June 20, 1912[1]

SS
D-6, Tree Studies
Western Yellow Pine

District Forester,
Portland, Ore.

Dear Sir:

Reference is made to your letter of April 27:

While Bright's report is not, as you say, in shape for publication, it contains a great amount of data from which I am sure an excellent monograph on western yellow pine in Oregon can be prepared. The completion of this study was designated in the list of approved projects for your District as the most important to be undertaken during the present year, and I shall be much interested to see the final report. In preparing this, it strikes me that it would be well to discuss more fully than is done in either Bright's or Munger's reports the possibility and the advisability of converting uneven-aged stands of yellow pine into even-aged stands. The intolerance of the tree and the fact that in parts of its range it occurs in large, even-aged groups seem to indicate that the tree is adapted to management in even-aged stands. The intolerance of the tree and the fact that in parts of its range it occurs in large, even-aged groups seem to indicate that the tree is adapted to management in even-aged stands. Doubtless better yields could be obtained from stands of this character. While the change from uneven-aged to even-aged stands in your District may not be practicable at the present time and may involve risks in securing good reproduction on cut-over areas, I feel that this phase of the management of the species deserves serious study.

Very truly yours,

W.B. Greeley

Assistant Forester

"Study of the Growth of Yellow Pine in Oregon," by G.A. Bright. April 5, 1912

[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.

Address Reply to
"District Forester"

UNITED STATES DEPARTMENT OF AGRICULTURE

Enclosure with SS
Tree Studies, D6
Western Yellow Pine,
4-27-'12

FOREST SERVICE
DISTRICT 6

Pinus ponderosa

Beck Building
Portland, Oregon

Forest Supervisor, April 29, 1912

Dear Sir:

During the past two seasons a silvical and growth study* of western yellow pine has been in progress east of the Cascades in Oregon, and the compilation of the data obtained in this study has now been completed. A full report on yellow pine in Oregon, which it is proposed to issue as a Forest Service publication, is now in preparation in this office. The volume tables resulting from this study (either the Klamath, the Austin, the Looking Glass Creek or the Blue Mountain volume tables for western yellow pine) were sent you some time ago.

I think that you may be interested in some of the conclusions in regard to the growth and yield of this species which this study has brought out, which may be briefly stated as follows:

1. Yellow pine in eastern and central Oregon is an extremely slow-growing tree, but its growth is very closely dependent upon climatic and soil conditions. Where the conditions are favorable, average early diameter growth may be twice, and height growth three times, as fast as in apparently the same class of timber where the conditions are severe.
2. The following table shows the ages at which trees reach a diameter at breast height of 12 inches (the usually accepted lower limit of merchantability) and at which they become 30 inches (a good size for the ordinary commercial tree) for several typical localities:

TABLE I

The age at which the average tree in the virgin woods reaches 12 inches and 30 inches in diameter at breast height for several typical localities in Oregon:

Locality	Age at which average tree becomes:	
	12" D.B.H.	30" D.B.H.
Lapine. Crook Co. (unfavorable site on pumice flat of Deschutes basin)	116	290
Ft. Klamath, Klamath Co. (Good site on slope southern Cascades)	76	228
Embody, Lake Co. (dry unfavorable site on central Oregon ridge)	112	402
Austin & Whitney, Grant and Baker Cos. (dry exposure of Blue Mts.)	111	450
Mill Cr. Crook Co. (fair northerly exposure in Blue Mts.)	103	335
Palmer Jc., Union Co. (good situations in coves in Blue Mts.)	86	C. 312

3. An analysis of the growth data shows that in the unfavorable sites growth is slower but it is continued very much longer than on the good sites, the tree evidently attaining a certain size on all sites, even if it takes longer, before active growth is stopped. Hence there is less proportional difference between the diameters on good soils and on poor soils, with old trees than with young trees.
4. On situations bordering the desert, where conditions are unfavorable, height growth is very much less, but not necessarily diameter growth, which in such situations is often as rapid as on good sites.
5. The factor which seems to affect growth particularly is available soil moisture (provided the drainage is good). In the more humid locations, as on the rainy side of the ridges, on north slopes, and in coves, growth is at its best.
6. The maximum mean annual height growth is attained usually at an age of 95 to 120 years, while the maximum mean annual diameter growth is attained a few years later. The maximum current height growth is attained usually at an age of about 55 to 75 years, while the maximum current diameter growth is attained on the average 10 years later.
7. The growth of a tree is proportionally faster the more space it has, up to a certain point, above which there is no increase.

The following summary table shows the total height in feet and the diameter at breast height in inches at various ages, for a number of typical localities in Oregon. These figures do not attempt to show comparatively the rate of growth in the several parts of the State, but each is a sample of the growth under a certain set of conditions, and each is indicative of the growth under these conditions.

TABLE II

Average diameter at breast height and average total height of trees of various ages for several localities in Oregon.

Locality		Total Age of Trees, Years						
		100	150	200	250	300	350	400
Lapine, Crook Creek Co. Soil poor, pumice; climate dry.	Diam.	9.6	17.9	23.2	27.4	30.6	33.2	35.5
	Hgt.	48	81	99	111	117	121	122
Fort Klamath. Soil fair; pumice; climate good.	Diam.	17.1	24.3	28.2	31.2	33.8	36.3	38.5
	Hgt.	69	92	106	114	118	121	124
Odessa, Klamath Co. Soil loam; climate good.	Diam.	13.9	20.0	23.8	26.5	28.8	30.9	33.0
	Hgt.	69	92	106	114	118	121	124
Sisters, Crook Co. Soil sand; climate dry.	Diam.	12.1	17.8	22.2	26.0	28.8	30.9	32.6
	Hgt.	59	79	88	91	92	93	93
Embody, Lake Co. Soil pumice; climate dry.	Diam.	10.5	16.1	20.1	23.1	25.5	27.8	29.9
	Hgt.	59	80	91	97	103	108	113
Metolius Cr., Crook Co. Soil loam; climate good.	Diam.	13.1	19.1	23.6	27.1	30.0	32.2	33.8
	Hgt.	65	95	113	124	129	130	130
Meadow Lake, Klamath Co. Soil & climate fair.	Diam.	13.3	19.3	23.3	26.5	28.8	30.7	32.5
	Hgt.	69	92	106	114	118	121	124
Tamarack Cr., Wasco Co. Soil & climate fair.	Diam.	14.6	20.5	24.0	26.2	28.1	29.7	31.0
	Hgt.	70	95	106	108	109	109	108
Austin & Whitney, Grant & Baker Cos. Soil loam, dry exposure.	Diam.	10.8	15.7	19.4	22.2	24.4	26.5	28.8
	Hgt.	58	86	100	110	115	117	119
Palmer Jc., Union Co. Soil & climate excellent.	Diam.	14.1	19.4	22.7	25.5	29.0	32.7	34.1
	Hgt.	79	104	115	119	121	122	123
Winlock, Wheeler Co., Soil loam, exposure dry.	Diam.	9.9	15.2	19.0	22.7	26.4	30.0	33.0
	Hgt.	-	-	-	-	-	-	-
Mill Cr., Crook Co. Soil loam, exposure north.	Diam.	11.6	17.6	22.0	25.6	28.4	30.6	32.4
	Hgt.	66	88	107	118	124	126	129
Parker's Mill, Morrow Co. Soil loam; climate fair.	Diam.	10.2	15.8	20.2	24.2	27.8	30.8	33.4
	Hgt.	-	-	-	-	-	-	-

Yield The future yield of stands cut over now by the selection system are so dependent upon a number of factors, that cannot be definitely measured, such as increased growth after cutting, mortality of the reserved trees before the next cut, etc., that it is difficult to predict precisely how much future growth will actually be secured on land cut over now in yellow pine timber sales.

From the data at hand it is not possible to predict what diameter limit will give the largest returns in the long run, or what length of cutting cycle is the most desirable.

Like the growth of individual trees, the future yield of stands is extremely variable, depending, of course, upon the rate of growth of the individual trees in that locality and also largely on the density of the stand left after cutting.

Table III, shows the probable amount of the second cut and the mean annual growth per acre for several typical localities after they have been cut over by a selection cutting, conducted according to Forest Service methods of marking, it being assumed that the second cut is made by the same method as the first and after a lapse of 60 years, that is the cutting cycle is 60 years. These figures may be taken as representative of the actual productive capacity of yellow pine land where the stand is at least moderately well stocked, and they are conservative since no account is taken of the increase in the growth after the first cutting. I think you may find them of value in ascertaining the potential yield on similar land in the yellow pine type of your Forest, particularly for determining the value of land for forest purposes in accordance with letter (L, Settlement) of March 18.

TABLE III

Predicted future yield of yellow pine stand cut under
the selection system on a cutting cycle of 60 years, for several sample localities in Oregon.

Locality	Original stand ft. B. M. *	Left standing after cutting ft. B. M. *	Future periodic cut ft. B. M.	Mean Annual growth feet B.M.
Crawford. Cr., Grant Co. Excellent south and west pine slopes on Baker W. P. sale area in Blue Mts.	22,426	6,028	6,672	111
Looking Glass Cr., Union Co. Excellent situations in coves in Blue Mountains.	28,238	3,221#	7,631 #	206#
Winlock, Wheeler Co. Poor quality timber, south slopes in Blue Mts.	7,110	1,887	4,468	74
Mill Creek, Crook Co. Fair northerly slopes, Blue Mountains.	23,041	6,068	9,123	152
Embody, Lake Co. Good stand on exposed central Oregon ridges.	21,744	3,910	5,305	88
Lapine, Crook Co. Unfavorable pumice soil site in Deschutes basin.	15,243	4,668	3,075	51
Klamath region, Klamath Co. Excellent sites on foothills southern Cascades.	32,612	2,118#	5,932#	202#
Odessa, Klamath Co. Good site near Pelican Bay on Moore sale area.	–	2,747	7,133	119

* The figures for the yield are rather high because in using volume table no allowance is made for defects or breakage, and the measurements are made in fully stocked stands.
#Cutting to a rigid 20-inch diameter limit

Full reports, one dealing with the growth and one with the yield of yellow pine in Oregon, have been prepared in which are included detailed tables of diameter, and height growth, and of yield for each of the localities in which data was taken. If you or any of your Forest officers desire to see either of these reports, I shall be glad to send them to you on loan for a few days.

Very truly yours

C.S. Judd

Assistant District Forester

ADDRESS REPLY TO
"DISTRICT FORESTER"

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
DISTRICT 6

BECK BUILDING
PORTLAND, OREGON

SS
Tree Studies
Western Yellow Pine. April 27, 1912

The Forester,

Washington, D. C.

Dear Sir:

I enclose herewith a copy of Mr. Bright's report on the growth of western yellow pine in Oregon. As you know, this report is the result of the two seasons' study of yellow pine in the state, and is based on a very large number of measurements. This report, as you will see, is not intended for publication, but is designed as an office report to include as a basis of reference in tabulated form all the growth data which we have obtained on this subject. I think you will be interested in the side study described on pages 61, et seg., in which it has been attempted to demonstrate that the young trees now are growing at the same rate that the old trees did when they were young. This was necessary in order to prove that the virgin yellow pine forests have been in the past, as their present condition indicates, true selection forests composed of many age classes. Another interesting side study discussed in this report, on pages 88 et seg., is the crown space study, in which it was attempted to show that the rate of growth increases with an increase in the available space that the tree has. The results show this to be the case, but the figures are not regular enough to demonstrate any conclusive laws as to what the interrelation is between the crown space and the rate of growth.

I am also including a discussion by Mr. Munger of the yield of yellow pine stands in Oregon, based upon the growth data included in Mr. Bright's report, and upon a large number of stand measurements. In working up this yield data it was hoped that some conclusions could be reached in regard to the relative merits of various lengths of cutting cycle and of various densities of cutting, but, as you will see, the tables point to no final conclusions, because there are a number of factors, fully discussed in this report, which is impossible to fully take account of. The yield figures have decided value, however, in showing the comparative growth on different classes of land and in defining the range of growth under average conditions.

As you know, as a result of this study, and based to some extent on these two reports, a monograph on western yellow pine in Oregon, designed for publication as a Forest Service circular or bulletin, is now being prepared by Mr. Munger, and I hope will be ready to send to you before many weeks.

Very truly yours,

Chas. H. Flory

Acting District Forester.

Enclosures

A STUDY OF THE GROWTH OF YELLOW PINE IN OREGON

By
G.A. Bright
April 5, 1912

During the summer of 1911 the field study of western yellow pine, begun in eastern Oregon a year ago, was continued, the work being concentrated on parts of Oregon which had not been covered the previous year. It is hoped that sufficient silvical and growth data on this species have now been obtained in Oregon to meet the present requirements in forest management.

The special objects of the season's work were to gather data showing the rate of diameter, height, and volume growth of yellow pine, which, in conjunction with stand data and reconnaissance estimates, will make it possible to determine the yield of pure stands of this tree, and thus be useful in placing the National Forests on an intelligent sustained yield basis.

Organization of Party.

The fieldwork in connection with the study was done by three crews of three men each, each crew consisting of a Forest assistant and two field assistants. These crews were in the field approximately three months each, during which time the stumps of 4,997 yellow pine trees were analyzed. Volume and stand data were also gathered during part of this time, but the discussion of these subjects will not be included in this report, which will be confined strictly to growth.

Region Covered.

The field study was conducted in twenty different localities, on, or in the vicinity of, National Forests east of the crest of the Cascades in Oregon, in representative bodies of yellow pine timber where yellow pine formed at least 80 percent, and more often 100 percent, of the stand.

As the data could only be obtained where logging operations had recently been or still were being put in progress, it was not always possible to find suitable localities within the National Forests where the desired data could be gathered, but in such cases the physical conditions of topography, soil and climate were so similar to those on the nearest adjacent Forest that there could be little material difference in the rate of growth of the trees.

Tracts.

