UNITED STATES DEPARTMENT OF AGRICULTURE

F O R E S T   S E R V I C E

DISTRICT 6

ADDRESS REPLY TO
DISTRICT FORESTER
AND REFER TO

Beck Building
Portland, Oreg.

RS
Mc-101

June 18, 1917

Pinus ponderosa[1]
(Western Yellow Pine)

Forest Officer,

Dear Sir:

The report of the yellow pine management study of the past season, which has recently been completed by Mr. Weitknecht, contains a number of interesting and valuable facts, all of which bear upon the proper silvicultural method of handling yellow pine. I shall be glad to loan a copy to those who care to read the full report of 45 pages. In order that all Forest officers may know if the more important findings of the study, an abstract of the report is here given.

The study has now been carried on in Eastern Oregon for three years. Last summer's field work was conducted on the Ochoco and Malheur Forests, partly with the object of checking, for the western portion of the Blue Mountains, the results previously obtained on the Whitman and Minam Forests. This year the study will be extended to the Klamath region of southern Oregon and to southern Idaho under a cooperative plan with District IV.

It will be recalled that the digest of last year's report, which was sent to you in circular letter 1,731 of May 13, 1916, described the decided accelerated growth which was found in trees left standing in old selection cuttings on the Whitman Forest. This stimulated growth was more than 100% and sometimes as high as 300% faster than the growth before cutting and it continued for 40 to 50 years following cutting. Last summer's work showed that this increased growth behaved exactly the same in the western part of the Blue Mountains, and that it is of universal occurrence wherever stands are sufficiently opened up by partial cutting.

The results with regard to accelerated growth, together with the results of the study of loss of trees in old cuttings, afford a basis for making yield tables in which a quantitative allowance for these factors can be made. Heretofore this has never been done. Thus, for the first time for western yellow pine, and probably for any many-aged species in America, yield tables are given in this report in which such allowance has been made. The following is the

[1] This document was transcribed from a photocopy of the original, which is located in the Supervisor's Office Silviculture Library Archives. To the greatest extent possible, this version is an exact duplicate of the original text.

Austin-Whitney yield table made both by the conventional method and the revised method, so as to show the accelerated growth and the loss which heretofore have not been considered.

Showing yield per acre after Forest Service selection cutting in which 20% of the original stand has been reserved.

Years after cutting	Yield per acre in board feet	
	Conventional method	Method allowing for accelerated growth and loss
0	4,310	4,310
20	5,585	6,496
40	7,380	9,254
60	10,320	11,658

A new point, brought out by the report, is that accelerated volume growth is greatest in the lower portion of the trunk and diminishes with increase of height on the trunk. This different distribution of increment after cutting indicates that reserved trees have a more rapid taper and thus a lower form factor than trees in the virgin stand. This means that the use of our present volume table in cruising in the reserved stand of a timber sale cutting would give exaggerated results; for example, a reserved tree 18 inches d.b.h., with its comparative swell butt, would have a lower actual volume than the volume of the 18-inch tree given in the table above, allowance was made for this factor.

With regard to windfall among the reserved trees, the report shows that, although heavy windthrow may be expected in many places in the Blue Mountains, amounting to as much as 22% in the course of twenty years, or until the remaining trees acquire adequate windfirmness, there are localities where it may be light, amounting, as in several cases studied last summer, to less than 2% in 18 to 27 years. In the preceding table the figures are based on a loss from windthrow of 13% for the first twenty years and 5% for each twenty-year period thereafter.

Although western yellow pine is known to be a species which occurs in true many-aged stands, the virgin forest in Oregon has been observed for the most part to contain a marked disproportion of age classes characterized by an absence of poles and young trees. To investigate this closely, the twenty-acre plots recently logged were laid out and the ages of all trees on each were obtained. The results show that 73% and 76% respectively of all the yellow pines above four inches d.b.h. were over 180 years old. It is evident that this lack of young trees must be considered in the marking and cutting plans for market units.

With regard to reproduction, the report shows that the cover of seedlings on old cuttings in the western part of the Blue Mountains was as uniformly abundant and thrifty as on cuttings elsewhere in this region. And on the whole, the greater and more important proportion of it was found to be advance.

The important point brought out in this connection is that, although this reproduction is so abundant, it has required in most cases from 20 to 30 years of gradual seeding and establishment to attain this abundant cover. All of the data of the study show decidedly that a good stand of reproduction, whether in the virgin or cut-over forest, does not result from one seed crop but is the combined result of a number of good establishment years. An exceptionally abundant seed crop one year may be followed by a year or two in which severe frost or drought will kill practically all the freshly germinated seedlings. On the other hand, a succession of two or three favorable years for establishment may follow mediocre seed years. The latter is, without doubt, the more common way in which reproduction in eastern Oregon originates. All this goes to emphasize the great value of the reproduction now on the ground and the importance of preserving it.

Very truly yours,

F. E. Ames, Assistant District Forester

By *W.H. Gibbons* Acting

Enclosure with
RS
Mc-101, D-6,
6-4-'17

Pinus ponderosa

YELLOW PINE MANAGEMENT STUDY

IN OREGON IN 1916.

By

Robert H. Weidman

May 10, 1917

For the Information of the Forester.

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PROGRESS OF THE YELLOW PINE MANAGEMENT STUDY
IN OREGON IN 1916.

The yellow pine management study comprises the permanent sample plot on the Whitman National Forest and the field study conducted on old cut-over areas. This report is concerned only with the results attained in the field study in 1916; it supplements the more exhaustive report of April 15, 1916, which summarizes the work of the two preceding seasons.

It will be recalled that the main objects of the study on old cut-over areas are to determine the practical importance of accelerated volume growth after a partial cutting, to investigate loss of trees—particularly by windfall—as it occurs through the years following such a cutting, and to study reproduction in its relation to cutting methods. These objects were attained for the region of the Whitman and Minam National Forests by the field work of 1914 and 1915. It was the purpose of the field work of 1916 to ascertain whether the findings would hold for the western part of the Blue Mountains. Thus a number of old cuttings on the Ochoco, Malheur, and Whitman National Forest were studied last year. The writer and one field assistant were engaged upon this work for two and a half months. The methods employed in the field work were essentially the same as those used previously and described in detail in last year's report.

Accelerated Growth of Trees Left in a Partial Cutting

In this study accelerated growth due to cutting is expressed in the per cent by which basal area growth (measured at breast height) occurs more rapidly after than before cutting. And this per cent of acceleration is secured for sample acres which represent different localities and various degrees of cutting. In the course of the study, 22 such plots were taken in the eastern part of the Blue Mountain region in 1914 and 1915, and last summer four plots were taken in the western part of this region mostly within the Ochoco National Forest. The results of these 26 plots are summarized in Table 1. It will be seen that the data secured in the vicinity of the Ochoco Forest fit in very well with the data gotten in the eastern part of the Blue Mountains, i.e., accelerated growth after cutting behaves exactly the same in both places.

TABLE 1

Summary Showing Relation of Accelerated Growth to Per Cent of Trees Reserved to their Volume, Diameter, Number, Age, Etc.

