures obtained from analyses of about one hundred stumps. The results of these measurements were averaged by a series of curves from which the following table was constructed in order to show the relation between the diameter, height, merchantable and clear length, and age of Jeffrey Pine and White Fir:

TABLE 4. RELATION OF DIAMETER TO HEIGHT, MERCHANTABLE AND CLEAR LENGTH, AND AGE.

| D. B. H. Inches | Total Height In Feet | | Merchantable Length In Feet | | Clear Length In Feet | | Total Age In Years | |
|---|---|---|---|---|---|---|---|---|
| | J. Pine | W. Fir | J. Pine | W. Fir | J. Pine | W. Fir | J. Pine | W. Fir |
| 6 | 14 | 20 | | | | | 80 | 72 |
| 8 | 24 | 28 | | | | | 90 | 80 |
| 10 | 34 | 38 | | | | | 104 | 88 |
| 12 | 44 | 46 | 16 | | 21 | | 116 | 95 |
| 14 | 52 | 54 | 22 | | 24 | | 130 | 104 |
| 16 | 60 | 62 | 28 | | 27 | | 144 | 112 |
| 18 | 70 | 69 | 36 | 18 | 29 | 2 | 158 | 124 |
| 20 | 77 | 75 | 44 | 25 | 30 | 4 | 176 | 135 |
| 22 | 84 | 80 | 50 | 32 | 32 | 6 | 194 | 144 |
| 24 | 92 | 86 | 57 | 42 | 33 | 10 | 218 | 154 |
| 26 | 98 | 92 | 63 | 49 | 34 | 13 | 242 | 165 |
| 28 | 104 | 97 | 69 | 55 | 35 | 17 | 266 | 180 |
| 30 | 110 | 102 | 74 | 62 | 36 | 20 | 294 | 198 |
| 32 | 114 | 108 | 78 | 69 | 36 | 23 | 320 | 215 |
| 34 | 117 | 112 | 82 | 75 | 36 | 26 | 352 | 230 |
| 36 | 121 | 117 | 86 | 80 | 36 | 30 | 385 | 245 |
| 38 | 124 | 122 | 90 | 85 | 37 | 34 | 420 | 260 |
| 40 | 127 | 126 | 94 | 89 | 37 | 37 | 460 | 282 |
| 42 | 130 | 131 | 97 | 93 | 37 | 40 | | |
| 44 | 132 | 136 | 101 | 98 | 37 | 43 | | |
| 46 | 134 | 140 | 104 | 102 | 38 | 46 | | |
| 48 | 136 | 144 | 106 | 106 | 38 | 48 | | |

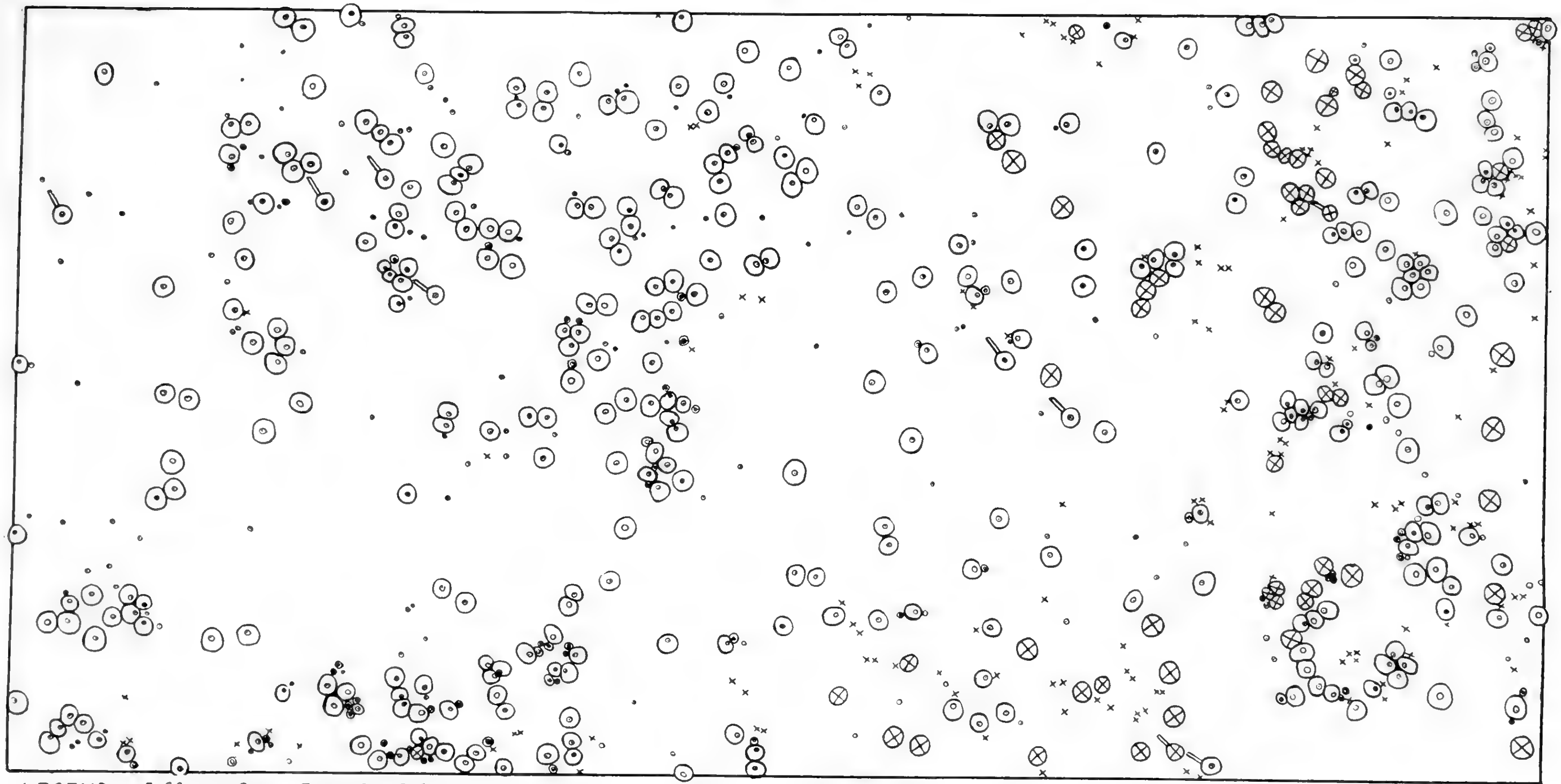
The above data cannot be considered general because the figures were based on the measurement of too few trees occuring in a restricted locality. However, they may be taken as average figures for similar sites. The data is rather surprising in that it shows that on this site Jeffrey Pine between eighteen and forty inches in diameter breast-high is taller than White Fir of the same diameter. The height growth of the Fir is more rapid than that of the Pine. The crown of the Fir is narrow and cone-shaped while that of the Pine is broad and oval. From this fact, since all subsequent cuttings in this type have the nature of a thinning operation, the inference can be drawn that although the Fir is very tolerant and the Pine is intolerant, an immense amount of Fir will be required before it will crowd out the Pine because of the relative size of the crowns of the two species. This will be modified by the policy of marking already described.

The following table shows relative heights of the two species for different age classes. This table was read from a curve which related the ages and heights given in the above table.

TABLE 5. HEIGHT GROWTH.

| Age in Years | Height in Feet | |
|---|---|---|
| | Jeffrey Pine | White Fir |
| 80 | 14 | 28 |
| 100 | 33 | 50 |
| 120 | 47 | 67 |
| 140 | 57 | 79 |
| 160 | 68 | 89 |
| 180 | 79 | 97 |
| 200 | 86 | 103 |
| 220 | 92 | 109 |
| 240 | 98 | 116 |
| 260 | 103 | 121 |
| 280 | 107 | 126 |
| 300 | 111 | |
| 320 | 114 | |
| 340 | 116 | |
| 360 | 118 | |
| 380 | 120 | |
| 400 | 122 | |
| 420 | 124 | |
| 440 | 126 | |

PLATE II



LEGEND - Jeffrey Pine Tree ◎, Jeffrey Pine Stump ∘, White Fir Tree ⊗, White Fir Stump ×, Windthrown ⊸

**Plat of 20-Acre Sample Area Showing Location of Trees and Stumps Above 6 Inches in Diameter.**

A temporary sample plot containing five acres was selected on adjoining private land which had been cut over at the same time that the timber on the Government sale was cut. All merchantable Jeffrey Pine above twenty inches in diameter breast-high and all merchantable White Fir above thirty inches was removed when this area was logged. Privately logged-over areas contain about 1,500 board feet per acre, and have about the following composition:

| | |
|---|---|
| Jeffrey Pine | 65 per cent |
| White Fir | 34 per cent |
| Other species | 1 per cent |

The following data was collected from the two plots for use in the study of the comparative financial returns to be derived from clear cutting, as is the case on most private lands, and from cutting for an anticipated second crop, which is one of the objects of the Forest Service in the management of the forests owned by the Federal Government:

1. All trees left on the permanent plot which would have been utilized in a private logging operation were scaled.

2. All material left on the plot on the privately-logged area which would have been utilized if the logging had been supervised by Forest Officers were scaled.

3. All material was scaled on the plot on Government land which could have been removed but was not.

4. About one hundred stump analyses of Jeffrey Pine and White Fir were made, from which tables were to be constructed showing the time required for a tree to grow from one D. B. H. class to the next. From these tables the rate of growth of the stand in board feet thirty years from now on the plot on the Government land can be computed.

5. About fifty seedling analyses were made which were used to determine the length of time it takes a seedling to grow to stump height. This age must be added to the age of the stump found by analysis. The data obtained in this study was averaged by a curve relating to total age. The following table showing the age of seedlings of various heights was read from this curve:

TABLE 6. HEIGHT AND AGE OF SEEDLINGS.

| Height in Feet | Age in Years | |
|---|---|---|
| | Jeffrey Pine | White Fir |
| 1 | 17 | 18 |
| 2 | 26 | 24 |
| 3 | 33 | 28 |
| 4 | 39 | 32 |
| 5 | 45 | 34 |

The time required for two men to establish the permanent sample plots and collect the data may be summorized as follows:

| | |
|---|---|
| Location, survey and setting stakes | 1 day |
| Running strips through plot and taking measurements | 3 days |
| Making stump and seedling analyses | 3½ days |
| Establishing three reproduction plots | ½ day |
| Total | 8 days |

The cost of establishing the four permanent sample plots and collecting the data may be apportioned as follows:

| | |
|---|---|
| Salaries (One Forest Assistant and one Field Assistant) at $5 per day for 8 days | $40.00 |
| Expenses at $1 per day per man for 9 days | 18.00 |
| 500 galvanized iron tags at $37.50 per 5,000 | 3.75 |
| 5 lbs. No. 12, 6. copper nails at 30 cts. per lb | 1.50 |
| 35 stakes at 10 cts. each | 3.50 |
| Total | $66.75 |

This makes a total cost of $66.75 for establishing (1) the twenty acre plot on which a study of growth, a study of marking and a study of comparative returns will be made, and (2) three reproduction plots each containing four-tenths of an acre. This figure also includes the cost of collecting data for the comparative return study and the first series of measurements for the growth study.

The comparative return study, when completed, should show the following results:

1. The amount and present value of the standing timber per unit area which would have been taken out in an unregulated logging operation.

2. The amount and the present value per unit area left in the woods by the unregulated logging operation which would have been utilized in a Government timber sale.

3. The amount and the future value of the second crop that is expected to be cut in thirty years.

4. The return per cent, calculated at compound interest, on the present investment represented by the value of the anticipated second cut.

In this study the taxes and cost of protection for thirty years will be considered as annual expenses. The cost of marking and brush disposal on the timber sale together with the added cost of logging on Government land, because all of the trees are not removed, will be considered as initial expenses in making the financial calculations involved in the study. These calculations will show the profit or loss at the end of thirty years as a result of conservative cutting.

## NOTES ON THE MANUFACTURE OF VENEER.

R. A. Phillips.

The manufacture of veneer consists in cutting up pieces of wood into very thin sheets. This practise originated in the use of the more valuable woods such as Mahogany, in which the cost of the solid pieces was so great as to place it beyond the reach of many people. When, however, the Mahogany is cut into sheets 1/16 inch or less in thickness and these sheets glued on cheaper woods as a base, the effect is solid Mahogany at a much reduced cost. At present, however, veneer manufacture is not confined to the expensive woods only but many cheaper woods such as Red Gum, Cottonwood and Pine are cut for the manufacture of packing cases, boxes, baskets, and barrels. Cabinet woods such as Oak, Maple, Walnut, Mahogany and Birch are used where beauty of finish is desired.

There are three methods of making veneer,—sawing, slicing and rotary cutting. The sawing method has been longest used and is the best method for Oak, Mahogany and valuable cabinet woods. The slicing method ranks next in the order of quality and is also used for cabinet woods. The rotary cut method is, however, most widely used. In 1909 about 85 per cent of all veneer was cut by the rotary method. It is used principally for Red Gum, Cottonwood, Birch, Tupelo, Elm and Basswood. The veneer industry is rapidly growing and in 1909 there were 435,891,000 board feet cut for veneer which was nearly 10 per cent of the material cut for lumber in that year.

The plant of a company in northern Wisconsin is described here as being typical for the veneer industry. This company owns a two-story frame factory about 80 feet square, on one side of which a two-story brick wing 40 feet square has been annexed to serve as a warehouse. This gives a total floor space of about 15,000 square feet. In the basement are the boiler and engine which furnish power for the machinery and run the dynamo for lighting the plant. On each floor of the factory is a large standpipe for use in case of fire. Just outside the building is a city water hydrant which supplies a pressure of 50 pounds. The total value of the plant is placed at $40,000.

About a million board feet of logs are kept in the log-yard and about 20,000 surface feet of veneer is kept in the warehouse. The species used are Red Oak, Yellow Birch, Ash and Basswood, most of which comes from northern Michigan and Wisconsin. Oak stumpage in 1910 was $18.00 per thousand, Birch $5.00, Ash $8.00, Basswood $10.00. Nothing but number one grade logs over 12 inches in diameter are used.

The process of manufacture consists in cutting the veneer from the log by the rotary method, clipping the veneer into the desired sizes, drying, grading and packing it. The total number of men employed for running the plant and for handling the logs in the log-yard varies from 70 to 80, wages varying from $1.50 to $3.00 per day.

The first step in the process is to cut the logs into lengths corresponding to the size of the three machines used. After being sawed up, the logs are put in a large tank of steam-heated water beneath the floor and soaked for at least 24 hours. This softens the wood and lessens the danger of splitting or breaking the veneer as it is cut off. From the tank the logs are rolled up to their respective machines which accommodate logs 100, 75 and 54 inches in length. At each machine there are three men, who peel the bark from the logs by means of axes. Birch and Oak are harder to peel while Basswood is easiest. The logs are then grappled by hook and chain and hoisted to the machines where they are clamped in by means of a chuck at each end. Fine grained, clear logs are chosen for the better grades and thinner veneers. Logs 14 to 16 inches in diameter cut nicest and give best veneer.

After being set in the machine the log is slowly rotated and a long knife, a trifle longer than the log, is brought to bear on it tangentially so that the veneer is cut off in long sheets. The knife is really composed of two blades and the veneer forced between under pressure. This keeps the veneer from breaking or flying apart. The thickness is regulated by a screw which adjusts the position of the blades, allowance being made for shrinkage as veneer drys. An automatic device causes the edge of the blades to move gradually toward the center of the log as the veneer is cut off. The amount the blades move in one revolution of the log is of course dependent on the thickness of the veneer being cut.

The log is rotated until it is cut down to about 6 inches in diameter. Below this diameter it is difficult to cut good veneer, and besides this, the iron chucks at the end of the log are exposed at this point and interfere with the knife which projects over them. The "core" is then removed from the machine, sawed into 16 inch lengths and sold for firewood at $5.00 per cord. Some of the Oak and Birch cores are sold to sawmills, where they are used for rollers. The sale of core-wood saves the company about $2.00 on every thousand feet of logs they buy.

For the operation of the largest machine which takes 100 inch logs, 6 men are required. One hoister puts the logs in the machine, sweeps them off, gets other logs ready and helps saw up cores. Another man, the operator, tends only to the operation of the machine and regulates the thickness of the veneer. Two helpers assist in the various duties as they are needed and two "breakers" pull the veneer out as it comes from the log, and break it off in strips about 10 feet in length. This machine can take logs up to 50 inches in diameter. For the 75 inch machine one helper less is needed, thus leaving five men to operate. For the 54 inch machine one helper and one breaker are dispensed with, leaving four men. One core cutter is employed for all three machines. The knives in each machine are changed once a week and sharpened. They are whetted three or four times a day. A keener knife is required for Birch than for the other species used.

After the veneer has been cut in long strips it has to be cut up in various sizes depending on its use. This is accomplished by means of the clippers. The clipping machines are three in number and consist of tables 16 feet long with widths varying to accommodate veneer from the different sized machines, 100, 75 and 54 inches. About five feet from the end of the table is the clipping knife, which may be lowered by means of a lever so as to clip pieces of veneer from the long strip to the desired width across the grain. If it is desired to cut the pieces in smaller lengths with the grain. they are fed between two rollers, one of which has small spur-like knife blades on it and cuts the veneer as it revolves. Rollers are kept on hand with different numbers of knife blades on them for cutting different sized pieces. Suppose for instance pieces of veneer 25 inches square are desired. A strip from the 100 inch machine is selected, placed under the clipping blade and a piece is clipped off 25 inches wide. It is still 100 inches long, so it is fed between rollers which have a knife blade at each 25 inch mark. Thus four pieces are obtained each 25 inches square.

As the veneer is clipped while it is still moist, a certain shrinkage factor must be allowed in order to have the pieces the desired size when dry. Shrinkage varies with the species. Basswood shrinks about 10 per cent across the grain, Birch and Oak about 8½ per cent. In order to accomplish this easily, a series of holes are made in the table at certain distances from the knife blade. The distances are figured for certain widths of veneer with the shrinkage allowed. Pegs are placed in the holes so that the veneer may be pulled just to the pegs and clipped off. A different series of holes must be used for species with different shrinkage percents. Shrinkage is thus mechanically allowed for. In clipping the veneer defective parts are cut out. Yellow Birch seemed to have most defects. Oak stood next while Ash and Basswood proved least defective. The defective material was ground up and used for fuel in the furnace.

After being clipped, the pieces of veneer are ready for the dryer. Two methods are used in drying it; one method, the roller dryer, for stock ⅛ inch and less in thickness and the other method, the dry kiln, for stock over ⅛ inch thick. The roller dryer consists of a frame work about 10 feet high, 12 feet wide and 100 feet long, covered with sheet iron. Inside are a series of 900 rollers about 5 inches in diameter arranged in horizontal layers. These layers of rollers are placed very close together and so arranged that they revolve just as the rollers do in a clothes ringer. There are several pairs of rollers which carry the veneer from one end to the other as it is fed between them. When it comes out at the other end it is then fed between other sets of rollers which carry the veneer back causes the edge of the blades to move gradually toward the center of the log as the veneer is cut off. The amount the blades move in one revolution of the log is of course dependent on the thickness of the veneer being cut.

The log is rotated until it is cut down to about 6 inches in diameter. Below this diameter it is difficult to cut good veneer, and besides this, the iron chucks at the end of the log are exposed at this point and interfere with the knife which projects over them. The "core" is then removed from the machine, sawed into 16 inch lengths and sold for firewood at $5.00 per cord. Some of the Oak and Birch cores are sold to sawmills, where they are used for rollers. The sale of core-wood saves the company about $2.00 on every thousand feet of logs they buy.

For the operation of the largest machine which takes 100 inch logs, 6 men are required. One hoister puts the logs in the machine, sweeps them off, gets other logs ready and helps saw up cores. Another man, the operator, tends only to the operation of the machine and regulates the thickness of the veneer. Two helpers assist in the various duties as they are needed and two "breakers" pull the veneer out as it comes from the log, and break it off in strips about 10 feet in length. This machine can take logs up to 50 inches in diameter. For the 75 inch machine one helper less is needed, thus leaving five men to operate. For the 54 inch machine one helper and one breaker are dispensed with, leaving four men. One core cutter is employed for all three machines. The knives in each machine are changed once a week and sharpened. They are whetted three or four times a day. A keener knife is required for Birch than for the other species used.

After the veneer has been cut in long strips it has to be cut up in various sizes depending on its use. This is accomplished by means of the clippers. The clipping machines are three in number and consist of tables 16 feet long with widths varying to accommodate veneer from the different sized machines, 100, 75 and 54 inches. About five feet from the end of the table is the clipping knife, which may be lowered by means of a lever so as to clip pieces of veneer from the long strip to the desired width across the grain. If it is desired to cut the pieces in smaller lengths with the grain, they are fed between two rollers, one of which has small spur-like knife blades on it and cuts the veneer as it revolves. Rollers are kept on hand with different numbers of knife blades on them for cutting different sized pieces. Suppose for instance pieces of veneer 25 inches square are desired. A strip from the 100 inch machine is selected, placed under the clipping blade and a piece is clipped off 25 inches wide. It is still 100 inches long, so it is fed between rollers which have a knife blade at each 25 inch mark. Thus four pieces are obtained each 25 inches square.

As the veneer is clipped while it is still moist, a certain shrinkage factor must be allowed in order to have the pieces the desired size when dry. Shrinkage varies with the species. Basswood shrinks about 10 per cent across the grain, Birch and Oak about 8½ per cent. In order to accomplish this easily, a series of holes are made in the table at certain distances from the knife blade. The distances are figured for certain widths of veneer with the shrinkage allowed. Pegs are placed in the holes so that the veneer may be pulled just to the pegs and clipped off. A different series of holes must be used for species with different shrinkage percents. Shrinkage is thus mechanically allowed for. In clipping the veneer defective parts are cut out. Yellow Birch seemed to have most defects. Oak stood next while Ash and Basswood proved least defective. The defective material was ground up and used for fuel in the furnace.

After being clipped, the pieces of veneer are ready for the dryer. Two methods are used in drying it; one method, the roller dryer, for stock ⅛ inch and less in thickness and the other method, the dry kiln, for stock over ⅛ inch thick. The roller dryer consists of a frame work about 10 feet high, 12 feet wide and 100 feet long, covered with sheet iron. Inside are a series of 900 rollers about 5 inches in diameter arranged in horizontal layers. These layers of rollers are placed very close together and so arranged that they revolve just as the rollers do in a clothes ringer. There are several pairs of rollers which carry the veneer from one end to the other as it is fed between them. When it comes out at the other end it is then fed between other sets of rollers which carry the veneer back to the starting point. Two men are required at each end to "feed" the machine. Steam pipes within the dryer maintain an average temperature of 200 degrees Fahr. The speed at which the rollers revolve determines the length of time the stock remains in the dryer. Thinner veneer dries quicker than thick and Birch dries quicker than Oak. Nearly all will dry, however, in about one hour, hence the rollers are so timed that it takes half an hour for the stock to go one way in the machine, the return trip completing the process. The object of the rollers is to keep the stock under pressure while drying and thus prevent warping and splitting.

Veneer over 1/8 inch in thickness is dried in the dry kiln. This is 72 feet long, 15 feet wide and 8 feet high. It is divided into two chambers 7½ feet wide which connect at the back end. Trucks laden with veneer are pushed in at the mouth of one chamber. As each succeeding truck is placed in the chamber the whole number of trucks is pushed back until at the end the track turns and the trucks run over into and back through the adjoining chamber. The kiln is operated on the moist air principle as follows: the chamber in which the trucks are first placed is kept at a temperature of about 100 degrees Fahr. and the air is kept very moist by means of steam. At the far end of the chamber the temperature becomes about 130 degrees and the air is much dryer. When the trucks have been forced into the next chamber and start back on the return trip the temperature is raised to 160 degrees and a thorough circulation of air is maintained by means of a large fan which draws the moist air out at the side while hot air is supplied from the bottom. The object of this is to keep the pores open on the surface by means of the warm, moist air till the inner cells are dried and moisture is brought to the surface. Then as the temperature is raised and ventilation increases, all the moisture evaporates. Trucks remain in the kiln 24 hours.

After the veneer is dried it is ready to be graded and shipped. The stock is graded by twelve graders who sort it as to species, thickness and quality. Sizes are designated as to machine and net sizes. Machine sizes are those pieces that were clipped while wet and the shrinkage allowed for, while net sizes are cut after being dried to give the exact size. The pieces are then packed in bundles of 75 and sold by the square foot. Birch and Oak are used for door panels and drawers. Basswood is used for drawers, cheese boxes and pyrography, the latter use taking about two car loads per year from this factory.

# EXAMINATIONS FOR HOMESTEADS IN THE NATIONAL FORESTS.

D. G. White.

It is the policy of the Forest Service to put lands within National Forests to their highest economic use. To this end the Federal Government created the Forest Homestead Act of June 11, 1906. This act is an extension of the homestead law to tracts examined under government authority, and found to be of agricultural value, with the essential difference that there is no provision for commutation; that is, the applicant is required to live on the land the entire five years and is not allowed to prove up at the end of fourteen months by paying so much per acre for the land. The Secretary of Agriculture is authorized, in his discretion, to examine and ascertain, upon application or otherwise, as to the location and extent of land within permanent or temporary forest reserves, excepting certain counties of California, that are chiefly valuable for agriculture, and which in his opinion may be occupied for agricultural purposes without injury to the forest reserves, and which are not needed for public purposes. He may list and describe the same by metes and bounds, or otherwise, and file the lists and descriptions with the Secretary of the Interior, with the request that the said lands be opened for entry.

Since all the land on the National Forests has not been surveyed the Act would include all surveyed and unsurveyed agricultural land, and since the recommendations for listing lands are left to the discretion of the Secretary of Agriculture, he may instruct that such lands be suspended from listing as water-sheds, power sites, lands on which standing timber is of considerable importance, or lands which are regarded by the Forest Service to have a higher use than cultivation by one settler. On the Kootenai National Forest provision was made whereby land on which the standing timber ran four thousand board feet per acre was surveyed but suspended from listing until the timber had been cut and removed. When the examiner saw that the timber was of considerable value he made a survey of the land and estimated the amount of timber per acre. On surveyed lands where the cover was of value, listing could be recommended in rectangular plots as small as two and one-half acres. Although the Act of June 11, 1906, reads that the tracts should not contain over one hundred and sixty acres and should not exceed one mile in length, the following construction of the Act was adopted: "Any tract not exceeding 160 acres in area which may be contained in a square mile, the sides of which extend in cardinal directions, is understood to be within the meaning of the law."

"Surveys of tracts entered under this Act will not be required when such tracts can be described as quarter-quarter sections or lotted portions of surveyed sections, or as a quarter or a half of a surveyed quarter-quarter section or rectangular lotted tract, or as a quarter of a half of a surveyed quarter quarter-quarter section or rectangular lotted tract. Only unsurveyed lands and parts of lotted subdivisions of surveyed sections which are not rectangular are to be surveyed, and not platted subdivisions or aliquot parts of such platted subdivisions as are rectangular."

Before October 11, 1911, when it was necessary to survey the land to be listed, two surveys had to be made. Under the Forest Homestead Law it was necessary for the Secretary of Agriculture to recommend to the Secretary of the Interior those lands which were to be listed for settlement, and listing was not possible until a survey was made. Employees of the Department of Agriculture were sent to ascertain the character of the land and find out if it would better suited to agriculture than to forests, and at the same time to make a survey of it by metes and bounds if a survey was necessary. As this survey was not under the supervision of the Surveyor General, another survey authorized by the Land Department was necessary before the title was considered legal. Under this arrangement it was necessary for the settler to pay for the second survey. Now by an agreement between the Secretary of Agriculture and the Secretary of Interior the surveys made by the employees of the Forest Service will be under the supervision of the Surveyor General so that they can be accepted as final by the General Land Office and the applicant will be called upon to meet only the cost of checking up and platting the surveys by the Surveyor General.

Considerable June 11th work was done in the Yaak River Valley on the Kootenai National Forest, Montana, during the summer of 1911, and was typical for the Northern Rockies. Only one application and one examination was considered for one applicant at one time. When application was made for a tract of land the examiner not only examined that tract alone, but all land in the vicinity for which application was likely to be made, and thus obviated the necessity and expense of another trip into the same neighborhood upon similar applications. When examined, each tract applied for was given an application number and each tract examined which was not applied for, was given a unit number. These numbers were for convenience and for reference. All lands was classified as to its value at the time of application. No land chiefly valuable for the standing timber on it was listed for the purpose of a woodlot, since the settler within the forest could secure necessary forest products by a free-use permit. Of course small interior patches of timber could properly be included within the listed areas.

A crew necessary to survey June 11th Homesteads usually consisted of four to six men depending upon the amount and density of undergrowth, the number of small trees, the amount of blazing to be done, and other factors which determined the length of time it took to accomplish the work. Under favorable conditions a crew of five men could run a claim in a day. One or two axmen were usually required to clear and blaze the lines, and they also cut and marked corners and monuments under the direction of the foreman. The foreman of the crew usually ran the compass and kept the notes. One of the crew acted as head chainman and one as rear chainman. It was often convenient for the head chainman to carry a small handax in order to help blaze or to help cut down brush where there happened to be an unusual amount of it on the line.

The equipment usually consisted or two two-pound axes, a small handax, a Forest Service Standard compass and Jacob Staff, a surveyor's chain and pins, a timber scribe, chisel, a rule graduated in inches and twentieths, traverse tables, 6H pencil, protractor, colored crayons, canvass carrying case, and necessary forms and blanks. The camp equipment is not given here as that was typical for the region.

It was necessary before a tract could be surveyed to find or establish a definite land mark, recognized by the Surveyor General, as a Forest Service Monument, a United States Geological Survey Bench Mark, a United States Land Mark, or any corner of an accepted Public Land Survey, and to run a connecting or tie line from such corner to the land applied for; if, however, none of these land marks existed within two miles, a Forest Service Monument was established and a tie line run from that to the tract. The tie line survey was always initiated from that corner of the claim nearest to the monument and this corner was always designated as corner No. 1.

In describing the dimensions of a corner the usual order was length, breadth, and thickness respectively. The dimensions of the corners and witnesses and also the distance the corner was set in the ground was always stated and marked as per instructions. All monuments and corners were set at least one-half their length in the ground and posts were surrounded by a mound of stones and earth, leaving only 1 ft. of the length projecting. Whenever trees or large rocks were not available for witness monuments a mound of stones was erected near the corner and in addition a pit 24x24x12 inches was dug seven feet from the corner across each of the intersecting survey lines.

When there was an adjoining claim and the monuments of the original survey could not be found the lines were retraced, using the intention of the original surveyor as the principal guide for relocation; for this reason the field notes always stated whether the lines of survey followed older authentic lines. When the surveyor found it desirable to locate corners at points coincident with those of the public surveys, or of previous accepted surveys of Ranger Stations or June 11th tracts, it was unnecessary to set a new monument at this point or to place new markings on the old monument, as it was considered sufficient to describe the corner previously set and the markings thereon and state the survey for which it stood.

In meandering a large stream, thus making it the boundary of a claim, no corners were set along the stream except at the ends of the traverse. To designate the banks of the stream the bank on the left hand when proceeding down stream was considered the left bank and the bank on the right hand, the right bank. When there was a considerable number of corners and courses the error of closure was usually large. Although the allowable error of closure was one link to the chain the combined error of latitude and departure for a 160 acre tract was seldom over one-eighth of a link per chain.

It is very important that the surveyor write up field notes and make the plats in the field. Also it was necessary that the notes and reports should be properly signed, as the General Land Office would not accept notes signed with a typewriter or a stamp. In making plats a scale of eight inches to the mile was used. It was desirable to show relief by hachures or in rare cases by contours. When using hachures the system used was three lines in the hachure to indicate the foot of a bench, four lines to indicate the top of a bench, and five lines to indicate the foot of a mountain. (See accompanying map). Ridges are indicated by the conventional chain-link sign. The plat showed all distinct land features, water courses, springs, railroads, trails, wagon roads, log chutes, mining claims, power sites and all important natural and cultural features. The maps were platted in the field. Some distances and directions were figured by latitude and departure, and areas were computed by the double meridian distance method. The composition of the stand as to species and amount of each was shown by heavy black figures and letters, and the type of cover of the land was indicated by colored crayons which showed classifications in conformity with the Forest Service Atlas Legend, as for example, cultivated land was indicated by solid red; areas applied for were surrounded by a blue line; areas recommended for listing by an orange line; and areas suspended from listing by a green line.

