FOREST SUCCESSION AS A BASIS OF THE SILVICULTURE OF WESTERN YELLOW PINE[1]

By Robert H. Weidman

U. S. Forest Service

Since the beginning of timber sales on the National Forests 15 years ago, the silvicultural system generally used in western yellow pine has been characterized by a selection method of cutting. At the beginning this method aimed to remove about two-thirds of the virgin stand in the first cutting operation. Inasmuch as the virgin forest was uneven-aged and contained a considerable proportion of mature and decadent trees, the silvicultural objects of the method were to cut over the forest rapidly in order to save the decadent timber, to maintain the uneven-agedness by leaving part of the original stand, and to leave an overwood to start and safeguard reproduction. Another object in reserving part of the stand was to have a basis for periodic cuts on the same ground which would come at intervals of one-third or one-fourth of the rotation.

Tentatively a rotation of 180 to 200 years was considered, with cutting periods of 40 to 60 years. Whatever the rotation, it was recognized that the first cut would greatly exceed any of the later periodic cuts. In the case of a rotation of 180 years with three cutting periods, it was considered that after the initial cut each periodic cut at intervals of 60 years would amount to approximately one-third of the total rotational yield. And in this case it was assumed that the managed forest would become one in which there would be three more or less distinct age classes differing by 60 years.

These in general are the ideas which governed the choice of the selection system for western yellow pine. They were based naturally on preliminary studies and observations in the virgin forest. Since then there has been opportunity for thorough study of the results of fifteen years of selection cutting on timber sales, and also of the results of fifty years of cutting on old private areas—cutting which ranged from selection on the older areas to clear cutting on the newer

[1] Paper read before the Society of American Foresters, Berkeley, Calif., August 4-6, 1921.

areas. This further study has revealed much information on the habits of regeneration and forest succession in yellow pine that was not evident at first. It is the object of this paper to present the facts of this study in their relation to the method of cutting now being practiced on timber sales and to the method which it is believed our present knowledge justifies. Only the pure yellow pine forest is considered. The observations upon which these remarks are based were made in Oregon and Washington, but it is believed that the forest conditions found here prevail generally in the western yellow pine region and that the conclusions herein expressed will apply generally, except possibly in parts of the Southwest.

In general the pure yellow pine forest is characterized by open, irregular and uneven-aged stands with a preponderance of mature and overmature trees. In addition there is generally an excellent ground cover of advance reproduction made up partly of dense groups of seedlings here and there in the openings of the forest, but mostly of uniformly distributed and suppressed little seedlings struggling along directly under the overwood. This latter form of reproduction, which has generally been unnoticed, is small and inconspicuous, but has a great power of recovery which, after the overwood is cut, enables it to make a wonderfully dense and even stand of flourishing saplings.

While the virgin forest is very evidently uneven-aged, there is on the whole, and contrary to general opinion, an exceedingly unbalanced representation of the age classes, in which mature and overmature trees preponderate and young trees are only negligibly represented. This was studied very intensively on two 20-acre sample plots on cut-over land in the Whitman Forest, upon which were secured the ages of all the trees above four inches in diameter breast height that had stood on the areas, and the ages of a representative proportion of the tree growth under this size. Upon correlating and averaging the data it was found that of all the trees over 4 inches in diameter, 9 per cent fell in the class 20-100 years, 22 per cent in the class 100-200 years, 45 per cent in that 200-300, 6 per cent in that 300-400, 15 per cent in that 400-500, and 3 per cent in that 500-600. Thus 69 per cent of all the trees above reproduction size were between 200 and 600 years old. This means that only a small proportion of the stand was under 200 years—the maximum rotation age usually considered in yellow pine. On sample plots totaling 417 acres taken in other localities, but upon which the trees were classified by diameter only, it was found that 67

to 74 per cent were over 12 inches at breast height. These figures show very strikingly a relation exactly the reverse of that in a true selection forest where the young trees greatly outnumber the old ones.

This sort of overwood with a fairly abundant ground cover of small advance reproduction is the kind of yellow pine forest the forester has to deal with in Oregon and Washington. From the figures just given showing the scarcity of young trees, it can be easily understood why after selection cutting on timber sales only a rather meager remaining stand is to be found. Representative cruises on the large timber sale cuttings of the Whitman Forest show that the average amount left is 17 per cent by volume of the original stand, or 11 trees per acre 12 inches and over, and 13 trees between 4 and 11 inches, inclusive.

