THE PROBABLE RATE OF GROWTH OF WESTERN YELLOW PINE IN CUT OVER AREAS, AS INDICATED BY SAMPLE PLOT STUDIES.

THESIS FOR DEGREE OF M. FOR

H. BASIL WALES

1916

Forestry

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In December, 1910, the Forest Service established three permanent sample plots in a recently cut over area in the Western Yellow Pine type, in the San Mateo mountains. All the trees above 3.5 inches in diameter were tagged and their diameters and heights recorded, as well as the characteristics of the individual. This study contemplated a remeasurement of the trees in September, 1915, with a comparison of the measurements to determine the periodic and annual growth and the rate of growth as influenced by disease, mistletoe, tree class, etc.

In order to make the growth data obtained comparable and applicable to other stands in the Southwest, it is necessary to record the general forest conditions in the locality, and the specific conditions within the areas themselves.

The Locality.

The San Mateo division of the Datil National

Forest is a large, isolated forest body growing upon the San Mateo mountain range. This range lies in a general north and south direction, and rises to a height of 9500 to 10500 feet. North and west of the main ridge of the mountains the slope to the adjoining rolling plains is very gradual; to the east and south the mountains break off almost abruptly to the plains. As a consequence the runoff of surface water is much less rapid to the north and west, and moisture conditions within the area are more favorable. The character of forest growth is indicative of this. On the east and south where the slope is very steep and abrupt, the forest vegetation is that of the woodland type; the species being principally juniper, (Juniperous monosperma and pachyphlea), pinon, (Pinus edulis), live oak, (Quercus chrysolepis and undulata), and mountain mahogany, (Cercocarpus breviflorus), while on the gradual slopes, retentive of moisture, the pure yellow pine type predominates. In the more moist places, as canyon bottoms and north slopes at the higher elevations, the composite type, comprised of yellow pine, (Pinus ponderosa), Douglas fir, (Pseudotsuga taxifolia), white fir, (Abies concolor), limber pine, (Pinus flexilis), may be found. Blue and Engelmann spruce, (Picea parryana and engelmanni), are found within the division. The broad leaf species are limited to Gambel's oak (Quercus gambelii), mountain maple, (Acer sp.), and aspen,

(Populus tremuloides), at the higher elevations, and cottonwood, (Populus angustifolia), along canyon bottoms at the lower elevations near the forest boundary.

Two forms of Pinus ponderosa are recognized; black jack, the younger and more thrifty, and yellow pine, the tree as it approaches maturity. Studies made by the Forest Service have determined that the black jack taper much more rapidly than the yellow pine. Hence the volume of a black jack in board feet and in cubic feet is less than the volume of a yellow pine having the same diameter and height. Separate volume tables for black jack and yellow pine have been prepared by the Forest Service, and these tables have been used, interpolating where necessary, in the computations of volumes herein given.

Plate I. shows in a comprehensive way the forest types within this division of the National Forest, the type lines being based upon the general knowledge of the forest cover on the part of the author.

The following table gives a general climatological summary of the conditions as recorded at Magdalena,* New Mexico, northeast of the San Mateo Division, and approximately thirty miles distant from the locality studied. Precipitation is, however, probably much higher and temperature lower on the sample plots than at Magdalena, by reason of the increased elevation.

Climatological Summary.

* Magdalena Cooperative Weather Station.

	Length of Record in Years.	Mean Annual.
Rainfall	10	14.3 (inches).
Snowfall	9	29.00 "
Mean Temperature	8	51.9°
Max. "	8	102.0°
Min. "	8	-21.0°

* Magdalena is taken as the governing station since it is the nearest one having generally similar conditions.

These figures give a general idea of climatical conditions in this portion of New Mexico, but are not typical of the forest regions because of the general higher altitude of the forests and of topographic features which influence the climate. The prevailing winds are from the southwest.

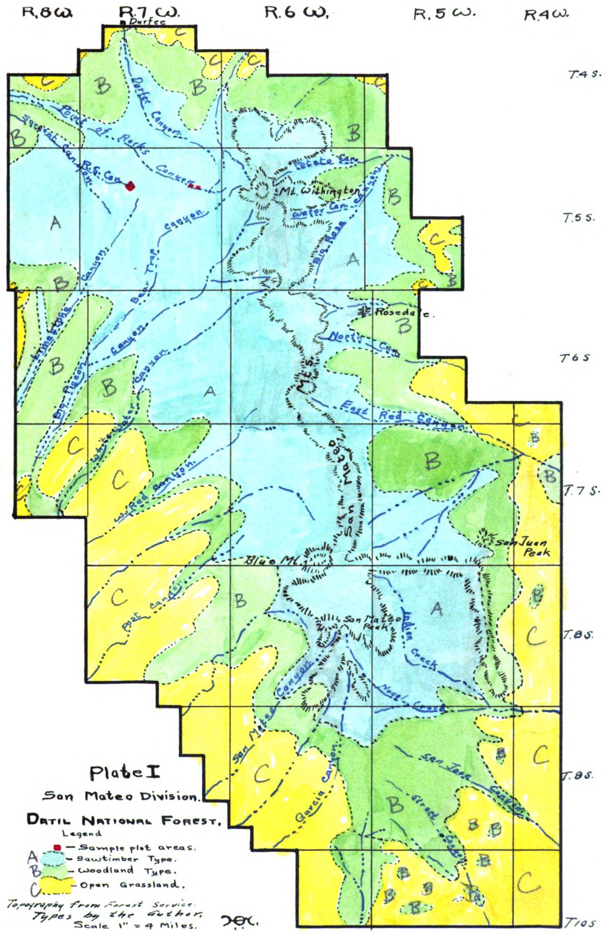
The Areas.