In listing lands where it was necessary to protect National Forest interests or the interests of the public at large, a passage on or across said land was reserved. For instance, if it was found necessary to run a road or a trail through a claim, an explicit statement was made in the body of the recommendation stating, "except a strip of land 30 feet wide within the exterior boundary lines thereof which strip is particularly described in the field notes attached hereto.'' The width of the strip was not necessarily 30 feet in each instance but was varied according to the purpose to be served. The starting and closing points of the right-of-way were each marked by a stake or stone, which were established in a manner to conform with the instruction relating to the establishment of monuments and corners. It is not necessary in making right-of-way surveys to mark the turning corners where angles occurred in the interior of the tract recommended for listing.

The regulations required that all the boundaries of the claim should be run and plainly blazed. Any tree standing exactly in the line was blazed fore and aft; those standing at either side of the line or near it, were blazed on two sides quartering toward the line. In blazing for a trail the blaze was about the width of an ax blade, about six inches long, with a horizontal notch at the top of the scar.

In making a triangulation to determine the location of an inaccessible point the field notes always contained a description of all the operations. The formula was inserted on which the computations were based.

The following marks are examples of those that were most commonly used:

F. S. M. = Forest Service Monument.

$\frac{R}{1}$ = Corner one of the ranger station survey.

$\frac{H}{2}$ = Corner two of homestead survey.

$\frac{W}{1}$ = Starting point of right-of-way.

$\frac{W}{2}$ = Closing point of right-of-way.

All monuments or corners had at least two witnesses on which the following system of marking was used:

$\frac{WR}{2}$ = Witness corner two of ranger station survey.

$\frac{WH}{3}$ = Witness corner three of homestead survey.

$\frac{WW}{1}$ = Witness starting point of right-of-way.

$\frac{WW}{2}$ = Witness closing point of right-of-way.

All witnesses were on the claim applied for, unless the corner or monument of the claim was coincident with that of another claim already described. In any case, however, the witnesses were described and their direction and distance given. The witnesses were usually close to the corner or monument and were always within three rods. To indicate the intersection of one of the Forest Service lines with a Land Office line and to show the approximate distance to the nearest Land Office corner, a tree near the point of intersection was barked on the wood about eight by ten inches on the side facing the corner. A letter C with horizontal cross-bars was then scribed upon the scar. The following cut shows the method used:

About 5 chains to corner. | About 10 chains to corner. | About 15 chains to corner. | About 20 chains to corner. | About 25 chains To corner, etc.

In settlement work to indicate the distance to a Forest Service corner the letter S instead of C was used. If this mark was not visible from the trail or road an X was cut

PLATE I

FORM 220.

# UNITED STATES DEPARTMENT OF AGRICULTURE.
## FOREST SERVICE

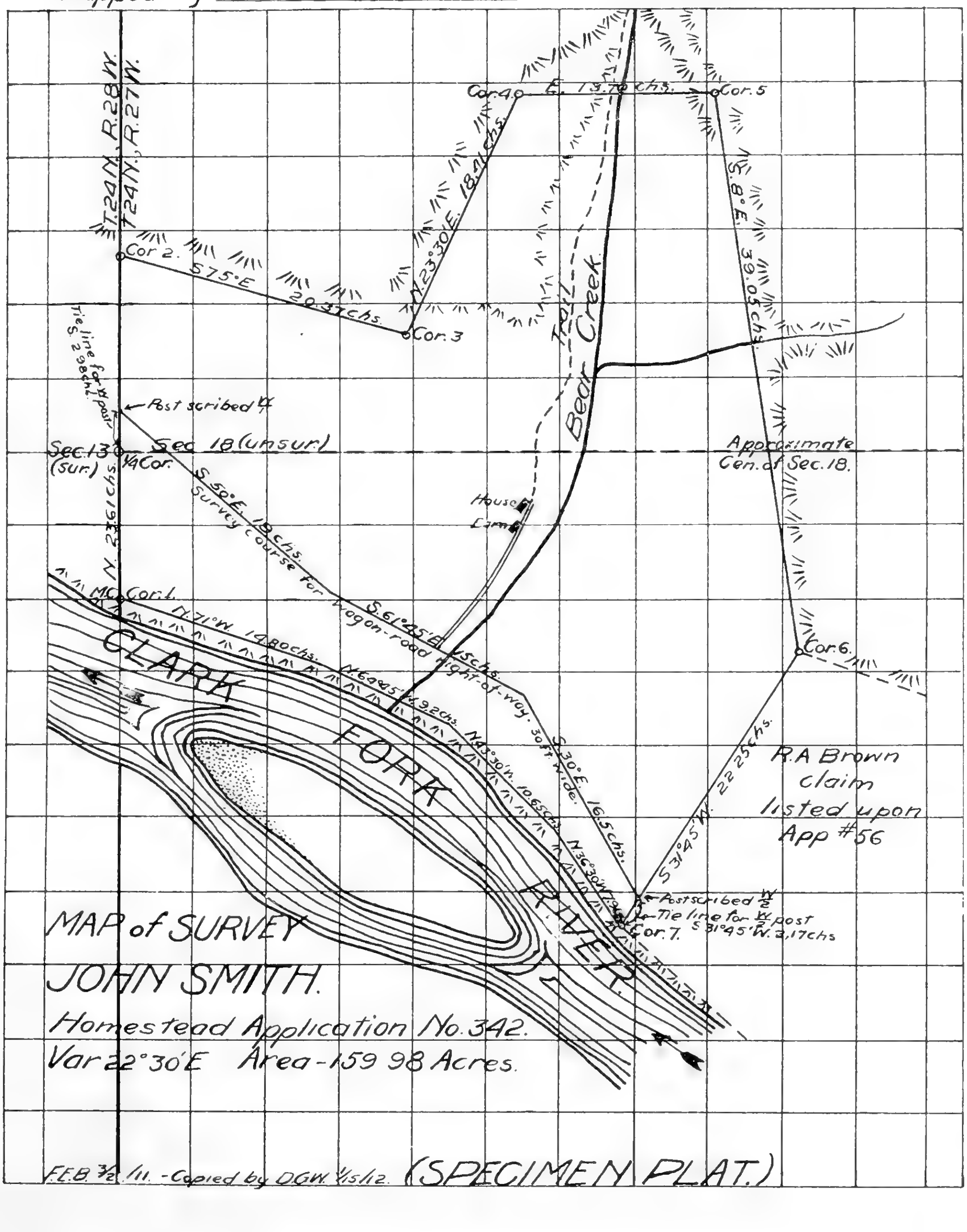
## MAP SHEET

__________ No. __________ Cabinet - National Forest.

Division __________ District ______, Block ______

T. 24 N., R. 27 W., ______ M., Section 18 (uns.) Quarter ______

Mapped by __________ Scale: 8 inches = 1 mile



through the bark on the side toward the highway. The letter Y was often used to indicate that the trail forked at this point and was useful when there is snow on the ground.

The form indicated on pages 64 and 65 of the "Manual of Instructions for Survey of Public Lands" relative to objects intersected by the line or in its vicinity was followed in writing up field notes. The field notes were very thorough and were accompanied by a map of the area. The map always showed in colored pencil the area applied for on a scale of eight inches to the mile, besides topography, cover, trails, agricultural land, and improvements. A small amount of the surrounding country was sketched in. (See accompanying map.) The "Examiners Report on Agricultural Homestead Applications" (Forest Service Form 110) was used.

# NOTES ON BARK STRUCTURE

Theo. Krueger.

There is very little material in English on the subject of bark structure, and most of that is of a very general nature. It was thought that the following notes would be useful especially since they deal with the more common genera of American forest trees. They were taken from Dr. Joseph Moeller's "Anatomie der Baumrinden," published in Berlin, 1882, which gives detailed observations of a great many species including a number of American trees. Whether a sufficient number of species in each genus were studied to allow the generalization of structure for the whole genus remains to be shown by further work. No attempt was made in these notes to collect all of the facts brought out concerning our American trees; the idea of the author was to get a step further away from the broad generalizations that are commonly found, by giving the more prominent features of the genera. The characteristics given hold good for the genus only in so far as they apply to the species investigated.

The bark is composed of three more or less distinct parts: the outer bark includes all tissues outside the innermost layer of phellogen; the middle bark includes primary phloem and the phelloderm of the innermost phellogen layer; the inner bark, the secondary phloem inside the innermost layer of phelloderm.

Bark characters are not sufficiently distinct to make an absolutely reliable key for identification.

It cannot be doubted that the formation of "borke", the scales and plates of bark on the outside of the tree, is not governed by a certain stage of development but rather that it is dependent on outside mechanical as well as physiological influences.

## CONIFERAE.

**Outer bark.** Most conifers develop the periderm during the first vegetative period, and as a rule the epidermis falls off soon afterward. *Pinus* and *Taxodium* keep the epidermis for a longer time and on *Abies* it remains often longer than the third year. The phellogen forms in the second to fifth year or even later in *Cupressus, Sequoia* and *Taxus,* and the epidermis remains longer and expands as the twig thickens.

The differences in appearance and in the method of shedding the plates and scales are due to the position and the lateral extent of the cork-layers, or periderm. In general the inner cork layers resemble in structure the superficial ones. In *Taxus, Sequoia, Abies, Taxodium, Cupressus, Thuja, Libocedrus* and *Juniperus,* the periderm is thin, while in *Pinus, Picea* and *Larix,* it is thickened. The periderm in *Abies canadensis* takes up the coloring matter in alternate layers. The phellogen remains active for more than one vegetative period in *Larix* and so forms annual layers in its periderm: this in other genera is rare. A sclerotic periderm is almost exclusively characteristic of *Pinus.* Excellent examples of ring "borke" are found in *Thuja, Juniperus, Cupressus, Taxodium* and *Libocedrus;* of scaly bark, in *Taxus, Larix, Picea* and *Pinus;* and of bark which does not exfoliate, in *Abies.*

**Middle bark.** A hypoderm of sclerotic fibers is found in *Cupressus, Thuja, Libocedrus, Picea* and *Sequoia;* while in *Pinus* and *Larix* it consists of sclerenchyma cells occurring singly or in groups, around the periphery.

Collenchyma occurs in a typical closed layer in *Picea, Abies,* and *Larix,* while in the remaining conifers it appears as a broken layer of regular sized columnar bundles. *Abies, Picea,* and *Larix* are characterized by sclerotic cells scattered and also in groups throughout the middle bark; generally they have fantastic shapes and the cells are considerably enlarged. These sclerotic cells do not occur in *Pinus, Sequoia, Taxus, Taxodium, Cupressus, Thuja, Libocedrus* nor *Juniperus.*

The phelloderm takes part in the building up of the middle bark in a prominent manner when "borke" formation is late, but is nearly always absent from the inner periderm. It is formed in *Pinus* and *Taxus* but always consists of a very few rows of cells even in heavily developed cork layers. In *Pinus, Larix* and *Picea,* it becomes hardened (sclerotic).

Crystals of calcium oxalate occur in various ways. They are characteristic of *Pinus* in the aggregate form. In *Libro-*
are characteristic of *Pinus* in the aggregate form. In *Libo-*

*cedrus* very fine crystals have been found in the cells, while other genera have crystal sand deposited in the cell-wall, and still others have no crystals whatever.

Primary bast fiber bundles are missing in *Taxus, Taxodium, Cupressus, Thuja, Libocedrus, Juniperus* and most species of *Pinus*. They occur in *Sequoia* and *Taxodium* as weak bundles with the form of the fibers essentially different from that of the secondary bast fibers.

**Inner bark.** The secondary bark of *Sequoia, Taxus, Taxodium, Cupressus, Thuja, Libocedrus* and *Juniperus,* has as a common characteristic the concentric arrangement of the elements. *Pinus,* for the greater part, is characterized by the want of bast fibers and a regular arrangement of the elements of the soft bast.

The bast fibers are arranged in single rows. Their radical distance is three rows of cells of the soft bast in *Sequoia, Taxus, Taxodium, Cupressus, Thuja, Libocedrus,* and *Juniperus.* In the five last mentioned genera the bast fibers have greatly thickened walls and occur in tangential rows in which the slightly sclerotic fibers are occasionally interpolated, and these are nearly always arranged in several tangential rows. The latter is generally the case in *Taxus* where a row of thin walled fibers occur between every two rows of sclerotic fibers. In *Sequoia* all of the bast fibers were found to be entirely sclerotic and here and there stone cells occur. *Pinus* forms no stone cells, while in *Abies, Picea* and *Larix,* sclerotic cells are present.

If the soft bast consists of only three rows of cells which are enclosed between bast fiber layers *(Sequoia, Taxus, Taxodium, Cupressus, Thuja, Libocedrus* and *Juniperus)* then the middle row is parenchyma and the row on each side is made up of sieve tubes. This periodic change in the formation of the elements is demonstrated also in *Pinus* where several layers of sieve tubes are always separated by simple and less numerous rows of parenchyma. The parenchyma cells have large pits; the sieve tubes, which have no cross-plates, are covered along the whole wall with fine-pored sieve plates.

Schizogenous resin pockets are wanting in the secondary bark excepting in *Thuja* where they were found in the outside layers. On the other hand lysigenous resin cysts are characteristic of *Taxodium, Cupressus, Thuja, Libocedrus,* and *Juniperus.*

Calcium oxalate occurs in *Pinus* in the same form as in the middle bark. In *Taxodium, Cupressus, Thuja, Libocedrus,* and *Juniperus,* the radial membranes of all elements and in *Taxus* the whole wall of the bast fibers and stone cells receive deposits of very small crystals.

All conifers have pith rays of a single row of cells, excepting in *Pinus* and *Picea,* where they broaden out to make room for a resin canal.

Key to the Genera:

A. Bast fibers (on cross-section rounded-rectangular) in concentric mostly single rows; 3 rows of soft bast.

1. Bast fibers very thick walled; here and there large stone cells with relatively thin walls.

*Sequoia*

2. Thick walled and thin walled fibers alternating; no stone cells.

(a) Crystals in the walls of the bast fibers; bast parenchyma thick walled, large pitted, free from resin; scaly bark.

*Taxus*

(b) Crystals in all the radial walls; resin cysts; ring "borke." (No safe distinctions in the structure of the bast.)

*Taxodium*
*Cupressus*
*Thuja*
*Libocedrus*
*Juniperus*

B. Bast fibers wanting.

1. No sclerenchyma except the hard walled cork layers; crystals prism-shaped.

*Pinus*

2. Scattered stone cells in the soft bast; isodiametric crystals.

(a) Branched stone cells mostly combined in groups.

(x) Cork layer thin walled.

*Abies*

(y) Cork hard walled; often sclerotic phelloderm.

*Picea*

b. Spindle form, mostly isolated bast-fiber-like stone cells; broad thin-walled cork layer with a narrow layer of sclerotic cork cells.

*Larix*

JULIFLORAE.*

**Outer bark.** In *Salix* the phellogen originates in the epidermis, in the other genera of this group it originates in the outermost layer of cells of the primary bark. On a year old twig usually several layers of cork are present. The epidermis remains on not longer than the second or third vegetative season while the superficial periderm renews itself for a longer period of years, certainly through a decade, and is only exceptionally or perhaps not at all thrown off in *Betula, Fagus* and *Carpinus.*

Strong walled plate cork is formed in *Betula, Alnus, Liquidambar, Ostrya, Carpinus, Corylus; Quercus, Fagus* and *Castanea.* Cubical and thin walled cork cells predominate in *Celtis, Ulmus, Morus, Platanus, Populus* and *Salix;* all of these except *Ulmus* form stone-cork plates.

**Middle bark.** The characteristics of the middle bark are found in the presence of secretion cavities and in the occurrence of sclerenchyma, and perhaps the most noticeable feature is the never failing presence of calcium oxalate crystals in all the genera of this group.

In the occurrence of sclerotic parenchyma several modifications may be distinguished, of which three are given below:

(a) The sclerenchyma accompanies the primary bast fibers and forms a closed ring of mixed stone-cells and bast fibers in *Betula, Alnus, Ostrya, Carpinus* and *Corylus.*

(b) Besides the closed ring mentioned in (a), sclerotic cells occur singly or in groups scattered throughout the whole region of the middle bark in *Celtis, Quercus, Fagus,* and *Castanea.*

(c) The parenchyma does not become sclerotic in *Ulmus* and in some species of *Morus, Salix* and *Populus.*

The phelloderm takes a prominent part in building up the middle bark in those species which have a persistent superficial periderm, and a rather insignificant part in those which do not have. Since the parenchyma of the middle bark does not undergo an unusual tangential stretching, and the primary

*Eichler's classification.

pith rays widen only very little, the growth in thickness must occur through division of the parenchyma of the entire bark.

**Inner bark.** In the secondary bark there is no characteristic common to all the genera of this group. *Betula, Alnus, Platanus,* and *Fagus* are characterized by the absence of bast fibers. Sclerotic bast parenchyma and bast fibers are both found in *Ostrya, Carpinus, Corylus, Quercus, Fagus, Castanea, Celtis, Morus, Liquidambar* and a few species of *Populus,* while bast fibers only and no sclerenchyma are found in *Ulmus, Morus,* and in some species of *Salix* and *Populus.* Several genera are characterized by bast fibers which differ from the usual typical appearance on account of their greater length, unusual fineness, elasticity and cross sectional form; among these are *Ulmus, Celtis,* and *Morus;* while in *Liquidambar* they look somewhat like stone cells.

The soft bast in all of these genera is composed of sieve tubes, parenchyma, and crystal cells. To these elements are added mucilage cells in *Ulmus* and latex tubes in *Morus.* The sclerotic parenchyma cells have a characteristic appearance in some of the genera; in *Quercus* they are very much thickened and have very many fine pores; while in *Platanus* they are only slightly thickened and have broad pores.

The variation in form of crystals and the manner of their distribution throughout the inner bark allows the following characteristics to be listed:

A. Single crystals alone or at least a crystal aggregate.
  1. Between the sclerenchyma cells; bast fibers wanting. *Platanus*
  2. In sclerotic companion cells accompanying the bast fiber bundles. *Liquidambar*
  3. Independent of details of the fiber bundles.
    (a) Exclusively single crystals. *Ulmus* *Celtis*
    (b) Sometimes also crystal aggregates. *Morus*

B. Single crystals and crystal aggregates always present together.
  1. Single crystals clothe the tangential areas of the bast fiber bundles.

(a) Crystal aggregates in soft bast.

*Quercus*
*Castanea*
*Salix*
*Populus*

(b) Crystal aggregates and single crystals in the soft bast.

*Ostrya*
*Carpinus*

2. Crystal aggregates primarily in the soft bast and single crystals in the sclerenchyma; bast fibers wanting.

*Betula*
*Alnus*
*Fagus*

Most of the genera have very broad pith rays, i. e. of more than one row of cells; only *Alnus, Castanea, Salix* and *Populus* have been composed of one row.

In *Fagus, Quercus, Ostrya, Carpinus, Liquidambar* and generally in *Platanus* the walls of pith rays become sclerotic where they adjoin sclerenchyma tissues; while in *Betula, Alnus, Castanea, Corylus, Salix* and *Populus* they remain thin-walled. Pith rays entirely separated from bast strands were found to be sclerotic in *Quercus, Fagus,* and *Platanus.*

In the genera which have pith rays of only one row of cells, no crystals were observed. Crystals in large amounts were found in the pith rays of *Ostrya, Carpinus* and *Corylus;* small amounts in *Quercus, Fagus,* and *Plantanus*; and only very few were found in the rays of *Betula, Castanea, Ulmus, Celtis, Morus,* and *Liquidambar.*

Key to the Genera:

A. Bast fibers wanting.

1. Bast parenchyma largely changed into moderately thickened stone cells, which, as well as wide partly sclerotic pith rays, contain crystals.

*Platanus*

2. Scattered groups of very much thickened stone cells.

(a) The sieve tube elements have a single wide pored cross-plate.

*Fagus*

(b) Numerous sieve plates arranged ladder-like.
(x) Pith rays in one row

*Alnus*

(y) Pith rays in several rows.

*Betula*

B. Bast fibers present, but there are none, or only very few stone cells.

1. Extensive, closely packed bast fiber bundles in tangential rows accompanied by crystal cells; sieve tubes with ladder-form plate system; pith rays of one row.
(One species of *Populus* develops sclerenchyma.)

*Salix*
*Populus*

2. Small bast fiber bundles, loosely grouped and independent of crystal cells; sieve tubes with simple cross-plates; pith rays with more than one row.
(a) Mucilage cells in soft bast; no stone cells.

*Ulmus*

(b) Latex tubes in the soft bast; sclerenchyma present.

*Morus*

C. Bast fibers and sclerenchyma both always present.

1. Bast fiber bundles grouped exclusively in large concentric tangential rows, and accompanied by crystal cells.
(a) Sclerenchyma predominating; pith rays broad, may become sclerotic, any place.

*Quercus*

(b) Regularity of the layers not influenced by the small amount of sclerenchyma present; pith rays one row.

*Castanea*

2. Bast fibers short and knotty combined with stone cells into plates and accompanied by crystal cells; pith rays of several rows.

*Liquidambar*

3. The rows of bast fiber bundles frequently indistinct.
(a) The bast fiber bundles accompanied by crystal cells.

(x) Crystal cells with crystal aggregates in large amounts accompanying the bast fibers.
*Corylus*

(y) Crystal aggregates only in soft bast; single crystals accompanying the sclerotic elements of the bast and the pith rays.

(m) Bast fiber plates in step-like layers.
*Ostrya*

(n) Bast fibers grouped predominantly radially or scattered; primary sclerenchyma ring is complete.
*Carpinus*

(b) Bast fiber bundles, small amount and loosely arranged, not surrounded by crystal cells.
*Celtis*

*Fraxinus.*

**Outer bark.** The periderm develops during the first vegetative period. It originates in the layers of cells of the primary bark, immediately under the epidermis. The outer bark remains thin as a consequence of the quick shedding of the superficial layers.

**Middle bark.** The primary bark is collenchyma like. The stone cells appear only in isolated groups and at first in the spaces between the primary bast bundles but without closing together to complete a sclerenchyma ring. Calcium oxalate occurs in the form of very delicate short crystal needles.

**Inner bark.** Bast fibers accompanied by stone cells from regular tangential concentric bands. The bast fibers are of typical form. The soft bast always forms a very large part of the inner bark. Calcium oxalate occurs as crystal sand or in very minute pointed crystals. The pith rays are very often only one or two rows wide. They contain a large amount of crystals in the same form as the bast parenchyma.

An important characteristic of *Fraxinus* bark is the partial thickening of the pith ray cell walls where they pass between the sclerotic bundles.

Summary:

Sclerenchyma groups are mixed with bast fibers and stone cells in regular concentric arrangement; pith rays occasionally partly sclerotic; bast fibers of typical form; crystal sand and delicate prisms occur in the soft bast and in the pith rays; sieve tubes wide with very large and net-like sieve fields.

*Fraxinus*

*Catalpa.*

**Outer bark.** The periderm is always developed early in the outermost layer of cells of the primary bark. The cells of the cork layer are large, slightly flattened and thin-walled. *Catalpa* has scaly bark.

**Middle bark.** The primary bark is of typical collenchyma, and contains no crystals. It never becomes sclerotic.

**Inner bark.** The secondary bark contains bast fibers in concentric tangential bands, but no stone cells. The soft bast consists mainly of parenchyma and contains an abundance of calcium oxalate in the form of either crystal sand, raphides, or small prisms, without reference to the bast fibers. The pith rays are never more than four rows wide, are never sclerotic and are filled with the same form of crystals as those found in the bast parenchyma.

The most striking characteristic is the absence of stone cell formation in the middle and inner bark.

Summary:

Bast fibers never accompanied by crystals, no stone cells in the secondary bark; pith rays always thin walled. Bast fibers in tangential bands broken only by pith rays; the latter of several rows of cells containing an abundance of raphides and crystal sand as does also the bast parenchyma. The layers of soft bast much broader than those of the bast fibers.

*Catalpa*

*Magnoliaceae.*

**Outer bark.** The periderm develops early. The phellogen originates in the layer of cells immediately adjoining the epidermis. The superficial periderm consists of a few rows of thin-walled cells. The inner periderm is characterized by a layer-like thickening of the cork.

**Middle bark.** A closed although rather weak hypoderma of collenchyma is formed. Short secretion cells are especially characteristic. Sclerotic idioblasts are formed in the middle bark of *Magnolia*. Calcium oxalate is present in *Liriodendron* in the form of fine sand.

**Inner bark.** The bast fibers are regularly arranged in concentric layers. In *Magnolia* they are mixed with stone cells. The bast parenchyma does not become sclerotic in *Liriodendron* while in *Magnolia* it does,but only in the outer layers. Stone cells in *Magnolia* are essentially enlarged and very thick walled. The bast fibers in *Magnolia* have a typical form while in *Liriodendron* they are often tangentially flattened. Calcium oxalate is wanting in *Magnolia* and occurs in *Liriodendron* as sand. *Magnolia* is characterized by secretion cells which are developed from single parenchyma cells. Pith rays are usually not more than three rows wide, but become broader as they approach the middle bark. Their cells are more delicately walled than the bast parenchyma and are generally radially stretched.

Key to Genera:

Bast fibers arranged in regular concentric layers.

1. The layers are a mixture of bast fibers and stone cells. In the young bast of the bundle the stone cells are branched. The sieve tubes are very wide. (In the inner bast layers stone cells are wanting).
*Magnolia*
2. The layers contain bast only; stone cells are wanting. The inner periderm is made up of alternate layers of thin and thick walled cells.
*Liriodendron*

*Tilia.*

**Outer bark.** The phellogen has its origin in the layer of cells immediately adjoining the epidermis. The superficial periderm is fully developed at the end of the first vegetative period; it is thick-walled and like the inner periderm in structure. The collenchyma is small celled.

**Middle bark.** Typical collenchyma forms the outer layer. The pelloderm is always found in *Tilia*. The slight tendency to form sclerotic cells is characteristic. Calcium oxalate is found in large quantities in the form of crystal aggregates.

**Inner bark.** Bast bands are many cells broad and irregular in width due to a bunching of the fibers in places. The bast fibers are always very long, straight and elastic, and are thickened not less than one-third their width. No crystals are present. The crystal cells contain peculiar large prisms, and almost completely surround the bast bundle. The parenchyma cells are nearly as wide as the bast fibers; they never develop into mucilage cells and are never sclerotic. The sieve tubes are broader than the parenchyma, and their ends are slanted and contain several sieve plates. Some of the pith ray cells show between fiber bundles, a trace of sclerotic wall.

Summary:

Tangential bast fiber bundles surrounded by crystal cells. Pith rays broad and wider toward the outside. Sieve-tubes with ladder-like end plates; crystals large, prismatic. Crystal-aggregates in primary pith rays; cork layer evenly small-celled.

*Tilia*

*Leguminosae.*

**Outer bark.** The phellogen develops from a fourth to sixth row of cells below the epidermis in the primary bark of *Robinia;* in *Gleditsia* from the second or third row and in *Gymnocladus,* from the row immediately adjoining the epidermis. The first formed periderm expands with the growth in thickness of the twig for several years in *Robinia.* The superficial periderm rarely reaches large dimensions despite its long persistance. In both *Robinia* and *Gleditsia* it consists of thin-walled spongy cork while in *Gymnocladus* it is thick walled. The cork cells are for the greater part cubical or only slightly flattened in form.

**Middle bark.** The hypoderma of collenchyma cells is either wanting or is only slightly developed. The thin-walled closely fitting parenchyma cells of the primary bark begin, in very young internodes, to become sclerotic between the bast fiber bundles and thus close the thick walled cells into a ring. This feature is characteristic of the *Leguminosae,* as also is the presence of very few crystals in the primary bark. Single crystals are formed in the region of the stone cells and in the thin walled parenchyma.

**Inner bark.** A characteristic of the *Leguminosae* is that the development of the pith rays is never influenced by the bast strands. The latter form concentric layers in *Gymnocladus* and *Gleditsia.* The crystal cells are thin-walled in *Robinia,* and partly sclerotic in *Gleditsia* and *Gymnocladus.* The soft bast of the two last mentioned genera is composed of bast fiber bundles surrounded with a layer of parenchyma and that in turn by layers of sieve tubes and layers of parenchyma alternating. In *Gleditsia,* only, a few aggregate crystals were found. The parenchyma cells are always a little wider than the bast fibers. The sieve tubes in *Robinia* are short, just a little wider than the parenchyma cells, and have simple cross plates; those of *Gleditsia* are much shorter. The pith rays are generally more than four rows wide, and rarely contain stone cells.

Key to the Genera:

Bast fiber bundles or plates in tangential rows cut through by broad pith rays.

1. Sieve tubes with lattice end-plates; bast fiber bundles enclosed by crystal cells, or at least accompanied by them in large quantities. Bundle rows frequently interrupted, accompanied by stone cells, between them smaller bundles and single fibers. Bast fibers more than 1 mm. long, crooked knotty.
   - (a) Sieve tube elements many times broader than parenchyma, with few sieve plates.

     *Gymnocladus*
   - (b) Sieve tube elements not noticeably broad, with large number of coarse pored sieve-plates; crystal aggregates in the bast parenchyma and pith rays.

     *Gleditsia*
2. Sieve tubes with simple cross-plates; bast fiber bundles surrounded by crystal cells, layers of bast fiber bundles alternate with broader and larger celled layers of soft bast; no stone cells; pith rays of even width.

   *Robinia*

*Acer.*

**Outer bark.** The superficial periderm develops in the first vegetative period from the layer of cells immediately under the epidermis.

**Middle bark.** Collenchyma is present; massive primary strands are developed. Calcium oxalate is found in rhomboidal crystals.

**Inner bark.** Stone cells slightly enlarged form an equal or even larger part of the inner bark than do the bast fibers. In older age, the layers of bast fibers are formed only at intervals of many years. The fibers are thin, smooth and long pointed. The sieve tubes, with simple horizontal cross-plates, are arranged in layers alternating with layers of parenchyma. The former are thinner walled. The crystal cells always contain rhomboidal single crystals. Pith rays are three to five rows wide; the cells with thinner walls than the bast parenchyma and stretching radially. The cell walls where immediately joining sclerotic cells do not become thickened.

Summary:

The secondary bark contains layers of bast fibers alternating with larger layers of stone cells. The former are surrounded by crystal cells. Pith rays are broad.

Summary:

*Acer*

List of genera mentioned, the number of species of each that were studied, and what American species investigated.

CONIFERS.

*Juniperus,* 3 species.
*J. communis* L.
*J. virginiana* L.
*Thuja,* 3 species.
*T. occidentalis* L.
*T. gigantae* Nutt.
*Cupressus,* 1 species.
None American.
*Sequoia,* 1 species.
*S. gigantea* Endl.
*Larix,* 2 species.
None American.
*Abies,* 2 species.
*A. canadensis* Mill.
*Picea,* 1 species.
None American.
*Taxus,* 1 species.
None American.
*Taxodium,* 1 species.
*T. distichum* Rich.
*Pinus,* 5 species.
*P. strobus* L.

BROADLEAF.

*Betula,* 2 species.
None American.
*Alnus,* 2 species.
*A. incana* Willd.
*Ostrya,* 1 species.
*O. virginica* L.
*Carpinus,* 1 species.
None American.
*Corylus,* 2 species.
None American.
*Platanus,* 1 species.
None American.
*Liquidambar,* 1 species
None American.
*Populus,* 4 species.
*P. tremula* L.

*Salix*, 2 species
*S. fragilis* L.
*Fraxinus*, 3 species.
*F. nigra* Marsh.
*Quercus*, 6 species
*Q. rubra* L.
*Castanea*; 1 species.
None American.
*Ulmus*, 4 species.
*U. fulva* Michx.
*Celtis*, 2 species.
*C. occidentalis* L.
*Morus*, 2 species.
None American.
*Maclura*, 1 species.
*M. aurantiaca* Nutt.
*Carya*, 1 species.
*C. amara* Nutt.
*Robinia*, 1 species.
*R. pseudacacia* L.
*Gleditsia*, 2 speies.
*G. triacanthos* L.
*Gymocladus*, 1 species.
*G. canadensis*. Lam.
*Catalpa*, 1 species.
*C. syringaefolia* Sims.
*Magnolia*, 1 species.
*M. acuminata* L.
*Liriodendron*, 1 species.
*L. tulipifera* L.
*Tilia*, 3 species.
*T. americana* L.
*Acer*, 4 species.
*A. negundo* L.
*Juglans*, 3 species.
*J. nigra* L.

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The Forest Club will be grateful for corrections in this directory.

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# FOREST CLUB ANNUAL
## Volume V. 1913.

