Studies of Planting Methods and Specific Gravity of Ponderosa Pine Grown in the Willamette Valley

by

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A Thesis

Presented to the Faculty

of the

School of Forestry

Oregon State College

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science

June 1940

Approved:

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Professor of Forestry

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Part II

INTRODUCTION

A. History of the Experiment.

The experiments on the methods of planting began in 1932 when T. J. Starker, Professor of Forestry, Oregon State College, and A. C. McIntire, then research forester for Pennsylvania State College, argued the pros and cons of puddled seedlings for planting. Tests were first begun at Pennsylvania State College which consisted of planting 1600 Norway pine (Pinus resinosa S.) 3-0 seedlings by 8 different methods. It suffered considerable damage from rabbits which made its value ineligible for a basis of planting technique. Later the plantation was destroyed by frost heaving and the project has since been abandoned.

In the fall of 1932 and the spring of 1933, the test was repeated twice using Ponderosa pine (Pinus ponderosa Law.) stock. These plantations were located on the McDonald Forest, Oregon State College, seven miles north of Corvallis, on highway 99-W. The object of the test was to determine if there would be any preferable method of field planting forest stock and, in part, to determine the amount of root exposure the seedlings would withstand.

B. Planting Procedure.

The trees to be planted were carefully graded as to size and condition with special attention given to the root systems. They were planted four feet apart in rows spaced

at eight feet. (Carefully supervised student labor was used.) Each row contained 50 trees, and each method of planting was repeated four times for both fall and spring planting. The methods were repeated in series so any small inequalities in site would tend to be balanced.

Fall Planting.

The sod was stripped from planting spots on October 20, 1932.

All trees were planted October 28, 1932.

1-1 Pinus ponderosa stock raised at the Clarke McNary nursery was used.

Temperature 67° F.

Relative Humidity 82%.

All planting was started on the south end of the rows.

It was a partially cloudy day, and rain fell the night of October 30, 1932.

The north end of the rows are labelled with aluminum tags indicating the method used on that row.

Lath are numbered on the south end of rows.

Spring Planting.

Sod stripping and planting all took place on the afternoon of April 10, 1933.

Temperature 53° F.

Relative Humidity 56%.

Two days before planting it had snowed 2 inches on

the area. It was cloudy when planting, thus the exposure of 15 minutes, 30 minutes and 60 minutes was not too severe.

A light rain fell the night following planting.

The method of planting was recorded on lath at the south end of each row; aluminum tags were substituted on April 18, 1933.

All planting was started on the south end of each row.

Methods Used in Planting.

Row 1. Cone planting. Theoretically, by building up a small cone of good earth in the bottom of the planting hole and spreading the roots over this cone, excellent results should be obtained. In the Pennsylvania test, 3-0 Norway pine seedlings were used and having a well-defined main root, did not lend themselves well to this method. The Oregon grown stock was 1-1 Ponderosa pine and had a more fibrous and branching root system. At the best, this was a slow and expensive method of planting.

Row 2. Puddled planting. A preparation of earth and water was used in this series making up a quantity about the consistency of thick cream and keeping the plants in the mixture during the progress of planting. Careful mattock planting was used in placing the seedlings in the ground. Toumey says "Puddling is not necessary and usually does more harm than good."

Row 3. Bunched. Great stress has been placed on the duty of a tree planter in getting the roots down straight and in a natural position. However, Cheyney in Minnesota made a limited test to determine the purposeful bunching of roots and found little difference in results. In this series, the roots were bent back one half their length and inserted in a spade-made slit. The root depth was therefore decreased one-half compared to that of the regularly planted stock.

Row 4. Slit planting. These trees were planted by the slit method. A heavy steel dibble or straight spade was used to make the slit and the roots were inserted to their natural depth. Care was used in closing the bottom of the slit so as not to leave an air pocket. The roots were comparatively well distributed over the surface of the slit.

Rows 5-6-7. 15, 30, and 60 minute exposure. Planted in this order was a series of three sets of plants, the first being exposed to the sun 15 minutes, the second 30 minutes, and those of row 7, 60 minutes. The plants were spread out on the ground so that the roots were directly exposed to the sun's rays. A thermometer placed between the roots recorded the maximum temperature.

The fall planted Oregon stock was exposed to a maximum temperature of 67° F. and a relative humidity of 82%. The spring planted stock was affected by a temp-

erature of 53° F. and a relative humidity of 82%.

All these trees were wrapped in moist burlap at the end of their exposed period and planted in a workmanlike manner with mattocks.

Row 8. Mattock planting. Carefully prepared mattock planting, with no special treatment of the stock, was used in these rows.

The Oregon fall planting occurred October 28, 1932, and a small amount of rain fell the night of October 30.

Two days before the Oregon spring planting, April 10, 1933, a snow of 2 inches covered the ground and during the planting day the weather was cloudy, and conditions were generally good for planting.

DESCRIPTION OF THE PLANTED AREA

A. Geographical.

The plantation lies in forty number eight, section 36, Township 11 South, Range 5 West, Willamette Meridian in the Peavy Arboretum.

The area is easily accessible from the town of Corvallis by taking U.S. highway 99-W north for 7 miles to the present site of the Arboretum Civil Conservation Corps camp. At this point, the gravel road to the Clarke-McNary nursery leads to the area which lies seven-tenths of a mile from the highway. Cars can be parked at the gate at this point and the plantation lies a hundred feet to the north of the point.

The area is more or less 3.43 acres. Its surface nowhere exceeds 25 percent slope and will average approximately 12 percent, having an average aspect of northeast. The elevation ranges from 330 to 430 feet above mean sea level.

B. Silvicultural Description.

Soil. The soil throughout the plantation is of the Aikin-Clay type and is of the same type as the soil found in the remainder of the Peavy Arboretum. This soil is generally considered good for the growth of conifers, expecially Douglas fir and White fir.

The pH value of this soil is 6.0 to 6.3 being determined by tests carried on by the Soils Department of the School of Agriculture, Oregon State College.

Several tests of the soil in different portions of the plantation were made with soil auger. The following statistics show the depth of layers A and B in various tests.

Exposure	Layer	Depth of Soil (inches)
North	A	24
Do	B	14
Northeast	A	21
Do	B	14
Southeast	A	20
Do	B	7
Southwest	A	23
Do	B	11

The soil taking the area as a unit is medium to poorly drained. The soil is heavy, and there is only a thin layer of humus and litter, so there is some tendency for erosion during the rainy season. The surface of the soil cakes and hardens during the hot summer months so that moisture absorbent qualities are inhibited.

Competition from other Species. Oregon white oak (Quercus garryana), Oregon maple (Acer macrophyllum) and blackberry vines (Rubus spp.) are the main competing species for soil moisture on this area. On the southeastern and eastern sides there is some competition for light from oak and maples which have sprouted from stumps.

There is also a snag girdling experiment being carried on throughout this area, and two of said snags have been wind thrown and have crushed several pine saplings. These pine will eventually die unless these snags are removed.

Biotic Factors. While working on the area, it was noted that several of the smaller pine saplings have been damaged due to the fact that rabbits have nibbled upon the lower branches and needles.

Several oak and maple stumps and the blackberry bushes offer favorable cover for rabbits and gophers.

It is possible and probable that man has caused some damage to the pine, as numerous silviculture classes have made growth studies in previous years, and boys from

the C.C.C. camp located three-fourths miles east on the main highway have well worn paths through the plantation.

C. Statistical Description.

In the past a standard sheet (see index) has been used each year for the recording of growth and survival data of the area. It has been customary for the junior silviculture class to spend one laboratory period of four hours annually to compile this data.