It is important now to consider what sort of a forest this remaining stand after selection cutting will develop into and how the proposed periodic cuts at 60-year intervals will affect it. From old private cuttings, a few of which are already 50 years old, it is possible to get a very good idea what the development will be. The private areas cut-over previous to 20 years ago had practiced upon them a partial cutting method similar as far as the number of trees left per acre is concerned, to the present selection method on timber sales. Thus the old logger's cutting and the present timber sale cutting are comparable in effect. On these old cut-over areas—and there are many thousands of acres of them—there are uniformly dense stands of yellow pine second growth which are practically even-aged. The advance reproduction, in most cases sufficient in itself as a ground cover, has everywhere been filled in with new reproduction, making the cover complete. The cuttings 20 to 25 years old are most extensive, particularly those in the Sumpter Valley near Baker, Oregon, where there are large unbroken areas of thrifty sapling growth about 20 feet tall. The older cuttings closer to Baker contain sapling stands 25 to 30 feet tall and some of these with their remaining trees make the appearance of a managed forest of even-aged second growth with standards. Here and there in the vicinity of Baker, also, are the oldest cuttings in the region, those made by placer miners 50 to 55 years ago. Near Galena, on the Whitman Forest, is an excellent cutting of this sort containing a fine body of even-aged second-growth 50 years old. This is a thrifty stand of small poles having a height of 35 to 40 feet, a maximum breast-height diameter of 12 inches and an average of 5 inches.

This prevailing occurrence of practically even-aged masses of second growth on large areas of old cuttings indicates what will be the future condition of our timber sale areas. If upon these old cuttings the remaining or overwood trees should be removed, the young growth would then absolutely make an even-aged yellow pine forest in the sapling stage. In the case of the 50-year-old miners' cutting near Galena, such a removal of the overwood trees was actually effected a number of years ago—by the early settlers for the purpose of getting conveniently located firewood—and the forest now on the ground is a pure, even-aged stand of poles. With this succession of even-aged young growth after heavy selection cutting on old private areas prevailing so universally, it is safe to expect with the passage of time, the same sort of succession after timber sale cutting. If the future is looked into 60 years hence to the first periodic cut when most of the present overwood will be removed, it is not inconceivable that the liberated underwood will then be a stand of small poles very similar to that on the old miner's cutting at Galena.

The statement that western yellow pine, now almost everywhere a many-aged forest in its virgin condition, will develop after heavy cutting into an even-aged forest will perhaps be difficult for most foresters to accept unchallenged. But there is no doubt of the ultimate acceptance of the idea, for the proof of it already exists. The doubt may be expressed, however, that yellow pine may not continue its even-aged character beyond 50 years, the age of the oldest stands arising from logging in this region. It may be said that shortly after this the stand may open up and gradually take on again the many-aged character of the virgin forest. In proof that this is not the case is an even-aged stand on the Whitman National Forest of 150 years and some 20 acres in extent which evidently originated naturally by some rare combination of favorable conditions. Elsewhere on the National Forests there are doubtless more such small areas of even-aged yellow pine which have so far been passed unnoticed. Several other examples are known in Oregon which have not been studied. And as is generally known the Black Hills region contains quite large bodies of even-aged stands of yellow pine, some of which are of merchantable size.

How is this anomaly of even and uneven agedness in western yellow pine to be explained? Foresters have long known about the temporary types which follow destructive fires such as the aspen type which temporarily supplants Engelmann spruce in the Rocky Mountains.