Plots	Per Cent Left by Volume	Average Basal Area Growth per Tree per Half Decade in Sq. Ft. — Before Cutting	Average Basal Area Growth per Tree per Half Decade in Sq. Ft. — After Cutting	Per Cent of Acceleration	Description — Stand per Acre Before Cutting in Bd. Ft.	Volume per Acre Left at Time of Cutting	°Trees left Over 12" — No. per acre	°Trees left Over 12" — Av. Diam.	°Trees left Over 12" — Approx. Ages	Years Since Cutting	Site	Remarks
Vicinity of the Whitman and Minam National Forests												
Sanger II	8	.041	.146	256	23,399	1,881	5	21	140-280	22	I	4 acre plot.
Sumpter I	9	.020	.082	310	23,145	2,105	11	17	270	17	II	Dry site.
Granite I	9	.031	.128	312	38,900	3,545	17	19	240-270	17	I	
Sumpter IV	10	.037	.118	219	28,025	2,800	13	18	200-260	17	I	
North Powder II	10	.034	.133	291	28,240	2,785	15	19	200-280	28	I	
North Powder I	11	.040	.127	217	31,625	3,615	21	17	170-280	10	I	
Sumpter II	12	.040	.137	242	34,505	3,990	17	19	150-270	17	I	
Sumpter V	15	.021	.076	262	21,985	3,400	18	16	230-290	15	II	Dry site.
Granite II	16	.031	.061	97	31,572	5,148	19	19	260-300	16	I	Crowns poor to fair; 2 to 5 trees in group
Starkey I	16	.029	.123	324	16,370	2,620	20	17	130-220	19	I	
Starkey III	16	.033	.122	270	20,220	3,265	21	17	170-230	19	I	
Starkey IV	17	.036	.097	169	20,710	3,455	15	18	200-250	18	I	
Starkey II	18	.027	.115	326	29,375	5,425	34	17	200-260	19	II	Rocky site.
Susanville II	20	.034	.082	141	20,130	4,135	13	18	200-260	11	I	
Starkey V	28	.030	.074	147	16,185	4,485	20	17	200-260	19	II	Rocky site.
Susanville I	32	.044	.089	102	23,245	7,515	19	19	200-250	11	I	
Susanville III	32	.063	.121	93	30,060	9,785	7	31	350	40	I	Old, big trees.
Sanger I	37	.096	.193	101	43,270	16,110	10	32	280-380	25	I	Old, big trees.
Catherine Cr. II	37	.060	.131	118	30,708	11,508	12	27	260-330	25	II	Poor crowns, rocky site
Sanger III	53	.082	.141	72	36,515	19,425	15	27	200-300	18	I	Mostly big trees.
Sumpter VI*	14	.046	.083	80	26,290	3,740	12	19	180-280	17	I	2 acre plot – 28 trees in group
Sumpter III*	22	.046	.075	63	21,260	4,585	18	19	140-200	17	I	1 acre plot – 18 trees in group
Vicinity of the Ochoco National Forest												
Ochoco I	19	.044	.090	105	24,255	4,705	11	22	240-310	15	I	Poor reserved trees
McKay I	25	.049	.137	180	33,280	8,290	10	29	190-350	27	I	
Badger I	32	.085	.170	100	41,015	13,125	17	28	180-530	25	I	
Ochoco II	39	.075	.159	112	16,370	6,470	26	20	80-160	15	I	Young trees; ½ acre plot.

° Figures under this heading refer to present condition of the trees left standing

* On all the plots except these the trees are evenly distributed; on these two they are arranged in big, single, intact groups

It will be noticed that the arrangement of the plots in this table is according to the degree of cutting, or in other words, according to the per cent by volume of the trees left standing in the cutting operation. This was done because the per cent of acceleration seemed to vary more consistently with per cent by volume of trees left in cutting than with the actual volume left, or the number of trees left, or their age, or the condition of the site. All these latter factors undoubtedly have a contributory influence on the amount and duration of accelerated growth, but it is firmly believed that the degree of the liberation, regardless of the volume of the original stand or the volume left, is by far the controlling factor.

A comparison of the two columns "Per Cent Left by Volume" and "Per Cent of Acceleration" shows that there is a close relation in which, with certain limitations, the lower the per cent of the trees left standing the greater the accelerated growth. In order to study this relation more closely, a curve, Figure 1, was plotted in which the coordinates are the values presented by these two columns. This curve shows that for stands of reserved trees (represented by 24 sample acres) a limit of acceleration of slightly over 300 per cent is reached when the reserved stand is about 9 per cent. No plots in which the cutting left less than 8 per cent were studied, but it is reasonable to assume that where less trees are left than 8 or 9 per cent the acceleration will not appreciably exceed 300 per cent. Table 2 shows the relation of the per cent of acceleration to the per cent of trees left standing as read from the curve. These figures hold for 30 to 40 years following cutting.

TABLE 2

Per Cent Left Standing	Per Cent of Accelerated Growth
10	290
15	210
20	170
25	140
30	115
35	100
40	85
45	75
50	65

