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Pinus ponderosa

THE FUTURE YIELD OF YELLOW PINE STANDS IN OREGON

By T.T. Munger

A silvical study was made by Forest Service field parties in the summer of 1910 and 1911, of western yellow pine in Oregon. Some of the principal objects of the study were to determine –

1. The future yield of stands which are cut over by the selection system.
2. The factors which most materially affect the yield of yellow pine forests.
3. The comparative yield with various lengths of cutting cycle.

The data collected consisted, in addition to extensive volume measurements and silvical data, of the stump analysis of about 5,700 trees and the measurement of a great many sample plots, aggregating 1,019 acres in various typical yellow pine stands of Central and Eastern Oregon. A full discussion of the growth of individual trees of this species is given in Forest Assistant Bright's report entitled "A Study of the Growth of Yellow Pine in Oregon" (April 5, 1912), which has been prepared as a result of this study.

An attempt has been made to deduce from the measurement of the individual trees and of sample acres, tables showing the yield of stands. The tables so prepared form a part of the present report, which also contains a description of how the tables are made, what their limitations are, and the conclusions that may be deduced from them.

It is not easy to determine from a study of this kind the future yield of yellow pine forests, for several reasons:

1. The growth in the thinned stands cut over by the selection system, in which all the reserved trees become dominant, will be materially different from that obtained in the virgin uncut forest, yet the only opportunity to get measurements is in the virgin forests. The heavier the selection cutting is, moreover, the greater will be the increased growth of the reserved trees.
2. A certain number of trees will die out of the stand before the second cutting, and will thereby decrease the volume of the second cut. The proportion of the trees that die is very variable, depending on two factors – the length of the cutting cycle and the severity of the first cutting.
3. The virgin forest from which the stand measurements had to be taken was irregularly stocked, usually deficient in trees of a certain age class and gave but a poor index of what the normal stand should contain and what its distribution of age classes should be.

4. The present forest is mixed to a variable degree with several other species, of which growth studies have not been made.

Method of Preparing the Tables

The yield tables which are given in these pages were compiled by applying local diameter and height growth data to average local stand tables in the following manner:

For each of the several localities or tracts a stand table was prepared showing the average number of trees per acre of each size, both for yellow pine and for other species. This stand table was based on the measurement of a large number of representative acres of timber. In several instances the table shows both the virgin stand before cutting and the actual stand that was left after a selection cutting had been made according to the system of marking used in Forest Service, timber sales in this locality.

It was then assumed that each tract was cut over in 5 different ways, (1) with a rigid diameter limit of 12 inches, (2) of 16 inches, (3) of 20 inches, (4) of 24 inches, and (5) by a flexible diameter limit according to the system of marking used in Forest Service practice.

To the trees of each diameter class, left after the assumed cutting was made, was applied the diameter (or volume) growth table for that particular locality, and in that way it was calculated by the use of a local volume table, interpolated to tenths of inches, what the volume of the standing trees would be in 10, 20, 30, 40, 50, 60 or 70 years hence.

The growth tables that were used assumed that the trees would grow in the future as fast as trees of that size had grown on the average, in the virgin forest. It is assumed that the trees now in the forest will remain alive and grow at the average rate during the entire length of the cutting cycle.

Assuming then that the stand was cut in the same way at the end of the cutting cycle (10, 20, etc. years hence) as it is now, the periodic cut is equivalent to the volume of all the trees at that time above the assumed rigid diameter limit, or in the case of the Forest Service marking, the volume of all the merchantable trees in excess of the volume left in the selection cutting.

The column labeled "Mean Annual Growth" shows the actual mean growth in board feet for various periods of all the trees left in the initial cutting over 12 inches in diameter.

Analysis of Tables

The mean annual growth steadily increases with an increase in the length of the cutting cycle (up to at least 70 years, the limit of this table) partly because the volume growth of individual trees increases steadily with an increase in age, and partly because each decade more and more trees are coming of a size to have merchantable volume (i.e. over 12" D.B.H.).

The tables also show the largest growth where the largest diameter limit is used, so that in the uncut virgin forest (see Winlock and Lapine tracts) growth is apparently at the maximum, i.e., the more trees in the stand on which increment may be found, the greater the tables show the gross growth to be. This is naturally true up to a certain point only, for in nature in the virgin forest all growth is offset by the death of some of the trees. This, of course, takes no account of (1) the loss by death of the older trees, which will be increasingly greater with an increase in the

diameter limit and (2) the increased growth after the cutting is proportionately greater the smaller the diameter limit.

The maximum mean annual growth (i.e. the next growth over and above loss by death) is probably attained with an intermediate diameter limit of somewhere between 20 and 30 inches, but from the data at hand it is impossible to determine what that diameter limit is.