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# GRAZING ADMINISTRATION OF THE NATIONAL FORESTS IN ARIZONA.*

R. R. Hill '06.

The stock industry in Arizona ranks third among the industries of the state with an annual output valued at $6,-000,000. Undoubtedly its relative importance to the prosperity of the state will not diminish because of the ever increasing demand for its products, and because a large part of the range upon which the business is dependent is unsuitable for agriculture. It is estimated that 50,000,000 acres, or about 70 per cent of the entire area of the state will remain, for many years to come, valuable chiefly for grazing. Of this area which is unsuitable for agricultural purposes 14,898,-000 acres, or 30 per cent of the total lies within the National Forests. In 1912, according to the Crop Report, these range lands supported approximately 104,000 head of horses, 774,-000 head of cattle, and 1,565,000 head of sheep. Of this number 8,218, or 8 per cent of the horses, 214,334, or 32 per cent of the cattle, and 415,074, or 26 per cent of the sheep were grazed during at least a part of the year upon the National Forests. The importance of the stock industry and its dependence upon the National Forests make it worth while to consider the grazing administration of the forests; the conditions at the time the ranges were placed under control; the general policy adopted; the bearing which the regulations provided have upon the stock business and other interests; the problems involved; and the probable future of range cotrol.

The dependence of the stock industry upon the National Forests is not due to arbitrary causes but is a result of natural conditions. The great range in altitude, from about sea level in the extreme south-western part of the state to

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elevations of between 6,000 and 12,000 feet over a plateau which extends southeast through the northern and central portions, is reflected in a wide variation in climatic conditions and in the character and composition of vegetation. With these varying though related conditions as a basis, the range of Arizona may be divided into three main classes, the winter range, the summer range, and the all-year range. The following table indicates the correlation of temperature, rainfall, and character of vegetation, with elevation, for three fairly representative localities within these main forage classes:

Early in the history of the stock business a system for handling stock developed whereby each of the three main range types were used at some time during the year. This system has remained in its essential features throughout the development of the industry. The mild winters of the lower valleys and mesas, together with the usually abundant short-lived winter annuals occurring there, make of these areas excellent ranges during the time when the high plateaus are snow-bound. As many stock winter among the foothills, in the all-year range, as the forage and water supplies will accommodate. When the spring droughts dry up the forage and water supplies on the low mesas, the stock on these mesas drift up toward the foothills, where the climate is cooler and where the serious effects of the drought are not felt so early. The consequent crowding of this type during the early spring usually removes all surplus vegetation by the time growth starts on the higher plateaus. By the middle of May the congestion on the lower range is relieved by a large portion of the stock drifting or being driven onto the high forested areas, where they remain until the fall storms force them back to the winter range.

Until the National Forests were created, grazing over the entire public domain was under no restrictions except those imposed by the stockmen themselves. As a result of the lack of a central authority, trouble between sheep-men and cow-men was frequent. The general practice was to sacrifice the future carrying capacity of the range for immediate returns; the range in many places was overstocked; and dry years often found the stand of forage depleted and very little water stored up to tide stock over. Small owners had no recourse when crowded out of business by large owners. Very few stock-men even considered the need of pro-

TABLE SHOWING CORRELATION OF ELEVATION, CLIMATIC CONDITIONS AND RANGE TYPES IN ARIZONA.

| STATION | ELEVATION | MEAN ANNUAL TEMPERATURE | ANNUAL RAINFALL | LOCATION WITH REFERENCE TO SEASONAL RANGE | CHARACTER OF FORAGE |
|---|---|---|---|---|---|
| Congress...... | 3,688 ft | 67° (Fahr.) | 13.2 in. | Lower mesa; winter range dependent upon temporary rain water. | Winter annuals, Cacti, Mesquite, Salt-bushes. |
| Prescott........ | 5,320 ft. | 52.7° (Fahr.) | 17.4 in. | High mesa and foot hills; suitable for year round range if permanent water were available; used mainly in fall, winter and spring. | Perennial grasses, summer and winter annuals; browse including Palo Verde, Oaks, Catsclaw, Mormon Tea. |
| Flagstaff...... | 6,907 ft. | 44.7° (Fahr.) | 23.8 in. | Forest areas—High plateaus; summer range. | Bunch and sod grasses, summer annuals, weeds, and browse including Gambel Oak, Locust, Ceanothus. |

tecting young tree growth against injury by grazing. Although many recognized and deplored these natural results of unrestricted grazing, they felt that government control would not better conditions; that regulation meant interference with their established rights; and that it would demoralize the stock business. The silviculturist, on the other hand, recognized that the prime purpose in withdrawing these large areas of forested lands was to conserve the timber supply. He considered that the forest cover should be maintained and that, if stock were interfering with the growth of young trees, grazing should be restricted and if necessary prohibited.

It became the duty of the forest officers to reconcile the demands of these apparently conflicting interests. The fairest plan proved to be such a coordination of all interests depending upon the forest resources as would result in the fullest use of these resources without jeapordizing their future yield. The policy adopted encouraged the grazing of stock so long as it did not impair the forage cover and did not seriously interfere with the growth of young timber. To accomplish these ends the following general regulations have been provided:

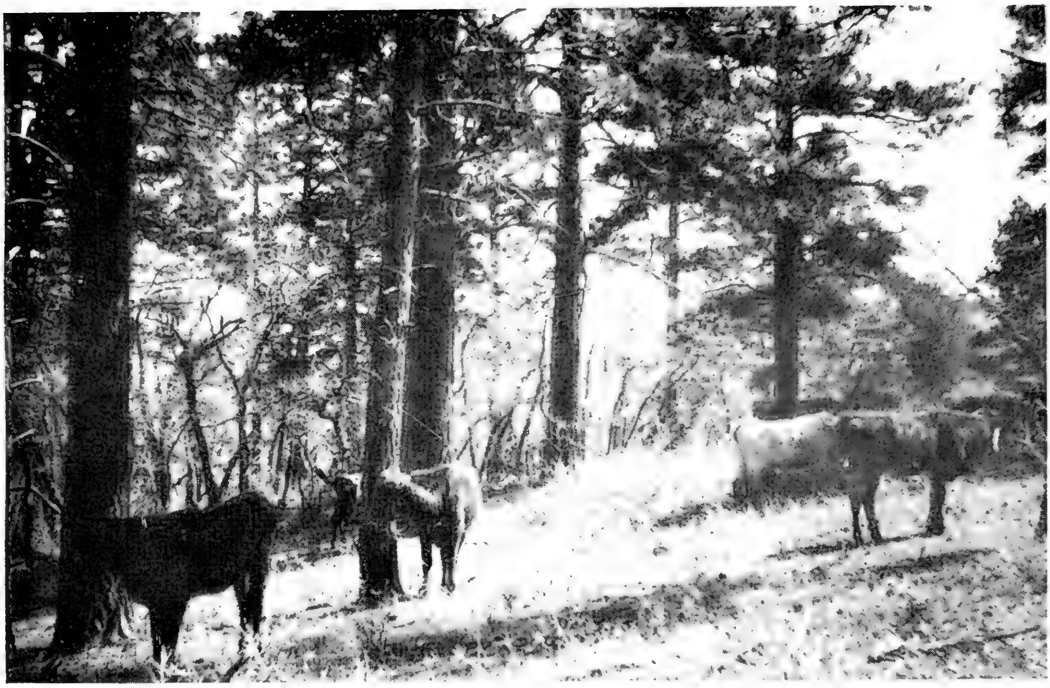
1. Permits are required for all stock using the range. This tends to prevent irresponsible grazing and is the first essential in any sort of range control.

2. Estimates are made each year of the carrying capacity of each forest divided into grazing districts and permits are based upon these estimates. In cases where it is necessary to reduce the number of stock in a given district, the reductions are made gradually, and wherever possible, the surplus stock are shifted to undergrazed areas.

3. Each permit specifies the area of the permitee's allotment. Where stock movements are under control, which is generally the case with sheep, and with cattle and horses where drift fences, pastures, and natural barriers form range boundaries, permittees are required to keep their stock within specified limits. Responsibility for the handling of any allotment is in this way fixed and the best distribution of stock according to the amount of feed and the general condition of the range is secured.

4. Permits specify the opening and closing dates of the season for which they are issued. These dates are so adjusted as to prevent too close grazing before forage growth

PLATE I.



Bunch Grass and Oak Browse in the Western Yellow Pine Type Make an Excellent Long Season Range.

Grama and Bunch Grass Range at the Edge of a Park in the Western Yellow Pine Type. One of the Most Important Forage Types on the Arizona National Forests.

has made a good start and to prevent the holding of stock on the forests after the herbaceous forage is consumed, for then stock might be forced to eat forest reproduction.

5. The development of water sufficient for the number of stock requested is necessary before a permit is issued to use an allotment. This provision is one of the greatest aids in preventing overstocking near old water holes, in opening up otherwise inaccessible range, and in fortifying the stock industry against long droughts.

6. The bona-fide settler is given the privilege of running a certain number of stock. Provision is made for his stock by reducing, if necessary, the number of stock run by the other permittees using the range.

7. A maximum limit restricting the number of stock which any one man or corporation is allowed to run on a forest is established in order to prevent possible monopoly.

8. Speculation is minimized by requiring permittees to own improved ranch property and to be the bona-fide owners of the stock which they desire to run on a forest.

9. Forest officers cooperate with stock associations in determining matters affecting the handling of stock, apportioning the range, and, as far as is practicable, the suggestions of permittees submitted through their advisory boards are considered by forest officers in working out administrative problems.

10. By Act of June 11, 1906 Congress provided that all government land within the forests that was better suited for agriculture than for growing timber should be subject to homestead entry. The liberal application of the provisions of this Act has resulted in many settlers taking up homes within the National Forests. Since these settlers are assured grazing privileges the result has been that the forests are dotted with ranches whose owners are enabled to make a comfortable living by combining farming with stock raising on a small scale. In this way the man of small means is helped in getting a start and the development of these natural resources is encouraged to an extent impossible without government regulation.

The effect of the enforcement of these regulations upon the carrying capacity of the range is indicated by the fact that in 1907 the average area required to support a cow upon the National Forests of Arizona was approximately 48 acres, while in 1912 only 40 acres were required.

The question of the amount of damage done to young forest growth is still unsettled. Special studies are being conducted to determine the various effects of grazing upon forest reproduction, but until these studies are completed no definite conclusions can be drawn. Extensive observations, however, indicate that carefully regulated grazing does not seriously interfere with new forest growth. Probably the damage done by eating tender shoots of seedlings is partly offset by the beneficial effects of keeping the grass cover eaten off, thereby giving the seedlings a more favorable chance to compete with other vegetation. In addition, the trampling, especially that of sheep, has its advantages since it aids germination of tree seed by helping to cover the seeds, mulch the surface, and stir the sod.

One important effect of grazing the forage crop each year has been the great reduction in loss from severe ground fires. Prior to extensive grazing, unrestricted fires did more, perhaps, than any other factor to kill young forest growth.

The development of permanent water and the assurance of continued use of allotments have helped to put the stock industry on a more stable basis. The stock-men know what range and what water resources they can rely upon from year to year and consequently are encouraged to handle their stock so that there will always be a reserve supply of feed and water. In a region where frequent droughts are apt to play havoc with a range having no reserve supply of forage or water these factors are of great importance in determining the stability of the industry. In turn, the increased stability of the industry has resulted in a marked improvement in the quality of range stock during recent years. Generally, only bulls, stallions, or bucks of a standard breed are now placed on the range. This improvement in the quality of stock together with the improved forage and water conditions enables stock-men to sell a larger per cent of sheep and cattle directly from the range for mutton and beef.

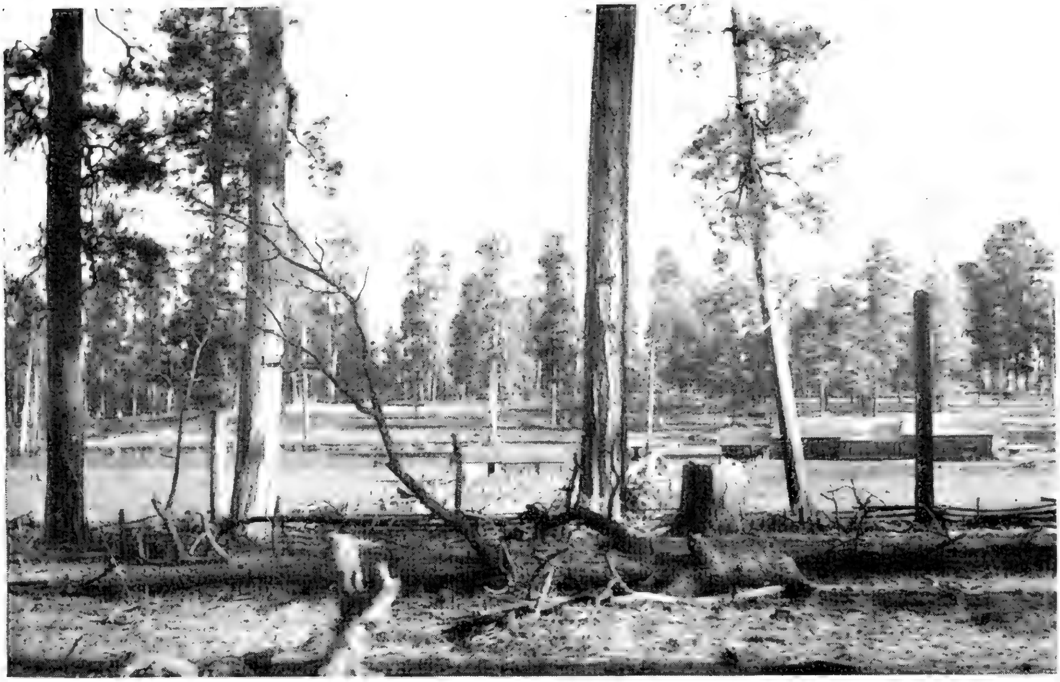
One of the most important results of the grazing administration has been the changed attitude of stockmen toward the Forest Service. While the large majority were originally skeptical of any good resulting from range supervision, if not openly hostile toward the innovation of range control, at present the belief is general that the Forest Ser-

PLATE II.

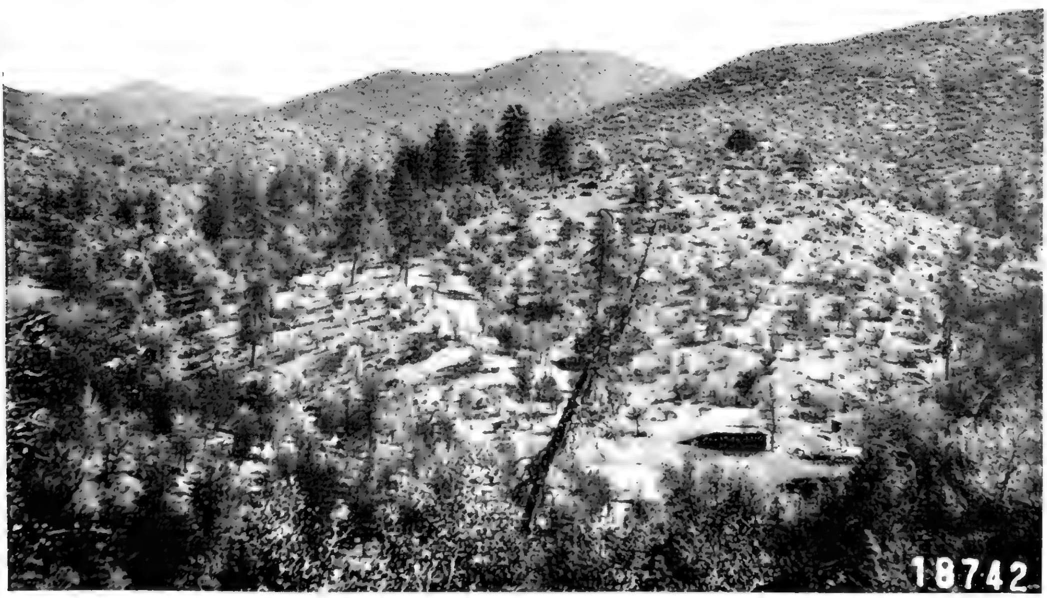
Sheep Feeding on a Sage Brush and Grama Grass Type Near the Lower Limits of a National Forest.

A Mixture of Browse, Weeds, and Grass found commonly among the Foothills makes Excellent Goat Forage.

PLATE III.



Many Parks Within National Forests have been Taken up by Homesteaders who Combine Farming with Stock Raising.




Wherever Springs or Other Natural Water Supplies are Available, Stockmen Have Permanent Camps.

vice has, in the main, justified its establishment. Stockmen are now as anxious to secure Forest Service protection as they formerly were to avoid coming within its jurisdiction. Although they may perceive imperfections in the Service, they believe that conditions have improved under government control and they now protest against excluding their range from the forest, preferring regulated grazing to the lack of control. Undoubtedly the gradual crystallizing of opinion among stockmen in favor of leasing all of the unappropriated public domain is, in a measure, due to the satisfactory results obtained under Federal regulation of the grazing resources of the National Forests.

The Forest Service has been so occupied with matters of organization and administration that until recently little attention has been given to problems of constructive improvement. In order to handle such problems it has long been felt that detailed information regarding grazing resources and conditions was necessary. This information is now being collected by grazing reconnaissance parties on two of the National Forests in Arizona; it is planned to extend the work to include all of the forests. The data collected include a map of each section showing timber and forage types, topography, and a detailed description of soil, forage species, distribution and abundance of poisonous and worthless plants, range destroying animals, utilization of forage, water facilities, and suggested improvements. With this detailed information to supplement the more general and practical information of the administrative officers, it is believed that most of the important range problems may be successfully handled.

Among these problems should be mentioned:

(1) How to secure the best utilization of the range. With detailed information of forage types, including distribution, abundance, and forage value of species and with accurate knowledge of water development, and seasons for which the types are best adapted, the proper distribution of stock becomes largely an administrative problem. Sheep movements can be readily controlled by confining them to certain prescribed allotments. Cattle will have to be controlled by drift fences, natural range boundaries, development of water, salting grounds, and by driving them onto their proper allotments.

(2) How to improve depleted ranges. With these areas

accurately located and described, the most practical remedy is to manage the grazing so that the forage species will have an opportunity to seed. This can be accomplished by shortening the grazing season, by rotating the movement of sheep so that they will not graze on the areas to be protected until the seed has matured. If a certain class of stock is responsible for overgrazing, this class of stock should be shifted to other allotments. Reseeding artificially should be tried and promising exogenous species introduced.

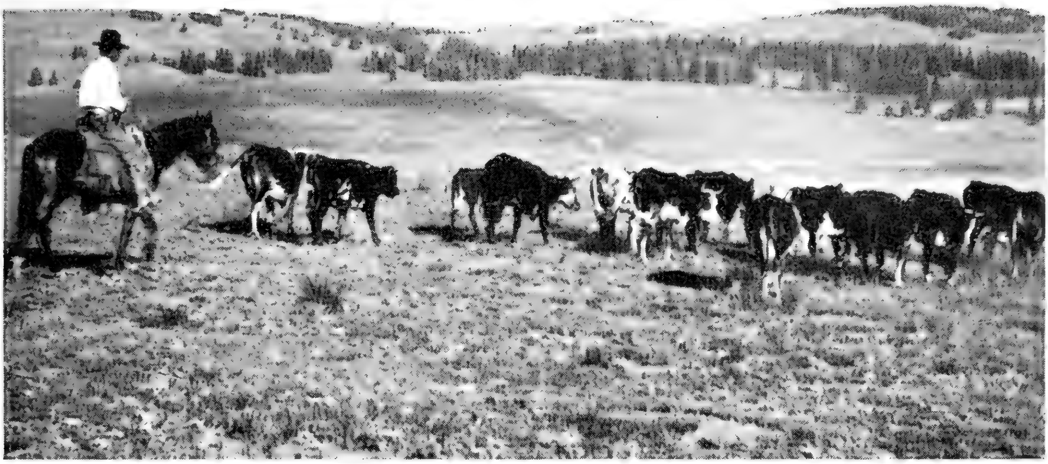
(3) How to prevent serious damage to young forest growth. As soon as the special studies determine the extent of damage, the class of stock mainly responsible, and the conditions under which severe injury is done, steps should be taken to remove the causes of serious injury. It is probable that the measures proposed to secure the best distribution of stock over a range will serve largely to do away with the serious damage to forest reproduction.

(4) How to minimize the danger from poisonous plants. This is a problem which deserves emphatic treatment. The spread of poisonous locos, milkweeds, the pingue, and several other obnoxious weeds over some of the ranges well supplied with forage and water has greatly reduced the practical value of these ranges and threatens to become a very serious menace to grazing not only upon the forests but upon all the higher ranges in the state. The eradication of these objectionable plants is properly a problem for the Bureau of Plant Industry, but the Forest Service with detailed information as to location, abundance, and habits of these plants on the various forests will be in a position to cooperate in any plan to exterminate them. Stockmen will be advised as to the areas infected, the periods when the different plants are apt to injure stock, the seasons when the stock may safely graze infected areas, and any preventives and methods of handling stock whereby the danger from poison may be minimized.

Judging from the state of public opinion, which has changed from one of unfriendliness to one of approval and cooperation toward the grazing administration of the forests in Arizona, it is reasonable to suppose that these ranges will continue under government regulation. In fact, it is entirely probable that the essential features of this control will be extended to all public ranges within the state.

The more intensive plans leading to the best utilization

PLATE IV.



Driving Cattle to Their Range on a National Forest.

A Large Stock Tank in the Woodland Type on a National Forest.

and fairest distribution of all range resources, the improvement of ranges so that they may reach their maximum carrying capacity, and the protection of forest reproduction will become prominent features of the grazing administration policy.

# LOGGING IN SOUTHEASTERN TEXAS.

F. D. Douthitt, '14.

In the southeastern part of Texas, in San Augustine county, the forests are composed of the southern pines mixed with hardwoods. The whole country is a plain about 300 feet above sea-level, cut by numerous streams, leaving the ridges flat and gently sloping to the streams about 200 feet below. These flat ridges vary in width from 1 to 3 miles making up about one-third of the whole area. The slopes are long and gentle and occupy another one-third of the area. The remainder is made up of bottom land and valleys from 2 to 5 miles in width. The soil on the ridges is a yellowish, deep sandy loam which is underlaid by various strata of sand and clay. Erosion has exposed these layers on the slopes so that the soils there vary from several colored sands near the top to blue and yellow clays at the bottom, while in the large valleys the soil is a deep black alluvium. The forest growth on the ridges is pure Longleaf Pine; on the upper half of the slopes a mixture of Longleaf Pine, Loblolly Pine, and some Shortleaf Pine; while on the lower half, stunted hardwoods predominate with scattered Loblolly Pine. The alluvial flats support a pure stand of hardwoods. The rainfall averages about 45 inches annually and is quite evenly distributed throughout the year. The growing season is long, killing frosts occurring only between November and March.

A lumber company is logging by railroad in this county over an area of about 100,000 acres which was formerly in nearly a solid block but is now cut up by interior holdings of small farmers. A railroad, formerly belonging to the company but now a common carrier, divides the area into north and south halves, while a river flowing south cuts the area into east and west halves. This makes the haul down grade for the first half and up grade for the rest of the way. The mill, sawing 100,000 feet B. M. in a 10 hour day, is located on a divide at the west end of the area and the logging operations are now near a second divide at the east end about 50 miles from the mill.

The area now under exploitation, or the "front," is situated on the main slope which is cut up by many small "branches" forming secondary ridges with very gentle slopes causing a breaking up of the general slope type into small patches of the three main types. Longleaf Pine on the tops of the ridges occurs in areas of several sections extent, the pure open stands ranging from 5,000 to 25,000 feet B. M., with an average volume of about 11,000 feet B. M. to the acre. On the slopes Loblolly and Shortleaf Pines occur and occupy an area about equal to that of the Longleaf Pine. This type, averaging about 5,000 feet B. M. to the acre, is scattered and has a dense undergrowth of scrubby oaks, dogwood, and hawthorn. The pines are all straight clean-boled trees, while the hardwoods are scrubby and gnarly due to fire and cattle injury. The Longleaf Pine varies from 2 to 3 feet in diameter and is about 100 feet in height; the Shortleaf Pine from 1 to 2 feet in diameter and about 80 feet in height; and the Lobolly Pine from 2½ to 3½ feet in diameter and a little less than 100 feet in height. There is no pine reproduction.

On the ridges the forest floor is bare of vegetation, while on the slopes the underbrush is so dense that it materially increases the cost of logging.

The camp is located on the main line of the railroad where considerable attention is paid to proper drainage and a good water supply sufficient for camp use and for the locomotives. It consists of about 175 portable houses, 10 boarding cars and 4 commissary cars remaining on wheels, a pump house, and an engine shed. The boarding and commissary cars are set on railroad spurs. The houses, on skids about two feet above ground, are set on both sides of railroad spurs. The camp is divided into three parts called "quarters," one for the whites, one for Mexicans, and one for Negroes. The white "quarter," consisting of about 75 houses and 6 boarding cars, is located near the commissary and office; the Negro "quarter," consisting of about 50 houses and 4 boarding cars is located on a spur about ¼ of a mile from the white "quarter;" and the Mexican "quarter," consisting of about 25 houses, is on the main line of the railroad about ⅛ of a mile from the Negro "quarter."

The portable houses have 24x30 feet of floor space and are 12 feet high at the ridge. They are built in two sections fitting together along the ridge line, each half making a large box and requiring a single logging car for moving. The houses have a door at each end and are equipped with four windows, two on a side. The office with one bookkeeper in charge is located in one of these houses. A carpenter is employed to keep the houses in repair. The commissary cars have 12x48 feet of floor space and are 8 feet high. Two of them are built with one open side in each. When these are set on railroad spurs laid side-by-side, they can be fitted together by the open sides making one storeroom with 24x48 feet of floor space. Another car is used as a storage room and the fourth as an ice and meat house. The cars have three windows in each side and doors at the end. A commissary manager assisted by one clerk has charge of the store. The boarding cars are the same dimensions as the commissary cars and are similar to them except that they have 6 windows in each side and a platform at each end which serves as a porch. Two are fitted up as cook cars, three as dining cars, and five as bunk cars. The engine shed with accommodations for two engines is built of corrugated iron. It is made in sections and can be taken down and moved quite easily. One hostler, who also acts as nightwatchman, cleans the engines at night, oils them, and gets up steam in the morning. Two engines are used regularly although the company keeps four on the operation.

The animals used on the operation are kept at a corral in the woods near where the work is being carried on. The corral is moved when the cutting area gets to be three miles or more distant. A stable built of poles with a corrugated iron roof which comes in sections, feed troughs for 60 head of stock, and 2 water tanks are located in the corral. One man lives in a portable house at this place and does the feeding and shoeing. The feed is stored in two portable houses near by. Feeding is done once a day, in the evening. The feed consists of alfalfa hay and corn chop.

The water supply for the boarding cars, engines, and animals is furnished by a steam pump and is stored in a reservoir several acres in area. The reservoir was made by building a dirt dam across a small "branch." The steam pump with a capacity of 10,000 gallons daily is located in a small wooden house beside the main line. A wooden water tank with a capacity of 2,000 gallons is located beside the pump house. One man is employed to run the pump and he also does blacksmith work at camp. Water is hauled to the corral in the woods in water cars of 800 gallons capacity. The water for the balance of the camp is furnished by 3 wells, one located in each "quarter."

A logging superintendent has general charge of the operation and all business connected with it. Most of his time is spent at camp, although he makes frequent inspection trips to the woods. A wood's foreman has charge of the operation in the woods and spends most of his time there. He also manages the boarding cars and has the fuel contracts, which are mentioned later. A team boss under the wood's foreman has charge of the swamping and skidding crews; he also attends to blazing out logging roads and spends all of his time in the woods. The wood's foreman and the team boss use saddle horses, while the logging superintendent uses a track velocipede on his inspection trips. The scaler working under the wood's foreman has charge of the cutting crew.

The company is logging about 80,000 feet B. M. daily at present but have equipment enough to get out twice as much. The following notes were secured while the logging was being carried on in the slope type.

The cutting is done by contract and all of the sawyers or "flatheads" do their own filing and at present furnish their own equipment, which consists of saws, axes, wedges, bottles of kerosene, and water kegs. Each sawyer uses his own favorite style of saw and ax. The company furnishes the measuring sticks. The cutting force numbers from 12 to 16 men, two men working together. They are principally small farmers who live at home. In felling the trees no care whatever is exercised to prevent injury to the forest, the only object being to make skidding as easy as possible. Everything is supposed to be taken which will cut a log over 8 inches in diameter at the small end and 16 feet long; but as there is no inspection of cutting, such small logs are rarely taken. Sawyers must limb the logs and cut them into lengths which are multiples of 2 feet, allowing one foot on long logs for cross cutting at the mill. The lengths must be from 16 to 32 feet. Long logs are preferred because they mean fewer logs to be handled; furthermore, short logs are difficult to load with the steam loader. This contract system of cutting results in high stumps and tops of large diameter left in the woods. The sawyers cut the tree at a height which enables them to do the most rapid work, usually 2 to 2½ feet above ground, and do not take time to trim far up in the tops if they are very limby. There is no inspection of the cutting, and therefore the sawyers do about as they please.

One scaler has charge of all sawing crews. He blazes small areas about 100 feet square in which each crew works, for the scaling is done in the woods where the tree lies after falling. The Doyle-Scribner Rule is used and no deductions are made for defects. The scaler has a rule with a fixed arm and a sliding arm which he uses as a caliper, scaling the logs outside the bark as near the small end as possible. Using a page in a note book for each crew, he records the number of logs and the scale of each log at every stump, and marks each stump with blue crayon when he scales the logs. At night the scale is entered on special forms in the office. As the company insists on the one foot allowance on long logs, the scaler must carry a tape line in order to check the sawyers on lengths, for they are inclined to leave off the extra foot where more limbing is necessary. The sawyers are supposed to notch the logs every 10 feet but they frequently neglect to do this, especially if they have left off the extra foot; so the scaler is forced to check the lengths frequently. The sawyers can not be certain that the scaler has measured all of their logs, since they attempt to remember the number of logs they cut each day instead of recording them. At night their count seldom agrees with that of the scaler and consequently there is some friction. Since there is no method of arbitration, the scaler's record being supreme, this frequently leads to ill feeling on the part of the sawyers against the scaler. The mill overcuts the wood's scale about 25 per cent, as the sawyers realize this they naturally expect the scaler to be liberal with them. The company is satisfied if the logs are of the required length but considerable diplomacy is necessary to satisfy the sawyers.

After cutting and scaling, the logs are skidded into piles of 1, 2, or 3 depending upon their diameter. This is called "bunching" and is done by horses and swivel tongs. Two teams are used for bunching, each team requiring a teamster or "buncher" and a swamper. The swampers clear the limbs from the logs so the buncher can get them out more easily. They clear what is called a "turn around," an area surrounding the bunched pile of logs, sufficiently large to enable the carts to get over the logs easily, and also help cut side roads to the main roads. Heavy draft horses are used entirely for bunching because their greater weight enables them to pull larger logs than mules can. The "buncher" uses his own judgment in placing the piles of logs where they will be most accessible to the carts and in deciding the number of logs for each pile.

The skidding proper consists in hauling the logs from the bunched piles to the skidways. Carts with 10 foot wheels and a sliding tongue of finished pine are used for this purpose. Each cart has 3 grab hooks, but unless the timber is small only 1 or 2 are used. Four carts are used with an extra one near in case of accident, and four mules are required for each cart. One cart driver, who rides on one of the back or "wheeler" mules, is required for each cart. One man sets the grab hooks for two carts and carries an ax to clear "turn arounds" that were not cut large enough by the swamper who accompanies the bunching teams. One swamper alternates between the four carts helping the "grab setters" make the "turn arounds" large enough. The object is to make work as easy as possible for the cart drivers as far as easy turns and getting over the logs are concerned in order that they can get out the maximum number of logs. This causes the "grab setters" and swampers to complain that they have to clear small farms around each pile of logs.

The skidways, put in by contract, are each about 40 x 48 feet in size. The contractor must clear enough room at both ends for the carts to get on the skidways and then furnish two skid poles for each. After the large trees are sawed off at the ground they are hauled out of the way by a mule and logging chain furnished by the company. The smaller trees and brush are cut with an ax and carried out of the way. The skidways, each made to hold approximately one car of logs, are usually placed in pairs on opposite sides of the track. The contractor furnishes his own tools and employs one or more helpers. Two men usually put in about 8 skidways daily.