Procedure for obtaining the necessary annual measurements is as follows:

The instructor goes over the procedure generally and usually measures some trees for an example. A yard stick is used, and inches are the basis of measurements; current annual height growth is measured from the top of the highest whorl of branches to the top of the terminal bud. Total length is measured from the ground line to the same point. Quality of the leader (current annual height growth) is judged asto color, size, and general condition. This is explained to the students by the instructor.

The procedure used in obtaining these measurements is to assign two men to a row under normal circumstances, one doing the measurements and the other tallying the results on the regular forms. Under this system it is estimated that approximately fifty man-hours of labor are used to measure the entire area.

The data of each sheet is averaged by the crew who

took it and as a whole the data is filed with the instructor under the file name of "Ponderosa Pine Planting Methods". This measuring was initiated in 1935 and is complete up to 1939, inclusive, with the exception of data on spring planting in 1937, which has been lost.

OBJECTIVES OF THESIS

The objectives of this thesis may be stated and expatiated as follows:

1. To compile scattered data into a single paper.

During the last five years these papers have been in the hands of different professors and in a general state of disorganization. It is our aim to bring these papers and statistics together under one file, so that they are easily accessible at all time.

2. To determine by statistical methods the results of planting this area by the different methods and to analyze the results of each.

To date no analysis or conclusions have been constructed from the data collected in previous years. This entire thesis will be directly based upon these figures which have collected since the year 1935. At this time, it is estimated that the trees in the plantation have made sufficient growth to comprehensively draw conclusions and to offer recommendations.

3. To conduct a silvicultural survey of the area.

As far as existent records indicate, very few if any studies have been made to determine the silvicultural aspects of the area, with the exception of a few inadequate observations made prior to the planting in 1932-33. It is evident that silvicultural aspects play a leading role in the condition of the growing stock. This survey is intended to be more of an extensive than of an intensive nature.

4. To provide a basis and recommendations for future research on this project.

It is our opinion that past data from this project has been insufficient as far as quality and quantity are concerned.

The final results of of this project, which can be obtained within the next decade, can be no more accurate than the data upon which it is based; therefore it will be our objective to outline new procedures for obtaining data upon a basis of the best quality in the optimum time.

5. To determine the relative merits of the eight methods of planting based upon survival and growth characteristics.

It was the original intent that the results of these different methods of planting be interpreted by the relative percentage survival of trees planted under each method, and the growth characteristics of each.

We will base our thesis on the same criterion, but

will not hold this policy as indefeasible, in the event that more efficient criteria are ascertained.

PROCEDURE

A. Field Work.

1. Survey of the area.

The beginning point for the survey was tied into the 1/16 corner section 36, Township 11 South, Range 5 West, Willamette Meridian. A staff compass, a two-chain trailer tape was used in determining the direction and distance, while one abney was used by the head chainman in determining differences in elevation. A rough map was made out in the field and final copies made in the office.

2. Measurements of leader lengths and total heights of Ponderosa pine.

Two pieces of lumber 1 by 2 inches by eight feet, were graduated into one-half inch divisions. Two men measured the total heights in addition to the leader lengths of all the trees, and the other man recorded the data.

3. Silvicultural analysis.

(a) Soil analyses. A soil auger was used to determine the soil depth and type of soil. Samples from four different points of the plantation were obtained and the depths of the A and B layers were recorded.

The pH value of the soil was obtained from data collected by the Soils Department of the School of Agriculture.

(b) Biotic factors. Each sapling was examined to determine any deleterious effects that might be due to rabbits feeding upon needles and branches and any other effects such as broken leaders and by men who collected data in previous years.

B. Office Work.

1. Preparation of data.

Data from previous years' measurements of the pine in this plantation was recovered from Professors W. F. McCulloch and T. J. Starker, School of Forestry, Corvallis, Oregon.

Each years data including our measurements for the year 1939 are compiled into one complete table entitled "Statistical Analysis of Ponderosa Pine Planting Study".

The average measurements of each type of planting for both fall and spring planting were then compiled and the total average heights by years were plotted in order to better determine the correlation between types of planting and the average rate of growth and heights for the past five years. There are two graphs for spring and fall planting in this part of the thesis.

2. Description of present improvements.

The only evidence of improvement on the area are stakes at the head of each row (north end). Most of these still remain intact. It was suggested to supplement these with new and more durable stakes, but this project was critized because improvements of this sort are too attract-

ive to marauders. The present stakes are in a state of decay but have been placed in positions where their identification is easy.

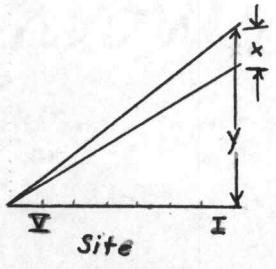
No cultural improvements, as vine and brush eradification, have been done although several portions of the area are in need of work of this character. Rodents could be controlled and eliminated almost completely by simple application of poison within the area.

3. Determination of statistical methods.

To date the only attempt at a statistical survey on this project was by Mr. Harry A. Fowells, California Forest Experiment Station, Berkeley, California, to whom the annual forms have been sent for statistical analysis. So far, no results have been gained from this source, so it was up to us to determine some way to compare the different planting methods and reach some logical and mathematical correct results.

An idea was conceived to form an index, which proved inadequate later and was abandoned. The description of this index is as follows:

The basic assumption was that all environmental factors, viz., site, would affect growth proportionately the same. The index was the relationship of current annual growth (leader length) to the total growth.



The above graph will explain how we thought site would affect the growth of seedlings. Let X equal the current annual growth and Y the total growth. OTBE, this growth would vary but would at all time X:Y would be the same.

Assuming this to be true, the value of using this index would be that deviations from this index would be because of planting methods. If a tree were planted by a poor method, the index would be below the average for the plantation or any one method selected as a basis of comparison. A method that was entirely satisfactory would produce an index higher than the average. The time it took for a seedling to overcome defects could also be seen in this system.

This statistical procedure was tried on several rows and it was found that there was very little correlation of the indices. The procedure was definitely faulty, although the exact cause for this failure was not derived.

The second method of statistical procedure was worked out on an entirely different basis and found to work to a satisfactory degree of accuracy. Its application is explained in the following section.

4. Application of statistical methods.

The statistical methods determined in the previous paragraph resulted in our eliminating several poor samples in every type of planting and row. The graphs showing total heights of trees in inches over age in years were used

so that the reader might better picture the comparative results of the different types of planting.

Total height in inches instead of leader length in inches was used as the dependent variable because it is considered that the total height will give the results of the last five years growth and will give us a better sample of growing conditions and vigor than if we were able to base our conclusions on only one year's growth.

CONCLUSIONS

A. Season Planting.

Although results indicate that there was no difference in survival of either spring and fall planting, we feel that the conditions of planting and the mild winter tend to minumize the differences there might have been in the fall and spring plantings.

Fall planting produced higher survival than spring planting under the following methods: slit, 15 minute, 30 minute, 60 minute and lower survival in cone and mattock. We conclude that there is no correlation between the season of planting and the survival. We believe that certain biotic factors have contributed more to the mortality than the season of planting.

B. Row Planting.

Fall planting. The greatest survival of trees in the fall planting method by rows (originally 50 trees planted per row) were the puddled (48), and silt (48) methods with little difference in mattock(46), cone(46), 15 min-

ute(46), 30 minute(46); 60 minute(34) showed the smallest number of surviving trees.

Spring planting. In the spring planting the survival was in the following order: bunched(48), mattock (48), puddled(48), cone(47.5), slit(44.2), 15 minute(43.5), 30 minute(42.8) and 60 minute(36.5).

Methods of planting cannot be considered as the single function as other factors such as competition and rabbit damage must be considered in arriving at any conclusions in percentage of mortality.

C. Growth Height over Age Years.

The puddled method in both fall and spring planting was consistently high while the sixty minute showed the least total height growth.