The three permanent sample plots, aggregating a total acreage of 26.4 acres, were laid out in the canyon bottoms and on the slopes of Ranch Supply and Point of Rocks canyons, which rise near the summit of the San Mateo mountains and drain northwest to the basin of the San Augustine Plains, a bolson plain sixty miles long and twenty to forty miles wide, which lie on the Continental Divide and have no surface outlet. The largest

of the three plots consists chiefly of a broad flat at the head of the canyon and is surrounded by low ridges. The other two plots lie on the south slope of Point of Rocks Canyon and have a southwest exposure. The slope within the three plots varies from 3% to approximately 50%. Plate I. shows the relative location of the three areas within the Division. Plates II., III., and IV. indicate the individual areas. The topography is merely sketched without the use of a level, but shows well the general nature of the area.

Basing an estimate upon the stand of virgin timber in similar locations in the vicinity, and checking by the size and frequency of stumps on the cut over areas, the author estimates an average of approximately 6 M feet B. M. per acre grew upon the largest plot prior to logging, and about 5 M feet B. M. per acre upon each of the two smaller plots. The virgin stand was largely Western Yellow Pine, although some Douglas fir and Limber pine was present, and was many aged. An excellent stand of advance growth was present on the more favorable portion of the area, but upon the exposed south slopes the reproduction was, as a whole, very scant.

The first cutting was made in the locality about twentyfive years ago, when a few of the very best trees were removed from the largest plot. Only the clear portion of the bole was logged, the remainder being left on the ground.


R.8 W.
R.7 W.
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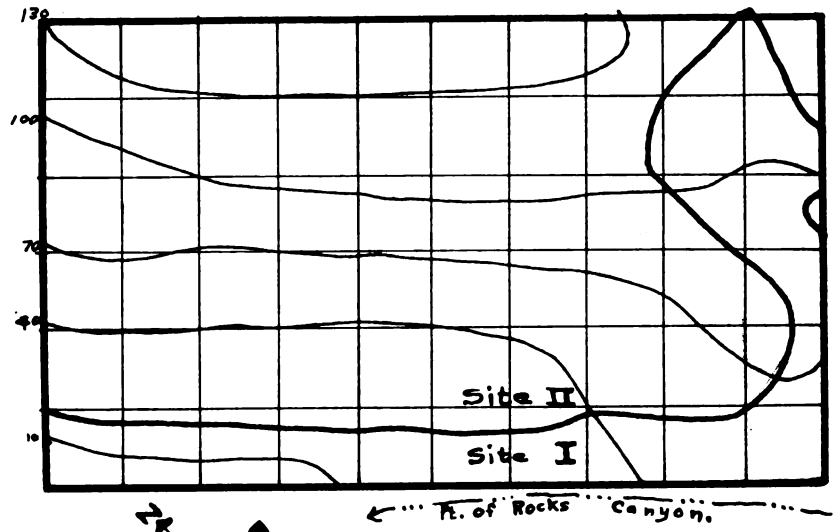
T10 S
Durfee
Durfee Canyon
Point of Rocks Canyon
Sargent Canyon
R.S. Can.
Mt. Withington
Water Can.
Bear Trap Canyon
Rosedale
North Can.
East Red Canyon
San Mateo Mts.
Limestone
Big Pigeon
W. Red Canyon
Blue Mt.
San Juan Peak
San Mateo Peak
Indian Creek
Post Canyon
San Mateo Canyon
Garcia Canyon
San Jose Canyon
A
B
C
Plate I
San Mateo Division.
Datil National Forest.
Legend
— Sample plot areas.
A — Sawtimber Type.
B — Woodland Type.
C — Open Grassland.
Topography from Forest Service.
Types by the author.
Scale 1" = 4 Miles.