Each area worked in whose physical and forest conditions were homogeneous throughout has been called a "Tract", given an appropriate name, and the data in each tract kept separately and worked up separately, as it was correctly anticipated that each locality would reveal distinct characteristics of growth. Changes in exposure or soil were sufficient ground for differentiating tracts. Thus it sometimes occurs that there is more than one tract in the same general region.

Occurrence of Yellow Pine.

Yellow pine in eastern Oregon occurs on distinct types of soils, as follows:

1. Pumice soil.
2. Gravelly or sandy soil.
3. Soil from decomposed volcanic rock.

All the soils are of volcanic origin and it is their physical rather than their chemical properties which distinguish them from one another. The pumic and gravelly or sandy soils are the results of violent volcanic eruptions. They were expelled from the craters of volcanoes to great heights and some of the lighter particles drifting on the prevailing winds did not fall to the ground for many miles. They constitute the pumice soil of the present day. The heavier particles, on the other hand, naturally fell sooner to the ground, and they form the gravelly or sandy soils close around the bases of old volcanoes. Of course the gravelly, sandy and pumice soils all grade into each other imperceptibly, depending upon the distance away from the mountain that was their source.

In the case of the Blue Mountains, there do not appear to have been any violent volcanic outbursts such as were common at one time in the Cascades. The soil is the result of the slow decomposition of lava which in times past broke through cracks and crevasses in the earth's crust and flowed out over the old sedimentary rock which it buried for often several hundreds of feet.

The regions in which growth data has been obtained have been grouped together according to the above described soil classification.

Five tracts were visited in the region characterized by a pumice soil. They have been named the Lapine Tract first, the Lapine Tract second, the Deschutes River Tract, the Fort Klamath Tract and the Bend Tract. The Lapine first tract and the Deschutes River tract were in T 22 S, R10 E,-W and the Lapine second tract was in T 23 S, R 10 E-W. These three tracts were so very similar that the following description will be applicable to all of them.

The absolute altitude above sea level was between 4200 and 4300 feet. The topography was flat with very few creeks. There is an annual precipitation of about 20 inches which is quickly absorbed by the loose pumice soil, and almost as readily given up again when the summer drought begins. This pumice soil is said in this region to lie for a depth of about 4 feet. It is a very poor retainer of moisture and an indifferent agricultural soil. The timber is very old, overmature and decadent. Successive fires have eaten into the butts of the trees allowing the entrance of beetles and fungous diseases, which in logging operations has necessitated the butting of about 30 percent of the trees over 20 inches in diameter. Density of the stand was below the average, being about .2. Yellow pine is the only merchantable species. Short scrubby lodgepole generally forms an under story which, with being generally un-merchantable itself, will also seriously interfere with the subsequent reproduction of yellow pine, especially after lumbering. There is no underbrush on the ground and only a very scanty ground cover. Reproduction occurs only in patches. Over the area as a whole it is very poor and uncertain. It will never be possible to graze this region more than very lightly as the soil shifts readily under foot as one walks over it. It would be very easy to stamp out all the ground cover and reproduction. Management of the timber and of the grazing resources will have to be very conservative, or the country will become waste land.

The Deschutes River tract is in a better site quality than either the Lapine first or second tracts, being located on a bench 15 feet above the Deschutes River, which bounds on one side of the tract. It receives some sub-irrigation from the river. It is distant from the Lapine first tract about one-half mile, and it is some 30 to 50 feet lower in its relative altitude above the Deschutes River.

The Fort Klamath tract is located about six miles north of Fort Klamath on the main road from Fort Klamath to Crater Lake and just south of the boundary of the Crater National Park, T 6 S, R 32 E – W. The topography is flat or very slightly rolling. There are very few creeks, the drainage being mostly under drainage. The timber was a practically pure, uneven aged stand of yellow pine. The tract was well-stocked, large openings being rare. Douglas fir, white fir, lodgepole and sugar pine form from 20 to 30 percent of the stand. The trees attained very large diameters and heights and although in general mature they were not deteriorating. Snowbrush and to a lesser extent manzanita were found over the entire tract, but nowhere as dense as in the open areas. Reproduction of yellow pine was excellent, the species maintaining its own over the other species. Damage from fire and grazing was not important.

The Bend tract was in T 17 S, R 12 E –W, within half a mile of the town of Bend. The relative altitude above the Deschutes River was 100 to 400 feet. The topography was hilly without being generally very steep. Slope from 0 to 35 percent toward the south. Climate dry and cold. Liable to have heavy frost any night during the summer. Soil very shallow with porous rock

outcropping frequently. A very dry and unfavorable location for tree growth. Timber of the poorest quality with often less than 10 feet clear length, and having very large limbs. Original stand not more than 2 to 3 M per acre. Typical of the forests which border the desert. Trees of medium age with no diseases of any sort. Density .1 or less. Juniper occurs in mixture running up from the desert. Underbrush consists of sagebrush and chemise brush. Good ground cover of grass and weeds in spring but in early summer thoroughly dried up and pulverized by the heat. Reproduction very poor.

Region of Gravelly or Sandy Soils.

The trees of four different tracts were studied in the region classified as having a gravelly or sandy soil, and these tracts will be known as the Sisters first tract, the Sisters second tract, the Odessa Flats tract, and the Embody tract.

The Sisters first tract is located in T 15 S, R 10 E – W, and the Sisters second tract in T 14 S, and on the line between R 9 and 10 E – W just along the boundary line of the Deschutes National Forest. Both tracts are very similar and a single description will serve the purpose of both.

The topography over this region is level with few creeks. The climate is frosty and of little use for agriculture. Hay, livestock and dairy products are the chief resources. There is 18 to 20 inches of rainfall, which is not enough to produce good tree growth on the loose easily dried out soil found here. The timber is younger and sounder than was found growing on the pumice soils, there being few defective stumps. The density was about 3. Yellow pine constituted 100 percent of the stand with no admixture of lodgepole. Reproduction is not prolific but is better than in the former region and could probably be relied upon to restock a scientifically logged area. A little chemise brush is found and the ground is covered with grass and weeds. Only very light grazing will ever be possible, however, because of the looseness of the soil. Little damage has resulted from fires or insects, probably partly because the stand is not as old as the trees described in the first region, and so they have not had time to pass through such a large number of successive fires. Also the trees being younger, scars caused by fire would heal over quickly.

The Odessa Flats tract is located south of Odessa station. The topography is flat or slightly rolling with a very gradual slope toward the mountains. The area studied included two benches with steep approaches. Two shallow canyons exist on the tract. They are wet only in spring. The forest is uneven aged and varies from a pure stand of pine to a mixed stand of pine, Douglas fir and white fir. Some sugar pine and Libocedrus also occurs in small numbers. The area had been cut over prior to 1911 and the reproduction of yellow pine favored as far as possible. There is very little brush on the tract, but there is a good ground cover of grass and weeds. Reproduction of yellow pine is fairly good, but white fir and Douglas fir are on the increase. There has been practically not damage to the stand by recent fire or fungus. Some of the young trees have been attacked by mistletoe.

The Embody tract is located in T 26 S, R 12 E – W. The country rises rapidly from the level of the so-called High Desert, which is about 4000 feet above sea level, to about 6000 feet. In a distance of 10 or 15 miles all the gradations in flora from desert to virgin forest are passed through. The aspect is southerly and the drainage toward the high desert. The climate is very high and frosty and the rainfall is at least 20 inches yearly. The timber is uneven aged but mostly mature, although not decadent, and it is of somewhat less than average height and clear length. Density is about .3. On the tract studied, which comprised the stumps on exactly forty acres, there were 4 to 5 sugar pine, 10 to 12 Douglas fir, 6 to 8 white fir and 10 to 12 lodgepole.

Except for these the stand was pure yellow pine. Reproduction over the entire tract is excellent. Underbrush consists of slick leaf and chemise brush. Ground cover abundant grass and weeds. No recent damage by fire or grazing.

Region of Decomposed Lava Soils

The soils derived from decomposed volcanic rock are typical of the entire Blue Mountain region where the trees on several different tracts were studied, and of parts of the Cascade range. The first seven of the tracts occurred in the Blue Mountains, and were given the following names: the Whitney tract, the Austin tract, the Palmer Junction tract, the Parkers Mill tract, the Winlock tract, the Ochoco Creek tract, and the Mill Creek tract. They represent yellow pine growing under a great variety of conditions over fully one-third of its natural range in the state of Oregon.

A description of the different tracts and their exact locations follows:

The Whitney tract, located in T 10 S, R 36 E – W, is about 1 ½ miles north of the town of Whitney and is typical of yellow pine stands as they are found on the Whitman National Forest. The Austin tract, located in T 11 S, R 34 E – W, and about 2 ½ miles northeast of Austin, is similar to the Whitney tract and will have the same description.

The absolute altitude of these two tracts is between 4500 and 4800 feet, that is, about 500 to 700 feet above the valley of the John Day river. The topography is characterized by low hills whose southern and western slopes are generally longer than the northern or eastern, so that the drainage is toward the south. The climatic conditions are average for the region, great extremes in temperature between day and night and summer and winter, and a slight precipitation most of which falls in winter. The soil, which is derived from decomposed basaltic lava, varies in depth with the steepness and height of the hills. In the bottoms and flats it is at least three feet deep and the trees here grow to a large size. Higher up the soil is shallow and the trees correspondingly short and small. In summer the soil, when it has become thoroughly dried out, is very light and powdery. The timber is of excellent merchantable quality. The stand is uneven aged and uneven sized by groups of trees. There are likely to be at least two or three distinct age classes in every acre. The stand has probably maintained its present volume for several hundred years and would be capable of maintaining itself indefinitely if unmolested without increase or diminution in volume. The small timber is free from defect and the large trees, although often badly fire scarred, are usually sound for their entire merchantable length. The largest trees are often stag-headed, but this does not usually interfere with their merchantable value. The Dendroctonous beetles are present and are becoming more numerous year by year. The density of the crown cover was about .3 over the parts of the Forest where stump analysis was carried on. The stand is 100 percent pure yellow pine. There is no underbrush but there is an abundant ground cover of pine grass and weeds. The reproduction is good, the seedlings generally coming up in groups and forming dense thickets in which root and light competition is very keen and growth consequently slow. The tract has been grazed, but not in excess. Fire has done little harm to the merchantable trees.

The Palmer Junction tract lies in T 3 N, R 40 E –W, about 1 mile north of Palmer Junction and is typical of yellow pine as it occurs on the Wenaha National Forest. The absolute altitude of the tract is about 3200 feet and it lies on a rolling plateau 400 to 500 feet above the Grande Ronde River. The climatic conditions are about average for the region, probably not quite as cold or frosty as the Whitney and Austin regions. The soil derived from decomposition of basaltic lava is generally deep with considerable humus in its composition, and this fact coupled with the gently rolling topography tends to hold the moisture in the surface layers of the soil rather than allow it to sink in or run off, so that more moisture is available for vegetation. This probably accounts for the excellent height growth of the trees in this region. The timber is of excellent merchantable

quality, better than the average for yellow pine and the trees are young compared with those studied at Whitney and Austin. As is typical of yellow pine the stand is uneven aged and uneven sized by groups. The density before logging was .3 to .4. The stand had reached the limit of its productiveness when cut, so that its increase in increment from year to year was about zero. Very little defect, caused either from insects or fungus, was noticed, the trees being universally thrifty. Yellow pine formed at least 95 percent of the stand, larch and Douglas fir composing the remaining percent. Slick leaf, chemise brush and huckleberry brush occurred in frequent patches over the forest floor, the presence of these shrubs being good witness of the depth and fertility of the soil. Reproduction was excellent over the entire region studied. Little or no damage from grazing or fire.

The Parker's Mill tract lies in T 5 S, R 26 E – W, about 1 mile north of the boundary of the Umatilla National Forest. The absolute altitude was 3500 feet and the stumps analyzed extended from the edge of a small creek up the bank to a relative altitude of 50 to 75 feet. The exposure was toward the south on a gently sloping side hill. The annual precipitation is about 20 inches. Most of the summer nights are frosty, and the days warm. Hay is probably the only possible crop. Snow does not entirely leave the region until the middle of April. The soil is 2 or 3 feet deep, which is better than the average. Coupled with the late lying snow the depth of the soil makes the moisture conditions of the soil better than is found under average conditions on the Umatilla National Forest. The timber was mature without being decadent and of the average size and age. Little or no insect or fungus infestation was observed in the vicinity. The density was about the average for yellow pine, or .3. The stand consisted of 100 percent pure yellow pine but directly across the creek on the opposite bank the type changed abruptly to the north slope type in which there was little or no yellow pine, the species being Douglas fir, white fir, and larch. The bed of the creek is a finely drawn line between the two types, neither of which seems able to encroach on the territory occupied by the other. Underbrush was scant or lacking, but the soil was well protected by a ground cover of grass and weeds. Reproduction is excellent. Unintentional selection cuttings have been made over the region for a past period of 15 to 20 years, which has favored reproduction. There has been no damage done by grazing and very little by any fire, at least in recent years.

The Winlock's Mill tract is located in T 7 S, R 24 E – W at Winlock's Mill, about 1 mile south of the boundary of the Umatilla National Forest. The absolute altitude is approximately 3300 feet, and the relative altitude about 500 feet above the John Day. The topography is characterized by long slopes toward the south and very short slopes toward the north, so that the topography falls very rapidly to the level of the John Day valley, and we have virtually a single long south slope from the divide produced by a spur of the Blue Mountains to the John Day River, a distance varying from 10 to 15 miles. A little more than halfway up this long slope is Winlock's Mill, where the tract under discussion was located. The summers are very hot and dry, and without frost during July and August. The rainfall on the divide is at least 20 inches, but decreases proportionately as the altitude decreases and the temperature becomes hotter. The soil is of good depth, at least 2 feet, but because of the long, hot south slope it dries out thoroughly during the summer. The timber is of fair quality, with rather short clear lengths, rarely more than 2 or 3 logs. It is mature but not decadent and of average age and size for mature yellow pine stands. The stand is 100 percent pure yellow pine and .2 to .3 densities. There is no competition with any other species of tree, the climate being too hot and dry. There is no underbrush on the ground, but good cover of pine grass and weeds. The reproduction is excellent. There has been no overgrazing and the damage from fires has been slight, due to the open character of the stand and the little amount of inflammable material on the ground. Little insect or fungus infestation was observed in this vicinity.