The remainder of the averaged rows planted by the various methods varied in each case of fall and spring planting, as in the fall planting the mattock method showed a lower average height growth than the method of planting by exposing the roots for 15 minutes while in the spring planting the mattock method rated third in average height growth.

There is as much variation in height in the individual rows because of site differentiation as there is between the different methods of planting. As there is no known statistical method of eliminating these site factors, the results of field data must be limited to some extent in accuracy.

The soil analysis of this area shows that there is no correlation between soil depth and average height growth.

On this area the differences in site may be attributed almost entirely to the drainage of the soil, as other soil characteristics as pH value, texture, depth, tilth are of a more or less homogeneous nature.

D. General Conclusions.

It is believed that the detrimental effects on the planting stock due to the methods of planting influence their growth only up to an age of (10-12) years at which time new roots will be formed, and the root system of all the trees will be of approximately the same condition. Under normal growing conditions in the forest, the results of different methods of planting can be seen through survival, which would largely be the result of the ability of of the trees to withstand competition during their infancy, and costs which would naturally be determined by the principle of the best survival at the least cost; for example, although the puddled and cone methods appear to give the best growth and survival, the extra time involved in the planting procedure would possibly eliminate these methods because of the economic considerations.

In a project of this type, all environmental factors as site, competition and etc., should be kept at a constant in order to safely conclude that the greatest differences in growth are the direct results of methods of planting.

On the present plantation these factors vary so greatly on different portions of the area that in many cases differences in growth caused by methods of planting are greatly subordinated.

RECOMMENDATIONS

The following recommendations are offered:

1. In order to secure greater accuracy in the obtaining of field data, every tenth tree in each row should be visibly marked so as to facilitate survival counting and specific trees could be found with greater ease.

2. In addition to the gathering of annual growth and survival data, it is recommended that approximately 20 man-hours of work be spent in the eradication of vines and brush which are at present influencing the results of the project in a harmful fashion.

3. It is recommended that if future annual surveys of the area are desired, it would be advantageous to allocate a part of one silviculture class (prior to the survey) to the teaching of students the importance of careful measurements and persuade them to subscribe to the principle that the results of the experiment can be no more accurate than the results of their measurements.

4. It is our opinion that the results are not as accurate as they were anticipated to be. The main reason is

that there are so many varying factors of sufficient magnitude to affect the growth of trees that differences in growth between rows cannot be attributed to methods of planting alone; therefore if sufficient significance be placed upon this project, we recommend that the project be repeated upon another area in the McDonald Forest where all these environmental factors are believed to be uniform enough so that any differences in height growth may be attributed directly to methods of planting. This area upon which the experiment may be repeated would be in the grasslands north of the Jackson Place. On this area, site, aspect, soil conditions, and biotic factors are practically uniform.

BIBLIOGRAPHY

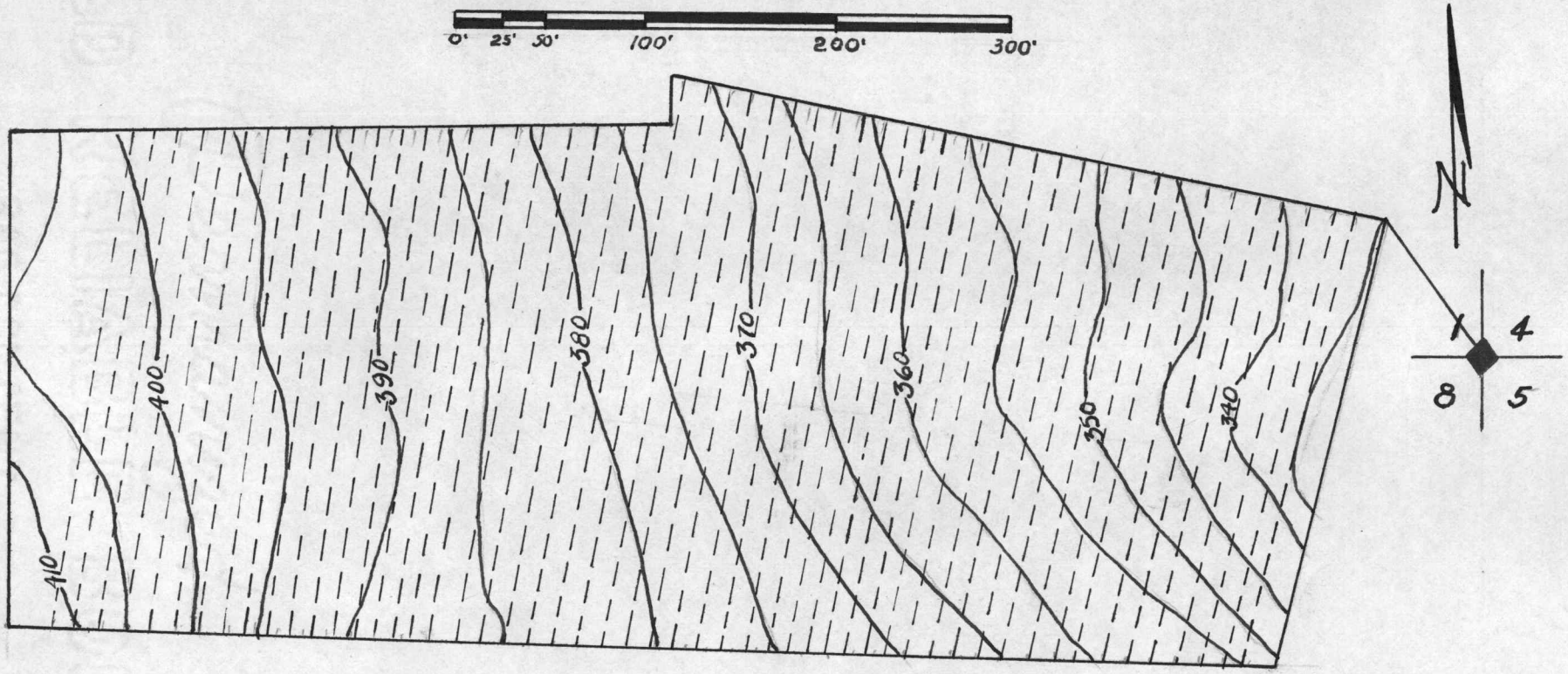
Due to the fact that there were no reference books used in the preparation of this thesis, no bibliography is listed. Conclusions and recommendations were arrived at through personal observations of the area.

Part I

APPENDIX

METHODS OF PLANTING PONDEROSA PINE
STUDY EXPERIMENTAL PLANTATION

Contour Interval: 5' **Scale: 1" = 80'**



STATISTICAL ANALYSIS OF PONDEROSA PINE PLANTING STUDY

1935

Fall					Spring		
Row No.	Ave. Ht. (in.)	Ave. L.L. (in.)	No. of Trees	*	Row No.	Ave. Ht. (in.)	Ave. L.L. (in.)	No. of Trees
				Cone				
1	18.7	8.54	49	*	33	21.97	9.38	47
9	19.8	7.24	46	*	41	21.65	8.98	46
17	20.6	8.1	46	*	49	22.96	8.96	49
25	21.3	9.4	47	*	57	25.31	10.68	48
				*				
Tot.	80.4	33.28	188	*	Tot.	91.89	38.0	190
Ave.	20.1	8.32	47	*	Ave.	22.72	9.50	47.5
				Puddled				
2	23.3	9.30	49	*	34	21.84	8.82	44
10	20.8	8.2	48	*	42	19.73	8.18	49
18	21.2	8.9	50	*	50	21.89	10.32	49
26	20.4	8.96	46	*	58	23.6	11.17	48
				*				
Tot.	85.7	35.36	193	*	Tot.	86.46	38.49	190
Ave.	21.4	8.34	48	*	Ave.	21.61	9.62	47.5
19								
27								
				Bunched				
3	19.9	7.04	48	*	35	18.01	7.29	48
11	20.2	8.13	48	*	43	18.92	7.68	49
19	22.7	9.84	49	*	51	20.59	8.74	47
27	19.7	8.06	49	*	59	21.64	10.14	49
				*				
Tot.	82.5	33.07	194	*	Tot.	79.16	33.85	193
Ave.	20.6	8.27	48.5	*	Ave.	19.79	8.46	48
				Slit				
4	20.4	8.66	48	*	36	18.8	8.62	46
12	20.5	8.56	49	*	44	18.7	8.23	42
20	19.3	8.39	48	*	52	20.9	7.89	42
28	21.0	9.28	47	*	60	19.9	8.74	49
				*				
Tot.	81.2	34.89	192	*	Tot.	78.3	33.48	179
Ave.	20.3	8.72	48	*	Ave.	19.6	8.37	45

1935 (cont.)