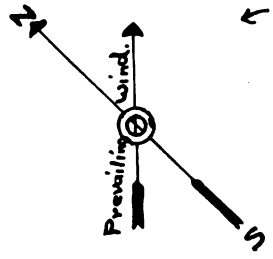
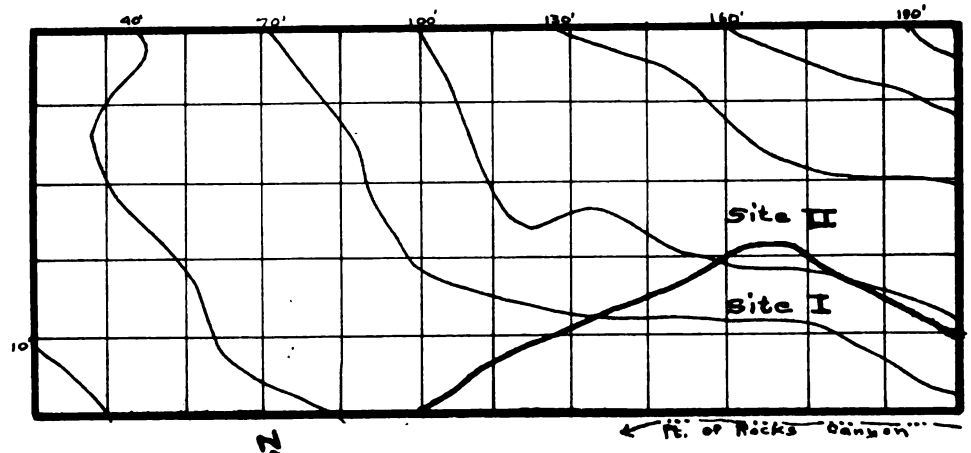


Plate II
Plot S-1-A
Sites I & II
San Mateo Division
Datil National Forest
Scale - 1 inch = 2½ ch.



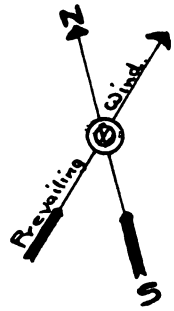
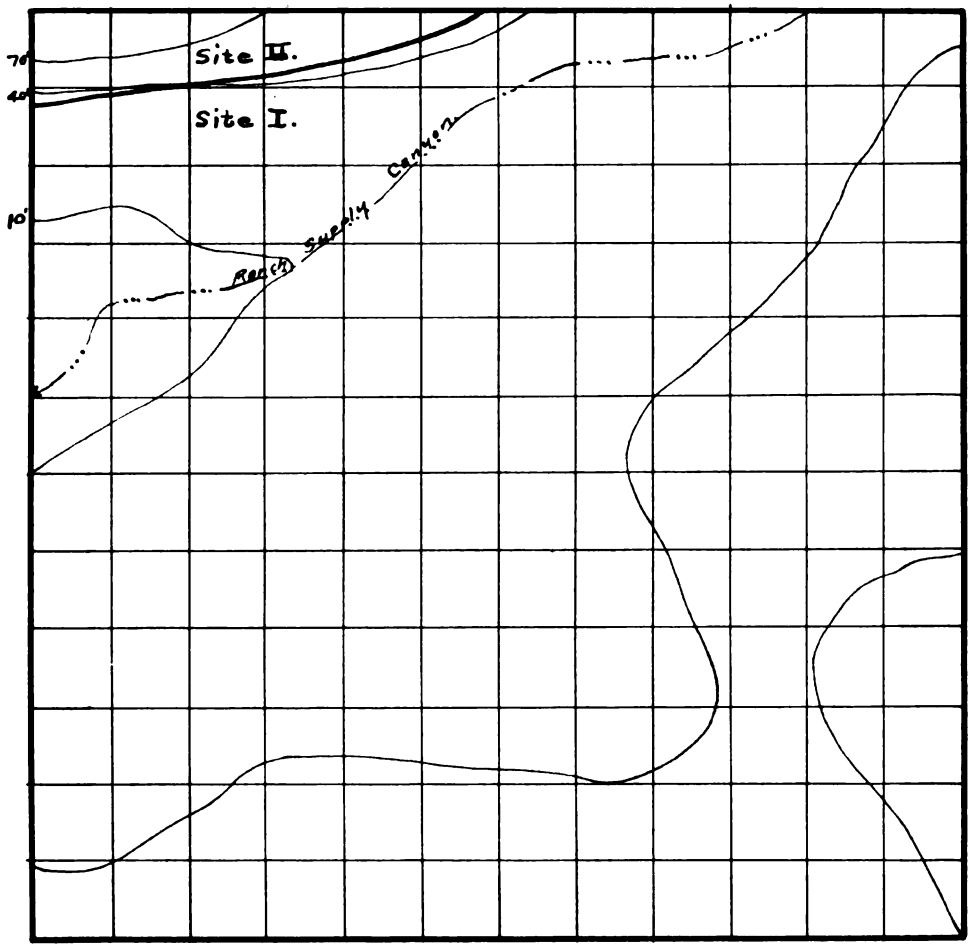


Plate III
Plot S-1-B
Sites I & II
San Mateo Division
Datil National Forest.
Scale 1 inch = 2 ½ ch.



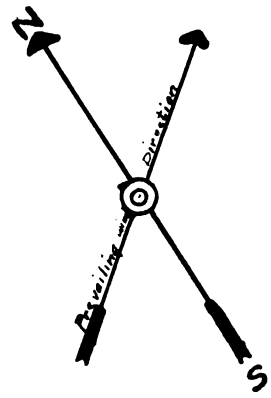


Plate IV.

Plot S-2-A
Sites I & II
area - 14.4 A.
San Mateo Division.
Datil National Forest.
Scale 1" = 2½ ch.

The next cutting was made in this vicinity from 1907 to 1910, the areas upon which this study was made being cut over in the summer and fall of 1910, a few months prior to the laying out of the plots and the initial measurement of the trees.