One man or sometimes two, depending upon the amount of undergrowth, are kept at road cutting. They cut a main road to each skidway and help the swampers cut side roads. The main roads, about 10 to 15 feet wide, are fairly well cleared; while the side roads, which are rarely used more than once, are cleared only enough to allow the carts to get out easily. Road cutting is done entirely with axes, the trees being felled along the road and pulled to one side.

The logs from the carts are handled on the skidways by two "skidwaymen." Each "skidwayman" handles the logs from two carts, each of which hauls about 100 daily. The McGiffert steam loader is used for the cars. One engineer, one fireman, and three negro "tong pullers" constitute the loading crew, which works under the direction of the wood's foreman. These men work on a "task," which consists of loading the cars brought to the woods the day before. When they have finished this, their work for the day is over, but since there are always from 25 to 30 cars to be loaded and the loader has to handle its own cars, they seldom finish before 4 or 5 o'clock in the afternoon. The engineer with the aid of the "tong pullers" does his own top loading, and as there is a covered bridge between the woods and the mill the loads must be well placed. Because the work is heavy and hard, there are 3 "tong pullers," each one getting a rest every third car. The fuel for the loader consists of pine knots cut by contract and stacked along the right of way.

The company has 16 miles of track but only about 10 miles are in actual use. A new spur is placed every 1,000 to 1,500 feet in level country. In rough country, or in the slope type, a spur site is governed by the amount of timber and by the topography. In locating the railroad the object is to place the main line on as low a level as possible so that the spur haul or the haul from the woods will be down grade for the loaded cars and up grade for the empty ones. The spurs are located in the same manner only in relation to the timber in order that the loaded carts will have a down hill haul to the skidways. The logging superintendent blazes the lines for spurs and no surveying is done.

The cutting of the right of way for the spurs, and the grading, is done by a gang of four or more Mexican or Negro laborers and a foreman. Since little grading is necessary, most of this crew's work consists of clearing the right of way. A space is cleared for a distance of 2 feet or more on each side of the track by sawing off all trees at the ground and dragging them out of the way with a team of mules. Few bridges are necessary, but where needed they are made by building a floor of small logs across the stream several feet above the water and grading with dirt to the proper level. Large scrapers and mules are used for this grading.

The track, which is of standard guage, is laid or removed by a steel gang, consisting of a foreman, one engineer, one fireman and from 9 to 15 Mexican and Negro laborers. A Shay engine, tool car, rail car, and 1 mule are used. This crew works on a "task" of laying eight rails per man per day or taking up nine rails per man per day. That is, if 10 men went out a day's work would be finished when eighty rails were laid or when ninety rails taken up. This frequently allows the steel gang to complete their work by 3 or 4 o'clock. The ties on the spurs are sap pine too small for saw logs; they are cut by contract and delivered on the right of way. Ties are hewn with 5 inch faces, 5 to 6 inches thick, and 8 feet long. About 2,600 ties per mile are used on the spurs. Thirty-five pound steel rails are used on the spurs. It requires about 176 rails per mile. A small lever switch is used for each spur. On fairly straight spurs the rails are spiked on one side only to every other tie. The spikes are alternated; the first one being placed on the outside of the rail and the next on the inside of the rail. This allows every tie to have one loose end. On a sharp curve the rails are spiked on the outside to every tie, and full spiked, or spiked on both sides, to every other tie. Because of the poorly laid spurs only 3 loaded cars can safely be taken from the woods at one time.

A section gang is required in order to keep the track straight and make necessary repairs. This gang, equipped with a hand car, spikes, shovels, picks, and crow-bars, consists of a foreman, 4 Mexican laborers, and 1 track-walker. Their duties are to straighten the track each morning and to replace any broken rails or ties. The track-walker carries a spike hammer and a sack of spikes, inspecting the rail fastenings and spikes, making any necessary repairs.

An ordinary rod-engine hauls the loaded cars from the woods to the make-up switch on the main line. The crew consists of one engineer, one fireman, and one brakeman. This crew also takes the empty cars to the woods, hauls the caboose from camp for the laborers, and the water cars to the corral in the woods. Fuel consists of pine-knots cut by contract and stacked on the right of way.

The main line haul to the mill is over a branch line of a common carrier and the logging train runs as a regular train over that line. An oil burning engine is used and besides the logging cars the train hauls a caboose for passengers. The crew consists of one engineer, one fireman, one conductor, and two negro brakemen who do the unloading. The train leaves the mill at 9 o'clock in the morning and gets back at about 3 o'clock in the afternoon. The unloading, switching, and checking-in are usually finished by 5 o'clock. The unloading dock about 100 feet long is built of creosoted pine with oak rolling timbers fastened by iron straps. The outside rail of the track is elevated so that the logs will roll off the cars easily. The unloading is done by hand, and axes are used to knock out the wedges holding the chains. Part of the load rolls off by gravity, while the balance is rolled off with cant hooks.

The cost of logging in this region varies principally with the type of timber being cut. In the open Longleaf Pine type of the ridges no skidway crew is necessary, no roads have to be cut, and little swamping is necessary. Since there is practically nothing to interfere with the bunching and skidding crews, they are able to get out the maximum amount of timber. Timber is better in this type, the logs are straight clean and easy to handle on the skidways and to load.

In the slope type, where the stand is scattering and where there is frequently a dense undergrowth, the cost of logging is naturally higher. More men and more equipment are required to get out the same amount of timber. If the country is rough it frequently interferes with the laying of the spurs close enough for a cheap haul to the skidways. On hauls of over 300 yards or on hauls out of depressions eight-wheeled wagons are used, but their use increases the cost of logging since less timber is gotten out. Underbrush makes it necessary to have a skidway crew, road cutters and more swampers. It is so much more difficult to get out timber that carts average only 80 to 100 logs daily in this type while they average 125 to 150 in the Longleaf Pine type. Extra animals are required, for the work is harder and it is necessary to rest the teams frequently, especially the bunching teams. The timber is of a poorer quality, more difficult to handle on the skidways, and to load. Wet weather, which frequently causes the operation to shut down 4 to 6 weeks in the spring of each year because of boggy ground, increases the cost of logging. The price of feed, all of which is shipped in, has a slight effect on the cost.

Cutting done by contract costs the company 40c per M feet when the sawyers furnish their own equipment and 35c per M feet when the company furnishes it. Fuel for the steam loader costs $28.00 per month stacked on the right of way and $90.00 per month for the engine on the spur haul. The skidways cost the Company 50c each for single skid-ways.

In 1910 the cost of logging varied from $2.06 per M feet in the Longleaf type to $3.66 in the slope type. The following table, figured on the mill scale where deduction is made for defects, illustrates the difference in the cost of logging in each type. Depreciation of equipment is not figured in the cost; but instead, all new equipment is included. The cost of supervision is included and proportioned among the various operations.

COST OF LOGGING PER M. FEET IN 1910.

| | Slope Type | Longleaf Type |
|---|---|---|
| Cutting, including limbing, sawing into lengths, and scaling | $ .44 | $ .30 |
| Bunching, including swamping | .30 | .16 |
| Skidding, including cost of skid-ways and handling | .55 | .30 |
| Loading on cars, including fuel | .26 | .16 |
| Spur haul, including fuel | .35 | .26 |
| Main line haul, including fuel and unloading | .96 | .56 |
| Cutting right of way and grading | .21 | .10 |
| Laying and removing steel, including upkeep | .34 | .12 |
| Horse Feed | .25 | .10 |
| Total | $3.66 | $2.06 |

The following table shows the average number of men and animals required when logging in each type.

| | Slope Type | Longleaf Type |
|---|---|---|
| Bunchers | 2 | 2 |
| Cart Drivers | 4 | 4 |
| Grab Setters | 2 | 2 |
| Skidwaymen | 2 | 2 |
| Loading Crew | 5 | 5 |
| Spur Haul Crew | 3 | 3 |
| Track Repair Crew | 6 | 6 |
| Superintendents | 3 | 3 |
| Swampers | 3 | 1 |
| Road Cutting Crew | 1-2 | 0 |
| Skidway Cutting Crew | 2 | 0 |
| Steel Gang | 18 | 12 |
| Grading Gang | 7-9 | 5 |
| Total Men | 58-61 | 45 |
| Mules | 26 | 20 |
| Horses | 6 | 4 |
| Total Animals | 32 | 24 |

The company does not board employees. Most of the men are married and rent houses from the company; the remainder live at the boarding cars, where room and board costs 60 cents per day. Company checks are issued to employees, thus doing away with the necessity of keeping charge accounts at the commissary. The commissary, oper ated by a subsidiary branch of the lumber company, is expected to show a profit of 33 1-3 per cent. The company has a doctor at camp and furnishes medicine for the employees. Single men are required to pay $1.00 a month and married men $1.50 a month for a doctor and medicine fee when they work 4 days or more a month. The doctor, who is also the postmaster, has a small practice outside of camp. An insurance company is also managed by the lumber company for the purpose of paying half wages to employees when sick or hurt. A fee of 75 cents a month is required of each employee, who has worked 4 days or more that month, in order to support this. A single man's fees, therefore, amount to $1.75 a month and a married man's to $2.25.

The company furnishes ice water to the men in the woods during the summer. The ice is packed in bags of sawdust and is brought from the mill by the logging train. A barrel, packed in sawdust in a box with handles on it, is used to hold the ice water in the woods. About 200 pounds of ice are required daily and a water boy is employed to carry water to the men.

The wages can be divided into three classes; by contract, by the day, and by the month. The laborers on the steel gang and on the section gang and the fireman on the loader receive the lowest wages, $1.50 a day, excepting the water boy who gets $1.00 a day. The laborers on the steel gang and the section gang are always Mexicans or Negroes. The fireman on the loader is paid lower wages because he is learning to be an engineer. Each operation has its specific wage and no man is paid extra for better work. The following table summarizes the wages which apply generally to this region.

***Wages.***

I. By Contract.
   1. Sawyers, 40 cents per M. ft.
   2. Skidway Crew, 50 cents per skidway.

II. By Day.
   1. $1.00 per day, Water Boy.
   2. $1.50 per day, Fireman on loader, laborers in steel gang, laborers in section gang.
   3. $1.65 per day, Laborers in grading gang.
   4. $1.75 per day, Swampers, road cutters, grab setters, firemen on engines.
   5. $2.00 per day, Cart drivers, skidwaymen, track walker, carpenter, night watchman.
   6. $2.50 per day, Scaler.
   7. $3.25 per day, Mechanic.

III. By Month.
   1. $50 per month, Foreman section gang.
   2. $60 per month, Foreman grading gang.
   3. $65 per month, Team boss, corral man, foreman steel gang.
   4. $75 per month, Engineers, commissary clerk.
   5. $85 per month, Wood's foreman.
   6. $100 per month, Commissary manager, bookkeeper, doctor.
   7. $150 per month, Superintendent.

The following table shows the present equipment on which figures were obtainable. It is sufficient for the logging of 160,000 to 200,000 feet B. M. daily and the figures given are the original cost and not the present value.

Value of Equipment for logging 200,000 feet B. M. daily.

| | | |
|---|---|---|
| 4 | second hand locomotives, $8,000 each | $32,000.00 |
| 1 | Shay locomotive | 12,000.00 |
| 2 | loaders, $8,000 each | 16,000.00 |
| 10 | carts, $150 each | 1,500.00 |
| 8 | wagons, $150 each | 1,200.00 |
| 60 | head of horses and mules; horses $250, mules $200 | 13,500.00 |
| 60 | sets of harness, $12.50 each | 750.00 |
| 175 | houses, $50 each | 8,750.00 |
| 7 | water tanks, 6 for water cars, 1 for camp, $150 each | 1,050.00 |
| 100 | log cars, $700 each | 70,000.00 |
| 14 | boarding and commissary cars, $300 each | 4,200.00 |
| 1 | pump house | 15.00 |
| 1 | reservoir | 1,500.00 |
| 12 | switches, $50 each | 600.00 |
| 400 | tons steel rails, $28 per ton | 70,000.00 |
| 40,000 | ties, 6 cents each | 2,400.00 |
| | Total | $235,465.00 |

The portable houses are rented to employees at $4.00 per month. Horses and mules may appear to be valued too high, but only heavy draft horses and the best mules are used in the woods. Steel rails, locomotives, loaders, and other equipment are quoted at market price, but the actual value of the equipment is much less on account of depreciation.

# NOTES ON FOREST CONDITIONS IN THE CENTRAL SIERRA NEVADAS.

W. A. Rockie, '14.

The following notes were collected in the east central part of California, from Lake Tahoe northward to the south fork of the Feather River which drains the Sierra Valley. The east boundary of this area is the desert while the 5,000 foot contour line may be roughly considered the western boundary. The area comprises the major part of the Tahoe National Forest and the forest conditions are typical of the central portion of the Sierra Nevada Mountains.

The main range has a general northwesterly direction through the center of the region. The altitude varies from nearly 5,000 feet at both the eastern and western borders to elevations of from 7,000 to 9,000 feet along the divide. The canyons and their lesser tributaries are generally of a steep and precipitous character, and vary in depth from 500 to 2,000 feet or more. The east slope, being the escarpment of the huge Sierra upheaval, is characteristically steeper and shorter than the west slope which has a gradual incline. Nearly all the peaks consist of an easily decomposed tuff breccia, resembling a poorly made cement mortar, underlaid with resistant granite of a great thickness. Since this formation overlies the granite, the soil from the upper tuff-breccia rock is carried down by gravity and does much to cover what would otherwise be bare granite slopes. Often on the uppermost slopes of the peaks and ridges the soil is too shallow or unstable to support forest growth. On the lower slopes only local areas of barren rock exist. The majority of these slopes, however, have a sufficient soil cover to support a dense forest growth. The type of soil found here is generally very gravelly in texture, being much coarser and more unproductive immediately below a bare rock area. Several flat mountain valleys or meadows were found where the soil was a very deep, black, gravelly loam which had washed in from the adjoining slopes. Although of sufficient fertility, these valleys are too high for successful agriculture.

The precipitation varies greatly with general altitude and exposure. Over the entire western slope the rainfall is very heavy, and the records at Summit, where the Southern Pacific Railway crosses the divide, may be considered representative. The records, which give 46.58 inches annual precipitation at this place, also show that over 40 inches of this amount is snowfall, totaling 37.1 feet in depth. At Truckee, only seven miles east of the divide and about 1,400 feet lower in altitude, the precipitation is but 26.98 inches, and from this place eastward the precipitation rapidly diminishes until at a distance of fifteen miles from the divide a desert climate is found.

This region is well drained by the highly developed trunk-streams and their tributaries. The Feather, Yuba and American river systems drain the well watered western slope. The east slope, since precipitation is rather low, has but a single main stream, the Truckee River. From the northwest part of Lake Tahoe, the river flows almost due north through the Truckee Canyon to Truckee, thence pursuing a northeasterly course to the desert, where it is used for irrigation and finally lost. Lake Tahoe drains a large area but the river itself has very few tributaries, most of these draining the region lying to the northwest. Nearly every stream of either slope has its origin in some lake or in the springs of some intermontane meadow, the two noteworthy examples of this feature being Lake Tahoe and the Sierra Valley. Besides these, the ranges are dotted with numerous lakes and meadows of lesser size and importance.

A clear cut classification into forest types is difficult in this region. A constant transition from one type to another, rather than a constant type over a considerable area, is almost universally the case. Since a definite line cannot readily be drawn, only those types which are easily determined are considered. These are:

1. Jeffrey Pine Type.
2. California Red Fir Type.
3. White Fir Type.
4. Brush Type.

### Jeffrey Pine Type.

The Jeffrey Pine Type covers most of the slopes below 6,500 feet. In the basin of the Truckee River, however, the

PLATE I.

Peaks and Upper Slopes Mostly Barren.

Scattered Jeffrey Pine with Dense Second Growth of Fir.

trees were often abundant and in good stands at an elevation of 7,000 feet, occasionally reaching an altitude of 7,200 feet. Although this type is more common on south and west slopes, the cleanest and heaviest stand observed during the summer was situated on a northeast slope. The Jeffrey Pine *(Pinus jeffreyi* "Oreg. Com.") is the most important tree of the type, not only as a timber tree but also in relative abundance as compared with other tree species. The White Fir *(Abies concolor* (Gord.) Parry, while almost as abundant as the pine, is an inferior species for mill timber. The Sugar Pine *(Pinus lambertiana* Dougl.), an important timber tree, often covers very limited areas with a nearly pure stand, but seldom extends over a sufficiently large area to require type classification. The California Red Fir *(Abies magnifica* Murr.) is generally found in the upper limits of this type where the Red Fir transition begins. Other species scattered through the forest of this type are Lodgepole Pine *(Pinus contorta* Loud.), Incense Cedar *(Libocedrus decurrens* Torr.), Western Yellow Pine *(Pinus ponderosa* Laws.), Western White Pine *(Pinus monticola* Dougl.), and Western Juniper *(Juniperus occidentalis* Hook).

The Jeffrey Pine seldom grows in dense stands, but tends to retain a more open character with considerable undergrowth of dense brush consisting of the species mentioned under the Brush Type. In many localities the mature trees have not been permitted to deteriorate from old age, as they, especially Jeffrey and Sugar Pines, have been heavily logged. This destructive logging has brought about a serious change in the composition of the forest. The White Fir, which reproduces quickly and well, has come in and crowded out the two more valuable species, Jeffrey Pine and Sugar Pine. Although the original type had a reproduction of Jeffrey Pine as great as that of any other species, the stand of poles and saplings which are now found in the area are about as follows: White Fir 65 per cent, Jeffrey Pine 20 per cent, while the species of lesser importance make up the remaining per cent. The administration of the forest is at present endeavoring to change this percentage of reproduction so that the future forest may be composed largely of Jeffrey and Sugar Pines. Most of the timber of this type has, in past years, been seriously burned, especially the bases of the older trees. The decreased reproduction of Jeffrey Pine is probably due to fire. With proper care in the future, this type may be made to yield the most valuable timber of the region.

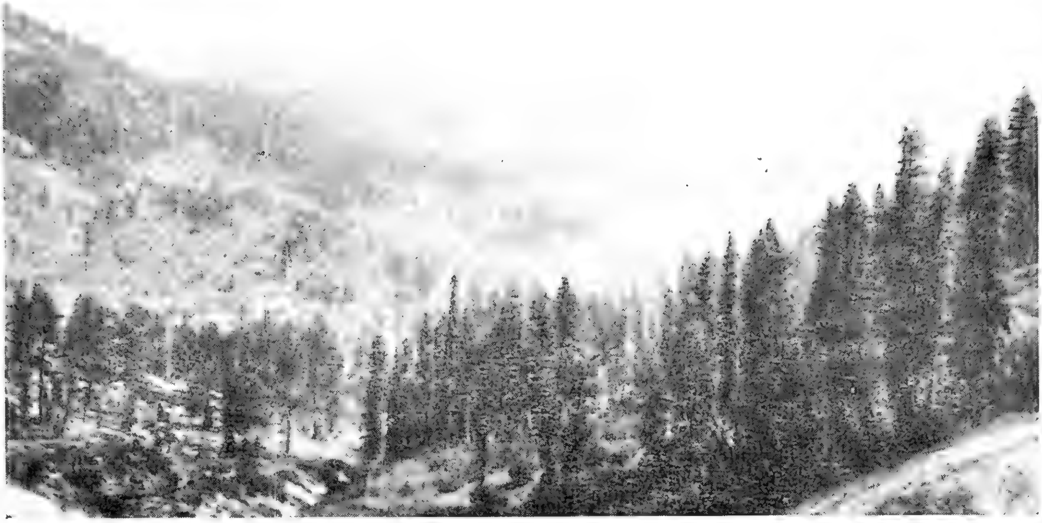
## California Red Fir Type.

The California Red Fir Type, found at an altitude of 6,000 feet and above, contains the densest forest growth of the region. This type is common on northerly slopes, level summits, and the gentler sloping south exposures. Stands averaging from 25,000 to 50,000 feet per acre quite commonly extend over a continuous area of several square miles. Much of the type, however, is of an inferior quality of timber. The California Red Fir is the most abundant species and often covers considerable areas with a pure stand. This tree often reaches a height from 200 to 225 feet, with a diameter of 5 to 7 feet, and a clear bole 75 to 100 feet in length. The White Fir is often an abundant species of the type, and in both height and diameter fully equals the Red Fir, but does not clear of limbs as well. Associated with these species Western White Pine often composes 25 per cent of the stand over rather limited areas. Large White Pines are scattered within many dense stands of mature Red Fir and these individual trees sometimes have the form of bole necessary for the finest quality of timber. Consequently, the writer believes that the White Pine with the proper system of management can be made the leading timber tree of the north slope. Black Hemlock *(Tsuga mertensiana* (Bong.) Carr.), although of practically no commercial importance, is of sufficient abundance to deserve a short description. It is found only on steep, moist, northerly exposures at an altitude generally above 7,500 feet. It seldom reaches a height of over 75 feet, but often a diameter of from 2½ to 3 feet. The tree is commonly so branched and scrubby in character that it has but little milling value. Other trees occurring with the type as merely scattered individuals are: Lodgepole Pine, White-bark Pine *(Pinus albicaulis* Engelm.), and Western Juniper.

## White Fir Type.

The White Fir type is commercially of less importance than either of the previous types, but White Fir reproduces in such dense, pure stands that it deserves special mention. The growth is usually at its best on a south aspect with a fairly deep soil. It is not confined, however, to such conditions, but is often found in almost pure stands on rough rocky slopes. The type, considered by some to be merely temporary, quickly covers a denuded

PLATE II.



Many Denuded Slopes Occur in the Jeffrey Pine Type.

Thrifty Stand of Red and White Firs. In Back Ground Dense Brush on South Slope.

area, and later is replaced by a more valuable species. This theory is verified by the presence of numerous seedlings and saplings of Jeffrey Pine frequently found growing beneath a pole stand of White Fir. A feature of the type is the frequent stands of dense poles, the individual trees often standing so close together that it is almost impossible to penetrate the area. This condition is merely local, however, and generally the forest is easily traversed. Scattered Red Fir and Jeffrey Pine sometimes occur here, but never in large proportions. The type as a whole is of but secondary value and importance in the economic use of the forest.

### Brush Type.

The Brush Type, although considered as a temporary stage in the succession, often persists for many years. The brush quickly covers an area after fire or cutting, often making a more dense cover following complete denudation. The type is not confined to any one aspect, but is found on all sites and under all conditions. The relative abundance of the various species is approximately shown by the order in the following list: Snow brush *(Ceanothus velutinus* Dougl.) ,Manzanita *(Arctostaphylos manzanita* Parry), Wild Cherry *(Prunus demissa* Walp.), Chinquapin *(Castanopsis chrysophylla* A. DC.), Huckleberry Oak *(Quercus vaccinifolia* Engelm.) and Buckbrush. Others of lesser importance in the ground cover are Dwarf Manzanita (Arctostaphylos nevadensis Gray.) and Squaw Mat. Although the type is of but little real commercial value, land erosion is diminished by it and much protection is given to the young seedlings.

## UTILIZATION.

As previously mentioned the Southern Pacific Railway cuts across and nearly bisects the region. As a result, all of the more accessible timber has been logged and the country deprived of one of its main assets. As the virgin timber here was excellent in quality, and apparently of an unlimited quantity, the early logging was carried on in a very destructive and wasteful manner. Evidences found of the wasteful logging practiced in the past, such as immense sawed, but abandoned, logs, are not uncommon. Sugar Pine and Jeffrey Pine logs from 3 to 4 feet in diameter are often found; in most cases they were left because they contained one or two large knots. At several abandoned mills, situated far back in the mountains, all the buildings were made of best quality of lumber. Even comparatively recent logging, which has been continually pushed farther and farther into territory more difficult of access, was done by careless methods, and much excellent timber was felled and left in the woods to decay.

**Hauling Lumber by Ox-Team.**

The area of virgin forest at the present time is very limited. As a result of destructive lumbering and repeated fires the most of the region is covered by either a second growth of trees or by those capable of making only a poor grade of lumber. Where virgin timber remains it is too inaccessible for immediate exploitation with the present state of development in transportation.

With the decreased supply of timber the mills have been compelled to close down, until now only two or three of any commercial importance remain. Aside from these, however, a few smaller ones supply the demand in their immediate vicinities. The Hobart Mills, the largest lumber producers of the region, are situated about six miles due north from Truckee on Prosser Creek, a small tributary of the Truckee River. The lumber and mill-work products are mostly of Jeffrey Pine and are transported to the main line of the Southern Pacific at

PLATE III.

A Veteran Western White Pine.

Mountain Meadow Surrounded by Dense Stand of Red Fir.

Truckee by a stub branch extending to the mills, although a great deal is hauled to Truckee by ox team. The mill proprietors own and operate a narrow gauge logging railroad, maintaining in all about twenty miles of track.

The Floriston Paper Mill is increasing its output and its variety of products each year. California Red Fir and White Fir are the chief species used in the manufacture of the paper, which is mostly of the cheaper grade, such as is used for wrapping fruits. Much firewood is cut along the northwestern shores of Lake Tahoe chiefly for the use of the large steamers which navigate the lake.

Although the manufacture of lumber within this area seems destined to decline, the paper industry and the cutting of cordwood for fuel have a promising future.

The above represents some of the conditions with which the administration of the Tahoe National Forest is compelled to deal. In very few parts of the western mountains have the slopes been so completely denuded of forest as is the case here. A common remark of the Forest Service officers upon finding a tree of merchantable size and quality is that the land must be privately owned. It is evident that such might be the case, since the railway is the owner of the odd-numbered sections and many of the other sections are homesteads, mining claims or summer homes. With proper administration of the forest in the future it is hoped that the percentage of brush slopes may be materially reduced, and that many of the areas now supporting stands of inferior timber can be made to produce to their full capacity.

# A KEY TO COMMON NEBRASKA SHRUBS.*

W. H. Lamb, Ex '11.

The following key, based on prominent distinctive characters that can readily be observed by those who have had no special training in botany, is intended only as a guide in the identification of the more common genera of Nebraska shrubs.

Shrubs are woody plants which have several or many stems arising from the same roots. In general, trees are larger than shrubs and have a single, erect stem or trunk. Woody vines are here regarded as shrubs.

## I.

## EVERGREEN SHRUBS.

I. Coniferous shrubs.

A. Leaves needle shaped, 1-2 cm. long, standing out loosely in threes; fruit a berry-like cone, dark blue, 6-8 mm. in diameter.............. *(Juniperus)* Juniper.

II. Broad-leaf shrubs.

A. Leaves simple.

1. Leaves alternate.

a. Fruit a red berry, 6-10 mm. in diameter, usually containing 5 coalescent nutlets; flowers small, nodding, white or pink, in terminal clusters; leaves spatulate, obtuse, entire, 12-25 mm. long. ......................... *(Arctostaphylos)* Bearberry

2. Leaves opposite.

a. Fruit a small 3-5 lobed, somewhat fleshy pod; flowers small, greenish or purplish, with 4-5 petals; twigs 4-angled, or marked with 4 longitudinal white lines; leaves 4-13 cm. long, entire or finely toothed ......................*(Berberis)* Barberry

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II.

## DECIDUOUS SHRUBS.

I. Broadleaf shrubs.

A. Leaves simple.

1. Leaves alternate.

a. Stems climbing or twining (vines).

b. With prickles.

c. With tendrils.

d. Leaves 2-5 cm. long, ovate, bearing a pair of tendrils at base; fruit a round cluster of black berries; stems with long weak blackish prickles.........*(Smilax)* Greenbrier

bb. Without prickles.

c. With tendrils.

d. Leaves usually palmately lobed or dentate; fruit an elongated cluster of round pulpy edible berries................*(Vitis)* Grape

cc. Without tendrils.

d. Leaves 1-2 dm. wide, ovate or with 3-7 lobes; flowers greenish white, 3-4 mm. wide; fruit a black berry 6-8 mm. in diameter, with a spiral shaped seed.......... ..................*(Menispermum)* Moonseed

dd. Leaves 2.5-5 cm. wide, 5-10 cm. long, with wavy margins; flowers greenish, about 4 mm. broad, in clusters 5-10 cm. long, fruit a yellow or orange capsule 10-12 mm. in diameter; seeds red...*(Celastrus)* Bittersweet

aa. Stems erect.

b. With prickles.

c. Leaves entire, linear, 1-4 cm. long, 2-3 mm. wide; fruit surrounded by a distinctly veined wing 8-12 mm. broad................. ......................*(Sarcobatus)* Greasewood

cc. Leaves lobed, broadly ovate, 2-5 cm. long; fruit a berry with shriveled remains of calyx at tip, in clusters of 1-5............ ........................*(Ribes)* Gooseberry

bb. Without prickles.

c. Leaves with entire margins (edge neither toothed nor notched).

d. Leaves large.

e. Leaves 15-30 cm. long, broader at top than at base; fruit fleshy, elongated, 7-20 cm. long, 2-7 cm. thick, edible when ripe....................*(Asimina)* Papaw

dd. Leaves small.

e. Flowers green, small, in terminal spikes and clustered in axils of the leaves; leaves linear-oblong, 4-10 mm. wide; fruit one-seeded, with a loose wall, 3-8 mm. broad, surrounded by bracts with margins entire or toothed and sides smooth, winged or knobby. .......... ......................*(Atriplex)* Atriplex

ee. Flowers yellow, small, in discoid 5-7 flowered heads; leaves linear or slightly spatulate, 2-5 cm. long, 2-6 mm. wide; fruit an achene (a small dry seed), elongated with a tuft of soft roughened bristles at tip. ..................... ......*(Chrysothamnus)* Rayless goldenrod

cc. Leaves toothed or notched.

d. Leaves deeply lobed with large notches.

e. Leaves as broad as long, with 3-5 regularly and finely toothed lobes.

f. Fruit a cluster of 3-5 small shining pods with slender oblique tips....... ..................*(Opulaster)* Ninebark

ff. Fruit an elongated cluster of small red, yellow or black berries, bearing the shriveled remnant of flowers at their tips. ..................*(Ribes)* Currant

ee. Leaves longer than broad.

f. Leaves green.

g. Fruit an acorn (a nut resting in a separable cup)........*(Quercus)* Oak

ff. Leaves silvery white.

g. Leaves wedge-shaped, 3-toothed at end, 1-4 cm. long, 2-6 mm. wide; flowers greenish or yellowish, in dense clusters of 5-8 flowered heads about 3 mm. broad. . . . . . . . . . . . . . . . . . . . . . . . . . . *(Artemisia)* Sage brush*

dd. Leaves with small teeth only.

e. Leaves palmately 3-veined, 2.5-7.5 cm. long; fruit dry, 3-lobed, separating longitudinally when ripe, into 3 nutlets; flowers small, white, numerous. Shrubs with large red root. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *(Ceanothus)* New Jersey tea

ee. Leaves pinnately veined.

f. Fruit with several seeds.

g. Fruit a berry, with 2-4 separate nutlike stones. . . . . *(Rhamnus)* Buckthorn

gg. Fruit a small 4-10 celled pome (like a tiny apple); flowers white. . . . . . . . . . . . . . *(Amelanchier)* Serviceberry

ff. Fruit with one seed.

g. Fruit dry, narrow, with long plumelike tips. . . . . . . . . . . . . . . . . . . . . . . . *(Cercocarpus)* Mountain mahogany

gg. Fruit fleshy, round, edible. . . . . . . . . . . . . . . . . . . . . . . . *(Prunus)* Wild cherry

fff. Fruit a small nut surrounded by a leafy bract.

g. Leaves with primary veins terminating in the larger teeth.

h. Bracts flat, 3-lobed, toothed. . . . . . . . . . . . . . . . . . *(Carpinus)* Hornbeam

hh. Bracts bladder-like, enclosing nut. . . . . . . . . . . . *(Ostrya)* Hop hornbeam

gg. Leaves finely and irregularly toothed; nut compressed, light brown, surrounded by two leafy, toothed bracts. . . . . . . . . . . . *(Corylus)* Hazelnut

ffff. Fruit a long cluster of little pods, filled with "cotton," leaves narrow, finely toothed, branches slender, usually tough. . . . . . . . . . . . . . . . . . *(Salix)* Willow

---

*Applies only to *Artemisia tridentata* Nutt. Little sage brush (*Artemisia cana* Pursh.) has very narrow, lance-linear leaves.

ddd. Leaves with wavy-toothed margins, 5-12 cm. long; flowers, bright yellow, appearing late in fall; fruit (ripening the next season), a woody, velvety capsule 6-8 mm. long, 2-valved at tip, bursting elastically when ripe, scattering the large, bony seeds. ............ *(Hamamelis)* Witch-hazel

2\. Leaves opposite.

a. Stems turning or climbing (vines).

b. Upper leaves united around the stem; flowers tubular or funnel-shaped; fruit a 2-3 celled berry. ................. *(Lonicera)* Honeysuckle

aa. Stems erect.

b. Leaves toothed or notched.

c. Fruit a cluster of small 1-seeded berries; flowers small, white or nearly pink.......... .................... *(Viburnum)* Sheep berry

cc. Fruit a pod, 12-16 mm. broad, deeply 3-4 lobed; flowers dark or greenish purple; twigs 4-angled...... *(Euonymus)* Burning bush

bb. Leaves neither toothed nor notched (margins entire).

c. Leaves velvety, silvery, or brownish; fruit small, fleshy, berry-like, enclosing a little nut. .............. *(Lepargyrea)* Buffalo-berry

cc. Leaves smooth, green.

d. Flowers white (occasionally rosy) with 4 conspicuous petal-like bracts; fruit a small cluster of 2-seeded berries, turning red in autumn. ................ *(Cornus)* Dogwood

dd. Flowers white, 8-12 mm. long, in dense ball-like heads about 2.5 cm. in diameter; fruit dry, 1-2 seeded. ................ ............... *(Cephalanthus)* Button bush

ddd. Flowers small, white or pink, clustered, in axils of leaves, or in interrupted terminal clusters; fruit a white (or red) 4-celled 2-seeded berry. *(Symphoricarpos)* Snowberry

AA. Leaves compound.