Fall					Spring			
Row No.	Ave. Ht. (in.)	Ave. L.L (in.)	No. of. Trees	* * * *	Row No.	Ave. Ht. (in.)	Ave. L.L. (in.)	No. of Trees
				15 Minute Exposure				
5	19.6	8.29	45	*	37	16.2	7.14	42
13	18.8	7.64	47	*	45	12.8	6.86	43
21	16.0	6.53	45	*	53	18.3	8.28	43
29	18.6	8.57	50	*	61	19.1	9.51	46
				*				
Tot.	73.0	31.03	187	*	Tot.	66.4	31.79	174
Ave.	18.25	7.76	47	*	Ave.	16.6	7.95	43.5
				30 Minute Exposure				
6	16.6	7.12	48	*	38	15.1	5.61	41
14	14.4	6.53	48	*	46	16.95	6.87	41
22	16.9	6.67	41	*	54	15.94	7.12	46
30	17.3	6.80	45	*	62	19.12	9.23	43
				*				
Tot.	65.2	27.12	182	*	Tot.	67.11	28.83	171
Ave.	16.3	6.78	45.5	*	Ave.	16.50	7.21	43
				60 Minute Exposure				
7	17.1	7.47	46	*	39	13.2	4.87	38
15	15.36	6.31	44	*	47	13.7	5.94	32
23	16.01	5.94	28	*	55	16.4	6.58	40
31	14.67	5.38	39	*	63	18.8	8.69	39
				*				
Tot.	63.14	25.10	157	*	Tot.	62.1	26.08	149
Ave.	15.78	6.27	39	*	Ave.	15.5	6.52	37
				Mattock				
8	19.22	8.17	45	*	40	19.5	8.41	50
16	20.74	8.26	49	*	48	20.4	8.73	50
24	18.47	7.51	50	*	56	23.5	10.53	47
32	18.02	6.57	47	*	64	21.7	10.40	50
				*				
Tot.	76.45	30.51	191	*	Tot.	85.1	38.09	197
Ave.	19.11	7.63	48	*	Ave.	sl.3	9.52	49

STATISTICAL ANALYSIS OF PONDEROSA PINE PLANTING STUDY

1936

Fall				Spring			
Row No.	Ave. Ht. (in.)	Ave. L.L. (in.)	No. of Trees	Row No.	Ave. Ht. (in.)	Ave. L.L. (in.)	No. of Trees
				Cone			
1	26.1	8.59	49	33	30.39	9.02	47
9	26.7	6.44	46	41	27.38	7.77	46
17	28.7	7.5	45	49	30.67	8.04	47
25	28.5	8.31	47	57	35.2	9.43	46
Tot.	110.0	30.84	187	Tot.	123.64	34.26	186
Ave.	27.5	7.71	47	Ave.	30.91	8.56	46.5
				Puddled			
2	32.8	9.63	49	34	29.88	8.45	42
10	28.6	9.74	48	42	27.25	7.75	49
18	29.7	8.27	50	50	29.37	8.84	47
26	28.8	8.84	45	58	34.14	10.09	48
Tot.	119.9	36.48	192	Tot.	120.64	35.13	186
Ave.	29.9	9.12	48	Ave.	30.16	8.78	46.5
				Bunched			
3	26.3	8.1	48	35	24.8	6.87	46
11	26.7	8.3	48	43	25.94	7.56	49
19	30.1	8.0	47	51	28.55	8.43	49
27	28.7	8.2	48	59	32.09	10.81	49
Tot.	111.8	32.6	191	Tot.	111.38	33.67	193
Ave.	27.9	8.15	48	Ave.	27.84	8.42	48
				Slit			
4	28.7	8.54	47	36	26.9	8.4	46
12	27.9	8.3	48	44	26.2	6.81	42
20	27.1	7.83	48	52	27.7	7.8	41
28	31.5	9.42	50	60	28.6	9.18	49
Tot.	115.2	34.09	193	Tot.	109.4	32.19	178
Ave.	28.8	8.52	48	Ave.	27.3	8.05	44.5

1936 (cont.)

Fall					Spring			
Row No.	Ave. Ht. (in.)	Ave. L.L. (in.)	No. of Trees	*	Row No.	Ave. Ht. (in.)	Ave. L.L. (in.)	No. of Trees
					15 Minute Exposure			
5	29.5	8.5	44	*	37	24.6	7.44	41
13	28.6	8.54	47	*	45	19.01	6.28	43
21	20.8	6.4	46	*	53	22.97	7.65	43
29	26.6	8.59	49	*	61	27.50	9.34	46
				*				
Tot.	105.5	32.03	186	*	Tot.	94.08	30.71	173
Ave.	26.4	8.01	46.5	*	Ave.	23.51	7.68	43
					30 Minute Exposure			
6	24.4	7.85	49	*	38	20.9	6.19	42
14	29.9	9.5	47	*	46	22.6	7.34	44
22	25.1	7.34	42	*	54	23.24	7.80	47
30	25.1	8.22	48	*	62	28.8	9.60	44
				*				
Tot.	105.4	32.91	186	*	Tot.	95.54	30.93	177
Ave.	26.3	8.23	46.5	*	Ave.	23.88	7.73	44
					60 Minute Exposure			
7	25.2	8.2	46	*	39	17.2	5.26	39
15	23.3	7.74	44	*	47	19.8	5.7	33
23	21.6	6.1	28	*	55	23.67	7.04	40
31	———	———	40	*	63	27.8	9.4	39
				*				
Tot.	70.1	22.04	158	*	Tot.	88.47	27.40	151
Ave.	23.4	7.35	39.5	*	Ave.	22.12	6.85	38
					Mattock			
8	27.6	7.8	45	*	40	26.9	8.06	50
16	29.2	8.11	46	*	48	27.14	7.10	50
24	24.6	6.92	50	*	56	32.7	9.64	46
32	20.9	6.98	46	*	64	31.9	10.20	47
				*				
Tot.	102.2	29.81	187	*	Tot.	119.24	35.00	193
Ave.	25.5	7.45	47	*	Ave.	29.81	8.75	48