These two factors – increased growth after cutting and death of some of the trees – are, to a degree, compensating. A study of the growth of trees which had been given more room by a heavy selection cutting 23 years ago, shows that in the last two decades this annual volume growth was 105 per cent faster than in the preceding three decades. This is an exceptional increase because the trees were growing very slowly before the cutting, and the cutting was very heavy. The loss by death in the thinned stand will probably not exceed 25% of the gross growth during the cutting cycle except in stands which are cut very lightly in the first place, so that many fairly old trees whose expectation of life is short are left standing. The increased growth will, therefore, undoubtedly more than compensate for the loss by death, particularly in the young stands and those which have been cut over closely.

Therefore, if these two tables could be corrected for these two partly compensating factors, the volumes where the smaller diameter limit is used, or where the short cutting cycles are assumed, would be increased proportionately more than where the larger diameter limits or the long cutting cycles are used.

Since this correction cannot be made with the data at hand, the tables are conservative, and understate rather than overstate the growth that may be expected in yellow pine stands under the selection system of management.

The periodic cut, as shown in these tables, is rather irregular and does not bear a constant relation to the mean annual growth. This is partly due to the fact that the "periodic cut" includes only the trees above the assumed diameter limit, (while the mean annual growth is based on all the trees) and it is partly due to the fact that since the stand table is based on two inch classes, there is an irregular progression in the number of trees that grow to be over the diameter limit.

Most of the stands for which this yield study was made consist, to the extent of at least 85%, of yellow pine, the remainder being mostly western larch, Douglas-fir, white fir and grand fir. Since growth data is not available for these species, in preparing these yield tables it was assumed that their rate of growth was the same as for yellow pine, an assumption which is conservative, since all of them usually grow faster than yellow pine.

The figures for the total stand per acre on these tracts are high and should not be considered as being estimates of the yield over large areas in the locality. They are large partly because in the computation the full scale of each tree is taken, no deduction being made for defect and breakage which would reduce the volume by about 15%, and partly because the sample acres are taken only in well stocked areas where there are no bare ledges, meadows, or other openings such as are scattered through yellow pine forests and reduce the yield for a large tract. In computing the yield tables, no trees are considered to have a merchantable volume until they are at least 12 inches in diameter at breast height.

It is, of course, evident that the future yield is closely dependent upon the number of trees left after the cutting, and is not directly proportional to the rapidity of the diameter and height growth. The Lapine tract shows a very low yield because there are so few trees per acre in this locality

while the growth of individual trees is quite similar to that at Embury, where the predicted yield per acre is considerably larger because the stand is dense.

From the tables of growth of individual trees, it is impossible to judge of the best length of cutting cycle or of the rotation for yellow pine stands. In nearly every instance the mean annual volume increment of individual trees does not culminate within the limit of the table, 500 years in several cases, while the volume increment percent is at its maximum at the very early age of the tree while it is still only 14-16 inches or thereabouts in diameter. The length of rotation will, therefore, be a multiple of the length of the cutting cycle which will produce trees of a good size for commercial use.

The volume increment percent of the stand, worked out from various cutting cycles, is in direct proportion to the mean annual growth, and shows, therefore, the same increase with a lengthening of the cutting cycle that the latter does.

Yield tables have been prepared for nine localities or tracts embracing a wide variety of conditions in various parts of Oregon. On each of these a separate set of diameter growth data was collected in addition to the stand measurements. These tracts do not attempt to show the average growth for the part of the State in which they were taken, i.e. from them alone the growth in the several geographic regions can not be compared, but each is a sample of a certain set of conditions and each is indicative of the growth under these conditions. To properly interpret the yield in these several tracts, a description of the physical conditions on each is necessary.

Description of Each Tract.

1. Crawford Creek, Grant County. This tract is located in Eastern Oregon near Austin, Grant County, at an elevation of about 3500 feet, in T 11 S, R35 ½ E, on the Baker White Pine Lumber Co. sale area. The forests upon which the data are based are fairly fully-stocked, many-aged, most of the trees being between 150 and 300 years old, somewhat open and almost free from underbrush. The topography is rolling but not abrupt, and the soil is loamy, derived from the decomposition of basalt which outcrops abundantly. This tract is typical of thousands of acres at this altitude on the south and west slopes of the Blue Mountains.
2. Austin & Whitney, Grant & Baker Counties, Oregon. This tract embraces the characteristic, fairly pure yellow pine slopes adjacent to Whitney and Austin, Grant County, Oregon. The stand table is the result of the measurement of 258½ acres in these localities. The altitude is about 4500 feet, the climate pretty dry, the soil a loam derived from the country rock – basalt – and the topography rolling but not abrupt. The physical and forest conditions are almost identical with those on the Crawford Creek tract, and it may be considered, therefore, as very representative of a large area of yellow pine forest land in this part of the State.
3. Looking Glass Creek, Union County. This tract is located in northeastern Oregon near Palmer Junction, Union County, on Looking Glass Creek, T 3 N, R 39 E. Though the altitude is only about 2500 feet, the locality is evidently more humid than most parts of Central and Eastern Oregon at this altitude. The yellow pine timber here is tall, thrifty and rather dense; the topography is gently rolling, the soil is loamy, and there is considerable underbrush. The growth in this locality is considerably superior to that of

most of the yellow pine forests in this part of the State, and the tract can be considered representative of only the most favored sites.