In marking the timber for cutting a selection system was used. At first a minimum diameter limit of eighteen inches was used in marking. But trees below this limit were often marked and trees above the limit were left standing where such action was deemed necessary for reseeding purposes or to insure protection to the forest against windfall or the undue drying out of the soil, caused by excessive openings in the crown cover. Later the minimum limit was reduced to fourteen inches, which is now the average on the Datil National Forest under the present Forest Service silvicultural policy.

Brush within the areas was disposed of by lopping and scattering, piling, piling and burning, and a very small amount by broadcast burning, according to proximity to stands of reproduction, necessity for preventing erosion on the steeper slopes, etc.

In 1910, at the time of the initial measurement, 1759 trees were recorded, of which 1575, or 89% were Western yellow pine; 51, or 3% were Douglas fir; and 133, or 8%, were limber pine. Of the 1575 yellow pine trees 1342, or 85%, were classed as black jack, and the

remainder, 233 trees, or 15%, were mature yellow pine.

The following table shows the number of trees in 1910 and 1915 by species, and the percent of the total number of trees.

	Number of Trees.			
Species	1910	% of Total: 1910	1915	% of Total. 1915.
Black Jack	1342	-	1420	-
Yellow Pine	233	-	264	-
Total for Species	1575	89	1684	89
Douglas Fir	51	3	50	2.6
Limber Pine	133	8	153	8.4

The greater percent of the trees now growing upon the plots will average from twentyfive to fifty years old, although a few individuals fully two hundred years old were left for reseeding or protective purposes. As is characteristic of Western yellow pine, the trees occur in groups of greater or less area.

84% of the trees now standing may be classed as dominant or codominant or as growing in the open.

Tree Class in 1915. (Western Yellow Pine only).

	No. of Trees:	% of Total
Dominant	259	15
Codominant	687	41
Intermediate	240	14
Suppressed	28	2
Growing in Open	470	28
Total	1684	100

Factors Influencing Growth.

(a) Climate.

A study of climatological conditions as recorded by the U. S. Weather Bureau does not show any material departure in the average amount of precipitation recorded at Magdalena, New Mexico, during the five year period covered by this study, from that established as the mean annual for a much longer period. The precipitation during 1911 and 1914 was considerably above the average, while the other three years are shown to have been practically normal. Since the climatic conditions during the five year period do not vary greatly from the average, the periodic and average annual growth as determined by this study will not be materially greater or less than the average during a long period of years,

other conditions being the same.

(b) Site Quality.

Two distinct sites may be recognized, the distinguishing characteristics being mainly soil, slope, and exposure. Upon Site I. the soil is a deep gravelly clay loam, having considerable humus and being retentive of moisture. This site is found on the canyon bottoms and the protected north slopes. Upon Site II. the soil is shallow and of a gravelly and mineral nature, having but little humus and being well drained. Without exception this site is found occupying the ridges and the exposed south slopes. The site quality influences greatly the number of trees per acre and the rate of growth. Approximately 16.0 acres is classed as Site I. and 10.4 as Site II. The following tables have been prepared:

Comparative Density. (All Species).

	Site I.		Site II.	
	1910:	1915:	1910:	1915:
No.Trees. Black Jack :	850:	875:	492:	545:
" " Yellow Pine:	108:	120:	125:	144:
Total for Species :	958:	995:	617:	689:
Limber Pine :	40:	40:	93:	113:
Douglas Fir :	20:	20:	31:	30:
Total No. Trees :	1018:	1055:	741:	832:
Average per acre :	64:	66:	71:	80:

Comperative Volumes - Western Yellow Pine.

	1910		1915	
Site I.	* Board Ft:	Cu. Ft. :	Bd. Ft:	Cu. Ft.
Black Jack	1672 :	9723.4 :	2266 :	10871.0
Yellow Pine	2225 :	4872.5 :	2669 :	5730.7
Total for Species:	3897 :	14595.9 :	4930 :	16601.7
Average per acre :				
Black Jack	104 :	607.7 :	217 :	1045.3
Yellow Pine	139 :	304.5 :	256 :	551.0
Av.for Species:	243 :	912.2 :	474 :	1596.3

* All board feet figures in this study are in tens unless otherwise specified, and are given only for trees above 12" D. B. H.

Comparative Volumes - Western Yellow Pine.

	1910		1915	
Site II.	Bd. Ft:	Cu. Ft. :	Bd. Ft:	Cu. Ft.
Black Jack	279 :	2955.5 :	343 :	3148.4
Yellow Pine	835 :	2642.6 :	1073 :	3244.7
Total for Species:	1114 :	5598.1 :	1416 :	6392.1
Average per Acre :				
Black Jack	27 :	284.1 :	33 :	302.7
Yellow Pine	80 :	254.1 :	103 :	311.9
Av.for Species:	107 :	538.2 :	136 :	614.6

Trees and Volumes by Inch Diameter Classes.

Black Jack - Site I.