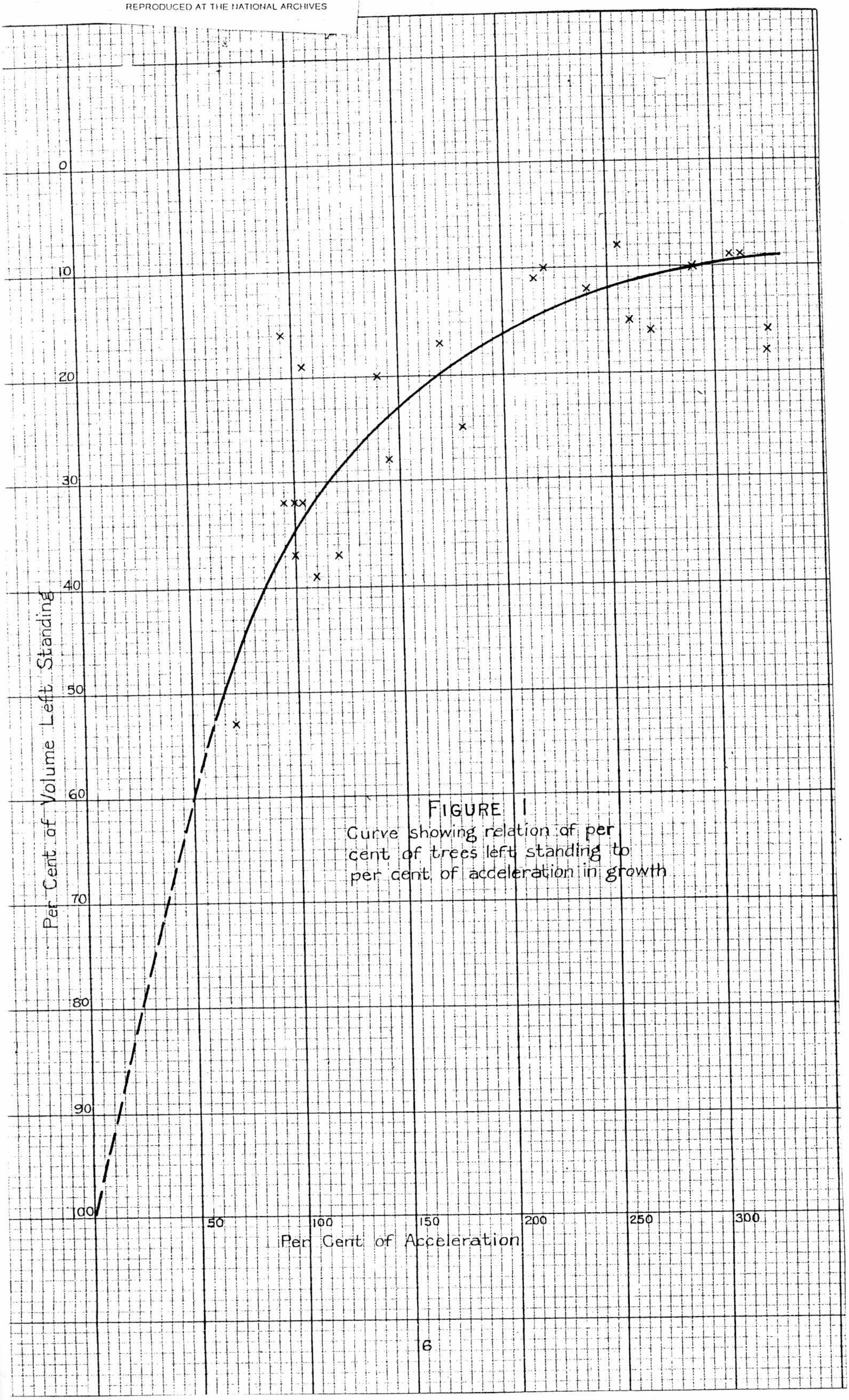

FIGURE 1
Curve showing relation of per cent of trees left standing to per cent of acceleration in growth

Distribution of Accelerated Increment

In order to determine whether there was any difference in the rate of accelerated growth throughout the stem as compared with the rate at breast height, a stem analysis of a few standing trees was made last summer. The trees occurred in a 15-year old cutting near Sumpter, Oregon, under conditions in which 10 per cent and less by volume was left standing. These were young and middle-aged trees which ranged from 16 to 27 inches in diameter and from 65 to 90 feet in total height. One increment core was taken at breast height and one at each 20-foot interval above this point to where the tree was approximately 8 inches in diameter. The cores were secured by climbing the trees with the aid of telephone climbers. The basal area growth for the last 75 years was computed by half-decade periods and the per cent of accelerated growth was determined for each individual core.

Table 3 gives the results of this little study.

TABLE 3

Height on Trunk Feet	Trees Analyzed						
	No. 1	No. 2	No.3	No. 4	No. 5	No. 6	Ave. Tree
	Per Cent of Accelerated Growth at Intervals up Trunk						
4.5	259	394	353	362	116	75	235
24.5	183	274	320	178	162	51	175
44.5	129	112	300	105	53	94	123
64.5	65	-	-	-	-	19	-

It was possible last summer to get these stem data on only the six trees here shown. While it is planned to make a more comprehensive stem analysis of a greater number of trees next season, it is believed that these results, though meager, are so indicative that they should be discussed a little at this time.

Except for the variations in trees Nos. 5 and 6, Table 3 shows that the accelerated growth due to cutting is greatest at the base of the tree and that it diminishes with increase of height on the trunk. This concentration of accretion at the lower portion of the trunk is in keeping with Robert hartig's findings regarding the influence of density of stand upon the distribution of increment. He found that in dominant trees the increment is chiefly in the lower part of the stem, and in suppressed trees in the upper part; he found also that suppressed trees sometimes even showed at breast height an entire lack of annual rings to correspond to those higher up the trunk.

For the scientific interest they may have Tables 4 and 5 are given; they show, for the six trees studied, the average half decade area growth before and after cutting at the 20-foot interval points. It is interesting to know in this connection that, in the uncut stand, the average tree of these tables made at the first 20-foot interval an area growth which was 85 per cent of the area growth at breast height, and at the second 20-foot interval an area growth of 65 per cent of that at breast height. When the stand was opened up by cutting, on the other hand, the average of these same trees made at the first 20-foot point an area growth of only 70 per cent of that at breast height and at the second 20-foot point an area growth of only 43 per cent of that at breast height.

TABLE 4

Average Area Growth Before Cutting

Height on Trunk Feet	Trees Analyzed						
	No. 1	No. 2	No.3	No. 4	No. 5	No. 6	Ave. Tree
	Ave. Area Growth per Half-Decade in Square Feet						
4.5	.070	.036	.019	.055	.032	.073	.048
24.5	.069	.027	.020	.050	.032	.049	.041
44.5	.055	.025	.015	.040	.019	.033	.031
64.5	.029					.032	

TABLE 5

Average Area Growth After Cutting

Height on Trunk Feet	Trees Analyzed						
	No. 1	No. 2	No.3	No. 4	No. 5	No. 6	Ave. Tree
	Ave. Area Growth per Half-Decade in Square Feet						
4.5	.251	.178	.086	.254	.069	.128	.161
24.5	.195	.101	.084	.139	.084	.074	.113
44.5	.126	.053	.060	.082	.029	.064	.069
64.5	.048					.038	

The fact that accelerated area growth is so strikingly concentrated in the lower portion of the trunk is a finding of practical importance for several reasons. Heretofore it often has been assumed that the per cent of accelerated area growth at breast height was equal to the per cent of accelerated volume growth, and this per cent was used without correction as a factor to determine the accelerated increment It is now evident that the average accelerated area growth of the trunk is the more correct factor to use for this purpose. It is readily apparent that so concentrated an area growth at breast height, as is shown by these figures, will produce a more rapid taper and will lower the form factor. Thus a reserved tree of 18 inches in diameter at breast height, with its comparative swell butt, will have a lower actual volume than the volume of an 18-inch tree as given in the present volume table. Thus the use of our present volume tables in computing the volume of reserved trees in future estimating on timber sale areas or in the periodic measurements of permanent sample plots, like the Mc plot on the Whitman National Forest, will give an exaggerated increase in volume.

<u>Relation of Accelerated Growth to Yield Tables</u>

Our present yellow pine yield tables in District 6 are based on growth studies of trees which grew in virgin stands; the tables having been made by the conventional method described on page 337 of Graves' "Mensuration". The chief need of yield tables in yellow pine, however, is to predict the future growth of stands which have been cut-over by a selection method. But the growth in the cut-over stand is radically different from that in the virgin stand, because, as has been shown, the liberation of the reserved trees produces an unusual accelerated growth which continues for 40 to 50 years following cutting. Thus our yellow pine yield tables are not applicable for the purpose intended. It is purposed in this study to revise our yield tables so as to allow for increased growth and loss.

Perhaps it would be well before proceeding further to give what it is believed should be the scope of yellow pine yield tables for Oregon. Separate yield tables, first of all, should be made for a number of representative localities or conditions of site. These tables should show for a number of degrees of cutting (in which, say, 10, 15, 20, 25, 30, and 35 per cent are left standing), the future yields by decades to at least 60 years following cutting. These should be actual net future yields as accurately as they can be scientifically determined. It is not necessary to emphasize the fact that accelerated growth and loss of trees are among the basic elements which should be considered. The yield tables should embrace at least 60 years, because they should certainly exceed a little the period of accretion and should cover enough time to include any reasonable length of cutting cycle.