4. Winlock's Mill, Wheeler County. This area is at Winlock's Mill in northeastern Wheeler County, Oregon, at an altitude of about 3300 feet. The topography is gently rolling to level with a southern aspect, the soil decomposed basalt. The forest is a practically pure, rather open stand of yellow pine, with little underbrush, and the trees are rather short and are slow-growing. This area is representative of the drier and more unfavorable situations on the western end of the Blue Mountains.
5. Mill Creek, Crook County. This tract lies near Mill Creek, in T 13 S, R 17 E, Crook County, Oregon, at an altitude of about 3500 feet. The topography where this data was taken is fairly level, but with a northerly aspect; the soil is decomposed basalt. The forest is many-aged, but not particularly over-mature, fairly dense, fairly pure yellow pine, and the trees are tall and clean. This tract is representative of the better class of yellow pine forests on the western end of the Blue Mountains.
6. Embody, Lake County. This area is situated in northwestern Lake County, Oregon, near Embody's mill, at an elevation of a little over 5000 feet. It is but a few miles to the lower limit of forest growth on the Fort Rock desert. The situation is, therefore, rather dry and growth rather slow. The soil is a fine pumice, the topography slopes gently to the East. The forest is fairly open, rather old but many-aged, and almost free of underbrush. This tract is typical of a large area of Central Oregon yellow pine forest, where the climatic conditions are severe.
7. Lapine, Crook County. The measurements for these tables were taken near Masten's mill, Lapine, Crook County, Oregon, at an elevation of about 4300 feet. The topography here is almost flat, and the soil an unfertile and dry pumice. The forest is rather open, except for thickets of lodgepole pine, and consists largely of rather old and short boled yellow pines. While this tract is fairly representative of quite a large territory in the Deschutes River basin, the figures for yield here given are probably rather low because the forests of this locality are poorly stocked, especially with the smaller trees, and the growth is slow.
8. Klamath Region. This tract represents the model acre obtained as the average of a large number of stand measurements made in western Klamath County at Reno, Fort Klamath, and Pelican Bay. The physical conditions are much the same as on the Odessa, Klamath Co., tract, altitude about 4300, climate not exceedingly dry, soil loamy decomposed basalt, with a little pumice mixed in. The forest is many-aged, but of rather old large yellow pines, with a smaller number than normal proportion of the younger age classes; there is a considerable admixture of Douglas fir and white fir in groups, and there is a good deal of underbrush. The yield on this tract may be taken as representative of that in the fully stocked yellow pine stands on the eastern slopes of the Cascades in western Klamath County.
9. Odessa, Klamath County. This tract lies on the low rolling hills at an elevation of about 4300 feet, near Odessa, on the west side of Klamath Lake, Oregon, on the area of the Moore Bros. timber sale, T 36 S, R 6 E. The soil is loamy, decomposed basalt, and the site is not exceedingly dry. The forest contains a good deal of Douglas fir and white fir in the moister spots on the hills, but is quite pure on the flats. There is considerable underbrush, and the forest is fully stocked with trees of many ages. This tract is

representative of a large area of yellow pine forests lying on the immediate eastern slope of the Cascades. Two sample areas are worked out for this tract, one an average of a fully stocked extra good forty on the flat, and the other an average of 360 acres on the flat and slope, all of which are upon the area cut over in the Moore Bros. sale.

I. CRAWFORD CREEK, GRANT COUNTY, OREGON

TABLE 1a.

Stand table, showing the average number of trees per acre of each diameter class, of yellow pine and of other species, both in the original forest and after a selection cutting had been made in a timber sale on the National Forest. Average of the measurement of 47½ typical fully stocked acres.