In.	No. Trees 1910	No. Trees 1915	Vol. Bd. Ft. 1910	Vol. Bd. Ft. 1915	Av. Vol. per Tree 1910	Av. Vol. per Tree 1915	Vol. Cu. Ft. 1910	Vol. Cu. Ft. 1915	Av. Vol. per Tree 1910	Av. Vol. per Tree 1915
4	17	36					24.5	37.4	1.4	1.0
5	89	65					178.9	118.4	2.0	1.8
6	95	78					296.1	225.3	3.1	2.9
7	105	91					475.5	369.0	4.5	4.1
8	104	97					639.2	574.1	6.1	5.9
9	82	90					739.1	720.1	9.0	8.0
10	85	75					1038.7	823.7	12.2	11.0
11	68	86					1036.4	1208.0	15.2	14.0
12	60	63	202	212	3	3	1057.9	1080.5	17.6	17.2
13	47	61	271	340	6	6	1000.7	1239.7	21.3	20.3
14	31	40	258	312	8	8	807.7	974.5	26.1	24.4
15	26	28	269	279	10	10	795.0	814.5	30.6	29.1
16	17	26	221	336	13	13	587.2	902.2	34.5	35.5
17	16	16	259	259	16	16	627.8	625.3	39.2	39.1
18	4	12	84	223	21	19	192.3	518.6	48.0	43.2
19	2	6	47	152	23	25	102.5	327.2	51.3	54.5
20	1	4	23	113	23	28	49.8	234.5	49.8	58.6
21	1	1	38	40	38	40	74.5	78.0	75.5	78.0

Trees and Volumes by Inch Diameter Classes.

Yellow Pine - Site I.

In.	No. Trees: 1910	No. Trees: 1915	Vol. Bd. Ft.: 1910	Vol. Bd. Ft.: 1915	Av. Vol. per Tree: 1910	Av. Vol. per Tree: 1915	Vol. Cu. Ft.: 1910	Vol. Cu. Ft.: 1915	Av. Vol. per Tree: 1910	Av. Vol. per Tree: 1915
7	2	2					5.3	6.9	2.6	3.4
8	1	1					4.4	5.8	4.4	5.8
9	2	3					27.7	31.3	13.8	10.4
10	3	1					39.5	7.0	13.1	7.0
11	2	4					24.0	73.5	12.0	18.4
12	9	8	31	37	3	4	190.0	159.5	21.1	19.9
13	8	8	59	64	7	8	179.2	185.2	22.4	23.1
14	12	9	145	105	12	12	354.3	262.2	29.5	29.1
15	8	13	104	172	13	14	253.6	419.4	31.7	32.2
16	18	12	283	185	16	15	648.6	435.5	36.0	36.3
17	11	17	229	344	21	20	512.7	773.7	46.7	45.5
18	10	12	240	275	24	23	518.6	594.6	51.8	49.6
19	7	10	207	298	30	30	429.0	615.1	61.3	61.5
20	3	4	121	134	40	34	237.5	268.0	79.2	67.0
21	2	4	86	164	43	41	164.5	315.5	82.2	78.9
22	2	2	86	116	43	58	161.0	217.0	80.5	108.5
23	1	1	52	43	52	43	94.5	80.5	94.5	80.5
24	5	1	332	49	66	49	593.9	88.5	118.8	88.5
25	-	5	-	351	-	70	-	625.0	-	125.0
26	-	1	-	64	-	64	-	115.0	-	115.0
27	-	-	-	-	-	-	-	-	-	-
28	1	1	101	101	101	101	175.5	175.5	175.5	175.5
29	1	1	149	166	149	166	249.7	276.0	249.7	276.0

Trees and Volumes by Inch Diameter Classes.

Black Jack - Site II.

In.	No. Trees 1910	No. Trees 1915	Vol. Bd. Ft. 1910	Vol. Bd. Ft. 1915	Av. Vol. per Tree 1910	Av. Vol. per Tree 1915	Vol. Cu. Ft. 1910	Vol. Cu. Ft. 1915	Av. Vol. per Tree 1910	Av. Vol. per Tree 1915
4	24	52					26.8	46.3	1.1	.9
5	65	62					104.2	81.1	1.6	1.3
6	91	77					225.8	167.6	2.4	2.2
7	64	81					222.3	252.8	3.5	3.1
8	64	63					304.9	277.9	4.8	4.4
9	52	62					341.9	375.6	6.6	6.1
10	50	50					419.1	407.1	8.4	8.1
11	31	36					342.0	386.9	11.0	10.8
12	25	25	73	67	3	3	355.5	325.2	14.2	13.0
13	8	18	33	81	4	4	129.0	302.9	16.1	16.6
14	8	7	54	44	7	6	166.8	136.2	20.8	19.5
15	5	5	46	43	9	9	132.7	121.3	26.5	24.3
16	3	5	35	62	12	12	95.2	165.8	31.7	33.3
17	1	-	20	-	20	-	46.8	-	46.8	-
18	1	1	18	22	18	22	42.5	49.5	42.5	49.5
19	-	1	-	24	-	24	-	52.2	-	52.2

Trees and Volumes by Inch Diameter Classes.

Yellow Pine - Site II.