The Ochoco Creek tract is located in T 13 S, R 19 E-W, about 2 miles north of Howard on the slopes draining directly into Ochoco Creek. It is within the boundaries of the Ochoco National Forest. The absolute altitude is about 3000 feet and the relative altitude from a few feet above the meadow bordering the creek, to 300 feet above the creek. The topography varies from nearly level to slopes having a grade of 35 to 40 percent. The aspect is southerly. The climate is very dry and hot, yellow pine being found exclusively where trees occur at all on both north and south slopes. The "North Slope" type, as commonly referred to, does not exist. Black sage is found growing among the trees on the south slopes. Desert and forest are contending for the mastery of this region. So far the forest has gained the supremacy, but when the forest has once been removed it will be difficult to reestablish it. On the steeper hillsides conditions are too arid for any tree growth whatsoever. The timber is short boled with large limbs. The clear length is rarely more than one or two logs long, and the timber manufactured from it is of poor quality. A large number of the trees are forked as is usual with open grown trees, and as there appears to be no profit in sawing up the poorer grades there is a very great waste. The density of the stand is about .2. There is no underbrush and the ground cover is scant. Reproduction is good in the more favorable spots. Over two-thirds of the area it is either very scant or lacking altogether. Owing to the lack of inflammable material on the ground fires have not been particularly disastrous. The region has never been overgrazed. No insect infestation was noted in the vicinity.

The Mill Creek tract was located in T 13 S, R 17 E – W, on Mill Creek near Barney's Mill within the boundaries of the Ochoco National Forest. The tract lay on a rolling plateau about 200 feet above Mill Creek. The topography is characterized by steep slopes topped by rolling plateaus. The general direction of the drainage is toward the north, but the slope is not steep and cool enough to produce a north slope type of forest. However, the tract is not representative of a south slope either, as there is an admixture of Douglas fir and larch in the stand to the amount of 8 to 10 percent which does not occur on the typical south slopes in this locality. The yellow pine is growing under ideal conditions to produce the straightest grained and clearest lumber. The soil is of good depth, at least 2 or 3 feet. The precipitation is sufficient to allow luxuriant growth of all the indigenous species of this region on north slopes, but on the dry south slopes yellow pine occurs pure and is of inferior grade to the pine on the tract studied. The age of the timber was the average for stands of mature yellow pine, that is, 230 to 250 years old. The height was above the average for this region. The density was at least .4, which is high for yellow pine. The soil was well protected by a complete ground cover of pine grass and weeds. There was little underbrush of any sort. Reproduction is abundant over the entire tract. Fires have burned lightly, due to moist soil, and there have been no recent ones. The tract has not been overgrazed.

Six different tracts were studied on the east slopes of the Cascades which possessed the same characteristics of soil as the Blue Mountain region. They were as follows: (1) Matolius Creek tract; (2) Odessa Slopes tract; (3) Meadow Lake tract; (4) Crystal Creek tract; (5) Keno tract; (6) Tamarack Creek tract.

The Matolius Creek tract is located in T 13 S, R 9 E – W. The country is generally level or rolling except when broken by Black Butte at the base of which the tract is located. This region is well watered, largely due to the proximity of Black Butte which rises at least 1000 feet about the general level. The country is extraordinary for the number and size of its springs. Matolius Creek rises from a spring, and 100 yards after it comes from the ground flows a stream one foot deep and 75 feet wide. The climate is frosty with heavy snows in winter. The timber is uneven aged and mostly mature, and in excellent merchantable condition, being very tall with long clear length and straight grain. It is typical of the timber around the base of Black Butte. Considerable underbrush covers the ground as snow brush, slick leaf and huckleberry. The ground cover is

very luxuriant, consisting of pine grass and weeds. Larch and fir are in mixture with pine to the extent of 5 percent of the merchantable stand. Slightly up on the side of the Butte incense cedar appears, showing that the country must have good moisture conditions. The reproduction of yellow pine is very good wherever there is an opening in the forest. No material damage from fire or insects in the region.

The Meadow Lake tract is located in Section 11, T 37 S, R 9 E – E, where the altitude is between 4500 and 5000 feet. The topography is characterized by rounded hills 125 to 175 feet above the valleys and by ravines with 15 to 30 percent slopes. The water level, measured in a well at the bottom of a valley, was 16 feet below the surface on August 24. The country is very dry during the summer. Limestone underlies the volcanic rock and outcrops and boulders of this rock are common on the hillsides. The site is quality I, and the timber is 90 percent yellow pine, except in valley or canyons facing due north, where white fir and Douglas fir enter into the mixture abundantly. Incense cedar is scattered throughout the entire stand. The underbrush consists of slick leaf, manzanita, mountain mahogany, squaw carpet, and cherry, and there is a good ground cover of grass and weeds. Considerable humus and litter covers the ground. The reproduction of yellow pine is poor. Of Libocedrus it is excellent. Present indications are that the next stand will be composed chiefly of Libocedrus. The health of the trees is good.

The Crystal Creek tract is located at the mouth of Crystal Creek in T 35 S, R 6 E – W. The data was gathered over the Mason sale area, and the description is essentially the same as for the Odessa Slopes tract, except that there is a larger percentage of white fir in mixture. There is also a thicker covering of underbrush on the ground, indicating a very deep and fertile soil.

The Keno tract is located in T 7 S, R 39 E – W, and is essentially the same as the Meadow Lake tract so that a separate description is superfluous.

The Tamarack Creek tract is located in T 1 S, R 12 E – W, averaging from 50 to 300 feet above Tamarack Creek within the boundaries of the Oregon National Forest. The timber is typical of yellow pine growing on the east slopes of the Cascades. The topography is hilly with the general drainage easterly. The slopes vary from 10 to 35 percent in steepness. Most of the trees were taken on the south bank of Tamarack Creek and the remaining few on the north bank. The timber growing on the north bank showed somewhat better height and diameter growth than on the south bank. The stand on the south bank was at least 95 percent yellow pine, and on the north bank at least 80 percent. No scrub oak occurred on the tract, although a mile farther down the creek and less than 200 feet lower in altitude it appeared in the stand and increased in proportion as the pine decreased until the semi-arid hills surrounding Dufur were reached where tree growth of any sort was impossible. Soil and climatic conditions on the tract were very favorable to tree growth. Density on south slope was .3, and on the north slope .5. .5 density is about the maximum for yellow pine, especially when the trees are tall and mature. Little underbrush occurred on the south slope, but on the north slope there was considerable huckleberry, snow bush, manzanita, et. Reproduction was very profuse everywhere. Grazing and fires and insects have done little damage in this vicinity.

Diameter Growth.

The most important part of the season's work consisted in making a complete stump analysis of individual trees in order to determine the diameter growth. The data was recorded on Form 334 sheets according to Forest Service usage. The blacks to be filled for diameter growth are the age column on the front of the sheet, which gives the total age at the stump, and the distance on the average radius from the heart or pith to each tenth ring (counting in), on the back of the sheet. The heart or pith is frequently not in the center, and the average radius is obtained by determining the average diameter inside the bark by averaging the long and short diameters measured at right angles, and taking one-half of this. With the rule this average radius (from

heart to inside of bark) is next found by trial and a pencil line drawn along it. Then, beginning on the outside, the rings are counted in a mark made to indicate each tenth ring. Usually the last period at the heart will contain less than ten rings. The rule is then laid alongside this radius and the distance from the pith to the first mark is entered under Column I on the back of the sheet, putting in the corner of the space the odd years, thus: 7/.8. The distance from the heart to the second mark is then placed under Column 2, and so on. The last measurement will be the entire radius and must be exactly half the diameter inside bark given on the front of the sheet for that section.

Stumps cut over a year ago were discarded, as they were liable to contain checks which would render data obtained from them inaccurate. As far as possible only the stumps of normal trees were used, the suppressed and badly formed trees being omitted. The crowns and trunks had generally been removed or destroyed so that it was in most cases necessary to guess at the tree class belonging to a particular stump by the size, position, proximity and number of the surrounding stumps.

Since it is desired to know the rate of growth of trees chiefly up to 300-350 years, it was not deemed necessary to analyze many stumps over this age. The tables have generally been extended one or two hundred years beyond this point as a matter of interest, but being based on fewer trees will not be quite so accurate.

The diameter inside bark on stump was converted to diameter outside bark at breast height by a table showing the relation of these two measurements.

In order to get the total age of each tree, the average age of seedlings for heights from one to four feet were determined and the number of years required to grow to stump height added to the number of rings counted on each stump. The number of years to be added of course depended upon the height at which the stump was cut.

Comparison of Diameter Growth for the Various Tracts

For purposes of ready comparison between the rate of diameter growth for trees on the various tracts and localities, table No. 1 had been compiled, in which only the diameters for every fifty years after 100 years and up to 400 years are recorded. Eighteen different tracts are represented in the table, the Crystal Creek and Bend tracts being omitted as not typical of conditions under which yellow pine usually occurs. Using the largest diameter of each of the 50-year periods found in any of the tracts as a unit, the diameters of each of the other seventeen tracts of the same 50-year period were compared with it and the comparison indicated by a number in the upper right hand corner of the space occupied by the particular diameter. Thus the number 1 indicates the largest diameter, and the number 18 the smallest diameter found in any of the eighteen tracts for the same 50-year period. The vertical columns of diameters were added and averaged to obtain the average diameter of yellow pine for each of the 50-year periods.

In the same manner a table has been made showing the relative growth in total height of yellow pine on the same tracts, for it is realized that diameter growth alone is not an absolute index of growth.

These two tables follow:

TABLE NO. 1.

Comparison of Diameter Growth of Yellow Pine for Eighteen Tracts

Name of Region	AGE						
	100	150	00	250	300	350	400
Lapine (1)	18 9.6	12 17.9	9 23.2	4 27.4	4 30.6	4 33.2	4 35.5
Lapine (2)	16 10.1	11 18.0	3 24.8	3 29.4	2 33.1	1 36.4	1 39.2
Deschutes River	12 11.5	3 20.2	2 26.0	2 29.9	3 32.8	3 35.1	3 36.7
Fort Klamath	1 17.1	1 24.3	1 28.2	1 31.2	1 33.8	2 36.3	2 38.5
Sisters (1)	8 12.8	9 18.6	10 22.7	11 25.8	8 28.8	7 31.3	6 33.6
Sisters (2)	10 12.1	13 17.8	12 22.2	10 26.0	8 28.8	8 30.9	10 32.6
Odessa	5 13.9	4 20.0	5 23.8	6 26.5	8 28.8	8 30.9	9 33.0
Embody	14 10.5	15 16.1	15 20.1	16 23.1	17 25.5	17 27.8	17 29.9
Austin & Whitney	13 10.8	17 15.7	17 19.4	18 22.2	18 24.4	18 26.5	18 28.4
Palmer Junction	3 14.1	6 19.4	10 22.7	13 25.5	6 29.0	5 32.7	5 34.1
Parker's Mill	15 10.2	16 15.8	16 20.2	15 24.2	14 27.8	10 30.8	8 33.4
Winlock	17 9.9	18 15.2	18 19.0	17 22.7	16 26.4	14 30.0	9 33.0
Ochoco Creek	9 12.3	10 18.2	13 22.1	14 25.2	14 27.8	15 29.7	16 30.7
Mill Creek	11 11.6	14 17.6	14 22.0	12 25.6	11 28.4	12 30.6	13 32.4
Meadow Lake	7 13.3	7 19.3	8 23.3	6 26.5	8 28.8	11 30.7	12 32.5
Keno	4 14.0	4 20.0	7 23.5	9 26.1	12 28.3	13 30.1	14 31.7
Tamarack Creek	2 14.6	2 20.5	4 24.0	8 26.2	13 28.1	15 29.7	15 31.0
Matolius Creek	6 13.1	8 19.1	6 23.6	5 27.1	5 30.0	6 32.2	6 33.8
Average	**12.3**	**18.5**	**22.8**	**26.1**	**29.0**	**31.3**	**33.5**

Note – Bend and Mason tracts omitted from this table as being not typical.

TABLE No. 2

Comparison of Height Growth of Yellow for Eighteen Tracts

	AGE							
	50	100	150	200	250	300	350	400
Lapine (1)	17 14	17 48	13 81	13 99	9 111	9 117	5 121	9 122
Lapine (2)	17 14	17 48	13 81	13 99	9 111	9 117	5 121	9 122
Deschutes River	8 24	9 64	8 90	9 105	4 116	3 122	3 125	3 126
Fort Klamath or U and B	2 29	3 69	4 92	4 106	5 114	4 118	5 121	4 124
Sisters (1)	9 22	10 59	16 79	17 88	17 91	17 92	17 93	17 93
Sisters (2)	9 22	10 59	16 79	17 88	17 91	17 92	17 93	17 93
Odessa	2 29	3 69	4 92	4 106	5 114	4 118	5 121	4 124
Embody	9 22	10 59	15 80	16 91	16 97	16 103	15 108	14 113
Whitney and Austin	9 22	13 58	10 86	10 100	11 110	11 115	11 117	11 119
Palmer Junction	1 38	1 79	1 104	1 115	2 119	4 121	4 122	8 123
Parker’s	9 22	13 58	10 86	10 100	11 110	11 115	11 117	11 119
Winlock’s	9 22	13 58	10 86	10 100	11 110	11 115	11 117	11 119
Ochoco Creek	16 19	16 54	16 79	15 93	15 101	15 104	16 106	16 107
Mill Creek	2 29	7 66	9 88	3 107	3 118	2 124	2 126	2 129
Matolius Creek	7 25	7 65	2 95	2 113	1 124	1 129	1 130	1 130
Meadow Lake	2 29	3 69	4 92	4 106	5 114	4 118	5 121	4 124
Keno	2 29	3 69	4 92	4 106	5 114	4 118	5 121	4 124
Tamarack	9 23	2 70	2 95	4 106	14 108	14 109	14 109	15 109
Average	24	62	88	102	110	114	116	118

Note: - Bend and Mason tracts omitted as being not typical.