1. Stems climbing or twining (vines).

a. Without prickles.

b. With tendrils.

c. Leaflets 5-7, all branching from end of leaf-stalk (palmate), 5-15 cm. long, toothed; fruit a blue 2-3 seeded berry, about 1.2 cm. in diameter, with red stems............ .............*(Parthenocissus)* Virginia creeper

2. Stems erect.

a. With prickles.

b. Leaflets toothed or notched.

c. Flowers large, red, pink, or white; leaflets 5-11, fruit a hard many-seeded berry (like a tiny apple) with shriveled remnant of flowers at tip..............*(Rosa)* Wild rose

cc. Flowers small, purple, pink, or white; leaflets 3-7, fruit a black or red aggregate (dense cluster) of tiny berries.

d. Fruit falling away from its dry base..... ...................... *(Rubus)* Raspberry

dd. Fruit remaining attached to its fleshy base. .......................*(Rubus)* Blackberry

bb. Leaflets with entire or wavy margins.

c. Flowers small, greenish, about 3 mm. broad, appearing before the leaves; leaflets 5-11, 3-5 cm. long; fruit a black, 2-valved, short-tipped pod, about 4 mm. long............ ..................*(Xanthoxylum)* Prickly ash

aa. Without prickles.

b. Leaflets toothed or notched.

c. Leaflets 3, finely toothed, 4-7 cm. long; flowers, white, about 8 mm. long, in clusters; fruit a bladder-like capsule about 5 cm. long, much inflated, 2-3 lobed. *(Staphylea)* Bladder nut

cc. Leaflets 5-11 (usually 7), finely toothed, 5-13 cm. long; flowers white, about 3 mm. broad; fruit berry-like, containing 3-5 1-seeded nutlets; stems with large white pith........ .....................*(Sambucus)* Elder berry bb. Leaflets with entire margins.

c. Leaflets numerous (13-49), 5-15 cm. long; flowers small, violet, blue, or white, 4-9 mm. long, in dense terminal clusters.......... ......................*(Amorpha)* Shoe string

# TREE PLANTING IN NEBRASKA

Professor W. J. Duppert.

The early settlers of Nebraska were planters of trees. They came from wooded sections of the East and from Europe; in order to feel at home they planted trees on the fertile but treeless plains. Windbreaks, woodlots and ornamental trees now found in this state owe their origin largely to the older generation. Planting, as a general policy, continued for many years, but finally the land came to possess such value that the owners felt that they could no longer afford to devote agricultural land to timber crops. This feeling caused a decline of interest in planting and resulted in the destruction of much of the native timber on lands that should have remained permanently forested. The lack of interest in tree planting and in the conservation of the supply of native timber is generally confined to the younger generation, the sons of the hardy pioneers, and can be said to have started in the early nineties.

Other causes for this indifference to tree planting are the failures due to the selection of poor species, lack of care after planting, destruction by fire and stock, and the selection of species not adapted to the climate or site they were to occupy. These failures served as excuses for the cutting of the native timber and for the decline of tree planting. During the extremely dry years in the early nineties many of the settlers were obliged to cut the trees on the school sections together with the small quantities growing on farms which had been acquired under the "Tree Culture Act." Thus some settlers were enabled to tide over the lean years and to remain on their homesteads; in this way trees were an important factor in the development of the state. It would seem that people who had been benefited so directly by the timber which they secured in time of great need would see the necessity of providing against a recurrence of similar periods of hard times by raising trees.

The Nebraska Agricultural Experiment Station at Lincoln started experiments to determine the species which would grow satisfactorily in eastern Nebraska, the rate of growth, the spacing best adapted to the different species and the silvicultural methods to be used in handling them. The soil at the Station is a black loam underlaid to an unknown depth with stiff, yellow clay.

Plantings were first made in 1896 in which Black Cherry was the principal species, mixed with Silver Maple, Box Elder, Green Ash, White Elm, Hardy Catalpa, and Russian Mulberry. Of the species mentioned only three have succeeded in making good growth. The average size of each of these species, sixteen years after planting, is as follows:

| Species | Average Height | Average D. B. H. |
|---|---|---|
| Black Locust | 37 feet | 7.4 inches |
| Black Cherry | 35 feet | 6.2 inches |
| Silver Maple | 32 feet | 5.7 inches |

The Black Locust has made an excellent growth in spite of the fact that the trees are badly affected by borers, which very greatly reduce their value for fence posts. Many posts, however, can be cut from the trees and, though they are of inferior quality, still they can be utilized. In sections of eastern Nebraska where the locust borer is not found this species can be safely recommended for planting. The writer knows of cases where two acres of Black Locust have furnished posts for a 160 acre farm besides some fuel.

The Black Cherry is excellent for planting on good moist soils in eastern Nebraska. The trees at the State Farm have made a growth of thirty-five feet in height and over six inches in diameter in sixteen years. The wood is very valuable, as its lumber takes a fine polish and is used for interior finish. This tree should come into favor with those who are looking for a species which will grow valuable timber on good land unsuitable for agriculture and who are willing to wait a long time for the trees to become merchantable as saw timber.

The Silver Maple has made a rapid growth, having attained an average height of thirty-two feet and an average diameter of five and seven-tenths inches in sixteen years. The wood of this species is chiefly valuable for fuel. On land which would otherwise remain idle and where the value for fuel is sufficiently great, this species can be planted and grown at a profit.

The Box Elder, Green Ash, White Elm, and Catalpa have not made good growth. The Russian Mulberry which was also planted in mixture as a nurse tree has assisted in establishing a good forest floor.

In 1907 experiments were started to determine the effect of different spacing on height and diameter growth. The trees are still too young and have not made growth sufficient to state accurately the comparative merits of wide and narrow spacing. There are, however, evidences of considerable difference which have already been brought out in the experiments and which are shown in the following table:

| Sub-lot and exp. | SPECIES | Spacing feet | Age of Plantation years | Average height feet | Average D. B. H. inches | Average diameter 1.5 feet from ground inches |
|---|---|---|---|---|---|---|
| 1-A | Ash | 6x6 | 6 | 11.9 | 1.54 | 2.1 |
| 3-A | Ash | 4x4 | 6 | 11.0 | 1.3 | 1.6 |
| 2-A | Catalpa | 6x6 | 6 | 13.4 | 2.4 | 3.1 |
| 4-A | Catalpa | 4x4 | 6 | 13.9 | 1.8 | 2.2 |
| 5-A | Catalpa (cut back 2d year) | 4x4 | 6 | 14.1 | 2.0 | 2.5 |
| 6-A | Catalpa (cut back 2d year) | 6x6 | 6 | 12.6 | 2.1 | 2.5 |
| 7-A | Honey Locust | 6x6 | 6 | 11.5 | 1.4 | 2.2 |
| 9-A | Honey Locust | 4x4 | 6 | 10.7 | 1.04 | 1.5 |
| 8-A | Osage Orange | 6x6 | 6 | 9.0 | 1.1 at 3' | ........ |
| 10-A | Osage Orange | 4x4 | 6 | 9.7 | 1.1 at 3' | ........ |
| 11-A | Catalpa | 4x4 | 5 | 11.4 | 1.6 | 2.2 |
| 12-A | Catalpa | 4x6 | 5 | 11.5 | 1.7 | 2.4 |
| 13-A | Ash | 4x4 | 5 | 9.8 | 1.2 | 1.5 |
| 14-A | Elm | 4x4 | 3 | 8.1 | .96 | 1.3 |

The Ash in Sub-lot 3 with 4x4 foot spacing have attained an average height growth which is 93 per cent of the height growth in Sub-lot 1 with 6x6 foot spacing. The average D. B. H. of the trees in Sub-lot 3 is 85 per cent while the diameter 1.5 feet from the ground is but 76 per cent of the respective diameters of the trees in Sub-lot 1. There seems to be a very evident advantage in favor of 6x6 foot spacing for Ash in this kind of soil and under these growing conditions.

The Catalpa in Sub-lot 2 with the 6x6 foot spacing show an average height growth 96 per cent of the height growth of the trees in Sub-lot 4 with the 4x4 foot spacing. The average D. B. H. of the trees in Sub-lot 2 is 133 per cent while the average diameter 1.5 feet from the ground is 140 per cent of the respective average diameters of the trees in Sub-lot 4.

The trees in Sub-lot 6 were cut back the second year. The average height growth of the trees in this plot is 94 per cent of the height growth of the trees in Sub-lot 2. The average D. B. H. is 89 per cent and the diameter 1.5 feet from the ground is 80 per cent of the respective diameters of the trees in Sub-lot 2. The greater growth of the trees which were not cut back would tend to cause one to recommend leaving the young trees without cutting them back. The trees which were cut back, however, are less branched, have fewer forks and the boles are straighter and more cylindrical than are the trees which have not been cut back. It is very probable that the trees which were cut back will, in a few years, overcome the lead which the other trees show at the present time and that this will prove to be the better method of handling the Catalpa.

As to the result of spacing upon the growth of the trees which were cut back, the trees in Sub-lot 6 with 6x6 foot spacing show an average height growth 89 per cent of that of Sub-lot 5 with 4x4 foot spacing. The average D. B. H. of the trees in Sub-lot 6 is 107 per cent of that in Sub-lot 5 while the average diameter 1.5 feet from the ground is the same in each Sub-lot. This would indicate that at the present time there is a considerable difference in the rate of height growth of trees when planted 4 and 6 feet apart and which have been cut back.

The trees in Sub-lot 5 with a 4x4 foot spacing and which were cut back at the end of the second year show a greater height growth than do those of any of the other Catalpa experiments. Sub-lot 4 with the same spacing distance shows the next highest growth. This would indicate that 4x4 foot spacing is better than 6x6 foot spacing for Catalpa, both when the trees are cut back and when they are allowed to grow without being cut back.

The Honey Locust in Sub-lot 9 with a 4x4 foot spacing show an average height growth 93 per cent of the height growth of the trees in Sub-lot 7 with 6x6 foot spacing. The average

PLATE I.

American Elm and Catalpa on Table Land, North Platte Experiment Station.

Honey Locust Grove on Table Land, North Platte Experiment Station.

D. B. H. of the trees in Sub-lot 9 is 72 per cent and the average diameter 1.5 feet from the ground is 70 per cent of the respective average diameters of the trees in Sub-lot 7. These figures would appear to show an advantage in favor of 6x6 foot spacing for Honey Locust.

The Osage Orange in Sub-lot 8 with 6x6 foot spacing show an average height growth which is 92 per cent of the height growth of the trees in Sub-lot 10 with 4x4 foot spacing. The diameter growth is approximately the same in either sace. The presence of many forks and the prevalence of branches would not lend much encouragement for the recommendation of Osage Orange plantations for the production of fence posts.

The absence of trees in western Nebraska is one of the noticeable features of the landscape. Many causes have contributed to the lack of tree growth, the principal ones being the lack of moisture, excessive evaporation, damage from fire and grazing and the neglect of the trees when first planted. Under the "Tree Culture Act" much of the land was acquired after a certain portion of the area had been planted to trees. The results of these plantings were generally very unsatisfactory. Many of the applicants could never have secured title if the examiners had not been lenient. The trees planted were usually inferior in size and quality and little or no attention was given to methods of planting. Consequently there was very slow growth and after a few years the trees became diseased and death followed. In other cases they were cut for fuel or fence posts before they had reached the size when they could be profitably utilized. The farmers either could see no value in growing trees or needed the material during the dry seasons which occurred in the early nineties.

The first settlers found but a small amount of native timber and that only along the stream courses. Those who settled on the tableland were obliged to haul the material needed for buildings, fuel and fence posts for long distances, sometimes as far as 75 miles. This was especially true in the case of Red Cedar found along the Dismal River and which was used by the settlers far to the south. The Western Yellow Pine found along the Pine Ridge was often hauled 125 miles to the south to furnish the settlers with building material. The building of the Union Pacific Railroad caused an increased demand for timber for ties and fuel for the locomotives. In all of these ways the native timber had an important part in the development of western Nebraska.

With the knowledge of the importance of timber in the development and progress of a community, it was deemed advisable to commence experiments at the Experiment Substation at North Platte, in order to determine, if possible, the species best suited to western Nebraska, the relation of soil and climate to the selection of species and the best silvicultural methods to be employed. The original plans were to plant 32,959 trees commencing in the spring of 1907 and finishing in the spring of 1910. These plans were somewhat changed but the entire twenty-five acres devoted to the experiments were planted.

The climate of this region is characterized by rather severe winters and warm summers, with sudden and extreme changes of temperature. The maximum temperature for thirty-four years, 1875 to 1908, was 107° F. and the minimum temperature was —35° F. The average date of late killing frosts in spring was May 1 and the average date of the first killing frosts in autumn was September 29. The mean annual relative humidity for twenty-one years, 1888 to 1908, was 71.0 per cent. The average annual rainfall from 1875 to 1908 was 18.72 inches. The average for the months of April, May, June, July and August was 13.55 inches or 72.0 per cent of the total for the year. The average wind velocity from 1875 to 1908 was 10.0 miles per hour. The average velocity for April, May, June, July and August was 10.4 miles per hour. The high wind velocity together with the high temperatures of summer causes excessive evaporation from the soil, which greatly decreases the amount of moisture available for plant growth and at the same time increases the amount actually needed by the trees.

The absolute elevation of North Platte is 2,825 feet. The relative altitude of the "bench land" is approximately seventy-five feet while the "table land" is one hundred fifty to two hundred feet above the Platte River. The "bench land" is located on the second bottom of the Platte River Valley and extends to the base of a range of hills to the south. The "table land" is the highest land on the Experiment Station Farm and is approximately one hundred twenty-five feet higher than the "bench land." This area is cut by many canyons which lead in all directions giving the region a very rough surface. The sides of the canyons are usually steep while the bottoms are generally narrow. There is a large acreage of this kind of land in the Sand Hills which should be forested if it is found that trees can be grown successfully.

The United States Forest Service has planted for ten years in the Sand Hills at Halsey, Nebraska, with considerable success, especially during the past few years.

The following species have been planted at the North Platte Experiment Substation:

Coniferous Species:

Black Hills Spruce *(Picea canadensis)*.
Norway Spruce *(Picea excelsa)*.
Colorado Blue Spruce *(Picea parryana)*.
Austrian Pine *(Pinus austriaca)*.
Jack Pine *(Pinus divaricata)*.
Western Yellow Pine *(Pinus ponderosa)*.
Scotch Pine *(Pinus sylvestris)*.
Douglas Fir *(Pseudotsuga taxifolia)*.

Broadleaf Species:

Box Elder *(Acer negundo)*.
Silver Maple *(Acer saccharinum)*.
Hardy Catalpa *(Catalpa speciosa)*.
Hackberry *(Celtis occidentalis)*.
Russian Olive *(Eleagnus angustifolia)*.
Green Ash *(Fraxinus lanceolata)*.
Honey Locust *(Gleditsia triacanthos)*.
Black Walnut *(Juglans nigra)*.
Russian Mulberry *(Morus tatarica)*.
Carolina Poplar *(Populus angulata)*.
Cottonwood *(Populus deltoides)*.
Norway Poplar (Commercial variety of Carolina Poplar).
Black Cherry *(Prunus serotina)*.
Bur Oak *(Quercus macrocarpa)*.
Black Locust *(Robinia pseudacacia)*.
White Willow *(Salix alba)*.
Golden Willow *(Salix vitellina)*.
Basswood *(Tilia americana)*.
Osage Orange *(Toxylon pomiferum)*.
White Elm *(Ulmus americana)*.

The area which was planted in the spring of 1907 was ploughed to a depth of eight inches and thoroughly cultivated in the fall of 1906. The following spring it was disced and harrowed before planting was commenced. The land which was planted in the canyons was not ploughed.

The stock which was planted was the best that could be obtained. Some of it, however, arrived in poor condition due to improper packing or to delay in transit. The broadleaf species were all one year old seedlings with the exception of the Cottonwood, Norway Poplar and Carolina Poplar which were one year old rooted cuttings. The Conifers were all three year transplants.

Two methods of planting were used, the slit method and the hole method. In the former method a spade was pushed into the ground leaving a narrow slit-like opening into which the plant was placed. The ground was then packed closely around the roots. In the latter method a hole was dug large enough to hold all of the roots without crowding them. The soil was then made firm about the roots.

Some of the trees developed forks and others produced many lateral branches. One of the forks was removed in all cases where it was possible to improve the tree. The larger lateral branches were also removed in order to allow the trees to develop better boles and also to permit cultivation.

The trees are still too young to show any decided results of different spacing distances and mixtures of species. It is quite probable that it will require at least ten years to show any decided difference in growth.

Some species have been subjected to injuries from gophers, cottontail rabbits, borers, freezing and winter drought. Gophers injured about twenty-five per cent of the Silver Maple during the first winter. Nearly all of the Honey Locust seedlings were cut off during the same period. The damage from gophers since that time has been slight. Cottontail rabbits did some damage to the Honey Locust seedlings by nibbling off the bark. Sprouts started at the bases of the young trees which were injured. Since that time no further injury has been observed.

Borers have attacked the Black Locust, Green Ash, and Honey Locust. Black Lucust Borers have succeeded in weakening the trees until nearly all of them have been blown over by the wind. The trees have made excellent growth and would be a most desirable species, since it will occupy almost any kind of soil, were it not for this most serious enemy. A large per centage of the Green Ash have been attacked by borers but have

PLATE II.


Norway Poplar and Hardy Catalpa on Bench Land, North Platte Experiment Station.

not been so severely injured as the Black Locust. A sufficient amount of damage has been done to prevent the recommendation of this species for general planting. During the past two years borers have been working on several Honey Locust trees. This attack, however, is not general, but if the borers should continue to spread they will become a serious menace to the growth of one of the best species for planting in western Nebraska.

During the first winter freezing killed nearly all of the Osage Orange and Basswood. These species will not endure the severe cold together with the dry weather which usually occurs in winter. It is quite probably that the latter cause is equally as important as the former in preventing a satisfactory growth of these species. Russian Mulberry was killed on the "bench land" but was only slightly frozen back on the "table land." Catalpa and Silver Maple freeze back each year. The injury to these species is sufficient to make them undesirable for general planting.

Of the twenty species of broadleaf trees which were planted, all showed more than 20 per cent of living trees except the Osage Orange and Basswood. The species which give promise of being most satisfactory for general planting are as follows:

| Species | Per cent living | Age years | Height, feet |
|---|---|---|---|
| Russian Mulberry | 97 | 6 | 6 (Table only) |
| Honey Locust | 92 | 6 | 8-12 |
| Carolina Poplar | 87 | 4 | 16-20 (Bench only) |
| Box Elder | 85 | 5 | 10-13 |
| Black Walnut | 75 | 5 | 5- 6 (Bench only) |
| White Elm | 66 | 5 | 8-12 |
| Hackberry | 63 | 5 | 8-12 |
| Cottonwood | 48 | 6 | 20-28 (Bench only) |
| Norway Poplar | 45 | 4 | 16-20 (Bench only) |
| Russian Olive | 20 | 5 | 8-12 |

Among the conifers the results have been generally unsatisfactory. Jack Pine and Western Yellow Pine have made fairly good growth when planted on favorable slopes along the canyon sides. The Jack Pine showed a large percentage of trees surviving when planted on north and northwest exposures. Western Yellow Pine showed similar results for the same exposures and smaller percentages of trees surviving when planted on west and east exposures. South exposures failed to show any trees living at the end of the first year. In every case where the trees were planted on cultivated land they were complete failures except when the trees were eighteen inches or more in height and had been transplanted three or four times.

# A STUDY OF THE STREET TREES OF LINCOLN.

T. B. Nichols '13.

Considerable interest has been aroused recently throughout the country in what has been called "city forestry." While not strictly forestry, and more within the province of arbor-culture, city forestry is becoming more important each year. The present study was undertaken to learn the factors affecting the growth and condition of street trees in Lincoln, Nebraska. The data and observations contained in this article were collected by field work in different parts of the city and it is hoped that they may be of some benefit to the owners of street trees in Lincoln and elsewhere. Considerable credit should be given W. A. Rockie '14 for his assistance in this work.

The trees were examined from almost every view-point, and the injuries done by man, fungi, insects, and the elements were carefully studied. The trees between the sidewalk and the street and those within ten feet of the sidewalk on the premises of the owner were the only ones considered in this survey.

Before taking the actual survey data, city maps were studied, typical conditions noted, and type localities selected which would, as nearly as possible, represent the average conditions found throughout the city. These selected type plots are located as follows:

1. R street from 31st to 32d;
2. S street from 31st to 33d;
3. 26th street from L to O;
4. D street from 11th to 15th;
5. R street from 14th to 16th.

It may seem that the first and second localities are rather close together, but the reason for such a choice is that they are of two distinct types. The type plots above represent but a small portion of the area covered by the total field work, but the remainder of the city was covered in a general way, rather than by the detailed studies noted on the particular streets mentioned. Most of the common shade trees were included in one or other of the selected plots.

Of the sections mentioned all are probably representative of the neighborhood at large. The block on R street between 31st and 32d is typical of most of the area south to O street and west for many blocks. Only a block north, however, on S street the plot is quite typical of the area east, north and west from that point. The blocks on South 26th street are representative of the surrounding area, and also much of southeast Lincoln, with the exception of that part of this section which is on the bottom land of Antelope Creek. In the Antelope bottoms, which form a wide belt bordering the creek on both sides and in places extending back to a considerable distance, is an area of trees that are in a very bad condition due chiefly to the lack of care. The plot selected on D street is very characteristic of the greater part of southwest Lincoln, and for a portion of south Lincoln; while the type on R street between 14th and 16th is typical of northwest Lincoln.

During the study a total of 347 trees were examined in detail on these plots following the form which is shown. The species are divided as follows:

| SPECIES | Number of each | Per cent of Total |
|---|---|---|
| White Elm—*Ulmus americana*<br>Slippery Elm—*Ulmus pubescens* | 113 | 32.6 |
| Box Elder—*Acer negundo* | 73 | 21.0 |
| Silver Maple—*Acer saccharinum* | 46 | 13.2 |
| Green Ash—*Fraxinus lanceolata*<br>White Ash—*Fraxinus americana* | 42 | 12.1 |
| Catalpa—*Catalpa catalpa* and *C. speciosa* | 21 | 6.1 |
| Black Walnut—*Juglans nigra* | 16 | 4.6 |
| Honey Locust—*Gleditsia triacanthos* | 12 | 3.4 |
| Carolina Poplar—*Poplulus angulata* | 7 | 2.0 |
| Cottonwood—*Populus deltoides* | 6 | 1.7 |
| Juniper—*Juniperus virginiana*<br>Linden—*Tilia americana*<br>Sycamore—*Platanus occidentalis*<br>Hackberry—*Celtis occidentalis* | 11 | 3.3 |

## TABLE SHOWING METHOD OF COLLECTING DATA.

| | SPECIES | TREE | | BOLE | | CROWN | | | DISEASED DUE TO | | CARE OF TREE | GROUND |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Height Feet | Diameter Inches | Fork Height Feet | Straight or Crooked | Form Regular or Irregular | Widest Spread Feet | Crowding | Break or Pruning | Fungi or Insect | Needs Pruning Well Cared For Broken or Topped | Hard or Soft |
| 1 | Ash, Green | 30 | 6 | 9 | Straight | Regular | 30 | Yes | Pruning | Insect | Needs pruning | Soft |
| 2 | Ash, Green | 40 | 12 | 10 | Straight | Regular | 40 | Yes | Pruning | Insect | Cared for | Soft |
| 3 | Box Elder | 25 | 7 | 9 | Straight | Regular | 15 | No | Pruning | Insect | Needs pruning badly | Soft |
| 4 | Catalpa | 35 | 16 | 8 | Straight | Fairly Regular | 30 | Yes | Pruning | —— | Well pruned | Soft |
| 5 | Box Elder | 30 | 10 | 9 | Crooked | Irregular | 30 | Yes | Pruning | Both | Should be cut out | Soft |
| 6 | Linden | 25 | 10 | 8 | Straight | Irregular | 25 | Yes | Pruning | Fungi | Needs pruning | Soft |
| 7 | Elm, White | 40 | 16 | 12 | Straight | Irregular | 45 | Yes | Pruning | Fungi | Injured at top | Soft |
| 8 | Elm, White | 40 | 12 | 7 | Straight | Irregular | 50 | Yes | Pruning | Fungi | Needs pruning | Soft |
| 9 | Box Elder | 35 | 18 | 5 | Crooked | Irregular | 40 | Yes | Pruning | Both | Crowding. Cut out | Soft |
| 10 | Elm, White | 50 | 30 | 3 | Straight | Irregular | 60 | Yes | —— | —— | Good condition | Soft |
| 11 | Elm, White | 40 | 18 | 7 | Straight | Regular | 35 | No | Pruning | Fungi | Poorly pruned | Soft |
| 12 | Elm, White | 40 | 16 | 10 | Straight | Regular | 50 | No | Pruning | Fungi | Poorly pruned | Soft |
| 13 | Elm, White | 35 | 8 | 4 | Straight | Irregular | 25 | No | —— | —— | Needs some care | Soft |

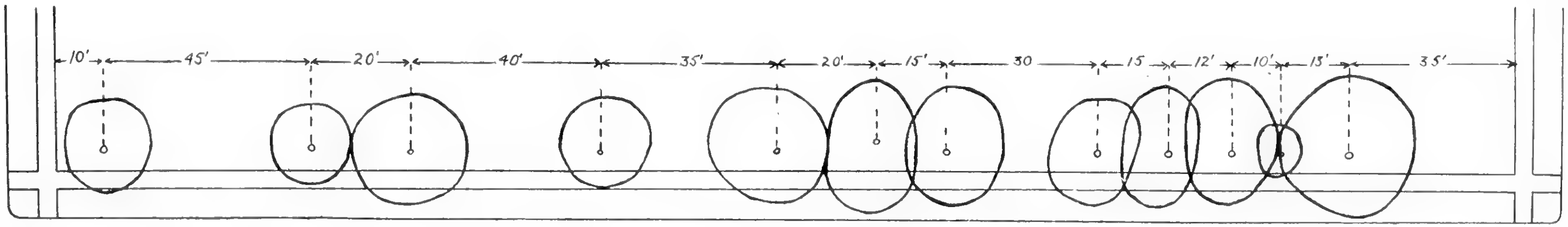



**Diagram of Trees Along a Street, Showing Poor Spacing and Crowding.**

Forty-nine per cent of this number were diseased in one way or another, while of these infected specimens 81 per cent were diseased because of bad pruning or unhealed wounds from wind-broken branches and of this 81 per cent of the diseased trees about eight-ninths were injured by pruning rather than by breaking. While speaking of diseased trees it will be well to mention here that the smoke injury is becoming quite noticeable. This matter was not thoroughly studied, but from investigations in other cities it has been found to be harmful. The leaves in many instances were found covered with soot, which is a hinderance to photosynthesis and respiration. The sulphur dioxide gas present in the smoke not only tends to poison the leaves but also to extract the water from them, thus causing an excessive evaporation.

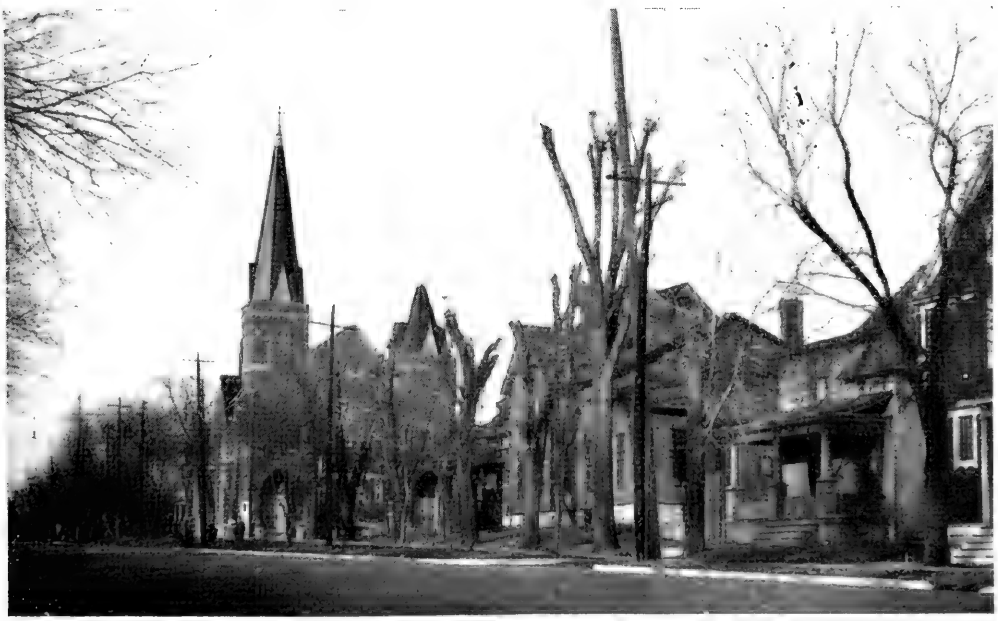
From other data gathered in reference to the shape of the tree it is shown that 160 trees, or 46 per cent of the total number examined, had irregular or suppressed crowns, or showed signs of having been suppressed. Excessive crowding due to very close spacing of trees is the main cause for the very poor shaped crown. There were 140 trees, or nearly 42 per cent of the total, that were crowded on one or more sides, and in a number of cases were overtopped by other trees. Close planting is justified when the trees are young and first planted, but as they become older some should be removed to make room for the remaining trees to develop their crowns. It is generally large well formed trees that are desired along a street, rather than a thick stand of straggling crowded trees. The diagram will show, in a measure, the close spacing of trees and the crowding of crowns as found on one of the streets.

The height and diameter were also taken for each tree shown in the table. For the majority of the different species the height was found to vary directly with the diameter. In the case of the Maple and Box Elder, however, this was not true. In either of these species trees with the same diameter would vary greatly in height and this was probably due to the crowding and overtopping of the crowns.

About 38 per cent of the trees had crooked stems, which is a simple matter to remedy, if the tree is properly handled when young. A tree planted loosely in the ground is easily bent by the wind and in all probability will not retain its original position, as the roots will be pulled out of place on one side. This leaves the tree leaning and the stem will bend as it grows, in order to give the tree an upright position, thereby causing a

PLATE I.

An Elm Overtopped and Suppressed.



Poor Pruning and Pollarding That Should Not be Permitted.

crooked stem. Strong continuous winds will also cause crooked stems in firmly planted trees; therefore it is advisable to brace trees in exposed locations until they have reached a medium sized diameter, and can well stand the strain of the wind. It was found that several species tended toward crookedness more than did other species, the Box Elder being the worst, with Maple, Elm, Cottonwood and Ash following in order given. The height at which the tree began to fork also varied with the species. Again the Box Elder and Maple gave the greatest percentage of the total with a very low fork height. Low forking is also chiefly due to improper care of the tree while young. The side branches are not kept pruned, thus giving the tree a chance to start a shoot low down on the stem that forms another leader to the tree.