In.	No. Trees 1910	No. Trees 1915	Vol. Bd. Ft. 1910	Vol. Bd. Ft. 1915	Av. Vol. per Tree 1910	Av. Vol. per Tree 1915	Vol. Cu. Ft. 1910	Vol. Cu. Ft. 1915	Av. Vol. per Tree 1910	Av. Vol. per Tree 1915
5	2						6.7		3.3	-
6	1	2					3.5	5.9	3.5	3.0
7	1	1					5.9	6.8	5.9	6.8
8	3	4					19.3	17.8	6.4	4.4
9	6	7					37.3	50.9	6.2	7.3
10	10	10					98.8	89.8	9.9	9.0
11	18	16					224.3	209.5	12.4	13.1
12	14	19	61	60	4	3	252.5	310.5	18.0	16.3
13	18	15	111	80	6	5	365.7	285.5	20.3	19.0
14	22	24	168	196	7	8	503.1	572.4	22.9	23.8
15	8	19	87	192	11	10	227.6	515.5	28.4	27.1
16	9	7	118	100	13	14	284.5	237.5	31.6	33.9
17	6	10	95	167	16	17	218.9	378.6	36.5	37.9
18	1	4	17	80	17	20	39.5	172.0	39.5	43.0
19	3	1	85	27	28	27	173.0	56.0	57.7	56.0
20	2	3	54	89	27	29	109.5	180.5	54.7	60.2
21	1	1	39	38	39	38	72.5	74.0	72.5	74.0
22	0	1	-	44	-	44	-	81.5	-	81.5

Trees and Volumes by Inch Diameter Classes.

Western Yellow Pine (Pinus ponderosa). Site I.

	No. Trees		Vol. Bd. Ft.		Av. Vol. per tree		Vol. Cu. Ft.		Av. Vol. per Tree.	
In.	1910	1915	1910	1915	1910	1915	1910	1915	1910	1915
4	17	36					24.5	37.4	1.4	1.0
5	89	65					178.9	118.4	2.0	1.8
6	95	78					296.1	225.3	3.1	3.0
7	107	93					480.8	375.9	4.5	4.0
8	105	98					643.6	579.9	6.1	6.0
9	84	99					766.8	751.4	9.1	7.6
10	88	76					1078.2	830.7	12.2	10.9
11	70	90					1060.4	1281.5	15.1	14.2
12	69	71	233	249	3	4	1247.9	1240.0	18.1	17.5
13	55	69	330	404	6	6	1179.9	1424.9	21.5	20.7
14	43	49	403	417	9	9	1162.0	1236.7	25.0	25.2
15	34	41	373	451	11	11	1048.6	1233.9	30.8	30.1
16	35	38	504	521	14	14	1235.8	1337.7	35.3	35.2
17	27	33	488	603	18	18	1140.5	1399.0	42.2	42.4
18	14	24	324	499	23	21	710.9	1113.2	50.8	46.4
19	9	16	254	450	28	28	531.5	942.3	59.1	58.9
20	4	8	144	247	36	31	287.3	502.5	71.8	62.8
21	3	5	124	204	41	41	239.0	393.5	79.7	78.7
22	2	2	86	116	43	58	161.0	217.0	80.5	108.5
23	1	1	52	43	52	43	94.5	80.5	94.5	80.5
24	5	1	332	49	66	49	593.9	88.5	118.8	88.5
25	-	5	-	351	70	-	-	625.0	-	125.0
26	-	1	-	64	-	64	-	115.0	-	115.0
27	-	-	-	-	-	-	-	-	-	-
28	1	1	101	101	101	101	175.5	175.5	175.5	175.5
29	1	1	149	166	149	166	249.7	276.0	249.7	276.0

Trees and Volumes by Inch Diameter Classes.

Western Yellow Pine (Pinus ponderosa). Site II.

	No. Trees		Vol.Bd.Ft.		Av.Vol.per Tree		Vol. Cu. Ft.		Av.Vol. per Tree.	
In.	1910	1915	1910	1915	1910	1915	1910	1915	1910	1915
4	24	52					26.8	46.3	1.1	.9
5	67	62					110.9	81.1	1.7	1.3
6	92	79					229.3	173.5	2.5	2.2
7	65	82					228.2	259.6	3.5	3.2
8	67	67					324.2	295.7	4.8	4.4
9	58	69					379.2	426.5	6.5	6.2
10	60	60					517.9	496.9	8.6	8.3
11	49	52					566.3	596.4	11.6	11.5
12	39.	44	134	127	3	3	608.0	635.7	15.6	14.4
13	26	33	144	161	6	5	494.7	588.4	19.0	17.8
14	30	31	222	240	7	8	669.9	708.6	22.3	22.9
15	13	24	133	235	10	10	360.3	636.8	27.7	26.5
16	12	12	153	162	13	14	379.7	403.3	31.6	33.6
17	7	10	115	167	16	17	265.7	378.6	38.0	37.9
18	2	5	35	102	18	20	82.0	221.5	41.0	44.3
19	3	2	85	51	28	26	173.0	108.2	57.7	54.1
20	2	3	54	89	27	30	109.5	180.5	54.8	60.2
21	1	1	39	38	39	38	72.5	74.0	72.5	74.0
22	-	1	-	44	-	44	-	81.5	-	81.5

Note-. The variance between the average volume per tree of the same diameter class in 1910 and 1915 is due to the unequal heights of the trees and unequal height growth.