But they have not appreciated the slow changes in type due to the gradual succession which takes place in plant formations. It has not been until the last decade that a beginning was made in this country to study forest types on the basis of plant ecology. As is known, in the process of plant succession a plant formation undergoes slow changes in which different species gradually succeed each other and the formation works toward an ultimate society called the climax. This can best be illustrated in the forest by the examples in lodgepole pine and Douglas fir. In lodgepole pine, Clements [2] found two more or less distinct types of forest, one a pure even-aged lodgepole pine forest and the other a mixed uneven-aged forest of lodgepole pine, Douglas fir and Engelmann spruce. He found that when the pure even-aged lodgepole pine forest became mature and advanced to overmaturity without suffering from any accident, such as holocaustic fire, other species invaded the stand as old lodgepole trees began to fall here and there throughout the stand in the process of loss through old age, fungous and insect attack. These invaders were not lodgepole pine seedlings, but seedlings of the more tolerant Douglas fir and Engelmann spruce. Lodgepole pine being intolerant cannot well reproduce under its own overwood and, in any event, cannot compete with tolerant species in so reproducing. As veterans in the lodgepole pine overwood gradually toppled over, the Douglas fir and Engelmann spruce filled the openings and in this way a truly mixed and uneven-aged forest of these three species occupied the ground where formerly had been a pure even-aged stand of lodgepole pine. But where the pure even-aged lodgepole pine forest upon maturity suffered a devastating fire, Clements found that a pure even-aged stand of lodgepole pine succeeded to make another forest exactly like the one that had been destroyed. Unless the pure lodgepole pine forest is destroyed by fire or is clear cut by man, it will inevitably, through slow stages of succession, develop into the mixed uneven-aged forest described above which the ecologist calls the climax forest of lodgepole pine. In the case of Douglas fir, Hofmann [3] found that when the pure even-aged Douglas fir forest is allowed to advance to overmaturity without destructive accident to the stand, a similar

[2] Clements, F. E. "The Life History of Lodgepole Burn Forests." U. S. Forest Service Bulletin 79, 1910.

[3] Hofmann, J. V. "Natural Reproduction from Seed Stored in the Forest Floor." Journ. Agr. Research, V. 11, No. 1, 1917. "The Establishment of a Douglas Fir Forest." Ecology, Vol. I, No. 1, 1920.

gradual succession takes place as in lodgepole pine in which, however, the tolerant hemlock and cedar become the invaders and the climax forest is a mixed uneven-aged forest composed mostly of western hemlock and western red cedar. When the pure even-aged forest suffered holocaustic fire at maturity, Hofmann found a succession forest of pure even-aged Douglas fir exactly like the forest that had been destroyed.

In the yellow pine forest, the same law of succession works as inevitably as it does in the lodgepole pine and Douglas fir forests. The effect, however, is less apparent to the eye, because the forest, with few exceptions, remains pure yellow pine. In the arid region in which yellow pine occurs, there is to be found no more tolerant species, in fact, no other species whatever, which can compete with it on its site Thus for the lack of an invader, yellow pine becomes its own successor, yellow pine seedlings occupying the places vacated by old trees as they drop out of the stand from time to time. The result is the climax forest of western yellow pine—the many-aged virgin forest of pure yellow pine which is so common in this region. If this forest is now removed at one stroke, an even-aged forest will succeed, just as in the case of Douglas fir and lodgepole. The succession, however, has an entirely different source than that of the compared species. Whereas Douglas fir succeeds through its seed stored in the duff and lodgepole, through its seed stored in serotinous cones, yellow pine succession is effected by the cover of reproduction already established on the forest floor. Yellow pine is but an infrequent seed producer; and even after a prolific seed crop an adequate cover of reproduction is never a certainty, because the frequent droughts and late frosts make for but a low rate of survival. The survivals from a number of years of seeding germination and establishment, however, make nearly everywhere in this region an excellent ground cover of advance reproduction—the natural source of the forest which will succeed even-aged when the overwood is removed at one stroke. In this case, the removal obviously cannot be by fire, but must be by cutting alone. And this doubtless explains why over the greater part of the yellow pine region there are so few examples of even-aged stands.

It is clear from this exposition that natural succession in yellow pine can give rise to both even-aged and uneven-aged forests—the latter being the climax forest. What now does this knowledge indicate with regard to the method of cutting? For one thing, it indicates that the present selection method of the Forest Service has been dictated by

the climax form of forest—the form which, because of the conflicting relation of fire, seeding and establishment, has become through the ages the prevailing form of forest. For another thing, it indicates that a clear cutting method may be in entire accord with Nature, if the even-aged succession form of forest is allowed to grow until maturity and then cut so as to reproduce in the same way.