Diameter at breast height	Number of trees per acre			
	Before cutting		After selection cutting	
	Yellow Pine	Other Species	Yellow Pine	Other Species
2	2.93*	2.69*	2.80*	.76*
4	4.80	.99	3.96	.29
6	4.65	.86	4.44	.67
8	4.57	.91	4.67	.36
10	3.37	.86	3.22	.46
12	2.86	.74	2.88	.28
14	2.19	.72	1.89	.30
16	2.63	.69	2.25	.40
18	2.06	.55	1.72	.26
20	2.40	.53	1.37	.04
22	1.96	.55	1.26	.02
24	2.27	.48	.99	.02
26	2.15	.34	.71	—
28	2.11	.34	.34	—
30	1.47	.25	.17	.02
32	.99	.19	.02	
34	.57	.17	.04	
36	.42	.02		
38	.27	.06		
40	.17	—		
42	.08	—		
44	.02	—		
46	.02	.02		
48	—	.02		
Total	44.96	11.98	32.73	3.88
Total over 12" D.B.H.	24.64	5.67	13.64	1.34

* The difference between the number of small trees before and after cutting is due to irregularities in calipering the trees in two-inch classes before and after the logging, and to the destruction of some of the saplings in logging.

1. CRAWFORD CREEK, GRANT COUNTY, OREGON
TABLE 1b

Yield table, showing the yield in board feet which can be obtained from the average acre (see the Stand Table) in various cutting cycles, (1) when the mature timber is cut as shown in the stand table according to Forest Service marking, and (2) when it is cut to an arbitrary diameter limit (12, 16, 20, or 24 inches) now and at each succeeding cutting.

	When cutting is made according to—									
	Forest Service marking		12 inch diameter limit		16 inch diameter limit		20 inch diameter limit		24 inch diameter limit	
Amt. of first cutting ft. B.M.	16398		22426		21549		19943		17103	
Left in first cutting ft. BM.	6028		0		877		2483		5323	
Length of cutting cycle	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth
10 years	436	44	0	0	0	16.5	0	44.7	0	60.6
20 years	1544	77	526	26.3	0	43.4	0	69.8	0	90.3
30 years	2166	72	626	20.9	763	39.9	1190	64.9	0	85.6
40 years	3674	92	1486	37.1	883	57.3	1298	82.3	0	103.0
50 years	5150	103	2409	45.2	1938	69.4	1408	94.4	1980	115.2
60 years	6672	111	2818	46.9	3204	69.2	3085	93.8	2088	115.1
70 years	7860	112	4126	58.9	3635	81.4	3322	105.9	2176	126.9

Note: The stand consists of the following proportions of each species: western yellow pine 86%, western larch 7%, Douglas fir 7%.

II. AUSTIN & WHITNEY, GRANT & BAKER COUNTIES, OREGON
TABLE 2a

Stand table, showing the average number of trees per acre of each diameter class of yellow pine and of other species, in the original forest. Average of the measurements of 258½ acres typically stocked with a many-sized virgin stand.

Diameter at breast height	Number of trees per acre	
	Yellow pine	Other species
2	3.70	4.30
4	2.46	3.44
6	2.22	2.58
8	2.29	1.41
10	1.90	1.04
12	2.01	.94
14	2.23	.86
16	2.21	.59
18	2.54	.69
20	2.65	.53
22	2.50	.53
24	2.45	.41
26	2.26	.32
28	1.99	.22
30	1.41	.20
32	1.15	.14
34	.80	.06
36	.52	.08
38	.37	.07
40	.16	.01
42	.08	.02
44	.04	.01
46	.03	.01
48	.02	.01
Total	38.00	18.47
No. of trees above 12" D.B.H.	25.42	5.70

2. AUSTIN & WHITNEY, GRANT & BAKER COUNTIES, OREGON
TABLE 2b

Yield table, showing the yield in board feet which can be obtained from the average acre (see stand table for this tract) in various cutting cycles where the stand is cut to an arbitrary diameter limit (12, 16, 20, or 24 inches) now and at each successive cutting.

	When cutting is made according to—							
	12 inch diameter limit		16 inch diameter limit		20 inch diameter limit		24 inch diameter limit	
Amt. of first cutting ft. B.M.	21591		20802		19054		15673	
Left after first cutting ft. BM.	0		789		2537		5918	
Length of cutting cycle	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth
10 years	0	—	0	8	0	31	0	44
20 years	297	15	0	32	0	57	0	78
30 years	366	12	796	30	1470	53	0	74
40 years	874	21	916	41	1600	64	0	86
50 years	1544	31	1781	51	1754	75	2466	99
60 years	1937	32	2022	53	3215	77	2507	99
70 years	2754	39	2235	59	3444	84	2647	107

Note: Western yellow pine forms 85.5% by volume of the stand, Douglas fir, 8%, western larch, 5%, grand fir, 1%, and lodgepole pine, .5%.

3. LOOKING-GLASS CREEK, UNION CO., OREGON
TABLE 3a

Stand table, showing the average number of trees per acre, of each diameter class, of yellow pine and of other species in the virgin uncut forest. Average of the measurement of 44 typical fully stocked acres.