Soundly constructed yield tables for such a many-aged species as western yellow pine really can be made, in the opinion of the writer, by but two methods. The first of these methods requires a number of suitable cuttings, which should be at least 50 or 60 years old. On these cuttings there would be found suitable spots upon which various degrees of cutting had been practiced and in these spots plots would be laid out. All the standing trees on each plot would then be cut down and complete stem analyses made and the trees which had been lost would be investigated as to their volume and the year of loss. The volume growth and loss data resulting from these studies properly compiled would make up the yield tables. The other method is the one in which a number of permanent sample plots of ten acres or larger are laid out in typical stands and representative sites. The timber on these plots is marked and cut to represent various methods and degrees of cutting. The reserved trees on each plot are then measured for volume every five years for 60 years, and account is kept also of the loss through the years. After 50 or 60 years the half-decade results will furnish data for yield tables of this length of time. This is the most accurate and scientific method of making yield tables for many-aged species.

Neither of the methods just described can produce at the present time the yield tables now needed. The analytic method is not possible because there are no suitable cuttings in Oregon older than 30 years. The synthetic method, if the term may be used, obviously can not produce yield tables now, because there are only three permanent sample plots in Oregon and these are not yet five years old. Many-aged yield tables can be made by empiric methods, however; that is, in fact, how they are largely made in the United States. While empiric methods are exceedingly unsatisfactory from a scientific standpoint, because of the many far-reaching assumptions which have to be made, yet empiricism has its advantage in that it produces immediately available yield tables. In this study, empiric construction necessarily has been employed in making the several yield tables which are offered.

The method here used will be explained in the terms of a specific example. Table 6 represents the Crawford Creek yield table* as made by the conventional methods and also as revised by the present method.

TABLE 6

CRAWFORD CREEK YIELD TABLE
Showing Yield per Acre after Forest Service
Selection Cutting to a Flexible Diameter Limit Reserving
6,028 B. F. (27% of the original stand)

Years after Cutting	Yield per Acres in Board Feet	
	Values derived by conventional method	Values derived by method allowing for accelerated growth & loss
0	6,028	6,028
20	7,572	8,079
40	9,702	11,074
60	12,700	13,402

*From manuscript report "The Future Yield of Yellow Pine Stands in Oregon," by Thornton T. Munger.

Since the final expression of the accelerated growth data in this study is in the form of the per cent by which growth after cutting is more rapid than that before, it is necessary in the present revision of yield tables to know the periodic volume growth for at least 20 years before cutting. In the present cases this was found to be 1,243 board feet and it was secured by the use of the same fundamental data as were employed by Munger in the original yield table, viz., the Crawford Creek Stand Table, Bright and Munger's Growth Table, and the Austin Volume Table. Next the per cent of acceleration for a reserved stand of 27 per cent was found to be 130 from the curve in Figure 1, which, it will be recalled, gives the acceleration in area growth at breast height. It was then assumed that the average area growth for the trunk, rather than the breast height area growth, is equal to the volume growth. And it was necessary to convert the breast height acceleration to the average trunk acceleration, which was done by aid of the data given in Table 3. The resulting acceleration factor of 102 per cent was applied to 1,243 board feet, the volume growth for 20 years before cutting, and 3,031 board feet was thus obtained. This was further increased slightly by the trees which had attained a diameter of 12 inches during the 20 year period. Then a loss factor of 13 per cent was applied and the net yield of 8,079 board feet was obtained. With regard to loss, it was decided to use 13 per cent as the average loss factor for the first 20 years following cutting and five per cent for each of the two 20-year periods after this; these factors being based partly on the results of study and partly on assumption. The high loss factor for the first 20-year period, which is probably excessive, is due to the heavy windfall liability in eastern Oregon.

Since practically no accelerated growth data are available beyond 25 or 30 years after cutting, because of the scarcity of older cuttings, it is necessary to assume the per cent of acceleration after the first 20-year period. For the period 20 to 40 years after cutting this is assumed to be the same as in the period 0 to 20 years; and the volume growth of the reserved trees in the period 40 to 60 years is assumed to be the same as it would have been during this period if no cutting at all had been made. In reality the per cent of acceleration in the second 20-year period is somewhat less than in the first 20 years, and there really is still a little acceleration occurring after 40 years following cutting; but the foregoing assumption is the simplest and perhaps the safest that can be made.

Thus the yield at 40 years after cutting was secured by the use of the acceleration factor of 102 per cent, and the yield at 60 years by the use of Bright and Munger's growth table. The net yield at each period was obtained by applying the loss factor of five per cent.

Tables 7 and 8 are two forms of the Austin-Whitney yield table which show the yields as derived, respectively, by the conventional method and by the method just described, allowing for accelerated growth and loss. Both tables give yield per acre and periodic increment for three degrees of cutting in which 10, 20 and 30 per cent are reserved. The stand table used in constructing thee tables is based on the measurement, by Bright and Munger in 1910, of 258 ½ typically stocked acres in the vicinity of Austin and Whitney. The stand of the average acre before cutting was 21,535 board feet.

TABLE 7

AUSTIN-WHITNEY YIELD TABLE
Constructed by the Conventional Method

Years after Cutting	Yield per Acre in Board Feet					
	2,140 B. F. (10%) reserved		4,310 B. F. (20% reserved)		6,540 B. F. (30% reserved)	
	Yield	Periodic Increment	Yield	Periodic Increment	Yield	Periodic Increment
0	2,140		4,310		6,540	
20	3,105	965	5,585	1,275	8,130	1,590
40	4,560	1,455	7,380	1,795	10,340	2,210
60	7,120	2,560	10,320	2,940	13,545	3,205

TABLE 8

AUSTIN-WHITNEY YIELD TABLE
Revised Allowing for Accelerated Growth and Loss

Years after Cutting	Yield per Acre in Board Feet					
	2,140 B. F. (10%) reserved		4,310 B. F. (20% reserved)		6,540 B. F. (30% reserved)	
	Yield	Periodic Increment	Yield	Periodic Increment	Yield	Periodic Increment
0	2,140		4,310		6,540	
20	4,649	2,509	6,496	2,186	8,512	1,972
40	7,542	2,893	9,254	2,758	11,249	2,737
60	9,661	2,119	11,658	2,404	13,811	2,562

It should be pointed out that the difference between the revised and original yields in Table 6 is not as striking as would have been the case had the cutting been heavier. In allowing for accelerated growth and loss as has been done here, the yields are greater than those of the original table by 507 board feet at 20 years, 1,372 board feet at 40 years, and 702 board feet at 60 years. In a heavier cutting, as in the case where 20 per cent is reserved in Table 8, the difference is very considerably greater. Here it will be seen that the yields are greater by 911 board feet at 20 years, 1,874 board feet at 40 years, and 1,338 board feet at 60 years, than the corresponding yields in Table 7.