The Lapine First, Lapine Second, and Deshutes River Diameter Growth Tables

The tracts where data for these three tables was obtained are located but short distances form each other, yet all three differ conspicuously in the rate of their diameter growth. As might be expected, the table obtained for the Deschutes River tract shows the fastest diameter growth. Located on a level bench bordering on, and about 15 feet above, the Deschutes River, it undoubtedly obtains some sub-irrigation. The table obtained from the Morson's Mill tract shows the next fastest rate of diameter growth. Judging from the character and condition of the ground cover, the soil was slightly moister here for some reason than on the Masten's Mill tract where the diameter growth is the slowest of any of the three tracts.

In spite of the difference in rate of diameter growth found in the region in general there is at least one striking resemblance between all of them. By referencing to Table No. 1 it will be seen by the small figures in the upper right hand corners that the diameters of the trees on these tracts compared with those of the other tracts for the first few 50-year periods are small but that, as the trees grow older, the diameters become larger faster in proportion to the age of the trees than is the general case. In other words, trees growing on these tracts grow slowly at first but maintain their growth to a much greater age than trees which grow fast in youth and mature early. The probable cause of the slow growth of trees of this region during their youth is the peculiarity of the soil. This consists, as already described, of a loose volcanic dust of a depth of about eight feet, through which every drop of moisture that reaches it immediately sinks. Beneath this volcanic dust, however, is a firmer soil which in a degree checks the moisture from penetrating farther below the surface, so that once trees have had a chance to tap this water supply they are able to make good growth, but until this time they must struggle along as best they can in the scant water supplied to them by the powdery soil above. This causes their growth in early years to be slow and reproduction very precarious. The height growth is very slow due to the openness of the stand and the dryness of the soil. Because of the openness of the stand the diameter growth is larger in proportion to the height growth than is normal.

The diameter and height growth tables follow:

Diameter Growth of Yellow Pine near Lapine, Oregon 1911
According to Quality of Site

Age	Table 3 Third Quality site Based on 361 trees Diameter	Table 4 Second Quality Site Based on 72 trees Diameter	Table 5 First Quality site Based on 91 trees Diameter
10	0	0	0
20	0	0	0
30	.4	.5	.4
40	1.6	1.7	1.8
50	2.8	3.0	3.4
60	4.0	4.3	4.8
70	5.4	5.6	6.4
80	6.7	7.0	8.0
90	8.1	8.6	9.7
100	9.6	10.1	11.5
110	11.0	11.6	13.4
120	12.5	13.2	15.2
130	14.0	14.7	17.0
140	15.4	16.3	18.7
150	16.9	18.0	20.2
160	18.3	19.7	21.6
170	19.6	21.2	22.9
180	20.9	22.6	24.0
190	22.1	23.8	25.0
200	23.2	24.8	26.0
210	24.2	25.8	26.9
220	25.1	26.8	27.7
230	26.0	27.7	28.5
240	26.7	28.6	29.2
250	27.4	29.4	29.9
260	28.1	30.2	30.6
270	28.8	30.9	31.2
280	29.4	31.6	31.8
290	30.0	32.4	32.3
300	30.6	33.1	32.8
310	31.2	33.8	33.3
320	31.7	34.4	33.8
330	32.2	35.1	34.2
340	32.7	35.7	34.2
350	33.2	36.4	35.1
360	33.7	37.0	35.4
370	34.2	37.5	35.8
380	34.7	38.1	36.1
390	35.1	38.6	36.4
400	35.5	39.2	36.7
410	35.9	39.7	36.9
420	36.3	40.2	37.2
430	36.6	40.7	37.4
440	37.0	41.2	37.7
450	37.3	41.7	38.0
500	39.0	43.7	--

Height Growth of Yellow Pine near Lapine, Oregon, 1911
According to Quality of Site.

Age	Table 6 Poor Quality Site Based on 131 trees	Table 7 Good Quality Site Based on 57 trees
	Total Height (feet)	Total Height (feet)
10	1	1
20	3	4
30	6	9
40	9	16
50	14	24
60	19	33
70	25	42
80	32	50
90	40	57
100	48	64
110	56	70
120	63	76
130	70	81
140	76	86
150	81	90
160	85	94
170	89	97
180	93	100
190	96	103
200	99	105
210	102	108
220	105	110
230	107	112
240	109	114
250	111	116
260	113	118
270	114	119
280	115	120
290	116	121
300	117	122
310	118	123
320	119	124
330	120	125
340	120	125
350	121	125
360	121	125
370	121	125
380	122	125
390	122	126
400	122	126
410	123	126
420	123	126
430	123	126
440	123	126
450	123	126

Fort Klamath Growth Tables

Although the soil of this tract is of the same origin as that on the former three tracts just described, the diameter growth of trees growing here is more rapid than on any one of the other seventeen tracts. The cause is the greater precipitation. An abundant supply of water is more important for trees than any other one factor, and although yellow pine can survive on very dry soils, the rate of growth always bear a distinct relation to the water supply. Yellow pine growing west of the mountains in soils such as are usually occupied by Douglas fir makes very nearly as good diameter growth as Douglas fir. Where sufficient moisture occurs good tree growth is the general rule on volcanic soils of eastern Oregon because the soils are usually of good depth and the chemical elements are in a readily assimilable form for plant life. The height growth for Keno, Odessa, Fort Klamath and Meadow Lake were so similar that only one height growth table has been made for all four regions. It shows a growth slightly above the average.

The diameter and height growth tables follow:

	TABLE 8	TABLE 9
	Diameter Growth of Yellow Pine near Fort Klamath, Oregon 1910 Based on 110 trees	Height Growth of Yellow Pine near Fort Klamath, Keno, Odessa, & Meadow Lake, Oregon, 1910 Based on 460 trees
Age	Diameter	Height (feet)
10	0	1
20	0	4
30	1.5	11
40	3.6	19
50	5.9	29
60	8.2	38
70	10.5	46
80	12.9	54
90	15.1	62
100	17.1	69
110	19.0	75
120	20.7	80
130	22.1	84
140	23.3	88
150	24.3	92
160	25.2	96
170	26.0	99
180	26.8	102
190	27.5	104
200	28.2	106
210	28.9	108
220	29.5	110
230	30.1	112
240	30.7	113
250	31.2	114
260	31.7	115
270	32.3	116
280	32.8	117
290	33.3	118
300	33.8	118
310	34.3	119
320	34.8	120
330	35.3	120
340	35.8	121
350	36.3	121
360	36.7	122
370	37.2	122
380	37.6	123
390	38.1	123
400	38.5	124
410	-	124
420	-	124
430	-	124
440	-	125
450	-	125

The Bend Growth Tables

In spite of the fact that the trees of this tract were growing under such unfavorable circumstances, they made surprisingly good growth. The diameter growth is considerably faster than the average, partly due to the fact that the trees are very open grown and so would naturally have a diameter larger in proportion to the height than is typical of normal trees. The height growth is considerably below the average, on the other hand, but is not the poorest. Apparently the trees, although hampered by lack of moisture, are somewhat compensated by an abundance of light on all sides. It is encouraging to find that yellow pine will make fair growth on the low, hot foot hills between the plains and the mountains which are now generally considered useless except for the little grass which they afford for grazing.

Tables 10 and 11 show the diameter and height growth, respectively, for this tract.

	TABLE 10	TABLE 11
	Diameter Growth of Yellow Pine near Bend, Oregon, 1910 Based on 183 trees	Height Growth of Yellow Pine near Bend, Oregon, 1910 Based on 66 trees
Age	Diameter	Height (feet)
10	0	1
20	0	4
30	.6	8
40	2.5	14
50	4.7	21
60	6.9	28
70	9.3	35
80	11.5	41
90	13.6	48
100	15.4	54
110	16.8	61
120	17.9	67
130	18.9	73
140	19.8	78
150	20.7	82
160	21.5	84
170	22.3	86
180	23.0	88
190	23.7	89
200	24.4	90
210	25.0	90
220	25.6	91
230	26.2	91
240	26.7	91
250	27.3	91
260	27.9	91
270	28.4	91
280	28.9	92
290	29.4	92
300	29.9	92
310	30.4	-
320	30.9	-

The Sisters First and Sisters Second Growth Tables

These tables show the same general characteristics of growth as one might expect from the similarity of the regions where the data for the tables was gathered. The diameter growth shows a tendency to be sustained throughout the entire age of the trees as is typical of trees growing on infertile soils. Each species of tree appears to have a size when mature which is typical of the particular species in question, and each species differs from all other species in this regard. If the trees, we will say for example, of yellow pine are growing on good soil they will reach the average size of mature trees of the species in about 250 years, but on poorer soils it may require 400 to 500 years to reach the same size. Of course, trees growing on very poor soils may never quite reach the average mature size of trees of their species, but the tendency will be to approach it as near as possible, and trees growing on exceptionally favorable sites will in general not exceed the average for their species by a very great deal. This phenomenan is particularly applicable to yellow pine which grows under a greater variety of climatic conditions than any other commercially important tree in North America, and should therefore be expected to exhibit great variations in form. The variations are, however, not as great as might be expected.

The probable cause of the slow growth of yellow pine on the two Sisters tracts is the great depth of the volcanic gravel and sand which was blown from craters in the Three Sisters less than 20 miles away. The roots of the trees are unable to penetrate through this layer to the firmer soil below, so that we do not see the same stimulation of growth here after the trees have passed the pole stage as in the Lapine (1) and Lapine (2) and Deschutes River tracts. The trees here live their entire lives exclusively on the loose gravelly volcanic soils so that their growth is uniformly slow throughout life and below the average. The growth tables for these regions follow.

	TABLE 12	TABLE 13	TABLE 14
	Diameter Growth of Yellow pine near Sisters, Oregon 1911 Based on 267 trees	Diameter Growth of Yellow Pine near Sisters, Oregon 1911 Based on 53 trees	Height Growth of Yellow Pine near Sisters, Oregon 1911 Based on 128 trees
Age	Diameter	Diameter	Height (feet)
10	0	0	1
20	0	0	3
30	.7	.7	7
40	2.2	2.3	14
50	3.9	3.9	22
60	5.7	5.6	31
70	7.5	7.3	39
80	9.4	9.0	46
90	11.2	10.6	53
100	12.8	12.1	59
110	14.3	13.5	64
120	15.6	14.8	69
130	16.7	15.9	73
140	17.7	16.9	76
150	18.6	17.8	79
160	19.5	18.8	82
170	20.3	19.7	84
180	21.2	20.5	86
190	22.0	21.3	87
200	22.7	22.2	88
210	23.3	23.0	89
220	24.0	23.8	89
230	24.6	24.6	90
240	25.2	25.3	90
250	25.8	26.0	91
260	26.5	26.7	91
270	27.1	27.2	91
280	27.7	27.8	91
290	28.2	28.3	92
300	28.8	28.8	92
310	29.3	29.3	-
320	29.8	29.8	-
330	30.3	30.2	-
340	30.8	30.6	-
350	31.3	30.9	-
360	31.8	31.3	-
370	32.3	31.6	-
380	32.7	32.0	-
390	33.2	32.3	-
400	33.6	32.6	-
410	34.1	32.9	-
420	34.5	33.2	-

	TABLE 12	TABLE 13	TABLE 14
	Diameter Growth of Yellow pine near Sisters, Oregon 1911 Based on 267 trees	Diameter Growth of Yellow Pine near Sisters, Oregon 1911 Based on 53 trees	Height Growth of Yellow Pine near Sisters, Oregon 1911 Based on 128 trees
Age	Diameter	Diameter	Height (feet)
430	34.9	33.5	-
440	35.3	33.7	-
450	35.7	34.0	-
			-
500	38.0	35.2	-

The Odessa Growth Tables

Only one diameter growth table was obtained for the two tracts studied south of Odessa Station. The increased precipitation in this region accounts for the more rapid diameter growth during the early life of the trees. The stand is mixed with other species and the trees are above the average height so that the diameter growth alone is not a true index of the growth of the trees as a whole. The trees have slighted their diameter growth somewhat to the advantage of their height growth.

The diameter and height growth tables follow:

Age	TABLE 15 Diameter Growth of Yellow pine near Odessa, Oregon, 1910 Based on 156 trees Diameter	TABLE 16 Height Growth Of Yellow Pine near Odessa, Oregon, 1910 Based on 460 trees Height (feet)
10	0	1
20	0	4
30	1.1	11
40	2.7	19
50	4.5	29
60	6.4	38
70	8.4	46
80	10.3	54
90	12.2	62
100	13.9	69
110	15.4	75
120	16.7	80
130	17.9	84
140	19.0	88
150	20.0	92
160	20.9	96
170	21.7	99
180	22.5	102
190	23.2	104
200	23.8	106
210	24.4	108
220	24.9	110
230	25.4	112
240	26.0	113
250	26.5	114
260	27.0	115
270	27.5	116
280	27.9	117
290	28.4	118
300	28.8	118
310	29.2	119
320	29.7	120
330	30.1	120
340	30.5	121
350	30.9	121
360	31.4	122
370	31.8	122
380	32.2	123
390	32.6	123
400	33.0	124
410	-	124
420	-	124
430	-	124
440	-	125
450	-	125

The Embody Growth Tables

These tables show a uniformly slow growth throughout, due primarily to the cold and frosty climate with its consequently short growing season. Trees grow very slowly here, but very persistently, living to great age for yellow pine and good size. In the future it will probably be impossible to wait a longer time than to allow the trees to reach more than half their possible diameter, or about 20 inches, which according to this table will require 200 years. In order to grow 10 inches in diameter beyond this point 200 years more would be required.