Diameter at breast height	Number of trees per acre	
	Yellow Pine	Other species
2	4.000	4.000
4	3.000	3.000
6	3.114	3.545
8	5.023	1.409
10	5.114	1.386
12	5.273	1.091
14	4.523	1.068
16	3.432	.591
18	3.341	.454
20	2.523	.569
22	2.864	.477
24	2.750	.295
26	2.682	.318
28	2.068	.092
30	1.409	.091
32	1.205	.068
34	.682	.091
36	.795	.114
38	.250	.090
40	.364	
42	.136	
44	.136	
46	.091	
48	.045	
Total	54.820	18.749
Total over 12" D.B.H.	34.569	5.409

3. LOOKING GLASS CREEK, UNION COUNTY, OREGON
TABLE 3b

Yield table, showing the yield in board feet which can be obtained from the average acre, as shown in the stand table, in various cutting cycles, when mature timber is cut to an arbitrary diameter limit (12, 16, 20, or 24 inches) now and at each successive cutting.

	When cutting is made according to—							
	12 inch diameter limit		16 inch diameter limit		20 inch diameter limit		24 inch diameter limit	
Amt. of first cutting ft. B.M.	28238		27085		25017		21298	
Left in first cutting ft. B.M.	0		1153		3221		6940	
Length of cutting cycle	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth
10 years	0	0	0	50.0	0	106.3	0	131.7
20 years	613	30.6	1281	83.8	0	134.3	0	161.9
30 years	1403	46.7	1628	105.4	1985	155.5	0	185.6
40 years	2505	62.6	3717	126.7	2127	175.1	2771	205.1
50 years	3851	77.0	6009	141.9	4521	190.6	3066	223.4
60 years	5513	91.9	8631	161.2	7631	206.1	3282	255.3
70 years	7270	104.0	11535	171.7	8238	217.8	6077	252.3

Note: The stand consists of the following proportion of each species: western yellow pine, 90%; western larch, 6.4%; Douglas fir, 3.6%.

IV. WINLOCK'S MILL, WHEELER COUNTY, OREGON
TABLE 4a

Stand table, showing the average number of trees per acre of each diameter class, both in the virgin forest and after an assumed selection cutting marked according to Forest Service methods. Average of the measurements of 20 acres typically stocked with a pure many aged stand of yellow pine.

Diameter at Breast Height	Number of trees per acre	
	<u>Before Cutting</u> Yellow Pine	<u>After Cutting</u> Yellow Pine
4	11.45	11.45
6	11.45	11.45
8	4.50	4.50
10	2.55	2.35
12	2.85	2.55
14	2.80	2.45
16	1.70	1.20
18	1.35	1.10
20	1.40	.90
22	1.50	.75
24	1.65	.45
26	1.25	.35
28	.95	.15
30	.55	
32	.25	
34	.30	
36	.10	
Total	46.60	39.65
Total above 12" D.B.H.	16.65	9.90

4. WINLOCK'S MILL, WHEELER COUNTY, OREGON
TABLE 4b

Yield table, showing the predicted future yield in board feet in 10, 20, 30, etc. years on the average acre (See stand table) when the present stand is cut now and at each successive cutting (1) according to Forest Service marking, and (2) according to various diameter limits, and when the virgin forest is uncut, no allowance being made for defect or breakage.

Length of cutting cycle	Forest Service marking		12 inch diameter limit		16 inch diameter limit		20 inch diameter limit		24 inch diameter limit		Uncut virgin forest	
	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth
Amt. of first cutting ft. B.M.	5223		7110		6871		6338		5172		0	
Left after cutting ft. B.M.	1887		0		239		772		1938		7110	
10 years	479	48	0	0	0	13	0	24	0	37	783	78
20 years	959	48	51	2	0	18	0	29	0	45	1708	85
30 years	1450	48	127	4	434	20	466	31	990	48	2749	91
40 years	2101	52	339	8	1227	25	526	36	1095	53	3907	98
50 years	3189	64	951	19	1072	36	601	48	1215	66	5467	109
60 years	4468	74	1735	29	1298	47	1295	59	2302	78	7261	121
70 years	5917	85	2596	37	1495	55	1453	68	2542	88	9307	133

Note: The stand is pure western yellow pine.

5. MILL CREEK, CROOK COUNTY, OREGON
TABLE 5a.

Stand table, showing the average number of trees per acre of each diameter class, of yellow pine and of other species, both in the original forest and after a selection marking made according to Forest Service methods. Average of the measurement of 20 acres typically stocked with an uneven virgin stand. Other species form 6% of total stand by volume before marking.