Increment.

Periodic Increment	Black Jack				Yellow Pine				Total for Species.			
	Bd.Ft.	%	Cu.Ft.	%	Bd.Ft.	%	Cu.Ft.	%	Bd.Ft.	%	Cu.Ft.	%
Site I.	589	35	1147.6	12	444	20	858.2	18	1033	26	2005.8	14
Site II.	64	25	192.9	6.5	238	28	602.1	23	302	27	794.0	16
Annual Increment												
Site I.	118	7	229.5	2.4	89	4	171.6	3.6	206	5.2	401.2	2.8
Site II.	13	4.5	38.6	1.3	47	7	120.4	4.5	60	5.4	158.8	3.2
Av. Annual Increment per Acre												
Site I.	7	-	14.3	-	6	-	10.7	-	14	-	25.1	-
Site II.	1	-	3.7	-	5	-	11.5	-	6	-	15.2	-

(c) Tree Classification.

The following tables show for Sites I., and II. the relative number of trees and volumes in board and cubic feet for each tree class. Since a number of trees recorded as black jack in 1910 have changed to yellow pine in the 1915 records, the two forms have not been shown separately but the tables have been prepared for Western Yellow Pine as a species.

Apparently the rate of growth is approximately the same whether the tree be dominant, codominant, or in the open. However, the mature yellow pine which have been left for seed insurance and which have a very slow growth, are entirely within the dominant class or growing in the open. The presence of these trees with their large volume as compared with the numerous smaller trees and smaller volume, greatly reduces the increment percent in these two classes. The apparently large increment percent of the intermediate and suppressed classes is due to the fact that a majority of the new trees recorded, (those reaching a diameter of four inches during the five year period), fall within these classes. Neglecting the new trees, the increment percents for intermediate and suppressed trees for Site I. are 10% and 5.7%, and for Site II., 11.6% and 2.4% respectively.

The board feet increments are of interest as indicative of the actual growing stock upon the two sites. As the smaller trees reach the 12" diameter class, the board feet increment will undoubtedly increase rapidly with each five year period, until most of the trees are of sawtimber size, after which the increment percent will approach a normal, sustained amount.

Tree Classification. Site I.

Class: 1915	No. Trees	Vol. Bd. Ft: 1910	1915	Increment Bd. Ft:	%	Vol. Cu. Ft. 1910	1915	Increment. Cu. Ft.:	%
D	168	1494:	1868:	374	25:	4436.2:	5054.0:	617.8	14
C	421	619:	1151:	532	86:	4918.3:	5640.6:	722.3	14
I	140	55:	64:	9	16:	654.4:	744.7:	90.3	17
S	20	- :	- :	-	-:	45.7:	57.0:	11.3	24
X	246	1529:	1852:	323	21:	4476.2:	5105.4:	629.2	14

Tree Classification. Site II.

	No. Trees	Vol. Bd. Ft: 1910	1915	Increment Bd. Ft:	%	Vol. Cu. Ft. 1910	1915	Increment. Cu. Ft.:	%
D	91	274:	365:	91	37:	1143.6:	1332.7:	189.1	17
C	266	202:	279:	77	38:	1855.8:	2108.2:	252.4	14
I	100	- :	- :	-	- :	193.4:	246.0:	52.6	26
S	8	- :	- :	-	- :	16.3:	20.4:	4.1	25
X	224	638:	772:	134	21:	2375.3:	2923.8:	548.5	23

In 1910, 221 trees were recorded as being suppressed prior to logging, but the logging and consequent opening of the crown cover to more light has allowed 146 trees to recover from their previous suppression.

(d) Injury by Lightning, Fire and Logging.

The following table shows the number of trees injured by lightning, fire, and logging, or other mechanical injuries, and the percent of the total number of trees on each site.

	Site I.		Site II.	
	No. Trees	% of Total	No. Trees	% of Total.
Lightning	1	0.1	1	0.1
Fire	59	6.0	29	4.2
Logging	15	1.5	11	1.6
Total	75	7.6	41	5.8
Av. per Acre	5	-	4	-

Total for entire area 116 . % of total 6.8

Average number of injured trees per acre 4.

There are probably too few trees to indicate any true effect of the injury upon the rate of growth.

However, in many cases the injury results in the death of the tree or in weakening it to such an extent as to make it susceptible to insect attack. The wood is exposed to the attack of borers and invariable becomes pitchy. The quality of the timber is seriously impaired even though the injury is not serious enough to affect the rate of growth.

(e) Mistletoe.

Mistletoe ultimately causes the death of many of the trees either directly or as a contributing factor. In marking the timber for cutting on these plots no attention was given to the presence of mistletoe infected trees. The opening of the crown cover has made conditions more favorable for the spread of the parasite. Whereas only sixty one trees were recorded as being infected in 1910, five years later mistletoe was found on one hundred and four trees, an increase of 66 2/3 %. The conditions on these plots bear out the result obtained in more extensive studies made by the Forest Service in the Southwestern District. In marking timber for cutting under current sales mistletoe infected timber is discriminated against, and by this means it is believed the further spread of the parasite

will be checked. A table has been prepared showing the number of infected trees and the total increment by sites.