The growth tables for this tract follow:

	TABLE 17	TABLE 18
	Diameter Growth of Yellow Pine near Embody, Oregon 1911 Based on 400 trees	Height Growth of Yellow Pine near Embody, Oregon 1911 Based on 22 trees
Age	Diameter	Height (feet)
10	0	1
20	0	3
30	.7	7
40	2.1	14
50	3.5	22
60	4.9	31
70	6.3	39
80	7.7	46
90	9.1	53
100	10.5	59
110	11.8	65
120	13.0	70
130	14.1	74
140	15.1	77
150	16.1	80
160	17.0	83
170	17.9	85
180	18.7	87
190	19.4	89
200	20.1	91
210	20.8	93
220	21.4	94
230	22.0	95
240	22.5	96
250	23.1	97
260	23.6	.99
270	24.1	100
280	24.6	101
290	25.1	102
300	25.5	103
310	25.9	104
320	26.3	105
330	26.8	106
340	27.3	107
350	27.8	108
360	28.3	109
370	28.7	110
380	29.2	111
390	29.6	112
400	29.9	113
410	30.3	113
420	30.7	114
430	31.1	115
440	31.5	115
450	31.8	116
500	33.5	119

The Whitney and Austin Growth Tables

The Whitney and Austin growth tables show the slowest diameter growth of any of the regions, due to the cold, dry climate with short growing season. Although of slow diameter growth the trees, if unmolested, grow to very large size, some of the largest yellow pine during the two summer's work having been found here, but a long period of time is required to reach even moderate size. The height growth will be seen to be about average for yellow pine by referring to Table 2. Although the dry, cold climate is in many ways unfavorable to tree growth, it is possible that it may be equally unfavorable for fungus growth, and this may account for the slow advance which tree diseases make in the timber of this region. Rarely do trees which have been even badly fire scarred show the attacks of fungus, so that one of the chief causes of death of old trees, in particular, is to a large extent lacking and so the trees live here to very old ages.

The growth tables follow:

	TABLE 19	TABLE 20
	Diameter Growth of Yellow Pine near Whitney and Austin, Oregon 1910 Based on 672 trees	Height Growth of Yellow Pine near Whitney and Austin, Oregon 1910 Based on 437 trees
Age	Diameter	Height (feet)
10	0	2
20	.6	5
30	1.6	10
40	2.7	16
50	4.0	22
60	5.3	28
70	6.7	35
80	8.1	42
90	9.5	50
100	10.8	58
110	11.9	66
120	12.9	72
130	13.9	77
140	14.8	82
150	15.7	86
160	16.5	89
170	17.3	92
180	18.0	95
190	18.7	98
200	19.4	100
210	20.0	102
220	20.6	105
230	21.2	107
240	21.7	108
250	22.2	110
260	22.6	111
270	23.1	112
280	23.5	113
290	24.0	114
300	24.4	115
310	24.8	115
320	25.2	116
330	25.7	116
340	26.1	117
350	26.5	117
360	26.9	118
370	27.3	118
380	27.7	119
390	28.1	119
400	28.4	119
410	28.7	120
420	29.1	120
430	29.4	120
440	29.7	120
450	30.0	120
500	31.4	121

Palmer Junction Growth Tables

The data for this table was not obtained on a National Forest and growth is very likely more rapid than is typical of most yellow pine in this region, due to very favorable local conditions. The diameter growth is only moderately above the average, but the height growth is the fastest for any region studied during the two summer's work.

The growth tables follow:

	TABLE 22	TABLE 23
	Diameter Growth of Yellow Pine near Palmer Junction, Oregon 1910 Based on 409 trees	Height Growth of Yellow Pine near Palmer Junction, Oregon 1910 Based on 508 trees
Age	Diameter	Height (feet)
10	0	2
20	1.2	6
30	3.0	16
40	4.8	27
50	6.6	38
60	8.3	48
70	9.9	57
80	11.4	65
90	12.8	72
100	14.1	79
110	15.3	86
120	16.4	91
130	17.5	96
140	18.5	100
150	19.4	104
160	20.2	107
170	20.8	110
180	21.5	112
190	22.1	114
200	22.7	115
210	23.2	116
220	23.8	117
230	24.4	118
240	24.9	118
250	25.5	119
260	26.2	119
270	26.8	120
280	27.5	120
290	28.3	120
300	29.0	121
310	29.8	121

Parker's Mill and Winlock Growth Tables

The Parker's Mill and Winlock diameter growth tables are essentially alike. The Parker's Mill table shows a slightly faster growth than the other, having the advantage of a slightly higher precipitation. Both diameter growth tables show a rate of growth below the average. No height growth data was obtainable on either tract, but it is believed that the Whitney and Austin height growth tables will apply very closely here, as conditions are essentially the same.

The tables of diameter growth follow:

For the Whitney and Austin height growth table refer to Table 20, page 33.

	TABLE 24	TABLE 25
	Diameter Growth of Yellow Pine at Parker's Mill, Oregon 1911 Based on 245 trees	Diameter Growth of Yellow Pine near Winlock, Oregon 1911 Based on 407 trees
Age	Diameter	Diameter
10	0.	0.
20	0	0.
30	0	.2
40	1.5	1.2
50	3.0	2.5
60	4.6	3.9
70	6.1	5.4
80	7.5	6.9
90	8.9	8.5
100	10.2	9.9
110	11.5	11.2
120	12.7	12.3
130	13.8	13.3
140	14.8	14.3
150	15.8	15.2
160	16.8	16.0
170	17.7	16.8
180	18.5	17.6
190	19.4	18.3
200	20.2	19.0
210	21.0	19.8
220	21.8	20.5
230	22.6	21.2
240	23.4	22.0
250	24.2	22.7
260	25.0	23.5
270	25.7	24.2
280	26.4	24.9
290	27.1	25.6
300	27.8	26.4
310	28.4	27.1
320	29.1	27.8
330	29.7	28.6
340	30.3	29.3
350	30.8	30.0
360	31.4	-
370	31.9	-
380	32.4	-
390	32.9	-
400	33.4	-
410	33.8	-
420	34.3	-
430	34.8	-
440	35.2	-
450	35.6	-

The Ochoco Creek Growth Tables

The height and diameter growth tables for this tract show consistently slow growth throughout, as would be expected from the character of the site. As is typical of yellow pine growing under unfavorable conditions the trees are older than usual and very short and limby. The tract is typical of yellow pine forests on the edges of deserts.

The height and diameter growth tables for this tract follow: The height growth is the slowest for any region studied.

	TABLE 26	TABLE 27
	Diameter Growth of Yellow Pine along Ochoco Creek, Oregon, 1911 Based on 474 trees	Height Growth of Yellow Pine along Ochoco Creek, Oregon, 1911 Based on 187 trees
Age	Diameter	Height (feet)
10	0	1
20	0	3
30	.6	6
40	2.4	11
50	4.4	19
60	6.2	26
70	7.8	33
80	9.4	40
90	10.9	47
100	12.3	54
110	13.7	60
120	15.0	66
130	16.1	71
140	17.2	75
150	18.2	79
160	19.1	83
170	19.9	86
180	20.7	88
190	21.4	91
200	22.1	93
210	22.8	95
220	23.4	97
230	24.0	99
240	20.6	100
250	25.2	101
260	25.8	102
270	26.3	103
280	26.8	103
290	27.3	104
300	27.8	104
310	28.2	105
320	28.6	105
330	29.0	105
340	29.4	106
350	29.7	106
360	29.9	-
370	30.2	-
380	30.4	-
390	30.6	-
400	30.7	-
410	30.8	-
420	31.0	-
430	31.1	-
440	31.2	-
450	31.4	-
500	31.8	-

Mill Creek Growth Tables

Although Mill Creek is but 12 or 15 miles from Ochoco Creek in a straight line the local conditions are quite dissimilar, being farther back in “the hills”, and the timber is of faster growth. The trees were growing in a particularly close stand where diameter growth was very much slighted for the sake of height growth, so that although the diameter growth shows the trees to be slightly below the average, the height growth is next to the highest obtained in any region. This shows the importance of obtaining height growth figures along with diameter growth figures.

The diameter and height growth tables follow:

	TABLE 28	TABLE 29
Age	Diameter Growth of Yellow Pine along Mill Creek, Oregon in the Ochoco National Forest 1911 Based on 405 trees	Height Growth of Yellow Pine along Mill Creek, Oregon in the Ochoco National Forest 1911 Based on 224 trees
Age	Diameter	Height (feet)
10	0	1
20	0	4
30	1.2	8
40	2.7	18
50	4.1	29
60	5.6	38
70	7.1	46
80	8.7	53
90	10.2	60
100	11.6	66
110	12.9	71
120	14.2	76
130	15.4	80
140	16.5	84
150	17.6	88
160	18.6	92
170	19.5	96
180	20.4	100
190	21.2	104
200	22.0	107
210	22.8	109
220	23.6	112
230	24.3	114
240	25.0	116
250	25.6	118
260	26.2	120
270	26.8	122
280	27.4	123
290	27.9	124
300	28.4	-
310	28.8	-
320	29.3	-
330	29.7	-
340	30.2	-
350	30.6	-
360	31.0	-
370	31.4	-
380	31.7	-
390	32.1	-
400	32.4	-
410	32.7	-
420	35.0	-
430	33.4	-
440	33.7	-
450	34.0	-
500	35.3	-

The Matolius Creek Growth Tables

The tract where data for this table was obtained was located in an exceptionally favorable place for tree growth. The forest here begins to take on the character of the wetter east slopes of the Cascades, and tree growth is in general more rapid than in the Blue Mountain region. The diameter growth is excellent, but the height growth is even better. It was possible to obtain only 66 trees on this tract so that the table may not prove to be widely applicable.

The diameter and height growth tables follow:

	TABLE 30	TABLE 31
	Diameter Growth of Yellow Pine at the head of Matolius Creek, Oregon 1911 Based on 66 trees	Height Growth of Yellow Pine at the head of Matolius Creek, Oregon 1911 Based on 36 trees
Age	Diameter	Height (feet)
10	0	1
20	0	4
30	1.1	9
40	2.7	16
50	4.4	25
60	6.2	34
70	8.1	43
80	9.9	51
90	11.6	58
100	13.1	65
110	14.4	72
120	15.6	78
130	16.8	84
140	18.0	90
150	19.1	95
160	20.1	99
170	21.0	103
180	21.9	107
190	22.8	110
200	23.6	113
210	24.3	116
220	25.0	119
230	25.7	121
240	26.4	123
250	27.1	124
260	27.7	125
270	28.3	126
280	28.9	127
290	29.5	128
300	30.0	129
310	30.5	129
320	31.0	130
330	31.4	130
340	31.8	130
350	32.2	130
360	32.5	-
370	32.9	-
380	33.2	-
390	33.5	-
		-
400	33.8	-
410	34.1	-
420	34.4	-
430	34.6	-
440	34.9	-
450	35.1	-
500	36.2	-

The Meadow Lake and Keno Growth Tables

The growth tables for these regions are very similar, the growth being slightly faster than the average growth of yellow pine for Eastern Oregon in general, there being a slightly greater precipitation here than in the Blue Mountain region. For height growth refer to Table 9, page 23.

The diameter growth tables for the two tracts follow:

	Table 32	Table 33
	Diameter Growth of Yellow Pine near Meadow Lake, Oregon. 1910 Based on 245 trees.	Diameter Growth of Yellow Pine near Keno, Oregon. 1910 Based on 52 trees.
Age	Diameter	Diameter
10	0	0
20	0	0
30	1.4	1.5
40	3.2	3.6
50	5.0	5.7
60	6.8	7.6
70	8.5	9.3
80	10.2	10.9
90	11.8	12.5
100	13.3	14.0
110	14.7	15.4
120	16.0	16.7
130	17.2	18.0
140	18.3	19.1
150	19.3	20.0
160	20.2	20.8
170	21.0	21.6
180	21.8	22.3
190	22.6	22.9
200	23.3	23.5
210	24.0	24.1
220	24.6	24.6
230	25.3	25.1
240	25.9	25.6
250	26.5	26.1
260	27.0	26.6
270	27.5	27.0
280	28.0	27.5
290	28.4	27.9
300	28.8	28.3
310	29.2	28.7
320	29.6	29.1
330	30.0	29.4
340	30.3	29.8
350	30.7	30.1
360	31.1	30.5
370	31.4	30.8
380	31.8	31.1
390	32.1	31.4
400	32.5	31.7
410	32.8	-
420	33.1	-
430	33.5	-
440	33.8	-
450	34.1	-
500	35.8	-

The Tamarack Creek Growth Tables

Although being on the east slopes of the Cascades the growth is not as fast here as at Matolius Creek, Meadow Lake, or Keno, probably due to the greater cold and shorter growing season. This tract is in the northern part of the state, while the other three are in the southern. It seemed to be typical of the timber of the region.

The growth tables follow:

	TABLE 34	TABLE 35
	Diameter Growth of Yellow Pine along Tamarack Creek near Dufur, Oregon. 1911 Based on 238 trees	Height Growth of Yellow Pine along Tamarack Creek near Dufur, Oregon. 1911 Based on 125 trees
Age	Diameter	Height (feet)
10	0	1
20	0	3
30	.7	6
40	2.7	14
50	5.0	23
60	7.2	34
70	9.2	44
80	11.2	53
90	13.0	62
100	14.0	70
110	16.0	76
120	17.3	82
130	18.5	87
140	19.6	91
150	20.5	95
160	21.4	98
170	22.2	101
180	22.8	103
190	23.4	105
200	24.0	106
210	24.5	107
220	25.0	107
230	25.4	108
240	25.8	108
250	26.2	108
260	26.6	108
270	27.0	109
280	27.4	109
290	27.7	109
300	28.1	109
310	28.4	109
320	28.8	109
330	29.1	109
340	29.4	109
350	29.7	109
360	30.0	-

The Crystal Creek Growth Tables

The tables for this tract have not been included in Tables 1 and 2, as the growth is so much more rapid than for any other tract studied. The diameter growth compares with the diameter growth of Douglas fir on the Coast. It probably represents the maximum rate of growth for a stand of yellow pine growing on the best quality of soil.