Diameter at breast height	Number of trees per average acre			
	Before cutting		After selection cutting	
	Yellow Pine	Other Species	Yellow Pine	Other Species
8	3.40	2.65	3.40	
10	3.10	1.50	3.10	
12	2.90	.45	2.55	
14	3.20	.70	2.65	None
16	3.05	.35	2.70	
18	3.15	.55	2.60	left
20	3.45	.25	2.70	
22	3.50	.35	1.30	after
24	3.70	.20	2.20	
26	2.25		.50	cutting
28	2.00		.10	
30	1.15	.05	.10	
32	1.10	.05		
34	.70	.15		
36	.35			
38	.25			
40	.20	.10		
Totals	37.45	7.35	23.90	
Totals over 12" D.B.H.	30.95	3.20	17.40	

Note. No trees below 8" D.B.H. were counted on this sample plot, so that there will be slightly less volume in the older age class than would be the case had the 2", 4" and 6" trees been taken into consideration.

5. MILL CREEK, CROOK COUNTY, OREGON
TABLE 5b

Yield table, showing the yield in board feet which can be obtained from the average acre (see stand table) in various cutting cycles, (1) when mature timber is cut as shown in the stand table according to Forest Service marking, and (2) when it is cut to an arbitrary diameter limit (12, 16, 20, or 24 inches) now and at each successive cutting.

	When cutting is made according to—									
	Forest Service marking		12 inches diameter limit		16 inches diameter limit		20 inches diameter limit		24 inches diameter limit	
Amt. first cutting ft. B.M.	16972		23041		22891		21366		17180	
Left after first cutting ft. B.M.	6068		0		150		1675		5861	
Length of cutting cycle	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth
10 years	1203	120	0	—	0	29	0	84	0	142
20 years	2335	123	84	8	645	39	0	93	0	154
30 years	3924	131	308	10	943	52	1948	107	3465	166
40 years	5621	141	693	17	1913	61	3762	117	3762	178
50 years	7270	145	1303	26	2470	72	4287	128	4025	188
60 years	9123	152	2031	34	3049	82	4865	138	7675	197
70 years	10920	156	2689	38	3594	88	5477	144	8296	203

Note: The stand consists of western yellow pine 94.6% by volume, Douglas-fir 4.7%, and western larch .7%.

6. EMBODY, LAKE COUNTY, OREGON
TABLE 6a.

Stand table, showing the average number of trees per acre of each diameter class, both in the virgin forest and after a selection marking made according to Forest Service methods. Average of the measurements of 30 acres typically stocked with a nearly pure stand of many-aged virgin yellow pine.

Diameter at breast height	Number of trees per acre.			
	Before cutting		After cutting	
	Yellow Pine	Other Species	Yellow Pine	Other Species
2	14.11	.08	14.11	
4	9.41	.07	9.41	
6	4.71	.05	4.71	
8	4.73	.13	4.73	None
10	4.33	.17	4.33	
12	3.27	.06	2.93	left
14	3.83	.06	2.83	
16	3.67		2.47	after
18	3.30	.06	2.07	
20	2.83		1.66	cutting
22	2.80		1.40	
24	2.23	.03	.97	
26	2.20		.50	
28	1.70		.27	
30	1.47		.10	
32	1.33		.07	
34	1.30		.07	
36	.80			
38	.37			
40	.20			
42	.30			
44	.20			
46	.07			
48				
50	.03			
52	.07			
54				
56	.03			
58				
Totals	69.29	.71	52.63	
Totals over 12" D.B.H.	32.00	.21	15.34	

6. EMBODY, LAKE COUNTY, OREGON
TABLE 6b.

Yield table, showing the yield in board feet which can be obtained from the average acre (see the stand table for this tract) in various cutting cycles, (1) when mature timber is cut as shown in the stand table according to Forest Service marking, and (2) when it is cut to an arbitrary diameter limit (12, 16, 20, or 24 inches) now and at each successive cutting.

	When cutting is made according to—									
	Forest Service marking		12 inches diameter limit		16 inches diameter limit		20 inches diameter limit		24 inches diameter limit	
Amt. of first cutting ft. B.M.	17834		21744		21408		20156		18032	
Left after first cutting ft. B.M.	3910		0		336		1588		3712	
Length of cutting cycle	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth
10 years	653	65	0	0	0	26	0	51	0	72
20 years	1290	67	130	6	594	34	0	60	0	84
30 years	2185	73	376	13	689	37	1089	63	0	86
40 years	3040	76	693	17	1330	42	1204	67	1736	91
50 years	4147	83	1177	24	1579	48	2613	73	1876	97
60 years	5305	88	1871	31	2542	56	2771	81	2030	106
70 years	6818	97	2682	38	2696	63	4256	89	3868	111

Note: The stand consists of 99% western yellow pine by volume, the balance being grand fir, lodgepole pine and sugar pine.

LAPINE, CROOK COUNTY, OREGON
TABLE 7a.

Stand table, showing average number of trees per acre of each diameter class, both in the original forest and after a selection marking according to Forest Service methods. Average of the measurements of 40 acres, lightly stocked with an uneven-aged stand of virgin yellow pine. Some lodgepole pine saplings (8.62 over 12" D.B.H. per acre) were in mixture with the yellow pine, but their volumes were disregarded in computing the yield for this tract.