Unsystematic tree planting has been the common practice in all parts of the city. For example: A property owner would plant a few street trees without giving any attention as to whether they were in line with his neighbors. This irregularity of trees gives the street a very bad appearance, as in several cases trees had been planted by one owner inside the sidewalk while those of his neighbors on each side were planted in the parking between the sidewalk and curbing. The break in the row of trees on this one block made a poor appearance which otherwise would have been symmetrical and artistic had this one property owner used a little judgment and cooperated with his neighbors in the planting of the trees. If the park is too narrow for successful tree growth, because of lack of surface for the absorption of sufficient rainfall and of room for root development, it will be necessary for the property owner to plant the trees on his own land. With such conditions all trees should be planted uniformly, that is, inside the sidewalk, and then, there would be no cause for the irregular appearance in the line of trees.

The surface of the soil was inspected to learn whether it was loose, hard and baked, or sodded. Some light might possibly have been thrown on the subject why some trees did not attain the growth they should, if the soil had been examined to some depth beneath the surface. Probably the poor growth of some of the trees was due to the poor soil.

To give a fair idea of the conditions of each of the different species of trees, the following descriptions of the most common species will be given. These brief descriptions will be more of the average tree with possibly an idea of what the tree should be like.

### The Silver Maple.

Silver Maple generally has a fairly regular formed crown if not crowded. It forks quite close to the ground, sometimes within two feet of the base of the tree. It attains a height of 30 to 38 feet, and varies greatly in diameter. An average diameter for a 35 foot tree is 16 inches, but may run far above or below this figure. It is readily susceptible to decay if not cared for. Although it is a fair shade tree, other species, such as Norway or Sugar Maple, are preferable.

### The Ashes.

Both the Green and White Ash will be considered together as there is very little, if any, difference in the conditions of the two trees. The Ashes have a very coarse spray, but due to the compound leaves makes a fairly good shade tree. They average about 8 inches in diameter, trees of this diameter reaching a height of nearly 30 feet, and growing to a height of from 11 to 14 feet before forking. Ash thrives well on nearly any site in the city, being well adapted to the drier sites. They usually are not attacked badly by insects or fungi.

### The Elms.

The White and Slippery Elms were the only species of the genus studied in this survey and they were considered together. These trees develop a beautiful broad topped crown with graceful, drooping branches. The average diameter is from 6 to 7 inches, and the average height from 20 to 25 feet. They finally attain a diameter of from 14 to 16 inches and a height of from 40 to 45 feet. The Elms fork at about 7 feet from the ground; but this can easily be changed to a height of from 12 to 15 feet, if properly cared for when young. The trees are attacked by insects to some extent, but they have not been affected as badly as in some other cities.

### Box Elder.

Box Elder usually has a very compact but unsymmetrical crown. The stem is very crooked and forks about 6 or 7 feet from the ground. The tree grows rapidly but is short lived, seldom living to attain a diameter over 18 inches; and rarely exceeds 40 feet in height. It is susceptible to attack by fungi and insects, and when once attacked by either, the tree deteriorates rapidly. It is one of the poorest species that can be planted in a city for shade purposes.

### Cottonwood.

Cottonwood grows rapidly, attains a large diameter and good height, compared with other trees found in the city. It develops a long and open crown which is often cut back in order to cause it to spread and thicken. This treatment is not recommended, since it gives an ungainly appearance to a street tree. As the branches are easily broken due to the weakness of the wood the trees become a source of danger. The roots spread to a great distance and cause much damage by pushing out curbing and raising up walks. This tree is unsuitable for street planting and many cities forbid its use as a street tree.

### Sycamore.

Sycamore is one of the best trees planted in the city. It grows rapidly, and attains a good size. Fifty feet is not an unusual height, with a diameter of from 10 to 15 inches. It has a well-shaped and compact crown, but it does not form dense shade even though its leaves are quite large. This tree has been grown extensively in many of the large cities with marked success.

### Hackberry.

For a rather slow growing tree, but one that will form good shade, Hackberry is one of the best. It grows well on almost any site, either wet or dry. The crown is generally compact and has a dense foliage. It attains a height of from 35 to 40 feet and a diameter of from 14 to 18 inches. The bole is generally straight and grows to a considerable height before forking.

Not all the trees in Lincoln are in poor condition, for some have been well cared for or are naturally well formed trees. The Red Oak *(Quercus rubra)* and the Pin Oak *(Quercus palustris)*, although not found in any of the sample plots, were carefully studied, and seem, beyond doubt, to be two of the most desirable species found. Both have excellent shaped crowns, giving good shade, and would add beauty to any one's property. Excellent specimens of Red Oak may be found at 824 South 18th Street and at 15th and C Streets. Other species suitable for street and shade trees in Lincoln are the Ashes, Elms, Linden, Hackberry and Sycamore. Some of the most common trees which should not be planted except for unusual reasons are the Box Elder, Silver Maple, Carolina Poplar and the Cottonwood. Where nothing else will grow these species have their uses, but otherwise they should be forbidden.

The shade tree should be thoroughly suited to the local climate and soil conditions. Besides these absolute requirements other desirable qualities by which a street tree should be chosen are:

1. Form of tree under normal conditions; should be chosen for particular environments.
2. Long-lived trees.
3. Rapidity of growth.
4. Quality of shade produced.
5. Beauty of tree.

In the past but little skillful care was given to the trees of this city. On one lawn, however, there was observed a recent well directed effort to improve a misshapen tree. In several instances, rotten trunks had been hollowed out and filled with cement to prevent further decay. These trees had been carefully and skillfully pruned, and after coating the cut with tar a painting of white lead was applied. It appears that most owners of trees as well as the pruners employed have no knowledge of proper pruning; frequently long stubs were left when removing the branches. Instances were found where the bark had been peeled for a considerable distance on the bole, because no under cut had been made when the limb was removed. Many trees had two main stems when one might have been secured had the tree been treated at the proper time. To keep these large forks from splitting apart some have bound them together with wire and nearly, if not quite, killed the tree. In a few instances, however, an iron bolt has wisely been placed through these two forks and afterwards painted. Many cases of injury to the trees are caused simply by driving nails into the tree trunk to fasten a wire or a clothes line, or for the purpose of hitching a horse. A very common injury is caused by bumping the lawnmower against the tree. This is not so harmful to the older trees as to the younger ones, but should be given some consideration.

Not all the points brought out have been spoken of in detail and in all probability some very important ones were overlooked. It seems highly desirable that the city begin controlling the planting and the care of street trees. With a street tree commission, or better still, an active well trained man in charge of the street trees of Lincoln a decided change for the better would soon result.

# THE LITERATURE OF NORTH AMERICAN SYSTEMATIC BOTANY.

Professor Charles E. Bessey.

There are so many times when the young forester must know how to determine the classification of the plants of the region in which he is at work that it has seemed advisable to make a concise statement here of what books he should have access to when such necessity arises. Some of these he should have with him in the field, but in order to make this article as useful as possible I have included quite a number of works that are only to be found in the larger and more complete college and university libraries, to which the forester may turn in order to consult them. I am quite of the opinion that some of the books that I list should be found in the permanent headquarters of the forest officials, and others should be owned individually by the foresters themselves, yet I know very well that no great burden of this kind should be laid upon the shoulders of men who too often can ill afford the expense of purchasing and transporting many books.

At the outset it must be said that we do not yet have a general manual which includes in one work all the higher plants of the whole country. So the forester is obliged to use the book or books best suited to the particular locality concerned. Herein is to be found the reason and necessity for such an article as this. When once we have a manual covering the whole country it will no longer be necessary to instruct the young forester in regard to the many books on Systematic Botany with which he must be acquainted. Until that time he must resort to the best of the many books now available, and while on the one hand he must not overlook any necessary works, on the other he should not waste his time on those that are valueless. In arranging the works here referred to, in order to simplify matters I have placed them under four heads, namely: I. General Works; II. Reports and Monographs; III. Manuals Covering Particular Regions; IV. Books on Trees Alone.

## GENERAL WORKS.

*Prodromus Systematis Naturalis Regni Vegetabilis*, by A. P. DeCandolle, and later Alphonse DeCandolle, 1824 to 1873: 17 volumes. Contains Latin descriptions of all the species of flowering plants then known to botanists, from all countries in the world. This is one of the most valuable of all general works. To these volumes must be added the thirteen supplementary volumes by Walpers, and Mueller *(Repertorium*, and *Annales* 1842-1868) containing thousands of additional descriptions. Here should also be placed the nine volumes of the *Monographiae Phanerogamarum*, by Alphonse and Casimir DeCandolle, 1878-1896.

*Die Naturlichen Pflanzenfamilien*, by A. Engler and K. Prantl, containing German descriptions of the genera of plants, accompanied by excellent figures. Whenever accessible it is always referred to by the systematic botanist. Here I may add a reference to my own *Synopsis of Plant Phyla*, published in the University of Nebraska Studies, 1907, and containing a rearrangement of Engler and Prantl's families, but based on that work.

*The Flora of North America*, by John Torrey and Asa Gray, was begun in 1838. One volume was completed within a few years and a second was begun, and when about half completed it was discontinued. This work, had it been completed, would have given us a North American manual. The descriptions in this old work are very well drawn up, and even today the book has much value.

*The Synoptical Flora of North America*, by Asa Gray, 1878 to 1884. This was an attempt by Dr. Gray to continue the work begun so many years earlier in the book just mentioned, but the author's death in 1888 brought it to a close, although a couple of pamphlet additions were brought out by B. L. Robinson under the same title some years later. One who has the earlier Flora of North America by Torrey and Gray, and Gray's Synoptical Flora, with the supplements by Robinson, will find them most helpful in whatever part of the country he may happen to be.

*The North American Flora*, published by the New York

Botanical Garden, is now in slow course of publication, a "part" appearing every few months . It is to include descriptions of all the plants of North America, but at the present rate of publication it will be nearly a hundred years before it is completed. Yet the forester will have to know about this work, and be able to consult it when necessary.

*The Index Kewensis,* (1893-1908) by B. D. Jackson, is a work of four large quarto volumes, with two supplementary volumes, filled with alphabetically arranged lists of the species and and genera of the higher plants, with their synonyms. While not in any sense a descriptive manual it is most useful in enabling one to determine questions of synonymy.

## REPORTS AND MONOGRAPHS.

There are many state and governmental reports that contain much of value to the young systematic botanist, but I shall keep my list down to as small a number as possible, yet it must be remembered that for some portions of the West and Southwest these reports contain the most accurate information that we yet possess.

Watson's *Report on Botany* (1871), in King's Report of the Geological Exploration of the 40th Parallel, contains an enumeration of the plants of Colorado, Utah and Nevada, with descriptions of the new, and the less commonly known species.

Rothrock's *Report on Botany* (1878), in Wheeler's Report upon the United States Geological Surveys West of the 100th Meridian, contains an enumeration of the plants of Colorado (southern), New Mexico and Arizona, with descriptions of the new, and the less commonly known species.

These two reports are of the highest value, because for much of the intermountain region they contain the most complete enumerations yet made.

Brewer, Watson and Gray's *Botany of California* (1876-1880), in the State Geological Survey of that state, contains a most complete and satisfactory treatment of the flowering plants and ferns of California and the contiguous territory. Unfortunately the volumes are no longer to be found, excepting in the larger libraries.

Rydberg's *Catalogue of the Flora of Montana and the Yellowstone National Park*, 1900, is a pretty complete enumeration of the ferns and flowering plants of the Yellowstone Park, and the state of Montana. Although only the new species are fully described, many helpful notes are appended to nearly all species, and the book will repay consultation.

Torrey, Gray, Bigelow and Newberry's papers in several of the volumes of the *Reports of Explorations and Surveys for a Railroad Route from the Mississippi River to the Pacific Ocean,* published about 1855, may be consulted with profit when the plants of the general central region from Nebraska and Kansas westward are under consideration.

Gray's Plants of Texas and New Mexico *(Plantae Wrightianae Texano-Neo Mexicanae,* 1852-3), and other reports on the Mexican Boundary Survey may be profitably consulted, when the plants of the southwest region are under consideration.

## MANUALS COVERING PARTICULAR REGIONS.

In the field the forester will have to depend very largely upon the local botanical manuals that have been prepared so as to include the plants of more or less restricted portions of the country. And it must always be remembered that such manuals aim to describe only the plants within certain areas, and that outside of these areas they are less and less usable, just as we get farther away from the borders of the region covered. So the forester in Arizona must not expect to be able to use successfully a manual designed for the New England or Atlantic Coast states.

For convenience I shall divide the country into four general regions, namely: I. The North Eastern States; II. The South Eastern States; III. The Rocky Mountain States; IV. The Pacific Coast States.

### I. THE NORTH EASTERN STATES.

This area extends east and north from the southwest corner of Kansas. For this region there are three standard manuals.

Britton's *Manual of the Flora of the Northern States and Canada.* It includes all of the ferns and flowering plants of Kansas, Nebraska, and the Dakotas eastward to the Atlantic Ocean, and indefinitely northward in Canada.

Britton and Brown's *Illustrated Flora of the Northern United States and Canada* (3 vols.) covering the same area, and including the same plants. Each species is illustrated by a small figure in the text.

Gray's *New Manual of Botany,* seventh edition. This book does not cover as large a territory as Britton's Manual, its western limit being the 96th meridian, and its northern extension being somewhat less in Canada. Many of the more difficult species are illustrated by small text figures.

### II. THE SOUTH EASTERN STATES.

The area here included lies south of the southern line of Kansas, Missouri, Kentucky and Virginia, and eastward of the 100th meridian.

Small's *Flora of the South Eastern United States* fully covers the flora of the whole region.

Chapman's *Flora of the Southern United States* is an older work, and does not extend as far westward as Small's book, including little, if any of the flora west of the Mississippi River.

### III. THE ROCKY MOUNTAIN STATES.

The eastern limits of this region are approximately from the western limits of II and III, above, and from this line the region extends westward to the Sierra Nevada, while north and south it extends from the Mexican boundary across the United States over the border to an indefinite extent in Canada.

Coulter and Nelson's *New Manual of the Botany of the Central Rocky Mountains* is a new edition of Coulter's Manual, which first appeared twenty-eight years ago. The new book covers the region very well from New Mexico and Arizona northward into Canada.

Rydberg's *Flora of Colorado* is complete for this state, and will serve fairly well for some of the contiguous territory.

Coulter's *Flora of Western Texas* will be helpful in western Texas, and a considerable portion of New Mexico.

Brown's *Alpine Flora of the Canadian Rocky Mountains* will prove helpful in the region indicated in its title.

### IV. THE PACIFIC COAST STATES.

Here I include California, Oregon, Washington and an indefinite part of British Columbia.

Jepson's *Flora of Western Middle California* is a helpful book for the middle region of California.

Abrams's *Flora of Los Angeles and Vicinity* contains a pretty full treatment of the plants of southern California.

Howell's *Flora of Northwest America* covers pretty well the Oregon, Washington and British Columbia region, with the addition of some parts of Idaho.

Frye and Riggs's *Northwest Flora* is a new book covering the states of Washington, Oregon and portions of Idaho and British Columbia.

Piper's *Flora of the State of Washington* completely covers Washington, and is helpful for the identification of the plants a little distance over the border in Oregon, Idaho, and British Columbia.

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The following arrangement by states may be more helpful for the western states than the more general statement given above. The names of books are abbreviated in order to save space.

*Western Texas:* use Small as a basis, supplemented by Coulter's Texan Flora, and Coulter and Nelson's Rocky Mountain Botany.

*New Mexico:* use Coulter and Nelson's Rocky Mountain Botany, supplemented by Coulter's Texan Flora, Small, and Rothrock's Botany in Wheeler's Reports.

*Colorado:* use Coulter and Nelson's Rocky Mountain Botany, and Rydberg's Flora.

*Wyoming:* use Coulter and Nelson's Rocky Mountain Botany.

*Montana:* use Coulter and Nelson's Rocky Mountain Botany.

*Idaho:* use Coulter and Nelson's Rocky Mountain Botany as a basis and supplement it with Frye and Riggs's Northwest Flora, and Piper's Flora of Washington.

*Utah:* use Coulter and Nelson's Rocky Mountain Botany.

*Nevada:* use Coulter and Nelson's Rocky Mountain Botany as a basis, and supplement it by Frye and Riggs's Northwest Flora, and Watson's Botany of King's Reports.

*Arizona:* use Coulter and Nelson's Rocky Mountain Botany as a basis, and supplement by Coulter's Texan Flora, Abrams's Los Angeles Flora, Rothrock's Botany in Wheeler's Reports, and Brewer, Watson and Gray's Botany of California, in the State Geological Survey.

*California:* use Jepson's Flora for middle California, Abrams's Flora for southern California, Frye and Riggs's Northwest Flora for northern California, supplemented by Brewer, Watson and Gray's Botany of California in the State Geological Survey, Rothrock's Botany in Wheeler's Reports for the south, and Watson's Botany in King's Reports for the middle and north.

*Oregon:* use Frye and Riggs's Northwest Flora, supplemented by Howell's Flora.

*Washington:* use Frye and Riggs's Northwest Flora, supplemented by Piper's Flora of Washington.

*British Columbia:* use Frye and Riggs's Northwest Flora, supplemented by Piper's Flora of Washington, and Howell's Flora.

## BOOKS ON THE NATIVE TREES.

Quite naturally the young forester is interested in books that enable him to determine exactly the classification of the trees he finds in his work in the forests. While this can be done very well in most cases by the use of the manuals given above, it is often desirable to make a more critical study of certain species than can be done without a resort to the books that treat of trees alone, in order that he may note their variations and peculiarities more closely.

Sargent's *Silva of North America* (1891 to 1902) in fourteen quarto volumes is the finest work of its kind ever published in any country. Every species is figured in life size as to leaves, flowers and fruits, accompanied by very full descriptions. It is the "court of last resort" in all questions as to the identity of our native trees.

Sargent's *Manual of the Trees of North America* (1905) is a compendium of the preceding, in one octavo volume, and is almost as useful for identifying the trees as the larger and more cumbersome work.

Britton's *North American Trees* (1908) is much like Sargent's Manual, but is considerably less technical. Both include all our native species throughout the country, so they can be used from Labrador to Arizona, and from Florida to British Columbia.

Michaux's *North American Sylva* (1857) although old cannot be ignored, since its colored illustrations make it one of the most attractive of the American books on trees. Although originally published in three volumes, two supplementary volumes were added by Nuttall in the style of the original work.

Sudworth's *Nomenclature of the Arborescent Flora of the United States* (1897) and the same author's *Check List of the Forest Trees of the United States* will necessarily be consulted where the forester wishes to be very exact in the citation of the names and synonyms of our forest trees.

Sudworth's *Forest Trees of the Pacific Slope* (1908). This volume of 436 pages, published by the Government, describes the 150 forest trees known to have a habitat in the Pacific coast region of North America north of Mexico.

I have been helped very often in my study of our American trees by several German books, the best of which are the following:

Koehne's *Deutsche Dendrologie* (1893), containing many critical notes upon American species.

Dippel's *Handbuch der Laubholzkunde* (3 vols., 1889-1893), which is much fuller than the preceding.

Koch's *Dendrologie* (2 vols. 1869-1872), an older but still valuable work.

I add here the names of two little known old books on American trees. It is needless to say that it is only in extreme cases that they will be useful to the forester, yet he should know about them, and also know where he can find copies should the occasion for using them ever arise.

Wangenheim's *Beytrag zur Forstwissenschaft* (1787) describes and figures many American species for the first time. It may interest the reader to know that it was in this book that the Hard Maple and the Silver Maple were confused, and that the confusion here started continued for more than a century.

Marshall's *Arbustum Americanum* (1785) was the first book ever written on American trees. In it are to be found the original descriptions and names of many of our species.

## WHERE RARE BOOKS MAY BE FOUND.

The rare books mentioned in this paper are found in many, but by no means all of the botanical libraries in the country. If the young forester finds himself near any considerable library it will be well for him to inquire whether such books are included in it. However, the following are suggested as quite certainly containing copies of all the books enumerated above, and usually they may be borrowed under conditions and restrictions which may be learned upon inquiry:

Library of the University of California, Berkeley, Calif.

Library of the University of Nebraska, Lincoln, Nebr.

Library of the University of Chicago, Chicago, Ill.

Missouri Botanical Garden, St. Louis, Mo.

New York Botanical Garden, Bronx Park, New York City, N. Y.

Library of Harvard University, Cambridge, Mass.

Philadelphia Academy of Natural Sciences, Philadelphia, Pa.

The Congressional, and the Smithsonian libraries, Washington, D. C.

Usually a properly worded request addressed to the librarian of any of the foregoing will secure the book or information as to how it may be obtained. On the other hand some libraries do not loan books to individuals, but even they will usually *loan to other libraries*. A local library may therefore be used to secure the book.

# GRAZING RECONNAISSANCE ON THE COCONINO NATIONAL FOREST.

R. E. Bodley, '12.

When it was definitely decided early in 1911 that a new line of work known as "Grazing Reconnaissance" was to be instituted by the United States Forest Service, preparations were made to start the work at once. But first, men had to be found for this new work and instructed in their duties. Accordingly a civil service examination was soon held and men with considerable training in botany and surveying and familiar with range conditions were thereby secured. These men, known as Grazing Examiners, were assigned to different Districts under the general supervision of Grazing Inspector J. T. Jardine, who planned the work.*

It was decided, however, before the Grazing Examiners started operations in their several Districts, that better results and greater uniformity could be obtained if all the Examiners were brought together on some one forest and given preliminary training and instruction under the direct supervision of the Grazing Inspector. For this purpose the four Grazing Examiners reported for duty in April at Flagstaff, Arizona, and grazing reconnaissance was started on the Coconino National Forest. About the middle of May the Grazing Inspector had to leave for other work and in a short time three of the Examiners were called to other Districts where grazing reconnaissance was to be initiated.

The fourth Examiner, left in charge of the work on the Coconino National Forest, was given a Deputy Supervisor and two Forest Guards, one of which was the writer. The qualifications of the men were that they should be conscientious workers, with previous experience in the field and in handling stock, and with special training in botany and engineering. About the mid-

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*Much credit is due Mr. J. T. Jardine for valuable suggestions found in his "Outline for Grazing Reconnaissance."

dle of October the two Guards left the party and the three Grazing Examiners again reported for work on the Coconino, having been forced to discontinue operations in their respective Districts on account of snow. The party continued the field work until the last of November.

The methods employed in the work on the Coconino National Forest were similar to those outlined by Arthur W. Sampson in Volume IV of this publication.

Because of valuable forest and forage growth and because of the importance of the stock industry, the Coconino National Forest was an ideal place on which to start the work. Its forests of almost pure stands of Western Yellow Pine on the higher portions and of Juniper and Pinon at lower elevations, supporting a great amount of forage, are not only valuable for watershed protection, but also yield an annual income of about 117,000 dollars from timber sales. Its forage plants not only serve as a blanket against soil erosion, but they also furnish a large part of the feed for approximately 130,000 head of cattle, horses and sheep annually, thereby furnishing an annual income of about 21,000 dollars in grazing fees.

The work of grazing reconnaissance essentially consists of three parts; the making of accurate maps, a concise descriptive report to accompany each map, and a complete plant collection of all the species on the forest. The data for the map and descriptive report were secured as follows:

## Field Work.

The maps of the area which had previously been covered by timber reconnaissance were examined in the office before field work started, and the topography and cultural features were copied, on blank Forms 764, from the permanent timber reconnaissance maps. When these sections were examined this topography and the cultural features were checked. If the area had not previously been examined, aneroids were carried and hundred foot contours were sketched in. Streams and such cultural features as roads, main trails, fences, cabins, corrals, watering places of all kinds, and telephone lines, were located on this map. In addition the types and subtypes were accurately mapped. Any type or subtype occupying ten acres or more was mapped separately, if it occupied less than ten acres it was not shown as a separate type but was written up with the type in which it occurred.

Since nearly all of the Coconino Forest is surveyed the section lines were used as base lines. In the unsurveyed areas a base line beginning from a known section corner was run as nearly as possible through the center of the area, providing it occupied not more than one township; if the area was greater than this, additional base lines had to be run. Each section was crossed twice, going out on one "forty line" and returning on the other and checking on each section corner. By crossing a section but twice it can readily be seen that frequent offsets were necessary in order to correctly map in a road, boundary of a type or other features that were to be shown.

The grazing land on the Coconino was divided into nine general types each being represented on the map by a number. The subtypes under these general types were represented by the initial letter or letters of the predominant forage. The tree species occurring on any of the types were shown by the initial letter or letters placed in parenthesis. The general types mentioned were as follows:

1. *Open grass land,* other than meadow. Many open areas or parks occurring in the timber and woodland types generally support a good stand of grasses. At upper elevations there are large Mountain Bunch Grass *(Muhlenbergia gracilis)* and Pine Grass *(Festuca arizonica)* areas, which were represented on the map as 1 B. and 1 P. respectively; if they both occurred on the same area they were represented as 1 B. P. Small parks occur in nearly all valleys and may either have a good stand of Blue Grama *(Bouteloua oligostachya)* and Black Sporobolus *(Sporobolus interruptus)* or may have been overgrazed in the past and now have only a stand of annuals. At lower elevations there are many large parks with Blue Grama predominating, which were represented as 1 G.

2. *Meadow.* The few wet meadow lands where water grasses (sedges) predominate occur as narrow bands around permanent lakes or may cover the entire bed of intermittent lakes.

3. *Weeds.* There are many untimbered areas where weeds predominate. On many of these there probably was once a good stand of grasses, but overgrazing in the past has caused the killing out of the grasses and the occupancy of the range by weeds, many of which have little or no forage value. Some of these overgrazed areas on which the grasses were not entirely killed out and which have been especially favored by some protection

in late years are slowly coming back to grass. The weeds may still predominate, but if there was enough grass to make its forage value more than that of the weeds, the area was shown as type 1. with the predominant grass as the sub-type. The few Aspen areas supporting a growth of weeds were included in this general type.

4. *Sagebrush.* This type, which includes all lands where sagebrush is the predominant forage, occurs in no appreciable areas on the Coconino National Forest.

5. *Browse.* All areas, outside of timber and woodland where browse (woody perennials) was the predominant forage, were shown under this type. These areas occur on the sides of canyons and on steep south slopes above medium elevations as well as over large areas of ridges and slopes at lower elevations.

6. *Timber range,* supporting a stand of grasses, weeds and browse. This is the principal type occurring on the forest with Yellow Pine as the predominant timber species though there are some small areas of the Transition, Douglas Fir, and Alpine timber types above the Yellow Pine. The forage that this type supports varies from pure stands of Bunch Grass and Pine Grass at higher elevations or Black Sporobolus and Blue Grama a little lower, with all variations of subtypes to a mixture of grasses, weeds and browse.

7. *Waste range.* There are very few waste range areas on the forest, the chief ones being in Manzanita brush and on the inaccessible sides of canyons. In case it was in dense brush the species predominating was represented as a subtype by the initial letter of its name.

8. *Barren Land.* All areas where naturally there is no vegetation, such as slide rock or lava beds, were shown as barren land.

9. *Woodland,* supporting a stand of grasses, weeds and browse. Woodland of Juniper, Pinon and Arizona Cypress occur at lower elevations on the forest. The forage supported by this type varies greatly, ranging from a well stocked Blue Grama stand to one made up almost entirely of worthless weeds or of browse. Often this area, especially the dense thickets of Arizona Cypress, might have been mapped as waste range because of the very sparse stand of forage plants.

The field notes, which were to constitute the descriptive report, were written on loose sheets, Form 874-13, in Forest Ser-

PLATE I.

Moving Camp in Accessible Areas.

Moving Camp in Rough Country.

vice note books, and described the following points:

1. *Surface.* Whether level, rolling or rough, the steepness of slopes, depth of canyons and height of rim rocks, if any were present, and all other points which would describe the appearance of the area.

2. *Soil.* Probable origin, composition, amount of rock, texture, depth, and moisture content.

3. *Vegetation.* The abundance and the composition of the vegetation were written up separately for each subtype. The species were listed under the heads of palatable and nonpalatable. The palatable vegetation was divided into (a) grasses; (b) weeds; (c) browse; while the nonpalatable consisted almost entirely of weeds, some of which were poisonous. If any trees were present their shade cover, or rather the fractional part of the surface from which herbaceous vegetation was excluded by tree shade, was given. The density of grasses, weeds, and browse taken together over the whole area was expressed in tenths, ten tenths indicating a perfect stand, while the portions occupied by grasses, weeds, and browse respectively were expressed in per cents of the total density. To illustrate: In the type 6 G (YP) the Western Yellow Pine has a shade cover of two tenths. There is a five tenths density of other vegetation consisting of grasses 50 per cent, weeds 30 per cent and browse 20 per cent. The condition and composition of each type were discussed separately.

4. *Water.* In a region so dry as this special stress was laid upon water facilities. The distance to nearest water, the amount present, and if none was on or near the area, the possibility of water development were discussed. Tanks (reservoirs) constructed by the stockmen furnish a large percentage of the water for stock in many places. These tanks, located in natural drainage lines, catch and hold a part of the water that comes down after a rain or while the snow is melting. Some are constructed by scraping out a large basin-shaped hole in the ground, using the dirt scraped out for the construction of the dam. The dams of the larger tanks are constructed of cement, often at a cost of several thousand dollars. In all cases a fine textured clay soil well "puddled" is necessary as a bottom in order to decrease the loss of water by seepage. It was customary to give the size of each tank, and estimate or inquire from the stockmen as to whether they were sufficiently large to supply the stock grazing on the area with

water during the dry season. The water supply problem is important in this region and development of water facilities should be encouraged in order that all parts of the range might be fully utilized.

5. *Poisonous Plants.* The species and abundance of poisonous plants and the exact location of badly infested areas were described. These occur scatteringly over much of the forest. However, some areas were found where they were so abundant that stock exclusion was recommended during the period of greatest danger or when other vegetation is scarce.

6. *Range Destroying Animals.* The kinds, and amount of damage done by each were given. If a certain area was badly infested, its exact location was given. Prairie dogs and gophers were very abundant in some localities; ants, badgers, coyotes, and moles were less common.

7. *Examiners' Comment.* Points not previously brought out and which the examiner thought were of sufficient importance were mentioned; such as reasons for poorly stocked conditions, the type of stock best adapted to graze on the area, whether the area was fully stocked, the time of year best suited for the different kinds of stock together with any other recommendations which were deemed important.

The area examined and described as above averaged about three sections each day, although this varied with topography, density of undergrowth, distance from camp, and uniformity of the vegetation. The sections examined by each man formed a continuous tier. Ordinarily the work was so arranged that none of the men needed to walk over three miles to work, unless it was on the day when camp was moved and the new camp was not more than three miles from the point where one finished work. On extra long runs the two men working farthest from camp would sometimes ride the team of mules to and from work, McClellan saddles being carried with the outfit. In moving camp if the new location was to be situated within about eight miles of the old camp site and the road was not rough, the cook took the outfit alone. If the distance was longer or the road very rough he was accompanied by one man, the other men examining sections and walking to the new camp at night. Every night each man matched the contours, types and streams on his sections with those of the adjoining sections. The man in charge of the party would plan the next day's work and each man would draw for his sections and get the blank maps of these sections ready for the next day.

### Plant Collection.

The work of collecting plants is a very essential part of grazing reconnaissance. It was the aim to collect three specimens of every species found on the forest. All of the men were informed of the species already collected and whenever any member of the party found one that had not already been collected he brought three specimens back to camp. Notes giving the forest, name of collector, elevation, soil, forage value, distribution, soil and moisture requirements, and phenological notes were written on the herbarium sheets in which the specimens were placed. Specimens which had been pressed and dried were sent into the office as soon as possible. When a number of different species were dry they were separated into three collections, each containing one specimen of each species. One collection was then sent to the National Herbarium at Washington, D. C. for identification, one was sent to the District office, and the third was kept for the files in the Forest Supervisor's office. Whenever a new plant was brought in it was identified, if possible, and given a name. If lack of time prevented proper identification, a common name was accepted by all the men in the party, so that the names in the notes would be uniform. All plants were numbered; the number, common name, and scientific name, if one were given, were listed in a catalogue kept in camp. In this catalogue was also written a description of each plant together with the notes copied from the herbarium sheet. These numbers were sent to Washington and the common name and scientific name checked and corrected, if the one given in camp was incorrect. Specimens of approximately four hundred species of herbaceous plants and seventy-five species of trees were collected on the Coconino Forest during the summers of 1911 and 1912.

### Mapping.

Mapping consisted of transferring the data from the field maps and the notes to the section plat sheets, Form 765, where the data was permanently kept. This work was accurately done. All cultural features, contours, type letters, boundary lines of types and subtypes, and corners known to be in place were represented on the permanent sheet with India ink.