It is almost a dictum among foresters to base the silvicultural system upon the form of virgin forest found on the ground. When the form found is the climax forest, this is not always wise. The foresters of India learned this after 30 or 40 years of experience with chir pine. They found the virgin forest largely in irregular, many-aged stands much as we find yellow pine, and they managed it at first by a selection method. Now they find it better forestry to cut chir pine so as to regenerate it in even-aged masses.

In general a silvicultural method of cutting should first of all be one in agreement with Nature, then one which produces the most profitable growth and which is most practical of accomplishment. It is sometimes stated arbitrarily that the selection forest is the only one which preserves the forest conditions of the site. When a forest by Nature grows even-aged and will repeatedly and vigorously do so on the same site as does Douglas fir, it is safe to say that it maintains the fertility of the site for the purpose of timber production. Indications are that yellow pine will generally do the same thing.

For a forest of pure composition, it may be said in general that it must grow even-aged to produce the most profitable volume growth; because the individuals being necessarily of uniform tolerance, either the smaller trees in the uneven-aged stand are inhibited in growth or the stand is open to permit their free growth, and in both cases the net volume production is restricted. In most regions Nature provides a balance which prevents the restriction of the net growth. Douglas fir is a well known example in which an uneven-aged stand may be had without loss of growth because the more tolerant understory trees of hemlock and cedar are able to grow profitably in the shade of the overwood firs. But as has already been shown, in the arid yellow pine region there is no other species, regardless of tolerance, which will grow on the typical yellow pine site. It would be well if exact figures showing the yield of even-aged as against uneven-aged forests of yellow pine could be given, but until there has been longer experience in forest management this cannot be done. Approximate figures are indicative,

however. The even-aged stand 150 years old mentioned in this paper, if carried to 180 years will give a cut of 48,000 board feet per acre. A yield table for a selection stand in the same locality has been made. In this, the distribution of age classes, the character of reproduction, the accelerated growth of the reserved trees as well as the loss of such trees, has been based upon a study of selection cuttings old enough to indicate what happens. This yield table gives as the sum of three periodic cuts through 180 years 36,000 board feet.

If the silvicultural and management requirements of a species indicate a clear cutting method, then it would seem that clear cutting should be practiced with it generally. It is not good forestry to be committed unalterably to a single method, however. A local forest condition should be managed on its own merits. Where a body of yellow pine is found containing a large proportion of pole age-classes, it would certainly be unwise to sacrifice this profitable growing stock by cutting it clear. Likewise on very severe site conditions it may be wise to maintain a selection forest.

The question now arises, how will the regeneration of the forest be cared for in clear cutting of yellow pine. In the Northwest the generally abundant advance reproduction in the present virgin forest is the already established second-growth. As an insurance against fire, and to seed up openings where they occur, there should be left four or five seed trees per acre which may be retained through the rotation. In the case of the future even-aged forest, more of an effort will be required to secure reproduction. At 180 years an even-aged stand of yellow pine is still young and still growing in too dense a condition to permit of much advance reproduction getting established under it. To secure reproduction it may be necessary to make first a seeding cut of 30 per cent or more of the stand and to allow time enough for a cover of reproduction to get started, such as is now found in the virgin forest. This may require 20 or 25 years, after which the main cutting of the overwood may take place.

In conclusion it may be said:

(1) An even-aged succession forest in western yellow pine is a proven fact.

(2) This even-aged forest is developing extensively on old private cut-over areas and on the more heavily cut of timber sale areas regardless of our intention.

(3) The present selection method is not resulting as intended, in an uneven-aged forest of properly balanced age classes, and it cannot so result.

(4) If it is decided to continue the present method of cutting, it should be recognized because of the constitution of the virgin forest, that the result for a hundred years or more will be a conversion forest in which special cutting or restraint in cutting must be exercised to bring about even a simple balance of the age classes.

(5) Clear cutting, with provision for safeguarding the advance reproduction by leaving scattered seed trees, would be a sound silvicultural system for the Northwest. To practice it would mean, practically, the cutting of but five or six additional trees per acre than are now cut on timber sales, and this would result in leaving the cover of advance reproduction to develop, without overhead competition, into a thrifty second-growth forest.