It is interesting in this connection to note the results of an investigation of growth after cutting made in Arizona several years ago by Greenamyre. Here approximately 20 per cent of the stand was left in the original logging operation, and 26 years later the remaining trees were clean cut. The fresh stumps and tops of the second cut enabled Greenamyre to make partial stem analyses, and he did this for all the trees that had been left on a single plot of 109 acres. The final results showed a very striking accelerated growth after cutting which at the end of 26 years gave a total of 61,040 board feet, or 560 board feet per acre, more than would have been found on the area had the growth taken place at the unstimulated rate which occurs in uncut timber.

A further study of Tables 7 and 8 indicates some interesting conclusions. In Table 8 the periodic growth culminates in the neighborhood of 50 years after cutting, while in Table 7 it increases consistently to 60 years and beyond. In Table 8 the periodic growth decreases the lighter the cutting, because the fewer the trees taken out in cutting the less the stimulation; but in Table 7 the periodic growth increases with the increase of the trees left standing. Thus Table 8 indicates that a comparatively heavy cut and a cutting cycle of not longer than 50 years will give the greatest volume production. It is manifestly desirable to have the end of the cutting cycle coincide with the termination of the accelerated growth, so that the next cutting may be made then and no time may be lost between accretions.

With regard to the yield tables, it should be mentioned that the accelerated growth data upon which they are largely based were secured in representative yellow pine stands. The 24 sample plots used in this work were taken in ten separate localities. In practically all cases the stands were pure yellow pine, and where they were not, yellow pine made up never less than 80 per cent of the total volume of the stand. Twenty of the plots were recorded as of first class site quality, and four as of second class. Three of the plots were classified as dry and three others as rocky; the remainder were of average soil conditions. With regard to the character of trees, a classification of 112 trees left standing on seven plots showed that 45% were thrifty and perfect young trees (bull pines), 20% were older and larger trees which were crooked or forked but otherwise sound, and 35% were suppressed or defective trees. Within the tree itself practically the only defect which interferes with volume growth is an unhealthy or very scant crown. All the plots were selected with a painstaking effort to exclude defective crowns as much as possible. As a result of this the crowns of the trees were very largely vigorous and compared well with those of reserved trees on timber sales.

In concluding the subject of yield tables, it is desired to emphasize the fact that no far-reaching claims are made for the yield tables appearing in this report. It is felt that these tables should have only a temporary value. They are in reality nothing more than approximations. Their only justification is that some sort of yield tables are now needed and that they are the closest approximations that can be made at present.

Moreover, it should be stated that the firm conviction reached in this study is that satisfactory yield tables for yellow pine can be made only by the permanent sample plot method. There is no question whatever about the ultimate advantages of this method over empiric methods, and in the light of the permanence of forest management in the United States there can be no objection to it. When forest regulation becomes a practical necessity in our timber sale business, there will be an urgent need for absolutely accurate yield tables. And the danger is that the need will come before enough time has elapsed to furnish sufficient data for tables built by the inductive method of permanent sample plots. Practical yield tables could be made in 40 to 50 years. It is not at all unreasonable to believe that they will be urgently needed by that time. It is said on very good authority, in fact, that practically all the privately-owed yellow pine in Oregon will have been cut in 35 to 40 years. This means that heavy cuttings in the yellow pine on the National Forests will also be made by that time, and for a long period thereafter the National Forests will be the only source of yellow pine. Before that time comes we should know all there is to know about growth and yield. Such being the case, it certainly should be the part of wisdom to establish a proper number of sample plots now rather than defer beginning this work for five or ten years.

<u>Loss by Windfall after a Partial Cutting</u>

The purpose of this phase of the study has been to determine quantitatively, by the study of actual cuttings over 15 years old, how serious is the windfall problem after partial cutting. Specifically the effort has been to determine the distribution of the volume of the windthrow through the years following cutting, and also to ascertain, in the cases of heavy windfall risk, whether all the trees are eventually blown down or whether the greater percentage of them gradually become windfirm enough to survive under partial cutting conditions. Previous to last summer three windfall plots in areas of moderately heavy windfall risk were studied; last summer two plots were taken where the windthrow was light. The results of all the plots are summarized in Table 9. This table shows for each plot the number of trees thrown and the per cent of volume thrown by five-year periods following cutting. The sizes of the plots, which were mostly 20 to 40 acres, are designated in the table. The year of throw was determined, of course, by the number of accelerated rings which the windthrown tree exhibited.

TABLE 9

SHOWING WINDFALL BY YEARS AFTER CUTTING

Years after cutting	0-5	5-10	10-15	15-20	20-25	25-30
Starkey Plot – 20 acres – 20 yrs. since cutting						
Number of trees thrown	28	12	2	1		
Per cent by volume thrown	54	30	5	11		
Whitney Plot – 40 acres – 15 yrs. since cutting						
Number of trees thrown	31	6	3			
Per cent by volume thrown	94	4	2			
Aggregate Plot – 24 separate acres – 15 yrs. since cutting						
Number of trees thrown	23	7	4			
Per cent of volume thrown	67	12	21			
Badger Creek Plot – 20 acres – 27 yrs. since cutting						
Number of trees thrown	3	3	2	1	1	1
Per cent of volume thrown	33	28	16	1	1	21
Sumpter Plot – 20 acres – 18 yrs. since cutting						
Number of trees thrown	3	1	0	0		

It will be noticed that the plots taken last summer, the Sumpter and Badger Creek Plots, corroborate the findings of the earlier plots in that they show a similar concentration of the windfall in the first few years immediately following cutting and a gradual falling-off thereafter. In several of the plots the uniform decrease of the volume thrown, year by year after cutting is disturbed in the later half-decades by unusually high per cents of volume. In every case this was caused by a single big tree which, because of it large size or a deep basal fire scar, was an exceedingly bad windrisk, and a tree which under no circumstances would have been reserved by a timber sale marker.

To amplify Table 9 the following little table is given; it shows the number of windfalls per acre for the several areas studied.

TABLE 10

Area	Number of Windfalls per acre	Period Covered in Years
Starkey	2.15	20
Whitney	1.00	15
Aggregate	1.42	15
Badger Creek	.55	28
Sumpter	.20	18

With regard to the discouragingly heavy windfall on the Eccles timber sale several years ago, it will be recalled that two severe windstorms coming in 1913 and 1914, within the first four years after cutting, blew down over a million feet of timber amounting to 18 per cent of the reserved stand. Knowing from the weather records that storms equally as severe as these occurred every three or four years, it was feared that his windfall loss was an index of what would happen with every storm that would follow. And at this rate it was feared that all the reserved trees eventually would be blown down. The results of this study indicate that this fear has no basis in fact. In the actual case of the Whitney area, where 41,310 board feet were left standing on 40 acres, the entire volume thrown in 15 years amounted to 8,995 board feet, or 22 per cent; and over 90 per cent of this was thrown in the first half-decade after cutting. On the twenty-four separate acres, 14 per cent by volume of the trees left standing was thrown in 15 years, and nearly 70 per cent of this was blown down in the first five years following cutting. It is interesting to note in this connection that the first half-decade after cutting in the above cases occurred in the years 1905 to 1905, while in the case of the Starkey area it occurred from 1897 to 1901.