Diameter at Breast Height	Number of trees per acre	
	<u>Before Cutting</u> Yellow Pine	<u>After Cutting</u> Yellow Pine
2	.75	.75
4	.50	.50
6	.25	.25
8	.32	.32
10	.22	.22
12	.25	.25
14	.35	.32
16	.25	.12
18	.42	.30
20	.65	.52
22	1.00	.67
24	1.10	.72
26	1.15	.67
28	1.22	.72
30	1.40	.75
32	1.32	.45
34	.67	.12
36	.80	.12
38	.60	
42	.42	
46	.15	
50	.12	
Total	13.91	7.77
Total above 12" D.B.H.	11.87	5.73

7. LAPINE, CROOK COUNTY, OREGON
TABLE 7b.

Yield table, showing the yield in board feet which can be obtained from the average acre (see the stand table for this tract) in various cutting cycles, (1) when mature timber is cut as shown in the stand table according to Forest Service marking, and (2) when it is cut to an arbitrary diameter limit (12, 16, 20, or 24 inches) now and at each successive cutting.

	Forest Service marking		12 inch diameter limit		16 inch diameter limit		20 inch diameter limit		24 inch diameter limit		Uncut virgin forest	
Amt. of first cutting ft. B.M.	10575		15243		15222		15243		14468		0	
Left after first cutting ft. B.M.	4668		0		21		129		775		—	
Length of cutting cycle	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth
10 years	463	46	0	—	0	2	0	6	0	20	860	86
20 years	967	48	7	—	51	2	145	7	620	22	1801	90
30 years	1447	48	20	1	118	4	261	9	715	23	2763	92
40 years	1991	50	36	1	146	4	318	9	1255	24	3734	93
50 years	2507	50	70	1	227	5	505	10	1620	25	4594	92
60 years	3075	51	124	2	336	6	680	11	1859	27	5612	94
70 years	3624	52	182	3	452	6	864	11	2225	27	6580	94

Note: The stand is pure yellow pine, except for small lodgepole pine (8.62 trees over 12" D.B.H. per acre) which are not included in the above calculations.

8. KLAMATH REGON, OREGON
TABLE 8a

Stand table, showing average number of trees per acre, of each diameter class, of Yellow pine and of other species in the virgin forest. Average of the measurement of 159 acres.

Diameter at Breast Height	Number of trees per acre	
	Yellow Pine	Other Species
2	6.711	8.516
4	5.528	5.288
6	2.723	5.276
8	2.094	2.464
10	1.937	1.294
12	1.786	1.351
14	1.836	1.062
16	1.994	1.214
18	2.094	.666
20	2.352	1.143
22	1.956	.452
24	2.270	.722
26	1.994	.615
28	2.459	.477
30	1.736	.446
32	1.346	.440
34	1.101	.364
36	.717	.239
38	.591	.157
40	.377	.150
42	.295	.081
44	.182	.075
46	.126	.050
48	.075	.056
50	.069	.075
Total	44.349	32.673
Total over 12" D.B.H.	25.356	9.835

8. KLAMATH REGION, OREGON
TABLE 8b.

Yield table, showing the yield in board feet which can be obtained from the average acre, as shown in the stand table, in various cutting cycles, when mature timber is cut to an arbitrary diameter limit (12, 26, 20, or 24 inches) now and at each successive cutting.

Length of cutting cycle	When cutting is made according to—							
	12 inches diameter limit		16 inches diameter limit		20 inches diameter limit		24 inches diameter limit	
Amt. first cutting ft. B.M.	32612		31976		30494		27708	
Left after 1 st cutting ft. B.M.	0		636		2118		4904	
	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth
10 years	0	0	0	24.9	0	58.1	0	95.6
20 years	749	37.4	692	66.2	1156	102.3	0	140.9
30 years	1680	56.0	1578	87.4	1345	124.7	1793	160.9
40 years	3310	82.7	2687	118.0	2970	153.2	1932	189.6
50 years	5766	115.3	4283	149.6	4606	187.2	2078	226.6
60 years	7798	129.9	6988	166.1	5932	202.5	4883	237.5
70 years	10189	145.5	10877	180.8	8025	218.2	6778	252.3

Note: The stand consists of the following proportion of each species: yellow pine, 75%; white fir, 14.8%; Douglas fir, 9.9%; sugar pine, 1%; incense cedar, 0.8%; lodgepole pine, 0.5%.

9. ODESSA, KLAMATH COUNTY, OREGON
TABLE 9a

Stand table, showing the average number of trees per acre of each diameter class of Yellow pine and of other species, after cutting according to Forest Service marking on the C. S. and R. E. Moore timber sale in Township 36 S., R. 6 E. W.M. Averages of the measurement of two tracts, one of 40 acres, the other of 360 acres.