The diameter and height growth tables follow:

	TABLE 36	TABLE 37
	Diameter Growth of Yellow Pine along Crystal Creek, T. 35 S., R. 6 E., W., Oregon 1910 Based on 87 trees	Height Growth of Yellow Pine along Crystal Creek, T. 35 S., R. 6 E., W., Oregon 1910 Based on 86 trees
Age	Diameter	Height (feet)
10	0	1
20	0	4
30	3.2	9
40	7.1	16
50	10.6	23
60	13.6	30
70	16.2	38
80	18.6	37
90	20.5	56
100	22.2	65
110	23.7	76
120	25.0	89
130	26.2	102
140	27.4	112
150	28.5	120
160	29.5	126
170	30.4	130
180	31.3	134
190	32.2	137
200	33.1	139
210	33.9	141
220	34.7	142
230	35.5	144
240	36.3	145
250	37.0	146
260	37.8	147
270	38.5	147
280	39.2	148
290	40.0	148
300	40.7	149
310	-	149
320	-	149
330	-	149
340	-	149
350	-	150
360	-	150
370	-	150
380	-	150
390	-	150
400	-	150
410	-	150
420	-	150
430	-	150
440	-	150
450	-	150
500	-	150

Present and Past Rate of Diameter Growth of Yellow Pine by Age Classes.

In connection with working up the diameter growth data a side study was made. It was thought possible that the growth of yellow pine in recent years might not be the same as in past times. This seems to be the popular idea among ranchers and farmers in Eastern Oregon. If such should prove to be the case it would be important to know this difference in predicting future growth and yields of stands.

For this purpose the trees of several of the tracts were first grouped by 100-year age classes (1-100, 101-200, 201-300, etc.) and then by 3-inch diameter classes. The growth was then added, averaged and curved separately for each of the age classes and for each of the diameter classes. It was found that in those cases where the trees were grouped into age classes that the growth was apparently faster for trees of any age in more recent times than for trees of the same age in past times. However, on grouping the trees from the same tracts according to diameter, it was found that the data worked up in this wise gave exactly opposite results. Here the smaller and therefore presumably the younger trees are growing at a slower rate of growth than the larger and therefore presumably older trees grew when at the same age as the younger trees now.

TABLE 38.

Lapine, Oregon

The relative rate of diameter growth at each 20-year period of their life of yellow pines which are now young, and of those which are now old. Table based on the stump analysis of 361 western yellow pines.

	Age classes of trees at present time.			
	101 to 200 year class	201 to 300 year class	301 to 400 year class	401 to 600 year class
Age	Diameter at breast height in inches			
20	0	0	0	0
40	1.5	1.4	1.7	1.0
60	3.8	3.5	4.2	2.6
80	7.2	5.9	6.8	4.5
100	11.7	8.7	9.6	6.8
120	16.6	11.8	12.5	9.5
140	20.8	15.1	15.1	12.5
160	24.0	18.5	17.7	15.5
180	26.5	21.9	20.2	18.5
200	28.2	24.8	22.5	21.2
220	-	27.0	24.6	23.3
240	-	28.7	26.4	25.1
260	-	30.0	28.0	26.8
280	-	31.2	29.4	28.4
300	-	31.2	30.8	29.8
320	-	-	32.0	30.9
340	-	-	33.1	32.0
360	-	-	34.2	33.0
380	-	-	35.2	34.0
400	-	-	35.2	35.0
420	-	-	-	35.8
440	-	-	-	36.6

TABLE NO. 39.

SISTERS, OREGON.

The relative rate of diameter growth at each 20 year period of their life of yellow pines which are now young, and of those which are now old. Table based on the stump analyses of 267 western yellow pines.

	Age classes of trees at present time.			
	1 to 200 year class	201 to 300 year class	301 to 400 year class	401 to 500 year class
Age	Diameter at breast height in inches			
20	.0	.0	.0	.0
40	2.3	1.8	2.3	1.4
60	6.1	4.7	6.0	3.8
80	10.1	8.1	9.5	6.8
100	13.6	11.6	12.8	10.4
120	16.1	14.7	15.5	13.9
140	18.1	17.2	17.6	16.5
160	19.7	19.1	19.5	18.8
180	21.2	20.8	21.2	20.8
200	22.5	22.3	22.6	22.5
220	-	23.6	23.8	23.9
240	-	24.8	25.0	25.5
260	-	26.0	26.2	26.6
280	-	27.2	27.4	27.8
300	-	28.4	28.5	29.0
320	-	-	29.5	30.0
340	-	-	30.5	31.0
360	-	-	31.4	31.9
380	-	-	32.4	32.8
400	-	-	33.3	33.6
420	-	-	-	34.5
440	-	-	-	35.3
460	-	-	-	-
480	-	-	-	-
			-	-
500	-	-	-	38.0

TABLE NO. 40.

EMBODY, OREGON.

The relative rate of diameter growth at each 20 year period of their life of yellow pines which are now young, and of those which are now old. Tables based on the stump analyses of 400 western yellow pines.

	Age classes of trees at present time.			
	1 to 200 year class	201 to 300 year class	301 to 400 year class	401 to 500 year class
Age	Diameter at breast height in inches			
20	0	.0	.0	.0
40	2.1	2.1	2.1	2.1
60	5.3	4.9	4.7	4.5
80	8.6	7.9	7.5	6.9
100	11.4	10.8	10.2	9.3
120	13.8	13.1	12.5	11.5
140	15.9	15.2	14.6	13.6
160	17.9	17.1	16.5	15.5
180	19.6	18.8	18.3	17.3
200	21.3	20.3	19.9	18.8
220	-	21.6	21.3	20.2
240	-	22.9	22.5	21.6
260	-	24.1	23.7	22.9
280	-	25.2	24.8	24.1
300	-	26.2	25.8	25.3
320	-	-	26.9	26.3
340	-	-	27.9	27.3
360	-	-	28.7	28.3
380	-	-	29.6	29.2
400	-	-	30.4	29.9
420	-	-	-	-
440	-	-	-	-
460	-	-	-	-
480	-	-	-	-
500	-	-	-	-

TABLE NO. 41.

AUSTIN, OREGON.

The relative rate of diameter growth at each 20 year period of their life of yellow pines which are now young and of those which are now old. Table based on the stump analysis of 672 trees.

	Age Classes of Trees at Present Time				
	1 to 100 years	101 to 200 years	201 to 300 years	301 to 400 years	401 to 500 years
Age	Diameter at breast height in inches				
20	0	0	0	0	0
40	3.3	2.5	2.4	2.1	2.0
60	8.1	6.4	5.4	4.6	4.3
80	12.6	10.2	8.4	7.4	6.8
100	16.0	13.4	11.2	10.2	9.2
120	-	15.8	13.5	12.6	11.6
140	-	17.7	15.5	14.9	13.8
160	-	19.2	17.4	17.0	15.6
180	-	20.4	19.1	18.8	17.2
200	-	21.4	20.6	20.5	18.7
220	-	-	21.7	21.8	20.1
240	-	-	22.6	23.0	21.4
260	-	-	23.3	24.2	22.7
280	-	-	23.8	25.2	23.8
300	-	-	24.2	26.1	24.8
320	-	-	-	27.0	25.7
340	-	-	-	27.8	26.7
360	-	-	-	28.5	27.5
380	-	-	-	29.2	28.2
400	-	-	-	29.8	28.9

TABLE 42.

PARKERS' MILL, OREGON.

The relative rate of diameter growth at each 20 year period of their life of yellow pines which are now young, and of those which are now old. Table based on the stump analyses of 245 western yellow pines.

Age	Age classes of trees at present time.		
	1 to 200 year class	201 to 300 year class	301 to 500 year class
	Diameter at breast height in inches		
20	.0	.0	.0
40	1.6	1.4	1.4
60	4.8	4.2	4.8
80	8.2	7.2	8.3
100	11.3	9.9	11.5
120	14.2	12.4	14.1
140	16.6	14.6	16.3
160	18.9	16.6	18.2
180	21.0	18.5	20.1
200	22.8	20.3	21.9
220	-	22.0	23.5
240	-	23.5	25.0
260	-	24.9	26.3
280	-	26.1	27.5
300	-	27.2	28.7
320	-	-	29.9
340	-	-	30.9
360	-	-	31.8
380	-	-	32.6
400	-	-	33.4
420	-	-	34.3
440	-	-	35.2
460	-	-	-
480	-	-	-

TABLE 43.

WINLOCK, OREGON.

The relative rate of diameter growth at each 20 year period of their life of yellow pines which are now young, and of those which are now old. Table based on the stump analyses of 407 western yellow pines.

Age	Age classes at present time		
	1 to 100 year class	101 to 200 year class	201 to 300 year class
	Diameter at breast height in inches		
20	.0	.0	.0
40	1.9	1.4	1.4
60	5.8	4.2	4.3
80	10.3	7.2	7.3
100	14.4	9.9	10.0
120	-	12.3	12.5
140	-	14.4	14.6
160	-	16.1	16.5
180	-	17.7	18.1
200	-	19.0	19.6
220	-	-	21.1
240	-	-	22.5
260	-	-	23.9
280	-	-	25.3
300	-	-	26.6
320	-	-	-
340	-	-	-
360	-	-	-
380	-	-	-
400	-	-	-

TABLE 44.

Ochoco Creek, Ochoco National Forest.

The relative rate of diameter growth at each 20 year period of their life of yellow pines which are now young and of those which are now old. Table based on the stump analysis of 474 trees of western yellow pines.

	Age classes at present time.				
	1 to 100 year class	101 to 200 year class	201 to 300 year class	301 to 400 year class	401 to 500 year class
Age	Diameter at breast height in inches				
20	.0	.0	.0	.0	.0
40	3.7	2.2	2.8	2.0	1.5
60	9.7	6.0	6.4	5.1	4.0
80	14.7	10.0	9.4	8.4	6.4
100	18.8	13.5	12.1	11.5	9.0
120	-	16.1	14.6	14.5	11.3
140	-	18.2	16.8	17.2	13.4
160	-	20.1	18.8	19.3	15.3
180	-	21.8	20.5	21.1	16.9
200	-	23.3	22.0	22.6	18.4
220	-	-	23.3	24.0	19.8
240	-	-	24.6	26.2	21.1
260	-	-	25.7	26.4	22.3
280	-	-	26.8	27.4	23.5
300	-	-	27.9	28.4	24.7
320	-	-	-	29.3	25.8
340	-	-	-	30.2	26.8
360	-	-	-	31.0	27.9
380	-	-	-	31.7	28.8
400	-	-	-	32.4	29.7
420	-	-	-	-	30.5
440	-	-	-	-	31.1
460	-	-	-	-	-
480	-	-	-	-	-
500	-	-	-	-	-

TABLE NO. 45.

MILL CREEK

The comparative rate of diameter growth at each 20 year period of their life of yellow pine of various diameters regardless of the total ages of the individual trees.

	Diameter Class								
Age	15”	18”	21”	24”	27”	30”	33”	36”	39”
20	1.74	1.83	1.94	1.84	2.03	2.33	2.20	2.93	3.47
40	3.82	3.87	4.16	4.22	4.99	5.74	5.25	8.05	9.87
60	5.66	5.87	6.48	6.72	8.09	9.33	8.54	12.36	15.87
80	7.24	7.79	8.76	9.26	11.10	12.68	11.68	16.01	20.87
100	8.44	9.63	10.87	11.74	13.95	15.87	14.79	19.30	25.45
120	9.55	10.88	12.68	14.07	16.43	18.61	17.87	22.33	29.32
140	10.32	12.26	14.28	15.97	18.21	21.09	20.62	24.84	31.92
160	11.28	13.72	15.61	17.48	20.30	22.46	23.13	26.28	34.42
180	11.94	14.95	16.75	19.14	22.05	24.23	25.46	28.24	36.45
200	13.02	16.20	18.16	20.75	23.63	25.72	27.64	29.44	37.97
220	13.78	17.05	19.47	22.12	24.07	27.25	29.42	30.60	39.50
240	14.80	18.02	20.18	22.87	24.73	28.52	29.22	30.59	41.20
260	14.70	17.73	20.21	22.56	24.87	28.07	30.68	30.03	38.30
280	15.20	17.70	20.53	21.50	24.88	28.43	31.23	31.40	38.90
300	-	18.80	21.14	22.47	25.54	28.87	31.74	31.78	39.70
320	-	-	21.77	22.98	25.68	29.20	34.00	32.85	40.50

Note:- The figures in this table have not been curved and irregularities in certain of the figures in the vertical columns are due to the fact that trees of the same size are not always of the same age, so that in tabulating the growth data certain trees fall sooner than others. When these trees happen to be those having the quickest diameter growth the average diameters appear sometimes to diminish rather than increase with age.

TABLE NO. 46.

WINLOCK

The comparative rate of diameter growth at each 20 year period of their life of yellow pine of various diameters and regardless of the total ages of the individual trees.

	Diameter Class								
Age	12”	15”	18”	21”	24”	27”	30”	33”	36”
20	1.50	1.91	1.97	1.93	2.35	2.21	2.48	2.17	3.12
40	3.25	4.00	4.14	4.60	5.02	5.21	6.56	5.30	7.32
60	4.80	6.08	6.38	7.25	7.80	8.43	10.29	9.23	11.65
80	6.39	7.95	8.65	9.90	10.69	11.53	13.70	12.87	15.42
100	7.07	9.31	10.42	12.17	13.17	14.10	16.61	16.22	19.17
120	8.42	10.50	12.15	13.97	15.50	16.51	19.03	19.06	21.52
140	9.09	11.58	13.57	15.73	17.41	18.85	21.27	21.86	24.47
160	10.11	12.67	14.83	17.10	18.90	20.74	23.11	24.28	26.40
180	11.14	13.73	16.24	18.40	20.58	22.50	24.76	26.12	28.15
200	12.50	14.74	17.12	19.46	21.81	24.04	26.21	27.77	28.40
220	13.00	15.01	17.36	19.85	21.58	24.32	26.70	29.46	30.20
240	-	15.17	17.63	19.46	21.47	24.82	27.97	30.51	32.20
260	-	-	18.00	20.09	22.12	25.80	28.60	31.93	34.47
280	-	-	18.00	20.25	22.89	25.73	29.62	32.25	35.75
300	-	-	-	18.70	23.42	25.20	30.40	-	34.80
320	-	-	-	20.60	-	-	-	-	36.20

Note:- See note on page.