The plots taken last summer are of particular interest because they show that disastrous windfall is not a universal condition in the Blue Mountains. The Badger Creek Plot was located in a 27-year old cutting where nearly 40 per cent by volume of the trees had been left standing. On this 20 acre plot, the entire windfall for 27 years amounted to only 1.9 per cent of the reserved volume. The reason for this very light windfall loss is not known. It may be that the density of the stand afforded a greater resistance to the first severe winds, but it is more probably that the stand has been protected from the force of storm winds by the high ridges on both sides of the Creek. The Sumpter Plot, also 20 acres in size, was located on the south side of the valley within three miles of the town of Sumpter in a cutting where about 8 per cent had been left standing. Here only four trees were windthrown in the 18 years since cutting, and it is estimated that this is a loss of only about on per cent by volume. The long, high ridge which flanks the south side of the valley undoubtedly protects the cutting here against storm winds from the south and southwest, from which direction the most disastrous winds in this region seem to come.

This study of the windfall history of these few old cuttings brings out some useful points. It shows that although heavy windfall may be expected anywhere in the Blue Mountains, there are localities where it can be expected to be light. The study has furnished no basis on which to predict whether, on any given area, the windfall will be light or heavy. Neither has it been possible for the study to state definitely whether dense or open reserved stands suffer most heavily. The conclusive fact brought out is that a heavy windfall in the first few years following cutting, like that of the Eccles timber sale, does not presage the total destruction of the reserved stand. Another outstanding fact is that the heaviest windfall studied on any cut-over area does not show that a selection method of cutting is prohibitive.

Reproduction after Cutting

One of the objects of the study is to determine what class of reproduction is found under cut-over conditions. Previous to last summer nine cut-over areas, where the period since cutting covered 10 to 30 years, had been studied for this purpose. On five of these areas advance reproduction made up from 56 to 96 per cent of all the reproduction; on two of the areas the advance and the subsequent reproduction comprised 50% each; on the remaining two areas the subsequent reproduction was in preponderance, comprising 78 and 98 per cent of the cover. Table 11 shows the proportion of advance and subsequent found on the areas studied last summer in the western part of the Blue Mountains. In the case of the two Austin areas the present proportion of the classes should not be taken as final, for the cutting has been done only recently and the subsequent may be either reduced by mortality or increased by seeding. The data were secured, as they were last year, by running arbitrary lines 20 chains long through a cutting and taking square rods every chain or two chains.

TABLE 11

PROPORTION OF ADVANCE AND SUBSEQUENT REPRODUCTION EXPRESSED IN PER CENT

Area	Advance	Subsequent	Basis in Square Rods	Years since Cutting
McKay	1	99	10	27
ochoco	93	7	10	15
John Day	57	43	10	25
Austin I	27	73	20	6
Austin II	44	56	20	5

This table shows, as did the previous work, that, on the whole, advance reproduction makes up the greater part of the reproduction on cut-over areas. Moreover it is nearly always the more important part of the reproduction, because it is larger in size and therefore comprises the greater per cent of the dominant reproduction.

An idea of the abundance of reproduction on cuttings can be gotten from Table 12, which shows the number of seedlings, including advance an subsequent, per average square rod for a number of areas. On all save the Austin areas the period since cutting covers 15 to 27 years. And on all the areas the reproduction is practically pure yellow pine except Austin II, where about 25 per cent of it is lodgepole pine.

TABLE 12

NUMBER OF SEEDLINGS PER AVERAGE SQUARE ROD

Area	Average Number per Square Rod	Basis in square rods
Sumpter A	25.4	20
Sumpter B & C	34.3	30
Starkey	12.5	8
Austin A	55.0	10
Austin I	45.9	20
Austin II	99.0	20
McKay	97.6	10
Ochoco	45.0	10
John Day	5.6	10

In connection with these figures it might be well to state what is meant by abundant reproducetion. On all the areas here given, except the Starkey and John Day areas, the reproduction is considered abundant. Using the average square rods in the table as measures of the stand per acre, it is found that the number of seedlings per acre ranges from 900 to 16,000. And, as a rule, where the reproduction cover is evenly distributed and numbers over 2,500 seedlings per acre, it is considered as abundant in this study. But number per acre is not alone an index of abundance or density; for example, thrifty, evenly distributed saplings 35 years old would make a dense stand if only 1,000 occupied an acre. On all but the Starkey and John Day areas, the reproduction appears noticeably dense to the eye and offers considerable obstruction to one walking through it. In the case of the two thinly stocked areas the reproduction is irregularly scattered with big blanks which have never been filled by subsequent reproduction.

In addition to the areas which were studied intensively last summer, all of which had sufficient reproduction, six areas were examined extensively. Two of these latter, or only two out of the eleven areas visited last year, contained less than 900 seedlings per acre. On one of these areas, though the reproduction was scant, it was believed to be within the minimum sufficiency for natural reproduction. The unusual scarcity of reproduction in these two cases cannot be readily explained; it is believed that on one area the extraordinarily dense stand left in cutting was inimical to establishment and that on both areas the grazing has been destructively heavy.

In an effort to discover the factors which affect the origin of yellow pine reproduction, the data gathered on all the areas where at least 10 square rods had been taken were compiled in Table 13. This table shows for each area all the seedlings per 10 square rods classified by the years when they germinated. In making this tabulation it was thought that the reproduction records, which covered 41 years, would reveal something regarding the frequency of favorable reproduction periods. It is now a generally accepted belief that in an arid region like eastern Oregon a crop of yellow pine reproduction will only follow a sequence of three or four years which are entirely favorable for the successive processes of seeding, germination and establishment. In order more readily to detect coincidence of favorable periods on the various areas, curves in which the ordinates were number of seedlings and years when they started, were plotted for each area and their peaks and depressions carefully scrutinized. The curves for the Ochoco and McKay areas, which are 20 miles apart, exhibited a coincidence of peaks every second year for 12 years beginning 1887, which indicates that a great number of seedlings became established every second year than was the case in the intervening year. The curves for the Sumpter and McEwen areas did not agree with the above, however, and these did not agree with each other, though the two areas are only 5 miles apart on opposite sides of the Sumpter Valley. Thus this comparison of the several areas does not show any general coincidence of favorable periods in the Blue Mts. And in this respect it indicates that such a factor as precipitation, the changes of which are felt uniformly over a large region, does not have so much of a controlling influence upon reproduction as frosts and such factors that occur differently upon sites which are but a few miles apart.

Table 13 contains several other points of interest. It shows strikingly how in some cases opening up of the stand by cutting is immediately followed by a pronounced increase in the coming in of reproduction. And a comparison of McKay A and McKay B areas throws an interesting side light on the matter of advance and subsequent reproduction. The McKay B series of square rods was taken in virgin timber within two miles of the McKay A series which, like all the rest in Table 13, was taken in a cutting. Practically all the reproduction on the cut-over area started in the 14 years immediately following cutting. Thus it was all subsequent and in number amounted to 97 per square rod. But during this same period of years, 1890 to 1903, nearly the same amount, namely, 80 seedlings per square rod, started in the virgin timber. And the years in which greater and less amounts started on the two areas coincided almost exactly throughout this period of 14 years. Although this Indicates that the subsequent reproduction on the McKay cutover area was primarily due to favorable conditions which prevailed equally in the virgin timber and in the cutting, it should not be accepted as indicating that all subsequent results from such conditions rather than from the opening up of the stand by cutting.