STATISTICAL ANALYSIS OF PONDEROSA PINE PLANTING STUDY

1937

Row No.	Fall Ave. Ht. (in.)	Fall Ave. L.L. (in.)	Fall No. of Trees	Row No.	Fall Ave. Ht. (in.)	Fall Ave. L.L. (in.)	Fall No. of Trees
	Cone				**15 Minute Exposure**		
1	39.4	13.4	49	5	41.3	12.9	44
9	38.1	11.1	46	13	41.2	14.2	47
17	43.6	14.4	44	21	32.6	11.4	43
25	42.5	14.1	46	29	39.9	12.94	49
Tot.	163.6	53.0	185	Tot.	155.0	51.44	183
Ave.	40.9	13.2	46	Ave.	38.7	12.83	46
	Puddled				**30 Minute Exposure**		
2	46.9	15.4	49	6	35.2	12.53	49
10	41.6	14.9	48	14	34.8	12.6	47
18	40.8	14.5	50	22	34.2	11.9	42
26	41.6	13.1	45	30	35.1	11.9	49
Tot.	170.9	57.9	192	Tot.	139.3	48.93	187
Ave.	42.7	14.5	48	Ave.	34.8	12.23	47
	Bunched				**60 Minute Exposure**		
3	38.8	12.6	46	7	35.4	12.01	47
11	38.5	13.3	48	15	34.5	11.54	44
19	42.6	14.3	47	23	38.9	15.35	28
27	38.2	12.0	49	31	30.4	10.15	39
Tot.	158.1	52.2	190	Tot.	139.2	49.05	158
Ave.	39.5	13.05	47.5	Ave.	34.8	12.26	39.5
	Slit				**Mattock**		
4	42.8	14.25	47	8	37.3	13.0	45
12	42.2	14.2	47	16	42.1	13.3	46
20	39.2	12.6	47	24	34.9	11.4	50
28	41.1	15.46	49	32	36.3	11.9	47
Tot.	165.3	56.51	190	Tot.	150.6	49.6	188
Ave.	41.3	14.13	47.5	Ave.	37.6	12.4	47

STATISTICAL ANALYSIS OF PONDEROSA PINE PLANTING STUDY

Fall				1938	Spring			
Row No.	Ave. Ht. (in.)	Ave. L.L. (in.)	No. of Trees	*	Row No.	Ave. Ht. (in.)	Ave. L.L. (in.)	No. of Trees
				Cone				
1	54	16	49	*	33	43	14	47
9	50	15	46	*	41	56	16	48
17	55	17	44	*	49	57	16	47
25	55	16	46	*	57	64	18	48
				*				
Tot.	214	64	185	*	Tot.	220	64	190
Ave.	53.5	16	46.2	*	Ave.	55	16	47.5
				*				
				Puddled				
2	61	14	49	*	34	55	15	45
10	56	17	48	*	42	55	15	49
18	56	17	49	*	50	56	15	49
26	53	16	47	*	58	65	18	49
				*				
Tot.	226	64	193	*	Tot.	231	63	191
Ave.	56.5	16	48	*	Ave.	57.8	15.7	48
				Bunched				
3	53	15	46	*	35	46	11	47
11	52	16	48	*	43	52	15	49
19	56	16	47	*	51	55	15	47
27	52	15	49	*	59	63	18	49
				*				
Tot.	213	62	190	*	Tot.	216	59	182
Ave.	53.3	15.5	47.5	*	Ave.	54	14.7	45.5
				Slit				
4	55	16	47	*	36	51	12	46
12	58	17	48	*	44	53	15	41
20	52	16	48	*	52	55	16	41
28	60	17	50	*	60	58	17	48
				*				
Tot	225	66	193	*	Tot.	217	60	176
Ave.	56.2	16.5	48	*	Ave.	54.2	15	44

1938 (cont.)

Fall				Spring			
Row No.	Ave. Ht. (in.)	Ave. L.L. (in.)	No. of Trees	* Row No.	Ave. Ht. (in.)	Ave. L.L. (in.)	No. of Trees
			15 Minute Exposure				
5	59	16	45	* 37	45	13	41
13	56	16	46	* 45	41	13	44
21	43	13	44	* 53	49	15	42
29	53	16	49	* 61	65	20	45
				*			
Tot.	211	61	184	* Tot.	220	61	172
Ave.	52.7	15.2	46	* Ave.	55	15.2	43
			30 Minute Exposure				
6	49	15	48	* 38	42	13	43
14	46	17	47	* 46	47	15	41
22	44	13	41	* 54	48	14	45
30	51	19	49	* 62	58	18	43
				*			
Tot.	190	64	185	* Tot.	197	60	172
Ave.	47.5	16	46	*Ave.	49.3	15	43
			60 Minute Exposure				
7	48	15	46	* 39	36	11	38
15	48	16	44	* 47	38	12	33
23	49	13	28	* 55	44	14	40
31	42	12	40	* 63	56	18	39
				*			
Tot.	187	56	158	* Tot.	174	55	150
Ave.	46.8	14	39.5	* Ave.	43.5	13.7	37.5
			Mattock				
8	52	15	46	* 40	54	13	50
16	58	16	46	* 48	55	16	50
24	47	14	50	* 56	62	17	47
32	46	13	45	* 64	61	17	47
				*			
Tot.	203	58	187	* Tot.	232	63	194
Ave.	50.9	14.5	47	* Ave.	58	15.7	48.5

STATISTICAL ANALYSIS OF PONDEROSA PINE PLANTING STUDY

1939

Fall				Spring			
Row No.	Ave. Ht. (in.)	Ave. L.L. (in.)	No. of Trees	Row No.	Ave. Ht. (in.)	Ave. L.L. (in.)	No. of Trees
				Cone			
1	66.8	11	49	33	67.7	12.5	47
9	61.5	10	45	41	69.3	13	47
17	66.9	12.3	44	49	69.9	13.4	48
25	67.4	12.4	47	57	65.5	13.9	48
Tot.	262.6	45.7	185	Tot.	272.4	52.8	190
Ave.	65.5	11.42	46	Ave.	68.1	13.2	47.5
				Puddled			
2	76.7	13.6	49	34	68.1	12.7	44
10	70.6	11.0	48	42	66.2	12.0	49
18	69.6	12.2	49	50	67.3	12.2	49
26	66.5	11.8	46	58	79.0	14.9	49
Tot.	283.4	48.6	192	Tot.	280.6	51.8	191
Ave.	70.85	11.9	48	Ave.	70.1	12.95	48
				Bunched			
3	64.7	10.7	46	35	57.9	11.2	49
11	64.0	10.4	48	43	61.3	11.3	49
19	68.0	11.3	47	51	65.5	12.2	47
27	64.4	12.8	49	59	80.6	15.0	48
Tot.	261.1	45.2	190	Tot.	265.3	49.7	193
Ave.	65.3	11.3	47	Ave.	66.3	12.4	48
				Slit			
4	68.5	10.2	47	36	62.3	13.7	46
12	69.5	11.0	48	44	63.1	11.0	41
20	62.6	10.2	48	52	64.4	12.9	40
28	74.0	13.3	48	60	72.0	14.9	50
Tot.	274.6	44.7	191	Tot.	261.8	52.2	177
Ave.	68.6	11.2	48	Ave.	65.4	13.1	44