Mistletoe Infected Trees.

		Vol.Bd.Ft:	Increment:	Vol.Cu.Ft.	Increment.
	No.Trees:	1910: 1915:	Bd. Ft.	1910: 1915:	Cu.Ft: % .
Site I.:	53	160: 208:	48	667.3: 759.5:	92.2: 15
Site II.:	75	89: 118:	29	488.4: 562.0:	73.6: 15

(f) Injury by Porcupine and Squirrels.

Seventy nine trees were recorded in 1915 as being injured by porcupine and squirrels on Site I., and nine on Site II. These animals girdle the leader and the smaller branches. Of the two, the porcupine does the greater damage since it usually attacks the leader of thrifty trees, often killing it back from two to six feet. Height growth is checked until a side branch becomes the leader. The bole of the tree develops a crook which may or may not be overcome as the tree grows older. The dead leader often becomes the center of infection of a heart rot, thus reducing the quality of the timber. Attack by these animals varies with the locality,

as it is known they infest some regions more than others. Plot S-2-A was most seriously infested.

(g) Growth as Influenced by Insects, Disease, etc.

For the purpose of comparison, all trees recorded as unhealthy in either the 1910 or 1915 measurement or in both, have been grouped. In this table black jack and yellow pine have been classed together.

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Unhealthy Trees.

	Site I.	Site II.
Unhealthy 1910	215	178
No. Recovered.	144	118
No. Dead	14	10
Unhealthy 1915	83	72
Unhealthy new Trees	10	15
Total Unhealthy either Year or Both.	241	200

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Rate of Growth of Unhealthy Trees.

	Vol.Bd.Ft.		Increment		Vol. Cu. Ft.		Increment.	
	1910	1915	Bd.Ft:	%	1910	1915	Cu.Ft.:	%
Site I.	571	649	78	13	2360.3	2465.8	105.5	4.5
Site II.	305	347	42	13	1537.4	1635.5	98.1	6.3

Rate of growth of Healthy Trees.

	Vol.Bd.Ft.		Increment		Vol. Cu. Ft.		Increment.	
	1910	1915	Bd.Ft:	%	1910	1915	Cu.Ft.:	%
Site I.	3326	4281	955	28	12235.6	14135.9	1900.3	15
Site II.	809	1069	260	32	4060.1	4756.6	696.5	12

	Site I.	Site II.
No. Trees died during period	14	10
Volume 1910	66.0	44.2
New Trees recorded in 1915	51	82
Volume 1915	59.6	80.1

Diameter Height Growth.

The average diameter growth for the five year period on Site I. is 0.85 inches for black jack, and 0.76 inches for yellow pine; on Site II. it is 0.71 inches for black jack, and 0.52 inches for yellow pine.

The average height growth for Site I. is approximately five feet for the five year period; on Site II. it is approximately three feet.

Summary of Results.

(1). The increment percent is influenced more or less by the amount of growing stock.

(2). The presence of mature timber left as "fire insurance" for reseeding purposes reduces the increment percent.

(3). Site quality influences the rate of growth to the greatest extent, the more rapid rate being, of course, on the better site. The diameter growth indicates this factor in the most pronounced degree, and is probably not so greatly influenced by the amount of growing stock as is the increment percent. On Site I. the average volume per tree for the same diameter class is larger than on Site II. The average height is therefore less on Site II. than on Site I. The smaller increment percent on Site I., (see table on page seventeen), is probably entirely due to differences in growing stock.

(4). Opening of the crown cover, by removal of the sawtimber, allows many suppressed trees to recover their former vigor. It does not follow, however, that these trees will retain their vigor, since some are permanently injured, while others will again become suppressed in future light competition.

(5). Fire and logging damage approximately seven per cent of the stand. These injuries are preventable by efficient protective measures and reasonable care in logging.

(6). Opening of the stand allows mistletoe infestations to spread and the growth is probably lessened correspondingly. Special rules for marking timber are necessary in infested areas.

(7). Damage by porcupines and squirrels varies with the number of animals in a given region.

(8). The physical condition of a tree influences the rate of growth, unhealthy trees apparently growing only one third to one half as much as healthy ones.

(9). Assuming the diameter growth to remain constant for each five year period in the future, the majority of the trees on Site I. will reach sawtimber size in twelve periods, or sixty years, and in four additional periods the stand will probably be mature and ready for a second cut. Assuming the average age of the stand to have been forty years in 1910, and allowing ten years as a factor of safety, a rotation of one hundred and thirty years is indicated. Since Site II. has a slower annual growth, the rotation will be

increased correspondingly.

(10). Because of the short interval elapsing since the virgin stand was opened, the mortality is less than it will be when the stand is again crowded. There is, therefore, no data available as to the probable stand at the end of the period of rotation, but it is safe to predict that the stand will at least be equal to the stand in 1910 before cutting was begun.

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