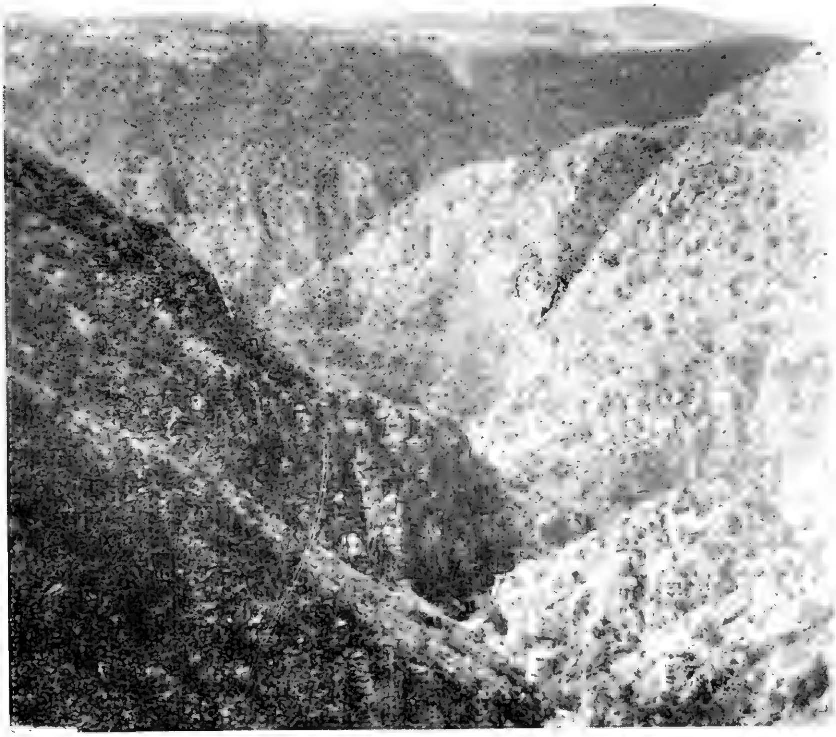
The types were represented with colored crayons according to the grazing reconnaissance legend, and were separated by a dotted black line. The condition of the range on each subtype was shown as follows: if an area was well stocked, that is, had a density of vegetation of three-tenths or more of palatable species, it was shown in the solid color. Poorly stocked portions, areas having less than a three-tenths density of palatable vegetation, were shown by vertical hatching in the type color; overgrazed areas were represented by horizontal hatching. The dividing lines between well stocked, poorly stocked, and overgrazed areas were shown by a solid line in the type color. As the range improves it will be possible to fill in the area with solid color.

The notes were written for the section as a whole, following the outline given under field notes, and the same subtypes were averaged together. About one-third of the space on the back of each sheet was reserved for a list of all the plants found on the section. The common and scientific names were given and the plants were listed as palatable or non-palatable.

An office tent, table, office box, and necessary crayons, pencils, sheets, inks, pens, and other equipment were carried with the outfit in order that the office work could be done on rainy days. It was the rule, however, not to allow the unmapped work to accumulate for more than a week, in order that the area might be fresh in the examiner's mind. When the men were not doing office work the table was used in the cook tent and the office tent was used for sleeping quarters.

The work in 1912 was largely a continuation of the work begun in 1911. The crew of 1912 consisted of one Grazing Examiner, an Assistant Forest Ranger and three Forest Guards. On account of other duties the Examiner was not in camp during all of the season.

Throughout the early part of the season of 1911 the crew stayed at logging camps, from which the surrounding country was worked. In the latter part of the season of



Deep Canyon Showing Rocky Cliffs. An Important Factor in Increasing Costs of Moving Camp and of Field Examination.

Open Woodland Type. The Bare Rock Pinnacles in Back Ground Make Field Examination Difficult.

1911 and during the entire season of 1912 a cook was employed.

A team of mules and a wagon were hired for the summer. If the country was very rough, burros and the team of mules were used for packing; while the wagon and extra supplies were left behind until the section of rough country was completed.

Monthly progress reports made by the man in charge of the party were sent to the Supervisor's office, the District Forester, and the Grazing Inspector to show what progress the party was making and what the costs were.

The field work on the Coconino was completed late in November, but the office work was continued during the winter. Following are a few figures taken from the reports of the work for 1911 and 1912:

| | |
|---|---|
| Area examined per effective day | 1780 acres |
| Area mapped per effective day | 2995 " |
| Average cost per acre for examination and mapping | $0.006145 |
| Cost of board per man per day | $0.594100 |
| Total cost per section when completed, approximately | $4.500000 |

The Examiner spends the winter in Washington checking up and compiling the data gathered during the summer and making his report. From this data a final map of the forest with scale of one inch to the mile is being made. This map will show:

1. All types and subtypes of grazing land ten acres or more in extent showing their condition.
2. All water facilities.
3. All cultural features.
4. Stock driveways.
5. The different allotments.
6. Any excluded or unused areas.
7. Topography.

The report that accompanies this map will discuss the forest by grazing districts, giving special attention to the following headings:

1. Full description of each type and subtype mapped, with special reference to the species of forage plants.

2. Condition of the range.

3. Unused range, extent and reasons for non-use of the areas with recommendations as to their future management.

4. Areas of poisonous plants.

5. Range destroying animals.

6. Water facilities.

7. Areas used for summer, winter, or for the entire year and any recommendations as to their future management.

8. Any other features that the Examiner thinks are of sufficient importance to be mentioned.

It is planned, early in 1913, to fence a large area in one or more types of varying density. These fenced enclosures will be stocked with the different kinds of animals grazing on the forest, and in this way the carrying capacity of the enclosure will be determined.

Early in the spring of 1912 another important branch of the work was started. Studies were made and will be continued, to determine the forage value of the important forage plants, and to ascertain the damage to reproduction due to the grazing of different kinds of stock.

When this study has been completed the data derived from it and the information given by the reconnaissance map and report, together with the carrying capacity determined from the experiments with the fenced enclosures will serve as very good data upon which to base a working plan, giving the carrying capacity of each allotment and that of the forest as a whole.

Those familiar with ecological relations in this section of the country believe that the general types will not change materially for a long period of time. By using the working plan accompanying the map and report, the Supervisor can so apportion the stock on the forest, that the overgrazed areas and many of the poorly stocked areas can be given such protection as will allow them to become improved and eventually well stocked. By shifting more stock to the unused and lightly used areas, and, if necessary, by having tanks or other water facilities constructed on the areas he can bring about a more complete utilization of the forage resources of the forest.

# NOTES ON CONIFEROUS SEEDLINGS.

R. T. Guthrie '12.

An experiment was made to determine whether coniferous seedlings have distinctive specific or generic characteristics by which they may be recognized. The seed of twenty-two species representing nine genera were sown in sandy loam on a greenhouse bench. Seedlings of sixteen species representing seven genera were obtained. They were examined at the time of the development of the primary leaves which follow the cotyledons, no secondary or true foliage being formed within four months after planting. Many of the characters which were noted seem to be variable and cannot be used as a basis of classification. Very little difference was found between a number of species.

The serrulate character of leaves cannot be determined without the aid of a hand lens. The lens shows minute, colorless, sometimes recurved projections scattered at intervals or rather numerously along the edges of the leaf. The number of cotyledons given is the range found in the seedlings grown in this experiment. A more extended test would doubtless show a greater range in several of the species in which the number is variable. The cotyledons of pine and spruce are wedge-shaped in cross-section, forming a sector of the circle formed by their whole number. The length of stem and leaves probably varies with the conditions under which the seedlings are grown; namely, soil, moisture, temperature, depth of planting, and character of the seed.

Very little detailed work seems to have been done in the study of coniferous seedling characteristics. H. Marshall Ward in "Trees," Vol. V, gives a seedling key that includes thirteen coniferous species. Three of these, *Pinus strobus, Juniperus* *communis,* and *Thuya occidentalis,* are American species. He gives a drawing of each, but does not include a complete description. The characters used are serrulation of leaves and length and number of cotyledons. He describes *Larix europea,* which is probably very much like the *L. americana,* as having both leaves and cotyledons smooth; the drawing shows them to be sharp pointed and seven in number.

Sir John Lubbock in his book entitled "On Seedlings," Vol. 2, p. 548, gives a difference between *Thuya occidentalis* and *Thuya gigantea,* the former having two opposite primary leaves and then about five whorls of three, while the latter has four primary leaves opposite in pairs with whorls of three above. *Pinus rigida,* he says, has from four to six cotyledons from ½ to ¾ inch long. He described one year old seedlings of seven coniferous genera but does not mention other American species.

Charles Mohr in "Notes on Red Cedar," U. S. Forest Service Bulletin 31, describes the seedling of that species *(Juniperus virginiana).* It has two cotyledons, the primary leaves are in whorls of three or rarely two, ⅜ inch long, rigid, sharp pointed, channeled above with a sharp midrib, the stomata irregular in four or five rows.

Drawings of seedlings of southern pines are found in Bulletin 13 and of White Pine in Bulletin 22, and of many coniferous species in C. S. Sargent's "Silva of North America," but none of them are detailed enough to give much definite information. In his "Manual of the Trees of North America" Sargent gives the number of cotyledons in different genera as follows:

| | | | |
|---|---|---|---|
| *Pinus* | 3 to 18 | *Taxodium* | 4 to 9 |
| *Picea* | 4 to 15 | *Libocedrus* | 2 |
| *Larix* | 6 | *Thuya* | 2 |
| *Tsuga* | 3 to 6 | *Cupressus* | 3 or 4 |
| *Pseudotsuga* | 6 to 12 | *Chamaecyparis* | 2 |
| *Abies* | 4 to 10 | *Juniperus* | 2 (or 4 to 6) |
| *Sequoia* | 4 to 6 | *Tumion* and *Taxus* | 2 |

These points are combined as far as possible with the observations made in this experiment in the preparation of the following key.

A. Cotyledons varying in number from 3 to many.

I. Stems mostly 1 inch long; cotyledons ¾ to 1 inch long, smooth or serrulate on 3 sides, triangular in cross-section. *Pinus*

a. Cotyledons smooth, leaves serrulate.

1. Cotyledons 3 to 5, 1 inch long; stem ½ inch long, slender. *P. contorta*
2. Cotyledons 5 to 8, 1 inch long; stem 1 inch long, reddish at base. *P. ponderosa*
3. Cotyledons 6 to 10, 1 inch long; stem 1 to 1¼ inches long, slightly reddish; leaves only slightly serrulate. *P. austriaca*

b. Cotyledons and leaves both more or less serrulate.

1. Cotyledons 3 to 5, remotely serrulate, ¾ inch long; stem 1 inch long, thin, buff colored or light reddish; leaves distinctly serrulate on 2 edges. *P. divaricata*
2. Cotyledons 4 to 6, 1 inch long, slightly serrulate; stem ¾ inch long, pinkish at base. *P. sylvestris*
3. Cotyledons 6 or 7, remotely serrulate, ¾ inch long; stem 1 inch or longer, dark red at base, very remotely spinulose; stomata with indistinct white markings. *P. resinosa*
4. Cotyledons 7 or 8, 1 inch long; stem 2 inches long, light reddish. *P. taeda*
5. Cotyledons 8 or 9, 1 inch long; leaves ½ inch long; stem ¾ inch long, thick, yellowish brown; stomata with indistinct white markings. *P. flexilis*
6. Cotyledons 7 to 10, ½ to 1 inch long; stem 1 to 2 inches long, reddish green at base. *P. strobus*
7. Cotyledons 10, 1¼ inches long; stem ¾ to 1 inch long, brownish to purplish; leaves ¾ to 1 inch long, sharp pointed, bluish bloom. *P. edulis*

II. Stem usually less than 1 inch long; cotyledons usually about ½ inch long, triangular in cross-section; leaves flattened or 4-sided, white stomatal markings.

a. Cotyledons not flattened; primary leaves 4-sided, serrulate on 4 sides. *Picea*

1. Cotyledons 5 to 7, ½ inch long; stem ½ to 1 inch long, reddish at base; scattered stomata. *P. engelmanni*
2. Cotyledons 6 to 8, ½ inch long, scattered stomata:

stem ½ to 1 inch long, somewhat spinulose, green. *P. excelsa*

b. Cotyledons and primary leaves smooth; cotyledons 6 or 7, triangular in cross section, sharp pointed. *Larix europea*

c. Cotyledons and primary leaves flattened, smooth; primary leaves sharp pointed. *Pseudotsuga*

1. Cotyledons 5 to 7, ½ inch long, smooth, rounded above, spreading, stomata more distinctly marked with white above; stem ½ to ¾ inch long, red with blue-green leaves or greenish with yellow-green leaves; primary leaves flattened, sharp pointed. *P. taxifolia*

d. Cotyledons and primary leaves more or less flattened, smooth, points rounded. *Abies*

1. Cotyledons 5, ½ inch long, stomatal markings distinct; stem ½ to ¾ inch long, brownish. *A. balsamea*

e. Cotyledons flattened, smooth, not sharp pointed, spreading, almost always 3, sometimes up to 6. *Tsuga*

1. Primary leaves in 3's, bluish green, stomatiferous above. *T. canadensis*

B. Cotyledons always 2.

I. Cotyledons flat, rounded tip, 1/3 inch long, light green, stomatiferous above; stem ½ inch long, reddish. *Thuya*

a. 2 primary leaves opposite with whorls of 3 above. *T. occidentalis*

b. 4 primary leaves opposite in pairs with whorls of 3 above. *T. gigantea*

II. Cotyledons flat, rounded tips, 1/3 inch long, dark green; leaves ¼ inch long, in whorls of 4; stem ½ to ⅞ inch long, reddish brown. *Chamaecyparis lawsoniana*

III. Cotyledons flat; primary leaves in whorls of 3 or rarely 2, ⅜ inch long, rigid, sharp pointed, with a sharp midrib, the stomata irregular in 4 or 5 rows. *Juniperus virginiana*

# TIMBER SALES IN SELECTION FORESTS.

Professor W. J. Morrill.

When a request has been made for a sale of timber the Forest officer has some of the following matters to consider or duties to perform:

1. *Is the sale advisable?*

(a) A timber sale is generally advisable when silviculturally the stand can be made to become thriftier and more productive. Virgin forests are non-productive, since growth is about balanced by decay. There is usually decadent timber in every stand that has not been properly cut over in the last few years. Frequently it is found that the stand, although thrifty, is overstocked, and that by means of fellings it can be advanced toward normality not only by reducing the stock, but by correcting in a measure the abnormality in diameter class gradations. This matter has been discussed by the writer in the April, 1913, number of the Forest Quarterly.

(b) If the amount of material or its quality makes the felling budget likely to prove unprofitable to the purchaser at present, he should, as a matter of policy, be discouraged in his proposed enterprise. A purchaser's losing money is usually conducive to administrative difficulties and unpleasant business relations.

(c) A sale should not be made if the area desired, when cut over, will leave isolated or more remote tracts that cannot independently be logged at a profit. The whole or none should be sold; later some purchaser for the whole can be found.

(d) Rarely there are stands which serve so highly for protective purposes or for recreation that even light cuttings are undesirable.

(e) Occasionally local markets demand all the timber available to them, rendering a sale for the purpose of supplying distant markets a bad policy.

(f) If a prospective purchaser will take only a desirable species in a mixed stand while inferior usable species are refused, silviculturally the stand might be injured from such a cutting; therefore the sale should be postponed until a purchaser is willing to cut a portion of the inferior species.

2. *The choice of the silvicultural system* of management for securing regeneration and involving the severity of the felling is logically the next consideration. The Forest officer has ordinarily to choose from the three systems, or their modifications, namely, Selection, Compartment Under Shelterwood, and Clear Cutting.

3. *The rotation should be next determined,* in order that the diameter limit may be determined from a diameter-age table. The matter of choosing the rotation can be approached from several angles, all of which may influence the final choice. One may assume that dominant trees should not be retained after they fail to make an annual growth equivalent to a certain percentage of their volume. To illustrate: It may be assumed that dominant trees not making the following growth in volume shall be considered mature and subject to removal unless silvicultural reasons intervene: In the Rocky Mountain Region on Quality I sites, 2 per cent; on Quality II sites, 1½ per cent; on Quality III sites, 1 per cent. The purpose for which the timber will be used may be another view point; fuel or ties, for instance, can be grown under a shorter rotation than saw timber. Since the Government can best afford to sacrifice financial considerations its forests are usually managed with long rotations, especially where the forests serve primarily as protection against soil erosion and for water conservation. Western Yellow Pine stands are being handled in the Northwest with a rotation of 150 years, and Engelmann Spruce requires as long a time, or longer in most localities, when grown for saw timber. Schneider's formula,* *rate of growth equals* 400 *divided by the number of rings in the last inch multiplied by the diameter at breast height outside the bark,* is a convenient method for determining the rate of growth of trees which are nearing maturity.

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*More accurate results are obtained by using 450 in case the trees are near maturity, 500 for medium aged trees and 600 for rapid growing trees.

4. *An analysis of the stand should next be made.* A convenient method for doing this will be found farther along in this article and the discussion of it is therefore deferred.

5. *The felling budget is then computed.* This may be done by several methods or combinations of them:

(a) From an analysis of the stand the number of trees above the diameter limit is computed together with the other trees that should be removed for cultural reasons. With the use of a volume table or a volume curve the contents of these trees are found.

(b) The felling volume may be computed by the Von Mantel formula. The trees which enter into this volume will be:

(1) Those which should be removed for cultural reasons, being indicated for removal in the analysis made;

(2) Those above the diameter limit.

(3) Enough others to make up amount called for in periodic budget.

The Von Mantel formula gives the volume of the felling budget as follows: Annual budget equals actual volume of the stand divided by one-half the rotation. The application of this formula is a safeguard against overcutting the stand and should eventually bring about an approach to normal volume of growing stock. The annual felling budget multiplied by a number which will give a product large enough to make logging profitable represents the periodic felling budget. The number by which the annual budget is multiplied is the number of years in the cutting cycle, or the number of years that must elapse before an equal amount can be again cut, if the stock is normal, which is, however, not usual.

When marking for cutting the diameter limit will not be inflexible. It will be presumed that the volume of those marked that are below the limit will about equal those left for silvicultural reasons above the limit.

The second method may be employed in determining the felling budget, but when marking is being done some effort should be made roughly to regulate diameter class gradations. Or the effort may be carried still further along the same lines and care may be taken that the normal numbers in those classes be left regulated to a greater or less degree as suggested in the April number of the Forest Quarterly. Even in the analysis these features may be incorporated and the estimate of the timber to be cut can include them. If the analysis should show that more timber should be cut for purely cultural reasons than the Von Mantel formula would indicate, then the stand is too irregular or too much abused by fire or misuse to apply regulation at present. The felling, then, would be based wholly on silvicultural considerations.

The emphatic idea in conducting a sale in the selection forest is to cause the stand to approach normality in as high a degree as is consistent with profitable lumbering or to better the silvicultural conditions.

6. *An estimate of the costs;* logging, manufacturing and transporting the lumber to market, cost of brush disposal, and value received by the manufacturer for his product. After this an equable stumpage value can be determined.

The following formula has been suggested for determining the stumpage charge per thousand board feet:

$$X = \frac{S}{1+P} - O,$$ in which X = stumpage charge per thousand, S = selling price of the manufactured lumber, P = a reasonable per cent of profit, say 20 per cent, and O = cost of operation including logging, milling and risk.

7. *Sample areas are then marked for cutting.* These will serve as arbiters in possible future disputes with the purchaser, who should express his approval of the sample areas before the purchase is finally made.

8. *Finally the contract is prepared and executed.*

## The Analysis of the Stand.

Unless the area has been covered previously by a reconnaissance party, the Forest officer must gather the data necessary to analyze correctly the stand. This will be done partly for his own use and partly for records that can be used by other officers for checking his judgment in the management of the sale. The Forest officer usually must gather his data unassisted. At present he is required to place his data on a certain "Estimate Sheet" and in a "Forest Description" report along definite lines. Both of these forms properly filled in with data carefully obtained serve very satisfactorily not only in determining the volume of timber which can be sold, but as the basis for planning the operations to effect some definite headway toward normality or toward silvicultural improvement.

The data can be gathered satisfactorily in various ways. The following one-man method, adapted by the writer and tested by him for several years, is believed to be sufficiently thorough, practical, expeditious and elastic to fit many different conditions.

*Location of Area.* The sale area is located as accurately as conditions warrant. If alienated land can possibly conflict with the sale area, great accuracy in location is obviously necessary, even if assistance must be called. Usually the area is tied to a government section corner. Occasionally it becomes necessary, unfortunately, to tie the area to some natural object that can be located on the map of the district or forest.

### *Mapping the Area.*

Simultaneously with the gathering of stock data a rough map is prepared. It shows: (a) the chief features of topography, preferably by contour lines, but less satisfactorily by hachures; (b) location and extent of grassy parks, burned areas, inaccessible portions, woodlands and other non-merchantable timbered areas, meadows, swamps, and *especially the location and extent of the merchantable timber;* (c) streams, roads, trails and any other features of interest. The Forest Service Atlas legend can be conveniently used and the colors applied with crayons while on the area.

*The scale* had best be 4, 8, 16, or 32 inches to the mile, as the size of the area dictates. This scale is convenient with the Forest Service Map Sheet form, which is commonly used. The map sheet can be tacked to a thin board and suspended from the shoulder by a strap. On the back of the board a protractor can be drawn with the rays from the focus extending to the edges of the board, so that a convenient clinometer is the result after a cord supporting a light weight is suspended from the focus. The cord is long enough to pass the edges of the board. This little device is very useful in measuring the angle of elevation of a hill or height of a tree in order that in connection with a natural tangent table printed on the board, the heights of objects can be quickly found by multiplying the natural tangent of the angle by the distance to the object. Better than this is the "Roth board." With the relative heights of ridges and hills the contour map is made more accurate; and the heights of a few trees

PLATE I.

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

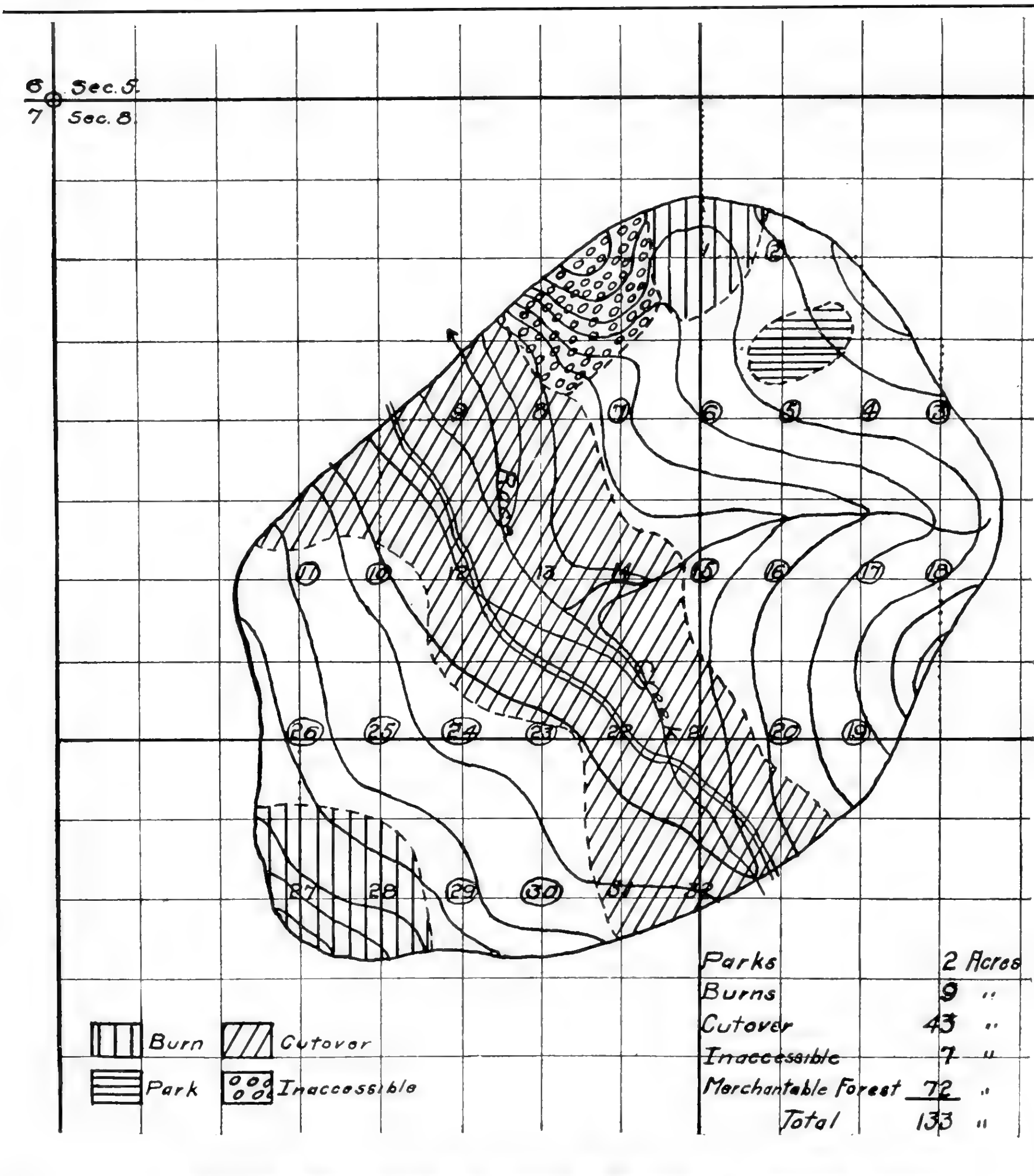
# MAP SHEET

_No.______ ______________________________ ___National Forest

*Division*____________________ *District*____________________, *Block*__________

*T.*__________, *R.*__________, __________*M., Section,* __________*Quarter*__________

*Mapped by*________________________________________ *Scale: 8 inches = 1 mile.*




Sample Map Sheet, Showing Method of Covering Area.

of known diameter is often useful later in applying volume tables.

The other equipment will consist of a *compass,* the Standard Forest Service Compass being admirably adapted to the purpose, and *calipers.* The *"Biltmore Stick"* will serve for calipers and is far more conveniently carried, but these have not been generally supplied to Forest officers. Distance measurements are made by pacing.

*Parallel Courses.* The area should be covered systematically along parallel lines, pacing the distances and using the compass for getting the courses. The distance between the lines should be uniform, not so much for the map making as for the stock data. Because of the scale, chosen in reference to the ruled map sheet, the distance between the parallel lines should be some multiple of 330 feet. If quarter acre plots, on which stock data is obtained, are used, the distance between these lines is usually 660 feet. With larger sample plots 990 feet would be satisfactory, or in very careful work small plots only 330 feet apart. The lines should be so close that no essential features of the map or stock may be missed. The courses should be toward the cardinal points in order that no protractor or scale may be needed.

*Stations at regular Intervals.* At regular intervals, usually of 330 feet, and less frequently of 660 feet, stops, or stations, are made on the lines. At these stations, consecutively numbered, the map features are sketched in and interpolations made.

*Gathering Stock Data.*

While the map is thus being made, at each or alternate stations a sample plot is laid off and a record is made of the stock thereon. Should the station and sample plot, however, fall within an area that is not merchantable forest, no stock is recorded for it, but the map work is continued as usual. In this case, of course, there is no sample plot data to enter into the average stock data. If the sale area contains such small patches of non-commercial forest or parks that they cannot be well mapped, a sample plot had best be assigned to such stations. But a note should be attached that it contains no stock, in order that the average stock shall include these areas as if they did contain stock, since the map will not indicate that there are these small patches of non merchantable timber or blanks.

The sample plots are numbered to correspond with the station number, which is retained on the rough map draft made in the forest, but omitted in the finished map. Thus later the place where any particular plot was taken can be located precisely on the rough map draft. This is essential especially where two or more types of forest are found on the same sale area, as the types can be indicated from the sample plot sheets on the finished map. Each sample plot should be recorded on a separate sheet in order that the sheets may be grouped according to types or for other reasons.

*Shape and Size of Plots.* A circular plot, if no larger than one acre, can be laid off roughly more readily than plots of other shapes. The boundary of circular plots is shorter than that of other shaped plots for the area enclosed. Although the shape of the plot is not essential the circular one has been found more convenient.

Plots of less than one-fourth acre, except for seedling and sapling counts, are neither necessary nor advisable. The larger the plot is the better, in many respects. But a practical one-man method demands that the plots be quite small, especially in the denser stands, in order that one may not become confused when he records the diameters of the trees, which time may not permit being marked by a timber scribe.

One-sixteenth acre plots (roughly with 29 foot radius) are often as large as is expedient for the enumeration of seedlings and saplings, especially if they are moderately plentiful. Where this class of stock is very sparse a one-fourth acre plot is equally expeditious and of course better. In rare cases the seedlings are so plentiful that only 100 square feet (10 feet square) in each plot is advisable, while the saplings may be counted on a larger plot.

One-fourth acre (radius nearly 59 feet) plots have given satisfactory results in dense stands of such species as Engelmann Spruce, Lodgepole Pine and Douglas Fir, and occasionally in the denser stands of Western Yellow Pine.

One-half acre (radius approximately 83 feet) plots may be used in the more open stands of the above and other species.

One acre (radius about 118 feet) plots may be used in very open stands where there is no difficulty in seeing distinctly from the center to the perimeter.

*Percentage of Total Area in Sample Plots.* No estimate of timber on a sale area should ordinarily be based on plots that do not aggregate at least 5 per cent of the total area. Between 5 and 10 per cent is the usual safe percentage chosen. If the area is nearly uniformly covered by trees the former percentage is sufficient; if the forest is irregular, the latter is preferable. If one-fourth acre plots are taken at 330 foot intervals along parallel lines that are 660 feet apart, the usual percentage of the whole area taken in the plots will be about 7 per cent, depending upon the shape of the tract and upon large blanks. With half acre plots the intervals between them may be 660 feet, or at alternate map stations, to obtain about the same percentage as in the previous case. As large a percentage of sample plot area as time will permit, however, is desirable; but only under exceptional circumstances should one feel safe in less than 5 per cent. With more intensive methods in the future the percentage in sample plots will increase.

*Laying off the Plot.* Prominent principles in this method are: (1) to take plots always of the same size, the size being chosen before the work begins; (2) to take these plots at regular intervals, in order that one may not be tempted to involuntarily choose areas better than the average. If one wanders aimlessly through the stand occasionally laying off a sample plot that seems representative, he not only does not know about what percentage of the area he is including in his sample plots, but, worse still, he is almost sure to choose, quite unintentionally, plots that are better than average ones.

The average stock data will be adversely affected if plots of various sizes are taken, since stock conditions are usually different on every plot. If a plot larger than the others should be taken on an area better than the average, the total estimate will be too large; if on an area poorer than the average the total estimate will be too small, since that particular area is given undue weight in the calculations.

The best way, then, is to locate your sample plots at regular mapping stations. Having paced along the line to a station, set up the compass and fill in the map features. Next, from the compass as the center, pace to the circumference of the circle and mark the point in some way such as tying a rag to a limb or stick; repeat the operation until there are enough points to make you sure of your enclosure. Frequently four of such points dividing an area into quadrants are found sufficient, since then each quadrant can be treated separately in enumerating the stock. With practice, in the one-fourth acre plots, the distance to the circumference is often estimated by the eye and no points are marked.

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The following table will show how the records may be conveniently kept:

PLOT 1 (¼ Acre.)

| LEAVE | | | | CUT | | | |
|---|---|---|---|---|---|---|---|
| D. B. H. inches | Engelmann Spruce | Alpine Fir | Douglas Fir | Engelmann Spruce | Alpine Fir | Douglas Fir | Merchantable Dead |
| 6 | | | | | | | |
| 7 | | | | | | | |
| 8 | | | | | | | |
| | | | | | | | |
| 24 | | | | | | | |
| 25 | | | | | | | |
| Seedlings | | | | 1/16 Acre. | | | |
| Saplings | | | | | | | |

## REMARKS.

*Quality of Locality II*—A 12 inch Engelmann Spruce was 65 feet high.

*Soil*—Fresh sandy loam—erosion likely to occur after logging.

*Humus*—Well rotted—½ inch thick—covers 50 per cent of area.

*Rock*—not plentiful—a few, small granite boulders.

*Trees*—Merchantable quality fair—inclined to grow in clumps. No unusual amount of decay noticeable.—The 17 and 18 inch trees recorded are dead in tops for 6 feet down.

*Logging*—fairly easy—ground smooth, but steep (15°) N. W.

*Silvicultural System*—Selection best here.

*Miscellaneous*—Plot not exposed to much wind danger. Reproduction well distributed.