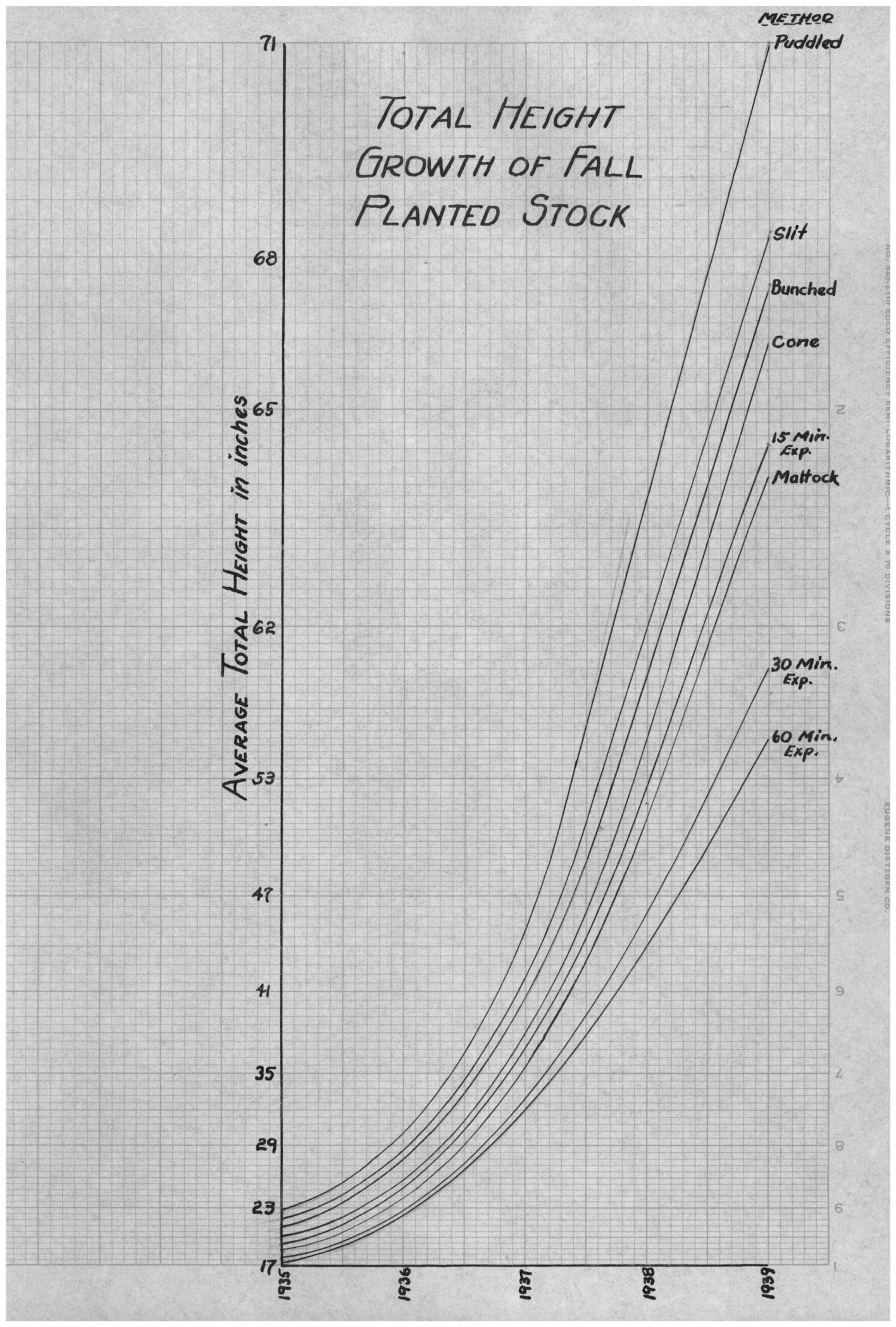
1939 (cont.)

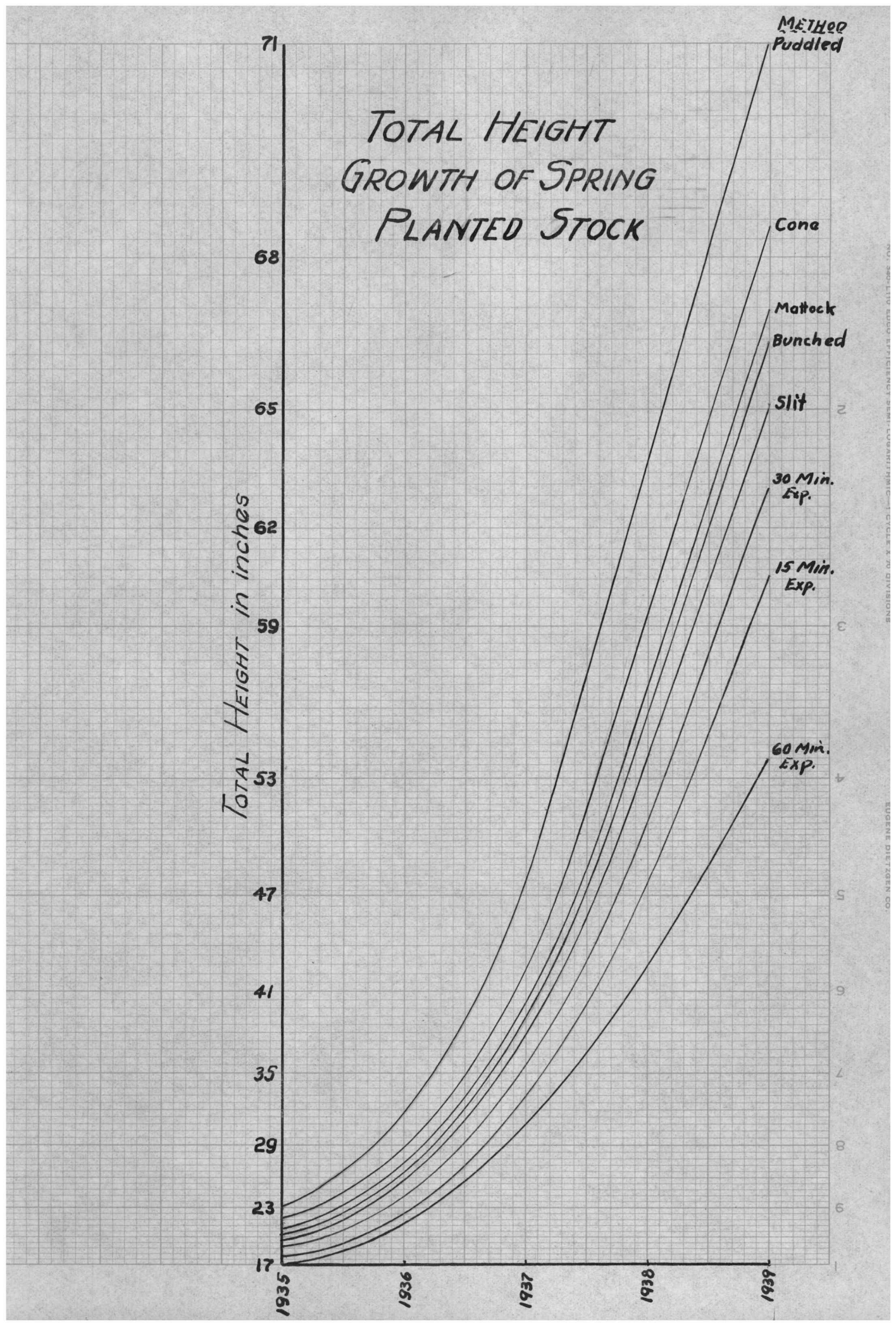
Fall					Spring			
Row No.	Ave. Ht. (in.)	Ave. L.L. (in.)	No. of Trees	*	Row No.	Ave. Ht. (in.)	Ave. L.L. (in.)	No. of Trees
					15 Minute Exposure			
5	67.8	11.1	45	*	37	57.3	11.46	42
13	68.7	10.7	47	*	45	49.1	9.94	44
21	54.1	9.4	44	*	53	61.0	12.0	42
29	68.0	13.1	49	*	61	74.5	16.5	46
				*				
Tot.	258.6	44.3	185	*	Tot.	241.9	48.9	174
Ave.	64	11.07	46	*	Ave.	60.5	12.5	43
					30 Minute Exposure			
6	59.3	9.5	48	*	38	51.7	9.98	42
14	55.5	9.6	48	*	46	61.7	11.8	41
22	57.0	9.5	39	*	54	56.7	11.3	46
30	61.4	13.5	49	*	62	72.4	14.9	42
				*				
Tot.	233.2	42.1	184	*	Tot.	242.5	47.98	171
Ave.	58.3	10.5	46	*	Ave.	60.6	12.0	43
					60 Minute Exposure			
7	61.2	10.3	47	*	39	45.3	9.0	37
15	60.7	11.2	44	*	47	48.3	9.92	31
23	51.0	10.8	28	*	55	58.3	11.9	40
31	55.4	12.8	38	*	63	69.1	14.5	38
				*				
Tot.	228.3	45.1	157	*	Tot.	221.0	45.3	146
Ave.	57.1	11.3	39	*	Ave.	55.2	11.3	36
					Mattock			
8	67.1	11.1	44	*	40	61.0	11.0	50
16	67.3	11.8	46	*	48	67.2	12.0	49
24	56.8	9.4	50	*	56	79.0	14.2	47
32	63.1	13.9	46	*	64	73.7	13.9	47
				*				
Tot.	254.3	46.2	186	*	Tot.	280.9	51.1	193
Ave.	63.6	11.5	46.5	*	Ave.	70.2	12.8	48