TABLE 13

Showing the number of established seedlings per 10 square rods and the year in which they germinated, for various cut-over areas in the Blue Mts. (Red line marks time of cutting.)

Year of Germ-ination	Number of seedlings on 10 square rods								
	I	II	III	IV	V	VI	VII	VIII	IX
1916				0	0				
1915				0	1.5				
1914				34.5	14.0				
1913				285.5	403.5				
1912				1.5					
1911				6.5	3.0				
1910				3.5					
1909				7.0	10.5			5	1
1908	.5			1.0					
1907				8.0	14.0			6	3
1906	.5	2.5		7.5				2	
1905	2.0	1.5		14.5	57.0		10		1
1904		6.0		3.5				5	3
1903	1.5	8.5		20.5	41.0	7	6	1	
1902	9.0	2.0	3	3.5		30	10	14	
1901	10.0	7.0	1	1.0	53.0	46	20		
1900	27.0	21.5		4.5		81	46	12	
1899	73.5	14.0	11	9.0	46.5	78	60	21	5
1898	69.0	8.5	12	1.5		140	72	15	
1897	7.5	5.0	29	8.0	53.0	100	86	29	4
1896	9.5	13.0	54	2.0		98	62	9	3
1895	7.0		9	4.0	25.0	119	104	34	
1894	5.5	10.0	61	5.5		84	60	19	
1893	6.5	4.0	8	1.0	10.0	68	94	25	1
1892	6.0	3.5	42			40	52	10	3
1891	4.0	5.0	20	.5	6.0	49	66	36	1
1890	3.5	1.0	64	.5		33	50	30	7
1889	.5	10.0			1.5		52	23	3
1888	4.0	8.0	98				40	13	2
1887	.5	5.5	8			3	48	65	5
1886	3.0	6.5	74			1	40	8	
1885	1.5	34.5	19				10	21	5
1884		13.0	44			1	18	6	1
1883		6.0					8	6	1
1882		13.5	26				4	14	2
1881		1.0					2	4	
1880		2.0	6					5	1
1879		1.0						3	
1878		4.0	1					1	
1877								4	1
1876	.5	2.5	2						
Total on 10 sq. rds.	254	220	589	458	990	976	1026	448	56

Key to Areas:

I – Sumpter
II – McEwen A
III – McEwen B
IV – Austin I
V – Austin II (tallied by 2-year classes)
VI – McKay A
VII – McKay B (virgin forest)
VIII – Ochoco
IX – John Day

Reproduction in Relation to Stock Grazing

On old cuttings the cover of reproduction is nearly everywhere so dense as to prevent grazing entirely. But such cuttings, except a few like that in the Sumpter Valley, are still insignificant in size and are everywhere surrounded by the virgin timber. In the virgin timber, however, the former open forest floor is gradually being changed by the establishment of a cover of advance reproduction. And in open, overmature stands this reproduction is even now so dense and large in many places as to practically prevent grazing. This advance reproduction has mostly come in during the last 25 or 30 years, and is due to the protection from fire which the forest has received partly by the Forest Service and partly by the unconscious efforts of the settlers and stockmen.

With the growth of the reproduction now in the virgin forest and the coming in of more of it, it is very evident that the available forage will be much decreased and that consequently grazing cannot help but be greatly restricted in the next 15 or 20 years. Both forest officers and stockmen have been fearing this for some time. It has been predicted that within the next ten years incendiary fires will be set out extensively where the situation becomes acute. In an endeavor to solve the problem, it has been suggested that on forests like the Malheur where the timber will not be accessible for cutting for 30 years or more, it would be good management to keep the forest floor clear of reproduction until within about 10 years of the time when the timber will be cut. This plan, it is claimed, would provide for excellent grazing for 20 years and at the same time allow ample time for advance reproduction to come in before the timber is to be cut. It has also been said that this problem will not be of long enough duration to be serious, because as soon as reproduction develops into poles grazing will again be possible. But this view fails to take into account the length of time required before a dense cover of young growth opens its canopy sufficiently to permit grass and herbage to thrive. On the four cuttings between 40 and 50 years old which were visited in the course of this study, dense stands of saplings and poles as old as 50 years were found and under these practically no green ground cover whatever occurred.

Whatever the policy with respect to advance reproduction which may be effected by stock grazing, the practical value of this reproduction after cutting should be kept clearly in mind, and particularly should be kept in mind the length of time required for a cover of reproduction to be established. All the data of this study show decidedly that a good stand of reproduction, whether in the virgin forest or the cut-over forest, does not result from one seed crop, but is the combined result of a number of good establishment years. An exceptionally abundant seed crop one year may be followed by a year in which severe frosts will kill practically all the freshly germinated seedlings, or it may be followed two years later by an exceedingly dry summer in which drought will cause a high mortality among the young seedlings. On the other hand, a succession of two or three favorable years for establishment may follow mediocre seed years. The latter is, without doubt, the more common way in which reproduction in eastern Oregon originates; at least this is to be deduced from the wide range of ages found in the stands of reproduction shown in Table 13. The study of burned-over cuttings brought out clearly in last year's report the slowness with which a cover of yellow pine reproduction becomes established on a bare forest floor.

The Reproduction Problem on Land Exchange Areas

A special act of Congress last year authorized the exchange of private cut-over lands in the Whitman National Forest near Austin and Whitney for National Forest stumpage. If this exchange is effected nearly 20,000 acres of cut-over land in two blocks will be added to the Whitman Forest. The first cutting on these areas was done about 15 years ago and has been continued to the present time. These cut-over areas are in several respects unlike the older cuttings in the Sumpter Valley and elsewhere. The logging operations were almost clear cuttings, so that over most of the ground there are but few standing trees, and these are widely scattered little bull pines and runts which have practically no importance whatever in the way of seeding. The reproduction, where it has not been destroyed by slash fires, is ample, but is practically all advance and occurs more in patches than in even distribution. Five or six years ago slash disposal in compliance with State law was begun, and this has been characterized by exceedingly careless broadcast burning. As a result of this, the ground cut-over in the last six years contains large patches on which practically all the reproduction has been destroyed.

Except for a little meadowland, the Whitney and Austin cuttings contain no agricultural land. Thus these areas will remain forest land and the first effort, after they are acquired by the Government, should be to protect the reproduction on them from farther destruction by fire. The Sumpter Valley Railroad passes through both areas and every summer starts a number of fires which do more or less damage to the reproduction.

There is still considerable privately-owned acreage of virgin timber in these localities which the owners doubtless contemplate exchanging for stumpage after they log it. If it has not already been done, provision should be made that this timber be cut according to the standard timber sale marking methods. Whether this is possible or not, it certainly should be an absolute requirement that slash be burned in piles under Forest Service supervision.