Thus we have apparently two theories both equally convincing which are pulling in exactly opposite directions.

The probable difficulty, however, lies in the fact that all the trees analyzed did not belong to the same tree class. Most were dominant, to be sure, but there was a considerable percentage of intermediate and even a few suppressed trees among the number. Now, in the case of the division of the trees into age classes a larger percent of the suppressed and intermediate trees would be included among the higher age classes than among the lower age classes for the obvious reason that suppressed or intermediate trees are of slower growth than dominant trees.

In those cases, on the other hand, where the trees have been classed according to diameter, most of the old suppressed and intermediate trees would be included with the young dominant trees, which would bring down the average growth of the latter below that of the trees of large size which must include only those which have always been dominant in the stand.

In order to compare the rate of growth of trees now, with that of the past, it would be necessary to pick out trees of all sizes belonging exclusively to precisely the same tree class. It is thought, however, that the slight increase in time required to work up the data into separate age classes, has been well spent, for by so doing it will [sentence not completed in original document]

Increased Growth Due to Unnatural Causes

Unfortunately lack of opportunity prevented any data from being gathered on the increased growth of yellow pine due to thinnings.

In a small side study it was found that growth had been distinctly stimulated on a small area used as a sheep bedding ground for about ten years.

The average growth for the last ten years was .40 inches, and for the four preceding decades in order, as follows: .29- .30- .34 and .33. The study was based on 37 trees.

Height Growth

Whenever possible, ring counts were obtained at intervals up the tree to the top and the height of these points above the ground measured. These counts were used as the basis in preparing the height growth tables which have been included in this report. There is great variation in the rate of height growth of yellow pine, as might be expected from the extent of its range and the great variety of conditions under which it can survive. For example, at Sisters the height growth for the first 300 years was 92 feet and at Crystal Creek it was 149 feet, or approximately 50 percent faster. If only the diameter growth were given for either one of these two tracts, a very wrong idea would be obtained in estimating future yields for the other tract. It is to be regretted that it was not always possible to obtain very full data on height growth, as often part or all of the trees on certain tracts had been removed from the cutting area, but it is believed that sufficient data was obtained to eliminate the possibility of any very large errors.

Often yellow pine growing in the open appears to have a very much faster height growth than when it occurs in a stand having a normal crown cover. The long crowns and short clear lengths give open grown trees the appearance of being shorter than they really are. On the other hand, the short crowns and long clear lengths of tree growing in normal forests give the trees the appearance of being taller than they really are, but in reality the difference in height between the two classes is not as great as a casual glance might lead one at first to suppose.

Seedling Height Growth

The height growth of yellow pine in the seedling stage is exceedingly slow, even when it occurs under the light canopy of larger trees of the same species. In the open it is somewhat faster and under the selection cuttings such as are practiced on the National Forests, better height growth may safely be expected than is shown in the accompanying tables. Growing under ordinary yellow pine forest conditions 10 percent to 20 percent of the total age of the tree is often required to grow to stump height. This is an argument in favor of making selection cuttings in this species rather heavy.

Tables showing the height growth of seedlings in several localities follow:

TABLE NO. 47

SEEDLING HEIGHT GROWTH

The average height of thrifty Yellow Pine Seedlings at various ages; Baker, Grant and Union Counties, Oregon. 1910.

Based on 1,182 measurements.

Age Years	Total Height (feet)
1	.2
2	.3
3	.5
4	.6
5	.8
6	1.0
7	1.1
8	1.3
9	1.5
10	1.7
11	1.9
12	2.1
13	2.3
14	2.5
15	2.7
16	3.0
17	3.2
18	3.5
19	3.7
20	4.0
21	4.3
22	4.6

TABLE NO. 48

SEEDLING HEIGHT GROWTH

The average height of thrifty Yellow Pine Seedlings for various ages at Embody, Oregon, 1911. Based on 1803 measurements.

Age Years	Total Height feet
1	.2
2	.4
3	.6
4	.8
5	1.1
6	1.2
7	1.4
8	1.5
9	1.7
10	1.8
11	1.9
12	2.1
13	2.2
14	2.4
15	2.6
16	2.7
17	2.8
18	3.0
19	3.2
20	3.4
21	3.7
22	3.9
23	4.2
24	4.5

Age	TABLE 49 The average height of thrifty Yellow Pine seedlings for various ages at Lapine, Oregon 1911 Based on 357 measurements Height (feet)	TABLE 49 (a) The average height of thrifty Yellow Pine seedlings for various ages at Winlock, Wheeler County, Oregon. 1911 Based on 1239 measurements Height (feet)
1	.2	.2
2	.3	.3
3	.4	.4
4	.5	.5
5	.6	.5
6	.7	.6
7	.8	.7
8	1.0	.8
9	1.1	.9
10	1.2	1.0
11	1.3	1.1
12	1.4	1.2
13	1.6	1.3
14	1.7	1.4
15	1.8	1.6
16	2.0	1.7
17	2.2	1.8
18	2.4	2.0
19	2.6	2.2
20	2.7	2.3
21	2.9	2.5
22	3.2	2.6
23	3.4	2.7
24	3.7	2.9
25	4.0	3.1

Mean and Current Annual Height Growth

The points of culmination of the mean and current annual height growths, and the age at which the mean and current annual height growth are identical, has been obtained from the height growth tables. The mean annual height growth reaches its maximum, of course, at the point where it is equal to the current annual height growth. With certain kinds of timber in some localities where the demand for lumber is great a knowledge of the mean and current annual height growth is important in helping to determine the proper rotation, but in the case of yellow pine in Oregon where the only demand at present is saw log dimension stuff, this information is not particularly valuable from a practical standpoint. It is, however, of interest scientifically. Yellow pine reaches the point of the culmination of its mean annual height growth and current annual height growth long before it is large enough to be merchantable under the existing market. In the future when the use of lumber will become more intensive through greater scarcity, there will be practical as well as scientific value in having this information.

For some of the tracts the current and mean annual diameter growth has also been computed, and it is included in the accompanying table along with the current and mean annual height growth for purposes of comparison.

TABLE 50

Culmination of the Maximum Current and Mean Annual Height and Diameter Growth of Yellow Pine for various localities in Oregon.

	Culmination of Maximum Current Growth in-		Culmination of Maximum Mean Annual Growth in-	
	Height	Diameter	Height	Diameter
Name of Tract	Age	Age	Age	Age
Lapine 3rd quality	95	100-150	145	180-200
Lapine 2nd quality	95	150-160	145	170-190
Deschutes River 1st quality	60	110	99	150-170
Ft. Klamath	45	80	95	110
Sisters (1)	55	80	99	110-120
Sisters (2)	55	60-80	99	110-120
Odessa	45	60-90	95	110
Embody	55	60-110	100	120-140
Whitney & Austin	97	70-90	119	100-110
Palmer Junction	44	30-50	78	80-90
Parker's Mill	97	60	119	130
Winlock	97	90	119	110-140
Ochoco Creek	46	50	120	120
Mill Creek	43	80	82	120
Matolius Creek	56	70	110	100-110
Meadow Lake	45	40-60	95	110
Keno	45	40-50	95	100-110
Tamarack	55	50	102	100
Bend	56	70	126	100
Crystal Creek	115	40	145	80
Average, All tracts	65	75	109	120

It was expected that this table would bring out certain points in relation to growth, as for example the generally inferred supposition that fast growing trees reach their point of greatest height growth at an earlier period than slow growing trees. Although there is wide variation in the age at which mean annual growth and current annual growth culminate, this theory does not seem to be entirely substantiated. There are many exceptions, although in general the theory seems to be true.

Volume Growth

The volume growth tables in this report for the various regions have been obtained by means of applying appropriate volume tables to trees of all diameters and heights for each 20-year period. For example, we may find that the average yellow pine in that locality which is 180 years old has a diameter of 18 inches and merchantable height of four logs. If we then look up the volume of this 180 year old tree in the appropriate local volume table we will find that it has a volume of 285 board feet. In other words, it requires 180 years to produce a tree containing 285 board feet.

Volume growth is a truer index of tree growth than either height or diameter growth, as it is dependent on both of these to an equal degree for its determination. Cubic volume is more accurate and scientific than board foot volume, but has little practical value in this county at the present time as regards yellow pine and it has not been included in this report. The board foot volume growth tables for the different tracts follow:

TABLE NO. 51.
VOLUME GROWTH
NAME OF TRACT

Age	Lapine Quality III	Lapine Quality II	Deschutes River Quality I.	Fort Klamath	Sisters (1)	Sisters (2)	Odessa	Embody	Whitney & Austin	Palmer Junction	Parker's Mill	Winlock	Ochoco Creek	Mill Creek	Metolius Creek	Meadow Lake	Keno	Tamarack Creek	Bend	Crystal Creek
0																				
20																				
40																				
60																20				90
80				80			20									50	30	20		350
100				230	20	20	90		50	150					50	95	95	160	100	620
120		40	20	400	105	95	180	10	150	260	10	20	70	30	160	160	180	270	215	900
140	80	150	185	600	195	175	300	115	205	380	75	75	165	170	280	250	310	375	300	1200
160	210	300	390	800	290	260	440	180	275	500	155	140	265	325	420	360	450	488	400	1500
180	370	490	610	1000	390	360	580	250	350	605	240	205	375	490	580	490	600	580	510	1800
200	540	710	840	1190	500	480	710	320	430	705	340	280	480	670	750	630	740	690	630	2130
220	730	940	1060	1370	610	600	830	400	510	810	460	365	600	840	920	780	870	790	750	2460
240	920	1160	1260	1550	730	720	950	480	590	935	595	470	720	1000	1090	920	990	890	880	2790
260	1110	1390	1460	1730	860	850	1060	570	670	1070	750	590	840	1150	1250	1050	1110	980	1000	3120
280	1300	1620	1650	1910	980	970	1170	670	750	1230	900	740	960	1290	1400	1170	1210	1070	1130	3460
300	1480	1860	1820	2090	1110	1090	1280	770	835	1430	1050	900	1070	1420	1560	1290	1310	1160	1250	3830
320	1660	2080	1980	2260	1240	1220	1380	880	925		1200	1090	1170	1550	1700	1400	1400	1250	1370	
340	1820	2310	2120	2430	1370	1320	1480	990	1020		1360	1270	1260	1660	1830	1510	1490	1340		
360	1980	2540	2260	2600	1500	1410	1580	1110	1110		1520		1320	1760	1950	1610	1570	1420		
380	2120	2760	2370	2770	1600	1500	1680	1230	1210		1680		1370	1860	2070	1700	1650			
400	2260	2970	2480	2940	1790	1560	1770	1340	1300		1840		1420	1950	2190	1790	1720			
420	2400	3180	2590		1930	1620		1440	1390		2000		1450	2040	2300	1870				
440	2540	3370	2690		2070	1670		1540	1480		2180		1470	2120	2410	1940				
460	2680	3530			2210	1710		1640	1570				1490	2200	2510	2010				
480	2820	3700			2350	1740		1730	1660				1500	2280	2540	2080				
500	2960	3860			2490	1760		1820	1750				1510	2360	2560	2150				

Note:- In the Column of Averages, the Crystal Creek data has not been included as it is not typical of yellow pine as they usually occur

Current annual and mean annual volume growth have been obtained for 50-year periods in several representative regions. It will be noticed from the following table (no. 51a) that the mean annual and current annual growth do not always culminate within the limits of the tables. This is due to the fact that a slight increase in diameter in the larger trees means a very much larger increase proportionally in volume than the same increase in diameter in the smaller trees, so that it is easily understood why there should be no culmination of growth in any except the very oldest trees which growth has slowed down to the minimum. This is true even although the height growth is greater in the young than in the old trees. The increase in volume due to height is not as great as that due to diameter.

In the same table (No. 51a) the current increment percent has been worked out for each 50-year period, or in other words the rate percent at which the trees are increasing in volume at these periods. It will be noticed from this table that the percent increases in volume falls off very rapidly with the age of the tree.

TABLE NO. 51 A

Current annual and mean annual volume growth is shown in board feet and current increment percent of yellow pine for several typical regions in Oregon, 1911.

Age years	Lapine Quality III			Whitney & Austin			Palmer Junction			Fort Klamath			Embody		
	Cur. An. Gr. B.F.	Mean An. Gr. B.F	Cur. Increment %	Cur. An. Gr. B.F.	Mean An. Gr. B.F.	Cur. Increment %	Cur. An. Gr. B.F.	Mean An. Gr. B.F.	Cur. Increment %	Cur. An. Gr. B.F.	Mean An. Gr. B.F	Cur Increment %	Cur. An Gr. B.F.	Mean An. Gr. B.F.	Cur. Increment %
50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
100							5	1	5.0	8	2	3.0	--	--	--
150	6	1	4.6	3	2	1.7	6	3	1.6	10	4	1.0	3	1	2.3
200	9	2	1.6	4	2	1.0	6	4	.8	9	6	.8	4	2	1.1
250	10	4	.9	4	3	.7	6	4	.7	9	7	.5	4	2	1.1
300	9	5	.7	4	3	.6	8	5	.8	8	7	.4	5	3	.6
350	8	5	.4	4	3	.4	=	=	=	8	7	.3	6	3	.5
400	7	6	.3	4	3	.3	=	=	=	8	7	.3	5	3	.4
450	6	6	.3	4	3	.3	=	=	=	=	=	=	4	3	.3
500	5	6	.2	4	3	.3	=	=	=	=	=	=	3	4	.2

Types of Yellow Pine Forest

The types of forest most commonly found in eastern Oregon may be classified as follows;

1. The south slope type
2. The north slope type
3. The flat or bench type
4. The juniper type
5. The canyon type

The South Slope type is typical of south and west slopes of moderate steepness and soil depth, and is generally covered by pure, or nearly pure, yellow pine – at least 80 percent of the stand. The most common associate of yellow pine on the south slope is Douglas fir. Larch occurs quite commonly on the better sites in the northern part of the State, but is rare south of the Blue Mountains. White fir occurs in the better sites throughout the whole of the eastern part of the State. Lodgepole is frequently in mixture, but usually does not compete as strongly with yellow pine on the south slopes as on certain other types. In the southern third of the State, sugar pine enters into mixture with yellow pine. On the whole, yellow pine does not have to put up with serious competition with other species on this type. The south slope type is the most important from the standpoint of the lumberman as on it occurs the greatest part of the merchantable yellow pine in the State.