NORTHWEST PORTION

OF PONDEROSA PINE PLANTATION

Fig.1


METHOD
Puddled
Slit
Bunched
Cone
15 Min. Exp.
Maltock
30 Min. Exp.
60 Min. Exp.
TOTAL HEIGHT GROWTH OF FALL PLANTED STOCK
AVERAGE TOTAL HEIGHT in inches
71
68
65
62
53
47
41
35
29
23
17
1935
1936
1937
1938
1939


TOTAL HEIGHT GROWTH OF SPRING PLANTED STOCK
TOTAL HEIGHT in inches
71
68
65
62
59
53
47
41
35
29
23
17
1935
1936
1937
1938
1939
METHOD
Puddled
Cone
Mattock
Bunched
Slit
30 Min. Exp.
15 Min. Exp.
60 Min. Exp.

PART II

Determination of the Specific Gravity of Ponderosa Pine Occurring Naturally in the Upper Willamette Valley

Introduction.

The purpose of this thesis is to scientifically determine the specific gravity of Ponderosa pine of a diameter of 12 inches and larger grown in the Willamette valley. Assuming strength properties of woods to vary proportionately to the specific gravity, characteristics of Ponderosa pine in this region may be compared with those growing under drier, more adverse environments.

This investigation was undertaken with the sagacity that the conclusion reached would indicate the necessity for more detailed studies of this wood as to physical and mechanical properties. If Ponderosa pine which can be planted upon the poorer sites in the Willamette valley and may attain a larger diameter and greater height in a shorter length of time and still compare favorably as to strength and figure qualities with Ponderosa pine grown in Eastern Oregon, a new field for timber growers and managers may be opened.

Probably the only previous study related to this investigation was that made by Wallace Anderson, O.S.C. '39, and whose objective was to study the western yellow pine as found in the Willamette valley with a purpose of determining its possible migratory means, its growth rate, reproduction, and soil type upon which it was found.

Quoting Mr. Anderson a brief review is made upon the

above points:

The only plausible means of migration is that the flood waters of the tributaries of the Willamette river carried the original seeds to their present location. Since pure forests are found on the headwaters of this river, and floods occur during the fall, winter and early spring; coupledwith the fact that the seeds germinate the spring following dissemination, this theory seems to fit the case better than any other.

Reproduction varies from one extreme to the other. Stands of saplings, poles and larger trees are quite uneven-aged. The reasons for this state could be either a washing away of seeds after dissemination, failure to extend a deep enough tap root to withstand the dry summer, or a wet, cold period during germination.

The most common soil types found where Ponderosa pine grows are Willamette silty clay loam and Camas gravelly loam, the best growth occurring on the former. The other soil types include the Chehalis, Dayton, and Wapato silty clay loams, Newberg loam, and Chchalis fine sandy loam. A loamy subsoil seems to be the favorite soil.

Growth studies in diameter made by Anderson indicate that more depended upon the site occupied by the trees which were bored. Some of the trees growing in the open made fast early growth, and others, slower growth as they grew older; those growing in fairly dense stands made a

slow early growth, but as they attained a dominant position in the stand, greater annual growth was the result.

Method of Procedure and Source of Data.

Investigative data was obtained from a grove of Ponderosa pine located near the Willamette river and was 8 miles southeast of Corvallis, Oregon.

Increment borings were obtained from 200 trees, 12 inches and larger at breast high. A few of the borings were obtained at heights of 10 to 110 feet. The three men (co-workers upon this thesis) made all of the borings. The cores were wrapped in paper and the diameter recorded on each core.

It is estimated that 28 man hours were needed to make all of the borings.

To determine the specific gravity of each core, it was necessary to dry said cores in a small electric heated oven furnished by the Wood Products Department of the School of Forestry.

The temperature of the oven was regulated between 85° C. and 105° C., and the cores were left in the oven for two days. The next step necessitated the weighing of the cores upon scales also furnished by the School of Forestry; the cores were then dipped in melted paraffin or wax and then weighed again, the weights being recorded for each time. The wax was necessary to prevent the cores from absorbing water when the tests were made to determine the

weights in water.

A burette tube graduated in centimeters was then partially filled with water. The height of the water was recorded without the insertion of the core, and taking each core individually, they were submerged in the tube, and the reading in centimeters was again recorded. After this work was completed it was fairly simple to compute the specific gravity of each core.

The following formulae was the method used in the determination of the various specific gravities obtained:

1. Weight of wood with wax minus weight of wood equals the weight of wax.
2. Specific gravity of wax equals .89.
3. Specific gravity of water (1.00) over specific gravity of wax (.89) equals (1.12) volume of a gram of wax.
4. Weight times the volume of wax equals the weight of water displaced by the entire mass of wax on core.
5. Weight of water displaced by wood and wax submerged minus the weight of water displaced by wax equals the weight of water displaced by wood alone.
6. Weight of wood in air over the weight of water displaced by wood equals the specific gravity of wood.

Sampling Procedure.

Increment borings were taken from 200 trees 12 inches D.B.H. and up. It is believed this is sufficient sampling to form definite conclusions as to the average specific

gravity of the wood.

Due to the fact that approximately forty of the cores were burned quite badly in the drying oven it was deemed inadvisable to include these in the tests.

The specific gravities obtained from tests on each core were then averaged and the standard deviation determined. Any sample whose specific gravity deviated from the average deviation by two times the standard deviation was considered a bad sample and discarded.

After throwing out the bad samples, an average of the remaining samples was determined and this figure was the final average specific gravity for all of the samples.

Results.

The results in a summarized form show that following specific gravities taken from different portions of the trees sampled are:

Average Specific Gravity taken at D.B.H.	.572
Average Specific Gravity taken at 20 ft.	.462
Average Specific Gravity at 7 in. top diam.	.376
Total Specific Gravity	1.410
Average Specific Gravity	.47

From the average specific gravity of the average tree, the bending qualities, compressional strengths, hardness, and other physical properties may be determined by formulae found in any Wood Handbook.

Conclusions.

The results of the average specific gravity of .47 for the Ponderosa pine grown in the Willamette valley is .07 greater than Ponderosa pine grown east of the Cascade Mountains.

There are three reasons advanced for this difference in specific gravities, namely:

1. Seventy-five percent of the increment borings were taken from the butt log (or at D.B.H.); although these were averaged as one unit, the resulting average specific gravity can be no more accurate than the average specific gravities of the remaining 25 percent of the borings taken at the end of the first 20 foot log and at the top diameter of seven inches.

2. A considerable number of the samples were taken from bull pine, 12 to 16 inches D.B.H. and this would show a higher specific gravity.

3. It is thought that due to different site and climatic factors in the Willamette valley, that Ponderosa pine shows a higher specific gravity than east of the Cascade Mountains, just as Douglas fir in the Willamette valley has a .08 higher specific gravity than Douglas fir grown in the Rocky Mountains.

As the Ponderosa pine shows a .07 higher specific gravity than Eastern Oregon grown Ponderosa pine, there is the possibility of planting Ponderosa pine on sandy and gravelly sites and denuded hillsides, using a shorter cutting

cycle than those used in Eastern Oregon, and producing a much stronger wood. The poor sites which can be planted with Ponderosa pine will grow merchantable timber in a much shorter time than if planted with Douglas fir.