Diameter at breast height	Number of trees per average acre			
	Average of 40 acres		Average of 360 acres	
	N.W. ¼ N.E. ¼ Sec. 25	Other Species	in Secs. 23, 24 and 25	Other Species
	*Yellow Pine		Yellow Pine	
1	20.00	.85	10.000	.750
2	9.05	—	3.110	1.000
4	8.00	—	2.000	.990
6	3.60	.07	2.000	.800
8	2.00	—	1.000	.650
10	2.00	—	.480	.400
12	2.10	.02	1.780	.890
14	1.07	.02	.930	.520
16	2.65	.02	1.950	.270
18	2.40	.02	1.250	.078
20	.92		.450	.032
22	.57		.350	.022
24	.40		.370	.020
26	.17		.180	.010
28	.22		.150	.012
30	.28		.110	.004
32	.32		.080	.002
34	.04		.020	
36			.004	
38			.010	
40			.005	

* Includes about 1% of sugar pine

9. ODESSA, KLAMATH COUNTY, OREGON
TABLE 9b.

Yield table, showing the yield in board feet which may be obtained in various cutting cycles on the average acre on two sample tracts in T 36 S, R 6 E, (See stand table). Cut over in the C.S. and R.S. Moore timber sale by the selection system.

Left after first cutting ft. BM. Length of cutting cycle	Average of NW ¼ of the NE ¼ of Section 25. 4086*		Average of 380 acres in Secs. 23, 24 and 25. 2747#	
	Periodic cut	Mean Annual Growth	Periodic Cut	Mean Annual Growth
10 years	601	60	563	56
20 years	1728	86	1349	67
30 years	2765	92	2299	76
40 years	4727	118	3329	83
50 years	7186	143	4855	97
60 years	11217	187	7133	119
70 years	13996	200	8855	126

* The stand consists of western yellow pine to the extent of 99.7 percent.

The stand consists of western yellow pine (and sugar pine about 1 percent) 89.4 percent, white fir 3.4 and Douglas fir, incense cedar and lodgepole pine, 7.2 percent.

Conclusion

1. The yield tables each show that the higher the diameter limit the greater the annual growth after cutting. This is due, as explained above, to there being more trees upon which growth could be laid down. This is probably a true principle up to a certain limit, beyond which the loss by death of the large trees and a failure to get rapid growth because the stand is too dense would offset this increase. It cannot be ascertained from the data at hand what this limit is. It is presumably above 24 inches.
2. According to the yield tables, the larger the cutting cycle the greater is the mean annual growth. This is probably the actual case up to about 70 years at least, the limit of these tables, and it indicates a long cutting cycle, if the principal object is to get the greatest mean annual growth. Were it possible to consider every factor that influences growth with increase in density and increased less by death with increased cutting cycles, would partly counter-balance this apparent larger mean growth in the long cutting cycles.

Furthermore, the first heavy cutting in the virgin forest is really, in part, a removal of the surplus growing stock. If this surplus were apportioned through the cutting cycle, as the surplus is distributed theoretically in the Austrian formula, it would mean that the mean annual yield for the shorter cutting cycle would be relatively larger.

3. Judging by a comparison of the stand left after cutting to an arbitrary diameter limit, and according to Forest Service marking, the Forest Service method of marking leaves as a reserve stand an amount equal to what it would be if the stand were cut to the following diameter limits:

<u>Actual timber sale</u>	Volume of stand left equivalent to <u>diameter limit of –</u>
At Crawford Creek	Over 24 inches
<u>Provisional marking</u>	
At Winlock's Mill,	Between 20-24 inches
At Lapine,	Over 24 inches
At Embury,	Over 24 inches
At Mill Creek,	Over 24 inches

4. The present data does not give an indication of the most profitable length of rotation. The mean annual volume growth of the individual tree does not reach its maximum within the limits of the growth tables for individual trees – up to 500 years for some localities – yet it must be assumed that the maximum mean for the stand would be obtained with younger trees than this. The length of rotation must be based upon the most valuable size, commercially, which the average tree would be allowed to reach before being cut, and this size is reached apparently between 180 and 240 years.
5. There is a very striking variation in the yield in different localities. When the climatic and soil conditions are favorable, the mean annual growth per acre may be several times as large as in a similar pure pine forest where the conditions are not favorable for growth.
6. Over a large part of Oregon the mean annual growth with the method of marking now in use, which silvicultural and economic conditions dictate, and with a cutting cycle of 60

years, the period which has been tentatively set, the mean annual growth per acre is between 75 and 150 ft. B.M. On exceptionally good soils the growth may be 200 feet, or a little more per year. On poor soils it may be as low as 50 ft. B. M. per year.

T. T. Munger
April 26, 1912