The North Slope type is found on north and east slopes, often very steep, and in narrow ravines where little light penetrates. The slopes are often so steep that if they faced the south they would be quickly dried out by the sun to such an extent that tree life would be impossible on them. Frequently, however, they are not steep and are capable of supporting a luxuriant forest growth. White pine, larch, spruce and Douglas fir are the most common species, but are unfortunately inferior in value to yellow pine, which is here very subordinate in numbers. It is evident that yellow pine is fitted to grow on north slopes, however, if the competition with other more tolerant species could be eliminated, because whenever it is once able to get a start it makes exceptionally good growth in such localities. It is wrong to say that yellow pine prefers dry south slopes because it happens to be usually found on them and that fir and spruce prefer shady, moist north slopes. If the spruce, for example, could be given as much light as the yellow pine and the yellow pine as much moisture as the spruce, both would thrive better. Yellow pine can get along without much moisture, but it must have abundant light, and the spruce can get along without much light, but it must have abundant moisture. All species of trees require varying amounts of light and moisture, and the degree in which they require one or the other determines the kind of site in which they must grow. If the north slopes could be stripped of their present growth and planted to yellow pine, the growth and yield of the resultant forests would far exceed that shown by any of the tables included in this report. The wisdom of such a move would, however, be doubtful for two reasons. First, a commercial use may be found in future fir species which are now classed as undesirable or totally unmerchantable, such as occur on the north slope; and second, because of the absolutely prohibitive expense which it would be necessary to entail.

The Flat or Bench type: In the Blue Mountains flats and benches are typically found bordering creeks and extending back for a quarter of a mile or less, until they rise into rolling hills or more elevated scab rock flats and ridges. Some of the best quality of yellow pine is found in this type, and the percent of other species in the stand is usually small.

On the east slopes of the Cascades the bench type is not always covered with pure yellow pine. Lodgepole is a strongly competing species, and in localities where there have been many successive fires lodgepole has obtained the upper hand to the detriment of the more valuable yellow pine. The management of the forest so as to prevent the increase in the percentage of lodgepole is here a serious silvical problem.

The Juniper type: On the east side of the crest of the Cascades the mountains rise very abruptly from the level of rolling plains. Yellow pine usually extends out over these plains, but the farther away from the mountains the harder it is for tree life to endure, so that beyond 25 to 30 miles from the mountains the conditions have become too severe for yellow pine, which then givens place to juniper and sage brush. The line between the pure yellow pine type and the juniper type is, of course, not abrupt, the two species intermingling for a strip 2 or 3 miles wide between the absolute juniper type one the one side, and the absolute yellow pine type on the other. The town of Bend, Oregon, is about on the line midway between these two types.

The Canyon type is very common in the Blue Mountains. The tops of the canyons are usually treeless plateaus covered with scab rock. The trees at the extreme bottoms of the canyons are often of good size, but grow quickly shorter and limbier as they extend up the sides of the canyons. Pure yellow pine, with only a very occasional Douglas fir, is the species of tree occurring in these canyons, which are 300 to 800 feet in depth and invariably have very steep slopes, often ending in cliffs of basaltic rock. The trees in the bottoms are unmerchantable because of their few numbers and inaccessibility. They serve a purpose in retarding erosion and conserving the water supply to a slight degree, and in seeding up those portions of the scab rock plateau which are not too rocky for tree growth. It seems likely that parts of these plateaus are capable of growing trees, as it is certain that they did in former years. The ridges were formerly covered with bunchgrass which carried fire, but since the bunch grass has been grazed off, reproduction is creeping out over the plateau from the edges, and the growth of the young trees up to 20 to 30 years is often very rapid due to the abundance of sunlight. Beyond this age, the rate of growth rapidly falls off. Reproduction on these plateaus will always be very precarious, however, and trees up to 20 years of age are often killed by a particularly dry summer. Often all the reproduction is killed over several acres in these scab rock flats by a dry summer such as that of 1910.

Factors Affecting Growth

The single most important factor determining the rate of growth of yellow pine is the amount of available moisture. In this regard, the degree of annual precipitation is not the only circumstance which determines the amount of available moisture. On very nearly any one of the National Forests in eastern Oregon and Washington conditions vary all the way from desert to luxuriant tree growth, although the precipitation may vary only in a slight degree over the entire area. The factors which tend to modify growth other than precipitation are (1) altitude, (2) soil, (3) aspect, (4) slope and (5) competition with other species or with individuals of the same species.

(1) Altitude: Yellow pine prefers the lower elevations. It is the first commercial species of tree to border the desert and it is about the first to disappear in the higher elevations. Larch, Douglas fir, lodgepole, spruce, and white barked pine can live at higher elevations. All these species, however, including yellow pine make their best growth at the medium high elevations where they obtain sufficient moisture without too excessive cold.

(2) Soil: The chemical constituents of the soil are unimportant for yellow pine, but the depth and physical properties of the soil are all important. If the soil is shallow the trees will be small and stunted, as on steep hillsides. On the other hand, if is a poor water retainer, no matter what the depth, tree growth will be slow and precarious

as on the volcanic ash soils in the vicinity of Bend, Oregon. Unfortunately much of the soil in eastern Oregon is a poor retainer of moisture which is particularly unfortunate, as the annual precipitation is light. The chemical constituents of the soil are excellent and in forms very easily assimilable whenever there is sufficient moisture to sustain plant life.

(3) Aspect: Trees make better growth on north and east slopes than on south and west slopes, but this is due to the fact that such slopes do not dry out as fast, so that there is more moisture available for plant life.

(4) Slope: The angle at which a slope lies is important because, in general, the steeper the slope the shallower the soil. Excessive root competition such as occurs in shallow soil retards the growth of the trees.

(5) Competition with other trees: The greater part of yellow pine is growing in pure or nearly pure stands in localities so harsh that other species of trees are unable to obtain a foothold and compete with it for the ground, so that competition occurs chiefly with members of its own kind. Yellow pine is such an intolerant tree that it requires a great deal of sunlight from its earliest youth up so that it is generally shaded out and killed while a seedling. This is why we see so few suppressed yellow pine in a stand. Most of the living trees are dominant or at least intermediate for the reason that they require an abundance of light. If they could not get this light they would not be in existence.

In order to determine if there exists a relation between the rate of growth of a yellow pine and the space which it occupies in typical stands of the same species for each tree analyzed on three of the tracts the square foot area surrounding the stump and bounded on all sides by half the distance to the nearest neighboring stumps of merchantable size, was measured by pacing and marked on rough sketch map. These maps were later plotted to scale in the office and the area determined by the planimeter. The trees were then grouped, first according to diameter and then according to size of crown space, those having the smallest crowns being classed together, as were also those having the largest crowns. When sufficient number allowed it, several intermediate classes were made. In one of the three tracts, the grouping by crown area was arbitrary, the size of the crown spaces for each diameter being thrown together by 500-foot classes. In the other two cases the division into crown classes was made wherever it was most convenient to do so, and the results by this method were somewhat more regular than in the arbitrary method. The next step was to add and average the growth for the last two decades for each of those groups of trees having the same diameter and belonging to the same crown class. The growth was of course obtained from the back of the Form 334 sheets. Comparison between the rates of growth of trees belonging to each diameter class but having varying degrees of space surrounding them could then be readily made.

The data obtained in the crown space study has been summarized and included in the followings tables in this report:

TABLE NO. 52

Mill Creek – Crown Space Study.

	14" diameter class		17" diameter class		18" diameter class		19" diameter class			20" diameter class				21" diameter class		
Average Crown Space	517	2795	287	1080	493	1374	540	866	1620	592	954	1388	2005	589	1166	1880
Average Growth Last 20 yrs.	1.22	.75	.60	.78	.61	.66	.48	.59	.64	.65	.67	.56	.70	.64	1.01	.80

	22" diameter class				23" diameter class			24" diameter class				25" diameter class			26" diameter class		
Average crown space	573	973	1385	3670	350	796	1656	458	818	1615	2166	658	1214	2052	477	817	1511
Average growth last 20 yrs.	.64	.55	.80	.98	.70	.54	.65	.54	.63	.63	.87	.95	.73	1.00	.50	.74	.73

	27" diameter class			28" & 29" diameter class			30" & 31" diameter class		32" & 33" diameter class		34" diameter class & up	
Average Crown space	509	860	1403	680	1207	2042	757	2003	620	1893	1582	3310
Average Growth Last 20 yrs.	.65	.60	.67	.47	.80	.69	.45	.71	.90	1.03	.72	.61

TABLE NO. 53.
Winlock – Crown Space Study.

	15” diameter Class					18” diameter class			21” diameter class				
Average crown space	164	475	957	1595	2587	428	1286	2337	380	773	1107	1824	3928
Growth last decade	.29	.32	.40	.24	.32	.34	.38	.45	.25	.24	.25	.27	.45

Average Crown space	24” diameter class					27” diameter class		30” diameter class		
Growth	474	976	1612	2635	3612	1021	3729	747	2008	3661
last decade	.24	.38	.28	.34	.40	.41	.35	.35	.33	.35

TABLE 54
EMBODY CROWN SPACE STUDY

Crown space	Diameter inside bark							
	16”	19”	22”	25”	28”	31”	33”	Average of all sizes
1-500 sq .ft.	.73	.56	.54	.59	.34	.37		.53
501-1000 sq. ft.	.70	.77	.62	.52	.51	.35	.75	.60
1001-1500 sq. ft.	.92	.66	.78	.50	.50	.43	.50	.61
1501-2000 sq. ft.	.90	.95	.79	.70	.64	.45	.47	.70
2001-3000 sq. ft.	.42	.52	.64	.47	.29	.49	.57	.49
3001 & up sq. ft.	.78	1.07	.73	.24	.67	--	.34	.64

From the tables it will be noticed that in the majority of cases there appears to be a tendency toward more rapid growth among the trees having an increasingly larger space surrounding them up to a certain point. Beyond this point, however, there appears to be falling off in rate of growth as though too much space where almost as unfavorable as too little. This is very likely due to the fact that areas unprotected from the sun and wind dry out more rapidly than areas shielded by the crowns of trees. It is not likely that in the case of mature yellow pine root competition is often very great, so that the advantage in this regard of being two or three hundred feet from any other tree would be nil.

The method just described of gathering the crown space data has been found to be too crude to give satisfactory results. In the case of tolerant, close grown trees some method of this sort might be practicable, but in the open-grown irregular type of forest characteristic of yellow pine, some other more careful method will have to be devised.

SUMMARY

In briefly summarizing this report, it may be noted that the data on growth of yellow pine was gathered in twenty different localities in eastern Oregon, and on three distinct types of soil; namely, pumice soil, gravelly or sandy soil, and soil from decomposed volcanic rock. It is believed that the derived tables on growth will be of great value in placing the National Forest under scientific management.

From an inspection of the diameter growth and height growth tables it will be noted that yellow pine growing under severe climatic conditions reaches the culmination of its mean annual growth at a later date than yellow pine growing under favorable climatic conditions; also that there is a size typical of mature yellow pine which trees of this species strive to attain. If growing in a good locality this average mature size is attained earlier than if growing in a poor locality.

It was found that notwithstanding popular opinion to the contrary, there does not appear to be any basis for the belief that young, so-called “bull pines” are growing at a faster rate now than formerly. In order to prove this absolutely, however, it will be necessary to analyze trees of all ages which have always been of the same tree class. This probably will not be practicable, as it will be impossible to tell if large trees have always been in the same tree class as at the present time.

It was found that young dominant yellow pines grow at a much faster rate in every region studied than the average of all the trees for the same region, so that the tables on average diameter growth would prove to be very conservative in predicting future growth on National Forests after scientific logging, when only the young, thrifty trees are left standing.

Open grown trees always sacrifice their height growth somewhat to diameter growth and vice versa, so that either diameter or height growth alone is not sufficient basis on which to predict future growth. One should never be considered without the other.

Seedling height growth is very slow, ten to twenty years being required to reach stump height, that is, a height between 18 and 24 inches.

Volume growth, B. F. is a better index of tree growth than either diameter or height growth because it is dependent on both of these to an equal degree for its determination. It is an interesting fact that the mean annual and current annual volume growths do not always culminate, due to the fact that a small increase in diameter in a large tree gives a greater proportional volume increase than the same increase in diameter in a small tree.

The table on increment percent shows that the rate percent of volume increase falls off rapidly as the tree grows older.

Height growth usually reaches its culmination earlier on favorable sites than on unfavorable sites.

Yellow pine prefers the cool north slopes to the dry hot slopes, but as it is a very intolerant tree it cannot compete with the more tolerant trees usually found on the north slopes. Where yellow pine does occur on north slopes it makes better growth than on the south slopes. Yellow pine can grow under more severe conditions than lodgepole or any other commercially important tree in District VI.

In a study to determine the importance of competition of yellow pine with members of its own species in a pure stand, it was found that up to a certain point an increasingly large space surrounding the individual tree stimulated growth. Beyond this point greater space appeared to be harmful and to retard growth, probably due to the drying effect of wind and sun over the unsheltered ground.