*Recording the data.* If only the amount of timber which is to be sold is desired, the diameters of only the merchantable trees by species are recorded or, if preferred, their contents may be estimated in merchantable logs. If the total stand is to be estimated only to any diameter limit, they may be recorded as above.

But to make a complete analysis of the stand as is required by the Forest Service previous to making a sale, more detail is required. Whether we later use the data, practically no more work is required to record separately the trees which should be removed and those which should be cut for cultural reasons. Should we regulate the cutting solely with the view of working towards definite normality, separate columns for the trees "to leave" and "to cut" need not be kept. If they are to be kept separate, one should have pretty well defined ideas from the start regarding the diameter limit, even if he takes some time to consider the matter.

The diameters of trees under 15 or 16 inches can, with practice, be estimated; but for larger diameters it is safer to use calipers or the "Biltmore Stick." The measurement of the height of an occasional tree may be taken with the assistance of the clinometer or otherwise, if you have a volume table based on diameters and heights, in order that more accuracy may be had in applying the volume table. The estimated quality of locality may also assist in choosing the volume in such a volume table.

*Working up Stock Data.*

For a concrete example we will suppose that after covering the sale area we have recorded 20 quarter acre plots.

By species and separately for the trees to be left and for those to be cut we would next proceed to find the total number of trees in each diameter class on the 20 plots aggregating 5 acres. By dividing these sums by 5 we find the number of trees in each diameter class for each species on the average acre. Next we find the total basal area of two or more diameter groups i. e., the total area in square feet of the tops of stumps that would result if all the trees were cut smoothly off with a saw at breast height. Then, by dividing this total basal area in each group by the total number of trees in the group we obtain the basal area of the average tree of each group. Finally the diameter of a circle of that area is computed or found in a table of areas of circles such as all Forest officers have in the *Woodman's Handbook, U. S. F. S. Bulletin 36*. The volume of this average tree may be determined in a volume table or by cutting two or three down and averaging their contents after having scaled them. It is better still to make a volume curve from the measured contents of three or more average trees of different diameters. The volume of the average tree multiplied by the total number of trees represented in the group will give the total volume of the trees on the average acre. The total number of acres of merchantable forest in the sale area, computed from the map, usually by counting the squares, multiplied by the average volume per acre gives the total volume for the tract.

An accurate estimate of the timber, then, is about equally dependent upon both an accurate map from which the area of the merchantable forest is determined and an accurate average acre analysis.

In the same manner the stand per acre of Engelmann Spruce to be cut is ascertained, which multiplied by the total acreage of merchantable forest gives the total amount of this species to be sold. These operations are repeated for each species.

The seedlings and saplings by species are totaled and computed for the average acre and the percentage of each found. The number of trees per acre above 6 inches in diameter by species to be left are noted from the analysis and the percentage of each species calculated.

The total acreage in sample plots divided by the total area in merchantable forest will give the percentage estimated. Then, with the areas in burns, cutover land and other classes of non-merchantable forest computed from the map, the examiner finds that every bit of information required on the "Estimate Sheet" can be derived from data gathered as outlined above and worked up as here shown; nothing is left to be supplied by the imagination. It is suggested that in recording the sample plot data only the trees that should be cut for purely cultural reasons be placed in the column headed "To Cut." He can combine the volumes of the trees "to be cut" and "to be left" and apply the Von Mantel formula to determine the felling budget. In short, with the data thus obtained he can analyze the stand and governed by the analysis have the fellings executed along the lines which his judgment dictates.

The foregoing explanations are illustrated in the following table for the trees to be left:

| D. B. H. (inches) | Number of trees Engel Spruce in 5 acres of sample plots. | Average number Engel Spruce per acre. | Basal Area per Tree (sq. ft.) | Total Basal Area (sq. ft.). | Number of Group. | Number of Trees in Group on average acre. | Total Basal Area of Groups (sq. ft.). | Basal Area Average Tree (sq. ft.). | Diameter of Average Tree in inches. (From table of areas.) | Volume of Average Tree, Bd. ft. (From volume table.) | Total Volume, Bd. ft. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 109 | 21.8 | 0.27 | 5.9 | | | | | | | |
| 6 | 135 | 27.0 | 0.20 | 5.4 | | | | | | | |
| 8 | 92 | 18.4 | 0.35 | 6.4 | I. | 103.2 | 36.9 | 0.357 | 8 | 20 | 2064 |
| 9 | 73 | 14.6 | 0.44 | 6.4 | | | | | | | |
| 10 | 61 | 12.2 | 0.55 | 6.7 | | | | | | | |
| 11 | 46 | 9.2 | 0.66 | 6.1 | | | | | | | |
| 12 | 30 | 6.0 | 0.79 | 4.7 | | | | | | | |
| 13 | 22 | 4.4 | 0.92 | 4.0 | | | | | | | |
| 14 | 15 | 3.0 | 1.07 | 3.2 | II. | 16.2 | 15.5 | 0.956 | 13.2 | 100 | 1620 |
| 15 | 10 | 2.0 | 1.23 | 2.5 | | | | | | | |
| 16 | 4 | 0.8 | 1.40 | 1.1 | | | | | | | |
| Total | | | | | | | | | | | 3684 |

# REFORESTATION IN NORTHERN ARIZONA.

E. W. Nelson '13.

Large areas in Northern Arizona once forested are at present not growing trees. Since timber is the most valuable crop that can be grown on many of these areas, reforestation presents an important problem. Natural reforestation of these denuded areas is practically impossible and artificial reforestation must be resorted to.

The altitudinal range of this region varies from 3,500 feet at the southern extremity of the Colorado Plateau to 12,800 feet at the summit of the highest peak of the San Francisco Mountains in the north central part. The southern part is dissected by numerous deep canyons; while the northern part is dotted with many volcanic cones. The general slopes of the region are toward the northeast and sonthwest, the northeast slope descends gradually with but few breaks toward the Little Colorado River, while the southwest slope is quite gradual until it drops off precipitously into the Verde Valley.

The soil typical of this region is of four kinds, as follows: gravelly loam, or malpais soil, consisting of loamy or adobe constituents mixed with considerable volcanic debris; the limestone soil covers rather extensive areas; loamy gravel, which occurs in the limestone belt, and in the northeast portion in the desert areas; and cinder soil, which is a mixture of volcanic cinders and clayey loam, occurring in the volcanic region surrounding the San Francisco Peaks.

The climatic conditions existing in this region are not favorable for natural reproduction. The annual precipitation averaging about twenty inches falls chiefly during the winter and late summer months, with a dry period in the spring and another in the fall. The dry season of spring extends from April to July during which severe southwest winds prevail. These winds cause the surface soil to dry out so readily that a large percentage of the seed fails to germinate, and the few seedlings that do come up usually die for lack of moisture. After the beginning of the rainy season in late summer the seed germinates, but early frosts commonly kill many of the seedlings. During the winter seedlings on the heavy soils are liable to be "heaved out" of the ground by constant freezing and thawing of the top layer of the soil.

The forest types are determined largely by precipitation, altitude and exposure. The Woodland type occurs between the elevations of 4,000 and 6,200 feet, where purely semi-arid climatic and soil conditions prevail. The principal species are: One-seed Juniper *(Juniperus monosperma* (Engelm.) Sarg.). Alligator Juniper *(Juniperus pachyphloea* Torr.) and Pinon *(Pinus edulis* Engelm.), which occur scattering and in rather open stands. In some parts of this region thickets of Arizona Cypress *(Cupressus arizonica* Greene) occur.

The Western Yellow Pine type, composed of nearly pure stands of Western Yellow Pine *(Pinus ponderosa* Laws.) is found at elevations extending from 6,200 to 8,500 feet. Near its lower altitudinal limit there are scattered specimens of Pinon, while the Gambel Oak, *(Quercus gambelii* Nutt.) and Alligator Juniper are found scattered over the entire area. The climatic conditions approach the semi-humid, the annual precipitation averaging about twenty-two inches. The characteristic nature of this type is that the trees occur in open continuous stands interspersed with many open parks.

The Transition type is a narrow and irregular belt occurring at elevations of 8,500 to 9,800 feet. The climatic and soil conditions are excellent for tree growth. In this type are found Douglas Fir *(Pseudotsuga taxifolia* Britton), White Fir *(Abies concolor* Parry), Limber Pine *(Pinus flexilis* James), scattering Western Yellow Pine, Aspen *(Populus tremuloides* Michx.), and Engelmann Spruce *(Picea engelmanni* Engelm.).

The Sub-alpine type occurs at elevations of 9,800 to 12,000 feet, which embraces a region of considerable rainfall. The chief species found in this type are: Engelmann Spruce, Bristlecone Pine *(Pinus aristata* Engelm.), Foxtail Pine *(Pinus balfouriana* Murr), and Aspen. The trees are stunted and scattered as timber line is approached until finally they become mere shrubs.

Natural reproduction of Western Yellow Pine occurs normally in scattered groups throughout the mature stands. In areas that have not been heavily logged the natural reproduction has usually come up in fairly dense stands, especially on the rocky malpais ridges.

The factors affecting natural reproduction in this region are as follows:

1. Old and New Logging Methods.
2. Fire.
3. Tree Disease.
4. Insects.
5. Grazing.
6. Climate.
7. Soil.

## LOGGING METHODS.

Under the old methods of logging, areas on the limestone soil type were nearly clear cut, only the non-merchantable trees being left, and many of these blew down; while the few that remained were not sufficient to restock the partly denuded areas. Many of the seedlings that came up either succumbed to drought or frost as they were afforded very little protection. Forests on the malpais soil were generally not as heavily logged as those on the limestone soil. Natural reproduction is much better on these areas because of more seed trees and the fact that the rocks protect the seedlings to some extent from grazing, drought, the drying winds, and from the direct rays of the sun.

Under the present methods of logging the practice is to leave all the young trees, except those that are diseased, and to cut all mature trees, except those needed as seed trees. Various silvicultural treatments have been tried to secure natural reproduction and careful marking is being practiced in order to secure the best conditions possible. On one of the timber sale areas brush scattering after logging was tried in order to determine its effect on the growth of seedlings and soil-moisture. It was found that seedlings growing under the brush which had been lopped from the trees felled in logging were not frost killed as readily as seedlings growing out in the open with no protection whatever. Soil-moisture determinations also showed a greater percentage of moisture in the brush covered soil.

### FIRE.

The mature Western Yellow Pine is very fire resistant, but the young trees are either injured or killed by fire. Fires are not so prevalent now as formerly because of the greater efficiency of fire patrol and better methods of fire fighting. Extensive areas in the Transition type were burned over about thirty years ago. It will be necessary to restock these areas artificially, if they are to bear their best crop, since hardly any seed trees were left. In a few places Aspen has taken the place of the former stands of Douglas Fir; while over the rest of the area there is no tree growth.

### TREE DISEASE.

The mistletoe *(Razoumofskya robusta* (Engelm.) Kuntze.) is a parasite which attacks both the mature and young Western Yellow Pine, fastening itself on the branches of the trees. The leaves of this mistletoe are reduced to mere bracts. The shoots push out from the sub-epidermal portions of the host in the latter part of April. Flowers are produced in June and July, and seeds are matured in August and September. The fruit is a single-seeded berry which is attached to a short stalk. When the berry ripens it bursts and expels the sticky seed which falls on lower branches where it fastens itself and develops haustoria, which penetrate longitudinally the tissues of the host. The damage by mistletoe is serious; as high as three-fourths of the trees are affected over extensive areas.

### INSECTS.

Several species of the boring beetles belonging to the genus Dendroctonus do considerable damage to young Western Yellow Pine trees. The larvae in burrowing out of their egg galleries make galleries all through the inner bark. The canals or burrows made by the larvae sometimes completely girdle the tree finally causing it to die. The work of the Dendroctonus beetles is rather extensive in the Western Yellow Pine type.

Another insect which has done considerable damage to reproduction is the Nantucket Pine Moth *(Retinia frustrana).* The larvae completely destroy the growing tips of the young trees by boring from the base of the current year's growth to the terminal bud. Observations made on one Western Yellow Pine about four feet high showed twenty-two out of thirty growing tips killed by the larvae of this moth. Other young pines examined did not show as much damage, but at least the terminal shoot had been killed; lateral shoots develop from the base of the killed tip, which tend to give the tree a very stunted appearance. This moth affects seedlings over practically the entire Western Yellow Pine type of this region.

### GRAZING.

Grazing is one of the most important factors affecting reproductior in this region. The amount of damage varies with the class of stock and the abundance of forage and of reproduction. Sheep do considerable damage to all seedlings under four feet in height. If they browse off the leaders early in the grazing season the seedlings will often recover and make a new growth that year, but the greatest amount of damage is done in the late summer and fall when the forage has been closely grazed. Cattle do very little damage unless they are in great numbers, as in holding pastures that are heavily grazed, or near watering places. It is found that more damage is done to reproduction on areas that have poor stands of forage. The amount of reproduction is very important because where it is dense damage is negligible; but on areas in the limestone soil type, that were heavily logged and since burned over several times, the reproduction is scarce, and practically every plant had its terminal shoot and most of its lateral shoots destroyed, either by grazing or by the tip moth. Under such conditions it is utterly impossible for a seedling to gain any headway. Many seedlings between 5 and 15 years old were examined and found to be less than a foot in height because they had been injured by having the terminal shoot eaten off practically every year.

Climate and soil are two of the most important natural factors affecting reproduction. They will be discussed in connection with other parts of the article.

### REFORESTATION.

Artificial reforestation is necessary on the heavily logged areas in the Western Yellow Pine type, and on the old burns in the Transition type. Three methods of reforestation, namely, seed spot sowing, broadcasting, and planting are being tried in the two forest types.

Seed spot sowing was tried in the Western Yellow Pine type on a brush scattered area. This area is located in the vol-

PLATE I.

Reproduction Coming in After Logging Under the Old Methods.

Large Park in Western Yellow Pine Type.

canic cinder soil formation at an elevation of 6,800 feet. Poisoned oats were scattered over the area before the seed spot sowing was started, in an attempt to poison the rodents. The seed spots were spaced six by six feet, and a space fifteen inches square was dug up to a depth of about four inches. Three men prepared the spots with mattocks, while one man sowed the seeds and covered them with a rake. A count later in the season showed that very few seed had germinated. This may be accounted for by the following factors; failure of poisoned oats to kill the rodents, the small amount of precipitation during the past growing season, and the excessive evaporation from the cinder soil due to scant covering of vegetation and looseness of the soil.

Broadcasting of Western Yellow Pine was also tried on the brush scattered area at the same time that the spots were sown. A count later in the season showed that no seed had germinated; this can be accounted for by the same factors as those affecting the seed spot results.

Below in tabular form is given the various items entering into the cost of seed spot sowing and broadcasting of Western Yellow Pine.

| Method | Number of acres | Number of pounds of Seed | | Cost per pound | Crew | Number of days | Cost per acre |
|---|---|---|---|---|---|---|---|
| | | Per acre | Total | | | | |
| Seed spot Sowing | 25 | 3 | 75 | $1.02 | 4 | 6 | $9.56 |
| Broad-casting | 100 | 8 | 800 | 1.02 | 3 | 4 | 9.08 |

The cost per acre also includes time spent in getting equipment to and from the area, and team hire.

In order to raise plants for experimental planting a nursery was established by the Forest Service nine miles northwest of Flagstaff, Arizona. The site selected for the nursery proper is on an east slope protected by trees from the prevailing southwest winds. The soil is a very fertile loam mixed with small rocks of volcanic origin.

About a week previous to sowing seed beds four feet wide and twelve feet long were marked out and spaded to a depth of approximately fourteen inches. After the large clods had been broken up with a rake, the soil to a depth of eight inches was put through a one-fourth inch wire mesh sieve. The treatment of the soil in this manner gave an excellent medium for the development of good root systems. Before any seed sowing was done a "Pettis style" shade frame was made for each bed. The height of the frame above the ground was eighteen inches; wire screening with one-fourth inch mesh was used and the top part of the frame was constructed so that it could be taken off easily. The purpose of these frames is to keep out rodents and to reduce evaporation. The seed sowing was done at the beginning of the rainy season. Each seed bed was levelled with a rake, then thoroughly soaked, after which the soil was tamped to make the surface level. The seed was weighed in order that equal amounts would be sown in each bed. The amount varied from a half a pound to a pound per bed depending upon the age of the seed, but was based on the number of seed per pound, and the germination per cent, which had been previously determined. The seed was sown in drills one inch wide and four inches apart, and then covered to a depth equal to the thickness of the seed. The bed was then tamped lightly, sprinkled, and pieces of wet burlap were spread over the surface; later the top part of the frame was fitted on. The seed beds were watered every day excepting rainy ones during the germination period. Since the rainy season during the past year started much later than usual, considerable artificial watering was necessary. Because of the prevalence of the "damping off" disease, care was taken that too much water was not applied. It was necessary to water and weed the beds only occasionally during the remainder of the summer. In the fall the seed beds were mulched with pine needles in order to prevent "heaving out" of the seedlings.

The transplant beds were prepared by spading up the soil to a depth of about fourteen inches, the large clods being broken up with a rake. Then the beds were raked smooth, properly levelled off and then heavily watered. Before the transplanting was started a burlap shelter was constructed, which was used in the "threading operation." Seedlings were dug up from the seed beds and placed in a pail filled with puddled soil. A crew of four men, two operating the transplant boards, one making the trench with the trencher and one threading the transplant boards, were necessary for transplanting. After the transplanting was finished the beds were watered. Whenever necessary they were weeded, and cultivated with a rake.

Below in tabular form is given the approximate cost per thousand of raising 1½—1 Western Yellow Pine transplants in

Arizona. 1½—1 transplants consist of stock raised 1½ years as seedlings and 1 year as transplants. The reason for the ½ year class is that the seed is sown about July 1st so that the seedlings get but one-half year's growth.

| | |
|---|---|
| Seed | $ .05 |
| Placing frame | .06 |
| Putting in seed beds and sowing | .25 |
| Care first year | .30 |
| Care second year | .20 |
| Cost of taking up seedlings | .15 |
| Transplanting | 1.75 |
| Cost of weeding third year | .25 |
| Cost of taking up transplants | .50 |
| Bunching, grading, and packing | .90 |
| Miscellaneous | .10 |
| Total | $4.51 |

Several classes of stock including both seedlings and transplants were used in planting on an area typical of the malpais soil type. The area was divided into blocks, and each block was sub-divided into plots one chain square. Plots of similar nature were selected for planting. The "middle of the hole" method was used, which consisted of planting the seedling or transplant in the center of a hole, dug with a mattock, 10 to 12 inches deep and 5 to 6 inches wide. The classes of stock used were 1½ year seedlings, ½—1—1 transplants, 1½—1 transplants, ½—1 transplants, and ½—2 transplants. Below in tabular form is given the results obtained from planting with the different classes of stock.

| Class of Stock | Plot Number* | Cost of raising stock | Cost of planting | Total Costs | Per cent living | Soil Moisture % Average of 3 Samples | |
|---|---|---|---|---|---|---|---|
| | | | | | | July | Sept. |
| 1½ seedlings | 16 | $ .126 | $1.79 | $1.916 | 80 | 6.8 | 9.3 |
| ½--1--1 Transplants | 17 | .701 | 2.16 | 2.816 | 93 | 7.6 | 6.6 |
| 1½—1 " | 18 | .451 | 1.79 | 2.241 | 96 | 7.4 | 7.9 |
| ½—1 " | 19 | .431 | 1.79 | 2.221 | 91 | 9.9 | 7.7 |
| ½—2 " | 20 | .446 | 2.16 | 2.606 | 97 | 8.7 | 7.7 |

*Each plot contained 100 plants.

The 1½ year seedlings are not desirable planting stock because of insufficient root development. The ½—1—1 transplants are not suitable because the cost of raising them is excessive and the ½ year seedlings are too small to handle in transplanting. The 1½—1 transplants are undoubtedly the best, because of their excellent root systems and the comparative ease in handling them both in transplanting and in field planting. The ½—1 transplants have an insufficient root system and the ½ year old seedlings are very hard to handle in transplanting because of their small size. The ½—2 transplants are not desirable stock as these are too large to handle satisfactorily in field planting and also their small size as seedlings make them hard to transplant. One thing of interest is the high per cent of living plants for each class, when in fact the per cent of moisture in the soil was very low.

The three characteristic soil types in the Western Yellow Pine type are the malpais, limestone and cinder soils. Select 1½—1 Western Yellow Pine transplants were planted the latter part of April, 1912; counts made in August showed the following results:

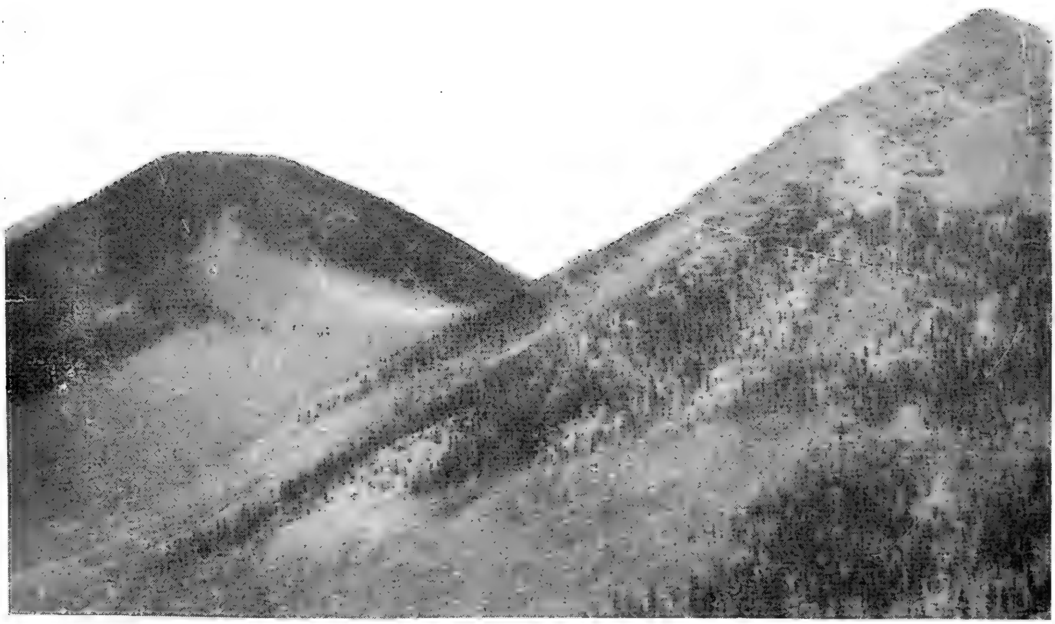
| Class of stock | Soil type | Cost of Stock | Cost of planting | Total cost | Per cent moisture during driest period. Average of 3 samples | Per cent living |
|---|---|---|---|---|---|---|
| 1½—1 transplants | Malpais-rocky ridge | $.451 | $4.32 | $4.770 | 13.2 | 95 |
| 1½—1 transplants | Malpais-flat | .451 | .92 | 1.371 | 5.6 | 100 |
| 1½—1 transplants | Limestone | .451 | 2.06 | 2.510 | 2.5 | 96 |
| 1½—1 transplants | Cinders | .451 | 2.16 | 2.610 | 4.9 | 87 |

Although results show that planting is feasible on all the soil types, excessive cost of planting on the rocky ridges prohibits it here and furthermore, the natural reproduction is generally sufficient to give fully stocked stands on these areas.

Below is given conservative costs of planting per acre in two different soil types. The difference in cost of planting on the cinder and limestone soils is so small that only the limestone need be given.

**PLATE II.**

Western Yellow Pine Reproduction Encroaching on Grassland Near the Lower Elevation of the Western Yellow Pine Type.



Large Burns in the Transition Type Which are in Need of Reforestation.

*(From U. S. Forest Service.)*

| Soil type | Class of Stock | Numqer of plants per acre | Number of plants per day | Number of days | Number of men in crew | Salary per day | Cost per acre | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Planting | Stock | Total |
| Lime-stone | 1½—1 trans-plants | 1210 | 800 | 1½ | 3 | 1 man at $3.33<br>1 men at $2.50 each | $12.50 | $5.46 | $17.96 |
| Malpais-more or less rock | 1½—1 trans-plants | 1210 | 600 | 2 | 3 | | $16.66 | $5.46 | $22.12 |

Forestation of parks or areas devoid of trees, which occur in the pure Western Yellow Pine type, is of great importance. In many instances forestation of these areas is not desirable on account of their agricultural value. Some attribute the presence of these parks to the results of fire, winds or soil conditions and in some instances to old lake beds. The soil of these parks is very rich and is mixed with many broken volcanic rock fragments. A layer of hard pan which occurs at different depths below the surface soil, in places is far enough below the surface to render the soil well adapted to agricultural pursuits.

Planting in parks until two years ago proved a failure, chiefly because of poor quality of stock. To ascertain whether the physical factors were the causes of the dying of the plants a shelter made of boards was erected in a large park at right angles to the direction of the prevailing wind. Select 1½—1 transplants were planted by the "mound method" on opposite sides of the shelter. Counts later in the season showed only a negligible difference between the two sides, and soil-moisture samples taken on both sides of the shelter at intervals of approximately one month apart showed no appreciable difference. For extensive plantings it probably would cost too much to erect suitable artificial shelters, but results show that probably all that is necessary is to grow plants with excellent root systems, which can withstand adverse climatic conditions.

In the Transition type large areas once covered with good stands of trees have been devastated by fires. These areas serve as water sheds for towns and consequently are in need of artificial reforestation to give the best protection and at the same time to be raising the most valuable crop. Where Aspen has taken possession of parts of the burned areas, it serves to protect the surface of the soil from excessive evaporation.

Both seed spot sowing and broadcasting of Douglas Fir seed were done on an area located at the bottom of a canyon at an elevation of approximately 9,000 feet. Before the seed spot sowing and broadcasting were started two men spent one-half day scattering poisoned wheat over the area, placing it near fallen logs and in squirrel caches. In the seed spot sowing four men prepared the spots with mattocks, while two men sowed and covered the seed. The spacing of the spots either six by six feet or ten by ten feet was determined by the amount of debris on the ground. Forty-five pounds of Douglas Fir seed were used on an area of approximately forty acres. In the broadcasting, four men worked one-half day and covered an area of about ten acres, sowing an average of four pounds of seed to the acre.

Below in tabular form are given the various costs:

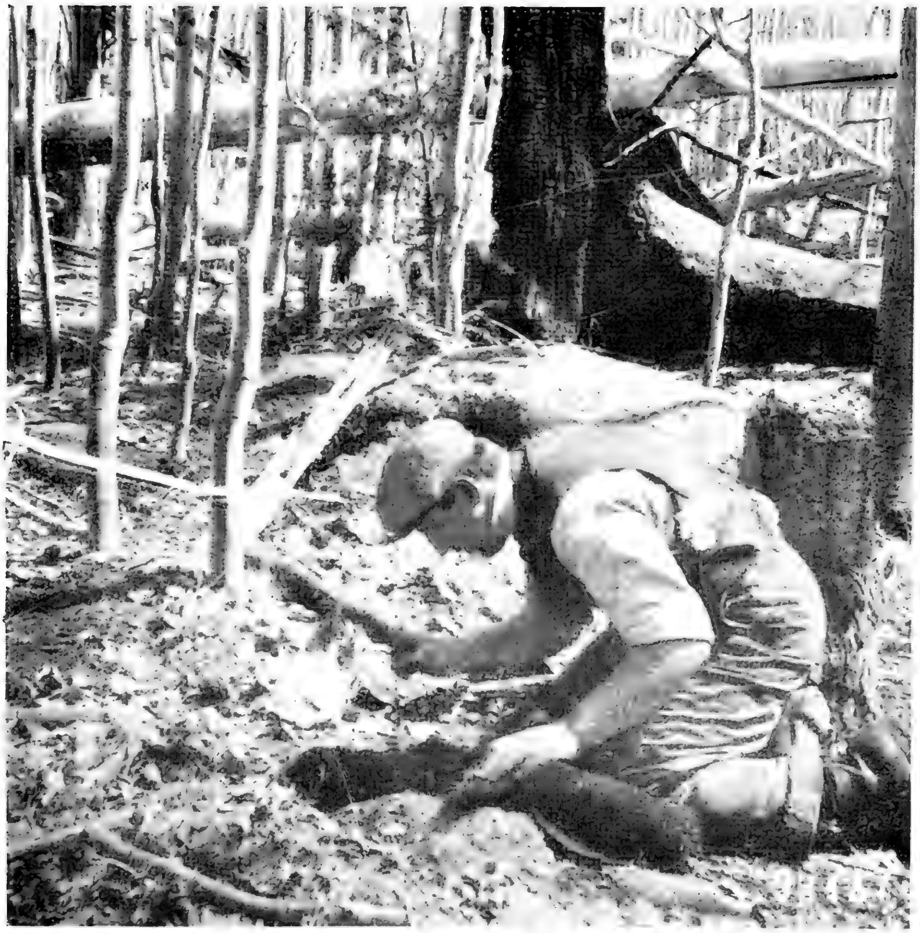
| Methods | Number acres | Number pounds | | Crew | Number days | Cost of seed per pound | Total cost per acre* |
|---|---|---|---|---|---|---|---|
| | | Per acre | Total | | | | |
| Broad-casting | 10 | 4 | 40 | 4 | ½ | 1.00 | 5.60 |
| Seed spot sowing | 40 | 1⅛ | 45 | 6 | 8½ | $1.00 | $6.05 |

The cost per acre also includes time lost in getting equipment to and from the area, meals during this time and team hire.

An examination made later in the season showed seedlings in about five per cent of the seed spots. Considerable of the seed remains dormant until the next season as has been proven in former work with Douglas Fir. Douglas Fir seed sown in seed spots a year previous did not germinate very well during that summer, but an examination made at the beginning of last year's growing season showed seedlings in a large number of the spots, especially in the spots shaded by Aspen.

Planting has been quite successful in the Transition type, although the stock was secured from nurseries in other states. The planting area is located on the southwest side of Mount Agassiz, one of the San Francisco Peaks, at an elevation of 8,700 feet. The area is fenced to exclude stock; Aspen trees occur in numerous groups throughout the area; and the soil is a gravelly loam. 2—1 Douglas Fir transplants from the Gallinas Nursery, Las Vegas, New Mexico were planted on four plots, two in the open and two shaded by Aspen. Soil samples to deter-

PLATE III.



Litter of Dead Leaves and Branches Under Aspen. Proper Position in Planting, Body Shades the Plant.

*(From U. S. Forest Service.)*

Dense Stand of Aspen in Transition Type.

mine the difference in soil moisture between Aspen covered and open plots were taken at approximate intervals of one month and the results are tabulated below.

| MONTHS | Depth of soil sample in inches | Character of plots | |
|---|---|---|---|
| | | Aspen covered. Per cent moisture | Open. Per cent moisture |
| May | 4-10 | 37.50 | 29.47 |
| June | 4-10 | 24.20 | 16.65 |
| July | 4-10 | 12.42 | 13.60 |
| August | 4-10 | 14.92 | 15.82 |
| September | 4-10 | 8.57 | 6.65 |

Results show that the soil in the Aspen covered plots contains more moisture and therefore they are more suited to planting. The decomposed leaf litter undoubtedly aids in holding the moisture in the ground while the Aspen cover lessens evaporation. Counts on the open plots, made near the end of the season, showed an average of seventy-eight per cent living, and on the shaded plots an average of eighty-eight per cent living.

## Conclusion.

Artificial reforestation of the areas in the Western Yellow Pine type that are being logged under the present silvicultural systems is not necessary, because in marking for cutting enough seed trees are left to seed the area and besides there are usually some young trees already established. Scattering the brush will aid reproduction since it protects the seedlings from frost, and helps to conserve soil-moisture. Artificial reforestation by broadcasting and seed spot sowing will not be possible on heavily logged areas of the Western Yellow Pine type on the cinder soil, because there is not sufficient soil cover to check the excessive evaporation and to protect the seedlings from drying winds and frosts that are so prevalent in this region. In the limestone area the grass is so thick in places and the surface soil becomes so dry that broadcasting and seed spot sowing is not practical. The results of planting on these areas show that by developing plants with excellent root systems planting will be successful. Although these assumptions are based on only one year's results, it must be remembered that conditions for growth during the past season have been very adverse.

Artificial reforestation in the Transition type probably will be more successful than in the Western Yellow Pine type because of the increased amount of precipitation and of the greater protection offered by the Aspen cover. The ravages of rodents must be checked before broadcasting and seed spot sowing can be done successfully. Planting under Aspen cover with select stock undoubtedly will be successful. The one drawback to planting in this type is the high cost, but this can be reduced after more experience.

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of the

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The Forest Club will be grateful for corrections in this directory.