If the wood did not prove to be of the desired qualities for structural and shop lumber, there is the possibility of opening a new field in the Willamette valley; namely that of box manufacture for local use.

Recommendations.

The following recommendations are offered:

1. Further research upon the strength qualities of the wood by actually sawing lumber from the trees and running tests in the School of Forestry testing machine.

2. Tests for durability of Willamette grown Ponderosa pine.

3. Determination of workability and finish to see how it compares with Ponderosa pine grown east of the Cascade Mountains.

4. Planting studies to determine sites best favorable for the growth of Ponderosa pine. From this a determination of the amount of land in the Willamette valley that could be planted from an economic and silvicultural standpoint.

5. Growth studies to determine economic, technical and financial rotations.

6. A study to determine how it withstands competition with other conifers and hardwoods.

7. A beetle survey in present Ponderosa pine stands in the Willamette valley to determine the degree of infestation and from this see if it would be economically possible to control this factor.

Part II

APPENDIX

PONDEROSA PINE TYPE FROM

WHICH SAMPLES WERE TAKEN

Fig.2

WOOD CORE SAMPLES USED

IN SPECIFIC GRAVITY TESTS

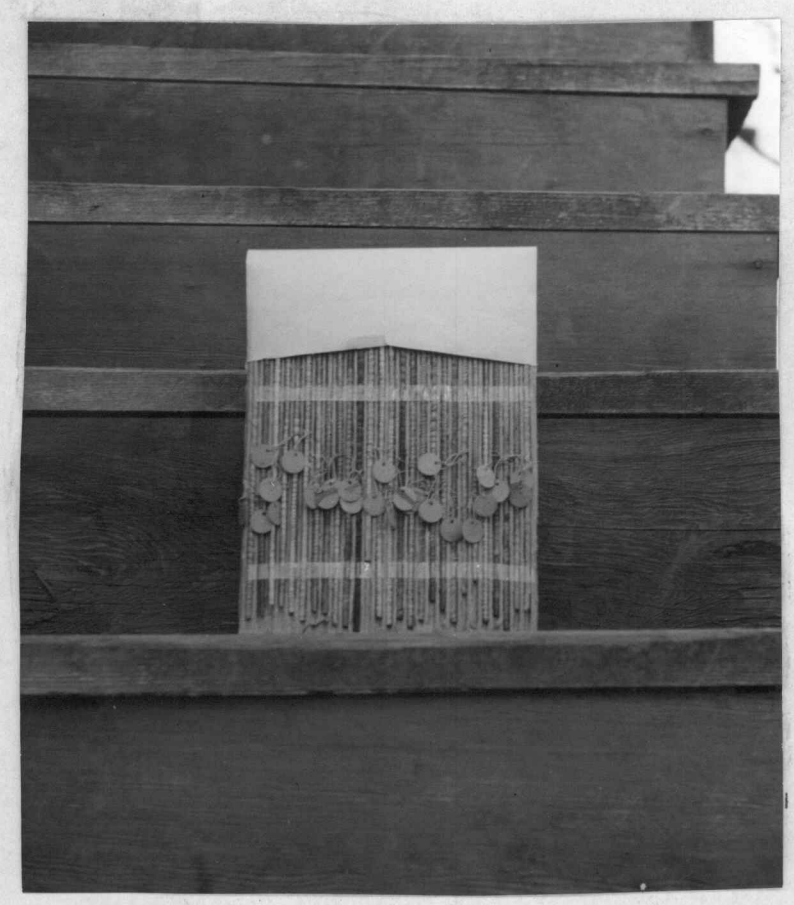
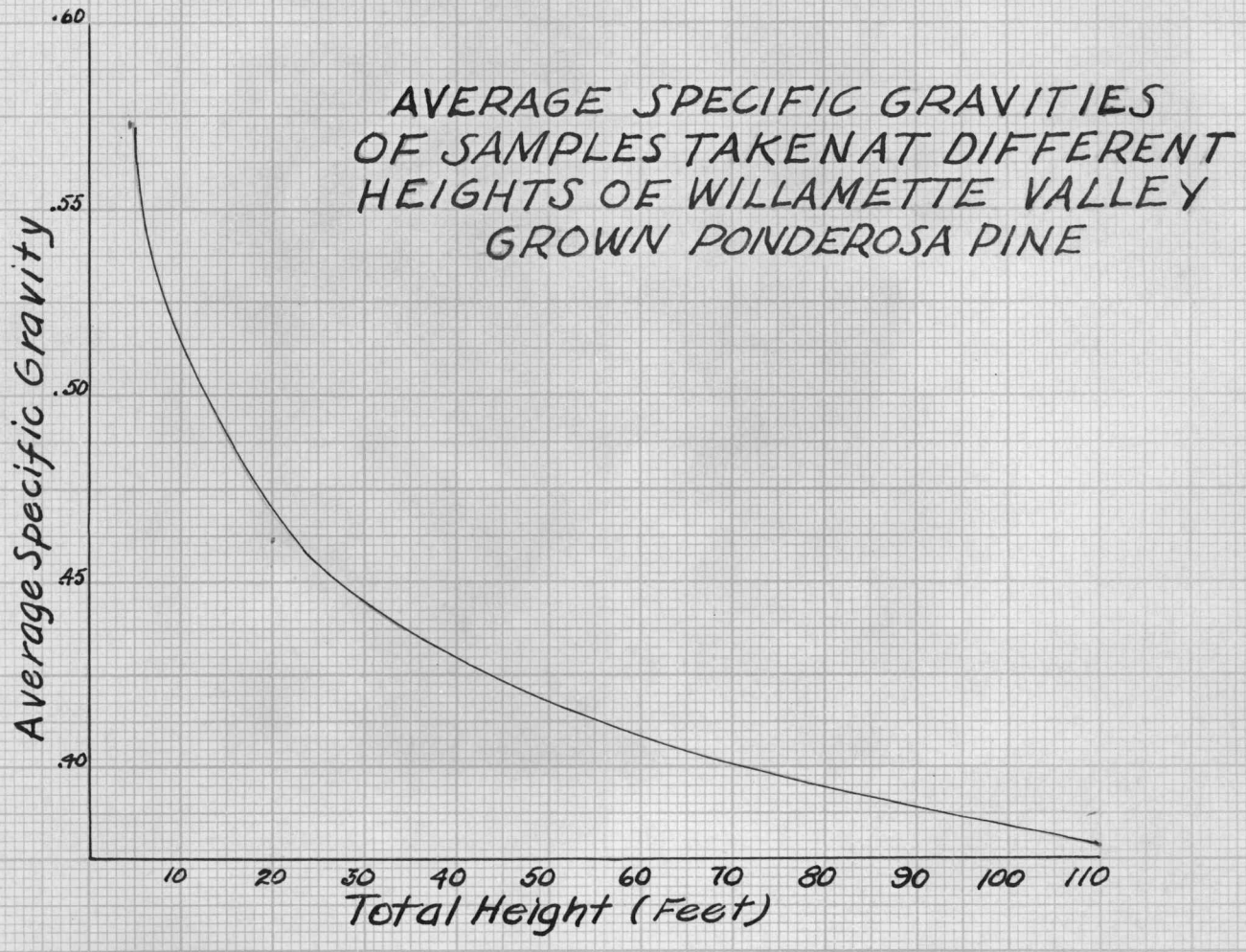


Fig.3


AVERAGE SPECIFIC GRAVITIES
OF SAMPLES TAKEN AT DIFFERENT
HEIGHTS OF WILLAMETTE VALLEY
GROWN PONDEROSA PINE
Average Specific Gravity
.60
.55
.50
.45
.40
10
20
30
40
50
60
70
80
90
100
110
Total Height (Feet)