Such larger burned-over areas within these cuttings that are not reseeding should be planted. These areas are close to settled communities and it is therefore more important to have a forest crop started on them than on isolated burns, like the much larger ones west of the Cascades, where planting is now being done.

<u>Age Classes in the Yellow Pine Forest</u>

The yellow pine forest in eastern Oregon has been observed in this study to be characterized by a noticeable disproportion in age classes. Stands appeared to be made up mostly of mature trees and young reproduction with scarcely any intermediate poles and young trees. If this condition actually existed, it was seen that the present plan of cutting over the ground every 60 years would not work out, because after the present reserved trees were cut 60 years hence there would be no merchantable trees until 180 years from now, assuming that it requires 180 years for a tree to grow to merchantable size. Thus 120 years would elapse without a cut.

To determine whether this condition actually existed as it appeared to the eye, two plots 20 acres in size were taken last summer in recent cuttings on the Whitman Forest near Austin. On these two plots the age of every tree above 4 inches in diameter breast height was ascertained and the age and amount of the reproduction below this size was secured by means of 20 sample square rods arbitrarily located. Austin Plot I was located in a private cutting which had been practically clean cut; and Austin Plot II was located about two miles from it in the Eccles timber sale cutting, in a spot where the reserved trees had been very heavily windthrown and later logged, thus permitting the ages of all the trees to be readily obtained. The results given by Austin Plot II are shown in Table 14.

TABLE 14

Showing the Ages of all the Tree Growth
on an Area of 20 Acres.
(Austin Plot II)

Age Class in Years	Total Number of Trees		Number of Yellow Pines Reserved in Cutting
	Yellow Pine (Includes 12 larches)	Lodgepole Pine	
1-20	103,360	35,840	103,360
21-40	2,402	78	2,402
41-60	14	72	14
61-80	44	36	44
81-100	4	33	4
101-120	1	113	1
121-140	18	13	17
141-160	16	11	12
161-180	4		4
181-200	11		9
201-220	23		13
221-240	77		42
241-260	50		21
261-280	9		
281-300	5		1
301-320	4		
321-340	3		1
341-360	12		
361-380	8		
381-400	9		3
401-420	15		2
421-440	21		
441-460	36		2
461-480	15		
481-500	12		
501-520	8		
521-540	6		
541-560	4		
561-580	2		
581-600	1		

In the case of Austin Plot II, the 20-acre area contained 434 yellow pines over four inches in diameter breast height; or 21.7 trees per acre, of which only 5.1 trees were under 180 years old. The 20 acres comprising Austin Plot I contained 614 yellow pines over four inches; or 31 trees per acre, of which only 8 trees were under 180 years old. Thus of all the yellow pines in the stand on Plot II, 76% was over 180 years old, and on Plot I, 73% was over this age. It is plain that on these two plots the gap between reproduction and mature trees actually exists, and these plots are very typical samples of the yellow pine forest in eastern Oregon. Austin Plot I was not worked up as intensively as Plot II and, therefore, there is not table similar to Table 14 for it.

Although there is this serious lack of intermediate age classes in the stand, it does not entirely preclude a cut 120 years from now. It will be possible, by reducing the periodic cut 60 years hence, to carry over sufficient of these old reserved trees to afford a cut at the 120-year period. If the original marking in the virgin stand is done very heavily, however, the amount left will only be enough to justify the first cut 60 years later, and there will then be in fact no cut at the 120-year period. This last will always be true of old, overmature stands in which, as is now the case, the marking is excessively heavy. But after the average virgin stand has been cut over two or three times it should contain a more proper distribution of age classes, which should then furnish a sufficient volume for each periodic cut.

<u>Summary of Results Obtained in 1916</u>

With regard to reserved trees:

1) Accelerated growth in trees after a partial cutting was found to behave exactly the same in the western part of the Blue Mountains as in the eastern part. In this region increased volume growth has now been studied on sixteen scattered cuttings from 10 to 50 years of age, and the amount and duration of stimulated growth as set forth in the reports of this study can safely be said to occur universally in the Blue Mountains.

2) It was found that accelerated area growth in the individual tree is greatest in the lower portion of the trunk and diminishes with increase of height in the trunk. This different distribution of increment after cutting indicates a lower form factor for reserved trees, and will require for these trees a different volume table than the present one for trees in the virgin forest.

3) For the first time for western yellow pine, and probably for any many-aged species in this country, yield tables have been made in this study which make quantitative allowance for increased growth and loss after cutting. Despite the quantitative measurements, however, empiric methods had to be employed, and several far-reaching assumptions were necessary, because only a breast height analysis of growth was made and because the available cuttings suitable for yield study are still under 30 years old while the yield tables cover 60 years. Mainly for these reasons the tables, although they may serve the present need, will not ultimately be satisfactory. In the work in connection with these tables, the firm conviction has been reached that satisfactory yield tables can be made only by the inductive method of permanent sample plots.

4) The windfall results of last summer's study show that, although heavy windthrow may be expected anywhere in the Blue Mountains, amounting to as much as 22% before the remaining trees become of adequate windfirmness; there are localities where it may be light amounting, as in several cases, to less than 2% in 18 to 27 years.

5) In the study of age classes, it was found that on two 20-acre plots 73% and 76% of all the yellow pines above 4 inches d. b. h. were over 180 years old. This shows plainly that there actually is a gap between reproduction and mature trees. It is evident that this lack of poles and young trees must be considered in the cutting and marking plans for market units.

With regard to reproduction:

6) The reproduction on old cuttings in the western part of the Blue Mountains was found to be as uniformly abundant and thrifty as on cuttings everywhere else in this region. And on the whole the greater and more important proportion of it was found to be advance.

7) The study this year particularly brings out the important point that although this reproduction is so abundant, it requires in most cases from 20 to 30 years of gradual seeding and establishment to attain this abundant cover.

8) The density of reproduction in the older open stands of the virgin yellow pine forest is beginning to affect stock grazing and in a few years will present quite a serious problem.

9) If the big privately cut-over areas near Austin and Whitney are acquired by the Government as now seems probable, a policy with regard to the reproduction on these areas should be adopted immediately.

Present Status of Study and Future Work

The study so far has been confined to the Blue Mountains, where field work, which has been carried on for parts of three seasons, has covered the length of the region, including the vicinities of the Ochoco, Malheur, Whitman, and Minam National Forests. The main results of the study have been thoroughly checked throughout this region and further work here is not necessary.

The study should next be carried on in the Klamath region of the Crater National Forest, where about two months should be spent in the field. Three or four sample plots of reserved trees should be taken to check the results with regard to accelerated growth made in eastern Oregon. Wherever suitable conditions can be found the loss of trees after cutting, particularly the windfall loss, should be studied by means of large plots 20 or 40 acres in size. Reproduction on numerous old cuttings should be studied intensively to ascertain its abundance, distribution, whether it is advance or subsequent, and also to learn everything possible regarding the conditions which govern its establishment. In particular, stem analyses of 20 or more selected trees in old cuttings should be made this summer, in order to determine thoroughly the distribution of accelerated increment. The methods to be used in the coming field work should, in the main, be those developed during the last three years and described in detail in the report of April 15, 1916.

Portland, Oregon

May 10, 1917

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